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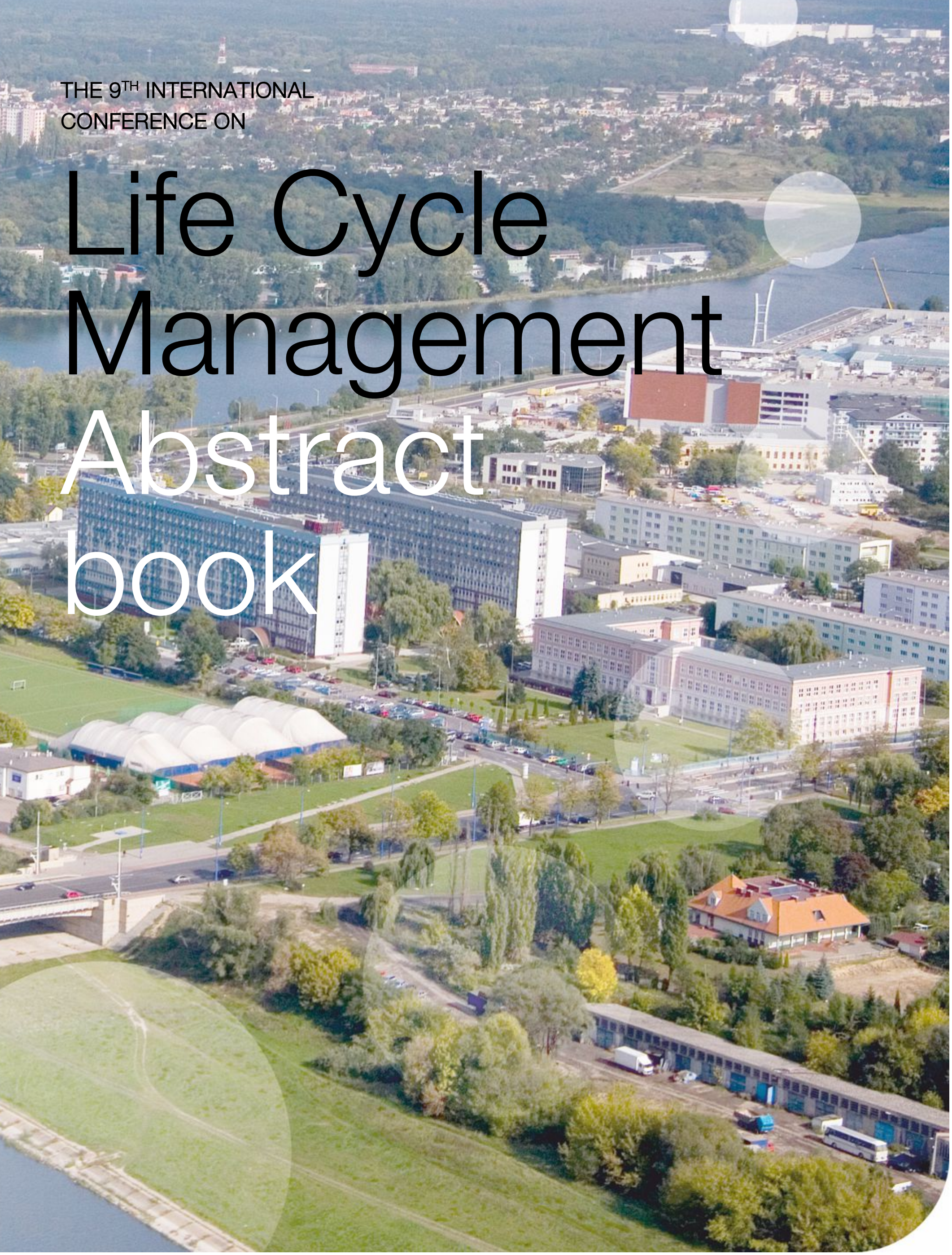
Abstract book



LCM 2019

1 – 4 SEPTEMBER 2019
POZNAN, POLAND

Oral presentations

SESSION T1-7 Sustainable Mobility

2nd September 2019, Monday 1:30 - 3:00 pm

Metal life cycle greenhouse gas intensity in future sustainable mobility systems

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ArcelorMittal Global R&D

Goal:

Current mobility systems for personal transportation in Europe are regulated on a mass basis using gCO_2/km (emissions from vehicle tailpipe). Vehicle weight reduction via material lightweighting has been the main approach used by automakers to attain such targets for internal combustion vehicles (ICV). The European Commission is aiming at values below the 100 gCO_2/km line. From an efficiency perspective additional improvements are attainable with a switch of powertrains to electric motors which are much more efficient, point at which lightweighting becomes optional for automakers.

A question that raises is: how will the transition towards electrification impacts the vehicle design and metal selection for the body (closures, chassis, and side panels)? The objective of this work is to assess the performance of personal electric vehicles (EV) from a material selection and life cycle perspective accounting for the metal production, vehicle operation (battery charging), and battery production.

Methods:

Three questions have been chosen to meet the objective: (1) Does lightweighting matter for EV?, (2) What is the role of the electricity mix?, and (3) What is the role of the battery? The first step of this work was to develop an Excel-based model inspired by the UCSB Automotive Energy & GHG Model ("UCSB Model"). Life cycle inventory of a baseline vehicle was compiled from recent literature publications and model parameters were obtained from literature (government, metal industry, and automakers reports). Two scenarios are compared to the baseline vehicle: (1) advance high strength steel (AHSS) intensive vehicle, (2) Aluminum intensive vehicle.

Results:

The two scenarios performed similar relative to the baseline when the average European electricity mix is used for battery charging. Lightweighting remains a significant approach at both the production stage and total life cycle performance. Switching to a greener electricity mix, high share of hydro energy, is much beneficial to steel; in this case metal production becomes more relevant than the use phase because steel production requires much less energy than Aluminium. Using a hydro grid mix could potentially reduce the use phase contribution down to 8%; the total impact of AHSS vehicle is negative relative to the baseline, whereas it is positive for aluminium. The share of battery production impacts is greater than AHSS metal production, while for the Aluminum case metal production is much more relevant than the battery. Further improvements to battery production impacts have no significant influence on the AHSS vehicle, for the Aluminium vehicle the total emissions increase relative to the baseline vehicle.

Results show that electrification will allow automakers to meet the EU targets below the 100 line. However, if there is massive penetration of EV, the tailpipe regulations could be missing around 55% and 85% of the total GHG emissions for AHSS and Aluminium. The results also provide insights into how the transition towards electrification will impact the two main metals used in vehicles and provide a foundation to inform material selection by automakers that seek to incorporate life cycle in their decisions.

SESSION T1-7 Sustainable Mobility
2nd September 2019, Monday 1:30 - 3:00 pm

Simulating multimodal passenger mobility and its environmental consequences at a territorial scale

Tomás Navarrete Gutiérrez, Thomas Gibon, Paul Baustert, Laurent Chion, Enrico Benetto

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[Goal]

Transportation accounts for about one quarter of global energy-related CO2 emissions according to the IPCC Fifth Assessment Report. As needs for personal mobility increase globally, transitioning away from fossil fuel-based transportation arise as one of the most important measures that could be undertaken to mitigate greenhouse gas emissions. Electric and multimodal mobility are foreseen as two levers enabling low-carbon transportation while keeping satisfying these mobility needs. Here we aim at quantifying the range of environmental impacts consequential to enforcing these two levers as territorial policies.

[Methods]

We assess here various scenarios of cross-border commuting between France and Luxembourg (the European country with the highest demographic and job growth) to estimate the environmental consequences of public policy measures encouraging electromobility and multimodal public transportation, as well as a more generalized environmental consciousness of commuters. To this end, the influence of both sociodemographic and contextual, (e.g., infrastructure or subsidies) factors on the individual choices of the cross-border commuter population are studies. Two types of choices ultimately are relevant in the cause-effect chain towards environmental impacts: the individual mode choice and car purchase behavior.

We rely on an agent-based model (ABM) to create synthetic populations, their daily activity patterns (which specify the agent's sequence of activities, where, when, for how long, using which transportation modes for what distances) and their car purchase behavior. The results of these simulations in turn feed a life cycle assessment (LCA) model determining the related environmental impacts, to analyze four scenarios. Focusing on the individual activity patterns (which ultimately determine the mode choice), we designed a travel activity pattern model (TAP) to predict which modal options are used over what distances, based on a survey conducted among 3352 French cross-border commuters. As contextual factors actual considerations of commuters' connections to the available transport modes (car, train, bus, multimodal and soft mobility) are considered, while sociodemographic characteristics are derived from the survey data.

Specifically, the link to the available transport modes is made in TAP through a sequence of econometric models predicting activity types, durations, locations and transport modes. These discrete choice models allow predicting mode choice using the sociodemographic factors and the four scenarios of urban infrastructure development and their effects on the existing transport network (i.e., travel times). Consequently, the agents' choices differ among these scenarios and lead to different patterns of mobility needs on the population level.

Parameterized life cycle inventories are used to model the passenger vehicle fleet to model cohorts of vehicles with a fine resolution. In parallel, a user-friendly web-based tool (called "Climobil") is introduced to illustrate the parameterization work, comparing inventories for internal combustion engine and electric vehicles. Other background inventories such as electricity mixes are also parameterized to match the scenarios' storylines.

[Results]

Results will be presented for the full-scale assessment, highlighting the potential environmental trade-offs and benefits between the high infrastructure investment of a sustainable transportation system and business-as-usual behaviors.

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SESSION T1-7 Sustainable Mobility
2nd September 2019, Monday 1:30 - 3:00 pm

Estimation of CO2 emissions of internal combustion engine vehicle and battery electric vehicle using LCA

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[Goal] In order to reduce greenhouse gases (GHGs) at a global scale, it was paid attention to reduce GHGs of vehicles not only on the operational phase, but also on the fuel extraction, refining, power generation, and end-of-life phases. In this study, the CO2 emissions of the conventional internal combustion engine vehicles (ICV) using gasoline and diesel and the advanced powertrain namely battery electric vehicles (BEV) were evaluated using the methodology of Lifecycle Assessment. Also, the effect of variation of driving distance and the CO2 emission from battery production on the total lifecycle CO2 emissions was evaluated.

[Method] In most of the current studies, the CO2 emissions were calculated assuming that the region where the vehicles were used, the lifetime driving distance in that region and the CO2 emission from the battery production were fixed. However, in this study, after the US, EU, Japan, China, and Australia were selected as the regions where the vehicles were used, the lifecycle CO2 emissions in each region were calculated taking the vehicle's lifetime driving distance in each region and the deviations of the CO2 emission for battery production into consideration.

[Results] The calculation results showed that although the CO2 emission of BEV up to the assembly was larger than that of ICV because the battery production emitted more CO2, the longer the lifetime driving distance was, the lower the CO2 emissions of BEV were than those of ICV in the region where renewable energies were well introduced and thus lower CO2 emission factor of electric power generation. But for BEV it should be considered that the CO2 emission for replacing the battery with a new one must be added when the lifetime driving distance was over 160,000 km. Moreover, it was shown that the CO2 emission of ICV was apt to be smaller than that of BEV when the CO2 emissions for battery production were very large.

SESSION T1-7 Sustainable Mobility
2nd September 2019, Monday 1:30 - 3:00 pm

Battery life cycle management for sustainable mobility

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Abstract: Solaris Bus & Coach is a leading European manufacturer of innovative public transportation vehicles. Since its launch in 1996, nearly 17 000 vehicles have left the factory gate and drive on roads in 32 countries. Solaris Urbino 12 electric was named “Bus of the Year 2017”. Emerging environmental consciousness and government financial support for zero-emission vehicles is causing the Public Transport Operators to invest in electric buses. Operators are interested in obtaining cost-efficient

tailor-made vehicles. The battery system is a major cost of the electric vehicle and therefore reducing it amount causes considerable price and LCC reduction.

1. Goals: The main challenge for the manufacturer during introduction of electric vehicles to the market is to perform the appropriate sizing of traction batteries. Oversized batteries were used during initial phase of electromobility introduction, but it was not a proper method. Optimal choice of the energy storage system minimalizes the negative impact on the environment due to lesser amount of resources needed to produce vehicle batteries. Additionally, the proper selection of the batteries affects positively the vehicle energy consumption, as it is more lightweight solution. The second goal was to find the most advantageous stage of the vehicle battery replacement. After the first stage of the usage the energy storage system in no longer suitable for automotive duty, however it is still a valuable device. The second life application may contribute to lowering the LCC.

2. Methods: In order to meet the goals the Solaris in cooperation with cell sub supplier developed the simulation tool based on MATLAB. The battery lifespan estimation algorithm was invented to include vehicle operating circumstances including climate, road conditions, the battery load and cycling. The solutions for lengthening battery lifespan for electric bus purposes will be presented. The particular attention was given to the valid usage and maintenance of the energy storage systems. Management of the thermal behavior of the battery packs was also inspected as it has vast influence on the energy storage system endurance. The battery packs developed by Solaris Bus & Coach are designed for compatibility with future second life applications.

3. Results: The main result of the research was identifying the proper battery selection and replacement strategy for unique vehicle configuration and its' working conditions. Authors will describe advantages of using appropriate choice and management of the energy storage systems. The feasible second-life applications of the electric bus batteries will be shown. Tailor-made solutions lead not only to optimizing the energy consumption of the vehicle, but also positively affect the environment due to full utilization of the battery potential. Experience earned on the usage of battery electric vehicles in real conditions will provide additional data needed for further development of the simulating software.

SESSION T1-7 Sustainable Mobility
2nd September 2019, Monday 1:30 - 3:00 pm

Economic and Environmental Assessment of Hydrogen Fuelling Infrastructure for Heavy-Duty Trucks

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thinkstep

(Goals):

A viable fuel supply chain is a prerequisite for advanced low-emission mobility. Several studies have assessed the costs and environmental impacts of fuel cell electric vehicles and related fuel supply infrastructure. However, most of them focused on passenger cars or did not include manufacturing and end of life of the vehicles and infrastructure components in their assessments. The aim of this study is to investigate costs and greenhouse gas emissions of heavy-duty mobility from a life cycle perspective, with a focus on Germany.

(Methods):

Different scenarios for the production, conversion, transport and supply of hydrogen have been determined. Besides the centralised production in large facilities (scenario 1), a decentralised production directly at the refuelling stations is possible (scenario 2). Additionally, hydrogen could be produced from abundant solar resources in North Africa and Middle East and subsequently shipped to and distributed in Europe (scenario 3). Techno-economic models that cover these different well-to-tank scenarios for two different timeframes (2020 and 2050) have been developed and analysed in the study.

In a second step, the investment and operational costs, as well as the emissions of greenhouse gases during the operation of heavy-duty fuel cell trucks across the assessed pathways have been compared with those of conventional diesel trucks of equal size and capacity. This well-to-wheel assessment results in estimates for costs and greenhouse gas emissions per driven kilometre for each of the two technologies and allows a direct comparison of fuel cell trucks with diesel trucks.

(Results):

From an economic point of view, heavy-duty fuel cell trucks are not yet competitive with equivalent conventional diesel trucks. Higher vehicle costs and the complex fuel supply chain lead to higher costs per kilometre. In the future, however, when the efficiencies of hydrogen production and fuel cell drivetrain technologies will be further improved and equipment will be produced in larger numbers, a potential to reduce costs compared to conventional trucks has been identified.

In terms of greenhouse gases, heavy-duty fuel cell trucks lead to a considerable reduction of emissions per kilometre already today, when renewable electricity is used and the whole life cycle is considered. During manufacturing of a fuel cell truck, more greenhouse gases are emitted than for equivalent diesel trucks. During the operation, however, no greenhouse gas is discharged to the atmosphere. In the future, greenhouse gas emissions over the whole life cycle are potentially even lower, because significant improvements of efficiencies for hydrogen production and fuel cell technologies are expected.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 1:30 - 3:00 pm

The Environmental Impact of Bitcoin – Are We Moving Towards a Sustainable Blockchain Future?

Susanne Köhler, Massimo Pizzol

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This study represents ongoing work and preliminary results of the Sustainable Blockchain Technologies project. Blockchain and blockchain-based technologies are expected to become an innovative and disruptive force in the future, and some claim this emerging technology has a great potential to foster sustainable development. Blockchains are appealing because they allow for secure, robust, and trustworthy solutions, that are not reliant on central authorities, but keep data in a decentralized fashion by a network of peers. To do so, the peers in the network must continuously maintain a distributed consensus protocol. Proof-of-work (PoW), which is used by Bitcoin and Ethereum, allows for large decentralization and high security, which is mainly achieved through computing power used in mining. Bitcoin, the oldest and largest blockchain in terms of miners, has gained media attention during the price boom of late 2017 due to its high energy consumption related to mining. DeVries (2018) estimates Bitcoin's power use between 2.55 and 7.57 GW. Other studies – mostly grey literature – have been conduct, but so far, no complete scientific study analyzing the environmental impact of that power use exists. Furthermore, current studies focus on the past and lack a forward-looking perspective.

Therefore, this study analyzes the environmental impact of Bitcoin from a life cycle perspective and examines its potential impact both ex-post and ex-ante. A life cycle assessment (LCA) model of the bitcoin network is developed from existing literature as well as bitcoin data and is used to model the past and status quo of bitcoin's environmental impact in order to provide a benchmark for current impacts and to verify its results against existing studies. Subsequently, a prospective LCA is conducted outlining different scenarios of likely developments. These scenarios are used to model different futures related to technology advances, market price developments, and policy changes. Key model assumptions and their uncertainties such as miners' locations, efficiency of mining equipment, and bitcoin scaling improvements are critically discussed. Such an ex-ante LCA of an emerging technology does not predict the future, but explores different scenarios in order to guide the design and implementation process (Cucurachi et al. 2018).

Preliminary results show that the environmental impact is neither linearly related to the price nor to the number of transactions. The study's results can be considered a proxy of other PoW blockchains and will be a starting point for further discussions of the environmental impact of cryptocurrency and blockchain technologies in more general.

Literature:

Cucurachi, S., Van Der Giesen, C., Guinée, J. 2018. Ex-ante LCA of Emerging Technologies. Procedia CIRP 69, p. 463-468.

De Vries, A. 2018. Bitcoin's Growing Energy Problem. Joule 2 (5), p. 801-805.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 1:30 - 3:00 pm

Accounting for the temporal fluctuation of renewable energy production when assessing their environmental impacts with LCA: combining wind power with power-to-gas in Denmark.

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Renewable energy systems (RES) such as wind turbines and photovoltaic systems are increasingly developed and installed globally. Even though RES are based on renewable sources, they are not neutral to the environment, since energy and materials are required to manufacture, install, maintain and dismantle them. Life Cycle Assessment (LCA) is an appropriate tool, often applied to assess the environmental footprint of RES. LCA results available in the literature highlight that RES generally present significantly lower environmental footprint over the life-cycle than fossil fuel based alternatives.

However, the electricity production of these RES is weather dependent. As a consequence, the massive integration of these technologies into the electricity mix requires either the use of dispatchable power plants and/or the need for storage systems to be able to balance production with the consumption load profile at any time to maintain the stability of the grid. Several technologies exist for dispatchable power plants such as dam-equipped hydropower plants or thermal plants powered by fossil or biofuel. Regarding the storage systems, pumped hydro storage, electrochemical batteries, compressed air energy storage or power-to-gas can be used depending on the local context, the energy volume to store and the storage duration required. These solutions are not impact-free and their associated impacts should be considered in the assessment of the overall environmental performance of RES.

We have developed a dynamic method to assess the environmental life-cycle performance of renewable energy deployment accounting for the energy storage induced by the temporal variability of weather dependent renewable energy production and consumption. This method has been applied to a case study in Denmark, in which wind power installations are combined with a power-to-gas system to provide electricity according to the Danish load consumption profile.

This method is based on time-series with an hourly temporal resolution to represent the variability of the production and consumption. First, time series of the production of the weather-dependent production system (i.e.: wind power in our case) were established from weather time series sourced from MERRA-2, a weather reanalysis model widely available and system efficiency (i.e.: power curve in our case). Then historical time series were used to build the consumption time-series. The required storage capacity and energy losses were calculated from those time-series and storage efficiency. Finally, technical data were collected from the power-to-gas manufacturer to establish the life cycle inventories of such power-to-gas system.

The first LCA results for the Danish case study highlight the importance of including the impact related to the storage. : When considering the load consumption directly and only provided by wind power (i.e.: ignoring intermittency) the carbon footprint is as low as 10-15 gCO2eq/kWh. It rises to 25-40 gCO2eq/kWh when power-to-gas is used to match with the load consumption profile. In comparison, when gas is used as a backup energy, it raises the footprint to around 200-250 gCO2eq/kWh. These results are encouraging for the development of solutions coupling power-to-gas to wind energy with a significant reduction of the carbon footprint.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 1:30 - 3:00 pm

Printed electronics: sustainable enabler for the internet of things?

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Goal:

Exponential decrease in size and cost of electronic devices within the last decades and an increase of digital interconnections of ‘smart’ objects enable the automated use of real-time status information in an internet of things (IoT). Particularly, a paradigm shift in electronics industry from silicone-based conventional to additive manufacturing is considered a game changer. Nano-enabled conductive inks combined with large-area, high-speed roll-to-roll (R2R) printing allow for rapid, low-cost manufacturing of flexible, lightweight, and fully autonomous devices, opening a multitude of new use-cases. Consequently, device numbers are expected to significantly proliferate over the next years. However, consequences of a massive rollout are mostly unknown to date. And while costly, environmentally harmful etching from conventional manufacturing could be replaced, impacts for printed electronics cannot be neglected. Consequently, the goal of this contribution is to holistically identify environmental and economic hotspots within the entire life cycle of printed electronics to help manufacturers, practitioners, and users understand implications of design variants, functionalities, and use-cases, and to avoid sustainability pitfalls already during early development phases.

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Methods:

R2R printed, passive RFID transponders are evaluated as exemplary devices, since their development is considered a crucial enabler for IoT. Hereby, different printing techniques and substrates are investigated, as well as conductive inks and adhesives based on a variety of conductive nanoparticles. Moreover, integrated circuits and additional optional components are discussed to outline hotspots on device level, and more globally, in respect of future raw material demand scenarios. Data from literature and research networks is used to build a robust and precise representation of component manufacturing and ink formulations within a high-resolution, generic LCA model. All analysed production processes are reviewed by experts and industry partners to ensure high quality models and subsequent results. Additional input from manufacturers and user input on planned applications allow for a bi-directional approach including supplier-specific manufacturing assessment, as well as recommendations of for the selection of device setups from environmental and economic viewpoints, while considering legal frameworks and technical restrictions.

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Results:

This contribution offers the first high-resolution quantitative environmental assessment of printed RFID transponders. Hereby, shortage and rising prices of critical raw materials are an essential benchmark for a thorough investigation of the technology’s future sustainability potential. The metal nanoparticles, previously identified to be the most critical component in printed electronics, are assessed through different end-of-life scenarios. By a modular design of the developed model, the contribution helps building a universal base for assessing the viability of printed electronics as future mass devices. With this data, detailed understanding of potentials and constraints of printed electronics for its mass application can be provided.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 1:30 - 3:00 pm

Prospective LCA for electrochemical reduction of carbon dioxide to formic acid

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In order to reuse carbon dioxide (CO2) instead of emitting it to the atmosphere, especially the chemical industry faces challenges in introducing these CO2-based process technologies. The electrochemical CO2 reduction to formic acid is one of multiple emerging technologies to valorize CO2. The goal of this work is to evaluate the environmental impacts of the lab-scale electrochemical reactor and for an up-scaled industrial plant by using prospective life cycle assessment (LCA).

For evaluating the environmental impacts, prospective LCA is applied and a four-stage approach is followed. The four-stage approach is an iterative procedure as every outcome of a stage gives advice for the previous stages and allows the execution of the following one. On stage 1, an LCA is performed using the primary laboratory data which is provided by the experiments. In order to compare the impacts of the lab-scale with the scaled process, upstream and down-stream systems are modeled whenever necessary following a heuristic procedure. The learnings of stage 1 should allow the scale-up of the process as well as identifying hotspots in the process chain. On stage 2, an LCA is conducted for the best-case scenario. The process of stage 1 is scaled to a larger product system considering best-case assumptions. A comparison with the competitive commercial applied process is examined in order to forecast whether the emerging process might be able to compete with the commercial process. On stage 3, at least one LCA is performed making realistic assumptions for the industrial scale. On stage 4, the results from stage 3 are compared to the environmental impacts of today's commercial production of formic acid.

The functional unit chosen for the comparative analysis is the production of 1 kg of formic acid (85 wt%). The analysis was carried out using openLCA 1.7.3 (Ciroth, 2007). Background data is taken from the ecoinvent database 3.4 consequential (Wernet et al., 2016). The focus of this work lies on global warming impacts (GWI). Besides, results for further environmental impacts are calculated using the ILCD 1.0.8 2016 midpoint impact categories (European Commission-Joint Research Centre (EC-JRC), 2011).

Preliminary results show that producing formic acid with the lab-scale plant technology has a substantially higher GWI compared to the conventional production route. Electricity needed for the electrochemical reactor is the most contributing process to the overall GWI. Results for the best case and realistic scaled industrial process show a lower GWI than the conventional process. In summary, it could be shown that the four-stage approach is useful to apply prospective LCA.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 1:30 - 3:00 pm

Prospective life cycle assessment of an emerging photovoltaic technology

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Emerging innovative energy technologies are the key feature of the German energy transition as well as of a prospective sustainable and low-carbon economy. However, the sustainability assessment of emerging energy technologies is characterised by high design freedoms and high uncertainties about the finalised future technology. The decision about the sustainable future or rising risks of emerging technologies is not entirely clear and can lead to wrong conclusions. On the contrary, high design freedoms offer opportunities to guide the development of emerging technologies sustainably which is difficult at a later development stage. The integration of sustainability assessment into the early-stage development is an important way to show the future chances and risks of an emerging technology and advance sustainable developments. Therefore, we developed a new approach for guiding the development of an emerging photovoltaic technology, the perovskite solar cell, from a life cycle perspective. The perovskite solar cell has shown an outstanding evolution from power conversion efficiency of 3.8% in 2009 to 25.2% in 2019 and is one of the most promising emerging photovoltaic technology. Our approach integrates a parametrised and modular life cycle assessment (LCA) method and scale effects into the development of perovskite solar cells. Based on this LCA, key assumptions which have great influences on the interpretation of current and prospective chances and risks are identified.

One key assumption is the technology scale. The technology scale of an emerging technology indicates if the status quo is considered in the LCA, i.e. primary data measured during laboratory manufacturing, or if future scenarios of an industrial manufacturing are integrated in the LCA. This knowledge is important for the interpretation of LCA results, since the manufacturing of emerging technologies, especially on laboratory scale, shows higher processing energies than on industrial scale and, consequently, higher environmental impacts. Therefore, a special feature of our approach is the scale-up of the processing energy from laboratory to industrial scale by the means of scale effects.

Further key assumptions are the layer configurations, the prospective efficiencies of the finalised products, the future application field as well as the end-of-life scenario. We show the influence of the further key assumptions exemplified for the efficiency based on a sensitivity analysis. The sensitivity analysis enables the consideration of future development which shows on the one hand more and more efficient cells based on cell configurations that have not necessarily changed significantly. Accordinlgy, their environmental impacts behave similar and changing efficiencies are the only influencing parameters. On the other hand, there are cell configurations with lower maximum achievable efficiencies than others, e.g. perovskite solar cells including tin show generally lower efficiencies than the ones with lead, but the great breakthrough may come in future.

Our modular and parameterised approach enables simple and fast adjustments of the cell configurations, material or manufacturing choices during the development stage.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices
2nd September 2019, Monday 1:30 - 3:00 pm

LCA in Brazilian businesses: latest results and opportunities

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Center for Sustainability Studies from Getulio Vargas Foundation - FGVces

The CiViA - Applied Life Cycle Initiative was launched in 2015 with the aim of promoting life cycle thinking (LCT) and the use of the Life Cycle Assessment (LCA) within Brazilian companies. Coordinated by the Center for Sustainability Studies of the Getulio Vargas Foundation (FGVces), this business network has been working on capacitating and disseminating the life cycle approach to large companies through trainings, workshops and technical support for the piloting of LCA studies in Brazil. It is known that the use of LCA in the corporate environment is still very recent in the country: Almeida (2017) and Cherubini and Ribeiro (2015) have shown an expressive development in the academic, but only few results in its application since 2004. The creation of the Brazilian Business Network for LCA in 2013, reinforces the growing interest of companies in the use of LCA, which still needs dissemination and clarity in its applications, especially when related to decision-making processes (KISS, 2018). This abstract presents the results of the four years of CiViA, connecting LCA with the business practices in Brazil, aiming at discussing the trends and opportunities for its development, as well as bringing the attention to this growing community.

The information presented in this abstract was extracted from observations and records of CiViA activities' throughout the 2015-2018 quadrennium made by the project team, who conducted trainings, workshops, working groups and events regarding the use of LCA in Brazilian businesses. In addition, impressions and statements from representatives of CiViA's member companies were also collected, serving as input for the results shown below.

The results showed a significant increase in the number of companies interested in LCA in Brazil: from 14 CiViA members in 2015 to 30 in 2016. During the four-year-period, 48 different businesses participated, with 60% staying active for 2 or more years. 14 different sectors are represented, being the energy sector the one with the largest number of companies (15%), followed by agribusiness (13%) and service providers (10%). There was a high demand for capacity building in LCA and 127 business people were trained. Furthermore, workshops were offered on several LCA-related topics, that served as input to foster the life cycle management in companies: communication and labels, use of software and databases, life cycle inventories, carbon and water footprint, trade-offs between impact categories and others. It can be concluded, therefore, that there are still many opportunities to be explored in the field of capacity building in LCA in Brazil: the high demand for courses, lectures and all kinds of knowledge acquisition can help boost this agenda in the region. At the same time, there has been a growing number of business cases carried out in different sectors, which should guide the trends and push forward the development of LCA in the country. Undoubtedly, there are still important obstacles to be overcome, from developing national databases to engaging high-level managers. However, this potential has already started to be unlocked and will soon be part of business practices in Brazil.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices
2nd September 2019, Monday 1:30 - 3:00 pm

Understanding Sustainable Innovation with a Life Cycle Perspective

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FSLCI

According to Sheryl Sandberg (COO, Facebook), "What Mark worries about the most is the lack of change, the lack of innovation, becoming the innovator's dilemma company that gets big and stops moving and stops staying ahead." Innovation is one of the buzzwords and key drivers in businesses and companies around the world who strive to be as innovative as possible to keep up with the continuously changing environments in which they operate.

Innovation, however, much like sustainability, is a word with many different meanings and interpretations. Still, the focus on innovation in companies and businesses offers an avenue to advance sustainability by addressing sustainability considerations as part of innovation processes. Putting both together, thus requires not only a good understanding of what constitutes innovation, but also sustainability.

To better understand what constitutes sustainable innovation with a life cycle perspective, the Forum for Sustainability through Life Cycle Innovation e.V. (FSLCI) organized a workshop in May 2018 with experts from both the Life Cycle and Innovation community. The workshop report was then launched and discussed during the Life Cycle Innovation Conference (LCIC) which was organized by the FSLCI at the end of August 2018 in Berlin, Germany.

The presentation during LCM 2019 will highlight the conclusions from the workshop in May as well as key feedback collected during the LCIC 2018 in Berlin, Germany. It will not only focus on how sustainable innovation was defined, but also provide an overview of concrete examples and case studies which were shown and discussed during LCIC 2018.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices
2nd September 2019, Monday 1:30 - 3:00 pm

Multi-purpose Applications of Life Cycle Management (LCM) solutions to enable multiple business value and successful implementation in existing company structures.

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Goal

Companies apply Life Cycle Management in different ways to innovative products or mitigate risks of regulations and markets since longer. This is often done on "project basis" for (key) products as industries are under various pressure: internally (e.g. creating innovation and business value) and externally (comply with standards and regulations or meeting customer demands).

Doing the LCM step from "projects" to "processes" in a company and to harvest many business opportunities is asking for more than "good project management" and "result presentations".

LCM in companies needs to become applicable for any product and operation and being responsible, obligatory, reliable, repeatable, calculable and affordable in terms of time and resources, while being able to address and quantify business values gained.

Method

To successfully implement and establish LCM into existing company structures certain prerequisites on different levels and clear procedures are needed:

Commitment by the higher management (e.g. assign LCM the leading role to implement sustainability into the company or announce quantitative environmental targets that will be managed/achieved by LCM).

Integration of existing Environmental Initiatives, EHS or CSR into LCM (LCM as conductor of existing activities, to build on exiting work and foster internal acceptance)

Allocation of responsibilities and resources to the team responsible to act on LCM (any company may define their individual mix of "make or buy", depending on the existence and size of an LCM Team and its ability to do LCM internally or to buy in support.)

Integration of knowhow expert teams in the company (LCM shall benefit from the knowhow of other internal experts by managing and offering tool-supported exchange of information beyond pure LCM terminology, however directly usable in LCM).

Installation of professional tool and data solutions for in-house, supply chain and background data (a core element to ensure specific company results using "own in-house information", complemented by relevant supplier data and up-to-date and compliant background data.

Connection of LCM tools and data to existing company information systems as well as automatization of standardized workflows (many data needed in LCM is already existing somewhere in the company, so integration with PLM/ERP tools as well automated data import into LCM tools including system setup as well as automated report generation are key drivers of efficiency)

Definition of procedures, quality assurance and update routines to keep the systems and data actual (the core procedures, compliance and quality guidelines are to be defined, trained and preserved).

Communication of results throughout the company, to marketing and customers (result communication internally and externally is as important as the conservation of the results, systems and data for future activities or needs.)

Results

The presentation will show on solid examples and the effects how various companies connect the demand side (need or pressure) with the effect side (business value and risk reduction) based on LCM solutions for Multi-purpose Applications. Different thought leaders in industry defined their individual way to implement Life Cycle based Sustainability Solutions in their organization successfully.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices
2nd September 2019, Monday 1:30 - 3:00 pm

The Ten Golden Rules for the Application of Life Cycle Information

Corresponding author: Jim Fava

Anthesis & FSLCI

Goal: We have seen rivers burning, marine litter growing, climate change impacts increasing, limited resources to name a few. Often our resources are directed towards actions which will create unexpected impacts elsewhere, because we have not considered the full range of impacts along a product life cycle. Life cycle assessment has increasing become a tool of choice to understand the environmental and social trade-offs associated with product and packaging systems. What have we learned that can accelerate the generation and use of life cycle information to inform decision making?

Methods: As we are approaching nearly 30 years of experiences, there is much still to do to develop the capacity and capabilities to generate and use life cycle information to ensure we are working on the right issue, at the right place in the value chain, and by the right groups.

Results: We see a future where products will be designed, manufactured, used and managed at the end of life in ways to create reduced environmental and social impacts than the previous generation. These innovative products will create business value, e.g., growing revenue, enhancing brand, reducing costs, and mitigating risk). All actors over a product's life cycle have a role. New business models will surfaced. These outcomes are happening now, but not at the scale needed. Based upon nearly 30 years of experiences, we have identified Ten Golden Rules for applying life cycle information. These will be described with examples and guidance on how they can be applied within your own organization. For many LCA practitioners, these may seem self-evident and useful as you continue to engage users of the results of your investigations. For individuals who we want to use life cycle information more in their decision/policy making processes, these Golden Rules provide a solid foundation.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes
2nd September 2019, Monday 1:30 - 3:00 pm

New perspectives for sustainability initiatives in the chemical industry

Corresponding author: Peter Juergens

REDcert GmbH

Making a significant contribution to reducing greenhouse gases and conserving resources in the long term, the using of certified and sustainable biomass gains in importance. Besides of the branches of trade which work with sustainable biomass for some time – like the biofuel-, food- and beverage industry – also other industrial sector have developed the possibility of using biomass in terms of substitution of fossil-based raw materials. One of these branches of trade is the chemical industry which is increasingly relying on sustainably produced and certified biomass to replace fossil-based raw materials. In the context of highly complex chemical production processes, when biomass is used as a raw material, it is first broken down and separated into atomic or molecular components in the same way as fossil-based raw materials in order to incorporate them into a range of different products. The sustainable biogenic content in these products can vary considerably, making it virtually impossible to reach a valid conclusion about the content in the end product based on analytical evidence as a result of large-scale chemical compound processes.

In order to indicate the replacement of fossil-based raw materials by sustainable produced and certified biomass a concept for a mass balancing approach was jointly developed by BASF SE and TÜV SÜD which is not based on the mass of the biomass used, but on the chemical valence of its individual atomic components. It represents a stoichiometric balancing approach based on an equivalence analysis and documented in a corresponding account management system. This standard, published as CMS 71, was adopted by REDcert and integrated into the REDcert² scheme as an optional approach to meeting the needs of the chemical industry. Special feature of this new certification approach is that this method offers a close and traceable chain of custody which ensures a particular input of sustainable biomass in the chemical industry. Biomass can be regarded as sustainable not until it complies with several recognized standards making sure that the biomass is produced in a sustainable way.

As a result, companies operating in the chemical industry can obtain REDcert² certification. This would stimulate companies in this branch replacing fossil-based raw materials by biomass, which will lead to a lower fossilized chemical industry. The REDcert² scheme allows product-specific conclusions to be drawn about the sustainably certified biomass used as a raw material at a chemical site, but does not make it possible to make statements about the percentages of biomass contained in the products or their use for energy. This means, by owning this certificate and drawing specified conclusions, added value can be generated while simultaneously it is ensured that no inapplicable conclusions will be drawn and the de-fossilization of this branch is supported.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes
2nd September 2019, Monday 1:30 - 3:00 pm

Implementing Circular Economy in the Construction and Real Estate Industry

Christine Lemaitre, Anna Braune, Christine Ruiz Durán

Corresponding author: Christine Ruiz Durán

Deutsche Gesellschaft für Nachhaltiges Bauen – DGNB e.V.

Goal

Since its foundation in 2007, promoting the conscious and responsible use of natural resources has been one of the key concerns of the German Sustainable Building Council (DGNB). In order to ensure the availability and high quality of these valuable resources for future generations, it is crucial to increase their appreciation as well as to reduce waste by promoting reuse and recycling. The concept of the circular economy, aiming at reducing the use of natural resources, maintaining their quality by closing the loops and taking into account the external effects and costs, presents an important lever for the achievement of these goals.

The building sector plays a crucial role in contributing to foster a more circular resource use, being responsible for large parts of the global CO2 emissions, energy consumption and waste generation. The DGNB as Europe's largest network for sustainable construction strives to promote the implementation of the circular economy in the construction and real estate industry through a broad range of activities.

Methods

The DGNB has integrated circular economy bonuses into the current version 2018 of the DGNB System, providing a positive impact on the overall certification outcome. The DGNB System is thus the first of its kind to make circular economy principles an assessable and measurable aspect of buildings. The circular economy bonuses range from the reduction of the material input and the avoidance of waste through the reuse and recycling of building components up to the implementation of sharing models leading to an increased usage intensity of the buildings. In order to raise awareness regarding the importance of a circular built environment, the DGNB has developed a guideline on the integration of circular economy aspects into the construction and real estate industry, identifying relevant fields of action, providing circular examples within the built environment and encouraging planners to integrate innovative and circular building solutions into the planning of sustainable buildings.

Results

Furthermore, in order to support the actual implementation into the construction and real estate industry, the DGNB in close cooperation with its members, is currently developing a certificate addressing the topic of the deconstruction of buildings and districts. Addressing the existing building stock, the certificate aims at closing material flows, fostering reuse and recycling of materials and components and promoting the development of innovative methods and processes. The certificate is expected to be available for a testing phase by end of 2019.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes
2nd September 2019, Monday 1:30 - 3:00 pm

Completeness of inventories for environmental product declarations (EPD)

Lars G. F. Tellnes, Anne R. Rønning

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Ostfold Research

Goal:

Environmental product declarations (EPD) are more and more commonly used to select building products in building projects. Since different LCA practitioners are developing and verifying these EPD, the results can potentially vary based on the completeness of the inventories. The goal of the work has been to identify potential missing completeness of inventories and better define what a complete inventory is when developing product category rules (PCR) for building products.

Methods:

Review of standards and experiences from third party verification has been used to identify missing requirements for completeness in PCR. The standards reviewed are ISO 14044, ISO 14025 and EN 15804, in addition to the general program instructions of EPD-Norway. The experiences by the authors from verifying EPD according to EPD-Norway requirements and EN 15804 has been the main empirical input to the work.

Results:

The experiences from verification show that activities such raw material production, energy use, transport of raw materials, direct emissions and waste treatment are commonly included. However, flows for buildings, machinery, transport of persons and materials not ending in the final product are often left out. These can in some cases have a major importance for the results of some environmental indicators. Especially machinery and buildings are important for abiotic depletion potential of elements. It is proposed that the completeness needs to be evaluated against the economic accounts of at least the core inventory of the manufacturing company when developing EPD.

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SESSION T4-4 LCM - Standards, Certification and Labelling Schemes
2nd September 2019, Monday 1:30 - 3:00 pm

Social Life Cycle Indicators towards a sustainability label of natural stone for coverings

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GOALS

The stone industry plays an important economic role in Italy and worldwide but in the same time provides negative impacts on environment and society.

Natural stone is now widely used in the construction sector for hard coverings. The relevance of the product led the European Commission to develop specific criteria for natural stone within the Ecolabel scheme for hard coverings (Commission Decision 2009/607/EC), today under revision.

In order to provide environmental information and to establish and maintain their comparison the eco-labelling schemes recognized the Life Cycle Assessment (LCA) as a scientific method for the development of the environmental performance criteria. To support a more comprehensive sustainability assessment, the evaluation of environmental issues should be complemented by the Social Life Cycle Assessment (S-LCA).

In fact, in its current form the European Ecolabel scheme only considers environmental impacts, overlooking the high potential of social impacts on workers and local communities throughout the product life cycle. The main purpose of this study is to define a set of social criteria with reference to issues related to natural stone coverings products, as a first contribution towards a sustainability comprehensive assessment of natural stone products.

METHODS

We started from the screening of the three groups of main stakeholder categories (workers, local communities, and smallholders) that should be considered in the social impact assessment in according with the guidelines for Social Life Cycle Assessment carried out by UNEP/SETAC Life Cycle Initiative (2009) and its revised version (September 2019), and we identified as a priority to consider safe and health of the workers and the extraction and manufacturing phases of the life cycle.

Initially a review of the literature on work health and safety related to the issues arising in the natural stone industry was carried out and we identified some indicators used in this studies.

Subsequently, we did a review of social criteria already used in flower scheme also for products other than natural stone, and in some survey of natural stone companies aimed to Life Cycle Assessment.

Finally, we made survey of statistical data related to the workers health and injuries in the natural stone industry, limiting our study to Italian data. This survey shows that the principal issues are connected with the effect of the dust, sludge or other industrial waste released into the workers environment during the stone quarry processes or within on phases of stone manufacturing.

Comparing the output of the different survey and review an overview of the social impact and the relative indicators used to assess negative and positive impact of those product has been given.

RESULTS

The results are a set of criteria for S-LCA inventory and impact indicators related to workers safe and health of the natural stone coverings industry, to be added in the Ecolabel of these products that allows a reliable and more complete communication of their sustainable performance, as a first step for the inclusion of similar criteria for other covering products.

SESSION T5-1 Strengthen LCM by Blending Approaches
2nd September 2019, Monday 1:30 - 3:00 pm

Product Biodiversity Footprint – A novel approach to compare the impact of products on biodiversity combining Life Cycle Assessment and Ecology

Anne Asselin, Suzanne Rabaud, Caroline Catalan, Benjamin Leveque, Jacques L'Haridon, Patricia Martz, Guillaume Neveux

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Sayari

Goal:

Product impacts on ecosystem quality have long been addressed by the top-down approach known as Life Cycle Assessment (LCA). Impacts are most of the time assessed within the "biodiversity loss" damage category indicator. However, LCA methods do not cover the 5 drivers of biodiversity loss as identified by (Millenium Ecosystem Assessment, 2005) (MEA): only land occupation and transformation, pollution, climate change are covered, species overexploitation and invasive species are not. Besides, ecologists work on the ground to measure concrete impacts from given practices on biodiversity in a given area, in a more bottom-up approach, for some parts of the value chain of the product (e.g. production of agricultural bio material).

The Product Biodiversity footprint (PBF) approach aims at bridging the gap between LCA and Ecology. Its objective is to allow comparison of variants of a product for eco-design, being to our knowledge the first method to address the five drivers of MEA. The methodology combines LCA and Ecology and organizes them towards practical indicators and representations for business decision.

Methods:

The general architecture is represented by three modules : i) Module 1 computes life cycle impact assessment; ii) Module 2 refines the quantification of the pressure on 'habitat change', using specific information on practices including ecological data; this second Module, combined with Module 1, allows comparison along the value chain for MEA drivers from habitat change, pollution and climate change; iii) Module 3 qualitatively assesses aspects that are not included in LCA models, with 'species management' and 'invasive species' indicators, allowing comparison for those two remaining MEA drivers.

Results:

PBF has been tested in three business case studies. It demonstrates that the integration of ecological data enables to specify LCA results and suggests that current LCA methods tend to overestimate impacts on biodiversity caused by agriculture when "biodiversity-friendly" practices are implemented. The method and the main outcomes of the case study conducted with L'Oréal on a simplified shower gel will be presented.

This method is dependent on the available data/literature connecting specific practices and biodiversity, calling for streamlined data gathering as a potential next step.

SESSION T5-1 Strengthen LCM by Blending Approaches

2nd September 2019, Monday 1:30 - 3:00 pm

Product Variability and Personalization in dynamic LCA and LCM

Matthias Fischer, Thomas Betten, Daniel Wehner

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The consideration of environmental effects and sustainability aspects over the whole life cycle of a product is nowadays seen as common sense and performed for various products. These considerations are mostly carried out on a static basis using averaged inventory data and strictly defined utilization scenarios. Yet, the product diversity is constantly increasing, with more product variants, more options for personalized products being available and in particular with the constant adaption of the utilization to individual requirements for products with a long lifetime (e.g. buildings). These variations and customizations in product systems lead to significant challenges and uncertainties in predictive LCA. Furthermore also the background systems (e.g. energy supply) and the boundary conditions (e.g. available technologies, technical boundaries, and natural boundaries) change continuously. Therefore, the goal which future LCA studies have to take into account is to consider these variabilities in Life Cycle Assessment and Life Cycle Management and provide a consistent methodology to achieve robust results for significant decision support.

Currently product variabilities and personalized variants are considered by including selected, confined scenarios in LCA. These scenarios are clearly defined through their parameters and show results for the defined parameter settings. By generating a dynamic model with variable parameters, a flexible consideration of changes in several dimensions can be realized. The dynamization of the model primarily includes:

- options for change in utilization (e.g. use intensity or conversion in use),
- variability in alternative options for retrofit (e.g. new technologies and elements),
- variable boundary conditions in the background system (e.g. composition of energy supply), and
- changes in the background systems over time (e.g. change of energy supply).

The use of dynamic LCA will be shown by the example of buildings, taking into consideration regular retrofit measures, the inclusion of new building services engineering technologies as well as a variable background model for energy supply until the year 2050. This is realized by combining LCA and digital technologies with calculation procedures and variable life cycle parameters. Results are temporally resolved environmental impacts over the life cycle of the building.

The described methodology will support the Life Cycle Management with robust results for significant decision support. Questions, like if and what technical solution should be installed in the building or under what circumstances which measure or activity is environmentally beneficial, can be answered. The method can be applied even in the design phase of the building and the design can be respectively adjusted to allow the most suitable construction and technical equipment for the anticipated use of the building.

SESSION T5-1 Strengthen LCM by Blending Approaches

2nd September 2019, Monday 1:30 - 3:00 pm

Differences between Social and Environmental LCA

Mark Goedkoop, Ilonka de Beer, Diana Indrane

Corresponding author: Mark Goedkoop

PRé Sustainability

Over the last 5 years the Roundtable on Product Social Metrics has been developing a framework and a methodology for Social Assessment of Products- what you could call Social LCA. Over the years it became evident that Social LCA is not just a simple extension of environmental LCA.

Goal:

Describe and characterise the fundamental and practical differences between environmental and Social LCA, and describe the consequences of these for the Social LCA methodology development

Method.

During the three iterations in the development of the Product Social Metrics Handbook, over a dozen case studies were executed by the companies in the roundtable; this has resulted in a series of important observations and questions, which led to a number of improvements in the methodology, but also a series of observations that can give important inputs to the further methodology research agenda on social LCA.

Results:

While at first sight social and environmental LCA look very similar in concept the following differences were identified:

1. It is far less obvious to describe the cause and effect pathways and select the most relevant impact categories. Can the social and human capital approach function as a basis for a solution?
2. It is in foreseeable future not likely that a database with secondary data on social topics can be developed with the same representativeness and reliability, as we know in environmental LCA. As a consequence it will be very difficult in practice to make a complete inventory of all impacts in the life cycle.
3. It is highly unlikely that questionnaires can be used to get reliable primary data, as this could imply companies have to reveal that they are operating below compliance with local law, or for instance benefit from underpaying workers or using children.
4. It is by far not clear if there is benefit in quantitative approaches, as it is not so useful to report how many slaves are working for a company; it is much more useful to know whether there is slavery, and what a company is doing to prevent this.
5. To date, social LCA approaches focus on minimising risks caused by social problems in the supply chain, but risk assessment is something very different from measuring potential impacts as in environmental LCA. So what are we measuring; Risks, impacts or perhaps it would be better to measure progress?
6. The ISO standard provides guidelines on how to disclose the results of environmental LCA, this guidance may or may not be applicable on social LCA results.

This paper provides a systematic overview of these issues and what options we have to answer them, and which we chose in the Product Social Metrics Handbook. The aim is to contribute to a rethinking of the research agenda for this still emerging field of methodology development.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 1:30 - 3:00 pm

LCA literature review in the context of European Green Public Procurement for imaging equipment: Focus on circular economy aspects

Candela Vidal-Abarca Garrido, Renata Kaps

Corresponding author: Candela Vidal-Abarca Garrido

JRC Growth and Innovation

Goal

The European Green Public Procurement Communication (EU GPP) is a voluntary policy instrument that aims to incentivize public authorities in Member States to choose environmentally friendly goods, services and works. It can help stimulate a critical mass of demand for more sustainable goods and services and is therefore a strong stimulus for green eco-innovation. The existing EU GPP criteria for imaging equipment, i.e. printers, copiers and multifunctional devices (MFDs), are currently under revision. The new set should reflect the provisions of the EU action plan for the circular economy. This contribution presents, on the hand, the results of the LCA review for imaging equipment with special consideration given to the aspects of circular economy, and, on the other hand, the consequent material efficiency requirements proposed for this product group, like reusability, recyclability or remanufacturability.

Methods

A review of nine pre-selected LCA studies has been carried out to identify the environmental hotspots and the improvement options for this product group, which consequently guided the revision. A wide range of products and functional units have been addressed in analysed studies. In this process, the so called "circularity" aspects were analysed with special attention. The review encompassed also LCAs for cartridges, which are more scarcely available though. Three studies comparing application of single use with remanufactured/refilled cartridges were analysed.

Results

Due to the wide diversity of functional units used, establishing precise quantitative comparisons between LCAs was challenging. Even more if we keep in mind that the introduction of networked technologies caused those MFDs, beside traditional coping/printing, perform other ICT functions. Paper consumption and energy efficiency in use phase were the obvious main hotspots. The review showed that is definitely true for some technologies, as for instance the MFDs which use solid ink printing, where the use phase contribution to the overall environmental impact is the most dominant. Still, it has also been noticed that in case of more efficient technologies, like the laser one, impacts from of cartridges are equally important as energy consumption. In this case contribution from manufacturing was also of high relevance. The review of LCAs on cartridges showed that cartridge refills can contribute to significant reductions in environmental impacts compared to single use inkjet cartridges. The results of the assessment support the proposal of scope broadening to include cartridges (i.e. revised EU GPP will include requirements that could be used when purchasing this consumable) and the focus on circular economy related requirements, which are the most relevant novelties of the current revision. Some criteria examples with focus on material efficiency of imaging equipment and cartridges are:

Imaging equipment:

- reduced number of materials,
- postconsumer recycled plastic,
- reparability and recyclability (spare parts availability, design for disassembly and repair, design for recycling),
- warranty and services agreements,
- take-back system implementation.

Consumables (cartridges and containers):

- resource efficiency (ink and plastic),
- reduced number of materials,
- reusability and remanufacturability,
- take-back system implementation.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 1:30 - 3:00 pm

Circular Design and its impact on Life Cycle Assessment

Marina Proske, Karsten Schischke, Nils F. Nissen, Klaus-Dieter Lang

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TU Berlin

Goal: Life cycle assessments model the environmental impact of products along the whole product life. Assessing all impacts from raw material, manufacturing, transport, use and end-of-life with all its different parts and materials is a challenging task. Design strategies for circular economy add another challenge to the LCA: they do not only change the way products are built, but also fundamentally how products are used.

For life cycle assessments, this means that standardized use phase assumptions (e.g. lifetime, use pattern) from product category rules (PCRs) or the product environmental footprint (PEF) can often not reflect the specifics of new designs.

Methods:

Based on the assessment of different CE design strategies for ICT (with the focus on mobile products such as smartphones) the possible questions and effects for life cycle modelling will be discussed.

If standardized use phase assumptions are applied, the focus of the design aspects cannot be reflected and the design strategies might lead to higher environmental impacts in comparison. Modular devices – as an exemplary design strategy – have a higher manufacturing impact due to more precious metals in additional connectors, more housing materials, and larger printed circuit board area. This might or might not pay of environmentally, depending how the product is actually used.

From the perspective of the new design strategy, it has to be clear what the focus of the strategy is and how the new design will change the use and/or re-use of the device which should be reflected in the LCA.

A focus on a repairable design leads to the question how often products will be repaired, which parts are most likely for damage and repair and how a the ability to repair impacts the actual use-time of the device.

If products can be easily disassembled, refurbished and re-used, it has to be assumed how many products will actually enter a refurbishment stream, what the impact of a refurbishment process is and how long the second use phase will be.

The definition of these aspects is highly speculative – and it focusses on the intended changes in the use phase. To assess such design strategies in a fair manner, it is also necessary to address possible rebounds or drawbacks which can result from the new designs (e.g. upgradable design could lead to even more accelerated replacement cycles).

Results:

Based on an exemplary smartphone LCA, the impact of different use phase assumptions will be discussed and the necessity for valid and realistic scenarios will be shown. In case of conflicting scenarios, the calculation of break-even points can be relevant for decision making.

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SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 1:30 - 3:00 pm

LCA-modelling of different end-of-use scenarios for smartphones

Rainer Pamminger, Sebastian Glaser, Wolfgang Wimmer, Karsten Schischke, Marina Proske

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Technische Universität Wien

Goals

Modelling secondary product life cycles (e.g. remanufacturing) of smart mobile devices (smart phones, tablets, etc.) for environmental assessments is relevant to evaluate the environmental utility of different circular business strategies. At a first glimpse, it seems that those business strategies will help to reduce the environmental impact of products, but taking a closer look may unveil the opposite.

The objective of this research was to compare a smartphone with different end-of-use scenario variants and gather requirements for modelling secondary product life cycles in order to adapt current product category rules.

Methods

A regular smartphone serves as the reference product to model and analyse via life cycle assessment four different end-of-use strategies:

- Repairing the device and extending its use-time by exchanging broken parts.
- Refurbishment of a device and reselling it.
- Extending the lifetime of components via remanufacturing.
- Recapturing critical raw materials of the device.

The four strategies entail different process steps (collection, sorting, disassembly, chip de-soldering and remanufacturing, data erasing etc.). New innovative approaches of these processes were explored, implemented and assessed, within the EU-funded project sustainablySMART . The project therefore serves as a broad database for the modelling of the scenarios.

Results

Comparing these four end-of-use strategies shows their potential to minimize environmental impacts and respectively their framework to achieve a positive impact.

One of the standards for modelling life cycle assessment of smart mobile devises is ETSI ES 203 199 , which currently focuses rather on linear product life's without considering secondary life cycles. The paper discusses challenges that occurred during the modelling of the four scenarios and defines requirements for an integration of secondary product life cycles or a prolonged product life within the ETSI standard.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 1:30 - 3:00 pm

The "Environmental Activation Energy" of Modularity and Conditions for an Environmental Payback

Karsten Schischke, Marina Proske, Rainer Pamminger, Sebastian Glaser, Nils F. Nissen, Martin Schneider-Ramelow

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Fraunhofer IZM

Goals:

Similar to the meaning of "activation energy" in physics and chemistry there is a certain environmental investment needed for some circular design approaches: On the example of modular mobile devices the additional environmental impact of implementing "modularity" is explained. This additional impact can be over-compensated through lifetime extension effects, if the design and related business models trigger the intended circularity effect.

Methods:

The paper will first systematically categorize the different variants of modularity, explained on the example of smartphones: (1) add-on modularity, (2) material modularity, (3) platform modularity, (4) repair modularity, (5) serviceability modularity, (6) mix-and-match modularity. Each of these modularity approaches features specific circularity aspects, including repair, upgrade, customization as a means to not over-spec a product, reuse and repurposing of modules. These life cycle management aspects will be discussed on the example of various smart mobile products, some of them being introduced to the market already, such as Motorola's moto mods, Shiftphone's shift6m or the Fairphone 2, some in a conceptual or design study status, such as Puzzlephone or the discontinued Google ARA project.

Results:

The comparison of modularity approaches shows the broad variety circular design strategies can have even for a rather narrow product segment: smart mobile devices.

The "environmental activation energy" is higher for those products, which are built for end-user interaction, such as the DIY repair approach of the Fairphone 2 or a mix-and-match approach of functional modularity, than for those, which follow e.g. the serviceability approach only, where connectors do not need to withstand laymen's interaction. The potential environmental payback however is the highest, where the product remains in the hands of the end-user for a repair or even upgrade. However, also business models, which built on modularity in a business-to-business market can yield significant environmental savings over the lifetime. Some modularity concepts are at risk not to contribute to circularity at all, but have an adverse environmental impact of the full product life cycle: Where modularity is likely to trigger major rebound effects, the overall life cycle impact is likely to increase on top of the "environmental activation energy" of modularity.

This discussion on modularity and related environmental life cycle impacts is meant to contribute to a better understanding of the right drivers for more sustainable product concepts and factors fostering those developments.

This research is part of the project sustainablySMART which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 680640.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 1:30 - 3:00 pm

Environmental assessment of durability of Electrolux cooking appliances

Stefano Zuin, Rustem Saitov, Monica Celotto, Irma Rustemi, Marcello Massaroni, Gianluca Brotto,

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Electrolux Italia

GOAL: The environmental benefits of an extended lifetime of domestic appliances have already been investigated for some products (e.g. washing machines, vacuum cleaners), but without detailed analysis of critical components strongly affecting product durability. In this study, three cooking products – gas hob, induction hob and electromechanical oven - are analysed to answer the following question: Does the lifetime extension of these appliances have environmental benefits through the replacement of selected critical components and to what extent?

METHOD: The Life Cycle Assessment (LCA) methodology is used to assess life cycle impacts of the cooking products from cradle to grave, while the assessment of an extended lifetime of hobs and oven is performed by means of the Resource Efficiency Assessment of Products (REAPro) method developed by the JRC/EC. The latter is based on a comparison between two scenarios from a life cycle perspective: “base case” and “durability” scenario. The “durability” scenario assumes an extension of the product service life for a certain period by the replacement of some critical components, while in the “base case” scenario the appliance is replaced, at the end of its life, with a new product that is more energy efficient. For the scope of our study, the following environmental indicators are used: Global Warming Potential (GWP), water footprint (WF; AWARE method), Cumulative Energy Demand (CED), and Terrestrial acidification (TA). Critical components are selected taking into account results of reliability and durability test of the three products. The use phase of products is modelled in EU-28 and in some EU countries where electricity is generated mainly with fossil fuels or renewable sources. Consumption of natural gas and electricity comes from the harmonised test (i.e. water boiling test for hobs and wet brick test for oven) and EU regulation for energy labelling.

RESULTS: Evaluation of durability mostly depends on environmental indicators selected, the extension of product lifetime, products’ composition and features (e.g. induction hob has more electric components than gas hob, trend of energy consumption over time, etc.), and the impact of replacement components. Therefore, an extension of product lifetime may become less beneficial, or even disadvantageous, on the base of several conditions and assumptions done. The results also depend on the use pattern as this determines how much energy is consumed during the expected lifetime of cooking appliances, as well as on the energy mix for cooking (i.e. where the appliances are used). This latter aspect is very critical in the evaluation of some indicators, as GWP and CED. In order to make decision on durability, it is therefore essential to evaluate those aspects carefully.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 1:30 - 3:00 pm

Techno-economic and environmental assessment of small-scale power systems for remote communities

Jhud Mikhail Aberilla, Alejandro Gallego-Schmid, Laurence Stamford, Adisa Azapagic

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University of Manchester

Goal: More than a billion people worldwide, the majority in rural areas, still lack reliable access to electricity. To provide electricity for these communities, standalone microgrids have been suggested as a viable solution. However, to be sustainable, energy access should satisfy techno-economic, environmental and social criteria. This study focuses on the first two aspects and presents design, optimisation and evaluation of off-grid small-scale power systems for remote communities.

Methods: Techno-economic optimisation of a microgrid system, consisting of diesel generators, solar photovoltaics (PV), wind turbines and Li-ion batteries, has been performed with the HOMER Pro software. The simulation has been carried out in the context of a rural island community in the Philippines. Based on input parameters describing a typical residential demand profile, solar and wind resource availability, and technology costs, eight different system architectures have been designed and optimised on techno-economic criteria. They have then been evaluated for their economic and environmental performance using life cycle costing and life cycle assessment (LCA), respectively. Eighteen LCA impacts are considered, calculated through the ReCiPe method.

Results: The estimated levelised costs of electricity (LCOE) for the designed options range from 0.41-2.40 USD/kWh. Standalone solar PV and wind turbine systems have the highest LCOE, with >91% of the costs related to capital investment. The least costly option is a diesel-solar PV hybrid system with a share of renewables of 26%, with a total annualised cost of USD 93,100. Batteries, which are essential for off-grid solar PV and wind, constitute 33-44% of the total costs of the renewable energy options. However, energy storage is also found to benefit diesel generators and can reduce LCOE by 57%. Wind turbines have the highest non-fuel operating costs (0.20 USD/kWh), while fuel requirements for diesel generators amount to 0.51 USD/kWh.

Diesel generators also have the highest impacts in ten impact categories, including global warming potential. Options with solar PV have high ecotoxicity, land and water use impacts. Wind turbines contribute significantly to eutrophication, human toxicity and metal depletion. Although none of the eight designs dominates in all 18 impact categories, if equal weights are assumed for each impact category, the diesel-solar PV-wind hybrid is environmentally the most preferred alternative. The same outcome applies assuming equal weighting for both economic and environmental criteria. For the same assumptions, stand-alone diesel generators and wind turbines are the least preferred options.

While this study has focused on economic and environmental assessments, further work is needed to help identify overall the most sustainable choices, including consideration of social factors as well as stakeholder preferences for different sustainability criteria.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 1:30 - 3:00 pm

Potential implications of LCA methodological choices in energy planning: the case study of waste incineration when internalising external costs of electricity production

Ioan-Robert Istrate, Diego García-Gusano, Diego Iribarren, Javier Dufour,

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IMDEA Energy

Goal Among methodological choices in Life Cycle Assessment (LCA), the allocation of environmental burdens typically arises as a controversial issue when evaluating systems that perform more than one function. For instance, municipal solid waste incineration (MSWI) usually involves electricity production while performing a service for waste management. Accordingly, the allocation issue is particularly relevant when discussing on the impacts of MSWI, not only as single systems but also within national electricity production mixes. In fact, the environmental performance of MSWI may ultimately affect electricity production mixes when sustainability aspects are implemented in energy planning, e.g. through the monetisation of damages to the environment and human health. In this sense, this study follows a combined LCA, Energy Systems Modelling (ESM), and external costs internalisation approach in order to explore the techno-economic consequences of using alternative allocation approaches for MSWI plants on the long-term energy planning of a national power generation system.

Method An existing model for power generation in Spain built in LEAP-OSeMOSYS, a cost optimisation-based ESM framework, was used. The model was further enriched through the implementation of life-cycle climate change and human health external costs of the power generation technologies, thereby including life-cycle aspects directly in the techno-economic optimisation problem. Regarding MSWI plants, their external costs were estimated according to three alternative approaches: (i) waste management service bears all burdens; (ii) partitioning of environmental burdens according to revenue (electricity production bears 25% of the burdens); and (iii) electricity production bears all burdens. The alternative allocation of burdens leads to modifications in the life-cycle emissions and therefore in the external costs associated with MSWI plants. The influence of these modifications on the optimisation of the national electricity production mix was explored.

Results The results show a negligible contribution of MSWI plants to the prospective electricity production mix when their burdens are completely or partly allocated to the power generation function. On the other hand, a high share of MSWI plants (up to 10% of the total electricity production) is reached when the waste management service is assumed to bear all burdens. Hence, a great influence of the allocation approach on energy planning is concluded in this case study, as well as the need for energy policy-makers to set the allocation method for LCA of MSWI plants.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 1:30 - 3:00 pm

life-cycle impacts and costs of energy transitions

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2.-0 LCA Consultants

Goal: Sustainable global warming mitigation plans should have a comprehensive understanding of their potential consequences on human health and biodiversity. This study explores decarbonisation pathways of the energy sector in the province of Quebec (Canada) from a life-cycle perspective. The goal is first to understand which technologies would minimise total energy transition costs, to then evaluate the potential effects the technological changes on human health and ecosystems. A secondary goal is to create methods that facilitate similar assessments.

Methods: The potential consequences of the global warming mitigation strategies were calculated integrating an bottom-up TIMES energy model with LCA databases and impact assessment methods. Particularly, we model the consequences of reducing by 75% all combustion-related GW emissions by 2050. First the cost-optimal scenarios were developed in NATEM-Quebec, a TIMES model of Quebec. One scenario has a constraint on GW emissions and a counterfactual scenario without the constraint. Special attention was given to the modelling of freight and passenger road transport, the main contributors to global warming in the province. Car powertrains were modelled using data from THELMA project and road freight trucks from a review of the literature. An economic assessment was done using the capabilities of TIMES models.

NATEM results were used to create an inventory of the potential consequences of the energy transition. The integration process harmonised efficiencies and emission factors between models, updating fuel blends (e.g. higher use of biofuels) and identifying the most important changes between background and foregrounds of product systems. A cut-off criterion is used to simplify the inventory, minimising accuracy losses. When deemed necessary, regionalised characterisation factors of the Impact World+ method were used. The integration process is underpinned by open-source functions, and fully documented on shareable and reproducible electronic notebooks. The same procedure can be applied to other TIMES or bottom-up energy models.

Results: The scenarios suggest a gradual electrification of powertrains, from hybrid ones combined with second-generation biofuels to fully electric as GW contraints become more severe. Heavy trucks powered by electric catenaries seem to be a viable technology for busy corridors. Raises in total costs are driven by higher investment needs, maintenance costs and welfare losses.

When analysed from a life-cycle perspective, the introduction of low-carbon cost-minimising technologies resulted in reductions of human health and ecosystem quality indicators. Human health would be reduced because of reduced GW and reduced pressure on water resources outside Quebec. Ecosystem quality improvements are driven by reduced global warming and freshwater ecotoxicity. Here we present the methods that underpin the assessment.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 1:30 - 3:00 pm

The carbon footprint of transition to electricity based mobility in Switzerland: an integrated assessment

Didier Beloin-Saint-Pierre, Roland Hischier, Christian Bauer, Brian Cox, Kannan Ramachandran, Sinan Teske, Martin Rüdisüli, Gil Georges, Giacomo Pareschi, Fahmy Sherif Alaa Salaheldin, Mario Paolone, Christian Bach

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EMPA

Goal:

Recent developments in energy storage and conversion can now facilitate the transition from fossil intensive vehicles to electricity based mobility (EBM) which uses hydrogen (H2), synthetic natural gas (SNG) or batteries. The shares of storage option for an EBM fleet which minimise its carbon footprint during such a transition are, however, not clearly identified since many technological, economic and social aspects must be simultaneously considered. For example, the mismatch between renewable electricity availability and the period of energy consumption for cars will modify the carbon footprint of all EBM options depending on the capacity of electricity production, the prices and the customer needs. Moreover, such aspects should evolve and might vary between neighbourhoods, cities and regions or between hours, days and seasons thus requiring analysis at different spatial and time scales. An integrated model was therefore created to quantify future greenhouse gas (GHG) intensities of personal mobility and electricity supply in a case study of the Swiss context with its technological, economic and social constraints.

Methods:

This integrated model of personal mobility transition in Switzerland is built from three models. The first model, called ESMOBIL-RED, uses machine learning algorithms to define the number and types of personal vehicles with their hourly energy consumption. It is based on the analysis of drivers' behaviour for different regions of Switzerland. The second model, called STEM, is a Swiss specific TIMES model which defines the cost optimal energy mix to meet the evolving country's energy demand within different technological and economic constraints. The outputs of ESMOBIL-RED are therefore used to define the evolving energy demand for Swiss mobility. The third model, called PLF, uses probabilistic load flows to verify the stability of the electricity infrastructure when EBM developments occur. These checks can be done at different spatial levels such as a neighbourhoods, cities or cantons.

Carbon footprints from LCA studies and experimental measures of efficiency for charge, storage and power-train of different vehicles are then used to define constraints and GHG emission levels within the consistent scope of the integrated model. This step-wise framework thus considers:

- Dynamic profiles of mobility demand and energy storage options for different vehicles
- Scenarios of electricity production under different economic and legislative assumptions
- Network stability under increased charging levels and total energy consumption
- Future GHG intensities from electricity production sources and available vehicles

Results:

The integrated assessment first reveals the potential GHG emissions per travelled km for each type of vehicle in Switzerland until 2050 while considering possible developments of the electricity mix. Evolving fleet compositions with lower GHG intensities are then identified under different constraints such as the charging flexibility of different storage options. These results are then combined to offer an evaluation of national GHG emissions, power requirements, energy demand and necessary modifications to the grid for a more sustainable transition to an EBM scheme in Switzerland. Additionally, this integrated assessment framework offers broader benefits since it could be applied to other energy systems such as smart buildings or cities.

SESSION T1-7 Sustainable Mobility

2nd September 2019, Monday 3:30 - 5:00 pm

Batteries for electric vehicles: assessment of potential environmental impacts due to the manufacturing phase

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Goal

Decarbonization and Circular Economy goals, set at European and International contexts, are pushing the automotive sector towards the search and implementation of more sustainable solutions. In this context, the present paper focuses on the production of batteries for electric vehicles (EV) with the goal of providing a clearer picture on the current EV batteries framework. Moreover, this study aims to identify the main variables affecting environmental impacts and resource use. These analyses constitute, as well, a relevant basis to evaluate in which measure impacts could be minimized in possible future scenarios.

Method

The study here developed follows the international and well-established methodology of Life Cycle Assessment (LCA). Basing on a critical literature review of the most recent LCAs on EV batteries, this study employs the currently available most reliable life cycle inventory on Li-ion batteries manufacturing to calculate impacts of 1 kWh of battery pack capacity and 1 kg of battery pack. The possible choices of functional unit are discussed as well. Results of this phase are the basis for analyzing the processes that majorly contribute to the impacts, with particular focus on the global warming potential (GWP) impact category. The margin for improvements of the environmental profile is identified and discussed and simulation of different energy scenarios are carried out.

Results

The developed LCA bring to average carbon dioxide emission factors of 116 kg CO2eq/kWh of energy storage capacity or 14 kg CO2eq/kg of battery pack. In addition, results show that the GWP impact is largely affected by the supply chain of battery cell raw materials, which results averagely contributing from 27% to 51%. Another 44% of the GWP impact is due to the energy employed during the manufacturing, averagely composed by a 33% of electricity and 11% of heat supply. However, the impact of electricity has high margins of improvement: a battery production entirely powered by renewable energy (such as the Tesla Gigafactory in Nevada) is able to decreases of about 30% the total GWP impact with reference to the current default scenario.

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SESSION T1-7 Sustainable Mobility
2nd September 2019, Monday 3:30 - 5:00 pm

How Copper contributes to Sustainable Mobility

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Since the discovery of electricity and the large-scale use of copper in the early 19th century, copper has become one of the key indicators to describe improvements in humankind's modern life. Discussion around decarbonisation of our society leads to the fact that mobility has become a hotspot that we need to tackle. Since many years a lot of effort has been made to electrify mobility. In this context a lot of questions have popped up about copper and its use as one of the most important functional materials in mobility. Different alternative concepts of traction technology have been designed. However, for each of them a cradle to cradle assessment including aspects like availability, criticality, recyclability and circularity is important to secure a sustainable transition from the combustion engine to the electric motor. This presentation intends to give some key facts which help to answer some of the questions raised by some stakeholders, such as availability and sustainability, while comparing two concepts, the permanent magnet synchronous motor which relies on permanent magnets made of rare earth materials and the asynchronous induction motor which improves performance by improved use of copper and steel.

SESSION T1-7 Sustainable Mobility
2nd September 2019, Monday 3:30 - 5:00 pm

How can OEMs reach CO2 reduction targets? Modelling absolute CO2 emissions of OEMs selling private vehicles and mobility services from a life cycle perspective

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Volkswagen

Goal:

We seek to support OEMs in reaching absolute CO2 reduction targets. The Science-Based Targets Initiative (SBTi) provides approaches for OEMs to calculate CO2 reduction targets in line with the Paris Agreement. It does not, however, provide guidance on how to achieve a specific target or comply with the respective CO2 budget.

To decide on the most effective carbon reduction measures, OEMs must be able to model CO2 emissions until 2050 which marks the target year of the Paris Agreement. We therefore aim at developing a methodology that facilitates modelling future absolute carbon emission of OEMs.

Methodology:

To develop the “carbon budget compliance methodology” for OEMs, we set up requirements that must be met. As calculating an OEM-specific carbon reduction target is based on and monitored by reported absolute CO2 emissions to CDP, modelled future emissions must cover the same scope as reported past emissions, i.e. Scope 1-3 emissions (“Equal scope”). Hence, we refine current past-oriented carbon accounting systems to compute future emissions (“Future emissions”). The development of these emissions is influenced by external and internal parameters. External parameters include emissions legislations, the carbon intensity of market-specific fuel and energy supply chains. Internal parameters include brand-specific decisions taken on product level such as type of vehicles produced and powertrain mixes on fleet level.

Though by 2030, absolute emission of OEMs will not only be caused over the life cycle of sold vehicles but also by offered mobility services, i.e. by vehicles remaining property of OEMs. The impact of partially selling mobility instead of vehicles on OEMs’ carbon emissions is therefore quantified (“Mobility services”).

LCAs of vehicles indicate CO2 hotspots and respective reduction potentials depending on the assessed powertrain. These include e.g. renewable energy for the use phase of Battery Electric Vehicles (BEV) and for the production of Lithium Ion Batteries (LIB). By applying a modular LCA-based approach, CO2 reduction measures on vehicle level are extrapolated to fleet levels (“Lifecycle reduction measures”).

As external and internal parameters can each develop within a range of possible options until 2050, the method should support modelling scenarios (“Scenario capability”). These scenarios result in an amount of absolute CO2 emissions caused by an OEM’s sold vehicles and offered mobility services from the base year until 2050. The modelled emissions are set in relation to a carbon budget compatible with the Paris Agreement (“Carbon budget”).

Results:

The methodology is exemplarily applied to model carbon emissions of Volkswagen Group (VW). Publicly available data is used to backcast emissions of 2015 and to project emission until 2050 within three scenarios. Scenario 1 represents the basic scenario including vehicles with increasing shares of BEVs in all markets. In Scenario 2 the reduction measures renewable electricity for BEV use phase and LIB production are combined with Scenario 1. Scenario 3 is based on Scenario 2 and includes vehicles and mobility services. The scenarios are evaluated for their capability of staying within VW’s carbon budget according to the absolute-based approach of the SBTi.

SESSION T1-7 Sustainable Mobility

2nd September 2019, Monday 3:30 - 5:00 pm

City Air Management: LCA based decision support model to improve air quality

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Continuous urbanization has resulted in population growth, sprawling land use and changes in mobility behavior. Despite public transit investments, congestion is worsening globally. The sheer volume of inter- and intra-urban transportation has outpaced improvements in and customer uptake of clean transport technology. As a result, air quality has deteriorated in many cities, large and small, and city leaders are accepting that, at its core, poor air quality is an issue of public health and wellbeing.

Siemens has developed an emission model of cities to understand the root cause and interactions to reduce air emissions. The City Air Management (CyAM) consists of monitoring, forecasting and simulation of measures. CyAM model aims to provide formation on air pollution reduction potential of short term measures to take the right actions to minimize and avoid pollution peaks before they are likely to happen. The goal is to understand and mitigate the challenge of air pollution (NO2 specifically) around motorways and major roads.

The methodology uses a parameterized life cycle assessment model for transport emissions and calculates the local impact on air quality KPIs of individual transport measureses at the specific hotspot. The system is able to forecast air quality and by how it is expected to exceed health or regulatory thresholds over the coming 5 days. Using this we can simulate specific pre-defined emission-reducing actions against the expected pollution levels in order to reduce the risk of exceeding thresholds or key indicators. The relative reduction potential of traffic related air pollution at hot spot per short term measure at specific temperature ranges will be delivered for on different day types in an hourly resolution for NO2, PM10, PM2.5.

In this paper the LCA-model and results from selected cities will be presented: Case studies show how a specific combination of technologies/measures will reduce the transport demand, enhance traffic flow or improve the efficiency of the vehicle fleet in the vicinity of the emission hotspot/monitoring station.

SESSION T1-7 Sustainable Mobility

2nd September 2019, Monday 3:30 - 5:00 pm

Case study LCA on automotive light-weighting, using different datasets

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Goals:

Practitioners need quick but accurate methods for decision making when choosing materials in e.g. car chassis components. Simplified LCA is commonly used for this but choice of database, impact assessment method, material source and system boundaries can distort results and decision-making.

This case study investigating steel versus aluminum in a cars roof evaluates effects from making lighter vehicles and demonstrates how the calculation results differ depending on choice of data-sets. The impact of sourcing recycled or virgin material and depending on carbon intensity of energy source is assessed. Implications regarding future development and LCA-modelling of e.g. light-weighting of electric cars is discussed.

Methods:

The model considers manufacturing of a car roof from two optional materials, aluminum and steel, and the difference in fuel/electrical consumption for 10 years. The LCA-system model compares the environmental impact of the material production with the weight-induced incremental fuel consumption impact of carrying the roof. The system boundary includes all life cycle phases, but in line with EPD-system rules, end-of-life (EoL) recycling is considered at the input material level. Cars are regulated to 85% material recycling, with near 100% for metal chassis. Also, from overview analysis of component production plants (stamping and joining) the chassis production difference was omitted.

The functional unit is use of a car roof during car life cycle. A 17 kg steel roof is compared to a 7 kg aluminum roof, where the requirement of functionality stays the same for the roof regardless of the material chosen.

In this study the following impact categories are used:

-Climate impact

-Acidification

-Ground-level ozone (Photo-chemical oxidation)

-Over-fertilization (Eutrophication)

Cost impact is also calculated to compare with literature.

The evaluation only considers the effect of light-weighting a car depending on its energy source. It cannot be used to compare cars using different energy sources. The system boundaries and functional unit does not include the production of engines nor anything else of the car except the roof. Thus, the study is limited to comparing differences in the material production with the weight-induced energy consumption changes.

Results:

The study validates earlier studies on climate, eutrophication and economic gains in changing car body. For photo-chemical oxidation and acidification, the result differs depending on database, no robust conclusion can be. One data-set always gives reduced environmental impact on the chosen categories. The reason is that these data incorporates the effects of future recycling. This could be interpreted as in a system with effective end-of-life recycling and a high use of recycled materials, all investigated impacts would be reduced by light-weighting. For electric cars, light-weighting of chassis can minimize battery size and/or increase drive range.

Adaptions for other materials must consider that the assumption of negligible impact changes in the car manufacturing plant is only true for metal plate in a mixed model line, thus the component plant has to be accounted for. Also, many reinforced plastic compounds are not recycled but incinerated, thus EoL-combustion need to be accounted for.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 3:30 - 5:00 pm

Towards sustainable smart farming

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Due to the population growth, food demand and production have been also in continuously growth bringing important negative environmental, economic and social impacts which are mainly caused by an intensive use of natural resources. Therefore, it is crucial to deploy efficient technologies to cover food demands with positive impacts to the society and environment. In this paper, we discuss how the use of “smart farming” (SF) can contribute to that purpose.

SF is associated to high-tech farming that is expected to play an important role in the sustainable development of the agricultural sector due to the use of diverse precision agriculture technologies, e.g. IoT, big data, drones and other ICT in farming that enhance resources management.

To illustrate the SF environmental benefits, the use of robots in precision agriculture has proved to have a considerable CO2 emissions reduction during the pest control operations (high precision application of herbicides). Some authors describe the use of robot-farmer-assistant in greenhouses during the application of nitrogen fertilizers. In general, the use of robots improved the management efficiency by achieving fertilizers reductions (range between 15-18%).

Moreover, SF is associated to a greater profitability and the reduction of environmental impacts, but they also indicate the need to consider the social effects associated to the digitalization of agriculture, in particular those effects related to the employees and farmers.

For all arguments here above-mentioned, in this paper we try to integrate the social, environmental and economic dimensions of sustainability to analyse SF. This intention brought us to the term of “sustainable smart farming (SSF)”. Even further, we also discuss the need to assess the SF from the systematic approach of life cycle assessment (LCA) that includes the three sustainability dimensions to construct an assessment framework for SSF.

Our driving research questions for this paper are: (i) How is the technological level of SF measured and (ii) how can SSF be defined?

Secondary informational sources were systematically reviewed to respond these research questions. As a part of the preliminary findings from the literature review, elements for the evaluation of the technical component of SF applied to horticultural farming were identified to construct an evaluation matrix, particularly in the cultivation of vegetables in greenhouses answering the first research question. We also gave a first attempt to define the SSF term to respond the second research question.

The matrix as a tool allows the level of SF to be categorized into three technological levels: (i) high; (ii) medium; and (iii) low. The tool provides information to decide the technological level of the farms, that information can be used to categorize them.

The matrix takes into consideration all the stages of the productive process (e.g. sowing, transplant, fertilization, irrigation, pest control, weed control, harvest, among others. The technologies used in SF will be considered for the design of the matrix (e.g., sensors, big data, drones, robots, IoT, among others).

Our future research will identify the most appropriate methodology to measure the social and environmental impacts generated by SF.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?

2nd September 2019, Monday 3:30 - 5:00 pm

Impact of digitalization in automobile manufacturing sector on raw material consumption and waste management

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Goal: With a goal to increase efficiency and decrease energy and resource consumption, the manufacturing sector is undergoing a transformation towards digitalization, with an increase of automation of manufacturing processes and data exchange within different technologies. Such a transformation requires a shift from current infrastructure to accommodate the software and hardware demand of the technologies. Even though positive impacts are anticipated with the application of digitalization in material, energy and waste flow within the system, the impacts of infrastructure development to facilitate digitalization are not clear. Moreover, these technologies need to be studied together from a systems perspective to identify the interaction between them in order to move the sector to a more sustainable state instead of having large rebound effects. Therefore, the aim of this project is to study the interaction and impacts of different technologies, associated with digitalization of automobile manufacturing and waste management, on the material cycle and raw material consumption. This study furthers aims to compare the environmental impacts and raw material demand of a vehicle manufactured from conventional manufacturing and digitalized manufacturing.

Methodology: The focus of the study is on integration and application of two digitization technologies, namely, Cyber Physical Systems (CPS) and Internet of Things (IoT) in the manufacturing, logistics and waste management. To reach the first goal, the analysis is done in two parts. The first part includes defining a novel and detailed system model with various scenarios representing the various applications of CPS and IoT as components of smart factory and smart logistics followed by the quantitative analysis of the material consumption for their development and installation. The second part analyses the effect of CPS and IoT on material flow from the waste management phase back to the production cycle. To reach the second goal, cradle-to-gate analysis using attribution Life Cycle Assessment (LCA) is done for two product systems, namely, vehicle production from conventional manufacturing sector i.e. the present manufacturing scenario and vehicle production with the application of CPS and IoT.

Results: The results describe a system model with various possibilities of integration of digitalization technologies in logistics, manufacturing and waste management in the automobile sector. Furthermore, this model highlights the change in material consumption and waste generation due to the application and integration of CPS and IoT in the conventional manufacturing techniques and their impacts in value retention process at the waste management industries. At the product level, the preliminary results quantify the change in material consumption for the production of vehicles through digitalized manufacturing with respect to the vehicles produced by conventional manufacturing. Moreover, the results show a comparative analysis of environmental impacts of two vehicles. This study contributes in holistic analysis of application of digitalization in automobile industry and its impact on the product's life cycle environmental impact.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 3:30 - 5:00 pm

Integrating the future in life cycle assessment? A case study of emerging slag treatment technologies

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Goals. The integration of an environmental assessment of emerging circular technologies at an early stage of their technological development is crucial to identify the most promising pathways for further development efforts in terms of maximum circularity potential with minimum environmental impact. However, the final goal is not to assess the environmental performance of emerging technologies at a lab or pilot scale, but to achieve this for the potential future scaled-up technology. Given the future-oriented nature of such assessments, they can be defined as ex-ante LCAs. Moreover, for a legitimate comparison of emerging technologies with their more mature counterparts an ex-ante approach is indispensable as well.

The management of waste and by-products of industrial processes is an illustrative case for the development of innovative circular technologies. A promising pathway is to unlock the potential of metals entrapped within the vast amounts of by-products supplied by the steel industry. Building upon the results of the H2020 project CHROMIC, this case study includes the assessment of emerging technologies to recover residual metals entrapped in Ferrochrome (FeCr), stainless steel (SS) and carbon steel (CS) slags, such as chromium (Cr), vanadium (V), niobium (Nb) and molybdenum (Mo) while guaranteeing the residual metal-free mineral matrix can still be applied as a secondary resource in the construction sector, a so called 'zero-waste approach'.

In this context, the goal of this study is to assess the potential future scaled-up environmental profile of emerging slag treatment technologies by incorporating an ex-ante approach in LCA.

Methods. The assessment of the environmental profiles is based on an engineering approach, where a relationship with a certain degree of predictability is assumed between learning effects, scale and technology development. This way a static assessment can be made dynamic. Two approaches to anticipate on possible developments will be analysed. First, a proxy technology transfer strategy will be applied, where similar but mature technologies will be used as a reference to build ex-ante life cycle inventories (LCIs). Second, exploratory scenarios based on expert judgements will be developed, including the most likely scenarios and some extreme ones. These approaches are applied on the possible technological pathways from CHROMIC, which all include (1) a mineral pre-treatment, (2) a metal extraction through leaching, (3) a metal recovery and (4) a matrix recovery step.

Results. The results represent the scaled-up environmental profile after a first iteration of the technology development. The preliminary results indicate that multiple pathways are technically feasible, such as magnetic separation and standard crushing and milling (mineral pre-treatment), traditional roasting with water leaching and heap leaching (metal extraction) and advanced sorption and solvent extraction (metal recovery). For these promising technologies, the environmental profile at full scale will be presented including multiple scenarios based on the proxy technology transfer strategy and expert judgements. The main added value of this study consists of an increased understanding on how to deal with circular innovation processes and ensuring maximum environmental benefits can be achieved. Additionally, the results can be used to streamline further development efforts.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 3:30 - 5:00 pm

SOCIAL SUSTAINABILITY ASSESSMENT OF TECHNOLOGIES FOR THE ENERGY TRANSITION – FOCUS ON SOCIETAL ACCEPTANCE

Marcel Weil, Manuel Baumann, Jens F. Peters, Christina Wulf, Petra Zapp, Martina Haase, Christine Rösch, Jens Buchgeister, Tobias Junne, Tobias Naegler, Philip Emmerich

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ITAS / KIT

Decarbonization and increased sustainability are the major targets of the energy and mobility transition. Both transitions rely on new and emerging technologies, which allow on the one side the integration of renewable energy sources, and ensures on the other side the stable and uninterrupted provision of energy to industry and whole society. The new and emerging technologies have an economic and ecological impact, which has to be assessed in a systemic perspective. But also the social impacts need to be analyzed in a holistic manner, which is the major goal of this research. Based on the Sustainability Indicator System (SIS), which was developed for the assessment of the German energy system and its transition, three indicators are selected and adopted to analyze social im-plications of technologies:

- Innovation - Number of domestic patents
- Value for society - Domestic value added related to the technology
- Societal acceptance - Acceptance of the technology

For the later a quantitative and qualitative survey is conducted for three independent technologies. It is considered: Hydrogen filling station, biofuel production plant and large scale stationary battery storage facility. A total of 211 data sets were generated via the platform of sosci-survey, approximately one-third for each technology. The preliminary results exhibit, that the considered energy technologies were largely unknown to the questioned persons. In addition the most frequently mentioned concerns for hydrogen fill-ing stations and stationary battery storage systems are explosion and fire hazards, in the case of biofuel production plants, these are odor and noise pollution; also if such effects like explosion, fire hazards and odor would not occur in a controlled operation.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?
2nd September 2019, Monday 3:30 - 5:00 pm

Concurrent development and assessment of emerging technology: a case on carbon nanotube production

Corresponding author: Heng Yi Teah

Waseda University

[GOAL]

Carbon nanotubes (CNT) is a novel material with promising applications in the renewable energy systems. To realize the mass production of CNT, various production technologies have been innovated. In a lab environment, innovation often involves a series of trial-and-error of experimental variables. However, such an approach neglects the environmental impact of the choices that might lead to undesired consequences. This study proposed a concurrent development and assessment framework to support an emerging technology. Using the case of CNT, the goal was to show a cleaner production pathway via quantifying the environmental impact of innovation and identifying opportunities to improve the CNT synthesis methods.

[METHOD]

Previous life cycle assessment (LCA) studies showed a wide difference of result depending on the CNT product qualities and synthesis methods. To enable consistent comparisons, the functional unit of this study was to produce 1 g of vertically-aligned, single to few-walled CNT via chemical vapor deposition (CVD) methods. First, we analyzed the experimental datasets from our research laboratory over the past few years and selected the cases that would demonstrate innovation improves the environmental performance. Then, we assessed the life cycle performance of a synthesis method with global warming potential (GWP) based on the IPCC impact assessment method.

[RESULTS]

Three methods that showed the stepwise improvement of CNT synthesis were selected. First, in the on-substrate CVD method, we showed that using high-flowrate of CO2 as enhancer were better than low-flowrate of H2O due to the productivity dropped in H2O when scaling up the number of flat-substrates. Second, in the fluidized-bed CVD method, the CNT growth increased significantly due to better utilization of reactor space, from 2D to 3D (changing from the previous flat-plate to sphere-shaped substrates). Therefore, the performance was improved by three folds. The environmental hotspots for above methods were sputtering, a separated process in catalyst preparation. In the third case, a CVD method for catalyst preparation was introduced in the fluidized-bed CVD method, which would enable a semi-continuous production. The performance improved to 0.5 kg CO2e/g CNT (from initial 28 kg CO2e/g CNT in on-substrate CVD method). Although the impact was still relatively high in comparison to other carbon product such as mature carbon fiber (CF) production, 0.02 kg CO2e/g CF, fast development of the emerging technology is promising. Further improvement by changing the processes with high environmental impacts such as the use of carrier gases, and electricity demand for heating, is currently being explored in the on-going experiments. In short, with an iterative process of CNT synthesis experiments and LCA, we showed that an environmentally conscious innovation process for emerging technology is possible.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices
2nd September 2019, Monday 3:30 - 5:00 pm

Business and sustainability performance need not be a zero sum game

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Indian Institute of Management, Noida Campus

Many LCA practitioners tend to believe that if a tool or method is shown to be scientifically sound, there is no reason why it should not become popular, and often try to sell LCA only as a scientific tool to assess sustainability performance. The premise is that a scientific tool leads to sound conclusions and should therefore be widely used. In actual practice however, for any sustainability assessment tool to gain mainstream popularity, it must also resonate with business managers for whom sustainability is but one of the concerns. In today's commercial, for-profit business world, although sustainability issues are gaining more prominence with increasing awareness about environmental damages, these are not the main criteria for business decisions. More often, competition and profitability criteria score over sustainability performance.

The goal of this study is to discover how existing knowledge derived from LCA studies can show pathways to business practices that change the game by improving sustainability performance along with, and not at the cost of business performance.

In order to link the knowledge generated by LCA studies to good business practices, we followed a methodology consisting of four steps to undertake the analysis described in this submission: identification of target group of managers who are knowledgeable in both business and sustainability issues, clear articulation of their needs and expectations around improved practices, identification of a collection of LCA studies to derive good practices, and content analysis of the studies.

Put together, results of the analysis show that sustainability improvement initiatives linked to knowledge derived from existing LCA studies were attributable to four principle options or actions, viz. Reduction, Replenishment, Recovery, and Substitution. The submission concludes with the visual of a 2X2 matrix providing four strategic directions for deriving business benefits while simultaneously enhancing sustainability performance. Products for which possibility of reducing resource use and/or emissions is low and cost/effort for replenishment is high, need to be phased out as they are unsustainable and expose the business to higher risk of regulatory restraints in the future. Products for which reduction potential is low and cost/effort required for replenishment is also low, profits may be encashed and harvested early on since these will eventually have to be phased out due to the low reduction potential. Products with high reduction potential and low cost/effort for replenishment should be nurtured as stable businesses as they are the most sustainable and pose low risk. Finally, products with high reduction potential as well as high cost/effort for replenishment need to be anlayzed and researched further so that the replenishment cost/effort can be brought down.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices
2nd September 2019, Monday 3:30 - 5:00 pm

Augmenting life cycle thinking and circularity using gamification approaches within a large global company

Ravi Teja Pabbisetty, Ananda K Sekar, Rajesh Mehta, Ashok Menon

Corresponding author: Ravi Teja Pabbisetty

SABIC

Goal: Circularity of plastics has taken prominent position in European policy development with recent launch of Circular Economy Action Plan, which amongst others, focuses on reducing single use plastics besides setting ambitious targets for recycling rates. With policy developments across the globe strongly driving circularity of materials, it is imperative for us as sustainability experts of a global company to instill LCA insights on circularity into various sections of the organization from marketing teams to technologists and the like.

Method: LCA is often attributed to being “too technical” or “too complex” to comprehend. Hence, we developed an interactive decision making game on LCA that relies on “learning by doing” pedagogy for use in internal and external engagement workshops on sustainability.

With annual global sales exceeding 1.5 billion units ICT industry has a strong dependency on material resources and growing at significant pace. In view of its ubiquity and familiarity, coupled with its relevance for circularity, the game is themed on Life cycle of a Smart Phone.

Result: The interactive game relies on attributional as well as consequential LCA approaches, wherein, the player gets to make life cycle choices of a smart phone from choice of materials, battery capacity and display size, choice of packaging to various aspects of its use such as source of electricity, mobile data versus broadband network, GBs of data use, etc. The player also gets to make decisions on circularity such as frequency of changing the phones, choices on end-of-life such as resale, repurposing, recycling to even preserving them as collectibles. The game-play objective is to design a phone with lowest carbon footprint while staying within a certain allocated cost budget.

SESSION T5-7 LCM and Central Eastern European Countries – the Past, the Present and the Future
2nd September 2019, Monday 3:30 - 5:00 pm

ANALYSIS OF LCA AND ECO-DESIGN APPLICATION IN SCIENTIFIC PUBLICATIONS FROM SERBIA

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Goal: Application of life cycle management tools is important for modern society in order to achieve the sustainable development and circular economy concepts. Although expansion of life cycle assessment (LCA) studies begins after publication of ISO 14040 standards in 90's, the application of LCA in Serbia starts more than a decade later. Goal of this research is to perform an analysis of LCA and eco-design in scientific publications of researchers with affiliation from Serbian institutions.

Methods: The analysis was conducted through the following steps: search and selection of scientific publications, analysis of selected publications, and discussion of results. Search and selection of scientific publications is performed with Scopus database and Web of Science Core Collection, while NaRDuS (National Repository of Dissertations in Serbia) portal was used for search of Serbian PhD dissertation. In search and selection publications on English and Serbian languages were considered. The following keywords are used in search and selection: “LCA”, “life cycle assessment”, “life cycle analysis”, “ecodesign”, “eco-design”, and “eco design”. In search and selection step, only the title, abstract and keywords are considered. Analysis of the selected scientific publications provides information on number of selected studies in Serbia that included use of LCA and eco-design. The selected publications are organised and analysed using the following information: authors affiliation, year of publication, type of publication (journal paper, conference paper, book chapter, PhD dissertation). In final step, findings are reported and results are discussed.

Results: In total over 80 publications have been selected within the timespan from 2005 till 2018. Each selected publication meets the LCA search keywords, while only two publications have LCA and eco-design search keywords in title, abstract or authors keywords. Majority of selected publications, over two thirds, are journal papers while publications from conference paper, book chapters, and PhD dissertations are published after 2010. Furthermore, in most of the selected publications authors have affiliation from University of Novi Sad and University of Belgrade which are also the two largest universities in Serbia. The obtained results show increasing trend in publications of LCA and eco-design from Serbian scientific community. Although the first selected publication appeared in 2005, the majority of scientific documents are published in the last four years. The future research should include analysis of area of LCA application (goal and scope of LCA), use of life cycle impact assessment methods, use of one or more methods, tools, and software.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

2nd September 2019, Monday 3:30 - 5:00 pm

GISSus - GIS for Sustainability

Denis Sepoetro, Martin Kirchner

Corresponding author: Denis Sepoetro

Evonik Technology & Infrastructure GmbH

Goal:

Enabling rapid regionalized sustainability assessments in three dimensions (social, environmental, economic) with high accuracy for better-informed decision making.

Methods:

Setting up a Geographic Information System (GIS) that contains georeferenced data layers for all three sustainability dimensions ("people, planet, profit"). This system is then used to not only store large data amounts, but also for conducting complex analyses as well as presenting results in a sophisticated manner, e.g. maps serving as basis for discussion.

Results:

Good overview of links and interdependencies between different life cycle stages and sustainability dimensions. Clear, intuitive maps that can be used for communicating sustainablity issues to decision makers.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes
2nd September 2019, Monday 3:30 - 5:00 pm

The colour of Sustainability for the Paints in Europe

Dolla, Olympia, Huguet Ferran, Pau, Sonnen Max

Corresponding author: Olympia Dolla

CEPE

For the last years, the European paint industry has been very dedicated into bringing sustainable solutions to the market.

The journey started in 2012, where CEPE (the European Council of the Paint, Printing Ink and Artists' Colours Industry) started engaging the members of the association towards the analysis of the environmental impact of their products for the full life cycle (cradle to grave). As an answer to this call, the industry initially created an internal Life Cycle Inventory database (CEPE LCI project) for the raw materials that are commonly used in paints. This database was made available to all the paint sectors to perform LCA studies of their products. In the CEPE LCI database, we currently cover 323 raw materials for paints, and it keeps on growing and becoming better.

The LCI datasets were integrated in an interactive Eco-footprint tool, developed by Ecomatters, that enables non-expert users to calculate the environmental footprint of their products in a simple manner. The user only has to specify the paint formulation and basic performance and production parameters to obtain an environmental self-declaration. Still this type 1 eco-label relies on LCA data, and provides the companies and downstream users with quantitative Life Cycle information about their products to support decision making.

In 2013, the PEF pilot project for Decorative paints started, an initiative by the European Commission. The Deco paints adapted the methodology to their life cycle characteristics, and succeeded in the harmonization of the industry towards the method and the assumptions that shall be followed, which is the ultimate deliverable of the project. This brought the partially updated version of the CEPE LCI database to the EF compliant database for Chemicals for Paints, enabling calculations based on the PEF Category Rules.

One important goal for the industry is to enable the SMEs to participate in the PEF "game". Therefore, the CEPE PEF tool was created. The tool puts together all previous developments, creating an Eco-footprint tool based on the EF-compliant data and the Deco PEFCR, which allows non-expert users to make PEF studies effortless. And the journey from theory to practice begins. The dream of the industry is to harmonize, facilitate and engage all the players- upstream and downstream- of the paint supply chain to work on the hotspots, set goals, and improve.

This session will depict CEPE's path into bringing sustainable solutions, presenting all developments made during the last years with strong focus on the creation and implementation of the CEPE PEF tool. It will also present and discuss the main challenges found in the different steps of the progress, and will derive learnings and conclusions that could inspire other industries to implement effective eco-footprint methods and resources to reach widespread audiences.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes
2nd September 2019, Monday 3:30 - 5:00 pm

An approach towards complete automation for EPD generation by an International Thermal Insulation manufacturing company

Corresponding author: Magdalini Psarra

ROCKWOOL International A/S

For a company like ROCKWOOL International, with several manufacturing locations of mineral wool insulation across the globe and a big portfolio of products, the production of Environmental Product Declarations (EPD) representative of each product for the separate markets has been a burden for several years due to the considerable amount of manual work, involvement and coordination of various internal stakeholders as well as high verification costs. The purpose of this work is not only to discuss the burdens from the diversity of reporting formats across countries and the additional requirements for publishing EPDs, but to suggest a framework for an automatic generation of environmental information in a fast and cost-efficient way.

The framework includes the parametric design of a model in GaBi – a Life Cycle Assessment Software - to adapt to all variations of input and be representative for all the locations from where the input can originate. The parametric model is controlled by a big set of parameters, which is externally controlled by an automated MS Excel tool developed in Visual Basic (VBA). In this tool, various reports from all the internal systems used today in ROCKWOOL are consolidated, the data is correctly processed and automatically allocated to the correct parameters. Due to differences in reporting across the various locations, all the possible variations are considered for now. The parameters are subsequently copied into the LCA model and the impacts are generated. An additional supporting MS Excel tool is also programmed in VBA to easily generate the impacts for all the variations of products available.

The result of the approach is an advanced tool for LCA, which can be adapted to be representative of every product coming from every production site of ROCKWOOL. Internally the tool is used for decision making and investigation of improvement possibilities of our environmental performance and better understanding the hot spots. Additionally, the tool provided us with further insights regarding misalignments in various reports and helped to improve our data quality.

Externally the tool is third-party verified and used for the publication of EPD globally. Nowadays the need for publication in databases in different countries creates additional requirements and this along with the lack of mutual recognitions across the many databases for EPD publication, do not allow its complete automation. The manual calculations and the continuous revisions to fit the country specific requirements on the top of the additional financial burdens can often be a barrier to publication of more EPDs and lead to reduced transparency, accuracy and awareness of the environmental impacts of construction materials. Only via the complete harmonization of these databases and the formulation of internationally agreed rules for tool verifications will we be able to achieve increased awareness towards sustainability and be able to push for changes towards greener manufacturing and conscious decision making by the customers.

LCM 2019
1-4 September, 2019
Poznan University of Technology
Poznan, Poland

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SESSION T4-4 LCM - Standards, Certification and Labelling Schemes
2nd September 2019, Monday 3:30 - 5:00 pm

Twenty years since the first EPD was launched – taking stock of the development and growth of Type III Environmental Declarations

Corresponding author: Kristian Jelse

EPD International

This presentation takes stock of the development of Type III Environmental Declarations from 1998-2018, ever since the first Environmental Product Declaration (EPD) was registered by Vattenfall in Sweden for electricity generation from the Lule River in 1998.

SESSION T5-1 Strengthen LCM by Blending Approaches
2nd September 2019, Monday 3:30 - 5:00 pm

Integrated Approach to Sustainability Evaluation using Circular Economy Indicators and Life Cycle Assessment in the Chemical Industry

Rajesh Mehta, Salil Arora, Ashok Menon

Corresponding author: Rajesh Mehta

SABIC

Circular Economy (CE) concept looks beyond the current take-make-dispose industrial model to create value for the economy, society, and businesses by moving towards sustainable consumption.1-3 The CE methodology applies system thinking, 4R framework, and waste hierarchy to eliminate product “end of life”.2 To evaluate CE business models and products incorporating CE principles measurement of circularity is required. Multiple performance indicators and tools exist, both quantitative and semi-quantitative, to measure CE performance.4-7 Indicator scope varies from a macro level assessment of the economy, EU commission,5 to a micro level assessment of a company or a product system, Material Circularity Indicators (MCIs)4. The existence of multiple indicators increases complexity for designers, sustainability experts, value chain partners, and decision makers as there are differences and limitations in existing approaches to measuring product’s circularity performance.

In this work, we studied usefulness and applicability of existing CE indicators for measuring product circularity for polyolefin products going into different end-use applications: rigid and flexible packaging, automotive, and infrastructure pipes. Further, the study applied CE indicators together with LCA to 1) measure sustainability performance of the product; and 2) study relationship between CE indicator score and LCA impact assessment results. We also studied the impact of various parameters such as recycled content and end of life allocation approach on CE indicator score and lifecycle carbon footprint.

The research presentation will share insights gained and demonstrate our integrated approach to use MCI and CEIPT CE indicators with LCA models and LCA workflow for three different plastic product applications – rigid and flexible packaging, automotive and infrastructure pipes. The study concluded that LCA complements the Circular Economy frameworks and CE indicators. Results from our work demonstrated the ease of use of CE indicators for communication to non-LCA experts. However, CE indicators have limitations and CE scores cannot answer all questions from decision makers on sustainability impacts of a product system. Therefore, the suggested integrated approach is better suited for organizations with large non-expert LCA audience. However, there are opportunities to improve the proposed integrated approach by development and use of sectoral specific CE indicators.

SESSION T5-1 Strengthen LCM by Blending Approaches
2nd September 2019, Monday 3:30 - 5:00 pm

PROVING THE CONCEPT OF CIRCULAR VALUE ADDED TAX ON PRODUCTS AND SERVICES BY MONETIZING DIFFERENTIAL EXTERNALITIES

Yves Gérand (1),Anaëlle Dubosc (1),Stéphane Le Pochat (1),Sophie Laroche (1), Anne Bouter (2),Benoît Cheze (2),Jacques Villeneuve (3),Stéphanie Muller (3),Faustine Laurent (3), Louis Dupuy (4), Gamaris Tchomepi Mouaha (4), Romain Ferrari (5), Erwan Autret

Corresponding author: Sophie Laroche

EVEA

Goals :

In 2013, EVEA carried out a review[1] of available monetization factors quantifying the costs related to some environmental impacts, such as acidification (damage on forests, lakes, crops, structures), climate change, eutrophication, human toxicity (damage on health) and fossil fuel resource depletion. The review was sponsored by Fondation 2019, a non-profit organisation. Based on different monetization methods, these factors combined in a first database to link externality costs to Life Cycle Assessment flows or midpoint impact results.

The MODEXT project aimed at:

(i) updating this database (with both updated and new values corresponding to new kinds of damage) through a review of recent studies in the field,

(ii) proving the feasibility of using this database and Life Cycle Assessment to quantify a differential externality between ecodesigned and non-ecodesigned products and services, then

(iii) identifing major remaining hurdles in the deployment of a circular (or damage and) Value Added Tax (VAT)[2], [3] at the national level.

Method :

Three anonymized private companies contributed to this study by providing four manufactured products and one service (pilote products) chosen based on their proximity to the end user (B2B or B2C markets) and the ecodesign strategy established.

A systematic review of available monetization factors for human health, air quality and resource depletion was performed to complete the pre-existing database. Appropriate indicators (flows and midpoint impact indicators) that link the five pilote product LCA results to the overall monetization factor database were identified. These indicators and corresponding monetization factors were used to calculate externality costs of the corresponding functional units. Finally, the differential externality costs between ecodesigned and non-ecodesigned products were used to calculate a set of reduced VAT rates based on reduced product externalities.

Results :

Differential externality costs were successfully calculated for the five products and services. Even when controlling for product prices and the sensitivity of the results to parametrical uncertainties (methodological or political choices), these costs remain within the range of national VAT values. Furthermore, tangible and intangible as well as direct and indirect shares of the externalities were calculated.

These findings provide a rationale for a LCA-based VAT, where the tax break associated with a relatively lower rate would be linked to the environmental, social and health benefits of eco-design. Instead of ex-post compensations for sustainable development, incentives would be integrated in the tax system with an « automatic » equation of costs and benefits.

However, hurdles remain. Impacts are not yet spatialized in LCA, which prevent monetization factors from being used to their full potential. These factors are usually defined at the national level while LCA is a global approach. The proposed approach is particularly apt for the assessment of two closely related products or services (comparable functions and comparable production/consumption systems). Assessing externalities between a reference product and an ecodesigned product using a disruptive technology yields more uncertain results.

SESSION T5-1 Strengthen LCM by Blending Approaches

2nd September 2019, Monday 3:30 - 5:00 pm

Integrating Circularity and Environmental Indicators

Anne Gaasbeek (Pre Sustainability), Mantijn van Leeuwen (NIBE), Eric Mieras (Pre Sustainability)

Corresponding author: Mantijn van Leeuwen

NIBE

Goal

The Circular Building Platform CB'23 (www.platformcb23.nl) aims to connect parties in the building and construction sector with circular ambitions, both in civil engineering as well as construction. The aim is to have national consensus by 2023 on circular construction on a common framework, definitions and a method to quantify circularity in construction works. Our use of primary (natural) resources needs to be reduced significantly. In 2023 the Dutch Government will tender and purchase 100% circular. For the construction sector this will mean that high-quality recycling and reuse of products and materials will ask for a different approach in design, production, construction and maintenance of buildings and building products.

To measure the level of circularity is one of the taskforces within CB'23. To quantify the level of circularity of a building or building product we need a harmonized methodology or standard. We want to avoid that a multiple of different quantification methods arise, which makes comparison of the results impossible. Therefore the action team has set out to develop a methodology to quantify the level of circularity with a group of 45 parties involved.

At the same time LCA is already used as a way to calculate the environmental impact of construction materials and buildings. This makes no distinction between circular and linear products or designs. The same LCA method is used and is found to be quite able to provide a basis for comparison of products and designs, in which circular design philosophies (e.g. recycling, reuse, remanufacture, refurbish) seem to get quite well handled and can effectively be calculated.

Method

In The Netherlands an LCA method is used that is based on the EN 15804. This method is provided in the "Bepalingsmethode Gebouwen en GWW-werken [1]" and can be found at www.milieudatabse.nl. LCA of Building products, setup and reviewed in line with this method, can be made available in the National Environmental Database, that connects to different software packages for modelling of construction works (both buildings and civil engineering works). In the software packages the environmental effects are each converted to a common unit, called the Environmental Cost Indicator and summarized into a single score indicator. This single score indicator is used in design, tendering and legislation. Quite some experience has been built up in The Netherlands with this methodology over the last 10 years.

Results

As part of this project a method to measure circularity has been developed. One of the requirements was that the method could be combined with LCA. In this session we will present how the method was developed, present the method itself and also examples of how the method is applied in combination with LCA.

SESSION T5-1 Strengthen LCM by Blending Approaches
2nd September 2019, Monday 3:30 - 5:00 pm

A combination of LCC and ecosystem services assessment making use of system dynamics modelling

Javier BABI ALMENAR, Claudio PETUCCO, Thomas ELLIOT, Guido SONNEMANN, Davide GENELETTI, Benedetto RUGANI

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In the construction sector, traditional life cycle costing (LCC) is a well-known and robust approach useful to compare the total internal cost of (natural or grey) infrastructure alternatives from their design until their end of life. Two other types of LCC exist:environmental and social . The former, usually applied in combination with LCA, monetarise the cost of environmental externalities and the latterintegrates social externalities. However, it is difficult to take into account positive environmental and/or social externalities only making use of these methods. The combination of LCC with ecosystem services (i.e. the benefits that people obtain from natural elements) could facilitate to account negative and positive environmental and social externalities of solutions such as urban forests, green roofs/walls, or constructed wetlands. Since externalities of natural solutions are changing along time due to the interaction of factors, their valuation also requires use of techniques such as system dynamics models. In this research, we present a methodology that integrates social LCC with ecosystem services assessment, supported on a system dynamics model. This type of methodological integration would be useful for cost-benefit analysis of natural infrastructures where externalities should be considered. The methodology is applied to a pilot case study (a green roof), taking into account three types of costs (investment, operational, and deployment) for an expected operational life of 50 years. The application show the potentiality of blending LCC with ecosystem services assessment and system dynamics for cost-benefit analysis done under a sustainability perspective.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 3:30 - 5:00 pm

How green are electric vehicles? Quantifying life-cycle related environmental impacts of lithium-ion batteries including the comparison of different cell technologies and end of life scenarios.

Daxner Therese, Merl Adolf

Corresponding author: Therese Daxner

Daxner & Merl GmbH

Goal:

The transport sector represents an important contributor to the environmental impact of our global society. In order to conquer the challenges of our time, electrification of the transport sector represents a frequently announced strategy. As a result, electric vehicles must meet these goals leading to a reduction of transportation's environmental impacts while complying with highest security standards. In this context, the environmental impacts associated to lithium-ion batteries (LIB) including its circularity potential represent a decisive factor for the "greenness" of electric vehicles. This study therefore aims at the evaluation and quantification of life cycle related environmental impacts of various generations of lithium-ion batteries. This environmental analysis considers the production of different cell designs and technologies, the use phase and their end of life. End of life scenarios therefore evaluate recycling potentials and possible secondary life options in the light of circularity potentials. As a result, the entire analysis arrives in a cradle-to-grave environmental view of different cell designs.

In addition, the study aims at a holistic view on the risks and potentials associated to various cells including security considerations. Based on the results of detailed gas analyses, potential environmental risks associated to abuse conditions are assessed.

Methods:

The presented analysis complies with latest methodological developments considering the requirements of ISO 14040 and ISO 14044, recommendations given in the ILCD-handbook as well as the results of the environmental footprint pilot phase (PEF) of the European commission. This includes the indications given in the PEFCR for batteries.

Presented results are developed in the cooperative, interdisciplinary project "DianaBatt". The project consortium works in close interaction and consists of the Austrian Institute of Technology, the Technical University of Vienna, the Italian battery manufacturer Lithops and the LCA consultancy Daxner & Merl. The cooperation within the consortium thus enables high quality data collection based on primary data. Due to the products' high complexity, all calculations are based on state of the art software-tools and LCA modelling.

Results:

This contribution shows the results of the life-cycle impact assessment of various lithium-ion cell technologies. The studied cell chemistry includes LFP, NMC111, NMC532 and LNMO cells and refers to both a cradle-to-gate assessment of the production as well as scenarios for cell recycling in the context of a circular economy. In addition, the comprehensive assessment of the battery's life-cycle phases evaluates hot-spots and puts orders of magnitude on environmental impacts over its entire life-cycle. Next to the classical LCA approach, the project delivers insights into the cell's reaction in case of malfunction. As a result, the evolution of hazardous gases in case of abuse is analysed and further considered in the environmental risk assessment of emitted gas species.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 3:30 - 5:00 pm

Evaluation of Material Consumption and Recycling Scenarios of Data Center Components

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The quantity of data centers in Germany presents a continuous increasing trend. This results in a growing demand of ICT components, and a higher requirement of valuable materials for their production. This paper evaluates the amount of resources consumed for production of ICT devices for data centers, and the potential savings achievable through End-of-Life (EOL) treatment. Data centers use electronic equipment fabricated with non-renewable raw materials. Some of these are regarded as Critical Materials by the European Union due to its economic importance and supply risk. Through Life Cycle Assessment, the raw material and primary energy required for production, and the potential savings of different EOL scenarios are evaluated. Strategies for reducing overall energy consumption in the lifecycle of data center components considers recycling and recovery of valuable materials from high grade electronic parts, such as printed circuit boards, because of their concentration of precious metals, and it is seen as strategic for their content of critical materials, as per the EU definition of criticality. Using different impact assessment methods, which evaluate direct energy and material use, as well as equivalent resource consumption, results in this paper highlight the importance of precious metals and copper consumption in the overall impact and show that improved recycling scenarios can result in raw material savings of 81% of gold and 78% of copper, and can reduce metal depletion impacts by 45%, thus reflecting potential benefits for production and cost reduction. This results in savings of primary energy demand of 10.4% for the manufacturing phase and in savings of primary exergy demand of metals of 58.6%. Improved data quality on the modelled processes is required, since uncertainties are present as a result of lack of primary sources for data, which is addressed through Pedigree Analysis and Monte Carlo simulations. Due to propagation of errors, the standard deviation remains at around σ=10% of the mean value of the baseline scenarios. Evaluation of additional End-of-Life strategies is also to be considered. Apart from recycling, waste prevention, namely reuse, repair, remanufacture, might be more beneficial than waste treatment.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 3:30 - 5:00 pm

Integrating Life Cycle Management for a more Circular Data Centre Industry

Naeem ADIBI, Deborah Andrews, Manon Galachant, Maxime Samulewicz, Christian Traisnel, Christian Thomas, Beth Whitehead, Jaak Vlasveld, Kathrin Greiff

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WeLOOP

The Data Centre Industry (DCI) is concentrated in North-West Europe, especially UK, Germany, France & Netherlands. DC equipment is replaced every 1–5 years, substantially contributing to the production of WEEE (Waste Electrical & Electronic Equipment), one of the fastest growing waste streams. WEEE from DC equipment contains Critical Raw Materials of high technical and economic importance and vulnerable to supply disruption, partly exported or sent to landfill at end of life. At present small share of DC equipment Critical Raw Materials are recycled and recovered per year.

In this context, project partners from UK (London South Bank University), France (TEAM2, Terra Nova Development and WeLOOP), Germany (Wuppertal Institute for climate, environment and energy) and Netherlands (Green IT Amsterdam) are working together on a Circular Economy for the Data Centre Industry (CEDaCI). CEDaCI will facilitate the implementation of a Circular Economy (CE) for Critical Raw Materials in NWE and reduce the environmental impact arising from the growth in redundant equipment, by simultaneously increasing CRM recovery, reducing use of virgin materials and developing a secure and economically viable CRM supply chain. The project if co-funded by Interreg North-West Europe Programme.

This contribution aims at presenting the CEDaCI project and sharing results of the LCM situational analysis for Data Centre Industry. The results of this phase include: State of art and assessment of current practices & emerging trends (with focus in all partner countries), Identify challenges and barriers and potential solutions for implementation, Establishment of criteria (age of the equipment, technology, components, etc.) for selection of equipment for refurbishing and recycling.

SESSION T1-2 LCM for Electric and Electronic Products
2nd September 2019, Monday 3:30 - 5:00 pm

LCA of a fuel cell using gold for the bipolar plates

Saïcha Gerbinet, Anne-Pascale Romano, Giuseppe Caldarella, Nathalie Job, Sylvie Groslambert, Angélique Léonard

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The objective of this study is to assess the environmental impact of a fuel cell that uses gold for bipolar plates with a special focus on gold origin: could the use of secondary gold reduce the environmental impact of the fuel cell?

The inventory data for the fuel cell production are coming from a Walloon Project called HYLIFE that aims to optimize the lifetime of efficient materials for fuel cells. During this entire project, LCA has been used to help in the materials selection. The ReCiPe 2008 midpoint method has been used and the most relevant categories have been selected. The LCA is done in Simapro using ecoinvent v3.0 database. The materials selected by the project have been used to build a fuel cell prototype that is understudied here. It is composed of two bipolar plates covered with gold, a Nafion membrane, two diffusion layers (GDL). Platinum catalyst is used at anode and a platinum/cobalt catalyst is used at the cathode.

The first results underline the large contribution of gold in ecotoxicity categories, in toxicity and in freshwater eutrophication. The other categories are mostly linked to the platinum used in catalysts, except the ozone depletion that is mostly related to the Nafion membrane due to CFC emissions. A normalization is applied and underlines that the most impacting categories are those where gold has most of the impact. Therefore, two cases have been studied: an optimization of the amount of gold used by a reduction of lost during plates impregnation and the use of recycled gold from electronic materials using ecoinvent data. The first case, of course, leads to a diminution of the environmental impact in all the categories, especially those where gold contribution is high. The use of recycled gold, however, allows a reduction of the impact in some categories but also leads to an increase in some others. Indeed, even if gold is more concentrated in electronic scarps, its recovery is more difficult than in primary ores, due among others to the presence of other components such as fire retardant. Nevertheless, the use of recycled gold allows a reduction in all the categories where the gold is the major contributor in the case of the studied fuel cell, leading to an important gain for the environment with a reduction of the freshwater eutrophication and human toxicity of 60 %. The reduction in ecotoxicity categories is 50 % for freshwater and 30 % for terrestrial, therefore too small to be significant due to the large uncertainties in these categories. The largest increase is for terrestrial acidification with an increase of 15 % of the overall impact. To conclude, the use of recovery gold allows a reduction of the environmental impact of the fuel cell, especially in the categories where the gold is significant. Nevertheless, the question of secondary gold availability is not assessed by this study.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 3:30 - 5:00 pm

Small pump – big impact: How a novel type of adsorption heat pump using waste heat can change the sustainability performance of the Swiss energy system

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Paul Scherrer Institut

Energy provision is a key player in overall sustainability performance of global good production and service provision in our daily lifes. The more the different energy system sectors (electricity, heat, storage, transportation) are interlinked, the more a need for Life Cycle Management (LCM) is given. This includes the use of industrial waste heat or environmental heat. Within the Swiss National Research Program 70 (NRP70), the joint project “THRIVE - Thermally driven adsorption heat pump (adHP)” aimed to develop an adHP driven by low-temperature waste heat (below 100°C) for provision of space heating or datacenter cooling services, and to tailor potential application scenarios according to technological performance and availability of waste heat. Further, we performed a sustainability analysis to investigate the potential effects of adHP penetration on the energy sector in 2050 in Switzerland in terms of energy savings, and to identify trade-offs between cost, risk and environmental impacts.

The sustainability analyses of the THRIVE adHP was performed on three different levels: 1) The machine level: from the demonstrator developed within the project (“as built”) to “first of a kind” (FOAK), with further technology progression to an “nth of a kind” model (NOAK); 2) The upsizing and implementation of a NOAK adHP into four application scenarios; and finally 3) Integration of the four scenarios into the Swiss Energy Landscape 2050, namely into energy projections as presented in (Panos et al., to be published).

Environmental impacts were quantified by means of LCA; costs were calculated as levelised cost of energy and capital, and accident risks in the material and energy chains into the adHP were quantified with risk assessment. A Multi-Criteria Decision Analysis (MCDA) investigated the performance of the various application scenarios (level 2). LCA foreground and background data were adapted via application of an open source software package recently developed to show projected LCI for potential future conditions in 2050 (Cox et al. 2018).

Integration of the application scenarios as developed within THRIVE into energy projections for Switzerland revealed potential energy savings of 3-6% in the total end use Swiss energy sector, potentially saving 1 Mio t CO_2eq. The life cycle greenhouse gas (GHG) emissions calculated range very low from 1 to 11 g CO_2eq per MJ of heating or cooling service provided. The cumulative non-renewable energy input fraction is between 0.05-0.23 MJ/MJ. The levelised costs of thermal energy (LCOE) calculated for the NOAK THRIVE adHP range from 5.8 to 18 Swiss Rp/kWht, depending on its application. As a result of the MCDA, it was shown that the THRIVE adHP consistently equals or outperforms the benchmark alternatives for most of the environmental, economic and social indicators considered. Making use of waste heat by the THRIVE adHP could therefore be an important contributor to achieving the targets of the Swiss Energy Strategy 2050, and of sustainable energy provision in general.

Panos, E., Kober, T., Wokaun, A. Long term evaluation of electricity-based storage technologies versus alternative flexibility options for the Swiss energy system. Report for Studiengruppe Energieperspektiven. To be published.

Cox, B., et al., 2018. The uncertain environmental footprint of future electric vehicles. Environmental Science and Technology, DOI:10.1021/acs.est.8b00261

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 3:30 - 5:00 pm

Simulating hydrogen-based mobility and its environmental consequences at a territorial scale

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ENGIE

[Goal] The transition to a low-carbon economy induces an important change in personal mobility. Among other solutions, decarbonising the automobile fleet is often seen as an efficient compromise between greenhouse gas (GHG) emissions mitigation potential and too drastic a change in consumer behaviour. Hydrogen fuel cell vehicles are a candidate to the replacement of part of the existing fleet, but their end-user prices and the scarce charging infrastructure are still an obstacle to full scale deployment. For that reason, companies may be adequate early adopters. Just how fast H2 vehicles can penetrate the market, and what the environmental consequences of such a shift are, are still uncertain. In the "Hydrogen-Electric Road Mobility Environmental Scenarios" (HERMES) project, we integrate agent-based modelling and life cycle assessment (LCA) techniques to simulate respectively a synthetic population of agents purchasing and using a fleet of vehicles, on the one hand, and to quantify the large-scale environmental impacts of various behaviours until 2030, for the Île-de-France region around Paris, on the other hand.

[Methods] The agent-based model uses a multinomial logit model as a basis for the agents' decision to renew their fleet, for a given demand, and for which energy (H2, full or hybrid electric, diesel, gasoline) depending on total cost of ownership (TCO), distance, and a "green consciousness" factor (alike to a willingness-to-pay factor for low-carbon compared to fossil-fuel segments). Usage is then modelled after data collected from stakeholder involvement (fleet managers, municipalities), for various types of agents: taxis, companies, artisans, and municipalities. Three scenarios are tested: baseline (current and planned policies), pessimistic (repelling of environmental policies), and pro-H2 (additional policies are introduced to accelerate H2 penetration). Parameters changing with scenarios are: prices of vehicles, incentives, energy prices, energy mixes, and "green consciousness" factors. Once calculated, this demand in vehicles and mobility feeds a life cycle model, built from life cycle inventories representative of every vehicle segment, and background processes such as electricity mixes. In turn, impacts can be calculated as the simulation runs. The ABM is stochastic, meaning that several simulations are needed to obtain significant results for the LCA of each scenario.

[Results] Given the high TCO of low-carbon powertrains (even including incentives), they do not penetrate the company fleet market substantially before actual fossil fuel bans are enforced (the municipality of Paris has planned to do so for diesel vehicles in 2024, and gasoline vehicles in 2030). A web-based simulator allows the visualisation of results at every level of resolution, from each agent, to the whole Île-de-France territory, including fleet renewals (and choices made then), fleet in use, and environmental impacts associated. The approach enables to understand and compare the effects of different levers that policy makers can use for environmental impact reduction.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 3:30 - 5:00 pm

Integrated Life Cycle Sustainability Assessment – Hydrogen production as a showcase for an emerging methodology

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Goals

Life Cycle Sustainability Assessment (LCSA) is an emerging methodology to map the sustainability of a technology. Although several publications have tackled this topic from different angles, the community is still exploring different approaches for LCSA. Often, there is a discrepancy between the demands on the approach and what can actually be implemented. In this work, we present a consistent approach for LCSA, which is still practical.

This approach is applied on an advanced alkaline water electrolyzer (AEL) at three different European locations. Electrolyzers are an important technology for the future. It is the corner stone of many Power-to-X processes and can deliver fuel for an electrified transport system as well as feedstock for other industrial processes. When run with electricity from renewable sources, it reduces greenhouse gas emissions considerably.

Methods

Classically, LCSA consists of Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and social Life Cycle Assessment (s-LCA) based on a joint technical model. For an integrated and consistent LCSA, however, this is not enough. Therefore, in this work, a coherent impact category selection based on the sustainable development goals (SDGs) was conducted. Furthermore, for interpretation of the results an integration of the three sustainability dimensions is mandatory. Thus, multi-criteria decision-analysis is necessary. For this work, the outranking method PROMETHEE is chosen. It does not allow full compensation of the sustainability indicators, which reflects a possible view on sustainability.

The analyzed system is a 6 MW pressurized electrolyzer. This electrolyzer is located in three different European countries, i.e. Spain, Germany and Austria, to illustrate the difference of industrial hydrogen production in industrialized countries with different structures in the electricity market. A state of the art technology is used under today`s conditions.

Results

Within each sustainability dimension a different location is favorable. From an ecological point of view, hydrogen production in Austria is the best option because the electricity is mainly generated from hydropower. The lowest hydrogen production cost, however, can be found in Germany because the electricity prices for energy-intensive industry are lower compared to Spain and Austria. A more diverse picture is drawn from the results of the s-LCA. Austria has for most impact categories the highest social risks. However, in Spain some social risks are much higher than in the other two countries, e.g. risk of unemployment or the risk that workers are not sufficiently represented due to the lack of trade unions. With such diverse results, decision making is difficult and PROMETHEE can guide such a process. If every dimension of sustainability has the same importance and within each dimension, each impact category has the same importance MCDA using PROMETHEE comes to the result that industrial hydrogen production in Germany is most preferable.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems
2nd September 2019, Monday 3:30 - 5:00 pm

Wind turbines components repair vs. substitution environmental impact analysis

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AIMEN

GOAL

Transmission parts for wind turbines are mechanical components subject to high loads. This causes their wear and failure 6-7 years of their commissioning. Most of the cases it causes total part replacement and damaged component scrapping. These parts are made mainly of steel (around 500-6,000 kg depending wind turbine power).

Two innovative strategies will be developed to repair these large size components:

1) Repairing by mean cladding processes based on laser technologies that ensures a high quality in the recovery of metal components.

2) Repairing by mean structural resins, low cost solution focused on components which, because of its large size, or by the difficulty of access to the damaged area, should be repaired on-site.

Wind turbine life time was considered 20 years. So that, 3 new transmission parts will be needed during this time if substitution scene is considered.

METHODS

In order to corroborate enviromental impact reduction for repairing activities, a consequential life cycle assessment for both repairing strategies was compare with damage component substitution scene. The assessment was performed using SIMAPRO 8.2 and EcoInvent 3.3 database. CLM-IA impact categories were evaluated.

Data were obtenined during repairing processess research activities in AIMEN, using real components and industrial operational parameters. Two different components were considered for laser cladding and structural resins repairing processes. Various structural resins were evaluated during research.

RESULTS

Cladding repairing process reduced 65% GHG emissions compare with component substitution scene, although considering steel recycling in all cases in “End Of Life” phase. The main reason is the main impact comes from steel required in manufacture. So that, used just one component and repair it during 20 years of life time has less impact instead of manufacture 3 new component.

In the case of resins repairing process, reduction will be 60-65% GHG emissions depending on the type of resin used. In Figure 2, results for an epoxi resin is shown. As in the case of laser cladding repairing process, the main impact comes from reduction on steel used in component manufacture. Other CLM-IA categories were evaluated with similar results.

Consequential analysis allows to compare both scenes and used it as decision tool to include these repair processes in maintenance operarions of wind energy generators. Results show than raw steel “savings” are the most important impact reduction and steel recycling positive impact is not so great.

Although repairing cladding processes have high energy requirements, they have a low impact comparing with steel necessary for a new component manufacture. In the 2nd case, although manufacture structural resins have higher potential environmental impact than steel, it would be necessary low amounts in repairing processes.

As a conclusion, in all cases repairing is better to substituting components, although steel recycling was considered.

Acknowledgement - Special thanks to Xunta de Galicia for funding ROTACION project and the partners involved in this project for the support and collaboration.

SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 10:30 - 12:00 am

How does extended Shelf Life of Food (ESL) prevent food waste? A model based approach

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Corbion

Food is lost or wasted throughout the supply chain, from initial agricultural production down to final household. Roughly 1/3 of the food produced for human consumption in the world is thrown away (FAO 2011). Food wastage has a very broad impact at the economic, environmental,

food security and social level. As a matter of fact, food waste leads to massive waste management costs, environmental pollution, degradation and depletion of the planet resources. Food waste reduction is an effective way to optimize the use of natural resources, by improving the overall field- to consumer yield.

While extended shelf-life (ESL) of food products is often suggested as a contributor to food waste reduction, there is limited scientific evidence that demonstrates and measures its impact. At Corbion we aim at measuring the positive impact of our ingredient solutions for extended shelf-life on food waste reduction and impact Sustainable Development Goal 12.3 (SDG 12.3). We expect to achieve this by creating a knowledge center and quantitative tools to advise stakeholders on the sustainability benefits of these ESL products.

The impact of Corbion ingredient solutions on ESL and food safety can be well predicted, for example using microbiological models such as the Corbion Listeria Control Model (determinant of use by date based on Listeria monocytogenes control). In this project, a comprehensive literature review and interviews with experts were conducted aiming at quantifying of the influence of ESL on food waste, focusing on the whole value chain: production, handling and storage, processing and packaging, distribution and market, consumption.

The research showed us that ESL can be effective tool in combating food waste along the entire supply chain but it needs to be integrated with other supply chain optimization approaches. Moreover, it is important to increase consumers awareness and understanding regarding food labels, freshness concepts and the acceptance of new technologies and food additives to achieve a positive impact on food waste reduction. A conceptual, statistic based model was developed to demonstrate the relationship between consumer behavior and food waste drivers, grouped by Motivational-ability-Opportunity (MAO) parameters. According to this model, applying shelf-life extended product can contribute to food waste reduction at the consumer-end by the premise that foods are wasted because consumer cannot consume the foods in time before the foods become overdue.

In the presentation, we will share the main results, describe the data collections challenges, the initial quantitative framework and next steps of the project, with focus on selected value chain stages (processing, packaging, distribution and market) and on consumer behavior.

SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 10:30 - 12:00 am

Life cycle assessment of peat substitutes: characteristics, availability, environmental sustainability and social impacts

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Goal

Peat extraction leads to environmental damage in terms of climate and biodiversity. In Switzerland, peat bogs have been protected since 1987 and no peat is currently extracted. However, Switzerland imports an estimated 524’000 m3 of peat per year. In order to reduce environmental damage abroad as well, the Federal Council adopted a peat phase-out concept in 2012.

The Institute of Natural Resource Sciences of the Zurich University of Applied Sciences (ZHAW) assessed the environmental sustainability of various peat substitutes as well as their characteristics, availability and social impacts. Among other products, coconut fibres, cocopeat, bark compost, wood fibres, wood chippings, and TEFA maize fibres were investigated. A follow-up study aimed at further promoting the termination of peat use by extending the study with additional peat alternatives. These are biochar, miscanthus, flax and hemp fibres, grain husks, and coal compost.

Methods

The present research project is intended to provide a picture of the environmental impacts of individual substrates and substrate mixtures by means of life cycle assessment, whereby the entire life cycle (raw material extraction, substrate production, transport, use, end-of-life) is taken into account. The substrate components and substrate mixtures are also being evaluated in particular with regard to their crop cultivation properties and medium- to long-term availability for Switzerland. In addition, the study also considers social criteria, which are assessed qualitatively. Finally, the study will provide recommendations for horticulture and, in particular, for producers of ornamental plants, perennials and vegetables.

Results

All substrate components exhibit both positive and negative properties with respect to the criteria investigated. Replacing peat with local products such as miscanthus, hemp and flax fibres, wood fibres, TEFA maize fibres or bark compost significantly reduces the emissions of extraction, transport and use of peat. With regard to ecological and social aspects, bark compost, TEFA maize fibres, wood fibres, wood chippings and husks perform very well. As these products are expected to be available in the future, their use as peat substitutes is highly recommended.

The availability of wood fibres and wood chippings depends on the price of the energy industry and is therefore subject to fluctuations. Hemp and flax fibres, husks, TEFA maize fibres, and bark compost, on the other hand, hardly compete with energy use. These products are therefore expected to be readily available for horticulture in the future and can be manufactured without significant negative ecological and social impacts.

The coconut-based substrate components are associated with higher environmental impacts and social risks than locally manufactured products. On the contrary, the social impacts of production and processing of peat substitutes are assumed to be very low or non-existent in Switzerland.

Biochar can be produced locally with readily available substrates and has similar consistency and properties to peat, making it an attractive peat alternative.

Environmental impact of peat substitutes are lowest if they are locally produced and processed with low material and energy consumption, when few pesticides and fertilisers have been used in agricultural cultivation and no thermal processing is necessary after harvesting.

SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 10:30 - 12:00 am

Typologies of Belgian consumers: variability in protein source consumption, environmental impact and nutritional quality

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KU Leuven

Our current food consumption patterns are not sufficiently sustainable. Especially our large meat and dairy consumption leads to major environmental impacts. Replacing such animal-based protein sources with plant-based protein sources (such as tofu or chickpeas) seems a promising way to lower these related environmental impacts on consumer level. However, one cannot blindly replace one food product with another as different food products contain essential nutrients in various levels. Moreover, changes in food consumption patterns will only become reality when they are acceptable and practically possible for individual consumers. Yet, studies that examine changes in food consumption patterns usually take into account average (national) patterns, ignoring differences between individuals. This research addresses the variability in Belgian food consumption patterns and their related environmental impacts, by identifying “protein typologies”: consumer groups with different consumption levels of different protein sources.

We use the Belgian National Food Consumption Survey (conducted in 2014) to assess the intakes of protein sources and to characterize the typologies in terms of personal characteristics (e.g., demographic information, employment, health, etc.) and in terms of the nutritional quality of the food consumption patterns. We include nine groups of protein sources: beef, pork, chicken, fish, dairy, eggs, meat replacers and legumes. To assess the nutritional quality of the food consumption patterns, we compare the intake of nutrients with recommended intakes, proposed in the Belgian nutritional guidelines. We consider the important nutrients of meat: protein, essential amino acids, vitamin B12, zinc and iron. To assess the environmental impact of the typologies, we use the Risk of Earth Destabilization (RED) index, which was developed by our research group (Goossens et al., 2018, J Clean Prod, 198, 601-611). The novel index is based on Life Cycle Assessment and uses weighting factors based on the Planetary Boundaries framework. It therewith captures the “planetary urgency” and hence the risk of earth destabilization.

We expect to identify 5 to 6 protein typologies. We will present the protein source consumption levels, nutritional adequacy, personal characteristics and RED index of each typology. The protein source consumption levels will be used as a starting point for formulating realistic and acceptable changes in food consumption patterns for Belgian consumers in order to lower their environmental impact while ensuring an adequate nutritional value.

SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 10:30 - 12:00 am

Hortifootprint: Product Environmental Footprint Category Rules for Horticulture in the making

Marisa Vieira, Hans Blonk, Piet Briet, Roel Helmes, Tommie Ponsioen, Rick van der Linden, Daan van Empel, Irina Verweij-Novikova

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PRé Sustainability

Goal: The demand for sustainably produced horticultural products is increasing. Consequently there is also a growing market for calculating the environmental footprints of horticultural products. While consumers and retailers want to know more about the sustainability credentials of these products, there is as yet no standard methodology for calculating them. To meet this growing demand the Hortifootprint project was recently launched to develop a uniform standard methodology that will be applicable to all horticultural products and that will be adopted across the whole horticultural value chain. The project was initiated by Royal Flora Holland, Dutch Fresh Produce Center and Wageningen Economic Research, with co-financing from the Dutch Fund for Horticulture & Propagation Materials, ABN AMRO Bank N.V., The Dutch sector organisation for greenhouse horticulture (Glastuinbouw Nederland), MPS, Rabobank, Foundation Benefits of Nature and advisory performed by Blonk Consultants and PRé Sustainability.

Method: The development of the methodology is following as much as possible the most recent Guidance for developing Product Environmental Category Rules (PEFCR) published by the European Commission. However, there are several topics that are still considered immature for horticulture in the PEFCR Guidance. So far, we identified the following: handling multifunctionality of combined heat and power systems used during cultivation; handling multifunctionality when multiple plants are grown in a protected (and heated) system; modelling of N and P emissions; impact assessment of pesticides; and modelling of capital goods. After having identified the issues, we developed and tested the proposed approaches in six screening studies, one for each representative product (RP).

The six RPs were selected with a relative high market share and a wide variety of applied technologies and origins of productions. These are:

• Apples (temperate perennial fruit with variability in energy consuming storage and global transport);

• Bananas (tropical perennial fruit with variability in energy consuming global transport);

• Phalaenopsis (ornamental plant cultivated in two stages, in substrate and in greenhouse);

• Roses (perennial plant yielding flower stems, grown in soil in a greenhouse, with and without air transport);

• Tomatoes (annual vegetable cultivated in greenhouse, on substrate);

• Tulip bulbs (annual crop in soil, grown without greenhouse protection, with ornamental function and input use during use phase).

The first draft PEFCR was released for stakeholder consultation in November 2018. Throughout the past two years, we also held various workshops with growers of horticulture products. The aim of those workshops was to involve them early on and to understand the feasibility of the data to be collected during cultivation.

Results: All six screening studies, one for each RP, were completed. Impact categories identified at least once for any of the screening studies as most relevant were: Acidification; Climate change; Eutrophication, terrestrial; Particulate matter; Photochemical ozone formation; Land use; Resource use, energy carriers; and Resource use, minerals and metals. Surprisingly, water use was not identified as most relevant impact category and land use was only identified for bananas.

The most relevant life cycle stages identified for any of the six screening studies were: Cultivation; Post-harvest handling; Packaging; Distribution; Storage; Use stage; and End-of-life. It should be noted that not all screening studies were cradle-to-gate, e.g. tulips only included cultivation and post-harvest handling. Except for retail, all other life cycle stages were identified as relevant for at least one of the studies. Cultivation was a most relevant impact category for all.

All in all, we observed that the studies were sensitive to some data and modelling choices, e.g. how to the handle multifunctionality of combined heat and power systems used during cultivation. This stresses the fact that alignment in the measurement of the environmental footprint of horticultural products is needed.

SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 10:30 - 12:00 am

LCC for the economic evaluation of tomato crop in an integrated rooftop greenhouse in Barcelona

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Autonomous University of Barcelona

Objective: The aim of this research is to analyze the economic viability of the tomato crop produced in an integrated rooftop greenhouse (i-RTG) in order to assess its possible contribution to improving the sustainability of the urban environment.

Method: The Life Cycle Cost (LCC) method was used as it represents an essential part of Life Cycle Sustainability Assessment (LCSA). As such, LCC is complementary to Life Cycle Assessment (LCA). Specifically, the LCC method was applied to assess the stages of construction (greenhouse infrastructure and technical installations), operation (day-to-day activities) and end-of-life (waste disposal and decomposition) of the tomato crop. The life cycle database used was built using both primary and secondary data. The period analyzed corresponded to the 2018 crop year (January-July).

Results: The results are useful in the identification of both major costs and consequent decisions required to be taken in order to improve the economic viability of this production activity. Our findings indicate that labour was the most significant cost, representing 41% of the total cost. Greenhouse infrastructure (17%) and rainwater (9%) were the next most significant costs. According to these results, we conclude that tomato production in the studied i-RTG could be economically viable if the following recommendations are considered: (i) control of the labour cost by standardization of the time used for each cultivation task; and (ii) calculation of the appropriate cost of the basic infrastructure needed for an i-RTG. Finally, we arrive to the recommendation that a business model which implements complementary activities and services in order to increase economic profitability should be developed for the i-RTG.

SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 10:30 - 12:00 am

Sustainable retail in series– mainstreaming sustainable construction from a life cycle perspective using standardised semi-automated LCA and LCC tools in the integral planning process

Adolf Daniel Merl, Therese Daxner

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Daxner & Merl GmbH

Goal:

Being accountable for a material portion of global resource and energy demand, the construction industry represents a key player to face the challenges of sustainable development. Answering this challenge with an innovative approach, the Austrian food retail chain SPAR has emerged as a leader in sustainable construction. Its journey started with the analysis of material sustainability aspects of lighthouse projects. Throughout an integrated planning process using the German quality label for sustainable construction (DGNB) including referring benchmarks, experts tested and optimised these buildings against all dimensions of sustainability considering ecologic, economic, social, functional and process related quality. Based on these findings, a standard process was developed to enable serial certification and foster further innovation. More than 50 buildings have been finished; 25 are currently under construction and the process continues.

This abstract presents the use Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) in this process.

Methods:

LCA and LCC provided a sound fundament to analyse the buildings' economic and environmental performance and their mutual interactions as well as the influence on further sustainability criteria from a life cycle perspective. Its distinction with the German DGNB label including its benchmarks further proves the performance of these buildings. With the help of innovative methods and tools, a holistic optimisation process was created.

The core tools applied represents a semi-automated parametrised LCA building model, which allows a big variety of scenario analyses for different constructions and technical building equipment. In addition, the LCC tool based on the net present value method provides cost information.

Results:

LCA and LCC provided feedback in an iterative process within the planning team. Most considerable results include:

- As around 50 % of energy is used for cooling, the combination of a heat pump using waste heat and photovoltaic electricity reduces environmental impacts and costs.
- The change partially halogenated refrigerants to the refrigerant CO2 lead to a significant reduction of greenhouse gas emissions.
- Economically and ecologically sound connection of the energy system with neighbouring buildings.
- As around 30 % of energy is used for lighting, energy efficient lighting in combination with daylight and presence control is very effective.
- The combination of lightweight structures and massive components enabling passive measures support energy efficiency and future flexibility.
- The combination of the design and technical equipment is well coordinated.

Backed with findings and refinements, the project succeeded in the creation of an outstanding standard for sustainable construction. For instance CO2 emissions were more than halved. With this holistic performance specification in place, it went into series: Every newly built supermarket of the organisation now complies with highest sustainability standards. Thus, serial certification not only stands for efficiency in the integrated planning process but also represents a strong commitment to quality.

The systematic semi-automated approach allows fast and reliable calculation of LCA and LCC results which can be compared against benchmarks. Thus it provides vital feedback to planners in order to realise further improvements in construction and technical equipment.

SESSION T2-9 Sustainability in the Construction Sector

3rd September 2019, Tuesday 10:30 - 12:00 am

Establishment of circularity indicators for buildings based on Material Flow Analysis

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EVEA

GOAL:

Since 2017, EVEA and Cerqual have been working on the development of an evaluation method for the circular economy performance of construction projects.

Until now, France had no operational method for quantifying the impact of a construction project on the circular economy. FDESs (French equivalent of EPDs for construction products) and PEPs (EPDs specifically for electric and electronic equipment for buildings) are established according to the standard EN15804, and include useful data about the circular economy, (i.e. indicators and end-of-life scenarios); however, until now this information is little used in the Life Cycle Analysis of buildings. Currently building LCAs, which are established according to the standard EN15978 as well as the French regulation E+C-, do not currently allow for a detailed breakdown of results by stages of the lifecycle. Additionally, the French method of building LCA (E+C-) uses a calculation that implicates a limited number of environmental indicators and does not consider impact on the circular economy.

METHOD:

The MFA method, developed by EVEA and Cerqual, provides a visual representation of product and waste flows during the lifecycle of a building as well as making use of some of the lesser used indicators in the EPDs. It uses circularity indicators that consider the complete lifecycle of a building operation (construction, maintenance, and deconstruction). The calculated circularity indicators are as follows:

- Recycled materials (%)
- Reemployed/reused materials (%)
- Recycled waste (%)
- Reemployed/reused waste (%)

In addition to the above, a locality indicator (transport intensity) is calculated, which can be broken down into sub-indicators according to product origin and the product waste management plan. These indicators enable the LCA to take into account the impact of transportation associated with the recycling of waste as well as with product and equipment supply.

The method described in this report is supported by an MFA model constructed using Umberto software. The model shows product and equipment flows in all building work packages during a building's construction, maintenance and deconstruction. It can be used in the analysis of several types of construction projects (offices, collective or individual housing, etc.) including new projects and renovations.

RESULTS:

Two of the challenges we encountered during the method's development were ensuring its compatibility with the French building LCA regulation E+C-5 (perimeter, work packages, product information sources, etc.) and implementing a system that could automatically gather information and results from a building LCA to facilitate the implementation of an MFA study construction project managers. An MFA Umberto model using an automatic spreadsheet is used to pilot the MFA model. An automatic connection between this spreadsheet and the INIES database, which regroups PEPs and FDESs, has also been considered.

In order to reinforce the methodology's applicability and establish some of the first operational circular indicators, EVEA will collaborate with Alliance HQE-GBC in 2019 to carry out the HQE Test of Circular Economy Performance. The test will examine the efficiency of this methodology when applied to 30 construction projects in France.

SESSION T2-9 Sustainability in the Construction Sector

3rd September 2019, Tuesday 10:30 - 12:00 am

Is the building industry in Norway on track to meet the climate targets in the Paris agreement.

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Asplan Viak AS

Experiences from Powerhouse projects in Norway indicates that a definition based on primary energy as the primary design parameter can sub-optimize for global warming potential (GWP).

It is not possible to achieve a net zero or negative carbon balance for a building in the same way that it is possible to achieve at net negative primary energy balance. This is due to the assumed future carbon intensity of the electricity from the grid, which reaches zero about year 2055. This makes it impossible for most buildings to pay back the initial carbon debt from construction by offsetting future emissions through the export of energy.

In the study of recommending a strategy for defining a new Powerhouse definition which does not sub-optimize for GWP and will be relevant for more than 5 years, it is developed a framework to link how buildings in general in Norway are performing to the overarching climate goals from the Paris agreement and IPCC 1,5 degree reduction targets.

The future carbon budget for buildings is rapidly declining from 2020 to 2050. The study shows that the current building industry in Norway is on track to meet the IPCC 1,5 degree target, but from around the year of 2020 we need to design and build low carbon buildings to bee on track.

LCM 2019
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SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 10:30 - 12:00 am

An absolute environmental sustainability assessment method to calculate greenhouse gas emissions reduction targets for residential and commercial office buildings

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Massey University

Context: The New Zealand Green Building Council implements two voluntary building environmental rating tools: Homestar for residential buildings and Green Star for commercial buildings. Currently, only Green Star recognises the use of Life Cycle Assessment in the design process, in which the quantified whole-of-life environmental impacts (including climate change) of a building design are compared to a similar reference building. Points are then awarded based on the cumulative percentage improvement in environmental impacts between the designed and reference buildings. Although this approach underpins improvements, it does not convey whether the proposed design aligns with achieving the global goal of limiting global warming to below 2°C above the pre-industrial levels.

Goal(s): Develop an absolute environmental sustainability assessment (AESA) method to calculate greenhouse gas emissions reduction targets for any residential and commercial office building typology.

Method(s): The procedure consists of four steps: (i) calculating a global carbon budget that is sufficient to limit global warming to below 2°C; (ii) assigning a share of the global carbon budget to the New Zealand building sector and then to different building typologies; (iii) calculating the carbon footprints of those buildings; and (iv) benchmarking the carbon footprints against the carbon budget shares to calculate greenhouse gas emissions reduction targets. The proposed AESA method involves with some assumptions and value-based choices; the influence of these aspects was tested by applying the method in the New Zealand context for three residential building typologies: stand-alone housing, medium-density housing and apartment, and commercial office typologies, differentiated by gross floor area.

Results and discussion: The study showed that greenhouse gas emissions from the New Zealand residential and office buildings need to be reduced by at least 67% to operate within their shares of the global carbon budget. The emissions reduction targets derived from this research are aimed at helping designers and other interested stakeholders understand the natural limits within which their building must operate across their life cycle in order to contribute to New Zealand's net zero carbon future.

SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 10:30 - 12:00 am

Green Public Procurement in practice- Case Study of Visund

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1. Goal - The public sector is an important factor in creating innovative and environmental friendly solutions to the best for public and society. Only in Norway the public sector procure goods and services for over 500 billion NOK annually. In green public procurement (GPP), policy driven environmental requirements are introduced in the formal procurement process with the aim to reduce the environmental impact. In practice, the policy requirements often appear disconnected from the formal procurement process, thereby limiting the effect of GPP. This case investigates how GPP has been implemented in the procurement process of an innovative building project, and how regionalized life cycle management has been important for the outcome of the process. 2. Method - The case study consists of an innovate project, Visund, built for the Norwegian defence within the Haakonsvern Naval Base in Bergen. The building is built and operated by the Norwegian Defence Estates Agency (NDEA). It is presently one of the most energy efficient buildings operating in Norway, with an energy consumption equivalent to a normal residential house. This paper has analysed how the handling of context and process has affected the procurement outcome of the building project. A life cycle environmental and economic assessment has been used to evaluate specific key performance indicators during the building life cycle, including global warming potential (GWP), and equivalent annual cost (EAC). 3. Results - The clue to successful implementation of green policy requirements on energy in this case was a combination of clear and defined targets and requirements combined with extensive cooperation between actors. This combination of being specific, functional and cooperative at the same time resulted in an innovative – green – building solution and an efficient construction process. Opening up for interaction gave room for innovative solutions with high environmental standards from the supplier side. At the same time, being clear on following up targets and requirements from the buyer side enabled a “green push” from the developers to the market. The case also identified limitations in the current procurement practice. One important contextual limitation is the problem of proving economic benefits of innovative solutions. This may limit the innovative efforts, and instead cause a lean on regulative environmental regulations that will result in traditional and approved solutions. The results from this case showed, however, only minor differences in EAC between traditional and low GWP solutions. This points to the importance of including LCA alongside with economic criteria in the procurement process. Considering the findings of the paper, a stronger relationship between formal governance and policy requirements can make GPP more effective.

SESSION T3-1 Life Cycle Thinking from the Purchasing Organization's Point of View
3rd September 2019, Tuesday 10:30 - 12:00 am

The circular customer

Emma Rex, Maria Thomtén, Fredrik Norefjell, Staffan Appelgren, Nina Wolf, Natalie Hafdelin, Anna Bohlin

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RISE

GOAL

A shift to a more circular economy most often requires organizational innovation such as new business models and other kinds of relationships for manufacturers and retailers. However, to realize circular economy in practice, the demand side of the market must also have capacity, knowledge, organization and motivation that makes it possible to be a "circular customer". In this project, called "the circular customer", the role of public organizations as customers in the transition towards a more circular economy is investigated in relation to office and healthcare furniture.

METHODS

Based on the so called “Value Hill”-model, a framework for analysis is developed that takes a holistic approach to ownership in a circular economy: Instead of just focusing on the purchasing situation, the framework assist in assessing current and potential practices to keep the furniture in use as long as possible in all phases of ownership, from acquisition to maintenance and end of life. Data collection is made through case studies in Swedish regions and cities, using interviews and document studies. Based on the case studies made, current practices are described in relation to the three phases of ownership (acquisition, maintenance and end of life), and their interaction. Barriers and enablers for increased circularity are identified, including both informal and formal factors that can affect the ability to act as a circular customer.

RESULTS

In the analysis, similarities and differences in practices in the studied organizations are identified. In particular, different ways of organizing, e.g. centralized or decentralized ownership, is analyzed in terms of premises and incentives for circularity. Conclusions are made both in relation to what is specific for circularity in the furniture industry, (such as perceptions of second hand versus vintage), and in relation to findings more general to circular economy (such as the different logics around renting and self-maintenance). The presentation ends with a discussion on the role of public organizations as agents for change towards a more circular economy, and areas in need of further development. The latter include both technical and organizational needs, e.g. tools to assess life cycle cost and capacity building at different levels in the organization.

SESSION T3-1 Life Cycle Thinking from the Purchasing Organization's Point of View
3rd September 2019, Tuesday 10:30 - 12:00 am

LCA based methodology for environmental impact assessment of the organization's supply chain

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Organizations around the world can benefit from the use of life cycle assessment (LCA) to support their purchasing process. Therefore, streamlined LCA methods has emerged as an efficient way to evaluate environmental features of a product life cycle. As a result, the implementation of LCA is more efficient and straightforward, at a fraction of time, cost and resources.

The aim of this work is to describe the methods for the design and development of a software for the environmental evaluation of products, based on the composition of the products. This proposal aims to be a guide for any organization that wishes to use LCA in its procurement process. To exemplify the application of the methodology, a generic product, "plastic bags", is used, since is a product with whom many organizations can relate, because it can be acquired to accomplish numerous activities inside any organization. However, that does not mean that the methodology is limited to this item, in fact, if all the steps are followed, it could be applied to a variety of products in the supply chain of the organization.

The methodology proposed consists of three big stages. First stage comprises the clear definition of elements based on LCA methodology: (1) goal and scope definition, (2) system boundaries limitation, (3) functional unit and (4) impact categories and evaluation. The second stage consists on: (1) product classification, (2) description of the components of the products and (3) database construction. The third stage is oriented to the software development: (1) user interface design and (2) key algorithms for the generation of results. In the following lines, the study case is explained.

First, the goal was established as "to evaluate environmental impacts caused by the acquisition of 1 kg of plastic bags by an organization", setting cradle to gate as the system limit. The impacts were evaluated under ReCiPe v1.08 midpoint (H) method. Four impact categories were selected: climate change, terrestrial acidification, photochemical oxidant formation and freshwater eutrophication. Secondly, an exhaustive bibliographical review was performed to obtain the composition of the product. For the plastic bags three types of products were found: plastic bags with prodegradant additives, plastic bags without additives and biopolymers. Subsequently, each component was divided according to the role that plays in the product. For the component "plastic film" there are three types of polyethylene: high density, low density and low linear density while for the component called "additives" two main types exists: cobalt and manganese. Afterwards, each component was searched in the ecoinvent v.3.3 database and each dataset was associated with their respective impact factor. For those components that were not found in ecoinvent, a simple LCA was performed with the intention to obtain its characterization factors. Thirdly, the software was programmed, having a simple interface so anyone can interact easily with the tool. For the interpretation of results, a summary table and a normalized impact graph were used. Finally, both the software and the methodology were verified, and improvement points were identified and attended.

SESSION T3-1 Life Cycle Thinking from the Purchasing Organization's Point of View
3rd September 2019, Tuesday 10:30 - 12:00 am

Green Public Procurement in the Municipality of Porto, Portugal

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Green Public Procurement (GPP) is a tool which guidelines are being developed by the EU to be used by public bodies in order to reduce the environmental impacts of the purchases of goods and services. These guidelines include environmental criteria, which are suggested to be included by public bodies in the tendering documents used for acquisitions.

This is an innovation tool, which is quite unknown in Portugal when compared to other EU member states.

The main objective of this work is to evaluate the degree of implementation of green purchasing practices in the acquisitions made by the Porto´s Municipality (PM). The methodology used was the following: at first, the evaluation of the types of categories of products and services which acquisition had larger volume of purchases and costs is carried out for the reference year 2017.

For the analysis of the current practices within the PM's practices, the products/services categories purchased having the largest volume of purchases were selected. Results show that the purchases of 1) Cleaning, 2) Gardening together with the 3) Food/Catering Products and Services are the three most significant purchases for the municipality. Results show that out of the three the acquisition of Cleaning Products and Services, makes use of a larger set of environmental criteria in acquisitions, but nevertheless reduced when compared to the list of environmental criteria proposed by the EU GPP criteria. The analysis of purchases was made by reading the tender documents for the products/services above-mentioned to identify the incorporation of the green criteria within public purchases. Conclusions from this asks show that although the environmental concern at the municipality in the procurement actions is notorious, the way these requirements are included in the specifications cannot, in most cases, be translated into something concrete that allows an adequate response of the products/services supplier.

An informal consultation with the suppliers of catering services was also made to better understand the possibilities they have to supply greener products/services. Four out of nine suppliers interviewed responded to the call. The answers to the questionnaire allowed to perceive that there is a lack of knowledge on the provider´s side on what the green criteria are, as well as a lack of knowledge on how PM and food service suppliers may make use of the EU green criteria to lower the impact associated with the provision of catering services. This show the great potential for development of this innovative tool for public environmental policies.

SESSION T3-1 Life Cycle Thinking from the Purchasing Organization's Point of View
3rd September 2019, Tuesday 10:30 - 12:00 am

Eco-efficient Management, Collaboration and Positive Results: Organizational LCM combined with employee engagement program enhances performance results in the industry.

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Fundação Epaço ECO - BASF S.A.

Demarchi + Ecoeficiente, the pioneering initiative of BASF in the world, is being designed in the locality of São Paulo/BR. With a focus on continuous improvement and increasingly eco-efficient management, the study involves an organizational life cycle analysis that relies on a diagnosis of the environmental and economic impacts generated directly and indirectly on the production site over the years since 2010. The Analysis revealed, among other things, which raw materials are the most relevant in the categories of environmental impact and how is the behavior of these inputs over the years. In addition, one of the main activities was the practical definition of possible improvements and the simulation of scenarios that could estimate the overall benefits in the implementation of some specific projects of cleaner production and circular economy, helping in the decision process. Thus they were simulated from internal projects that were already discussed and were implemented, such as the reuse of the exhaust dust of a given production line - which addresses the reduction in the consumption of two of the raw materials identified as influential in the study, until new projects still under discussion with the areas of product development, such as the replacement of glycerin for the production of resins, obtaining a favorable economic impact besides contributing to a better environmental performance. All these initiatives have been encouraged by the company so that circular economy soutions can be developed, in sense of being able to manage the impacts in the chain and to elucidate strategic forms of reduction, reuse and recycling of the resources.

In order for the benefits to be broadened and the culture of excellence could be internalized, the employee engagement program was carried out. A material with factory-specific consumption information, LCM concepts and project connection to day-to-day has been applied by the leaders who have verticalized the knowledge for all employees. After that, there was a volunteer activity where the employees who were most successful in a Quiz were awarded. Almost ninety percent of employees participated and this action causes the owner's spirit of belonging and attitude.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Circular principles and environmental impact reductions: current knowledge and the way forward

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Despite the increasing worldwide attention and focus of policy-makers on circular economy to reduce the pressure on the environment, the knowledge around the necessary conditions and boundaries to make circular products and circular business models environmentally sustainable remain unclear. Several researchers have argued that the link between circular economy and environmental impact is not as straightforward as promoted and that various aspects of circular economy (e.g. reuse, remanufacturing, and product-service systems) can have positive or negative environmental effects depending on the cases studied and assumptions made.

This study assesses the aforementioned link with the help of a systematic literature review, which facilitated mapping of the studies focused on environmental performance of circular versus linear products and identification of good practices for LCAs on circular products and circular business models. Factors impacting the environmental performance of circular products and business models were identified and a categorization was made. Based on the list of factors, a framework and guidelines for future LCAs was created. This framework is in the process of being tested with the help of a dozen companies currently designing and implementing circular products and circular business models.

Even though 239 papers were identified that discuss the environmental impact of circular products and/or circular business models, the far majority actually only considers a traditional product in a traditional sales model that is remanufactured and compares the impacts of remanufacturing with manufacturing new products. While it is important to quantify the impacts of remanufacturing, it is remarkable that product design strategies for circular economy (e.g. design for remanufacturing, upgradeability, modularity) and product-service systems or other types of circular business models are usually not considered in the LCA studies. Also other aspects that are related to circular economy, like increased share of renewable energy, and its effect on the environmental impact of circular versus linear products is almost never addressed. The results show that there is an urgent need for more LCAs done in a way that better captures the potential benefits and deficiencies of circular products. This includes: widening system boundaries to include impacts from return and non-recoverable items, assessing uncertainty in consumer behavior and consumption such as rebound effects, and (since many assessments merely approach linear products that happen to be handled in a circular process, e.g. remanufacturing) finding ways to assess the impact of optimizing product design and business models for circular economy. Only then will it be possible to make robust claims about the environmental sustainability of circular products and circular business models and finally circular economy in total.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management
3rd September 2019, Tuesday 10:30 - 12:00 am

A proposal to include social aspects in cyclical approaches: towards sustainability in circular economy

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Goals: The concept of industrial ecology aims to transform industry into cyclical systems so that the waste of one process can be used as resource for another process. Within this field, circular economy has emerged as a set of exchange structures to advance to a more eco-efficient industrial system, by establishing networks of waste material and energy exchanges. Even though the area has attracted much academic attention and has been reported to lead to economic and environmental benefits, initially, most of the contributions focused on the engineering and technical feasibility of the exchanges, whereas social elements remained mostly unaddressed. The purpose of this work is to contribute to the scientific research on circular economy. First, based on literature review and following new consensuses on the circular economy, we defined the challenges and limitations of CE from the perspective of social sustainability. Second, we proposed and provide a set of social concerns that must be included when conducting research analysis of CE in order to make progress in sustainable development through the usage of cyclical approaches.

Methods: The research design relies on the cross-comparison of several cyclical approaches (circular economy, industrial ecology, industrial symbiosis, blue economy, cradle to grave, bio-economy) and sustainability concepts (literature review). From a methodological perspective, the research is be based on a design that combines qualitative methods, including grounded theory, ethnography, social networks analysis and quantitative approaches, such life cycle thinking. The main sources of data are a) in-depth search of databases, b) interviews carry out with relevant actors involved in the design, creation and operation of networks and b) company and policy documents. The analysis of the institutional framework is also involved in the review of the regulatory framework and the mapping of institutions and policy analysis. Finally, the third part of the methodology is an analytical framework proposing the challenges and suggestions that contributes to social dimension of sustainable development.

Results: The main findings suggest that circular cyclical approaches are superficial and unorganized. These approaches seem to be a collection of vague and separate ideas from several fields and scientific concepts. Based on a systematic literature review the main issues to be addressed in the social dimension of cyclical approaches are: new employments opportunities through new uses of the value embedded in resources, increased sense of community, cooperation and participation through the sharing economy and, user groups share the function and service of a physical product instead of individual owing and consuming the physical product. These approaches, in particular, circular economy is important for its power to attract both the business community and policy-making community to sustainability work, but it needs scientific research to secure that the actual environmental impacts of circular economy work toward sustainability. It is demonstrated that circular economy has a great inspirational strength and equipped with critical sustainability assessment it can be important for global net sustainability.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Metal and plastic recycling flows in a circular value chain

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RISE IVF

Goal:

The importance of the production phase in the value chain is essential in sustainable development and circular economy as it currently accounts for 33% of total global energy consumption and 38% of direct and indirect carbon dioxide emission. In addition, the production phase contributes to different environmental effects including increased (virgin) raw material and energy consumption, great industrial waste volumes, and airborne emissions. The automotive industry is of particular interest to study, due to the fact that it negatively contributes to the majority of environmental effects.

This paper aims to present and compare the current flows of metals and plastics in the automotive value chain by two criteria namely information flow and standards and regulations. This will help to improve the overall material efficiency and industrial waste management by pinpointing the gaps, similarities and differences of two material flows as well as extending the collaboration in recycling loops.

Methods:

This paper is mainly based on empirical study, although a limited literature review was carried out. With limited understanding and lack of empirical studies on characteristics of metal and plastic flows in automotive value chain, a case study methodology consists of real-time empirical data from different companies within the value chain was adopted to fulfil the research objective. The studied companies are all value chain actors within the automotive industry but in the two separated metal and plastic loops. Studied companies range from primary production of raw materials, product manufacturers, foundry and waste management entrepreneurs to recycling companies

Results:

According to our initial empirical study results and performed interviews, metal waste is segregated with a high degree and low level of errors while mostly the exact chemical composition of the metal scrap is known. For instance, steel is not mixed with non-ferrous metals like aluminium or copper to get the best recycling option. The demand for recycled metals is also relatively good and current standards are fine. However, there are still some improvement potentials in metal flow management such as better communication and information sharing among actors which could positively affect number of transportations and incoming material selection for better recycling options at the end-of-life. On the other hand, plastic waste has low level of segregation with high level of errors in segregation process. The chemical composition is usually not known either. As a result, the plastic waste needs to be regularly checked, which implies additional waste handling and administration. With such low level of separation (due to several reasons) and correlated low volumes, inefficient transportation, quality errors and contaminations of segregated plastics, technological issues, and top of all insufficient demand for recycled plastics and low price of virgin plastics, current business model for and recycling are not economically interesting for companies in the value chain. There is a rather great requirement for more standardized fractions, and legal requirement as well as an economic motivation

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management
3rd September 2019, Tuesday 10:30 - 12:00 am

LCA and circular systems: insights to orientate industry towards the most environmentally sustainable management of secondary materials

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Vertech Group

GOAL

The switch from a linear to a circular economy is ongoing and industry is increasingly integrating the concept of circularity in their activities. However, circular systems embed many types of loops, from short loops, such as reuse or remanufacturing, to long loops, such as complete recycling of the material. These loops can also be closed, when secondary materials enter the same product system, or open, when secondary materials enter a different product system. Short and closed loop are often seen as the most sustainable approach. Nevertheless, it is not always the case, and industry is missing guidance on the parameters which might impact the choice between the most sustainable loops.

In this context, the association SCORE LCA (a collaborative research organization dedicated to Life Cycle Assessment and environmental evaluation) launched a project, conducted by Vertech Group and CEA Liten, on the environmental evaluation of different types of loops. It aims at giving inputs to industry regarding the hierarchy of the most environmentally sustainable loops depending on the type of materials and the context of the circular systems.

METHODS

The study starts with the definition of the different types of loops. The terms short, long, closed and open loops are specified, as well as the type of circular systems they embed. Then, a literature review is conducted to identify studies comparing different types of loops based on Life Cycle Assessment (LCA). The literature review allows identifying the most active sectors in the evaluation of circular loops, as well as the most assessed loops. In each study, the most impacting parameters and the main conclusions are identified. Specifically, elements related to treatment massification, waste characteristics and the usability of the secondary material are looked at. Finally, the LCA of three circular loops for magnets at their end-of-life (lifetime extension through cleaning and reshaping; production of new magnets through grinding and melting; production of rare earths elements through chemical treatment) is conducted. A sensitivity analysis is performed in order to identify the parameters impacting the most the choice of the loop.

RESULTS

This study provides insights on the most active sectors in the comparison of circular loops, as well as on the most compared types of loops found in literature. The trend regarding the life cycle parameters impacting the most the choice of loop is presented. Knowledge gaps limiting this choice are also discussed. The results of the LCA of the three loops for magnets management are presented, with a specific attention to the impact of the methodological approach and key parameters on the conclusions. Based on the outputs of the literature review and the case study, recommendations are provided to help industry orientate its choice, keeping in mind that a full LCA is necessary to confirm the choice towards the most sustainable secondary material circular management.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Modeling materials recycling

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Chalmers Univetsity of Technology

Goal: The method for modeling material recycling can have a decisive impact on the environmental assessment of products if they have a high content of recycled material or if they are recycled after use. How recycling should be modeled in LCA has been discussed since the early 90's but no consensus has yet been reached. The recent EU guideline on Product Environmental Footprint includes a rather complex approach. In response to this, the Swedish Life Cycle Center gathered Swedish companies, researchers and authorities in a project aiming to collect and disseminate knowledge on existing approaches to allocation at open-loop recycling, to systematically assess these methods, test important and promising methods in case studies, and to investigate to what extent a consensus can be reached among the Swedish actors regarding how recycling should be modelled in an LCA.

Method: Information on existing approaches to open-loop recycling is collected through a literature survey. The criteria used for assessing the methods are established as part of the project through an assessment and possible revision of an earlier set of criteria. These were based on the assumption that methods for environmental systems analysis are good to the extent that they can be assumed to contribute to reduced environmental impacts or, at least, to reduced environmental impacts per functional unit. For this purpose the methods has to be applicable and preferably easy to apply. The results should indicate what options reduce the total environmental impact, preferably with high accuracy. The method and the results should be possible to understand and preferably easy to communicate. The results should be perceived as relevant by decision-makers, and the method should be robust enough not to lend itself to creating obstacles to environmentally good actions.

Results: In this conference, we will present the results from the first part of the project with a focus on the systematic assessment of the open-loop approaches and the final criteria used for this assessment.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Current discussions about the relationship among LCA and circular economy

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Ecomatters BV

Currently there is a clear trend to work towards a circular economy. The European Union developed the Circular Economy Action plan with targets in 2020 and 2030, in order to accelerate the transition towards a circular economy and therefore enhance sustainable development growth. This plan focuses on five sectors: plastics, food waste, critical raw materials, construction and demolition, biomass and bio-based materials. The Netherlands itself has the target by 2050 to develop a full circular economy mostly focused on the raw materials area. This type of policy and legislation and the growing enthusiasm and awareness of consumers towards sustainability has led industries towards the implementation of circular principles and therefore provide circular products into the market.

As sustainability professionals ourselves we have witness the circular economy implementation eagerness from different organisations throughout discussions with them regarding circularity of products. During these discussions it has come to our attention, the criticism that exists towards LCA. In general, the use of LCA assessing environmental benefits is not a core part of the circular economy thinking. Therefore, it is sometimes perceived as a method with little connection with circular economy. We have also identified a mismatch in expectations on the role of LCA in supporting products circularity, which evidences the present disconnection between circular economy and life cycle assessment. We, as part of the LCA community are convinced that LCA and Circular economy should work hand-in-hand and different perceptions and opinions should be heard in order to make real progress.

From the discussions we have identified what are the most recurrent issues that lead to the disparity among LCA and circular economy and will demonstrate them by presenting 2-3 case studies in which this situation is evidenced. The identification of these issues serves as results that highlight which are the elements in which the LCA community and Circular Economy community have to collaborate in order to bridge the gap between LCA and circular economy.

We consider that this can serve as a starting point to the discussion about what LCA practitioners can do in order to better connect with the circular economy movement and overcome current barriers and misconceptions and bring more value to the circular economy movement. Therefore, this work aims at presenting the evidence of a disparity among LCA and Circular Economy that LCA practitioners as ourselves has gathered from discussions with different parties in order to be able to make a strategy in the future about how to overcome them.

Max Sonnen from Ecomatters, the presenter of this session, has been working for over 10 years on Life Cycle Assessment, PEF projects, monetization methods and circular economy. Ecomatters has supported companies in different industries, by conducting LCA as well as supporting them with sustainability strategies.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Integration of Leakage Rates into the Life Cycle Management of Products involving Plastic as a Material Choice

Takunda Yeukai Chitaka, Harro von Blottnitz

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The accumulation of plastic waste in the natural environment has been a major environmental concern for many decades. The new global agenda to address the increasing accumulation of plastic in the marine environment has resulted in key decision-makers being faced with the challenge of how to develop strategies to address this issue without foregoing the quantifiable environmental benefits associated with plastic in the bulk of its applications. Any life cycle impact assessment method needs product-specific inventory information on fractional release into the natural environment. This presents a critical challenge for the life cycle management of products destined for regions where they are likely to be dumped or littered.

Despite plastic leakage being acknowledged as a global concern there is limited quantitative data on the leakage propensities and rates of different products, particularly in developing countries which are often characterised by inadequate solid waste management practices. Beach accumulation surveys are often used to estimate plastic flows into the marine environment. The determination of leakage rates through the use of beach surveys coupled with product consumption or sales data, would allow a more accurate depiction of the fate of plastic materials at end-of-life. Thus, specific knowledge on leakage rates may play an integral role in the life cycle management of products which include plastic as a material choice.

In our work, situated within a South African context, we show that there exist vastly different marine leakage rates for different types of products involving plastic as a material choice. Plastic products associated with food consumed on-the-go are highly prone to leakage into the marine environment. This work also investigates current approaches to plastic pollution mitigation by key industry stakeholders, including brand-owners and retailers, as well as the potential influence of providing product-specific leakage rates on the life cycle management of plastic products. In particular, we explore whether a realistic understanding of product-specific leakage propensity may facilitate the development of effective interventions to mitigate the growing problem of plastic marine pollution.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Presenting the Plastic Leak Project: A pre-competitive initiative to harmonize plastic metrics

Laura Peano, Alexi Ernstoff, Carole Dubois, Melissa Zgola, Sébastien Humbert, Marcial Vargas-Gonzalez, Julien Boucher

Corresponding author: Marcial Vargas

Quantis

Goal

The goal of the Plastic Leak Project (PLP) is to develop robust methodological guidelines covering entire value chains. This will enable identifying the scale of losses and major drivers thereof. PLP's contribution is to develop metrics and methodology to forecast and map where leaks occur for products, companies, and countries as well as the magnitude of macro- and microplastic leaks. The project aims at identifying the drivers of leaks (e.g. mismanagement of wastes or tire wear on roads) and key areas of interventions to most effectively and efficiently curb the plastic leak.

The project is split into a strategic committee (e.g. Quantis, EA, IUCN, WBCSD, UNEP), an advisory board (e.g. MIT, SYSTEMIQ, FSLCI, CIRAIG, Ellen MacArthur Foundation, European Joint Research Centre) and industrial partners (e.g. Adidas, Arla, Dectahlon, Dow, European Bioplastics Association, Sympatex, Cyclos, PlasticsEurope, Cotton Inc., Mars). There are three different workstreams of the project that will be fulfilled in 2019 beginning with the development of global methodological guidelines as well as sectoral guidance with a set of related data.

Method

The global methodological guidelines defines general rules about quantifying and including plastic leakage in Life Cycle Assessments. This document will include guidance on the choice of functional units, inventory of the potential sources of leakage along the key industries considered, default loss rates for the different sources as well as release rates for a set of pathways (e.g. mismanaged waste, littering, road run-off, waste water treatment plant etc.), link of meta-data required to make the calculations and key sources of data for different regional archetypes. Finally, there is a need to map the typical supply chain to identify potentially hidden plastic leaks that aren't commonly known (e.g. plastic waste occurring at production sites), thus allowing for the approach to encompass also the indirect components of the footprint. This will be based on a comprehensive compilation of available literature. Based on these global methodological guidelines, sectoral guidance for some specific sectors (e.g. apparel, tyres, packaging) will be developed.

Results

The result of PLP will be to present global methodological guidelines to assess plastic leakage in Life Cycle Assessment as well as data and publish them as an openly available reference. Two pilot tests will be conducted, based on companies selected among the project members, from different sectors. The outcome of this pilot phase will be essential to test the guidance, and present results (Figure 1). The identification of possible solutions to plastic leakages require a proper understanding of the leakage sources and pathways and will enable identification of hotspots and key area interventions to close the plastic tap.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Management options for floating marine plastic debris in coastal waters

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Worldwide more than 300 million tons of plastics are produced every year, from which 4.8 to 12.7 million tons are estimated to end up as marine plastic debris in the world's oceans. One of the main reasons identified for the abundance of plastic litter in oceans is the mismanagement of waste in coastal areas. This phenomenon is observed in developing countries, where limited waste management is practiced, as well as in other regions of the world such as in the North Sea where plastic debris is now a growing concern.

Goal

The aim of this paper is to evaluate the environmental impacts of the collection and valorization of marine plastics. Despite the increasing number of publications focusing on the management of marine plastic debris, research is carried out using an upstream perspective, focused on sources and pathways of accumulating marine litter, as well as actions to prevent plastics from entering the environment. Studies describe collection methods and quantities of plastic litter that could be recovered from the marine environment during collection activities. However, only a few publications address the destinations of the collected marine plastic waste as regards possible valorization apart from the disposal in landfills or treatment in incineration plants, exploiting the unique characteristics of such material. A distinct review on methods that are available downstream for the management of marine plastic debris is missing so far. Even though several studies offer an important overview on existing technologies, process related data of established and currently developed technologies is limited, likewise their evaluation. Furthermore, the studies available do not adequately consider the differences between marine and other plastic waste regarding mechanical and chemical properties.

Method

In this work, the findings of an extensive literature review on existing state-of-the-art technologies for the collection and treatment of marine litter are coupled with process related data of a real-world case. Thereby, a complete management scheme is developed including the collection as well as the recycling of floating plastic debris in the North Sea. For the collection, an innovative approach is proposed that uses the principle of reverse sedimentation to concentrate the plastic litter on the sea surface. The collected material is then treated in a dedicated recycling plant. Consequently, a Life Cycle Assessment of the developed process scheme is performed.

Results

The highest contributions to global warming potential (GWP) and marine aquatic eco-toxicity potential are mainly from recycling processes at the plant while the transport of the marine waste from the collection point to the recycling plant has a minor contribution. However, most of the impacts can be related to the electricity consumption of the plant, where the extrusion stage is accountable for around 50% of the total impact of both categories, followed by the cleaning process and pre-treatment of 30% and10% respectively. Besides the environmental benefit of removing the hazardous plastic debris from the marine environment, results indicate that the valorization of one tonne of collected plastic debris saves around 1.1 tCO_2eq.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
3rd September 2019, Tuesday 10:30 - 12:00 am

Sustainable packaging in food products: What Latin American Millennials really want

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Iberoamerican Life Cycle Network / World Resources Forum Association

GOAL. This presentation aims to present market research results in Latin America of different packaging options for the food product, granola from the Peruvian company Union as part of the Better By Design project (//www.oneplanetnetwork.org/initiative/better-design-replicating-promising-practices-tools-and-methodologies-support-and-enable). This presentation also aims to provide an outlook on emerging sustainable packaging initiatives in Latin America.

BACKGROUND: Food production and consumption have the most significant influence on land and water use, overexploitation of fisheries and pollution with nitrogen and phosphorus and generation of waste packaging. More than 60% of global GHG emissions and 90% of water footprint are generated by the agri-food sector including livestock and packaging with most negative impacts in less developed countries (such as in Latin America) with weak waste management infra-structures (UNEP 2010).

On the other hand, 80% of the environmental impacts of products and services are determined in the early stages of design which represents an opportunity often disregarded.

Plastic is the most used food packaging material and its impacts have been neglected. 40% of about 300 Mio tonnes of plastic produced annually worldwide is single-use plastic from food products. About 75% of world plastics production becomes waste, out of which only 9% is recycled and channelled back to the circular economy and 12% is incinerated to recover energy (Geyer et al., 2017). The rest is disposed of or dumped on the land and in marine environments.

In Latin America, legislations urging plastics packaging reduction are emerging. These were issued in Argentina, Chile, Panama, Peru and Uruguay in 2018, as well as in Colombia in 2017. Following the growing pressure from legislations, businesses are starting to look for and develop options to reduce the distribution of plastic packaging or replace them for more sustainable options.

METHODS. The Better-by-Design project aimed to first define the hotspots in the value chains of selected product lines (granola in Peru, cleaner in Honduras and meat products in Nicaragua) based on a life cycle approach and using life cycle data. In addition, compliance of the product communication on-pack was assessed with the UN Guidelines for Providing Consumer Information (2017). Following on these results strategies for improvement were developed on eco-design and sustainable marketing, and the implementation of improvements also on the packaging. Technical assistance from LCA experts and providers of sustainable packaging was offered during the implementation.

The project was implemented in 2017 - 2018 and was carried out with the support of the Secretariat of the Ten-Year Framework of Programs on Sustainable Consumption and Production (10 YFP) based in UNEP, through the Sustainable Lifestyles Program and Education of 10 YFP and with economic support from the Government of Japan.

RESULTS. Main results on the preference for packaging options. It was found that consumers, especially millennials and groups below 30 years old, are increasingly demanding for more sustainable products and packaging and are willing to pay 10% to 30% more for these options. Under the scope of this project, sustainable packaging includes at-home and industrially compostable biodegradable packaging according to the EN 13432.

SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM
3rd September 2019, Tuesday 10:30 - 12:00 am

Contributing to the sustainable innovation of chemicals and materials by applying life cycle assessment to public research on emerging technologies

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Using life cycle approches for the sustainable innovation of chemicals and materials is still a quite new way of doing public research in major academic sub-disciplines of Chemistry (Organic Chemistry, Molecular Sciences, Polymer Chemistry, Solid Chemistry and Materials) and Materials Science. The presentation aims at showing by a number of case studies developed at the University of Bordeaux the complementarity of LCA with the Green Chemistry Principles and recent advances that make it possible to inform and make fact-based sustainability choices and optimise, in a holistic and quantitative approach, the most promising solutions to innovate chemicals and materials in a life cycle perspective.

The methods used include LCA, and other life cycle approaches such as material flow analysis, as well as the integration with environmental risk assessment and criticality assessment. The methodological challenges include how to use LCA for emerging technologies, how to assess the toxicity of unknown substances and how to provide a common assessment framework for including the criticality of raw materials. Examples stem from the choice of chemical solvents and raw materials as well as the development of organic electronics and the recycling of composites.

The results of the different case studies underline that Life Cycle (Sustainability) Assessment provides adequate means to measure progress for sustainable chemicals and materials development. Key sustainability challenges addressed include sourcing of raw materials, efficient manufacturing and design for recycling as well as assessing the carbon and environmental footprints, including certain toxicity aspects of engineered nanomaterials. Overall, the case studies provide a clear recommendation to use LCA jointly with Green Chemistry Principles for sustainable innovation of chemicals and materials in the context of emerging technologies. The indicators used, which partially have been developed as part of the research effort, allow to guide sustainable innovation, to communicate on the improvements made and to be transparent on the trade-offs that have to be taken into account. These efforts are part of mainstreaming LCM in the public sector. Due the focus on innovation priorites of the New Aquitaine region in France they also foster sustainable regional development.

Currently the work is focused on the environmental, human health and natural resource aspects of sustainability. Therefore, in the future a stronger consideration of economic and social aspects is foreseen by using Life Cycle Costing and contributing to the development of social LCA in order move to the use of a comprehensive Life Cycle Sustainability Assessment for the sustainable innovation of chemicals and materials.

SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM
3rd September 2019, Tuesday 10:30 - 12:00 am

Moving towards a bio-based wood painting sector: preliminary insights from the LIFE-BIOPAINT project

Francesca Recanati, Andreas Ciroth, Guido Sangiovanni, Marcello Vitale,

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GreenDelta GmbH

GOAL: The European paint and coating sector still mostly requires petrochemical derivatives as raw materials, is responsible for up to 50% of total EU NMVOC emissions, produces hazardous waste, and its workers come in contact with harmful chemicals. LIFE-BIOPAINT is an EU-funded project aiming at improving the production processes as well as the entire supply chain of the coating sector through novel, UV curing Bio Based Paints. The new products are being developed by IVM Chemicals, a major actor in the market of wood paintings and coatings.

Starting from the introduction of bio-based components as substitutes of petrochemicals, the design of new products and related production processes aims to improve the environmental performance of wood paintings by reducing energy consumption, waste production, and GHG emissions, as well as minimizing the human-health related risks by eliminating emissions of VOCs. Additionally, the substitution of traditional petroleum derivatives with bio-based resins obtained from bio-waste constitutes a real implementation of both the bio-economy and the circular economy frameworks. The EU-funded Life project “Life Biopaint” is investigating whether indeed the replacement of fossil resources is beneficial for the environment, the economy and also for social conditions, on site and over the supply chain.

METHOD: To this end, environmental Life Cycle Assessment (LCA) is integrated with Life Cycle Costing and Social LCA. Additionally, to assess the specific working environment and environmental conditions of the production site, elements from the environmental impact analysis are performed at one specific production site. These latter evaluations focus on emissions occurring during the production process like VOCs, and on the impacts on local environment, such as the nearby agricultural fields, water bodies, aquifer, and urban centers.

RESULTS: The first phase of the project regards the development of a qualitative screening diagram of the system under study, the LCI models of the different baseline scenarios (i.e., different existing products, processes and production plants), and the related data collection. Initial challenges regard the modeling and data collection for competing, fossil-based paint ingredients, modeling for the bio-based components, considering less mature production processes with differing, smaller scale compared to traditional, fossil-based production, and more versatile supply chains for bio-based materials.

The presentation will address these challenges and propose and explain solutions for overcoming them in the current project.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
3rd September 2019, Tuesday 10:30 - 12:00 am

Integration of market-related and environmental aspects into technical-driven R&D via the concept of sustainable innovation readiness level – The case of lignin-based resins

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The transition from a fossil-driven economy towards the emerging bioeconomy both requires and fosters interdisciplinary research and development (R&D) activities. The concept of Sustainable Innovation Readiness Level (SIRL) emphasis this transformation by fostering the integration of economic and environmental considerations into the technical-driven R&D activities. The SIRL as a new approach builds upon the well-known technology readiness level (TRL), focusing on the stages ‘research’ to ‘market introduction’. Because R&D activities in the emerging bio-economy are characterized by strong interdisciplinary and cross-sectoral characteristics, the SIRL provides a common knowledge platform for understanding the economic and environmental maturity of bio-based innovations, in line with the technological maturity. The goal of this study is the identification of sustainability and market levers for lignin-based resins at early stages to support the R&D progress. Sustainability levers are linked to any potential activities to improve the environmental impacts of the considered processes and products. Market levers are linked to any potential activities to improve stakeholder integration and thus supporting the aim to bridge the valley of death from research to market. Identifying those levers helps to support the R&D process towards successful and sustainable products.

A market-oriented approach in R&D projects goes beyond traditional research boundaries, looking more comprehensively at the full life cycle of newly developed products and thus has a special focus on environmental relevant issues. It helps to validate the opportunities for new products and provides an important guide towards sustainable and successful products. In terms of lignin-based resins, an Importance-Performance-Analysis (IPA) was carried out to provide information about potential market-related barriers and incentives through identifying so-called diffusion gaps along the value chain. Following a multi-actor approach, it was additionally possible to indicate potential knowledge and perception gaps between the stakeholders. Experts from industry and research evaluated 53 aspects influencing the implementation of lignin-based resins for wood-based panels. On the other hand environmental assessment at early research stages is often challenged by low data availability, high uncertainties and continuous project progress. In this study, a so-called environmental hotspots analysis as streamlining approach of Life Cycle Assessment (LCA) was carried out for two newly developed valorisation pathways for lignin. As a two-step approach, first of all, the environmental hotspots, such as energy or resource intensive process steps, were identified. Secondly, a variation analysis was carried out, which involves the identification of sustainability levers (e.g. selection of solvents, inputs, energy sources etc.). In conclusion, it was possible to show the strong interlinkages between market and environmental aspects of product development. Especially in the context of the emerging knowledge-based bioeconomy an awareness of these aspects, such as specific technical aspects (e.g. solubility), market-related aspect (e.g. availability) and environmental aspect (e.g. energy use) help to steer the strategic orientation towards achieving sustainability goals. It is thus of utmost importance to accompany R&D processes with sustainability and market assessment to systematically enhance environmental performance in line with the technical performance of the developed bio-based products.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 10:30 - 12:00 am

Evaluation of the principles used in SotA LCA of HTL Liquid Biofuel Production

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Aalborg University

Goal:

This paper investigates the diversity of LCA's of the HTL-technology (HydroThermal Liquefaction conversion technology) for the conversion of of biomass to LBF (Liquid BioFuel), focus is on the evaluation and discussion of the variety of approaches to taking into account key aspects including iLUC (indirect land-use-change), use of marginal or average technologies and supplies, scenario development for supply situations, and system-dependency on assessment internal assumptions. The paper aims at providing insight into the comparability between contemporary assessments and to forward recommendations on improving best practice.

Methods:

The core of the paper is a literature review of LCA's published in recognised journals. The output of the review is an overview of core assumptions regarding iLUC, functional units, feedstock scenarios, system-modelling principles. The review results in a characterisation of a limited number of generic approaches. These generic approaches is used to model the performance of three simple standardised scenarios.

Results:

The paper gives an insight to the consequences of modelling approaches applied in contemporary LCA's of HTL conversion of biomass to LBF. The results creates a starting point for discussing recommendations for the improvement of a common platform for assessing the lifecycle performance of bio conversion technologies, including HTL.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 10:30 - 12:00 am

Life Cycle Inventory of a pre-commercial demo plant using an innovative technology for the production of Sustainable Aviation Fuel (SAF) from flexible waste biomass

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Goal:

H2020 flexJET project (grant agreement no. 792216) consortium is building a pre-commercial plant for the production of advanced jet biofuel from waste vegetable oil and food waste, demonstrating the integrated SABR-TCR technology (traditional transesterification (TRANS) and Thermo-Catalytic Reforming (TCR) combined with hydrogen separation through pressure swing adsorption (PSA), hydro-deoxygenation (HDO) and hydro-cracking/isomerisation (HC)) to produce a fully equivalent SAF compliant with ASTM D7566 standard. Environmental impacts and benefits will be mapped through a Life Cycle Assessment (LCA), the first steps of which are within the scope of this study. Our purpose is to select the best suited LCA approach, to define the goal and scope of the analysis, to map and quantify all inputs and outputs from the SABR-TCR technology in the Life Cycle Inventory (LCI) phase and to identify alternative scenarios for results comparison.

Methods:

A literature review applied to biorefineries, to SABR-TCR system and its main products and co-products (including FAME and jet fuel), and to current uses of the feedstocks (waste vegetable oil and food waste, along with other organic feedstocks) was performed in order to map the state-of-the-art LCA approaches followed to define system boundaries, system functions, functional units, reference flows, data collection, allocation rules and other relevant aspects related to LCA methodology application within the specific sector. Building on this review, the scope of our analysis, in particular the system boundaries and functional unit of the SABR-TCR system developed within flexJET project, were determined. Furthermore, in order to compare the system's environmental performances with those of different ways to produce jet fuel and to valorise feedstocks, alternative scenarios were identified based on current conventional jet fuel production and the most significant fates of the feedstocks. As for the LCI phase, data will be collected from the integrated SABR-TCR plant design and will be used to quantify all relevant energy and material inputs and outputs and to create an inventory referred to the functional unit. The alternative scenarios inventories will also be generated. The collection of data will include a detailed process description, input and output flows and available characteristics of the products and co-products. The integrated SABR-TCR system generates multiple co-products, some of which are recycled as an energy source back into the plant, while others are used for other applications. Thus, appropriate data allocation procedures will also be adopted at this stage.

Results:

The input/output tables which will characterise each process included in the system boundaries will be used for LCA modelling by means of GaBi software and the GaBi Professional and Ecoinvent databases. The model will be structured on several levels, of which "Integrated SABR-TCR System" will be the main one and will contain the following sub-plans: "Feedstocks pre-treatment"; "Transesterification"; "Thermo-Catalytic Reforming"; "Pressure Swing Adsorption"; "Hydro-Deoxygenation"; "Hydro-Cracking & Isomerisation"; "Combined Heat & Power generation"; "Char management".

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels

3rd September 2019, Tuesday 10:30 - 12:00 am

Extending LCA methodology for assessing liquid biofuels by phosphate resource depletion and attributive land use / land use change

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Goal

Many pathways towards reaching decarbonisation goals build on a substantially increased production of bio-based products and energy carriers including liquid fuels. It is well known that land and phosphorous availability limit the potential of biomass production and use. However, it is challenging to adequately capture these limitations using standard LCI and LCIA methods. We propose new approaches to overcome these limitations.

Methods

A central limitation of land use (LU) for non-food purposes is the pressure it creates to convert natural land to agricultural land. It is however not easy to allocate shares of progressing land use change (LUC) to the use of a hectare of land or the bio-based products or energy carriers produced on it, respectively. Addressing LUC effects in LCA based on direct land use change (dLUC) is problematic because this requires deciding for an amortisation period and e.g. biofuels marketed in Europe usually stem from land that has been agricultural land for longer than commonly used amortisation periods while still exerting pressure on land markets. Models for indirect land use change (iLUC) on the other hand require numerous scenario settings and create substantial uncertainty. Moreover, iLUC is not appropriate for attributional LCAs.

Our approach termed attributive land use and land use change (aLU/aLUC) in essence evenly attributes land use change and related burdens occurring in one country as central political unit to the use of crop land in that country. This eliminates sources of uncertainty in LCAs involving land use.

A further limitation of a future bio-based economy will be the availability of exploitable phosphorous resources. In contrast to many other non-renewable resources, phosphorous cannot be replaced in its main application as fertiliser by other chemical elements and this application is not only indispensable for certain technological products but for feeding mankind. Thus, depletion timeline estimates for phosphate rock of 30 to 300 years[ref] create an urgent need for action. We present a life cycle impact assessment model and indicator “cumulated resource demand phosphate rock” to support the analysis and implementation of phosphorous recycling and efficiency measures. We propose to add it as a separate resource demand indicator without aggregation with other non-renewable resources at least in all LCAs involving biomass use.

Results

We are currently applying the methods aLU/aLUC and cumulated resource demand phosphate rock in several LCAs on food, feed, bio-based materials, biofuels and bioenergy in several projects including some funded by the Horizon 2020 programme. The presentation will describe the used approach and present exemplary insights gained by the successful application of these methods supporting their usefulness. Furthermore, the latest version of background data needed for the application will be presented.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 10:30 - 12:00 am

Holistic ecological evaluation of a fully integrated HTL-based fuel production chain

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Goals:

Hydrothermal liquefaction (HTL) is a promising technology for direct conversion of wet biomass into renewable fuels, offering the potential for cost-efficient production and low specific GHG emissions. The major advantage of HTL compared to other thermochemical processes for renewable fuel production is that essentially any kind of biogenic material can be processed without prior drying. Besides lignocellulosic materials, e.g. from dedicated energy crops such as miscanthus, but also "problematic"

waste streams, e.g. sewage sludge or manures are considered as feedstock.

For a favorable lifecycle balance of HTL-based fuel production, it is important to not only focus on the primary conversion pathway alone, but also on the upstream provision of biomass and the valorization of residual process streams. The EU-H2020 project HyFlexFuel [1] is dedicated to the development of an HTL-based production chain including feedstock supply, bio crude production and upgrading, wastewater treatment and recovery of nutrients, e.g. phosphorus and nitrogen. A particular challenge of the LCA is the need to consider very different feedstock materials, namely microalgae and land-based energy crops, but also wastes such as sewage sludge and manures. The ecological performance potential of fuel production from these different feedstock have to be compared on a common basis. A central task of the LCA work in HyFlexFuel is to develop a methodological framework for this comparative ecological assessment. Another challenge is associated with the accounting of non-energetic byproducts, such as fertilizers from recovered nutrients.

Methods:

Several studies have already been carried out on the accounting of GHG emissions from feedstock provision of cultivation biomass and waste streams [2]. In addition, there are publications which state how by-products e. g. produced fertilizer, can be assessed in terms of their CO2 emissions [3]. In the present study, established methods will be applied, modified and combined for the coherent comparative assessment of the environmental performance potential of an entire HTL-based value chain applying very different feedstocks, including energy crops and waste streams.

Results:

GHG emissions attributed to biomass from cultivated energy crops taking LUC into account, are mainly caused by the use of fertilizers, land management and harvest. The carbon stored in the biomass is calculated in form of GHG credits. When utilizing wastes or residues, GHG emissions are released during collection and processing of the feedstock. Additionally depending on whether the waste stream would have had a different use in the reference case or whether it would have been disposed of, emissions are accounted respectively positively as avoided burdens or negatively by the use of substitute materials.

It has to be discussed whether the struvite fertilizer (MgNH4PO4) produced as byproduct in the HyFlexFuel process can be assigned negative emissions, since it replaces otherwise required artificial and fossil fertilizers.

By considering the entire process chain, including biomass production, the fuel production process and finally the use phase, a suitable basis is provided that enables the comparison the produced fuels with competing process pathways and conventional fuels.

References

[1] www.hyflexfuel.eu; This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 764734

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SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 10:30 - 12:00 am

Socioeconomic impact assessment in Circular Economy schemes: case study of cork waste management by means of gasification technology

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GOAL

More often, methodologies to assess socioeconomic impact are focused on determining just a few indicators instead impacts, which do not use to cover the whole spectrum of socioeconomic insights. In this sense, the hybrid fulfilment-importance matrix emerges with the aim to solve these limitations and to calculate the socioeconomic impacts of a new process, service or project.

METHODOLOGY

This methodology relies on the holistic approach offered by the LCA, LCC and sLCA methodologies, and is based on concordance between indicators and impacts, which is quantified. In this way, it allows calculating in which degree the objectives have been achieved, and how the impacts and indicators affect the system under evaluation. This fact gives high degree of transparency and easy reproducibility, coupled to the possibility of hotspot identification. Furthermore, one of the main strong points is its integrated approach, which allows considering the impacts of the process, service or project during different dimensions of the project. In addition, and based in the life cycle perspective, hybrid fulfilment-importance matrix allows benchmarking the project performance and score against current and baseline situations.

The indicators, placed in rows, are organized in technical, environmental, economic, and social indicators. On its behalf, columns hold the foreseen impacts. These impacts also consider environmental, technical, economic and social insights. For each indicator and impact match, an importance value is given through a value between 0 and 3, based on expert judgement. Coupled to that, an achievement factor is given based on the performance achieved in the project; if the objectives have been fulfilled, a positive factor is applied. If the objectives are not achieved, the value is below zero.

The methodology has been applied in the frame of LIFE + ECORKWASTE project. Its main aim was to develop a gasification technology able to obtain energy from cork gasification, and avoiding cork landfilling. Hence, the above explained matrix has been built with the aim of determining the socioeconomic impacts of the project. For that, data coming from technical activities developed during the project had been assessed with the objective to determine the effect into the society and communities.

RESULTS

The obtained results demonstrate tangible benefits of the technology to society; impacts with special significance are cork valorisation increase, reduction of cork waste dumped in landfill, and competitiveness increase of cork sector and cork industries. Both technical and economic dimensions are those with more prominence when indicators are analysed. In conclusion, the socioeconomic benefits of ECORKWASTE gasification scheme are mainly obtained from the reduction of landfill practices, the production of clean energy, re-utilisation of by-products, improvement of knowledge, and investment in human capital. These conclusions remark the main objectives of the project, and allow quantifying the socioeconomic benefits from the process itself, potential service to be exploited or project implementation in companies interested. Hence, the hybrid importance-fulfilment matrix has been proven to socioeconomically asses the LIFE+ ECORKWASTE project in a quantitative, measurable and reproducible way.

LCM 2019
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SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 10:30 - 12:00 am

Life Cycle Assessment of TCR-PSA-HDO integrated system to produce biofuels from sewage sludge

Filippo Baioli, Diego Marazza, Andrea Contin, Luciano Vogli, Roberto Porcelli, Serena Righi

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Introduction

TO-SYN-FUEL - The Demonstration of Waste Biomass to Synthetic Fuels and Green Hydrogen project (grant agreement no. 745749) is a H2020 project that runs from 2017 to 2021. It aims to validate the conversion of sewage sludge into biofuels, building a pre-commercial plant with a nominal dry feedstock capacity of 500 kg/h. The project implements a new integrated process combining Thermo-Catalytic Reforming (TCR©), with hydrogen separation through pressure swing adsorption (PSA), and hydrodeoxygenation (HDO), to produce a fully equivalent gasoline and diesel substitute (compliant with EN228 and EN590 European Standards) and green hydrogen for use in transport.

The sustainability of the TCR-PSA-HDO integrated system is being analysed by means of LCA and calculation of Greenhouse gases (GHG) emission savings.

Materials and methods

The goal of the TCR-PSA-HDO integrated system is twofold then two different approaches was defined: 1) process oriented, 2) product oriented. The first approach considers the integrated system as an alternative sewage sludge (SS) management, where the function is to dispose the sewage sludge. Then, the integrated system will be compared among three different scenarios SS management, which are: 1) agricultural use of SS, 2) incineration of SS and 3) landfilling. They represent the three main methods of European SS management, as reported by Eurostat3. The functional unit chosen is 1 ton of sewage sludge ready to be treated (water content 99 %w/w). The second approach considers the integrated system as a suitable system to produce biofuels, which replace the conventional fuels. The function is the fuel production then, the system will be compared with: 1) standard gasoline and 2) standard diesel. Then, the functional unit chosen is 1 MJ of HHV in the produced fuel.

The system boundaries of the TCR-PSA-HDO integrated system include the following processes: thickening, dewatering, drying, TCR-PSA-HDO, distillation. Thickening, dewatering and drying are included also in the alternative scenarios of the process-oriented approach since the sewage sludge is managed differently in according to each scenario. The alternative scenarios regarding fuels production include: oil extraction, refining, biomass production and biofuels production since standard fuels include a percentage of bio-component.

Regarding allocation methods, system expansion is used in process-oriented approach whereas, energy allocation for diesel and gasoline and system expansion for the other co-products are used in product-oriented approach.

Regarding the inventory phase, the data of the TCR-PSA-HDO integrated system derive from the design and engineering phase of the demonstrator plant because it is the focus of the project instead, those of thickening, dewatering, drying, distillation and alternative scenarios derive from literature and LCA dedicated datasets.

The realization of the LCA model has been carried out utilizing GaBi software and Gabi Professional and Ecoinvent databases. ILCD recommended characterisation methods have been applied.

Results

Current LCA results are based on the design phase since the pre-commercial plant is being built and, presumably, no data will be available before 2020. In the presentation of LCM conference, results related to process-oriented approach will be shown and environmental performances of the TCR-PSA-HDO integrated system will be compared to the alternative sewage sludge management systems. Preliminary results appear encouraging in particular respect to some impact categories such as acidification, climate change and particulate matter formation.

SESSION T1-8 Sustainability of Agri-Food Products

3rd September 2019, Tuesday 1:30 - 3:00 pm

Is environmental efficiency compatible with economic competitiveness in dairy farming? A case study of 80 Luxembourgish farms.

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GOAL. The aim of the study was to investigate both environmental and economic performances of Luxembourgish dairy farms in order to assess possibilities and limits of improving economic competitiveness via increasing environmental efficiency. The case study was carried out against the background of the abolition of the milk-quota system in the European Union at the end of March 2015 and in the frame of the Interreg VA-Project "AUTOPROT".

METHODS. To achieve the goal, a combined environmental and economic analysis of 80 Luxembourgish dairy farms was carried out in the years 2014, 2015 and 2016. The farms, evenly distributed within the country, are representative of dairy production in Luxembourg. In the environmental field, four LCA-impact categories (carbon footprint, energy consumption, acidification, groundwater eutrophication) were analysed, while in the economic field, costs and incomes of the farms were investigated. Following the procedure developed by Lioy et al. (2014), the investigated farms were divided into four homogenous groups according to intensity and efficiency criteria.

RESULTS. A main result was that a sustainable dairy production with less environmental impact in all considered categories is also of advantage in terms of farm competitiveness. The most efficient farms reach also the highest profit. In terms of farm management, a key role is played by the farm feed production. The most efficient farms show a higher level of self-sufficiency in protein production (autarky degree), which allows them at same time to reduce production costs as well as environmental impact. The case study proves that a high environmental performance is not only of advantage in terms of economic competitiveness, but is even a necessary prerequisite for best economic performances.

LITERATURE

R. Lioy, T. Dusseldorf, A. Meier, R. Reding and S. Turmes: Carbon footprint and energy consumption of Luxembourgish dairy farms. The 11th European IFSA Symposium, 1-4 April 2014 in Berlin, Germany (WS 2.7)

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SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 1:30 - 3:00 pm

The concepts of food eco-design for efficient biomass recovery, components up-cycling and food waste reduction

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German Institute of Food Technologies (DIL e.V.)

Recent food studies, aiming to assess complete system of food production and consumption, indicate that agri-food system is responsible for up to 50% of anthropogenic environmental impacts. Multiple strategies and technology-oriented solutions are developed and implemented to reduce the environmental impact of food production system. However, growing population and its demand for more nutritionally rich and environmentally impacting foods became a challenge, which can not be solved without a conceptual change of agri-food production system. Current and future generations do not have a spare buffer to waste 30% of food biomass.

It is necessary to mention that eco-design of food products is rather non-existing. Some researchers define eco-design as the process of including environmental, efficient and cost saving criteria during the product design, which leads to the selection of more efficient production methods, optimized packaging and waste utilization methods according to the requirements of Life Cycle Assessment (LCA). But in most cases, it does not include the potential of eco-design approaches applied in other industries like design for disassembly (DfD), disassembly sequence generation (DSG), reconfigurable disassembly systems (RDS), design for remanufacturing (DfR), design for sustainability (DfS), design for upcycling (DfU) etc. Can you name a single food product, which could be easily disassembled into ingredients for reuse or upcycling?

Therefore, the objective of this study is to present the main conceptual approaches to eco-design of products in other industries and define the potential for their transfer to food production-consumption systems.

DfD is aiming to create a product, which is suitable for quick and ideally automated disassembly for further recycling, reuse or upcycling of components. Currently huge diversity of food products forms and sizes does not allow for the automation of disassembly. Therefore, the DfD would require unification or grouping of products into a few main options, which can be tacked by robotic equipment for repackaging and aggregation into a few main components.

DfR defines the potential components, which can be efficiently recycled into foods similar to the initial product. Most of wasted food products are neglected because of increased risk of contamination associated with microbial activation after certain period. At the same time, most processed foods can be reprocessed for the second time without the loss in quality. It can therefore increase the shelf-life of a product. Emerging technologies like high-pressure processing (HPP) allow to reprocess already packaged foods.

DfU on the other hand requires to connect the production of food to other industries, when non-used foods are applied for non-food purposes. There are commonly indicated options: bio-based products, construction materials and bio-fuels. However, more research is needed to define the potential of this option to be widely used and accepted.

Therefore, efficient eco-design of food products would require certain unification of food portions and sizes, applicable for disassembles at the end-of-the life. Certain products can be designed for reuse and reprocessing or, alternatively for reuse in other industries. It is a huge field, which require extensive research, but can provide system solutions.

SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 1:30 - 3:00 pm

Food consumption in Australia: Pathways to reducing water-scarcity impacts

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Goal: Target 6.4 of the United Nations Sustainable Development Goals identifies water-scarcity as a major global environmental concern, and the food system is a critically important intervention point, being responsible for around 70% of global freshwater use. However, there is a heterogeneous spatial distribution of water resources and human water demands, meaning that water-scarcity is acute in some regions but a lesser environmental concern in others. Quantifying the water-scarcity impacts associated with food consumption is therefore a complex challenge due to the diversity of individual eating patterns, the very large number of individual food products available, and the many different regions where food is grown or processed. Our objective was to identify pathways toward healthier diets with lower water-scarcity impacts in Australia.

Methods: In this study, a hybrid (input-output and process) life cycle assessment was used to model the water-scarcity footprints of 9,341 individual Australian adult diets obtained through 24-hour recall as part of the most recent Australian Health Survey. Three water-scarcity indicators were used, including the AWARE model recently developed by a project group working under the auspices of the Life Cycle Initiative (www.lifecycleinitiative.org). In addition, a diet quality score was calculated for each of these diets.

Results: Dietary water-scarcity footprints averaged 362 L-eq person-1 day-1 and were highly variable (sd. 218 L-eq person-1 day-1), reflecting the diversity of eating habits in the general community. The largest water-scarcity impacts were related to the consumption of discretionary foods (i.e. energy-dense and nutrient-poor foods that are not an essential or necessary part of a healthy dietary pattern and should be eaten occasionally and in small amounts), followed by fruits and then dairy products and alternatives. The potential to reduce dietary water-scarcity impacts is large, although the opportunity to intervene through amended dietary guidelines is not straightforward due to the large variations in water-scarcity footprint intensity between individual foods within a food group, and the inability of consumers to identify lower water-scarcity footprint products without additional food labeling. Reductions in the water-scarcity footprint of Australian food consumption are likely best achieved through reductions in food waste, technological change to improve water-use efficiency in food production, as well as the implementation of product reformulation and procurement strategies in the food manufacturing sector to avoid higher water-scarcity footprint intensity ingredients. This study provides important new evidence concerning the water-scarcity impacts related to whole-of-diet food consumption as most previous studies assess only volumetric water use, and it is well established that results after impact assessment can differ markedly.

SESSION T1-8 Sustainability of Agri-Food Products
3rd September 2019, Tuesday 1:30 - 3:00 pm

Sustainable pork production in Colombia: Life cycle assessment of "Grupo ALIAR"

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Fundação Espaço ECO

According to the United Nation, the world population is expected to reach 8.5 billion by 2030. The associated increase in food demand will boost pork production due to the high protein content and other benefits that pork has in the human diet. It will simultaneously increase the threat to the environment due to the environmental passives of livestock such as climate change, land use change and eutrophication.

In recent years, Colombia has increased its pork production in 10% and new players in the pork cluster industry such as "Grupo ALIAR" developed a sustainable business model with genetic improvement and circular bio-economy principles. The foundation of the model is to reuse organic waste in the value chain to mitigate the economic and environmental impacts, and to contribute to food security and poverty reduction in the country.

To determine the sustainability progress and measure the eco-efficiency of the productive model of Grupo ALIAR", a partnership was established with BASF and "Fundação Espaço ECO" from Brazil to evaluate the environmental impact associated with the swine production through a Life Cycle Assessment (LCA). The scope of the study was from resource extraction (cradle) to the farm gate, the alternatives compared were the production in 2015, 2016 and 2017, and the functional unit considered was 1 ton (1000 kg) of swine produced at the gate of the farm (before going to the slaughterhouse). The LCA model for the study was created in the GaBi software and was compound in four stages: Agriculture (Soy and Corn), feed production, growing to finish and manure treatment.The ecoefficiency analysis of "Grupo ALIAR" showed a reduction of 7.3% in the environmental impact and a decrease of 2,9% in economic impact between 2015 and 2017 mainly due to the increase of crop productivity and resources efficiency for feed production achieved by process improvements.

The most relevant categories of impact for swine production were climate change, acidification and eutrophication that represent together more than 90% of the total environmental impact. The environmental profile results for climate change vary from 2260 kg of CO_2 eq. till 2900 kg of CO_2 eq. that in comparison to emission intensities reported in the literature represents an average difference of -12,7% compared to Brazilian studies and -16% compared to European studies.

The agriculture and manure treatment stages have the greatest contributions in the environmental footprint, for that reason, favorable sustainable practices such as the anaerobic digestion for manure treatment have a significant reduction in negative externalities due to the reduction in the use of fertilizers for crop production and biogas capture for energy purposes.In conclusion, the study evaluated the swine production between 2015 and 2017 and validated the ecoefficiency progress of "Grupo ALIAR". It served to identify the main environmental impacts contributors, address efforts towards the opportunities for improving environmental performance and advocate future investments in sustainability.

SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 1:30 - 3:00 pm

Housing stock retrofitting at the urban scale: a spatio-temporal environmental assessment

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Goal:

Cities are responsible for 75% of global energy consumption and about 70% of the world greenhouse gas emissions. Reducing the energy consumption of residential buildings is one of the priority measures to achieve carbon mitigation of cities. To this aim, retrofitting has been identified as one of the most effective strategies to implement in the short term and public authorities need reliable tools to assess the effects of buildings retrofit scenarios at city level.

The goal of this study is to perform a spatially and temporally explicit life cycle assessment (LCA) of urban building stock retrofitting to support sustainable urban planning.

Methods:

A building-by-building stock model based on Geographical Information Systems (GIS), was developed to explicitly consider the variability of geometry, envelope and technical systems of residential buildings across the city of Esch-sur-Alzette (Luxembourg). Temporal aspects were taken into account by introducing dynamic evolution of the existing housing stock. For the impact assessment phase, we applied time-adjusted calculation for global warming potential (GWP) over a time horizon of 100 years.

The main geometry-related data for single georeferenced buildings are systematically determined in GRASS GIS combining digital surface model (DSM), digital terrain model (DTM) and building footprints vector data, based on previous studies. Building envelope surface areas are calculated for every building and allow estimating the material requirements for retrofitting, e.g. insulation. An energy demand model provides results on the energy savings potential after building retrofitting. Results are stored in a PostgreSQL database for the entire housing stock and provide the input for the environmental assessment. Building energy demand and material requirements for retrofitting are associated to Greenhouse Gases (GHG) emission on a building level, and the variation of carbon footprint along alternative scenarios for the entire housing stock is assessed using the software R. We analysed four different retrofitting scenarios, combining two retrofitting rates (current 0.5% and improved 2.0%) and two retrofitting standards (according to current regulation and improved standard).

Results:

The results of the simulations showed a potential reduction of final energy consumption by 35.3% and GWP by 30.8% after implementing conventional retrofitting measures at the city scale. However, at the current retrofit standard and rate, only a 4% GWP reduction would be achieved by 2035. Increasing the retrofit rate leads to a total 18% GWP reduction, while simultaneous improvement of retrofit standard and rate to a total 25% GWP reduction by 2035. The retrofitting stage accounts between 5% and 17% of the total GWP in the residual service life of buildings, depending on the retrofitting standard. The application of a time-adjusted calculation demonstrated a difference in GWP of almost 10% over a 20 years period compared to the evaluation based on a fixed GWP value (disregarding emission timing). This study highlights the importance of using a spatio-temporal life-cycle approach for urban building retrofit scenarios to avoid underestimation of environmental impacts reduction benefits.

SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 1:30 - 3:00 pm

EasyEPD

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Environmental Product Declarations (EPDs), equivalent to type III eco labels, are a broadly recognised LCA-based approach for quantifying the environmental impacts of building products. Since 2011, EPDs are mandatory for e.g. tenders for the construction of federal public buildings in Germany.

The need for EPDs challenges many Small and Medium-sized Enterprises (SMEs) for which the costs for collecting energy and material flows with Enterprise-Resource-Planning (ERP) software as well as the verification process in accordance with EN 15804 (creation and verification through independent experts) are prohibitive (typically several thousand euro). As a result, SMEs are often denied the potential benefits which EPDs could introduce by being able to access the market sustainable building as well as to simply showcase the environmental impacts of their products.

Therefore, a German research and development project aims at removing barriers for SMEs in creating EPDs for their products by developing a semi-automatic, quick and cost effective EPD creation process under use of smart software support. The approach based on a new software tool, is meant as a replacement for the current, typically manual, EPD verification.

The procedure and tool are developed for the sawmill and wood processing industry in Germany, with support from the largest EPD program operator in Germany. The basic idea is to let an LCA and EPD software perform steps of the EPD creation and verification as far as possible. As a result, only a final "supervision check" by EPD verifiers is needed. The tool will be quality-assured by the EPD program operator to ensure that it indeed performs the requested EPD creation and verification steps correctly. The result is a fully valid EPD created with less time and effort.

The presentation will summarise the idea for the project and tool, explain the verification process, and expand and discuss questions that are to be solved during the project, including:

• Steps in the creation and verification procedure which cannot be automatized

• Scope of products that can be "processed" by the tool, which is of course not able to deal with any kind of product; ways to identify whether a product out of scope is attempted to be modelled

• Security and sensitivity of data

• Requirements for the tool and for data storage and transmission to allow for verification of modelling and data submission by the tool

• IP and use of the tool and procedures after the end of the project

Overall, the project will ease collection of EPD-relevant data and simplify the verification process by the respective EPD programme operator. Moreover, it allows companies, including SMEs, to create verified EPDs much faster with less effort. In an outlook, an extension of the concept and tool to other sectors will be discussed.

SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 1:30 - 3:00 pm

Life cycle assessment benchmark for wooden buildings in Europe

Erwin M. Schau, Eva Prelovšek Niemelä, Aarne Johannes Niemelä, Tatiana Abaurre Alencar Gavric and Iztok Šušteršič

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The construction industry accounts for 15 % of all greenhouse gas emissions. During their use phase, buildings use 40 % of the total energy consumption, which contributes significantly to air polution and other environmental impacts. While the energy consumption during the use phase is predicted to decrease as efficient buldings, like zero and near near zero energy buildings, become more common, climate change and other environmental problems from the production or raw materials, construction and end of life remain serious concerns that need to be solved urgently.

Life cycle assessment (LCA) and the EU-recommended Environmental Footprint (EF) are well known and accpeted tools to measure a comprehensive set of environmental impacts throughout a products life cycle. However, to assess how good (or bad) a wooden building performs environmentally is still a challenge. In the EU Environmental Footprint pilot phase from 2013 – 2018, an average benchmark for the different product groups was found to be very useful.

Based upon the recomendations for a benchmark of all kinds of European dwellings, we developed a scenario of a typical European wooden building. This scenario is carried out using the ILCD method from 2012, which required an update. The new EF 3.0 characterisation factors (from Jan 2019) cover 16 recommended impact categories and can be normalised and weighted into 1 single point for easy and quick comparisons. The results are presented as the average impact per one square metre (m2) of floor area over one year.

The developed benchmark for wooden buildings is a suitable comparison point for new wooden building designs. The benchmark can be used by architects and designers early in the planning stages when changes still can be made to improve the environmental performance of wooden buildings, or to improve the communication and interpretation of the LCA results for customers and other stakeholders. This presentation will discuss the methodology, results, and how to apply them to a case study to improve the environmental performance of buildings.

SESSION T2-9 Sustainability in the Construction Sector

3rd September 2019, Tuesday 1:30 - 3:00 pm

Life cycle assessment of a plasticizer produced by lignin oxidation

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Vertech Group

Goal:

Concrete characteristics are highly influenced by the ratio of water used in the mixtures. For instance, if the water content is reduced it will be reflected in a stiffer mixture, which decrease the cement workability and increase the potential placement issues. In this regard, the superplasticizers can be added in order to reduce the water content in a mixture and to keep the proper consistency of un-hardened concrete. Regular superplasticizers can decrease the water content about 30%. Even if the superplasticizers show benefits to the concrete mixtures in terms of higher strength, lower permeability and higher durability, some environmental burdens are attributed to this sort of materials. According to some authors, superplasticizers contribute up to 10% of the total environmental impact of concrete, especially on impact categories such as photochemical ozone creation. In this regard, alternative sources of production, considering the valorization of waste materials is highly valuable. This is the case of the EU funded project LigniOx, which aims to produce a concrete plasticizer by lignin oxidation in a Kraft pulp mill system. The LigniOx lignin as a concrete plasticizer provides higher performance compared to lignosulfonate admixtures and show comparable or even better performance compared to some synthetic superplasticizers.

The aim of the present study is to compare the production of a concrete plasticizer from lignin oxidation in a Kraft pulp mill installation versus the benchmark synthetic alternatives currently at the market.

Methods:

For this assessment, only the production phases were analyzed, taking out the transport and use phases. Three concrete superplasticizer admixtures were selected for comparison (i.e. sulfonated naphthalene, sodium lignosulfonate and polycaboxylic ether based). The production of 1 kg of concrete plasticizer was considered as a functional unit. Five potential impact categories were assessed (global warming; acidification; eutrophication; abiotic depletion; and, ozone layer depletion). The method used was CML-IA baseline.

Results:

According to the results found in this study, the innovative lignin oxidation plasticizer produced in LigniOx project presented the best environmental performance, showing between 60 to 75% lower impacts in categories such as eutrophication, acidification and ozone layer depletion, and been about 85% lower in global warming and abiotic depletion indicators. The main contributors to the total environmental impacts in the lignin oxidation plasticizer were the use of chlorine dioxide and sodium hydroxide, around 70-84%. On the other hand, the outcomes of this analysis highlight the promising opportunities of integrate the lignin oxidation process into the classical Kraft pulp mill facilities in order to obtain valuable materials such as concrete plasticizers.

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SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 1:30 - 3:00 pm

Influence of recycled concrete on the environment

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Concrete is one of the most widely used building materials. In accordance with the circular economy different replacement of raw materials is considered even in concrete mixtures. Although some LCA studies on recycled concretes have been already published, there is still a lack of detailed studies including ecotoxicological aspects of all their life-cycle phases. The main goal of this contribution is to describe potential ecotoxicological impacts of concrete mixtures with secondary raw materials in comparison with the referential concrete. The further goal is to evaluate the environmental impacts of secondary raw materials used in concretes and estimate their influence on ecotoxicity potential of concrete.

In the first step, leachates of various types of concrete were prepared. Consequently, the content of toxic elements and aquatic ecotoxicity was determined in the leachates. In the second step, the obtained data were used for creating models of exposure scenarios. The LCA method was used as an analytical tool for the comparison of secondary raw materials and concrete mixtures, where GaBi Software ts for data processing was used. Environmental impacts assessment according to the ReCiPe method characterization, version 1.08 was used.

The ecotoxicity of leachates from concretes was compared. Created models of exposure scenarios show the environmental impact of referential concrete and secondary raw materials, which were used in concrete mixtures. Also, secondary raw materials with a large contribution to the environmental impact of concretes were identified. Furthermore, the general models for typical concrete mixtures were designed. Results can contribute to a better understanding of the interaction between different types of concrete and environment.

SESSION T2-9 Sustainability in the Construction Sector
3rd September 2019, Tuesday 1:30 - 3:00 pm

Active façades: life cycle environmental impacts and savings of photovoltaic power plants integrated into the building envelope

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1. GOAL

Increased energy supply from photovoltaics is a main priority in the “Energy Strategy 2050”. Within the research project “PV2050: Sustainability, market deployment and interaction to the grid – the impacts of advanced photovoltaic solutions” funded by the Swiss National Science Foundation, we analysed different options for the enhanced integration of photovoltaic (PV) technologies into the envelope of Swiss buildings using novel monolithic silicon heterojunction organometallic perovskite tandem cells (SHJ-PSC) with adaptions to improve the visual acceptance. In a joint effort of product developers, architects and scientists, this project aimed at providing pathways for the wide-scale use of PV façade solutions, and developing integrated designs based on emerging high-efficiency module technologies to improve the visual aspect and acceptance of PV systems installed in Switzerland. These so-called active façades using photovoltaic modules to produce electricity can provide a significant contribution to the energy transition away from fossil and nuclear fuels.

2. METHODS

We compared the environmental impacts of different types of construction for building façades with and without integrated monolithic silicon heterojunction perovskite tandem modules (SHJ-PSC) with improved visual design using a prospective life cycle assessment with a time horizon of 2025. The comparison includes a conventional roughcast façade, a wooden façade, and two different active façades using photovoltaic modules. Furthermore, we compared the environmental impacts caused by the construction of the different façades with the environmental impacts saved due to the electricity produced by the active façades composed of photovoltaic modules. In addition, we analysed the reduction in environmental impact of the building using building-integrated photovoltaics due to substitution of construction materials for the façade or roof.

3. RESULTS

The use of photovoltaic modules as façade or roof will increase the environmental impact of the façade or roof compared to the use of conventional construction materials. However, the environmental impacts over the whole life cycle are significantly reduced due to the PV electricity produced by the building. The environmental impacts of the BIPV façade are about two to three times higher compared to a conventional façade, but the savings due to the electricity produced by the BIPV are five to eight times higher than the impacts of the conventional façade. The use of BIPV panels in the façade of buildings will cause net savings of about 600 kg CO_2-eq per square meter over the whole life cycle of BIPV façades, while simultaneously saving 100 kg CO_2-eq per square meter of façade for the reduced material demand.

SESSION T3-3 New Types of Organizational LCA
3rd September 2019, Tuesday 1:30 - 3:00 pm

Assessing water use beyond the factory gate - methods and tools for the organizational water footprint

Daniel Thylmann (thinkstep AG), Maike Pieper (thinkstep AG), Silvia Forin (TU Berlin), Markus Berger (TU Berlin), Matthias Finkbeiner (TU Berlin)

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thinkstep AG

Goal: In current industry practice water is managed and controlled at the production site only – even though the largest share of water is usually consumed in the energy and material upstream chains. In order to tackle this shortcoming a method for analyzing the entire organizational water footprint has been developed within the research project WELLE funded by the German Ministry of Education and Research. In addition to a company's direct water use, the organizational water footprint includes indirect up- and downstream water uses and analyses potential regional impacts in addition to the volumetric consumption. To support applicability a water inventory database and a water footprint tool have been developed.

Method: A key limitation of current life cycle inventory (LCI) databases is the lacking spatial resolution of water flows – which are a prerequisite for applying recent geographically explicit impact assessment methods. In order to address this challenge, a method has been developed to regionalize the water inventory flows of datasets based on information in the underlying background data (bottom-up approach) as well as generic import mix and production shares (top-down approach). In this way regionalized water inventories have been established for a set of 100 relevant materials. In order to ensure applicability of the organizational water footprint method and database, an online tool has been developed. Based on thinkstep's GaBi and Envision software, the tool enables users to enter the direct water use at production sites, material and energy purchases, and water use during the products' use and end-of-life phases. By means of the regionalized water inventory database, the water footprint of organizations is determined comprising the direct as well as indirect up- and downstream water uses and resulting local impacts. In this way companies can identify hotspots in their supply chains, analyze the influence of purchase decisions on the companies' water footprint and develop water strategies in cooperation with suppliers – which can be more relevant and more efficient than saving water at own production sites.

Results: Both the database and tool have been tested in case studies conducted by industry partners Evonik, German Copper Alliance, Neoperl and Volkswagen to establish the first organizational water footprints in different branches. Based on the results of the water footprint, which identified potentially relevant water consumption patterns throughout the global supply chain, the local water risk at relevant suppliers is currently analyzed. Subsequently, a water stewardship process is started which aims at increasing water efficiency at supplier and to bring together local stakeholders (industrial consumers, agriculture, local authorities, NGOs, etc.) to start common actions in improving the local situation in the respective basin. Finally, recommendations are provided to combine the global perspective of the water footprint with locally acting water stewardship measures.

SESSION T3-3 New Types of Organizational LCA
3rd September 2019, Tuesday 1:30 - 3:00 pm

Environmental performance of cities considering future transformation processes

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Siemens AG

Goal: Cities contribute to a number of environmental pressures such as air pollution and climate change. About 80% of global greenhouse gas (GHG) emissions can be attributed to urban activities and the predicted growth of urban areas will further stress both in-boundary and cross-boundary environmental conditions. However, the environmental assessment of a city beyond GHG is not formalized yet. Multi-impact approaches are required to support urban decision makers in understanding the effects of socio-economic transformations (e.g. changing lifestyles) as well as future technological developments and thus in finding reasonable mitigation and adaptation strategies.

Methods: Organizational LCA (OLCA) as a new member in the LCA family contributes to the needed harmonization of environmental assessments (from products to organizations) and was identified as a potential candidate to develop a novel approach for city-scale assessments (from organizations to cities). Due to the complex and multifunctional nature of cities and a required long term assessment horizon, methodological adjustments had to be made especially during the goal and scope definition phase.

Results: This paper provides insights in the development of an LCA approach to support environmental management at city-scale and addresses main challenges encountered with scaling up OLCA. A case study of a European city will be discussed and first ideas on how to consider future urban transformations such as decentralized energy systems or autonomous driving will be presented.

SESSION T3-3 New Types of Organizational LCA
3rd September 2019, Tuesday 1:30 - 3:00 pm

" Enhancing social- environmental-economical systemic vision" : Applying OLCA in a NGO.

José Manuel Gil-Valle, Juan Pablo Chargoy-Amador

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LCI Member (Private)

Goal: Emmaüs International (1) a non-governmental organization (NGO) in the social and

environmental sector had practiced, since its foundation - now more than 60 years - , the recuperation of objects that others consider as waste. This activity had allowed to collect the funds to help the needy giving them the means to find their dignity that society had taken.

Nowadays the modes had changed and this recovery activities had made of Emmaüs

movement a well known actor against the non controlled waste “ an environmental actor “

working in the reuse and recycling. Given its environmental focus, Emmaüs has interest in assessing the environmental impacts of its own activities throughout the whole value chain.

Method: Therefore, an Organizational Life Cycle Assessment (O-LCA) study had been conducted (2) as a test in one Emmaüs community. The study was realized in the framework of the Road testing of the

UNEP/SETAC Guidance on Organizational Life Cycle Assessment. In a parallel study, the avoided burdens (see page 48 of the report) (3) originated by the nature of the organization (recycling) will be analyzed and complemented by the results of this project. It is important to mention that the avoided burdens assessment is not part of the O - LCA method.

Results:

- Detection of the main environmental impact categories and their contribution concerning indirect and direct activities
- A performance tracking of the mentioned activities could be established from this study on.
- The study delivers the basis for the communication of “Sustainable Development Issues” with stakeholders (customer, services providers and partners) and reporting.
- The data collected for this study will be the basis for performing a formal EMS (environmental management system).
- A basic model to apply the O- LCA methodology had been established in a recycling community that could be applied in other communities in the future.
- The tools developed to apply this methodology were designed with the aim to support recycling

communities around the world and the whole Emmaüs Organization to evaluate and to reduce their environmental impacts in their own communities but also in the regions where they operate, thus positively affecting local development

- Further applications of the study are being considered. First, the data collected could be

used in the future as environmental data basis for a formal Environmental Management

System (EMS). Second, the Emmaüs community could serve as a pilot project as O-LCA is

concerned. In fact, further recycling communities worldwide could apply the methodology in

the future, thus enabling an assessment of the whole organization or a broader part of it.

From this perspective, Emmaüs is a first-mover in the NGO-sector.

(1) https://www.youtube.com/watch?time_continue=142&v=p0upop-JJbY

(2) https://onedrive.live.com/?cid=82378FB7480A50F3&id=82378FB7480A50F3%21563&parId=82378FB7480A50F3%21619&o=OneUp

(3) http://emmaus-europe.org/wp-content/uploads/2017/05/EN_Emmaus-Etagnieres-OLCA-Final-Report-.pdf

SESSION T3-3 New Types of Organizational LCA
3rd September 2019, Tuesday 1:30 - 3:00 pm

Facts, Figures and Lessons Learned from Road Testing the Guidance on Organizational Life Cycle Assessment

Julia Martínez-Blanco, Silvia Forin, Matthias Finkbeiner

Corresponding author: Julia Martínez Blanco

Inèdit Innovació SL

Goals. 12 case studies from different locations, types of organizations and sizes, roadtested the Guidance on organizational LCA, that had been published by UN Environment in 2015. The aim is to display and analyze different aspects of the road testers' studies according to the feedback of the road testers. Particularly, we identify and discuss some methodological challenges that are specific to organizations or become more critical when applying LCA to organizations. The experience gained through the first case studies is key to highlight possible application paths able to inspire future practitioners.

Methods. An anonymous survey about the method application was conducted among the road testers that included, among others, questions regarding: the goals the organizations initially pursued and their achievement; and the methodological challenges were faced. Some of the challenges are further analyzed according to the results of the survey and according to the piloting process. Thanks to the experience gathered by the Flagship Activity's Secretariat – first during the drafting of the O-LCA Guidance, and mainly when reviewing the road testers' studies and attending the feedback calls.

Results. The survey showed that analytical goals were of priority for most road testers and obtained a higher achievement level than managerial and societal goals for which either long-term measures or the inclusion of stakeholders are needed. The list of challenges included at the goal and scope stage were the selection of a part of an organization as reporting organization, and the operability of the reporting flow. Regarding the system boundary, the issues identified were which parts of the supply chain should be included in the study, problems when setting the system boundary for the service sector, how to include supporting activities, and how to prepare the right system boundary diagrams. Regarding the inventory stage, the discussion starts with the alternatives for the categorization of the inventory into activities and the aggregation of those activities into groups. Three challenges were encountered during impact assessment and interpretation that are exclusive or particularly reinforced by the organizational perspective: the assessment of local impacts, scoping performance tracking, and the use of O-LCA results for an organization's strategy. The road-testing organizations verified the applicability and usefulness of the O-LCA Guidance and significantly widened the pool of case studies available. Further application testing is needed, along with research to support a future revision of the O-LCA Guidance, in line with the issues highlighted here and new challenges may arise in future case studies.

SESSION T3-3 New Types of Organizational LCA

3rd September 2019, Tuesday 1:30 - 3:00 pm

voestalpine's water scarcity footprint: Large scale O-LCA in the technology-intensive iron & steel industry analysing water scarcity along the value chain

Daxner Therese, Mayr Roland, Schuster S.

Corresponding author: Roland Mayr

voestalpine AG

Goal:

This study assesses voestalpine's water scarcity footprint along its entire value chain. The analysis aims at the communication of robust, science-based metrics when it comes to water consumption of heavy industries including their effects on water scarcity. Therefore, the study applies large scale organizational life cycle assessment (O-LCA).

voestalpine represents a global provider of product and system solutions based on steel and other metals of the highest quality in technology-intensive industries. As a result, the scope of the study refers to all entities under operational control of the group. This includes two integrated steel works, four stainless steel works, the direct reduction plant for the production of hot briquetted iron and roughly 120 other production sites for the processing of steel and other metals.

Methods:

All presented results comply with latest methodological developments and are thus based on novel approaches for organizational water footprinting. They are in line with the recommendations of latest guidelines for organizational life cycle assessment (UNEP O-LCA guidance) and water footprinting (ISO 14046). This includes the calculation of net water consumption of every single entity using regionalised inventories and the characterisation of water scarcity based on AWaRe.

Covering the group's impacts throughout the supply chain, high quality foreground data from 2017 are combined with background data from suppliers, literature and chosen from the latest LCA-databases available. A hybrid-approach for data collected for direct activities at the production sites includes top-down as well as process-oriented bottom-up considerations of the group's more complex sites. Data collection represented a thorough process in line with the recommendations of ISO 14044 and the O-LCA guidance. Furthermore, the external verification process confirmed the very high level of detail and robustness of this forward-looking study.

Results:

Aiming at the full representation of blue water consumption, complete water balances represent all 130 entities under study. Therefore, water withdrawal from rivers, lakes, sea, groundwater and tap water are included. Discharges including cooling, process water, evaporation losses and the treatment of polluted water are fully covered in the inventory.

Blue water consumption mainly results from evaporation losses and water released to sea water after treatment. The study further analysed the dominance of the group's single entities, used raw materials and unit production processes in its water profile. Despite to the presence of once-through cooling systems in the integrated steel plants of the group resulting in comparably large quantities withdrawn and discharged to rivers, direct blue water consumption represents a minor contributor compared to indirect water consumption in the supply chain.

Potential water scarcity mainly results from indirect impacts in the supply chain. Raw material provision such as the upstream supply chain of alloys, pellets and iron as well as hydropower generation represent the main drivers when it comes to the group's water scarcity footprint profile. As direct blue water consumption accounts for under 10% of potential water scarcity, raw material supply from regions challenged with limitations when it comes to water dominate the group's water scarcity profile.

SESSION T4-3 LCA in EU Policy

3rd September 2019, Tuesday 1:30 - 3:00 pm

Applicability of the Environmental Footprint (EF) methodology in Southern Mediterranean countries – Learnings and recommendations for enabling EF-compliant studies in regions outside of Europe

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PRé Sustainability

Goal

The European Commission is thinking about policy options for the European Environmental Footprint (EF) method and aims for a broad support. The SwitchMed initiative is a program with the overall objective to facilitate the shift towards Sustainable Consumption and Production in the Southern Mediterranean region. One of the objectives of this initiative, carried out in Egypt, Lebanon, Morocco, and Tunisia, is to facilitate access of companies from this region to the outcomes of the EF Rules pilot phase.

Methods

The project was composed of three consecutive phases: (I) Awareness raising; (II) Local pilots; and (III) Dissemination events. The awareness raising and technical workshop activities were meant to expose national stakeholders to the potential impact of the EF system for the national economies. Next, nine environmental footprint studies for selected product categories (so-called ‘PEF pilot studies’), were performed to create local capacity and expertise. These were leather and intermediate paper product for Egypt; two studies on wine and one on intermediate paper product in Lebanon; olive oil for Morocco; and pasta, olive oil and dairy for Tunisia. The learnings from the pilot studies were shared in national dissemination events, and used to formulate recommendations for enabling EF-compliant studies in regions outside of Europe.

Results

There was high attendance to the awareness events in each country. The pilot studies showed many similarities with the European screening studies, but also important differences in the identification of most relevant impact categories, life cycle stages and processes (‘hotspots analyses’), e.g. related to the local scarcity of water. Based on their pilot study, the local experts made concrete suggestions for shifting towards more sustainable consumption and production. One of the biggest successes of this project is that a couple of these recommendations have already been taken into account by the companies.

In Egypt, Lebanon and Tunisia, a few local experts with a significant level of LCA expertise could be identified and through this project we managed to create local PEF capacity too. In Morocco, more assistance was needed to finish the pilot study. This project made clear that the current ‘PEF and OEF methods’ has serious drawbacks for regions other than Europe. The rules of the EF method need to be reconsidered in order to enable EF-compliant studies in regions outside of Europe. In short, we recommend:

1. Developing databases with local inventory data for regions outside of Europe;
2. Taking the local availability of data into account when setting data quality requirements;
3. Adapting the rules for data collection and quality to allow for more precise adaptations; and
4. Updating existing rules specific for certain product categories regularly.

SESSION T4-3 LCA in EU Policy

3rd September 2019, Tuesday 1:30 - 3:00 pm

Environmental Footprint: the technical work ongoing

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European Commission

Goal:

In the context of the Communication Building the Single Market for Green Products (COM(2013) 196) the Commission carried out a four-year Environmental Footprint pilot phase. The main objectives of this pilot phase were to

- test the development of product-specific and sector-specific rules (Product Environmental Footprint Category Rules (PEFCRs) and Organisation Environmental Footprint Sector Rules (OEFSRs);
- test the development of product "benchmarks";
- test different approaches to verifying environmental footprint information;
- test different vehicles for communicating environmental footprint information.

The pilot phase included 28 pilots (out of which 22 are being finalised) and came to its end in April 2018. For details, see http://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm

Method:

Based on the experiences during the pilot phase, the European Commission is working on policy proposals to implement the revised Product and Organisation Environmental Footprint methods in policies. During the time between the end of the pilot phase and the adoption of new policies, the European Commission is putting in place a framework to allow:

- further development of PEFCRs/OEFSRs
- further improvement of modeling rules

This transition phase will last until a new policy is adopted, which is currently estimated not earlier than 2021.

Results:

This presentation will give an update of the state of play of the technical Environmental Footprint developments. Which new PEFCRs/OEFSRs are under development or will be developed in the coming years? (i) Which technical topics are on the agenda and will be / are discussed in additional working groups (e.g., agricultural modelling)? (ii) What work is ongoing considering EF compliant data development and data formats (e.g., data format for disaggregated datasets)? (iii) What are the additional studies we are performing on e.g., implementation of pilot phase results or consistency among the developed PEFCRs/OEFSRs?

SESSION T4-3 LCA in EU Policy

3rd September 2019, Tuesday 1:30 - 3:00 pm

Country-specific climate footprints of electricity mixes and battery electric vehicles in Europe

Christine Roxanne Hung, Steve Völler, Maxime Agez, Guillaume Majeau-Bettez, Anders Hammer Strømman

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NTNU

Goal:

Due to the higher production emissions attributed to the battery production for BEVs, fossil fuelled vehicles (ICEVs) may have lower lifecycle climate footprints than BEVs of similar size in countries with a heavy fossil share in the electricity mix. Given that many national economies are still heavily reliant on fossil technologies in the electricity generation, some regions may benefit from decarbonizing their electricity mix before introducing restrictions to ICEVs or incentivizing BEV uptake. Existing studies examining regional effects on the environmental impacts of BEVs have to some extent been performed, however, these are often US- or otherwise single-country based.

Methods:

In this study, we compare the lifecycle climate footprints of conventional fossil-fuelled vehicles and battery electric vehicles using country-specific electricity mixes for 32 European states. We use the EFI Multi-area Power market Simulator (EMPS) to model the European energy system. EMPS determines the dispatching of electricity while maximizing the socioeconomic profits of the system. Using the results from EMPS, we determine electricity production and consumption mixes at the country level. Combined with country-specific upstream emissions data from EXIOBASE, we calculate their climate impacts of both electricity mixes. The total lifecycle footprints of the vehicles for each country are then calculated. We also compare results in a scenario where it is assumed each European country assessed produces the batteries for the electric vehicles in their fleet.

Results:

Preliminary results indicate that there is relatively little electricity trading occurring in Europe, and therefore the electricity mixes across the continent are quite heterogeneous. The common assumption of an average European electricity mix is therefore insufficient, in the investigation of BEVs. In some cases, such an assumption could possibly result in counterproductive electric vehicle policies. Rather, BEV uptake initiatives within the European Union should be country-specific due to the significant regional differences in the carbon footprint of the electricity mixes. Further, we identify the countries that should prioritize BEV uptake policies, and those which should rather prioritize decarbonization of electricity.

SESSION T4-3 LCA in EU Policy

3rd September 2019, Tuesday 1:30 - 3:00 pm

Translating LCA evidence into performance based policy criteria for the photovoltaic product group

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Joint Research Centre, European Commission

/Goal/

Life cycle assessment has the potential to generate valuable information and knowledge for policy makers, as insights can be gained by applying LCA into the development of policy criteria. Ecodesign, Energy labelling, Ecolabel and Green Public Procurement, are the regulatory and voluntary policies for the sustainable production and consumption that the European Commission develops. Each tool has different market objectives; Ecodesign aims at setting minimum requirements for products entering the EU market, Energy label enables consumers to make informed purchases by classifying the energy performance of appliances, Ecolabel is an instrument to mark the most sustainable choices and the Green Public procurement is a set of voluntary requirements for public authorities to make purchases with lower environmental impacts. A preparatory study to assess the feasibility of these tools for the photovoltaic category group is currently on going. Knowledge derived from LCA evidence has been used to inform the assessment of the policy options.

/Methods/

A systematic LCA review has been conducted with a focus on the information needs of the policy tools. However, to be of relevant use, a LCA study should report the values, or give an interpretation of the results per components/substances, in order to support hotspot identification or allow for conducting it. This is specifically useful to develop in a later stage criteria for EU Ecolabel as an example. Apart from a LCA review, specifically designed for the development of Ecodesign and energy label is the Methodology for Energy related Products (MEErP). Product environmental footprint category rules (PEFCRs) when available can be complementary as it is the case for the photovoltaic modules, developed under the Commission's pilot programme. Sometimes, there are existing national or private Ecolabels where similar requirements have been laid down, such as the EU Blue Angel (inverters criteria), or the US based sustainability standards (NSF 457 Sustainability leadership for PV modules), and the Cradle to Cradle certification scheme. Finally, stakeholders participation though public consultations where experts feed into the process by e.g. providing primary data or identifying missing inputs, is an important pillar of the policy criteria development.

/Results/

The LCA review and parallel MEErP analysis has enabled the identification of hotspots at component and life cycle stages, the selection of design options to compare against a base case, and the determination of the type of information needed to translate hot spots into criteria. LCA evidence has therefore been translated into technical performance based criteria for the PV product group. As for Ecodesign, it has been preliminarily identified that a minimum level of energy yield should be achieved under fixed climatic conditions. For the Ecolabel, it has been found that the reporting of repairable components at set points along a design lifetime, as well as Energy Payback time could be feasible. Project stage related criteria that minimise both life cycle environmental impacts and costs, together with GWP based indicator results - as required in the French PV capacity auction requirement - could be integrated in a Green Public Procurement criteria set.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
3rd September 2019, Tuesday 1:30 - 3:00 pm

Elementary litter in life cycle inventories, approach and application

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GreenDelta

Goal

Litter and especially marine litter is one of the issues that gained a lot of public attention in the past few years. In LCA, despite its claim to be comprehensive, marine litter is so far not addressed. As an effect, today, there is awareness also in the LCA community that marine litter needs to be included in LCA (e.g., Medellin declaration, a recent “unprecedented scientific” workshop on LCA and marine litter on May 23 2018), but there is not yet an agreed approach on how to address litter neither in the inventory nor in the impact assessment.

Modeling the inventory and impact assessment is more complicated for litter than modeling “typical” industrial process networks, due to unpredictable, seemingly arbitrary pathways, for micro- and macroplastics in different compartments, to microplastic, and then again in the different nutrition chains for example.

These pathways need to be addressed with a proper modeling approach. In absence of an agreed impact assessment, developing inventory is somewhat guesswork, as the inventory should support the impact assessment, but on the other side this is also a hen and egg problem: in absence of inventory data, it is hard to develop LCIA methods.

Methods

Therefore, as first step, we are proposing an approach to determine the release of “elementary litter” released in different compartments, for the first time, as elementary flows. Using empirical and statistical data, we present a model to determine the release of elementary litter for various materials and for various processes in LCA, in amounts (number of pieces) and in mass.

Results

We apply this model to two databases, ecoinvent and LCAcommons, and present results for example product systems. Results show that there are key “producing” processes, as well as key “dissipating” processes (farming, ferries) in a life cycle.

Finally, the concept of elementary litter will be shown for a case study on cups for coffee to go, using paper and other types of cup, with and without consideration of litter. Results will be compared and discussed.

Taking a step back, we will discuss how far the addition of elementary litter supports a comprehensive Life Cycle Assessment, and conclude with what will be further needed in inventory modeling and impact assessment, to come to an overall understanding and assessment of litter in LCA.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
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Is the aquaculture industry a significant source of marine pollution? A material flow analysis of the Norwegian aquaculture industry

Erik Skontorp Hognes,Christofer Skaar

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SINTEF Building and Infrastructure

GOALS

There is increasing concern for the environmental impact of marine pollution in general and plastic waste especially. The Norwegian aquaculture industry is a significant actor, producing more than 1 million tonnes annually. The purpose of this study was to analyse to which degree the material use in Norwegian aquaculture facilities contributes to marine pollution. The scope of this study is limited to material in use (e.g. plastics, steel, etc.), and it does not address biological waste or microplastics.

METHODS

The main method used was material flow analysis (MFA) to analyse the material stocks and the flows in and out of the aquaculture facilities. Due to lack of data, a triangulation approach was used to gather and validate the data. This was based on i) initial mapping using available data through reports and statistics (e.g. from single companies, from the industry, from the government, and from research organisations), ii) interviews with a subset of aquaculture companies, and iii) interviews with a subset of waste management companies.

RESULTS

Based on scaled up subset data from aquaculture companies, we estimated the material in use (stocks) in the aquaculture industry to be up to 192.000 tonnes of plastic and up to 72.000 tonnes of metal. Subsequently we estimated the annual waste generation (flows) from the aquaculture industry to be in the range of 16.000-29.000 tonnes of plastic and 4.300-8.500 tonnes of metal. Based on an overall assessment of the interview results, current regulations and environmental certifications in the Norwegian aquaculture industry, we conclude that the Norwegian aquaculture facilities are unlikely to be a significant source of marine pollution of plastics and metals without it being detected. However, few aquaculture facilities are able to document the amount of waste delivered, how it is sorted and how it will be treated; and none log material use. Furthermore, aquaculture facilities typically do not assess what would be the best possible solution for their own waste. Instead they trust the waste companies to make these choices. The main criteria for selecting waste company is cost, with little to no focus on environmental performance. On the positive side, all informants report of a positive development in the latter years to reduce waste.

Interviews with Norwegian aquaculture companies and waste management companies show that Norwegian fish farmers have routines for handling their waste and that they are using available waste management services. However, the fish farmers have a low degree of documentation on waste amounts, waste fractions and waste treatment, although they know this type of information is available from the waste management companies.

Based on the findings we recommend three actions for improvement: transparently documenting waste management practices, evaluating environmental performance in a life cycle perspective when choosing waste management options, and applying principles of eco-design when designing equipment to generate less waste and increase the use of recyclable and recycled materials.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
3rd September 2019, Tuesday 1:30 - 3:00 pm

Plastic litter cleanup operations: learnings from 4 LCAs

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Chalmers University of Technology

GOAL: Marine debris, especially plastic litter has become a matter of serious concern. While many efforts rightly focus on prevention of plastic littering, the amount of plastics already in the environment is such that it also requires consideration. Even if plastic pollution were to be prevented now, marine plastic litter washing up on shorelines will remain a problem for years. These circumstances warrant an examination of different set-ups for plastic litter cleanup.

METHOD: LCA has beed used to evaluate different types of cleanup operations, both with regard to the environmental impacts associated with the cleanup itself and the recovery options for the collected plastics. Here, four LCA studies are presented and evaluated: 1/ arctic shoreline cleanup with volunteers (Lachmann 2016); 2/ shoreline cleanup with volunteers (Cañete Vela 2017); 3/ riverine cleanup with traps (Börling & Hein 2017); 4/ a sewerage-integrated collection with traps (Börling & Hein 2017). The explored options for plastics recovery include waste-to-energy, mechanical recycling and chemical recycling when landfilling can be avoided. The LCA studies were conducted as student projects under my supervision; the comparative evaluation is my own. Furthermore, personal experience of beach cleaning has provided a frame of reference against which LCA methodology applied to cleanup operations can be evaluated. The findings are discussed further in relation to other known cleanup operations around the world.

RESULTS: The assessments identify both negative and positive environmental impacts. Negative impacts are associated with the operative side of cleanup and collection, while positive impacts are associated with habitat improvement after cleanup or recovery of plastic material. Conventional LC impact assessment methodology was found lacking for describing the positive ecological impacts of cleanups. A combination of qualitative and quantitative site-sensitive assessment was deployed.

Based on the comparative evaluation, aspects important for planning plastic litter cleanups were identified. First, the site for a cleanup matters for what positive environmental impacts are achieved. Shoreline cleanup mainly provide habitat restoration. In contrast, riverine and sewerage-integrated traps provide the clearest possibilities for recovery of plastic material. The ecological benefits of shoreline cleanups are associated with coastal zones being feeding and breeding zones for many animals. While gyres have become known as accumulation zones of marine plastic litter, they are relatively ‘unpopulated’ as marine life is concentrated to the coastal zones where upwelling of nutrients happens. Second, the collection technique matters for what negative environmental impacts arise. Volunteer transportation to site of beach cleanup represent a significant proportion of CO_2 emissions. Working with local volunteers is important for keeping CO_2 emissions down. In comparison, riverine and sewerage-integrated collection can be carried out with well-placed passive traps. As these sit passively in a water stream, emissions related to collection can be kept to a minimum. Third, the material qualities of the collected litter determine recovery possibilities. Beach litter is generally too dirty, salty, degraded and stringy for any useful recovery — landfilling is common. Saltiness is avoided with riverine and sewer-traps. These also have the advantage of collecting more recent and less degraded litter, thereby facilitating various recovery options.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management

3rd September 2019, Tuesday 1:30 - 3:00 pm

Plastic litter composition and quantification to support a plastic litter methodology for Life Cycle Assessments.

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Corresponding author: Anna Schwarz

TNO

Goal:

At present, accumulation of plastic litter in aquatic environments is not yet included in Life Cycle Impact Assessment (LCIA) methodologies. This blind spot results in an underestimation of the environmental impact of plastic materials. Especially since the negative impacts of plastics through pollution are very visible, this missing impact category might lead to a lower confidence in LCIA as an instrument to measure environmental impact. Before a methodology can be developed, a better understanding on environmental plastic concentration is required. Hence, emission quantities and the variation therein between regions, product types and accumulation areas (environmental sinks) have to be obtained. Therefore, the goal of this study is to obtain quantitative data on emissions of plastic litter in different regions of the world, which is required to assess the concentration of plastics in the environment.

Methods:

The composition of total plastic litter of both plastic polymers (polyethylene, polyester e.d.) and product categories (packaging, building and construction, textiles e.d.) were determined. This was done for six aquatic sub-environments (beaches and freshwater shorelines, sediments and the epipelagic zone in both freshwater and ocean environments). For macroplastics (> 0.5 cm), data was collected through a literature review of plastic litter studies, where plastic litter was divided among plastic product category or plastic polymer type. For microplastics (< 0.5 cm), we used an existing Nanobox model to develop the transport and accumulation in environmental sinks of various microplastic polymer types. Next, global total plastic litter emission quantities in the aquatic environment are obtained from modelling studies and waste management data. With the composition studies, plastic polymers and product categories were distinguished.

Results:

Different plastic polymer types were observed in different aquatic sub-environments. Furthermore, the product category ‘packaging’ was overrepresented in especially freshwater environments, while in oceanic environments ‘industrial’ plastics dominate. Hence, the plastic product category determines the likelihood of the material ending up as plastic litter, while both the product category and plastic polymer type determine the location in the environment where the litter accumulates. The Nanobox study and plastic litter emission quantities are still studied and results will be finalized in September and included in the presentation. This study makes an important step to obtaining concentration values of plastics in the environment. Concentration data is required as input to the methodology. To obtain a complete LCIA methodology results from this study have to be combined with fate, exposure and effect levels of the different plastics polymers, product categories and sizes.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management
3rd September 2019, Tuesday 1:30 - 3:00 pm

Proposing a framework to account for marine litter generation at the life cycle inventory level

Esther Sanyé-Mengual, Simone Nessi, Serenella Sala, Rana Pant

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Goal: Marine litter (or debris) is the "waste created by humans that has been discharged into the coastal or marine environment". Representing between 60 and 90% of the marine litter, plastic debris is arising as an important environmental pressure and urgent policy matter. In the literature, the global generation of macroplastics and microplastics as well as the potential impacts to the marine environment, biodiversity and human health have been evaluated. Plastic marine litter includes macroplastics and microplastics, depending on the size and origin and the litter. Macroplastics (>5mm) and microplastics (<5mm) can be littered not only directly (e.g., beverage bottles on the beach) but also indirectly (e.g., littering from mismanaged landfill) to the environment at any stage of the life cycle of a product, which can eventually be emitted to the marine environment. In Life Cycle Assessment (LCA), the "Medellin Declaration on Marine Litter in Life Cycle Assessment and Management" highlighted the need to develop methods and provide data to address marine litter. In this context, the goal of this contribution is to define a framework for quantifying the generation of macro- and microplastics at the life cycle inventory (LCI) level towards setting the basis of an indicator to address marine litter in LCA.

Methods: Two indicators are proposed to account for the generation of marine litter along the life cycle of products: Cumulative macroplastics generation (CMaG) (kg) and Cumulative microplastics generation (CMiG) (kg). Concerning macroplastics, CMaG can be estimated by applying product-specific marine litter rates (MRL, %) to the mass of each product in the inventory. MRLs are estimated by product type and world region as the ratio between the amount of product littered (based on beach and marine counts) and the amount of product consumed. In the case of microplastics, these can be produced as primary microplastics (i.e., directly emitted as microplastics) or as secondary microplastics, when macroplastics are physically degraded into smaller pieces. Thus, CMiG can be estimated by quantifying the primary and secondary microplastics generation along the life cycle of products. The main sources of primary microplastics considered in this framework are plastic pellets (MiGp), tyres (MiGt), marine coatings (MiGmc), road markings (MiGrm) and synthetic textiles (MiGst) (i.e., cosmetics and dust were excluded as primary microplastics sources). Bottom-up estimations of CMiG are based on literature and adapted to the LCI of products in relation to the mass of products and transported distance, mainly. Regarding secondary microplastics generation (SMiG) can be estimated based on the total amount of macroplastics generated in the inventory by product type and estimated product type-specific degradation rates (i.e., conversion from macro- to microplastic).

Results: The expected results of this contribution expects are developing a framework for quantifying marine litter in LCA at the inventory level and applying it to case studies of plastic products for its verification. The developed framework is also expected to be applied at a larger scale, e.g., EU-28 consumption.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
3rd September 2019, Tuesday 1:30 - 3:00 pm

Ecological design of nitrile glove production : Quantifying the benefit of a new nitrile emulsion production

Tangi SENECHAL, Olivier TALON , Thian Hong Ng

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Materia Nova

In the frame of improving the process of single use nitrile rubber glove production, Synthomer company has decided to focus on the reduction of environmental impact, but not on their own cradle to gate production of nitrile emulsion, rather on the capacity of their development to reduce energy consumption during the dipping process of their customers. In order to quantify and possibly confirm the environmental gain, Life Cycle Assessment (LCA) has been used from the chemical emulsion process to the glove production, comparing the newer process to classical ones.

LCA is a methodology ruled by ISO (14040, 14044) standards that enables to evaluate the potential environmental impacts, for a series of impact categories including climate change but also, among others eutrophication or human health issues, of a product system. LCA encompasses all life cycle steps of the studied system, from raw material extraction to end-of-life treatments, including production phase, use phase and transports. A LCA study involves 4 steps: definition of goal and scope of the study, establishment of the inventory, impact calculation and interpretation. All exchanges between the studied system and the environment are compiled during the inventory step, and those flows are translated into environmental impacts through consensually approved scientific calculation methods.

In this paper, we used LCA tools and methodology to evaluate the environmental relevance of a new process for producing nitrile rubber gloves, in order to answer multiple questions: 1) are these gloves competitive, in terms of sustainability, with other gloves for the same application; 2) can this new process be considered as greener than our former process; 3) what are the environmental hotspots in the life cycle of our gloves, and on which production or other life cycle steps should we focus further eco-design efforts in order to achieve the best possible environmental optimization.

Interestingly, the impacts calculated with SimaPro software for nitrile emulsion production do not present an advantage for the newer process, mainly due to different chemical formulations. The analysis of glove production by dipping highlight an important influence of the energy use, compared to raw materials including nitrile emulsion.

Moreover, gloves produced from different formulations are not of the same thickness and different material consumption. Despite not being the more “environmentally friendly” formulation, the use of the newer nitrile emulsion in the dipping process allows to consume less energy, leading to gloves less impacting in every environmental category. It allows also to notice the importance of the definition of the functional unit.

In conclusion, the LCA study helped quantifying the environmental benefit of eco-designing an upstream formulation to improve the production of the final product. No benefits were calculated for the cradle to gate emulsion production of Synthomer, but a clear benefit is quantified for their customer.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
3rd September 2019, Tuesday 1:30 - 3:00 pm

Advanced mineralogical characterization and beneficiation: A key to cost efficient and safe exploitation of secondary geomaterials

Marja Lehtonen, Alan Butcher, Arno Kirpala, Tero Korhonen, Jukka Kuva, Yann Lahaye, Sari Lukkari, Hannu Tapani Makkonen, Mikael Niemistö, Hugh O'Brien, Antti Taskinen, Mia Tiljander

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Geological Survey of Finland

GOALS

The concept of circular economy creates a variety of potential secondary mineral-based raw materials. These secondary geomaterials include tailings, land masses, slags, ashes, dusts, and other side streams from mining, construction, industry and waste management. Many of the secondary geomaterials are already used for metal, chemical and power production, building, manufacturing, 3D printing, and for various additional purposes. However, the full potential and risks of secondary geomaterials have not yet been thoroughly investigated. They may have, for example, yet unexploited potential for valuables or unpredictable hazardous properties. In order to optimize their economic and safe usage and to predict their long-term behavior, it is crucial to characterize them profoundly by adapting the methodologies designed for primary geological materials: rocks, minerals and sediments.

METHODS

Geological Survey of Finland (GTK) hosts a unique mineral processing and materials research facility in Europe. The establishment covers the entire research chain from nanoparticles to micron scale major, trace and isotope compositional studies, to 2D- and 3D-structural characterization, to bench-scale testing to tens or hundreds of tons pilot scale work for proof of concept. Cutting edge research instruments allow one to study the elemental deportment of valuable and toxic elements into specific phases, their characteristics and properties, such as grain size distribution and associations to other phases. Versatile processing methods can be applied to concentrate and quantify the valuable and/or hazardous components in an optimal way. Side streams and by-products that form during the process are also characterized. Their chemical and mineralogical composition, geochemical properties and structure are studied for their potential and risks as raw materials.

RESULTS

The degree of utilization of secondary geomaterials can be increased in a cost-efficient and safe way by applying geological knowledge in their characterization and beneficiation tests. The resulting concentrates signify either commercial products or considerable volume reductions of toxic waste. Multidisciplinary and scientific approach is needed to predict the long-term behavior and optimal usage of secondary geomaterials. Mineral processing and materials research facility in Finland provides an exceptional testing ground for a variety of secondary geomaterials.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity
3rd September 2019, Tuesday 1:30 - 3:00 pm

Methodological framework for incorporating circularity elements into modeling of EOL recycling credits across lives of plastic products

Ananda Sekar, Ashok Menon

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SABIC

Circularity of plastics has taken a prominent position in European policy development with recent launch of Circular Economy Action Plan which among others, focuses on reducing single use plastics besides setting ambitious targets for recycling rates. Its growing significance is closely linked to other global issues such as ocean littering of plastics. Ellen MacArthur foundation has been involved in the development of indicators for Material circularity. With such evolving developments related to the quantification of circularity, it is imperative for a harmonized approach towards alignment and linking of circularity principles into LCA and vice versa.

Based on recent statistics from various sources including PlasticsEurope (2018)4, about a third of all plastic waste generated in Europe is effectively recycled via mechanical recycling; a little over a third is being incinerated for energy recovery and the rest is being landfilled. This implies that roughly two-thirds of the plastic waste is linked to a linear economy. Also, the polymers that are mechanically recycled undergo deterioration of mechanical properties leading to reduction in functionality and economic value potential.

Recent technological developments enable an alternate approach to recycling of polymers. Captured under the broad definition of "Chemical recycling", this can range from a single step direct recycling of monomers to chemical conversions that recover or re-form precursors to monomers, thereby leading to production of chemically recycled polymers that match virgin like properties and hence enriched value and functionality. This differentiation in product functionality and its potential for its limitless recyclability is not being fully captured by current LCA methodological framework, especially related to handling of EOL credits. Recent introduction of CFF (Circularity Footprint Formula) does capture the quality of recycled materials towards calculation of allocation of burdens across lives of plastic materials but through a traditional attributional LCA lens, this does not capture the potential advantages offered by chemical recycling.

Thus this requires a system level framework to assess product footprints of chemically and mechanically recycled polymers from life cycle perspective. The oral presentation will covers a proposed framework that introduces the use of multi life quality parameters to capture the differentiation in preservation of material quality between chemical and mechanical recycling. This methodology takes into account the following factors: 1. functionality reduction or quality equivalence of the recycled polymer 2. recycling rate 3. accumulative property retention factor. This presentation will also cover preliminary results based on a sample case study. Based on this calculation framework, after 3 or 4 life cycles, the property value or virgin equivalence matches only about 60% of value of virgin plastics. Chemical recycling does not lose property after several recycles as the pyrolysis process ensure the monomeric molecules are rebuilt again, ensuring full retention of mechanical properties. This could lead to 30% reduction in virgin feedstock requirements and substantial economic value in comparison to mechanical recycling. The study also proposes changes to LCA framework towards incorporation of these new dimension in circularity of polymers.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 1:30 - 3:00 pm

Trends in environmental performance of emerging biofuels in Australia

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Lifecycles

Goal

A Life Cycle Assessment of 20 emerging biofuel production pathways was undertaken to support the development of bio futures program in one of the Australian Northern states. The purpose of the LCA was to identify feedstock and conversion technologies which deliver GHG savings while limiting impacts on other environmental endpoints. The study also supports legislation which requires biofuels used to meet the Queensland biofuel mandate to be "sustainable" and is a follow up from an LCA of 10 existing or near future biofuel pathways (Grant, Bontinck et al. 2016).

Method

Data was collected through survey and personal interviews with more than 10 biofuel proponents using six different production processes (Ethanol using fermentation& distillation, biodiesel using transesterification, Renewable diesel pyrolysis, Renewable diesel catalytic depolymerization and Renewable diesel destructive distillation, Renewable diesel using Fischer Tropsch process) and 11 different feedstocks (agave, cotton gin trash, sugar cane juice, sugar cane biomass, prickly acacia, forestry residues, agriculture residues, municipal solid waste, residential green waste, source separated food waste and used tyres).

The data supplied varied the identification of a processing pathway and feedstock, through to detailed processes diagrams and mass balances. Because the focus was on emerging biofuels, data availability and quality varied substantially, so gaps in processes were filled with published research, stoichiometric calculations and analogous processes. The LCA follows the guidance provided by the Australian Renewable Energy Agency (Grant and Bengtsson 2016) which is closely aligned to the requirements of the ISO standard on Sustainability criteria for bioenergy (International Organization for Standardization 2015). The meant that by comparing the bioenergy system to business-as-usual (BAU) system, the alternative fate of the different feedstocks had to be modeled and included in the LCA.

Results

The results of the study showed that 17 of the 20 biofuels pathways had a greenhouse gas benefits of great than 20% over the conventional fossil fuel alternatives, which is the threshold for approval under the Queensland biofuel legislation. The three pathways which failed to achieve this benchmark all involved substantial storage of carbon in landfill as part of the alternative fate of tires and wood waste in the BAU option. Fuel pathways which utilize bioenergy for the production process and or generate electricity as a coproduct performed better than those which do neither. The pathways which removed degradable organic material from landfill can have enormous climate change benefits as methane emissions from landfill are avoided. Several of the renewable diesel pathways had substantial benefits from production carbon by-products however the ultimate markets from these was difficult to determine, with carbon black, char and coking carbon all being possible. Several crop-based biofuels have good climate change performance but do have higher impacts on land and water use indicators that the benchmark fossil fuel system. In general, the biofuel pathways emerging in Australia currently show dramatic improvement in environmental performance to those assessed in 2001 in the CSIRO comparison of transport fuels. (Beer, Grant et al. 2001)

Beer, T., T. Grant, G. Morgan, J. Lapszewicz, P. Anyon, J. Edwards, P. Nelson, H. Watson and D. Williams (2001). Comparison of Transport Fuels - Final Report to the Australian Greenhouse Office on the Stage 2 study of Life-cycle Emissions Analysis of Alternative Fuels for Heavy Vehicles. Aspendale, CSIRO.

Grant, T. and J. Bengtsson (2016). Life Cycle Assessment (LCA) of Bioenergy Products and Projects. Canberra, ARENA.

Grant, T., P.-A. Bontinck, B. Sharma and M. Renouf (2016). Greenhouse gas and sustainability footprints of current and future biofuels for Queensland. Melbourne, Australia, Lifecycles.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 1:30 - 3:00 pm

Life cycle impact assessment of combined fuel and protein production from microalgal biomass

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Ludwig-Maximilian-Universität München

Goals

Producing sustainable liquid fuels from microalgae – companies, governments and research groups around the world pursue this goal. In this context, the German research project Alpines AlgenKerosin (AAK) is developing a new approach. By applying a unique combination of existing and newly developed technologies, the consortium aims to maximize the economic and ecological benefits of algae-based fuels. This paper for the first time presents the AAK process to the public. We present a Life Cycle Inventory (LCI) based on preliminary experimental work of the consortium. We further present a Life Cycle Impact Analysis (LCIA) and compare the results to a conventional reference process.

Methods

We used engineering first-principles to establish mass- and energy balances of the AAK sub-processes. Downstream and upstream processes are modelled using data from the ecoinvent v3.5 database, choosing Allocation at the Point of Substitution as the system model. By-products are treated using displacement methods. Impact assessment is based on International Life Cycle Data system (ILCD) 2.0 midpoint methods. Models of the reference processes are taken as-is from the ecoinvent database. We calculated the relative LCIA contributions of the AAK subprocesses to identify the main drivers of the overall environmental impact.

Results

Our results show a mixed picture of the AAK process' environmental impact. As CO2 for algae nutrition is captured from air, the fuel product shows a significant GHG reduction compared to the conventional reference. Furthermore, we see reduced impacts in the categories marine eutrophication, photochemical ozone creation and land use. However, the product performs worse than the reference in all other ILCD-recommended impact categories. We identified algae cultivation as the main-contributor to the overall environmental footprint. Future work should particularly focus on replacement strategies for artificial fertilizers.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels
3rd September 2019, Tuesday 1:30 - 3:00 pm

The environmental impact of bioenergy for residential heating: Life Cycle Assessment (LCA) of renewable heating with pyrolysis oil from five different biomass feedstocks

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BTG Biomass Technology Group BV

Goal

To meet the requirements of the Paris agreement, greenhouse gas (GHG) reductions are necessary in all fields. One field where significant GHG reductions can be obtained is the domestic GHG production, which was responsible for 19% of GHG emissions in 2014.1 The majority of these emissions can be contributed to heat and warm water, which is responsible for 79% of the residential energy use in EU households.1

Increasingly efficient boilers and energy saving measures can slowly decrease the GHG from residential heating. However, to make a significant difference, a different source of energy needs to be found. An interesting alternative is the use of pyrolysis oil for residential heating. Pyrolysis oil can be obtained from several different biomass feedstocks, that are currently considered as residues.

Before promoting a switch to pyrolysis oil for residential heating, it has to be clear if this indeed results in a reduction in GHGs. Moreover, problem shifting, where the emissions on one part of the chain is shifted to a different part of the chain, has to be avoided. Also, the use of pyrolysis oil should not lead to other negative impacts, such as an inadmissible increase in acidification or fine particulate matter formation.

Method

In this study, the full impact of pyrolysis oil for residential heating is determined, using the methodology of a Life Cycle Assessment (LCA). The entire process chain, from biomass production to the generation of residential heat, is investigated. The resulting impacts are calculated using ReCiPe2016 and compared to those of current fossil methods (heating with natural gas and light fuel oil) and a bioenergy alternative (heating with wood pellets). Moreover, five different pyrolysis feedstocks are investigated in order to determine the value chain with the lowest environmental impact.

Results

The LCA clearly shows that residential heating with pyrolysis oil has many environmental benefits. In two chosen endpoint scores, human health and resource scarcity, bioenergy significantly outperforms fossil heating. The third impact category, ecosystems, results in similar impacts, where bioenergy scores slightly higher or lower depending on the feedstock used. Overall, bioenergy heating options are shown to have a lower environmental impact than fossil heating options.

SESSION T1-4 Sustainable Health Management – Performance of Health Services
3rd September 2019, Tuesday 3:30 - 5:00 pm

The Environmental Impact of Hospitals

Matthias Stucki, Regula Keller, Karen Muir

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Zurich University of Applied Sciences

1. GOAL

Which aspects of a hospital are relevant from an environmental point of view? Which impacts can realistically be reduced? The project "Green Hospital" aims to identify the environmentally relevant processes in hospitals as well as to suggest practical improvement options that at the same time increase the efficiency of the underlying processes. Although healthcare was determined to be the consumer sector with the fourth largest environmental impact, most research focuses on the three largest sectors: nutrition, mobility, and housing. Our research aim to fill the gap.

2. METHODS

A preliminary LCA was carried out using rudimentary data obtained by questionnaire from several hospitals in Switzerland. The results of this analysis were combined with the results of an improvement potential analysis carried out by project partners from the Fraunhofer Institute for Material Flow and Logistics to determine which environmentally relevant processes also have significant improvement potential. Detailed questionnaires were then sent to two partner hospitals to collect data in these specific areas. A second, more detailed LCA is currently being carried out to quantify the environmental impact of hospitals.

3. RESULTS

Catering, heat production and electricity were found to be the most environmentally relevant in our preliminary LCA. The five areas identified in our this analysis were: catering, energy provision, transport and mobility, waste treatment, and medicine, medical products, laundering, housekeeping and office supplies. For these chosen areas, specific data was collected to allow a broader scope for the second analysis. The results of the detailed analysis will be combined with the results of the process analysis to compile a list of best practices. Our partner hospitals will implement chosen practices later in the project. These will lead to reduction in the environmental impact along with an improvement in efficiency.

SESSION T1-4 Sustainable Health Management – Performance of Health Services

3rd September 2019, Tuesday 3:30 - 5:00 pm

Enabling sustainable healthcare through LCM in the pharmaceutical industry

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Corresponding author: Yasmine Emara

Technical University Berlin

Goal: Over the last few decades, a global rise in pharmaceutical consumption led to a parallel increase in the presence of pharmaceuticals in the environment and fuelled concern over the environmental impacts associated with human medications. The use of life cycle thinking and life cycle assessment (LCA) in the pharmaceutical industry is afflicted with several methodological shortcomings, as there are inconsistencies in LCA application to pharmaceutical products and processes (e.g. regarding the choice of system-boundaries or impact categories) and – at the current state of affairs – the methodology fails to include relevant flows (e.g. pharmaceutical emissions during the use- and end-of-life (EoL) phase of pharmaceuticals) and several pharma-specific impacts (e.g. endocrine disruption or antibiotic resistance). The aim of this project is to develop a robust and applicable LCA-based approach for assessing environmental impacts of pharmaceutical products and processes. Methods: On the basis of a review of the scientific literature (including LCA studies) on the harmful environmental effects of pharmaceuticals, first recommendations for product category rules (PCRs) are made. As part of the PCRs, a new approach to help model the use- and EoL of pharmaceutical products is under development, establishing a framework for modelling pharmaceutical emissions after the consumption phase. Additionally, new characterization models for endocrine disrupting chemicals as well as for antibiotics are developed in order to integrate their effects into the existing LCIA framework. The “draft PCR” and the new characterization models are tested in several product- and process-related case studies (e.g. production of an established pharmaceutical, development of a new nano-pharmaceutical). The whole project is supported and evaluated by an accompanying group of experts from politics, science, industry as well as non-governmental organizations.

Results: Final PCRs are developed for pharmaceutical products and processes and a new characterization models established. The new LCA-based approach for the pharma sector enables and enhances the practical implementation of LCA – and hence of life cycle management (LCM) – in that sector, thereby allowing pharmaceutical companies to comprehensively analyse the environmental performance of their products and providing input to sustainable healthcare systems.

This LCM conference will be used to share first results of the project – the PCRs, new characterization model(s), use and EoL model – with the international LCA community and with other interested parties, e.g. from the pharmaceutical and/or chemical industry.

SESSION T1-4 Sustainable Health Management – Performance of Health Services
3rd September 2019, Tuesday 3:30 - 5:00 pm

Environmental Impact of Digital Adherence Monitoring in Poorly Controlled Paediatric Asthma

Andy Whiting, Nigel Budgeon, Leonie Campbell, Michael Collins

Corresponding author: Andy Whiting

ERM

This appraisal considers the environmental impacts of poor control and improved control of paediatric asthma by use of intelligent digitally connected Dry Powdered Inhalers (DPI). In doing so, we assessed the life cycle environmental impacts of an Astra Zeneca inhaler and an Adherium smart inhaler device

The study conforms with the 2012 Greenhouse Gas Protocol Pharmaceutical and Care Pathways: Guidance on Appraising Sustainability. This guidance was used to assess the impact of the poor and improved patient care pathways.

This study estimates for a patient with poorly controlled asthma a reduction of overall greenhouse gas (GHG) emissions by around 50%, from improved adherence when using a DPI Smartinhaler™ device. Waste production and water consumption were estimated to be similarly reduced by Smartinhaler ™ device use, by around 60% and 32% respectively.

SESSION T3-6 Sustainable Product Portfolio - Best Practice and Tools for PP Management
3rd September 2019, Tuesday 3:30 - 5:00 pm

Identifying the sustainability stars in your product portfolio

Eric Mieras, Anne Gaasbeek

Corresponding author: Anne Gaasbeek

PRé Sustainability

Goal:

A growing number of companies would like a more holistic view on the environmental and social performance of their products. Instead of focusing on one specific (group of) products they would like to understand how this product (group) compares to other products within their portfolio on sustainability. Sustainable product portfolio assessment allows companies to take sustainability assessment to the next level. Whereas LCA focuses mainly on one product or product group, a product portfolio assessment provides companies insights in the high performing product-market combinations and the product-market combinations which are challenged from both a sustainability perspective as well as from an operational perspective. Assessing products from two perspectives (market alignment and operational performances) makes in our experience the assessment much more understandable for financial and marketing experts within a company than LCA.

Method:

We have developed an approach based on the framework for portfolio sustainability assessment from the WBSCD. The portfolio assessment does not look at specific environmental and social indicators but takes a more high level approach by assessing to what degree the products are aligned with the market performance on the most material social and environmental issues. On the other axe the operational vulnerability is taken into account, as revenue cannot be at a too high environmental or social expense. On basis of this assessment the reference product within a product portfolio can also be established.

Results:

When taking these two dimensions into account products can be plotted on basis of their market alignment with the social and environmental performance and their operational vulnerability. We will illustrate this with a case study during our presentation. Providing companies insight in which product (groups) are at risk and which are the potential sustainability stars within the company's portfolio.

SESSION T3-6 Sustainable Product Portfolio - Best Practice and Tools for PP Management
3rd September 2019, Tuesday 3:30 - 5:00 pm

Life cycle tools for assessing the sustainability of steel products from early stages of development through to commercialisation.

Nick Coleman, Peter Hodgson, Simon Ryalls, Mireille Rack,

Corresponding author: Dr Nick Coleman

Tata Steel

Society is becoming increasingly aware of sustainability issues associated with the use of materials. This is not just in terms of climate change but also in the context of themes such as the circular economy and responsible sourcing. The ability to evaluate and communicate the attributes of a new or existing product in terms of these issues is therefore growing in importance. Within Tata Steel, tools based on the principles of life cycle thinking have been developed, to assess the sustainability of both existing products and those which are in development.

Well established tools such as those based on Life Cycle Assessment (LCA) methods have provided the basis for evaluating the environmental attributes of Tata Steel's existing product portfolio. This has been refined to the point where it is now possible to provide product specific Life Cycle Inventories or Environmental Product Declarations, which cover different variants within the same brand.

However, experience had shown that when a product is at the early stages of development, and issues beyond the environmental dimension are to be considered, there is a compelling case for a more streamlined approach. For example, at an early stage of product development, data is less readily available than for established products, and therefore poses a number of challenges from an eco-design perspective. This has led to the creation of a New Product Development Sustainability Assessment Tool (NPD-SAT), which covers a broad spectrum of social, environmental and economic issues. The tool allows a product development team to gain some insights into the relevant issues, at an early stage, and is now being applied across all new product developments within Tata Steel Europe.

The NPD-SAT is based on the principles of life cycle thinking and through the STYLE Horizon 2020 project, which involved partners from a range of process industries, the tool was tested externally. This led to further refinements to the methods applied. Learnings from this project also fed into a STYLE roadmap, which made a series of recommendations to support the further development of such tools.

SESSION T3-7 Sustainability as a Part of Supply Chain Management in Organisations
3rd September 2019, Tuesday 3:30 - 5:00 pm

Organisational LCA in corporate sustainability target setting and implementation

Joana Almeida, Maisie Auld, Nicole Thompson, Jonas Bengtsson

Corresponding author: Joana Almeida

Edge Environment

Goal

Upstream and downstream environmental and social risks and impacts are increasingly being considered material in organisations' sustainability strategies. Yet, many organisations struggle to quantify and appropriate manage impacts and risks outside their direct control and operations. The aim of this presentation is to discuss the application of O-LCA in broader corporate sustainability strategy development and implementation. The examples will be drawn from three concluded studies on large Australia-based organisations from the telecom, aged-care and sports events sectors.

Methods

This presentation will focus on three corporate examples of applying organisational life cycle assessment (O- LCA) to:

- Quantifying scope 1, 2 and 3 greenhouse gas emissions and setting carbon reduction targets in accordance with the Science-Based Targets initiative;
- Establishing modern slavery risks in supply chains to manage corporate responses to the Australian Modern Slavery Act; and
- Informing sustainable procurement in accordance with the ISO 20400 guidelines.

These applications require mapping of potential social and environmental impacts across large supply chains, while also modelling detailed impact reduction scenarios and communicating the approach to internal and external stakeholders. This required a hybrid approach of O-LCA, hotspot analysis and input-output LCA. The presentation will also described how the O-LCA was integrated with corporate initiatives of strategy development and reporting.

Results

The presentation will describe and discuss the benefits and challenges from using an O-LCA approach, how data was managed and communicated with corporate stakeholders and the key outputs from the three examples.

SESSION T3-7 Sustainability as a Part of Supply Chain Management in Organisations
3rd September 2019, Tuesday 3:30 - 5:00 pm

Integrare Program: Adding value and promoting sustainable business in the Supply Chain

Taísa Cecília de Lima Caires, Umberto Brito, Helene Menu, Graziella Tramutola

Corresponding author: TAISA CECÍLIA DE LIMA CAIRES

Espaço ECO Foundation

One of the biggest business risk pointed out by the Allianz Risk Barometer (2018) is the interruption of supply in the value chain. Causes for this interruption are diverse, from fire and explosions, natural disasters to bankruptcy and insufficient management of social and environmental risk. The challenges are enormous, both for large companies and small businesses that need to meet the requirements to supply to large companies. In Brazil, supply chains are mostly composed by small businesses, which according to Sebrae (2018) study, small and micro enterprises (SME) represent more than 90% of the total brazilian companies, out of these 12% are companies that belong to the industry sector. In 1999, Integrare Project was created as a non-profit association, to promote sustainable development and to make feasible equal business opportunities between entrepreneurs belonging to minorities group (indigenous, people with disabilities and afro-descendants) and large corporations. After joining Integrare organization, large companies have access to pre-qualified small suppliers who deliver products or services. To integrate the Integrare's database, the small enterprises need to participate in some trainings and a pre-qualifying assessment to enable them to intregrate the value chain of big companies. After nineteen years operating, 1100 entrepreneurs are part of the Integrare Project, 19% are enabled to take part in selection process with compliance quality in big coporations, over 160 companies already did business with equal opportunity condictions, 220 million of dolars were generated in business between large companies and small businesses. In 2018 BASF, one of the big associated companies, member of this association since May 2012 promoted many meetings between her own buyers and Integrare’s suppliers in order to improve the business and align requirement between parts. This action allowed small companies to integrate BASF’s supply chain, generating 7 million euros in business with Integrare suppliers from 2016 to 2018.. Although the results of the initiative have been positive, the challenge of integrating SMEs into large supply chains is still big. Thinking about that, together with the Espaço ECO Foundation (FEE), a specialized consultancy to promote sustainability in the business environment through life cycle thinking, Integrare will start a project to identify the competitive differential of such partnership, to understand the difficulties of these small companies to attend to big companies’ supplying rules and finally identify potential improvements for the Program. The project is composed by three steps, first of all an analysis of the initiative carried out with purchasing companies and suppliers, after a documentary analysis of Integrare's validation criteria and improvement potential and last one step in Action plan and recommendations. Our goal is to ensure the continuity and success of sustainable business between big companies and small companies traditionally excluded from classic value chain.

SESSION T3-6 Sustainable Product Portfolio - Best Practice and Tools for PP Management
3rd September 2019, Tuesday 3:30 - 5:00 pm

SPM tool for Sustainable decision-making

Corresponding author: Alain Wathelet

Solvay SA

The Sustainable Portfolio Management (SPM) is a fact based and robust compass to steer Solvay's portfolio toward better business because more sustainable.
SPM is designed to boost Solvay's business performance and deliver higher growth.

With SPM, decision-makers are informed on the contribution of Solvay's products to sustainability considering both:

- Their environmental manufacturing footprint and its correlated risks and opportunities – vertical axis – quantitative assessment by 19 impact indicators.
- How in their applications they bring benefits or faces challenges in a market perspective – horizontal axis – qualitative assessment by 60 questions on social and environmental topics.

In short, SPM mapping is summarized in 5x5 matrix (see attachment)

With

1. Operations Vulnerability (vertical axis) is the ratio of monetized environmental footprint of products over their sales value. In other words, it is the monetized environmental manufacturing footprint per 1 EUR of revenue.

The higher the ratio, the higher the risk for Solvay of losing business to more sustainable solutions.

The lower the ratio, the higher the probability to displace a less environmental-friendly competing technology.

2. Market Alignment (horizontal axis) of products in their application analyzes the market signals of sustainability benefits and roadblocks and categorizes products on a five-scale spectrum from 'challenged' to 'star potential'. It analyzes whether one product in a given application is part of the sustainable development solution or part of the problem from a consumer and market perspective.

SPM tool is used to steer the product portfolio and also to pilot the R&I project towards more sustainable solutions, and to evaluate the investment projects. It was also shown that product in the "Solutions" area generates a significantly higher growth on the market than competitive ones.

Moreover, with this tool, Solvay is able to present their products not only in term of volume and price, but also offer to customers a real added value in term of sustainability for the society and the users which is a key differentiator for the business.

SESSION T4-2 Integration of Sustainable Development Goals Assessment and Bottom-Up LCA
3rd September 2019, Tuesday 3:30 - 5:00 pm

RenovaBio: the Brazilian biofuels policy and its Carbon Intensity calculator

Michelle Scachetti, Anna Pighinelli, Marília Folegatti, Juliana Picoli, Marcelo Morandi, Renan Novaes, Gustavo Bayma, Nilza Ramos, Joaquim Seabra, Marcelo Moreira, Mateus Chagas, Antônio Bonomi, Otavio Cavalett

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BASF - FUNDAÇÃO ESPAÇO ECO

It is well-known that the world is undergoing an energy transition due to global awareness regarding the climate change making the biofuels a consistent option for large-scale fossil fuel substitution.

Considering Brazil`s large tradition in producing bioenergy the country`s government assumed a Nationally Determined Contribution (NDC) during COP-21 which includes the reduction of GHG emissions of 43% by 2030. To fulfill the commitment, the Brazilian Energy sector proposes, among other goals, to increase the share of bioenergy in the national energy matrix to approximately 18%. As most emissions in the energy sector are related to transportation, one of the strategies for achieving this goal is to expand the biofuels consumption. In order to promote stability of the biofuels market and to achieve NDC, the Brazilian Ministry of Mines and Energy (MME) launched in December 2016 the RenovaBio Program. One year later it became a Federal Law (nº 13.576) which stablishes the Brazilian Biofuels Policy. By drawing up a joint strategy to recognize Brazilian biofuels contribution to energy security, predictability and mitigation of GHG emissions, RenovaBio has been acknowledged and praised in different spheres of society. The development of the program has occurred in a transparent way and with the involvement of research and academic institutes, private industries and sectors associations. RenovaBio encourages each biofuel producer unit to submit data for calculating Carbon Intensity index (g CO2 eq./MJ). The current Brazilian fuel matrix CI value is 74.25 g CO2 eq/MJ and in June 2018, national authorities set a GHG reduction target of 10.1% by 2028. This target will become individual targets and applied to fuel distributors. To achieve those targets distributors will need to acquire the so called CBIOs (decarbonization credits available as bonds to be freely traded on the stock market). Each CBIO corresponds to one tonne of CO2 that has been avoided and is calculated by multiplying the Environmental-Energy Efficiency Grade by the biofuel commercialization volume. The grade corresponds to the difference of the CI from a fossil to its biofuel alternative (e.g. gasoline and ethanol). Therefore, a customized LCA-based tool (RenovaCalc) was developed for a multidisciplinary team (LCA, LUC, GIS experts), to run calculations and support RenovaBio certification scheme. RenovaCalc`s framework is based on "well to wheels" attributional LCA approach using energy allocation criteria for calculating of Sucarcane and Corn Ethanol, Biodiesel, Biomethane and Biojetfuel grades. Background data (carbon profiles of inputs, like fertilizers, electricity, etc.) comes from Ecoinvent 3.1 and emission and characterizations factors from IPCC. With its powerful tools and mechanism, it is expected that RenovaBio can stimulate competition and encourage producers to be more efficient taking a Life Cycle Management approach in its routines. Research and innovation in new technologies development for system improvement (e.g. machinery efficiency, chemicals, fuels and fertilizers changes towards sustainable sources) and price and market analysis tends to grow with the success in RenovaBio implementation.

SESSION T4-2 Integration of Sustainable Development Goals Assessment and Bottom-Up LCA
3rd September 2019, Tuesday 3:30 - 5:00 pm

A Life Cycle impact pathway framework for the SDGs

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Goal: To provide business-relevant Life Cycle Inventory indicators and a quantitative Life Cycle Impact Assessment (LCIA) framework for the UN Sustainable Development Goals (SDGs), so that specific decisions can be related to the goals. The target group is organisations that wish to expand and substantiate their current environmental assessment work towards a more complete quantitative Life Cycle Sustainability Assessment, capturing both beneficial and detrimental impacts on all 17 SDGs in a comprehensive and consistent way, avoiding overlaps and gaps, and obtaining impact assessment results in comparable units that can potentially be expressed in monetary values and integrated with internal and supply-chain costing data.

Method: From existing scientific literature, the causal pathways have been identified from human activities to the Areas of Protection for each of the 17 SDGs. Each of the impact pathways have been developed with a starting point in midpoint impacts, measurable by indicators of annual human-induced annual increase or decrease in the relevant safeguard subject. The causes of these human-induced changes are then identified, based on the available scientific literature, providing a comprehensive description of the relevant (Life Cycle Inventory) activity and pressure indicators, (LCIA) midpoints, and endpoints. To ensure completeness of the model, one of the identified causes for each impact category is then characterised as the default impact pathway for any residual impact that cannot be explained by more specific impact pathways, so that all known impacts are traced back to a human activity. Next, characterisation factors are identified from the best available and authoritative data sources, relating each midpoint impact category backwards to pressure indicators and forwards to a single endpoint measure of sustainable wellbeing, based on well-established principles from welfare economics, following ISO 14008. Each official SDG indicator has been placed within this framework, showing its role in the overall impact pathway framework and pointing out missing indicators. The project identifies quantitative data sources for each indicator in the framework as well as priorities for further research. Uncertainty is provided on all data for the numerical indicators and applied when assessing the relative importance of the different impact pathways.

Results: Within this short abstract it is not possible to describe all the impact pathways. However, an example from the topic of “undernutrition” (topic of SDG 2) can be provided, namely the pathway leading to the midpoint impact category Suboptimal infant feeding practices, which is measured as weeks of premature cessation of breastfeeding: First, this midpoint impact category is related to two workplace pressure indicators Insufficient paid breaks for breastfeeding and Premature return to work after giving birth. The residual, not explained by these two pressures, is then attributed to the impact category Insufficient health care system, which is further related back to the pressure indicator Underpayment of labour or taxes. Finally, characterisation factors for each of these relations are identified, based on, e.g., ILO data and global studies reporting on the changes in the rate of exclusive breastfeeding in response to legal or contractual guarantees of paid breaks for breastfeeding.

SESSION T4-2 Integration of Sustainable Development Goals Assessment and Bottom-Up LCA
3rd September 2019, Tuesday 3:30 - 5:00 pm

Indicators of Sustainable Development Goals (SDG) as gauges of environmental sustainability?

Mikołaj Owsianiak, Alexis Laurent, Jette L. Marcher, Simone L. Hansen, Yan Dong, Michael Z. Hauschild

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Goal: The 2030 agenda for sustainable development, with its 17 sustainable development goals (SDG), 169 targets and 232 corresponding indicators, has identified areas of critical importance for humanity and the planet. Our previous work has identified 10 challenges for implementing the SDG agenda that life cycle engineering (LCE) community could help tackle and in a consultation process with LCE community a number of potential solutions to the challenges were proposed. For example, one potential solution to the challenge of decoupling economic growth from environmental impacts could be to develop key performance indicators (KPIs) for SDGs for companies and products. To determine whether solutions like this could be effective, we assessed the potential of environmentally-relevant SDG indicators to actually steward society towards environmental sustainability.

Methods: Inspired by three other environmental sustainability frameworks, namely driver-pressure-state-impact-response (DPSIR), life cycle impact assessment (LCIA) and planetary boundaries, the environmentally-relevant SDG indicators were evaluated with respect to their: (1) coverage of key environmental sustainability areas of concern, (2) consideration of absolute targets derived from ecological limits of the planet, (3) relation to their underlying targets and the goal, and (4) position on cause-effect chains linking pollutant emissions or resource consumption to eventual environmental damages.

Results: A total of 11, 13 and 17 out of 41 indicators address human health, ecosystem quality and resources, respectively, with much smaller number of indicators addressing ecosystem services and cultural values (1 each). The indicators are either inventory, or midpoint, or endpoint indicators, depending on the SDG target. The majority of indicators do not consider absolute environmental boundaries and do not define sustainability criteria (33 out of 45), assume that anticipated level of reduction is sufficient to make given sector sustainable (8 out of 45), or focus on efficiency in performing on the target rather than on effectiveness in reaching the target (8 out of 45). About one third (17 out of 45) of the SDG indicators is either misaligned with their corresponding target or assume that there is an obvious link between indicator and the target (4 out of 45). Overall, our results indicate that although the SDG framework can be given a credit to raise awareness in society on achieving sustainability, meeting the SDGs is not enough to achieve the state of environmental sustainability.

SESSION T4-2 Integration of Sustainable Development Goals Assessment and Bottom-Up LCA
3rd September 2019, Tuesday 3:30 - 5:00 pm

The Food Loss and Waste Value Calculator: A publicly available Life Cycle Management tool to improve efforts towards SDG 12.3

Alexi Ernstoff, Brecht De Roo, Chris Brown, Dalma Somogyi, and Sebastien Humbert

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Quantis

Goal:

The FAO estimates that globally 30% of food produced is lost or wasted along the value chain, inspiring Sustainable Development Goal (SDG) 12.3 that promotes halving food loss and waste (FLW) across the value chain by 2030. Nevertheless, knowledge gaps remain on how to align SDG 12.3 with sustainability metrics (like greenhouse gas emissions). Resolving this knowledge gap is essential to effectively inform decision making because foods have different production and disposal impacts as well various nutritional value. The goal of this study was to create a user-friendly and publicly available tool that uses bottom-up data from a Life Cycle Management perspective. In this way, decision makers can move beyond thinking of FLW as simply a homogenous quantity to reduce by half, but as an issue related directly and quantitatively to environmental sustainability.

Methods:

To respond to knowledge gaps and guide decision making, Quantis created the FLW Value Calculator (http://flwprotocol.org/why-measure/food-loss-and-waste-value-calculator/) supported by the Food Reform for Sustainability and Health (FReSH) initiative of the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). The Calculator instantly calculates the value of FLW with respect to environmental impacts and nutrition. The FLW Value Calculator screens the impacts of FLW with respect to 1) the agricultural impacts of food production for various crops in various regions, 2) the life cycle impacts and 3) the impacts of FLW destinations (e.g. landfill). The Calculator uses agricultural impact assessment, building on LCA expertise and available LCI databases (e.g. World Food LCA Database), and applies basic scenario assumptions for the destinations in order to calculate impacts. The calculator also considers the nutritional value. The Environmental Footprint method of the European Commission was applied. All methodological assumptions are detailed in the publicly available Calculator file.

Results:

The results of the Calculator demonstrate that the environmental impacts of various FLW streams due to their agricultural impacts vary greatly. This knowledge is already well established in the LCA community, but is less understood with respect to SDG 12.3. The Calculator demonstrates that the impacts of FLW vary greatly depending on the food and the FLW destination. For example, incineration and landfill impacts are directly tied to the proportional water and carbon content in the food. The Calculator also suggests that sending FLW to animal feed can be advantageous and for example lead to a environmental impact offset. This means that legislations that consider incineration with energy recovery as a way to “avoid” FLW are not necessarily reducing environmental impacts (e.g. in the case of fruits and vegetables with high water content). Generally, results suggest that although generic FLW mass-based initiatives like SDG 12.3 are essential to encourage FLW mitigation, the impacts of FLW will vary greatly across food types and regions and thus working towards SDG 12.3 with Life Cycle Management in mind can bring value with respect to other sustainability goals.

SESSION T1-9 Other (not mentioned above)
3rd September 2019, Tuesday 3:30 - 5:00 pm

Assessment of environmental benefits from the implementation of a national waste plan

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GOALS

The Finnish national waste plan (NWP) lays down the objectives and measures for waste management and prevention in Finland to 2023. By implementing these measures Finland aspires the target state defined for 2030, which includes e.g. high standard waste management, material efficient production and consumption, decreased volumes of waste, increased reuse and recycling that create new jobs, recovery of valuable materials present at low levels, decreased use of hazardous substances and high-quality research, experiments and competence in waste issues. Implementation of the Finnish NWP has since 2016 been promoted through an extensive EU Life IP project CIRCWASTE – Finland towards circular economy (LIFE15 IPE FI 004).

The CIRCWASTE project combines the efforts from 21 partners performing around 20 subprojects focusing on e.g. construction and demolition and food waste (http://www.materiaalitkiertoon.fi/en-US). The project is carried out within four Finnish regions. In addition to project partners, 10 forerunner municipalities are included in the CIRCWASTE network to carry out innovations towards more circular economy and to share experiences.

Environmental impacts of the project are assessed in order to improve the general understanding of relationships between the measures for resource efficiency and their impacts on the environment, especially on climate change mitigation. The results calculated for the four regions will generate new information that can be useful for the planning of new policy instruments and the content of new national waste management plans in the future.

METHODS

The environmental impacts caused by the measures of the Life IP project are monitored by assessing the impacts of the improvements in the waste treatment and circulation within the regions participating in the CIRCWASTE project. The first assessment will define the baseline against which the improvements will be reflected three times during the execution of the project.

The selected indicators for environmental impacts are greenhouse gas emissions, phosphorous and nitrogen emissions and natural resources, i.e. ferrous and non-ferrous metals, sand and clay, other minerals and biomass. The treatment and recovery of four specific waste flows (MSW, C&D waste, WEEE and biodegradable waste) are modelled according to the prevailing situation in the CIRCWASTE regions. These waste flows and their recovery and treatment processes form the regional waste management system to be assessed. In addition to the emissions and resources used by this regional waste management system, the impacts potentially avoided through recovery of materials and energy will be assessed. The inventory data for the assessment will be based on the Ecoinvent database (www.ecoinvent.ch), and Finland-specific life cycle inventory data gathered by SYKE.

RESULTS

The assessment of the baseline situation is under preparation currently and will be presented at the conference. The results will describe in a concrete way one important outcome type of the Life IP project to decision makers, stakeholders and the public. The publication of the results will strengthen the importance of the Life IP project in Finland and may generate new activities to improve circulation of waste also in other parts of Finland.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges
3rd September 2019, Tuesday 3:30 - 5:00 pm

How to assess mineral resource use in LCA? Guidance from the UN Environment Life Cycle Initiative's task force.

Markus Berger, Thomas Sonderegger, Rodrigo Alvarenga, Vanessa Bach, Alexander Cimprich, Jo Dewulf, Rolf Frischknecht, Jeroen Guinée, Christoph Helbig, Tom Huppertz, Olivier Jolliet, Masaharu Motoshita, Stephen Northey, Benedetto Rugani, Dieuwertje Schrijv

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Environmental impacts due to mineral resource extraction are addressed via relatively well established life cycle impact assessment (LCIA) categories (for example, climate change or acidification). However, assessing impacts of resource use, as such, has been a subject of persistent and controversial debate – and a wide range of LCIA methods based on different concepts is available. Therefore, as part of the Global Guidance for LCIA Indicators project within the Life Cycle Initiative hosted by UN Environment, more than 60 members of the task force "Mineral Resources" reviewed and evaluated LCIA methods for mineral resource use and provided recommendations of current methods and for future methodological developments.

In a comprehensive literature review, 27 methods assessing impacts of mineral resource use in LCA were identified. These methods have been clustered into four categories, depending on the impact mechanisms described: (1) methods assessing depletion of stocks, (2) methods assessing "future efforts" as an (assumed) consequence of current extraction, (3) methods using thermodynamic accounting (exergy and emergy approaches), and (4) methods assessing the supply risk of raw materials based on socio-economic aspects. Within the four method clusters, key axioms and methodological choices – like the resource stocks used in depletion methods, the assumed mining from higher to lower ore grades for many future efforts methods, the reference environment used in exergy methods, or the socioeconomic aspects (concentration of reserves, barriers of trade, etc.) considered in supply risk methods – have been discussed. All methods have been analyzed and compared using a comprehensive evaluation scheme comprising criteria like scientific robustness, documentation, applicability, and acceptance.

In order to provide recommendations, the safeguard subject for mineral resources within the Area of Protection "Natural Resources" has been more precisely defined. Subsequently, seven relevant questions with regard to resource use have been posed, grouped into 'inside-out' related questions (current resource use leading to changes in opportunities for future generations) and 'outside-in' related questions (potential resource availability issues for current resource users). Currently available LCIA methods have been assigned to these questions and seven methods (ADPultimate reserves, SOPURR, LIME2endpoint, CEENE, ADPeconomic reserves, ESSENZ, and GeoPolRisk) have been recommended for use in current LC(S)A studies at different levels of recommendation. All identified LCIA methods have been applied in a case study of an electric vehicle driving 1 km and show different findings since they model different impact mechanisms and address different questions related to resource use. Besides specific recommendations for individual methods and method groups, it is recommended that all methods should increase the number of minerals covered, keep their characterization factors updated, and consider the inclusion of secondary resources and anthropogenic stocks. Lastly, it is recommended that the concept of dissipative resource use should be defined and integrated in future method developments.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

3rd September 2019, Tuesday 3:30 - 5:00 pm

Improving Visualization of LCA Outcome for Decision Making

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thinkstep

Goal

There has been growing need of sound techniques to improve reporting of LCA results across the life cycle phases while transparently depicting the environmental impact variability amongst various impact categories. Current practices of visualization of LCA results pose inherent challenges to decision makers to understand the complexities of various environmental impact categories for the product system. This paper presents potential visualization examples of LCA outcome effectively. The aim is to provide better visualization of LCA results helping the decision makers to interpret coherently.

Method

Outcome of LCA for a product system generates large information covering various life cycle phases, drilling down to process and sub-process level for different impact categories. Absence of proper and inefficient abstraction of these information lead to improper interpretations and incomplete decisions. Attempts has been made to develop suitable visualization techniques for LCA results of complex life cycle phases to help decision makers comprehend in depth. Presentation aims to provide easy to understand comprehensive information. The overall requirements of information for various stakeholders were kept in view while developing the visualisation techniques for LCA results.

Results

This paper introduces the applicability of various visualization techniques to transmit life cycle assessment information. These techniques intend to reduce effort required for multiple screening, assimilation and processing of large amount of information for achieving informed decisions. Various conventional representations include bar charts, pie-charts, stacked column etc are widely used to present the results. LCA results of different product systems have been represented in terms of new techniques such as heat map, cluster heat map, spider diagram, bubble chart, network diagram, windrose diagram, Sankey diagram etc. Suitability of different visualization techniques are also discussed.

In order to avoid misleading interpretation by decision maker and save their time, next level of visualization techniques for LCA results need to be applied which will help in reducing the cognitive work of processing of complex and large amount of information as well as take well informed decisions.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

3rd September 2019, Tuesday 3:30 - 5:00 pm

Application of Discounting in Life Cycle Assessment

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TU Dresden

Goal

Discounting future cash flows to a net present value is a common practice in business decisions. Various influences, such as opportunity costs and general economic growth, as well as time preference for the present and uncertainty lead to a time-dependent valuation of cash. In the field of life cycle assessment, it is discussed whether discounting should also be applied to future environmental or social impacts. Although there is a consensus in literature, that setting time horizons for the impact assessment is equivalent to discounting at certain rates, only little information about how to apply discounting in practice can be found.

This might be due to the fact that discount functions must be derived from theoretical considerations and there seems to be confusion about discounting theory for LCA practitioners. We want to discuss the application in LCA and give a suggestion, whether and how to implement it.

Methods

Unless interest is known to people for thousands of years, the theory of discounting was only developed in the early twentieth century. We explain in a review the idea and history of discounting as well as current applications in business and economics in order to discuss whether discounting can be integrated in life cycle assessment. The rationale for discounting is derived from various influences, so that a discount function must contain multiple factors with different theoretical backgrounds. Most of them are highly individual and partly criticized by behavioral economists, social scientists and psychologists. From an ethical but also juridical point of view, it is questionable if highly individual factors should influence decisions that affect the whole and possibly the future society.

Results

We conclude that discounting does not fit to the idea of LCA. LCA is meant to be a universal information instrument. The outcome should not be dependent on the recipient. Contrariwise, discounting is fully dependent on the recipient as it is a tool for making intertemporal decisions on an individual basis. A unified discount function for LCA cannot be derived. We also found that discounting cannot be mixed with the time horizon discussion because time horizons are rather influenced by natural scientific criteria, like the actual impact time, or by a simple decision on the time horizon one wants to be informed about. This information step comes before the decision step where discounting can play a role.

We suggest not to integrate discounting in LCA. The outcome of an LCA can be regarded as the “environmental price” of a product, besides the monetary price. No seller would apply discounting on the price of a product - that is conducted by the consumer. Nevertheless, for internal use in companies or in cost benefit analysis, discounting can be useful for comparing different investment opportunities.

SESSION T5-1 Strengthen LCM by Blending Approaches
3rd September 2019, Tuesday 3:30 - 5:00 pm

Valuation of abiotic resources in life cycle assessment

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Goal: The use of non-renewable abiotic resources is treated differently in different impact assessment tools. In life-cycle assessment (LCA), resource depletion is considered an impact category in parallel to other non-marketed environmental impacts, such as climate change and human toxicity. In cost-benefit analysis on the other hand, increased scarcity is assumed to be included in market prices, basically leaving depletion issues aside. There are currently a large number of characterization methods available for assessment of abiotic resources in LCA. They produced different results and there is currently no consenus on which approach to choose. One reason may be that there is no agreement on the problem description; different LCA models define problems associated with resource depletion differently. The framework of total economic value – TEV – is usually applied in economic analysis when analysing benefits of renewable resources and ecosystem services. The aim of this paper is to analyse if the TEV can be used for identifying the values of abiotic non-renewable resources such as fossil fuels and metal ores, in order to examine if such resources have non-market values that may be distinguished from the more well-known non-marketed attributes associated with exploiting and consuming them and to analyse if this could be a basis for characterization of abiotic resources in LCA.

Method: The TEV divides the values in different categories. In this paper we analyse which categories could be relevant for abiotic, non-renewable resources. We also analyse which economic methods could be relevant for valuation of these resources.

Results: The major conclusion from this analysis is that abiotic resources can have option, quasi-option, insurance, altruistic and bequest values that are usually ignored, when impacts of non-renewable resource use are assessed and given a monetary value. The existence of these values supports the idea that depletion of abiotic resources should be considered as an impact category to be included in different impact assessments. Further research is required to assess the magnitude of these values. To assess non-use values and option values, non-market valuation methods based on stated preferences are preferred, but estimates from cost-based methods may be used as approximations of the total economic value. Concerning the need for a common theoretical platform of life-cycle assessment, it is concluded that there are things to learn from economics, and also vice versa, if a more comprehensive treatment of the impacts of abiotic resource depletion is aimed for within economics. Having identified values that are of relevance, the next step is to discuss how these could be captured in Life Cycle Impact Assessment.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others
3rd September 2019, Tuesday 3:30 - 5:00 pm

Carbon dioxide as feedstock in Germany: regulatory approach

Hans J. Garvens

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Umweltbundesamt - German Environment Agency

goal: Presentation of the regulatory approaches for carbon capture and utilisation in Germany

Methods: Assessment of papers

Results:

The reuse of carbon dioxide closes cycles in order to reduce GHG emissions at a point source as well as to use CO2 as carbon feedstock for various products, especially chemical products. German Environment Agency works on a background paper on CCU measures.

The assessment of CCU projects focusses on these criteria:

No energy related CO2

Carbon capture and utilization is a mean to reduce emissions to the atmosphere and to reuse the carbon in industrial processes. Because of the need to basically use the same energy for the chemical reaction from a CO2 molecule to some useful molecule as one gains from the incineration of that useful molecule to CO2, any energy converting process must not emit carbon dioxide, if long term reduction of CO2 concentration in the atmosphere is intended.

Use of Fossil carbon

Any extraction of fossil carbon from the earth will lead to a final increase of the CO2 concentration in the atmosphere. Since all but a very few feedstock applications of carbon containing resources will finally become waste and will today be incinerated, the extraction indirectly induces the rise in GWP based on life cycle thinking.

Avoidance of CO2 formation is the most important principle.

Reuse of CO2

In order to reuse CO2 most efficiently, a high concentration is favorable. Oxy fuel processes using oxygen instead of air for incineration or other chemical reactions lead to high CO2 concentrations and very low nitric oxide formation. The gain of efficiency in the subsequent processes is higher than the efforts to produce the pure oxygen for the incineration. From CO2 many useful materials might be synthesized like methane or other fuels, platform chemicals or others. Renewable energy sources are preferable for all parts of the processes and also for the hydrogen formation, which is often needed in the processes.

Life Cycle Approach

Case studies show, that under today's circumstances, it might already be favorable to reuse CO2 using energy still emitting some CO2 in the prechains. Favorable in this sense means to reduce today's GWP emissions to lower levels.

The holistic view of LCT also needs to closely observe changes in waste management. Even if the carbon for the products, which converted to waste, was not of fossil origin, waste incineration would not lead to energy gain (same amount is needed to convert CO2 back) and emitting CO2 to the atmosphere will only close cycles at high energy demand.

The whole transfer from today's economy towards a carbon neutral economy needs to be closely monitored by full scale LCA, in order to avoid too much burden shifting (increase in other impacts in order to reduce GWP)

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

3rd September 2019, Tuesday 3:30 - 5:00 pm

A guideline for standardized life cycle assessment on carbon capture and utilization – First experiences and new insights

Leonard Jan Müller, Arne Kätelhön, Marvin Bachmann, André Sternberg, André Bardow, Tim Langhorst

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Carbon capture and utilization (CCU) captures the greenhouse gas CO2 from point sources or ambient air and subsequently converts it into value-added products or services. CCU technologies have the potential to reduce environmental impacts. However, many CO2-based products lie thermodynamically uphill, i.e. CO2-based products have a higher Gibbs enthalpy of formation than CO2. As a result, the conversion of CO2 usually requires energy – and the generation of energy is also associated with environmental impacts. In consequence, intuitively expected environmental benefits of CCU technologies cannot be taken for granted and a systematic environmental assessment is needed. Such a systematic assessment is provided by Life Cycle Assessment (LCA). Even though LCA has been standardized in ISO 14040/14044, LCA studies on CCU products are often not comparable due different definitions e.g. of the functional unit. Even if studies are comparable, results can vary significantly. For example, for CO2-based methanol, greenhouse gas emissions vary from -1.5-9.7kgCO2-eq in the literature. In consequence, decision making based on LCA studies is difficult for stakeholders. For these reasons, the Scientific Advice Mechanism of the European Commission and practitioners requested LCA guidelines for CCU to enable sound decision-making.[1]

To meet this request, we have developed a guideline for standardized LCA for CCU.[2] The guideline builds upon existing LCA standards and guidelines and was funded by the Global CO2 Initiative and Climate-KIC. In this first version of the guideline, we have identified typical research questions (i.e., goal definition) from current LCA studies on CCU. By comparing these research questions to goal definitions described in the ILCD handbook, we have developed guidance on a systematic goal definition for LCA of CCU technologies. The document offers guidance on the scope definition covering the definition of the functional unit as a basis for comparison, the system boundaries, the life cycle inventory modelling approach and co-product management. The guidance has been refined for specific classes of CCU technologies such as fuels, chemical feedstock, materials and minerals. Ambiguity caused by inventory data sets for feedstock is reduced by introducing standard scenarios for main process inputs (e.g., electricity) for the status quo and potential future scenarios. Moreover, we provide guidance on how to account for temporary storage of CO2 and how to interpret negative emission.

The first version of the guideline already provides a robust framework for LCA on CCU technologies. To refine the guideline based on feedback from practitioners, policy makers and funders, a three years follow-up project has been set-up and is funded by Climate KIC and the Global CO2 Initiative to add the following aspects to the guideline:

- harmonization of current international activities for LCA on CCU
- guidance for policy maker's interpretation
- an approach to integrate LCA and techno-economic assessment
- a guideline for assessments in early development stages

In this talk, we share first experiences from the guidelines in the community and give insights from the current research project.

References

[1] Scientific Advice Mechanism-Scoping paper: Novel CCU technologies

[2] Techno-Economic-Assessment & Life-Cycle-Assessment Guidelines for CO2-Utilization URL:https://deepblue.lib.umich.edu/handle/2027.42/145436

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others
3rd September 2019, Tuesday 3:30 - 5:00 pm

Consequential life cycle assessment of carbon capture and use alternatives within the chemical industry

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Fraunhofer UMSICHT

Carbon dioxide (CO2) capture and utilization (CCU) is a promising measure for reducing greenhouse gas (GHG) emissions and fossil resource depletion. The potential as a climate mitigation practice for CCU is manifested in the recently published report from the Intergovernmental Panel on Climate Change (IPCC) (2018). However, environmental advantages of CCU cannot be taken for granted. Hence, an environmental assessment of CCU by conducting a life cycle assessment (LCA) is needed. The goal of this study is, therefore, to investigate environmentally favorable CO2-treatment options within the chemical industry (see Figure 1).

Consequential LCA is a change-oriented approach for estimating the environmental impacts of a product or service throughout the entire life cycle and allows for comparing CO2 treating activities. A life cycle inventory model built according to the consequential approach (Ekvall and Weidema, 2004) should reflect the consequences of a specific decision (Weidema et al., 2018). Only suppliers that are affected by the decision should be included in the system. These are called marginal suppliers, technically defined as suppliers that can respond to a marginal increase in demand for the product (Weidema et al., 1999). In order to identify the marginal suppliers for CO2 and H2, we followed the five-step-procedure explained in Weidema et al. (1999) and differentiated in a near- and long-term supplying scenario.

The functional unit chosen for the comparative analysis is the treatment of 1 kg of CO2. The analysis was carried out using openLCA 1.7.3 (Ciroth, 2007) and Brightway2 (Mutel, 2017) software. Background data is taken from the ecoinvent database 3.4 consequential (Wernet et al., 2016). The focus of this work lies on global warming impacts (GWI) of the different CCU alternatives. Besides, results for further environmental impacts are calculated using the ILCD 1.0.8 2016 midpoint impact categories (European Commission-Joint Research Centre (EC-JRC), 2011).

Twelve novel CUU routes where compared and result in carbon savings except for the production of Fischer-Tropsch-products, and the Dimethoxymethane production in the long-term. Formic acid and polyol production show the lowest GWI. However, the difference between formic acid routes and the polyol route is due to parameter uncertainty not significant. However, these three production routes are performing substantially better than the remainder. For most routes, impacts coming from the avoided product is the most contributing process. This is especially the case for routes producing formic acid, polyols, and DMC. Analyzing the correlation of the GWI with the other LCIA methods shows a rather high correlation for GWI with freshwater and terrestrial acidification, freshwater, marine, and terrestrial eutrophication. The correlation for other impact categories and GWI are rather low and therefore the ranking of the alternatives changed for those impact categories. In conclusion, it could be shown that CCU is a viable option for reducing GHGs in the future. Especially, the routes to produce formic acid and polyols are favorable as these routes have the largest GHG saving potentials. Differentiating between a near- and long-term scenario did not change the overall ranking of alternative with regards to the GWI.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others
3rd September 2019, Tuesday 3:30 - 5:00 pm

Environmental life cycle assessment comparison between urea produced from Basic Oxygen Furnace gas and natural gas

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Goals: In the BOF2UREA project, a process was developed in which Basic Oxygen Furnace (BOF) gas, an off-gas in an integrated steel mill, is used to produce urea. First, carbon dioxide (CO2) is captured from the BOF gas with the sorption enhance water-gas shift (SEWGS) technology, using a regenerative solid adsorbent. This creates a pure stream of highly concentrated CO2 and a stream of gas that is suitable for ammonia production. After ammonia synthesis, part of the concentrated CO2 stream is fed back to synthesize urea, leaving the rest of the CO2 ready for storage. The goal of this research was to quantify the environmental impacts of the BOF2UREA process and to compare these with the impacts of conventional natural gas-based urea production.

Methods: A Life Cycle Assessment (LCA) was performed with a functional unit of 'urea production of 50 kt per year (kta)'. The geographical location is North West Europe. Foreground data was collected from the companies developing the technology, representing the full value-chain of BOF2UREA process. The TEA/LCA guidelines of 2018 were followed except for that the more up to date ReCiPe 2016 (H) midpoint method was used to quantify the impacts of urea production via two routes: from BOF gas and natural gas reforming (reference system). Two scales of production were considered: 50 kta and 300 kta. 50 kta is the smallest commercially viable capacity of urea production while being in the range of scaling up of the SEWGS technology in five years' time. The large scale capacity represents the availability of BOF gas from a typical Western European integrated steel mill. System expansion was used as allocation method. In the reference system, BOF gas is used internally in the steel mill and the excess is combusted to produce electricity. For the 300 kta scale, this was accounted for by including the impacts from natural gas replacing the BOF gas internally in the steel mill and electricity from the grid replacing the production from combustion. For the 50 kta case only excess BOF gas is used, hence only the impacts of avoided electricity production were included.

Results: Preliminary results show that approximately 20% of the carbon dioxide that is adsorbed with the SEWGS technology can directly be used for urea production and that heat integration with waste heat steam from the steel mill reduces the heat demand by more than half. The heat integration potential is expected to be larger for the large scale case than for the small scale case, leading to a larger environmental impact reduction potential per kt of urea. In the presentation, the full LCA results will be shown, indicating which scenario has the largest environmental impact reduction potential. The sensitivity analysis will reveal to what extent the outcomes depend on assumptions regarding the efficiency of the SEWGS process, the share of renewable electricity of the grid, the extent to which heat recovery from the steel mill is possible and the possibility to sequester the remainder of the CO2.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges
3rd September 2019, Tuesday 3:30 - 5:00 pm

Taking into account final mining wastes in LCA: How to quantify the impacts of tailings?

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BRGM

In 2014, the European Union generated more than 700 million tons of waste in the mining and quarrying sector. Tailings are one typology of mining wastes and are generated during the mineral processing steps of metal production. If technology feasible and economically viable, these wastes can be re-processed to extract still remaining valuable resources. If not, these wastes are stocked is so called “tailings ponds” or “tailings dams” for a very long period that can extend beyond the mine closure. As tailings are resulting by-products of metallurgical processes, they often contain potentially hazardous elements that can have negative impacts on nearby waters and soils.

So far, only few life cycle assessment (LCA) studies consider the environmental impacts of tailings storage and management on metal production. The Ecoinvent database proposes two generic datasets concerning sulfidic and non-sulfidic tailings disposals. Nevertheless, tailings composition is linked to the type of ore treated, to the type of processing technologies used and to the geological and climatic conditions of the tailing storage. Thus, environmental impacts of tailings storage are site-specific in addition of being time-dependent. In fact, emissions can occur in a short (yearly) or a long time frame.

Assessing the timely dependent behavior of tailings and in particular the interactions between the tailings pond and the surrounding groundwater and underground can be done using reactive transport modeling. The aim of this presentation is to show how the results of geochemical modelling can be used in LCA to take into account the emissions induced by tailings in metal production.

This work will be illustrated with a mining plant producing copper, other metallic by-products and their associated sulfidic tailings. In a first place, the tailings pond and its associated characteristics (hydrodynamic properties, chemical composition of the pore water and mineralogical composition) are modeled alongside with the chemical composition of the tailings and its boundaries, initial and climatic conditions. Reactive transport of the chemical compounds of the tailings between the pond and the environment is simulated in order to quantify the specific emissions from the tailings in a time dependent scale. These quantifications are direct inputs for the life cycle inventory of the tailings management. Coupling geochemical modelling with LCA allows taking into consideration, for a given mine site, the impacts of tailings management in the LCA of metal production. This allows assessing the contribution of tailings against the other life cycle stages of metal production. Considering the resulting impacts of mining wastes also allows to better take into account the environmental benefits of mining waste retreatment.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges
3rd September 2019, Tuesday 3:30 - 5:00 pm

Greenhouse gas mitigation benefits from the use of ferrovanadium in steel alloys

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ERM

Goal

Increasingly, there is a need for more sustainable building practices and to create ‘more with less’. Steel is one of the most important construction materials currently in use, so how can we reduce the environmental impact of steel constructions? Ferrovanadium, when blended with steel, produces an alloy with significantly improved tensile strength compared with standard carbon steel, resulting in considerable lightweighting benefits. This study assesses the potential greenhouse gas (GHG) emissions mitigation benefits of using steel alloy containing ferrovanadium, as opposed to standard carbon steel.

Method

Using LCA, metallurgical services company, AMG Vanadium and environmental consultants, Environmental Resources Management, investigated the environmental impact of manufacturing AMG Vanadium’s ferrovanadium product and the potential benefits from its use in the steel industry. The study comprised a streamlined cradle-to-gate life cycle assessment of AMG’s ferrovanadium product, focussing on GHG emissions. AMG’s ferrovanadium manufacturing process uniquely sources vanadium from spent catalyst from the refining industry and makes beneficial use of what would otherwise be a waste product. The GHG emissions from the manufacture of AMG’s ferrovanadium product were compared with the manufacture of a generic product, where the vanadium is supplied from a primary source. The results of the streamlined LCA were then used to assess the GHG emissions mitigations benefits from its use in the manufacture of steel rebar, due to its lightweighting capabilities.

Results

The results of the streamlined LCA show that AMG’s ferrovanadium product, which acquires vanadium from a secondary source, has considerable GHG emissions benefits when compared with a generic ferrovanadium product where the vanadium is supplied from a primary source. The assessment of the GHG emissions mitigations benefits identified that, although on a weight for weight basis, the ferrovanadium steel alloy results in a higher environmental impact than standard carbon steel, when considering the impact of the lightweighting benefits from increased tensile strength, there are significant GHG emissions savings achievable from the use of ferrovanadium in steel alloy.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges
3rd September 2019, Tuesday 3:30 - 5:00 pm

LCA in the mining sector: the environmental implications of new recycling technologies for sulphidic mine residues

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Goals:

The mining of non-ferrous metals such as Cu, Zn, Co, Ni, can produce a large amount of metal-containing residues, which are not fully recovered today. Sulphidic mine residues, for instance, are the leftover from the metal extraction process and they are often stored as a slurry in impounding lakes. Such storage facilities require careful maintenance, because of the risk of surface and groundwater contamination. On the other hand, the recycling of sulphidic mine residues presents various benefits, such as the recovery of valuable metals and minerals, and the avoided need for storage facilities (i.e. tailing ponds). Through the recycling of sulphidic mine residues, adverse effects related to the oxidation and acidic mine drainage of residual sulphides is also eliminated.

Therefore, innovative techniques are currently developed to exploit the reuse potential of sulphidic mine residues. The goal of this study is to provide an analysis of the environmental costs and benefits of newly developed techniques for sulphidic mine residues valorisation.

Methods:

The “Horizon 2020” project NEMO stands for “Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy”. Among others, It investigates a large mining site in the EU, aiming at developing new ways to valorise sulphidic mine residues, through the recovery of valuable metals and critical raw materials (Cu, Pb, Zn, Ni, Co, REEs/Sc, Mn, Mg). The extraction of metals from residues is based on enhanced bioleaching processes, as well as on a range of technologies to recover metals from the pregnant leach solution (i.e. different steps of chemical precipitation and solvent extraction). NEMO will also use the residual, clean mineral fraction as a raw material for the mass production of cement and concrete for construction products. Sulphates will be recovered for the production of fertilizers and detergents. Together with the technical challenges posed by the sulphidic mine residues valorisation, NEMO aims at analysing the sustainability of the developed technologies. In this context, an LCA will be developed to study the environmental hotspots and the environmental benefits of the NEMO recovery technologies. The inventory analysis for the LCA will be mainly based on the information gathered directly at the mining sites.

Results:

The LCA analysis is expected to highlight the trade-off between the environmental costs and benefits of sulphidic mine residues valorisation. The recovery and reuse of valuable metals can indeed avoid the mining of new primary metals. This can be of relevance for REEs and cobalt, which are included in the list of critical raw materials by the European Commission. Moreover, the recycling of the inert fraction to produce new construction materials can have lower global warming potential (GWP) emissions compared to the traditional concrete based on Portland cement. On the other hand, it can highlight the environmental hotspots of the whole process (i.e. the energy consumption of the enhanced heap bioleaching, or the use of chemicals) providing a solid base for further optimisation of the newly developed technologies.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges
3rd September 2019, Tuesday 3:30 - 5:00 pm

Comparative life cycle assessment of primary low alloy steel with hydrogen direct reduced iron and optimized blast furnace processes

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Globally, steel production contributes significantly to climate change. To reduce climate impact according to Paris agreement targets, significant changes are needed along its entire value chain. One technology currently being considered to reduce the sector's climate impact is the use of hydrogen for the direct reduction of iron ore.

This study aims to compare the environmental impacts on a life-cycle basis to produce low alloy steel using three alternative processes for iron production: Firstly, an optimized blast furnace method, secondly hydrogen direct reduced iron (H-DRI) and finally a reference blast furnace process. These alternatives are compared based on 1 kg low alloy steel.

Foreground data for iron production in the optimized blast furnace process are taken from the NEEDS optimistic-realistic scenario (NEEDS, 2009). Foreground data for the H-DRI process is based on a recent Swedish pilot study (HYBRIT, 2018). It is assumed that hydrogen in this process is produced with an electricity mix with 90% renewables. Foreground data for the reference process are taken from the relevant ecoinvent v3.1 process. Background data for all alternatives are based on the relevant ecoinvent v3.1 process. It is further assumed that process energy requirements reduce by 20% and 35% compared to the reference for the optimized blast furnace and the hydrogen direct reduced iron processes respectively, based on recent assessments of future efficiency potential (IPCC, 2014).

Global warming potential (GWP) is 6 % and 45 % lower than the reference for the optimized blast furnace and the H-DRI processes respectively. Other impacts are also lower for H-DRI compared to the reference - fine particulate matter formation by 18%; terrestrial acidification by 11%; fossil resource scarcity by 32% and freshwater eutrophication by almost 7%. However, impacts such as terrestrial ecotoxicity and freshwater ecotoxicity increase for the H-DRI process compared to the reference. Analysis shows that all these changes are due to the substitution of coal in reference iron production with hydrogen based on largely renewable electricity in the H-DRI process.

Analysis also shows that the potential for H-DRI based low alloy steel to reduce GWP compared to a reference, is limited by the GWP due to alloying elements in low alloy steel such as nickel, chromium and molybdenum. On the other hand, the proportional GWP reduction for unalloyed carbon steel produced with H-DRI (without alloying metals) is potentially much greater than for low alloy steel considered here.

Novel processes for e.g. nickel production are also necessary to achieve GWP reductions for low alloy steel production in line with fulfilling the Paris agreement. This presents challenges in process and supply chain innovation but also business opportunities for innovators.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges
3rd September 2019, Tuesday 3:30 - 5:00 pm

Role of stochastic approach used to Life Cycle Inventory (LCI) of Rare Earth Elements (REEs) from secondary sources case studies

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GOAL

The EU position on the net import of rare earths every year (excluding REE in products) was approximately 8,000 tonnes. The Europe imports about 14% of the total REE production of China. Actually no rare earth production is currently located within the EU – but being developed in Norra Kärr (Sweden), some development Germany, Greenland and Turkey. Silmet plant in Estonia uses Russian materials for production.

The goals of this study is to use stochastic approach based on Monte Carlo (MC) simulation in order to quantify the uncertainty in Life Cycle Inventory (LCI) of Rare Earth Elements (REEs) from secondary sources.

METHODS

Monte Carlo (MC) simulation with the Crystal Ball (CB), associated with Microsoft Excel software was used to model the LCI under uncertainty. The input data for this study comes from the ENVIREE (ENVIronmentally friendly and efficient methods for extraction of Rare Earth Elements) source, i.e., from eco-innovative project funded by NCBiR (ERA-MIN/ENVIREE/02/2015) within the second ERA-NET ERA-MIN Joint Call for Sustainable Supply of Raw Materials in Europe 2014. The secondary data is taken from Ecoinvent database v.3.4. Case Studies described include the flotation tailings from the operating New Kankberg old gold mine (Sweden), and Covas old tungsten mine (Portugal) sent to re-processing/beneficiation for REEs recovery. Operating parameters, chemicals associated with the extraction of REEs from secondary sources, and the product data (REEs) have been inventoried. In this study, we conduct the MC analysis on the Cerium (Ce), Lanthanum (La), Neodymium (Nd) and Tungsten (W) taken from Covas flotation tailings. The Ce, La and Nd taken from New Kankberg flotation tailings are also considered in the apper. In the case of Covas, the weights of each selected Ce, La, Nd, and W are 32 ppm, 16 ppm, 15 ppm and 1900 ppm, respectively. In the case of New Kankberg the weights of each selected Ce, La and Nd are 170 ppm, 90 ppm, and 70 ppm, respectively.

RESULTS

For the caseconsidered, log-normal distribution has been assigned to Ce, La, Nd, and W. The results given by CB, after 10,000 runs are presented in the form of the frequency charts and summary statistics, as well as the sensitivity analysis (SA). The aim of sensitivity analysis is to ascertain how much the uncertainty in the output of the model is influenced by the uncertainty in its input factors. SA can be a very powerful tool because it reveals the strenghts and weaknesses of the analysis. The results obtained using MC simulation are more reliable than the results of deterministic approach. It is concluded that uncertainty analysis offers a well-defined procedure for LCI studies, early phase of Life Cycle Assessment (LCA), and provides the basis for defining the data needs for full LCA of the REE beneficiation process.

Thanks to uncertainty analysis based on the MC simulation confidence intervals (95%) estimating the values of the selected REEs have been performed. Final result is obtained in the form of the range of values. In the New Kankberg case the Ce, La and Ne forecast values in the 95% confidence intervals range from 136.98 ppm to 203.37 ppm, from 72.06 ppm to 107.19 ppm, and from 56.58 ppm to 83.76 ppm, respectively. In the Covas case the Ce, La, Ne and W forecast values in the 95% confidence intervals lie between: 26.17 and 38.29 ppm, 13.13 and 19.46 ppm, 12.24 and 18.06 ppm, 1556.96 and 2302.73 ppm, respectively. The results of this study are based on the real data. Being obtained with the use of MC simulation they are more reliable than those coming from deterministic analyses and they have the advantage that no normality is presumed. Finally, the results obtained may be useful and of interest to further studies of REEs recovery of both other domestic and international LCA studies.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 10:30 - 12:00 am

Classifying products to gain strategic environmental insights based on the product's life cycle characteristics

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(Goal) The purpose of this research is to classify diverse products based on their life cycle characteristics as a mean to generalize the relationship between product characteristics and their environmentally advantageous business models. Nowadays, products that are owned individually in convention are increasingly available for function-oriented business models, such as renting, leasing, and sharing. These models also have a potential to drive the current consumption activities toward environmental sustainability through using fewer artifacts; however, past studies presented mixed results depending on what – the type of product – is being accessed under which business model. For instance, the environmental impact per capita of products with high manufacturing impacts can likely be reduced through product renting or sharing, but shifting to such function-oriented business models could induce additional resource consumption. Life cycle characteristic alone is yet to determine renting and sharing as the most environmentally advantageous business model for such products.

(Methods) To clarify the relationship between product characteristics and the product's environmentally sound business model, we analyzed life cycle greenhouse gas emissions (GHG) of diverse products that are commonly traded in sharing economy. The list of products traded in sharing economy was generated through an expert workshop at the 1st Life Cycle Innovation Conference in 2018. With the list, we selected number of representative tangible products, and performed a simple Life Cycle Assessment (LCA) when they are individually owned by a consumer. The life cycle stages were consolidated into production, use, maintenance, and waste disposal for all LCA. Based on the LCA results, we grouped the products with similar life cycle GHG characteristics, i.e. the ratio of GHG contribution of life cycle stages. The product groups were then examined to identify characteristics and environmentally advantageous business models of each group.

(Results) As a result, we identified four groups of products with resembling life cycle characteristics: production-intensive, use-intensive, consumer-travel visible, and maintenance-visible products. Each product groups demonstrated distinct environmentally sustainable business model. For instance, products with little or no energy consumption in the use phase or used infrequently for its lifetime are classified into production-intensive products. Their environmental impact would be decrease from owning when shared with as many people as possible without consumers having to travel. When the results are examined. we also identified that life cycle characteristic of a product alone is insufficient to determine the environmental potential of function-oriented models. Further analysis on other characteristics of product use such as frequency of use when shared, type of sharing (i.e. sequential or simultaneous), and lifetime is beneficial to characterize the pattern of sustainable business model of products.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 10:30 - 12:00 am

Sustainability Stress Test as a tool for the reliable assessment of the use phase for complex and personalized products in the development phase

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Products and production systems are getting increasingly complex and with the additional challenge of Mass Personalization, the production of personalized products for the mass market, the conduction of reliable environmental assessments is more challenging than ever. The reasons for this mainly derive from the rising environmental significance of the use phase (e.g. due to low production impacts induced by efficient production technologies) and the rising product variation fuelled by the trend of Mass Personalization. To overcome this challenge, methods and tools, to assess, visualize and communicate the high variability of the environmental impact caused by personalized products are needed. The study contributes to this goal by introducing the Sustainability Stress Test as an LCA tool to visualize and utilize information on future product use in product development.

The Sustainability Stress Test is one of the enablers developed at the High Performance Centre Mass Personalization in Stuttgart, Germany, an interdisciplinary research initiative of the Fraunhofer institutes in Stuttgart, the University of Stuttgart and industry from various sectors, targeting pharmaceutical products, biomechanical assistance technologies and personalized living spaces (including automotive, built environment, and consumer products). The overarching framework for all enablers is the Stuttgart model. The model describes various aspects of Mass Personalization (e.g. product development or the personalization process). The Sustainability Stress Test enables the environmental optimisation in the product development process by providing means to simulate the effect of use phase and manufacturing variability on the life cycle environmental impacts of product designs. For that purpose scenario analysis and statistical methods are used in combination with LCA to depict potential, future user behaviour and the underlying uncertainties. With the produced information the developer can eliminate variants causing unwanted or particularly high environmental impacts.

For demonstration, the Sustainability Stress Test was applied to the hypothetical use case of the development of a new component in the automotive sector. Based on the environmental development targets of the developer and a wide database on user behaviour, the efficiency of the development actions was assessed. The results are presented in interactive dashboards as graphs, tables and textual information. The displayed scenario body is controlled via selection and exclusion of the various parameters. The content of the dashboard can be tailored to the specific question at that point in the development process. Exemplary questions of the developer that can be answered include the right choice of development actions, the limitation to certain production technologies, or evaluation of the most suitable target group. The scenarios are based on real user data that is normalized to the details of statistical reports if needed. Yet, the user classification into different target groups is done randomly but could be replaced by real-life data as it becomes available to the authors. The Sustainable Stress Test tool was thoroughly tested in this hypothetical use case and is planned to be applied in an industry case in the future.

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SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 10:30 - 12:00 am

USING LIFE CYCLE INFORMATION IN DECISION MAKING FOR REACHING AND SETTING SUSTAINABILITY GOALS

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A clear trend has been emerging and is mainstreaming today: multinational and stock listed companies are integrating sustainability aspects and environmental concerns into their corporate policies. This can be attributed to the demand to understand and report on financial risks related to environmental aspects, such as damages caused by natural catastrophes or extreme weather conditions, that could affect a company's own production sites or create a problem for one or several suppliers. Furthermore, the pressure of consumers to implement improvement measures and to communicate environmental performance transparently is increasing permanently.

Efficiency measure to reduce costs and create environmental and economic win-win-situations are always among the first achievement that companies realize, when starting to set sustainability goals and reduction target. Examples for such achievements are energy costs savings by reducing compressed air or introducing corporate bicycles or e-mobility on the factory premises, while overall environmental impacts are reduced. These are the low hanging fruits of early engagements, but more and more companies already are aware, that further steps are needed for example to reach the goals of the Paris Agreement, which requires a drastic decarbonization of industry and society as a whole. Those see the need to go into detail and encourage all possible business areas to think comprehensively. Volvo Group joined forces in life cycle management and behavioural science to create a graphical map to be used as a basis for discussions and recommendations on how to tailor life cycle information in order to support decision making throughout the company.

During this earlier completed collaboration project that Volvo Cars had conducted with several other companies a map was established which provides information on the flow of quantitative data between databases and users and also includes qualitative environmental and economic information. Besides the obtained mapping, the map is useful for employees outside the environmental departments, who can gain a bundled understanding of current operations and derive their own goals.

Currently, Volvo Cars and iPoint systems act jointly in improving availability of and accessibility to these information flows. To take the desperately needed quality and quantity of primary data sets for Life Cycle Assessment (LCA) to a higher level, a software solution is being created. The software will enable access to automatically collect environmentally relevant data from the production site of the company and as well operate as calculation engine for LCAs. The main idea behind the Live LCA development is to create a solution with which allows different roles in the company to assess material and energy efficiency and the environmental impacts for each manufactured product and each process step within the production and along the product life cycle. This assessment will make use of existing data in a company, e.g. from energy monitoring systems, production planning systems and material management systems etc. Live LCA will enable companies to use the benefits and address the challenges of Industry 4.0 (keywords “lot-size one”, “digital twin”) and support decisions which lead to a reduction in energy consumption and an improvement in environmental impacts throughout the entire life cycle.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 10:30 - 12:00 am

Digitalization as enabler for holistic product stewardship – how the digital twin of a product brings LCA and Product Compliance to the engineers minds and desks

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Challenge and goal

Within product stewardship both qualitative and quantitative methods are applied to understand and improve the sustainability performance of a product. Approaches to evaluate compliance with various product regulations in a global market, which support safe use and disposal of products, are complemented by approaches to assess and communicate the environmental or social footprint on the voluntary side. As products are getting more and more complex, as well as pressure from competitors on time to market, performance and cost is increasing, an ever faster and cost optimized development and manufacturing is considered essential to remain competitive in the market. An integrated digitalization of the whole product development and production processes will play a key role regarding this challenge.

Hence, in this paper now describes and evaluated how digitalization and the digital twin can be applied in context of an pro-active, holistic product stewardship process.

Methods

In this paper different approaches for PLM integrated compliance evaluations and LCA calculations are described, discussed and evaluated on the basis of a case study by the means of a strength and weaknesses analysis. Further, rough estimation are given regarding time/resource savings for the product stewardship process.

Results

The paper describes and discusses how LCA and product compliance can be jointly executed in a lean manner through being integrated in commercial Product Lifecycle Management (PLM) software, supporting digitalization in product development. Advantages of being fully in sync with the backbone of each Product Development, a PLM System, are: Consistency, savings in time and cost, and especially the ability to engage every practitioner in the value chain.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 10:30 - 12:00 am

Dynamic and localized LCA information supports the transition of complex systems to a more sustainable manner such as energy and transport systems

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Goal: Today's energy and transportation infrastructures have to be transformed reducing green house gas emissions globally and air pollution on a local level. Due to regulatory framework, high investment volumes and long lifetimes of infrastructure equipment the transformation processes are progressing slowly. Already realized conversion measures have to be utilized effectively due to energy and traffic management services considering ecological target functions within a sufficient spatial and temporal resolution.

Method: Today economical target functions are used for optimizing planning and operation of complex systems. Emission targets are used as side conditions however this has not been sufficient enough to drive the transition.

For example, in the energy sector power from renewable sources like wind or solar not always can be fed into the grid because electricity consumption and electricity supply must be balanced constantly. Improving the sustainability of electricity consumption by adapting the power consumption to the availability of renewable energy would use the existing sustainable power sources more effectively. Therefore dynamic energy management services have been implemented which reflect both renewable power generation and demand site management from a sustainability perspective.

Like for the energy sector the transition to a more sustainable transport system is progressing too slowly. Especially regulative air pollution limits are exceeded and repressive measures such as bans of private cars are discussed or already implemented. Air quality management services which monitor and forecast environmental parameters and initiate appropriate transport measures in a spatially and temporally limited frame have been developed keeping repressive measures to a minimum.

Therefore the LCA methodology has been enhanced with dynamic emission factors in spatial and temporal resolution used in energy and traffic management services and trading platforms. In contrast to economical optimization where price curves are provided by external partners – up to now no external ecological driven input curves are available. Therefore we build up ecological target functions on external prognosis of renewable power generation, residual load, traffic and weather forecasts or trading platforms to provide an ecological sound activity planning on a national, regional and local scale. Combining economical and ecological target functions leads to more sustainable, environmentally-conscious activities.

Results: The methodology will be demonstrated exemplarily for energy and transport systems. Results are presented for the adaption of power consumption by time shift of production processes, done in the "WindNODE" project at a Siemens production campus. Additionally the adaption of power consumption by storage solutions, done in the project "Energienetz Berlin Adlershof" demonstrates the benefits of the time shift of power demand from the grid by ecological load management. Utilizing the availability of renewable power can be supported by ecological optimized charging schedules for e-mobility and introduction of e-mobility at hotspots, done in the project "Mobility2grid". Finally the Siemens City Air Management service shows the ecological advantage of implementing restrictive measures on a temporary and local scale at high reduction potential.

A sensitivity analysis will present the results of different ecological target functions varying in scope and type of emissions considered and allocation methods.

SESSION T2-8 Negative Emission Technologies (Net)
4th September 2019, Wednesday 10:30 - 12:00 am

Biogas reforming with CCS and DACCS: Two promising options for Carbon Dioxide Removal from the atmosphere

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Goal.

Our life cycle analysis aims at the quantification of net amounts of carbon dioxide removal from the atmosphere and of associated environmental burdens of two technologies: biogas reforming with CO2 capture and direct atmospheric CO2 capture, both with subsequent permanent geological storage of CO2. While biogas reforming with CCS is supposed to generate “carbon-negative” hydrogen, which can be used as clean transport fuel, industrial feedstock or for power generation, the sole purpose of DACCS is CO2 removal from the atmosphere.

Both of these “carbon dioxide removal (CDR)” practices or “negative emission technologies (NET)” play important roles in climate change mitigation scenarios and seem to be required for limiting global warming at levels of 1.5-2°C. Therefore, they must be analyzed from a life-cycle perspective prior to large-scale implementation on regional or even global scale in order to understand and minimize unintended side effects on ecosystems or human health.

Methods.

We perform Life Cycle Assessment (LCA) of both CDR options according to ISO standards, considering state-of-the-art technologies for biogas reforming with CO2 separation, atmospheric CO2 capture, and geologic CO2 storage in saline aquifers. We include several types of biomass feedstock for biogas production, e.g. wood, manure, and organic waste. Our analysis of DAC builds upon the latest technology of climeworks, the first commercial developer and employer of DAC. We link detailed process models for biogas reforming and DAC with life cycle inventories allowing for the quantification of impacts of different separation processes, process performance variability and uncertainties as well as potential future technology development on LCA results. In order to represent the CO2 emission related benefits of clean hydrogen from biogas reforming with CCS correctly, we include its use in fuel cell vehicles – in comparison to conventional vehicles – in our analysis.

Results.

First preliminary results for direct air capture of CO2 indicate that the environmental performance of DAC predominantly depends on sources of electricity and heat required for the DAC process. An optimal process setup benefits from the availability of waste heat and electricity with a low-carbon intensity. Preliminary results for biogas reforming with CO2 capture show that hydrogen purities >99.97 vol% with a CO2 capture rate of >90% can be achieved; such clean hydrogen can be used in fuel cell vehicles almost directly and results in a very good environmental performance of such vehicles. However, methane losses in the biogas processing chain have to be avoided in order to guarantee benefits in terms of greenhouse gas emissions. The geological storage of CO2 in saline aquifers generates minor burdens.

SESSION T2-8 Negative Emission Technologies (Net)

4th September 2019, Wednesday 10:30 - 12:00 am

Introducing dynamic in (bio)CCS, does it matter ?

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IFP Energies Nouvelles

Goal

Global warming and the increasing Earth surface temperature is a global threat with ultimate severe impacts to human health and ecosystems. Climate scientists have proven with high certainty that the rising positive radiative forcing is due to anthropogenic activities. Global commitments and policy frameworks have developed measures and climate targets towards low-carbon nations and low-throughput societies, staying below 450 ppm or the 2 degrees Celsius limit. Carbon capture, utilization and sequestration (CCUS) are promising technologies to reduce the net release of CO2 and will play an important role in meeting energy and climate goals. For instance in the IEA Sustainable Development Scenario, CCUS accounts for 7% of the cumulative emissions reductions needed globally to 2040. Particular attention is paid to bio-energy with CCS, or BECCS, consisting in the conversion of biomass into energy with the resulting CO2 captured and geologically stored. Life Cycle Assessment (LCA) is a standardized method to assess multiple environmental impact categories of a system from extraction of raw materials to its final decommissioning. It is a well-established tool with a defined methodology. However, current methods used in LCA are limited for carbon accounting through linear simplifications and aggregation of carbon flows without accounting the timing of the emissions. Thus, under this study dynamic models are used to include the time dimension into dynamic LCA (inventories and impact assessment) of carbon flows from the carbon sequestration and storage in the vegetation to permanent sequestration.

Methods

The objective of this study is to assess the climate change impact of electricity generation, from fossil (coal) and renewable (biomass) resources, with and without CCS technologies. Short Rotation Coppice (SCR) such as poplar or willow are compared to more commonly used biomass for bioenergy with higher rotation periods. The dynamic biogenic carbon is assessed through a Cbio modelling tool of French forest developed at IFPEN. The model generates dynamic inventories of the Cbio embedded in the biomass. It applies dynamic growth models from forestry science, elaborated for the French forest wood industry. Both static and dynamic approach for climate change assessment are compared. The main purpose of this study is to find out whether dynamic models better assess the environmental profiles of (bio)CCS technologies and significantly influence their results and conclusions as compared with static approaches.

Results

Two time horizon (TH) are assessed (20 and 100 years) as recommended by the last IPCC report, and dynamic Global Warming Potential (dynGWP) are used. The setting of the temporal boundaries and assessment approaches need to be defined with precaution, particularly in the context of biogenic carbon accounting, as different assessment approaches are possible when taking into account different temporal boundaries considered for accounting the LCI balance. Static results are sensitive to the chosen fixed TH, while dynamic results provide temporal information on real-time climate change effects for any given year. Dynamic biogenic carbon accounting is proven relevant for forestry resources with long rotation /sequestration lengths.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges
4th September 2019, Wednesday 10:30 - 12:00 am

Assessment of resource use in aircraft manufacturing: a case study of an Airbus A330-200

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Goal: To attend the growing demand of passengers worldwide, in the next 20 years the aircraft fleet will almost double. At the same time, there are neither consolidated procedures for recycling of the retired aircrafts nor a binding legislation for it on national or global level. Thus, the demand for virgin materials for the production of new aircrafts has been and will be increasing. In this context, the goal of this study is to assess the supply risks as well as environmental impacts of resource use during aircraft manufacturing, demonstrated on the example of an Airbus A330-200. Further, the trend of using more composites materials instead of aluminium in the aircraft fuselage and wings is analyzed.

Methods: The integrated method to assess resource efficiency (hereinafter called ESSENZ) is adopted to assess environmental impacts and supply risks of the A330-200. For the environmental analysis, a life cycle assessment is performed with GaBi software applying the impact assessment methods CML-IA for the categories climate change, acidification, eutrophication, photochemical ozone creation and ozone depletion. Further, supply risks are evaluated for overall 11 potential supply constraints, e.g. political stability and trade barriers.

Results: Overall, the engine, wings and fuselage lead to the highest environmental impacts in all analyzed categories. In the category acidification, the engine production – more precisely the nickel alloy – is responsible for 45% of the impacts. In the categories eutrophication, photochemical ozone creation and ozone depletion the engine also has the highest impacts, but due to the titanium and tantalum alloys.

The structures fuselage and wings are responsible for most of the global warming potential (GWP) of the manufacturing process (71% of total impacts), mainly explained by their aluminium use. With regard to the supply risks, the metal tantalum contained in the engine dominates most of the categories. One exception is the category company concentration, where niobium is the main hotspot due to dominance of one Brazilian firm. Leaving the engine out of the analysis, aluminium has the highest result in 4 out of 11 categories, including demand growth and feasibility of exploration projects.

When assessing the trend of using more composite materials, a higher GWP is observed due to use of crude oil for their manufacturing. The partial substitution of the aluminium alloy by composite materials does not change existing supply risks significantly, with the exception of the category feasibility of exploration projects.

The study comes to the conclusion that the metals tantalum, aluminium, titanium and nickel are especially relevant from an environmental point of view as well as regarding the supply risks, also when considering higher amounts of composite materials in the aircraft manufacturing.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges
4th September 2019, Wednesday 10:30 - 12:00 am

Assessment of Biodiversity in LCA

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BASF SE

Goal

The use of land for agriculture, especially mono-cropping systems with intensive input use, can cause a sharp decline in biodiversity in a given landscape. Therefore, sustainable agriculture requires assessment methods to understand disturbance effects on biodiversity and the relevance of agro-ecological measures applied by farmers. Against this background, the concept for an LCA-compatible biodiversity indicator system was developed by BASF in the form of a customizable calculator for agricultural systems. The tool allows users to select a set of practices to estimate and potentially improve biodiversity impacts on-farm, through a management-driven approach. The first purpose of the calculator is to complement LCA results with a biodiversity perspective. A second application of this calculator is to support agricultural advisors and farmers, providing relevant information for decision-making towards continuous improvement in sustainable agriculture. In addition, other potential uses of the biodiversity calculator include educative sessions in environmental management, while the results of the calculator can be considered for corporate sustainability reporting.

Methods

The calculator combines two scientifically-proven methodologies. The regional or country specific characterization factors from Chaudhary et al. (2018) are adjusted by local factors that depict farmers' management practices (predicted farm-specific biodiversity loss, which were calculated based on information extracted from Conservation Evidence, a free-access database compiled by the University of Cambridge (Dicks et al, 2014), to support decisions about how to maintain and restore global biodiversity.

The calculator is customizable, allowing users to select measurements from a set of categories (country or ecoregion, land use type, scope of application etc.) that represent their farm management conditions. By filtering categories, a subset of practices that impact biodiversity are displayed. The user can choose the ones that he is currently applying to check the species diversity status of his farm and, eventually, test how additional practices change the biodiversity if implemented. Furthermore, filtering options specifying the scope of life cycle assessment are available for configuration.

Results

The methodology behind the biodiversity calculator is being reviewed by Prof. Jan-Paul Lindner. The calculator will be integrated into BASF's AgBalance™ methodology, thus enabling the combined assessment of biodiversity and LCA impacts caused by different farming practices. A plausibility check has shown that the tool can be used to predict meaningful results, through an index score system, together with an estimation of species loss characterization factors for land use occupation and transformation.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity
4th September 2019, Wednesday 10:30 - 12:00 am

A New Hope: Plastic packaging waste as enabler for Climate Change Mitigation in a Circular Economy

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Goal

From 2015 to 2050, the global plastics production is predicted to increase fourfold from 407 Mt to 1600 Mt annually. 91 percent of the global plastic waste has never been recycled. Even today, approximately half of the resulting solid plastic waste is landfilled. Exhaustive landfilling leads to uncontrolled plastic pollution of the natural environment. To reduce plastic pollution, politicians and scientists call for a transition to a Circular Economy. By using plastic waste as a resource, a Circular Economy aims to avoid virgin plastic production in the first place and thus also avoid the greenhouse gas emission associated with plastic production. Hence, the shift to a Circular Economy might not only provide a solution to plastic pollution but might also significantly contribute to climate change mitigation. However, a system-wide assessment of the future role of circulating plastic wastes to mitigate climate change is so far missing.

Method

To investigate the potential of circulating plastic wastes for climate change mitigation, in a first step, we set-up a bottom-up model of the chemical industry producing plastics. The bottom-up model of the chemical industry includes 160 industry-level datasets, including all mass- and energy balances following the basic principles of Life Cycle Assessment. The used datasets represent the production of those large-volume chemicals and plastics that account for more than 75 % of the industry's GHG emissions. In a second step, the bottom-up model of the chemical industry is expanded to a Circular Economy Model for plastic packaging wastes. For this purpose, we include technology-datasets for recycling technologies of the major plastic packaging wastes: PET, HDPE, LDPE, PP and PS. Finally, we use the Circular Economy model in a mathematical optimization to minimize the impact on climate change by applying optimal recycling pathways within the chemical industry. Recycling pathways are benchmarked to the incineration of all plastic packaging wastes to avoid uncontrolled plastic pollution.

Results

Our results suggest that mechanical recycling of plastic packaging waste can reduce up to 674 Mt of CO_2-eq emissions annually. If additionally ideal chemical recycling technologies are used, potential climate change impact reductions increase to 734 Mt of CO_2-eq. In conclusion, our analysis shows that, beside the benefits of reducing plastic pollution, a Circular Economy for plastic packaging wastes offers a large climate change mitigation potential.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

4th September 2019, Wednesday 10:30 - 12:00 am

Life cycle assessment of poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) characterized by bio-based content and biodegradability

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Goal

In this work, we performed a life cycle assessment of poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBH), which is made from biomass resources and has a characteristic of biodegradability in both soil and seawater. In order to reduce the dependency on petroleum resources and decrease marine plastics, increasing attention has been paid to bio-based and biodegradable polymers. Great expectations are shed on their “carbon neutrality” to mitigate global warming, and their ability to decompose into carbon dioxide and water to eliminate residual plastics in the environment. Until now, many papers about the environmental impacts of these biopolymers have been reported. However, the environmental impact of a biodegradable polymer that dissolves in an aquatic environment has not been clearly investigated yet. To discuss the effect of bioplastic introduction to the society, it is necessary to elucidate its impacts through its entire life cycle.

Method

We applied a life cycle assessment to PHBH products from the cultivation of biomass resource to the end-of-life, and we considered their environmental benefit to the society. This study characterized the environmental impacts of PHBH products used as a substitute for conventional fossil-derived products. The selected target is PHBH products and comparable conventional plastic products with the same function. The functional unit is the unit amount of product usage. Their resource extraction, production processes and end-of-life are different from each other. PHBH is biologically synthesized from plant oil and refined for pellets. We set a system boundary including biomass cultivation, microorganism fermentation, polymer extraction, product manufacture, use and end-of-life. Previous studies stated that the environmental burden of biodegradable plastics is largely influenced by how to treat the wasted products, and it is well known that waste management system differs from region to region. Therefore, we generated several end-of-life scenarios such as incineration, landfilling, recycling and dumping depending on local waste systems and consumer behaviors. To construct the inventory data, we investigated the actual production processes in Japan. We discussed the sustainability of biomass resource extraction based on the inventory data. The inventory data of the end-of-life were constructed through literature surveys and facility visit. Finally, we targeted global warming for the impact category to discuss whether PHBH can become a possible measure for climate change.

Results

Through the assessments, we will discuss which process within life cycle has a significant environmental impact and which end-of-life scenario can contribute to reducing greenhouse gas emission. Our results will help design and construct a better social system for biopolymers and provide deep insights for utilizing PHBH.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

4th September 2019, Wednesday 10:30 - 12:00 am

Approach to measure the circularity and environmental benefits of circular products made of plastics

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The Fraunhofer Society has launched the Fraunhofer Cluster of Excellence "Circular Plastics Economy" which is managed by Fraunhofer UMSICHT in Oberhausen. The main goal of the project is to develop special system services with and for the plastics industry, including its associated consumer and retail companies and the recycling economy. Apart from the development of two exemplary circular products, the goal is to develop a circularity assessment methodology in order to address the degree of circularity of the developed plastic products, their contribution to resource protection and to assess associated environmental impacts.

Starting from the Material Circularity Indicator developed by the Ellen MacArthur Foundation (EMF 2015), which considers the recycling content, the recycling after use and a utility factor that addresses life time and use intensity, the approach will be extended to better consider biobased plastics and the life time of plastics considering multiple cycles. In addition, a method to consider dissipative losses of plastics (material losses in the supply chain) will be developed and will be integrated into the circularity assessment. In order to consider environmental impacts of products, a life cycle assessment can be performed in parallel to identify trade-offs between circularity and environmental impacts. The biggest environmental benefits are expected in the use stage (Haupt and Zschokke 2017), which are associated with circular business models that consider reuse, refurbish or sharing of products. Therefore, appropriate LCA methods will be developed that allow the integration of complex alternatives for the use stage.

The development of the assessment methodology will be accompanied by stakeholder engagement in various dialog formats to ensure the applicability of the approach. Moreover, the developed methods will be tested in two case studies: for a children safety seat and for a packaging box. Both products will be designed against the goal to increase their circularity and will be manufactured within the Circular Plastics Economy Cluster.

The presentation will highlight shortcomings of current circularity indicators for plastic products and will make a proposal how to consider bioplastics and dissipative losses of plastics. Methodological approaches for LCAs focusing on the use stage will be presented. Moreover, trade-offs between the circularity of plastics products and their environmental impacts will be investigated and discussed.

Publication bibliography

EMF (2015): Circularity Indicators: An Approach to Measuring Circularity. Methodology. Edited by Ellen MacArthur Foundation (EMF).

Haupt, Melanie; Zschokke, Mischa (2017): How can LCA support the circular economy? —63rd discussion forum on life cycle assessment, Zurich, Switzerland, November 30, 2016. In Int J Life Cycle Assess 22 (5), pp. 832–837. DOI: 10.1007/s11367-017-1267-1.

SESSION T4-6 Indicators and Communication in LCM

4th September 2019, Wednesday 10:30 - 12:00 am

Improved communication of scale and severity of environmental impacts

Frida Røyne (RISE Research Institutes of Sweden), Michael Martin (IVL Swedish Environmental Research Institute), Louise Quistgaard (RISE Research Institutes of Sweden)

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That the climate impact of driving 1 km with a car can amount to 120 g CO2-eq is comprehensible to many. However, other products and associated environmental impact categories can impose more challenges and can be considered more intangible. For example, stating that the photochemical ozone creation potential of the production of 1 m3 of concrete is 0.04 kg C2H4-equivalents can be more confusing than helpful to non-LCA practitioners (and even for LCA practitioners). Due in part to these difficulties, many current LCAs include a limited set of indicators. For industry to improve the environmental performance of their products, which can ultimately lead to transparent and effective reporting to investors and customers, it is important that they understand the relative significance of impact category result; whether they are severe, and in relation to what. That leads to the goal of this study; to provide guidance on improved LCA result interpretation.

The study employs a mix of methods; interviews, literature studies and a final online survey. The focus is on the bioeconomy and emerging technologies within the product groups chemicals, plastics and fuels. The bioeconomy is a strategy for a sustainable transition. It is therefore extremely important that the developed technologies offer sustainable solutions and effective performance communication. Industry representatives and LCA researchers are interviewed on their viewpoints on accountable communication. Existing LCA studies and interpretation method suggestions are scanned, analyzed and categorized. The findings, exemplified in cases with different approaches, are used in an online questionnaire which is sent to three different groups of respondents to identify differences in preferences; industry representatives, LCA researchers, and communicators experienced with LCA results.

Based on the evaluation, guidelines and examples for best practice will be formulated. The guidelines will consider how scale and potential severity of environmental impact in different environmental impact categories can be communicated, and illustrate the benefits and challenges, such as level of abstraction and data availability, of using different methods for comparison; for example, the conventional product, current and expected emission levels, national goals on emission reductions, or planetary boundaries.

SESSION T4-6 Indicators and Communication in LCM

4th September 2019, Wednesday 10:30 - 12:00 am

Key aspects in hotspots analysis of national environmental footprint - from application to the case of Japan -

Masaharu Motoshita, Keisuke Nansai, Seiji Hashimoto, Takahiro Sasaki, Stephan Pfister, Matthias Finkbeiner

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"Hotspots analysis" has recently attracted attention and become common as a concept that aims to identify crucial processes in Life Cycles Assessment (LCA) and footprinting towards efficient improvement of environmental performance. From the viewpoints of policy design, hotspots analysis of comprehensive activities aggregated individual processes/products/organizations will help policy makers to grasp critical points. At national level, a wide variety of sectors have different supply chains in the global market, which makes it hard to identify critical aspects and points in terms of national environmental footprint. Thus, we aim to identify hotspots of environmental impacts associated with Japanese national activities from both aspects of production and consumption.

The Global Link Input-Output model (GLIO) is a Multi-Regional Input-Output models developed to represent global supply chains of Japanese national activities. Three environmental issues (GHGs emissions, freshwater consumption, deforestation) attributed to Japanese national activities are currently analyzed by adopting GLIO model. Direct environmental loads from each of sectors (Japan: 400, 113 countries: 57, rest: 1) are calculated on country scale (230 countries). GLIO model quantifies the embodied environmental loads in global supply chains associated with Japanese national activities.

The results of embodied environmental loads estimation show that influential sectors are different among three environmental issues. Environmental loads related to food products accounts for major part of total load of freshwater consumption (around 60%) and deforestation (around 70%), while for GHGs emissions they account for only 24%. In terms of global distribution, most of deforestation associated with Japanese national activities occurs outside of Japan, while foreign dependency is lower in the cases of GHGs emission (57% in Japan) and freshwater consumption (32% in Japan). More results of detailed analysis (e.g. comparison between production-base and consumption-base) will be given in the presentation.

SESSION T5-7 LCM and Central Eastern European Countries – the Past, the Present and the Future
4th September 2019, Wednesday 10:30 - 12:00 am

Report on the state of the Hungarian LCA

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Although the life cycle assessment has been known in Hungary since 1991, the demand on the application of it was only later in the early 2000's, mainly at research centre (universities, research institutes) and multinational companies. As there were typically one or two researchers working on a specific project, therefore the need for cooperation and sharing of experiences was soon established. This led to organise the first life cycle assessment conference in Szeged city in Hungary in 2006. In that time the participants determined to introduce and present the possibilities of life cycle assessment at conferences, scientific journals, educational materials, etc. Two years later, The Hungarian LCA Center Association was established. In the decade since then, the state of the Association has solidified and number of its members was increased, becoming a real hub for domestic LCA professionals.

Life cycle assessment research teams were established in the county which worked independent or collaborated with the association. The Bay Zoltán Nonprofit Ltd. and ÉMI have dominant role among companies, while among the universities there are strong research at University of Technology in Budapest, at the University of Debrecen and at the University of Miskolc. However, the universities involved the education of future professionals in the field of LCA is not negligible. In many cases, the students can learn the theoretical and practical side of LCA in separate course. The domestic industrial experiences often appear in the education helping to know the wide range of their knowledge.

The demand for life-cycle analysis is growing exponentially in recent years. This means that beside the life cycle analysts, the companies employ specialists directly provide the analysis with standard-compliant methods and software. The industry's demands - for Western European effects - are increasing, which is reflected in the fact that industrial companies want to be more environmentally conscious, pay attention to their own environmental impacts, want to know their contribution to the load and also want to meet market demands: in many cases e.g. eco-labels become available. The demand for the LCA in the last decade, the large companies include construction, product manufacturing, engineering, and chemical and food industry. But the LCA is an integral part of the domestic and international projects.

The LCA professionals of Hungary are in constant contact with the European LCA circulation. The first HUPLEE LCA Conference, the SETAC LCA Case Study Symposium were organised and the association is the founding member of CASE LCA Network. In addition, the researchers take part in conferences and courses, because the LCA constantly develop and change therefore the market demand has to fit. The LCA professionals share the achievements through the annual domestic LCA conferences and through the association's magazine.

SESSION T5-7 LCM and Central Eastern European Countries – the Past, the Present and the Future
4th September 2019, Wednesday 10:30 - 12:00 am

RESEARCH ACTIVITIES ON LCA AND LCM IN POLAND

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The main goal of this paper is presenting the history and actual situation in research on LCA and LCM in Poland. This task will be performed by reviewing the different activities and their results in these fields, from their very beginning. As a starting point, the first attempts of the introduction of LCA/LCM aspects into research practice in Poland are presented. These “pre-historical” activities were connected with the implementation of Life Cycle frames into analysis of the environmental impacts of technical objects, as it was presented in a paper: “Considerations on the Usefulness of Determination of Environmental Expenditure of the Existence of Machines and Devices”, published in Scientific Works of Poznań University of Technology, series: Machines and Vehicles, in 1986 (author: Zbigniew Kłos). Then there are presented other activities, like the first book on LCA related issues, entitled “Environment Protection Oriented Property of Technical Objects. A Study of Valuation of Machines and Devices Influence on Environment”, published by Editions of PUT in 1990 and first PhD thesis “Ecobalancing of Machines and Devices with the Example of Air Compressors”, defended by Grzegorz Laskowski at Faculty of Machines and Vehicles, Poznań University of Technology in 1999 (supervisor: Zbigniew Kłos). Then there were in the nineties’ other activities accomplished, like engagement in work activities of European LCA research groups: SETAC-Europe Workgroup on LCA and Conceptually Related Programs and SETAC-Europe Workgroup on LCA Case Studies and participation in European Union Research Programme LCANET as well as in European Union Concerted Action CHAINET. The paper includes the review of the activities of LCA/LCM main research centers in Poznań (Poznań University of Technology, Poznań University of Economics and Business), Cracow (Polish Academy of Sciences, AGH University of Science and Technology, Cracow University of Economics), Zielona Góra (University of Zielona Góra), Bydgoszcz (UTP University of Science and Technology), Katowice-Gliwice (Silesian University of Technology), Częstochowa (Częstochowa University of Technology), Szczecin (West Pomeranian University of Technology Szczecin). LCA researches are also cultivated in several smaller research groups in R&D centers. Co-operation of some groups with foreign centers will also be presented.

In the end of the paper some conclusions referring to the actual situation of research on LCA/LCM, dealing with critical evaluation of the LCA/LCM centers in Poland location, issues and problems addressed, areas of the projects covered and the desired activities in the future, are presented.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines
4th September 2019, Wednesday 10:30 - 12:00 am

Update on the revision of the Guidelines for Social Life Cycle Assessment of products

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Goal: the main goal of this contribution is the presentation of revised version of the guidelines for social life cycle assessment of products and give an overview on the steps of the project developed around it. This project started in September 2017 as a flagship activity of the 5th phase of the UN environment Life Cycle Initiative, that is one reason why the stakeholder involvements and a broader consultation process has been developed. The project consists of two phases: 1) revision of the Guidelines and 2) Implementations of the new version of the Guidelines throughout new case studies. The process takes place also in cooperation with the 10YFP Consumer Information Program.

Methodology: Since the launch of the first Guidelines for the social life cycle assessment of a product (UNEP, 2009) and its Methodological Sheets (UNEP, 2013) many S-LCA case studies have been conducted, and methodological improvements, i.e. the special issue on Social life cycle assessment, (Macombe et al 2018) have taken place. At the same time, similar initiatives from the business world were developed: e.g. development of the Handbook of Product Social Impact Assessment (2018) released by the Roundtable of Product Social metrics in different versions (2016, 2018).

Building on the existing literature, research activities and initiatives, experts in the field joined the “Social LC Alliance” effort to review the S-LCA Guidelines 10 years after its original publication by bringing a critical update.

The review process undertaking includes experts from all sectors (academia, business, government, NGOs,) working in small groups by topic. A comprehensive peer review process will be launched in 2019. The new capability-development format will support broadening the practice by making the Guidelines a cornerstone reference for anyone wanting to conduct a S- LCA, Social Organizational Life Cycle Assessment, Social Hotspots Assessment or a Human Rights Due Diligence Assessment.

Results An overview of the new S-LCA Guidelines draft with the particular attention on the new parts on the social life cycle impact assessment and new stakeholder categories included will be given with the description of the new aspects included as well as a description of the consultation process and inputs received to finalize the Guidelines.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines
4th September 2019, Wednesday 10:30 - 12:00 am

Handbook for Product Social Impact Assessment 2018

Diana Indrane, ArcelorMittal, Mark Goedkoop, PRé Sustainability, Ilonka de Beer, Sandalfon Sustainability

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ArcelorMittal

Goals.

Since 2013, the Roundtable for Product Social Metrics have worked on developing a consensus methodology for assessing the social impact of products life cycle, which was documented in the Handbook for Product Social Impact Assessment (PSIA). Since launching Handbook version 3.0 in 2016 (Fontes , 2016), the Roundtable members strengthened their knowledge by applying the PSIA method in case studies and internal company procedures. In order to consolidate the lessons learned, the Roundtable undertook a revision of the Handbook v3. The goal of this abstract is to introduce the updated Handbook for Product Social Impact Assessment 2018 and its underlying methodology. The Handbook 2018 (Goedkoop, et al., 2018a) presents guidance and practical steps on how to apply the method while the Methodology Report (Goedkoop, et al., 2018b) outlines the revised PSIA methodology.

Methods.

Starting in late 2017, the Roundtable for Product Social Metrics, consisting of 8 companies from various sectors, aimed to (i) consolidate their experiences with applying the PSIA method, (Ii) review the Handbook v3 2016, and (iii) update the PSIA method to reflect the state of art understanding among the Roundtable member companies. Four key elements of the PSIA methodology – stakeholder groups, social topics, impact assessment method and performance indicators - were reviewed, analysed and updated.

The PSIA methodology and Handbook were updated by an interactive and collaborative process facilitated by PRé Sustainability. Workshops and working groups were organised for companies to discuss fundamental methodological points and make choices. Before finalising Handbook 2018 and the Methodology Report, an external consultation was conducted with social life cycle experts who formed an academic review panel, other reviewers with a scientific background and potential business users. Ten external parties made contributions and the received feedback was taken into account in the final editing.

Results.

The PSIA methodology 2018 present social impact assessment of products that addresses four stakeholder groups: workers, users, local communities and small-scale entrepreneurs. Altogether 24 social topics were selected to assess social impacts on the stakeholders. For each social topic, we developed a detailed impact assessment method – reference scales – and presented the underlying performance indicators. Important new elements are introduced in the methodology such as a more carefully defined Area of Protection per stakeholder group and use of the five-capital approach to understand the mutual dependencies between companies and various stakeholders. Defining these dependencies facilitated a better understanding of the most salient social issues to be addressed for each stakeholder group. Another new element introduced is a set of clearly defined overarching guiding principles for establishing reference scales. This resulted in a much more consistent definition of reference scales and the underlying performance indicators for each social topic.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines
4th September 2019, Wednesday 10:30 - 12:00 am

Social Footprint of US industries: A first step towards Net Positive

Catherine Benoit Norris, Gregory Norris, Lina Azuero, John Pflueger, Diane Bunse, Lauren Zulli

Corresponding author: Catherine Benoit Norris

NewEarth B

Goal:

This presentation demonstrates the process and outcome of social life cycle assessment studies that we conducted and that focused on typical US industries (electronics, office furniture) company and their supply chain rather than a specific company. The objective is to calculate the social footprint of a baseline US company from governmental data and to identify salient social risks and social hotspots. This baseline can then be refined using company specific information about its supply chain and the social risk associated with its production activities and their location.

Method:

Social Life Cycle assessment is often applied at the product level. Here it is applied at the company level, using generic information about the inputs to a typical US computer manufacturing company and US office furniture company that are related to a global trade model and social impact database (SHDB). The global trade model enables us to map the likely supply chain based on where inputs are usually sourced from by the US sectors.

Results:

When LCA is applied at the company level it is considered under the banner Organizational LCA. Since there are not many examples of Organizational Social-LCA “SOLCA”, this study also represents a great example of it.

The later work establishes a methodology that enables to use the industry-level impacts and assessment in combination with the organization’ own data to calculate. The social footprint assessment is considered as an integral part of a social net positive assessment and also contributes to a human rights’ due diligence process.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines
4th September 2019, Wednesday 10:30 - 12:00 am

The different directions of Social Life Cycle Impact Assessment

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Goal: With the initial publication of the Guidelines for Social Life Cycle Assessment of products (UNEP, 2009), Social Life Cycle Assessment (S-LCA) started to gain importance and to be implemented in concrete case studies. Since then, various methodological suggestions and advancement have been made and dis-cussed. At the same time challenges to the S-LCA framework have been brought forward, pointing at Social Life Cycle Impact Assessment (S-LCIA) as the most challenging phase of the methodology.

Methods: With this presentation we introduce the different impact assessment approaches in S-LCA, by taking into account Type I (or Reference Scale) assessments as well as Type II (or Impact Pathway) assess-ments. While Type I describes the current state of a product system and seeks to evaluate its social perfor-mance and/or risk compared to a reference/benchmark, Type II tries to predict the past, current or even future social consequences along a defined impact pathway resulting from product systems. With the choice on the type of social impact assessment implicitly choices on the scope are made. This relates e.g. to the stakeholders included but as well to the results achieved, which may be social risks or even social impacts.

Results: With the new Guidelines we now distinguish five main types of performance reference points for Type I. PRPs can be either based on: 1) specific norms and best practice, 2) norms and best practice in the socio-economic context, 3) expert knowledge (generic form), 4) even portions or distribution relative to comparable peers, or 5) a combination of 1) and 4). Following on this, Type I impact assessments typically undertake three steps: 1. Assessing the distance to target (or referencing); 2. Applying the activity variable; and 3. Weighting the final result. In comparison, S-LCIA in Type II tries to establish causal relations by link-ing social activities with inventory indicators and at a later point of the impact pathway with impact indica-tors. Type II assessments are normally characterized by the existence of inventory and impact indicators, characterization models and the presence of correlations and/or causal relations described within impact pathways. For Type II no standard or consensual procedure on how to conduct the impact assessment has emerged so far, but four main paths on how to undertake it can be identified: 1. Calculation of single-unit indicator, 2. Calculation of single-unit health indicators, 3. Creation of indicator frameworks for mid-/endpoint impact categories, or 4. Macro-scale indicators representing endpoint impacts.

Conclusion: With these findings, guidance can be provided on when and how to use which kind of S-LCIA approach. We will further present the new impact assessment structure within the Guidelines including the current state of the art on the topic by also providing the inherent level of precision, strengths and limita-tions of the different impact assessment types. With this, practitioners will be equipped to use S-LCIA tai-lored to the specific application and target of their studies.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines
4th September 2019, Wednesday 10:30 - 12:00 am

An input-output inventory model for application in the social life cycle assessment of the Portuguese pulp and paper sector

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1. Goal

The assessment of the social dimension from a life-cycle perspective is still methodologically challenging. Advances in this field can pave the way towards the robust evaluation of national economic sectors. This could be particularly relevant in the case of the Portuguese pulp and paper sector, which contributed to about 1.3% of the Gross Domestic Product of the country in 2016. In this sense, the goal of this work is to develop a new input-output (IO) inventory model of the Portuguese pulp and paper sector for subsequent implementation in the Social Hotspots Database (SHDB) for social life cycle assessment (SLCA).

2. Methods

An IO analysis of the Portuguese pulp and paper sector was carried out. A new IO-based inventory model of the sector was built and implemented making use of SHDB. This allowed the subsequent evaluation of relevant life-cycle social indicators, which are assessed through different categories of stakeholders.

3. Results and conclusions

The IO-based inventory model of the Portuguese pulp and paper sector shows a high contribution of national sub-sectors in economic terms. In fact, more than 50% of the added value of the supply chain of the pulp and paper sector is originated from national suppliers, which reinforces the relevance of the sector to the national economy. Besides, the IO-based inventory model shows that a broad diversity of suppliers in the sectors of forest and logging, energy, mining and quarrying, and manufacture of chemicals. On the other hand, the SLCA results for the selected indicators show the key role played by non-Portuguese sub-sectors involved in the supply chain.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 10:30 - 12:00 am

Chemical Recycling: A Groundbreaking Technology towards a Sustainable Circular Economy

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BASF SE

Goal

BASF is breaking new ground in plastic waste recycling with its ChemCycling project. Chemical or feedstock recycling provides an innovative way to reutilize plastic waste that is currently not recycled, such as mixed or uncleaned plastics. Depending on the region, such waste is usually sent to landfill or incinerated with energy recovery. Chemical recycling offers an alternative: These plastics can be utilized in thermochemical processes to produce syngas or oils. These recycled raw materials have been used as inputs in BASF's production, thereby partially replacing fossil resources. BASF is thus one of the global pioneers in the industry. BASF is collaborating closely with its customers and partners, which range from waste management companies to technology providers and packaging producers, to build a circular value chain.

Methods

At the beginning of the production chain, BASF feeds oil derived from plastic waste by an oiling process into the Production Verbund. As an alternative, Syngas made from plastic waste can also be used. The first batch of this oil was fed into the steam cracker at BASF's site in Ludwigshafen in October 2018. The steam cracker is the starting point for Verbund production. It breaks down or "cracks" this raw material at temperatures of around 850 degrees Celsius. The primary outputs of the process are ethylene and propylene. These basic chemicals are used in the Verbund to make numerous chemical products. Under the mass balance approach, the share of recycled raw material can be mathematically is allocated to the final certified sales products. Each customer can select the up to 100% allocated percentage of recycled material.

Results

Market and society expect industry to offer constructive solutions to deal with plastic waste. Chemical recycling is an innovative complement to other recycling and waste management processes. A wide range of recovery options for plastic waste is needed, since not every solution is suitable for each type of waste or possible for each product application. The first choice should always be the solution that performs best along the life cycle. Therefore, BASF is evaluating the environmental burdens of chemical recycling in comparison to other recyling options like mechanical recycling or municipal waste incineration by Life Cycle Assessment (LCA). The presentation will cover the techology of chemical recycling and BASF's achievements so far, the application of mass balance approach to LCA and the environmental evaluation of different recycling options.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 10:30 - 12:00 am

Circular Economy Initiative for Enel Suppliers Engagement

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LCE

Goals

As a worldwide player in the energy sector, Enel group is committed to promote sustainability as a major asset for its business. According to circular economy pillars, as stated in BS 8001, procurement plays a key role in bending the supply chain from a linear to a circular shape. Therefore, in 2019, Enel launched the Circular Economy Initiative for Enel Suppliers Engagement; the project aims at involving suppliers from selected sectors in a joint mapping activity of the supply chain from environmental sustainability and circular economy point of view. Sectors involved in first edition of the project are Wind turbines, Photovoltaic modules, Power meter, Circuit Breakers and Insulators.

A first output of the project is thus to define KPIs which address circularity and sustainability issues throughout the supply chain. For each involved sector, a specific qualification protocol is published by Enel after third party verification; this document contains all the KPIs and target values, when present. Ultimate goal of the initiative is to include thresholds and hurdles into all future Enel tenders, in order to boost the diffusion of circular economy practices along a complex and articulated supply chain.

Methods

Main methodology behind the initiative is the Life Cycle Assessment (LCA). This methodology has been applied to the whole set of sectors involved to spot out relevant environmental KPIs along the life cycle. A technology review has been performed to confirm and validate considerations arising from LCA analyses. In the framework of the technology review, existing regulation has been investigated and available studies related to sustainability have been considered, to enrich robustness of the overall approach.

As the initiative is strongly oriented to circular economy, Enel designed a specific KPI to quantify circularity of the investigated product. This indicator is currently in prototypal phase but is expected to join the set of KPIs in future developments of the project.

To facilitate suppliers in participating to the project, a dedicated webtool has been developed. This way, companies located worldwide can easily provide requested information to cope with qualification protocol requirements.

Results

Main outcome of the project is the engagement of suppliers into a collaborative effort towards a more circular way of handling business in the energy sector. The adoption of sustainability criteria for supplier qualification represents a strong action which is embedded in a group strategy more and more oriented to sustainable future.

As a global leader in the energy sector, Enel is expected to positively contaminate other energy groups and other major actors in different sectors with this initiative in which sustainability and circularity are embedded in a sustainable development strategy at corporate level.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 10:30 - 12:00 am

Making best use of limited resources – from the choice of resources to eco-efficient engineering

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Empa

Circular economy (CE) promises an economy able to prosper on limited resources. However, it remains to prove that it is also a system of sustainable production and consumption and thus in line with the Sustainable Development Goals (SDGs). Closing material cycles alone doesn't guarantee environmental sustainability, as it leaves the question untouched how large and fast such cycles can be.

In the frame of the project "Laboratory for Applied Circular Economy (LACE)", a systemic and resource-based approach to define and operationalize CE is currently developed. LACE is part of the Swiss National Research Programme 73 "Sustainable economy" (NRP 73) and looks at boundary conditions and possible pathways towards a CE from the environmental, technical, legal and economic perspectives. The project is a collaboration of three Swiss research institutions (University of St. Gallen, University of Lausanne and Empa) and will be explored in close collaboration with seven private companies, representing four different industrial sectors.

In this contribution, we will explore the requirements for circular design of products and services derived from global sustainability criteria. The guiding question is how global earth system parameters can be considered in the design of products and services. For this, we will present a framework on how to translate the planetary boundaries (PB) into ecological available resource budgets. Resources are more or less available on a global scale in an environmentally sustainable way. Renewable resources are limited by the requirements for essential ecosystem functioning and their regeneration capacity. Finite resources, on the other hand, are limited by the consequences of the use of these resources on the environment as well as in some cases by the physical availability in the earth crust. The here developed methodology to assess their ecological availability will be presented briefly together with some preliminary results. In a second part, it will be shown, how this knowledge can influence the design of products and services. The highest economic and social value can be created from these limited resources, if all the resources are used according to their ecological availability. Consequently, products and services in a sustainable CE need to build on the ecological available resource mix, which gives guidance on material and energy selection during the design process. Maximizing the economic and social value creation not only depends on using the whole quantity of available resources, but even more so on using them most efficiently over multiple cycles. Thus, in the last part of our contribution, we will present engineering guidelines for a resource efficient product and service design over multiple cycles derived from their physical limitations. The CE-metabolism is a system with restricted in- and outflows due to global sustainability criteria. Within this system, physical laws, e.g. the laws of thermodynamics, limit the utilization of resources. The influence of these engineering guidelines on design will be shown in preliminary results from case studies within the LACE project.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 10:30 - 12:00 am

Innovation Camp – A tool for Circular Economy product development

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RISE IVF

GOAL: Circular Economy (CE) is proposed as an alternative to the traditional take-make-dispose linear economy (Bocken et al., 2017). Such alternative perspective on consumption and production is needed if we are to avoid the current high risk of irreversible environmental degradation (Wijkman & Rockström, 2012; Rockström, 2015). However, CE is still relatively uncommon in corporate practice (Bocken, Ritala, & Huotari, 2017) and there is need to find novel development practices where actors across all CE phases can rapidly and effectively develop CE optimized solutions.

The goal of this study is to define, and pilot test the Innovation Camp (IC) development approach in the context of CE. IC founded on Service Design (SD) (Zomerdijk & Voss, 2010) and co-creation (Ramaswamy & Ozcan, 2018) approaches works as a facilitated space for social interaction and knowledge exchange among carefully selected complimentary actors (Santonen, 2016) across the various CE phases. In a set timeframe–ranging from 2 to 5 days–IC participants develop novel solutions through multiple iterations while applying various co-creation and SD tools in cross-reflecting working groups.

METHOD: A participatory action research approach was applied (Kemmis & McTaggart, 2005). As a part of an H2020 funded project, the authors arranged a 3,5-day long IC which included 80 highly experienced industry and CE experts across the world. Solutions for sustainable consumption, collaborative recycling/reusing and co-creation of products and services were co-created by 7 working groups for 4 industries. Additionally, after the IC, an online feedback survey was sent to all participants, resulting in a 58,6 % response rate (47/80).

RESULTS: For solving complex problems such as CE, IC proved an excellent tool to rapidly establish new collaboration relationships and discover new insights and knowledge which can be practically applied to work. Nearly 90% of all respondents found new contacts initiated by the IC and all respondents gained new insights and knowledge at least to some extent. Importantly, over a third of the respondents could apply this new knowledge to great or to very great extent to their work, indicating that the IC had high practical relevance.

Moreover, the business owners in each of the 4 industries had obvious knowledge gaps which they could not solve by themselves and therefore needed help from various actors across the CE value chain. For example, a case company developing LED light products did not have adequate knowledge concerning the environmental impact of the product components or how to design products which were easy to recycle. As part of the IC, the company gained important insights and knowledge in these areas.

In sum, there are obvious interlinks between various CE phases, which needs to be considered already at the product design phase. Without using the shared knowledge from the different value chain actors, optimizing products for CE becomes difficult. The IC approach is therefore recommended as a tool, especially when there is need to rapidly develop solutions for CE, and when actors do not know each other before hand.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 10:30 - 12:00 am

Design methodology of multi-functional products integrating functional and environmental consequences on their life cycle

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This study aims to develop a design methodology of multi-functional products integrating functional and environmental consequences on the product life cycle. Currently, designers of multi-functional products face trade-offs between the functionalities and the environmental performance of products because functionality enhancement tends to increase the environmental impacts in the multiple stages of the life cycle. In the case of packaging, laminated film enhances the protective function for the distribution stage, whereas composite materials increase the environmental impacts of the end-of-life. Ideally, the designers should be aware of such design consequences of functionality enhancement on the entire product life cycle when designing products for sustainability. However, it is difficult for the designers to grasp the design consequences because the consequences are diverse. In reality, because the product design generally prioritizes functionality enhancement, they rarely consider the environmental consequences of the design. Therefore, a method is needed to assess the environmental impacts of the functions.

To support product design by integrating functional and environmental consequences, we presents a function-based environmental impact allocation method that quantifies the environmental impacts derived from a specific function. Our method comprises three steps: defining goal and scope, identifying the function-related design variables, and assessing the function. The first step is to define the target product and its functions for the assessment in addition to the goal and scope definition of conventional product-based life cycle assessment. The method requires two designs to be selected to consider the difference of the product functionalities. Based on the difference in the functionality enhancement and performance, the target function is determined as the focus of the assessment. The second step is to identify the relationships among product variables and processes associated with the target function for defining the functional consequences on the life cycle. Identifying the relationships represents the consequences of the functionality enhancement and its performance. The identified relationships can be defined as a function-based life cycle. As the third step, the environmental impacts from the function can be assessed based on the function-based life cycle. The environmental impacts of the function-based life cycle are extracted from the environmental impacts of the two designs. In the end, the environmental impacts of the target function are obtained by the difference in the extracted environmental impacts between the two designs. These three steps enable us to allocate the environmental impacts of the products associated with the target function.

We performed several case studies to confirm the applicability of our methodology. In the case of pre-cooked rice product, we targeted at a packaging function: the ability to use as a bowl. As a result, the function increased many environmental impacts because of the increase in the amount of packaging materials. From the results, the product designers can consider whether the enhancement of a target functionality is appropriate for the environmental impacts. By combining the functionality assessment with the function-based life cycle assessment, our methodology will contribute to evaluating the balance between the functionality enhancement and the increase of environmental impacts caused by a redesign.

SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

4th September 2019, Wednesday 10:30 - 12:00 am

Life cycle assessment of the CDW management system implemented in Lombardy region (Italy)

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Goal

The local government of Lombardy Region (Italy) has selected the Life Cycle Assessment (LCA) methodology as a strategic support decision tool in the planning of its own regional waste management. In particular, Regione Lombardia has decided to use it in the context of construction and demolition waste (CDW) management. The goal was to use the LCA to assess the current regional situation in order to define possible future scenarios with better environmental performance than the current one.

Methods

The following activities were performed: i) quantification of the amount of CDW generated in Lombardy region and the current level of recycling for each waste stream; ii) collection of information about the type, quality and actual uses and markets of secondary materials through field investigations and interviews at major recycling plants operating in the region; iii) evaluation of the type and amount of primary resources that can be replaced by secondary materials for the different end-uses, so that the actual technical applications and the regional market demand can be embodied in the evaluation; iv) LCA of the current CDW management system; v) LCA comparison of alternative management scenarios to identify possible improvements of the system. The environmental analysis focused on four waste streams: concrete, bricks and ceramics, reclaimed asphalt pavement (RAP), gypsum-based waste and mixed construction and demolition waste.

Results

In 2014, about 7 Mt of CDW were managed: the mixed waste was the main flow (80%). CDW were mainly treated in recycling facilities (90.7%) and only a limited amount (3.3%) was disposed of in landfills; the remaining 6% was stored in transfer stations without being subjected to any further treatment.

The impact assessment phase revealed that the current regional CDW management leads to additional burdens to the environment mainly ascribed to the mixed CDW fraction, due to the limited market demand of secondary materials in the region and the impact from waste transportation. Conversely, net environmental benefits come from the recycling chains of both reclaimed asphalt and gypsum wastes but, in the current scenario, their contributions are still too limited since the prevalent recycling option is the mixing of CDW to produce all-in recycled aggregates. By optimizing the recycling chain of each CDW stream, the environmental and energetic performance can be significantly enhanced; for instance, the global warming indicator, showing a net burden in the current scenario, can be turned into a net gain. The results from this LCA study allowed the formulation of recommendations for the local government. Among the most relevant, the promotion of the existing and new markets of secondary products produced out of the CDW waste is urgently needed; to this end, the enforcement of green public procurement laws, the dissemination of information relating to technical properties of mixed recycled aggregates, as well as the restriction of mining activities, can be suggested as potential effective actions. About RAP, the promotion of its recycling in hot mix asphalt while reducing its use as unbound material in road construction was recommended. Finally, the recycling of gypsum-based waste in dedicated plants and the adoption of adequate technologies able to achieve high-quality recycled gypsum and to separate cardboard/paper sufficiently pure to be destined to paper factories was recommended to improve the environmental performance of the system. Specifically, the use of recycled gypsum as a soil amendment was recognized as the most sustainable option.

SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development
4th September 2019, Wednesday 10:30 - 12:00 am

Incorporating LCA-based methods for assessing and managing a bioeconomy region

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The transformation towards a bio-based economy will need the support of all relevant actors in the society. Indeed, the estimated intensification of local biomass harvesting processes and of novel processing facilities for producing healthy foods, high value added materials and chemicals and clean energy will affect the environment as well as communities living near to biomass catchment areas and production sites. Within this new context, the current LCA tools cannot cover all aspects that should be considered for making decisions in the implementation of new bio-based technologies and/or the fostering of new bio-based products in the markets.

In this regard, as social acceptance will continue gaining importance as a central element for decision-making besides environmental and economic impacts, the overall assessment of these impacts at a regional level will become one of the next important challenges in the development of LCA-based tools. Moreover, the way of integrating these three perspectives (life cycle assessment (LCA), life cycle costing (LCC), and social LCA (sLCA)) will be another major relevant step in the LCA methodology, especially when in comes to regionalized approaches.

Goal of this work is therefore to present the advances in the development of a social LCA method and of an integrative sustainability approach for assessing the potential impacts of the implementation of a bioeconomy region in Central Germany.

SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development
4th September 2019, Wednesday 10:30 - 12:00 am

Results of a large-scale LCI data collection project on emerging economies: perspectives from a background database

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ecoinvent

Goal:

Life Cycle Assessment (LCA) can be employed to assess and mitigate the impacts of supply chains. Yet, LCA are built on LCI (Life Cycle Inventory) data, and because of a lack of sufficient background LCI data representing the situation for emerging economies, existing data were historically used, providing eventually misleading messages regarding the sustainability of local industries and policies. This underlined the critical role of sound regionalized LCI data for emerging economies, to be used as the consistent database to reflect the local practices and to conduct LCAs and report on environmental impacts.

Reflecting on that, the creation of reliable, consistent and transparent regionalized LCIs represented one of the core purposes of the Sustainable Recycling Industries-Life Cycle Inventories (SRI-LCI) project. SRI-LCI was a program funded by Swiss State Secretariat of Economic Affairs (SECO) and implemented by ecoinvent across Brazil, Colombia, India, Peru and South Africa, during the years 2015 – 2018.

Method:

More than 2'000 datasets, representing prominent industries in the above mentioned regions, were created using mainly data collected by local and international experts. The datasets were reviewed by experts and are or will be available within the ecoinvent database as well as in existing national data platforms. The project allowed also the creation of several tools, helping LCI creation in sectors such as waste treatment or crop production. In addition to data activities, SRI has considerably expanded the local knowledge and expertise on Life cycle thinking, conducting life cycle assessment, and LCI data generation.

Results:

This communication presents the SRI-LCI project, its goals, and its achievements in capacity building and LCI data collection activities. Special attention is given to the significance of data and tools provided by SRI for Latin America and India, and the LCA community. Future activities in data collection and capacity building, and the synergies for collaboration are also discussed.

Acknowledgements:

The SRI programme was supported and financed by the Swiss State Secretariat of Economic Affairs (SECO). We would like to express our gratitude to the more than 270 collaborators, data providers, LCA experts, editors, and other colleagues from various institutions, who made this project possible.

SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development
4th September 2019, Wednesday 10:30 - 12:00 am

Development of a municipal solid waste management planning tool for local and regional administrations: methodological approach and preliminary application to Madrid City

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IMDEA Energy

Goal: Municipal solid waste (MSW) management planning involves dealing with numerous waste streams with very different composition and properties, a broad variety of treatment technologies, a strong dependence on local circumstances, budget constraints as well as a rapidly evolving waste and environmental regulation. This presentation focus on a novel methodological framework, based on the combination of several systems analysis techniques, for the development of a tool that will allow municipal and regional administrations the joint consideration of all of these aspects. A case study of the MSW management system of Madrid City is presented, identifying the environmental benefits of the recently implemented source-segregation of food waste, and predicting the impact of the planned closure of the only incineration facility in the city.

Method: The methodology framework is based on the combination, by means of linear programming, of techno-economic analysis (TEA) and optimisation techniques, life cycle assessment (LCA), and environmental external costs or externalities estimation. The tool is able to work under two configurations: (i) as a LCA and TEA model, and (ii) as a techno-economic optimisation model. As a LCA-TEA model, it allows assessing the environmental and economic, including external costs, performance of the existing system or a pre-defined scenario. In the life-cycle inventory modelling, emissions are related to the mass and elemental waste composition, technological parameters and the energy system. Thus, the tool responds to any changes in the assumptions and local particularities and, therefore, is applicable to any geographical area. On the other hand, the tool is also intended to work as a techno-economic optimisation model. Under this option, MSW streams are allocated among the available or projected treatments by considering cost minimization (the internal cost or the social cost, which internalizes external costs and allows integrating the sustainability concept in the design of the MSW management system) and a set of constrains defined by the user. The environmental indicators of the new system are thus provided. Within this approach, the user can compare the environmental, economic, and externalities performance of the existing system with the optimal system and thus identify improvement opportunities.

Results: To date, the LCA model is finished and has been applied to explore the effects of two proposed MSW management strategies on the greenhouse gases (GHG) emissions in Madrid City. On the one hand, the recently implemented source-separation of organic waste would lead to a significant reduction of the GHG emissions as a consequence of a reduction on the amount of organic waste rejected from material recycling facilities (MRF) and disposed in landfill. On the other hand, the planned closure of the only incineration facility in Madrid by 2025 requires further alternatives since the existing treatment capacity would not be able to divert waste from landfill without incineration. Therefore, the tool has identified the need of enhancing recycling rates and the efficiency of MRF plants.

SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development
4th September 2019, Wednesday 10:30 - 12:00 am

Engaging stakeholders in local and regional Life Cycle Management decision-making for urban planification

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WeLOOP

Today, the local actors, are confronted with a series of expectations that seem sometimes contradictory: to maintain and develop the activity by stimulating the sustained economic performances, to respect the environment, and assume social role by considering the expectations of different stakeholders. Through the complexity of the local fabric, regional and local authorities wish to boost, protect and contribute to the development of their region through collective and creative cooperation actions.

Territorial Life Cycle Assessment - integrating environmental, social and economic aspects - provides a decision-making tool based on indicators co-constructed in a local context. It is about extending the process of Life Cycle Assessment - from cradle to grave: from resource extraction to use and the end-of-life - of products, services and organizations by making it consistent with the characteristics of its territory (its assets, its history) as well as the expectations of stakeholders living in the same territory (citizens).

Territorial LCA is the link between Life Cycle Management, industrial ecology, circular economy and the economy of service on one side and stakeholders on the other. Territorial LCA allows stakeholders to express their expectations and to contribute to the creation of shared values through a process of collective intelligence based on engaging dialogue and guided by a set of LCM toolbox. The approach is either based on top-down (e.g. input-output tables or statistics), bottom-up (e.g. collective intelligence) or a mix of both.

In this context, WeLOOP is collaborating with European Lille Metropole (MEL) to test and develop the concept of Territorial Life Cycle Assessment in the context of future urban planning. The urban sprawl and the natural ecosystems destruction caused by the conventional manufacturing process of the city is a major issue for European Metropole of Lille. The phenomena amplify the consumption of the main resources of the territories (soils and raw materials) without considering their next life cycles. It makes it impossible to accommodate the endless appearing needs for urban development on one hand, and the availability of finite resources on the other.

In this pilot project, Territorial LCA is applied to future urban planning focusing on use of resources and land. It supports the development of a new innovative circular urban planning approach based on positive externalities on human health, collaboration among the actors and natural ecosystems. Territorial LCA also proposes a set of indicators to support the decision making in this context. This contribution aims to present the first results and exchange with participants on this project.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 1:30 - 3:00 pm

An approach to handling uncertainties in LCA as decision making support for building design

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RISE

To establish circular economy in the society it is crucial to incorporate life cycle analysis (LCA) in the design process of products. The design paradox is a well-recognized problem in the design process. Early in the design phase it is easy to make changes, but less information is available. Late in the process there is more information, but difficult to make changes. The design paradox is not a specific problem for LCA, but the wide system perspective of LCA makes it more apparent, as there will be many uncertainties to manage when conducting LCA to use as a decision support tool when designing products.

When discussing uncertainties in LCA it is common to focus in the parametric uncertainties. A way to manage parametric uncertainties is, e.g., to use sensitivity analysis or Monte Carlo simulation on the system under investigation. However, this is not suitable for evaluation of design options when there is less information about the system. To only consider parametric uncertainties when large parts of the studied system is unknown might provide results with low quality. For LCA to be a valuable decision support, more aspects of uncertainty need to be considered in the design process, e.g., decision criteria, design choices, modelling choices and system boundaries. This paper presents and evaluates an approach to handling these aspects.

The goal of the study was to develop an approach that structures investigations in a way that clear decisions can be made from the calculated results. The study focused on defining the goal and scope of the study, to consider model choices and establish system boundary for technical design options when including model choice, design choice and parametric uncertainties. This approach is intended to be used in the early design phases of complex products or other studies with high level of freedom in the product life cycle.

To demonstrate and evaluate the approach a case study of an uncertain analysis of different design options for a building was carried out. Buildings are often designed in one or a few items with new combination of both building techniques as well as actors each time. This combined with a long use phase, often spanning more than 50 years, qualifies buildings to be a representative of a complex products with high degree of uncertainties during their life cycle.

The result of the study presents the approach on how to make LCA an effective tool for decision support on design alternatives when less information is available. The advantages and drawbacks of the proposed approach are discussed in order to spur further improvements of using LCA as a decision support tool.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 1:30 - 3:00 pm

Ecodesign in Latin America: Kuali Nextiyotl ("good design" in Nahuatl)

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Goals: Since 2014, the Latin American Ecodesign community works together to disseminate ecodesign as a design methodology for products and services, which will help to promote sustainable consumption and production in the public and private sectors in Latinamerica. The underlying principle is to use a simplified life cycle assessment (LCA) to calculate impacts to the design process, to make the process simple, fast, and to be able deliver quick results, in order to reach the design requirements – an LCA scan. Also to look at the strong ancestral focus.

Methods: The method includes to deliver a set of conferences and trainings, together with a learn by doing approach with expert coaching, the E3 challgenge (Ecodal Ecodesign Experience) in which the LCA based ecodesign methodology agreed upon in Latin America is used aiming at eco-innovation.

Results: Ecodal has helped to introduce the Ecodesign methodology at a Latin American level, contributing with practical experience to consolidate a network of actors from the student, business and government sphere, generating a knowledge platform led by scientific experts to create a Latin American Network of Ecodesign and provide state of the art guidance-

EcodAl Mexico 2018 was held on October 29 to 31, 2018 at the Universidad Iberoamericana in Puebla, Mexico. The topics addressed were the application of Ecodesign in: Public Policies, State of the Art Technologies, Ancestral Technologies and several case studies, for which this paper presents the main findings. 186 registered participants, from 13 different countries were present.

The findings of the Latin American Network for Ecodesign initiative in terms of academic programs will be presented, and also the outcomes of the various parallel activities in which it was assisted by experts and professionals from different specialties linked to Ecodesign and sustainability; including the five keynote addresses, nine conferences, and many other activities. The learnings from the panels include experiences of how the skills that Ecodesign provides for innovative business models, in teaching Ecodesign and policy. Lastly, the E3 experience, where Polyrafia, Metecno, Alen and Pesca la Garra participated with Ecodesign challenges. The E3 EcodAl Challenge was developed during the three days of the congress with the participants and experts coaching the process. At the end, a jury formed by the speakers of the congress, selected the team with the best eco-innovation: Polyrafia and Allen companies were the winners.

To promote good design, the participation of society is necessary: KUALI NEXTIYOTL are words in Nahuatl that are translated as "good design", but as sometimes happens in translation, the essence of the word is lost when translating it: KUALI is not only good, it is a concept that implies "the best", do it with passion, put your heart in what you do, and that is how we developed EcodAl 2018.

LCM 2019
1-4 September, 2019
Poznan University of Technology
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SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 1:30 - 3:00 pm

Knowledge Intensive Product and Service Innovation on Life Cycle Business Co-Evolution

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The business of manufacturing companies is evolving towards knowledge-intensive industrial services. It is important to stay as near to the customer process as possible in this evolution to enable the growth of efficiency of customer business over the life cycle. In this type of business, in addition to managing material and financial flows, information and knowledge flows have to be managed much better. However, complexity is also increasing because of the new offerings and the need to network all operations and manage distributed information and competence. It is obvious that the business model and other supporting business struc-tures of partners in the value network are in constant transition. It is thus important to master innovation in the customer process over its life cycle.

The objective of this article is to introduce a concept of knowledge intensive service and product innovation in life cycle business evolution routing. When business is changing, various types of innovations tackle it: business, market and life cycle innovation. Knowledge intensive service innovation needs open semantic infrastructure with master data structures provided by life cycle management architecture. The balance in running business comes by synergy management. The knowledge intensive innovation model is been developed as a joint initiative between research institute experts and case study SME-companies and was applied to individual company strategies in order to validate how trans-disciplinary innovation can be used to drive business value through creation of new services. Developed concept of life cycle business innovation is validated with one business case study. The case study company Noatek Corp. is a supplier of video control systems for high voltage substations.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation
4th September 2019, Wednesday 1:30 - 3:00 pm

Peculiarities of early stages of product life cycle for science-intensive products (aircraft)

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The science-intensive products are characterized by the following peculiarities: long life expectancy, high extent of production uncertainty, considerable risks connected with efficiency of investments utilization, as well as large temporary and resource expenditures.

Creation of such products requires using at an early stage the special methods and solutions: multiple projects feasibility study by the diversified specialists, non-terminal decision method, etc.

In the present article the actual examples of such methods and decisions utilization in the international cooperative aircraft-building projects are presented.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges
4th September 2019, Wednesday 1:30 - 3:00 pm

Environmental trade-off when using postconsumer wood in particleboards

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Goal: Particleboards can be manufactured from different sources of wood, for instance, from by-products of wood industry (e.g., wood shavings) or from postconsumer wood (PCW) (e.g., wood from demolition). On the one hand, a higher share of PCW in particleboard extends the life of the wood material (when avoiding incineration at the end of life); consequently, supports the circular economy and serves as carbon storage (decreasing carbon footprint). On the other hand, concentrations of heavy metals in PCW may generate environmental burdens at downstream manufacturers (e.g., furniture producers). The objective of this study was to evaluate the trade-off between human toxicity and climate change when increasing the share of PCW in particleboards.

Method: We performed a life cycle assessment with the 'basket of products' approach, considering three scenarios. In all, PCW was either incinerated (generating electricity) or used to manufacture particleboard. We used 1000 kg of PCW as reference flow, and the functional unit was 568kg of particleboard and 1133 kWh of electricity. Additional products (from average market) were included into the system to allow comparison between scenarios (e.g., electricity from the grid). In the baseline scenario (B0), 50% of PCW goes to particleboard, while in the two alternative scenarios (A1 and A2), 70% of PCW has that fate. The difference between A1 and A2 was regarding the contamination level of heavy metals in the PCW: A1 had the same concentration as B0, while A2 had a concentration of heavy metals five times higher. For human toxicity, we used the USEtox v2.1 (midpoint) method, with site-specific fate and exposure factors from Flanders, Belgium, for inhalation pathway of four heavy metals (arsenic, copper, lead and chromium), emitted by furniture manufacturer. For (midpoint) climate change, we used IPCC 2013 100a method with the addition of characterization factors for biogenic carbon dioxide from the method GHGBio. Moreover, the results of human toxicity and climate change were aggregated into an endpoint human health indicator, measured in disability-adjusted life year (DALY).

Results: Results show a 4% decrease in climate change for A1 and A2. This was mainly due to higher carbon storage in these scenarios. For human toxicity, A1 had lower environmental impact (-5%), while A2 had higher results (+27%), mainly due to higher emissions of heavy metals at furniture manufacturer. When aggregating the results in DALY, A1 had a lower human health impact (-4%), while A2 had higher impact (+9%). The turning point between A1 and A2 was a 2.3 times higher concentration than B0. In other words, the trade-off is only beneficial for human health impact (focused on human toxicity and climate change), if the concentration of heavy metals is limited to 2.3 of the average concentration of B0 (considering same increase in PCW in particleboard). These results contribute to demonstrate the need for assessment of actions towards circular economy, via life cycle perspective tools, since environmental trade-offs ought to occur.

SESSION T2-9 Sustainability in the Construction Sector

4th September 2019, Wednesday 1:30 - 3:00 pm

Characterising the construction waste in Chile in the context of circular economy: a first approach

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In Chile, the main cities are growing through the construction of high-rise housing buildings, which have becoming in the most common way to get a place to live. As is well-known, the character of site-specific and high resources demand of construction sector, requires that each country develop their own measures to manage them. Chile in the last years has been launching several initiatives to turn the construction sector more environmental and economic efficient. Specifically, the preventive approach for the waste generation in the construction sector has been the framework for a cross-wise consensus to put the first efforts. In this sense, the quantification and classification of wastes produced during the construction phase are still under development, due to the close linkage with the construction techniques. Moreover, the wide range of waste produced during the construction of housing building is a challenge itself and a few times before engaging with a revalorization plan. Appropriate characterization of wastes could be considered as the first step for a circular economy plan to be developed for a construction sector. The aim of this research is present the results of the quantification of waste in a high-rise apartments construction, based on primary information, and a proposal for its classification, taking into account the current local environmental regulations. These results are consolidated to get a first approach of the potentiality of a circular economy plan based on this type of construction. The data were obtained in the field from two 17-levels buildings located in the central-south zone of Chile, measuring the mass and volume of each waste and parametrized by resources and activities involved in the construction phase. The construction phase was dived into structural work and finishing stages. The classification was based using the hazardous waste legal framework and the European List of Waste.

The results show that the most part of the waste has the potentiality to be reused or recycled, opening the possibility to revalorization. The non-hazardous waste such debris, concrete, metals, and wood have the most important contribution in structural work (57 kg/m2), while the packaging (cardboard and plastics) have a relevant role in finishing stage (5 kg/m2). In the same sense, the waste from lubricants, oils, and paints are the most important specifically the paints can (packaging). These results highlight the need to include all the value chain in sustainable waste management, as well as was suggested by the law for Waste Management, Extended Responsibility to Producer and Recycling Promotion in Chile. These results could be taken as a first approach to develop a business model for a circular economy linking whole the stakeholders involved with the construction sector, even creating the opportunities for new business.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges
4th September 2019, Wednesday 1:30 - 3:00 pm

Resource efficiency assessment of digitized production networks within the manufacturing industry

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In industrialized countries, most of the material and energy resources are used in industrial production processes. Increasing resource efficiency within the manufacturing sector is therefore a necessary factor in reducing the global resource consumption. Nevertheless, there is often neither a detailed overview nor an evaluation method for the process-specific consumption of resources at company level. In this context, the industrial transition towards "Industry 4.0" is perceived as a big chance by society. Due to the utilization of innovative technologies, especially from the information and communication sector, the usage of resources should be optimized both by a holistic view and control of the product life cycle as well as by innovative production concepts [1, 2]. However, the implementation of enabling technologies for Industry 4.0 implies at the same time resource expenditures, which are, for example, associated with the production or the use phase of the tools. This requires a precise comparison of the actually possible saving effects within the production process with the opposing expenses. Thus, the resource reduction potential can be quantified and evaluated. The main goal of this study is to examine the resource efficiency potential attributed to the transformation from conventional production chains to agile production networks. The selected case study shows an exemplary production process from the metalworking industry for which a production network between two learning factories, the ETA-Fabrik and Prozesslernfabrik CiP on the Campus Lichtwiese of the Technical University of Darmstadt, will be set up and operated.

In order to quantify the resource efficiency potential, the methodology of the German VDI Guideline 4800-1 “Resource efficiency, Methodological principles and strategies” [3] is used. The guideline is based on the LCA methodology and is therefore appropriate to evaluate the environmental effects of the production systems before and after the installation of the enabling technologies. Due to its static nature, however, the underlying method of life cycle assessment present difficulties to map dynamic systems and thus agile production networks [4]. A possible solution is the application of a modular life cycle-based approach. For this purpose, all processing machines belonging to the production system as well as the enabling industrial 4.0 technologies, which are necessary for the construction of the agile production network, are separately recorded as modules in the life cycle assessment.

By measuring all input and output flows per module, a high degree of detail is achieved in the analysis. This enables the exact determination of resource consumption changes before and after the implementation of industry 4.0 technologies. The environmental impacts of the different production paths of the production network are calculated by adding the LCIA results of the single modules belonging to the respective path or system. In that way it is possible to represent the desired state of an agile production network dynamically. By comparing the cumulative environmental impacts of the different production variants, an assessment of the possible resource efficiency potentials of the production network can be made.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges
4th September 2019, Wednesday 1:30 - 3:00 pm

Towards sustainable smart farming

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Due to the population growth, food demand and production have been also in continuously growth bringing important negative environmental, economic and social impacts which are mainly caused by an intensive use of natural resources. Therefore, it is crucial to deploy efficient technologies to cover food demands with positive impacts to the society and environment. In this paper, we discuss how the use of "smart farming" (SF) can contribute to that purpose.

SF is associated to high-tech farming that is expected to play an important role in the sustainable development of the agricultural sector due to the use of diverse precision agriculture technologies, e.g. IoT, big data, drones and other ICT in farming that enhance resources management.

To illustrate the SF environmental benefits, the use of robots in precision agriculture has proved to have a considerable CO2 emissions reduction during the pest control operations (high precision application of herbicides). Some authors describe the use of robot-farmer-assistant in greenhouses during the application of nitrogen fertilizers. In general, the use of robots improved the management efficiency by achieving fertilizers reductions (range between 15-18%).

Moreover, SF is associated to a greater profitability and the reduction of environmental impacts, but they also indicate the need to consider the social effects associated to the digitalization of agriculture, in particular those effects related to the employees and farmers.

For all arguments here above-mentioned, in this paper we try to integrate the social, environmental and economic dimensions of sustainability to analyse SF. This intention brought us to the term of "sustainable smart farming (SSF)". Even further, we also discuss the need to assess the SF from the systematic approach of life cycle assessment (LCA) that includes the three sustainability dimensions to construct an assessment framework for SSF.

Our driving research questions for this paper are: (i) How is the technological level of SF measured and (ii) how can SSF be defined?

Secondary informational sources were systematically reviewed to respond these research questions. As a part of the preliminary findings from the literature review, elements for the evaluation of the technical component of SF applied to horticultural farming were identified to construct an evaluation matrix, particularly in the cultivation of vegetables in greenhouses answering the first research question. We also gave a first attempt to define the SSF term to respond the second research question.

The matrix as a tool allows the level of SF to be categorized into three technological levels: (i) high; (ii) medium; and (iii) low. The tool provides information to decide the technological level of the farms, that information can be used to categorize them.

The matrix takes into consideration all the stages of the productive process (e.g. sowing, transplant, fertilization, irrigation, pest control, weed control, harvest, among others. The technologies used in SF will be considered for the design of the matrix (e.g., sensors, big data, drones, robots, IoT, among others).

Our future research will identify the most appropriate methodology to measure the social and environmental impacts generated by SF.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges
4th September 2019, Wednesday 1:30 - 3:00 pm

Exploring the integrated benefits, challenges and supporting mechanisms of Water Resource Cascade-Utilization in EIPs: A case study from Shanghai Jinqiao EIP, China

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Towards sustainability in water recycling in EIPs, Water Resource Cascade-Utilization (WRCU) is an integral way to reuse water resources in a stepwise way as the water quality changes during the whole life-cycle, which can be operated within an enterprise, between different enterprises or industries. Nowadays most EIPs pay more attention on indicators such as “Freshwater consumption per unit of Industrial value-added”, “Freshwater consumption elastic coefficient”, “Industrial water reuse” and et al., as well as the lag of supporting mechanisms, WRCU between enterprises in EIPs is hard to implement.

The WRCU project in Shanghai Jinqiao EIP is the first large-scale WRCU project among the industry parks in Shanghai, which has been operating for nearly 10 years by now. In October 2008, Shanghai Shenmei Beverage & Food Co., Ltd. invested RMB 2.5 million to build a “recycled water reuse system”, which serves inside Shenmei Company as cooling tower circulating water supply, green land irrigation, car wash and toilet flushing, etc. In May 2013, cooperated with Shanghai Water Affairs Bureau, Shenmei invested RMB 1 million yuan in the “Water Resources Cascade-Utilization” project, then water from the recycled water can be filtered through a precision filter to further enhance the water quality, then it was stored in an 80 m3 stainless steel water tank to supply to Shanghai Sharp Electric Co., Ltd. through a constant pressure water supply system. The annual water supply is designed to be 80,000 to 100,000 tons. In May 2014, under the leadership of Shanghai Water Affairs Bureau and Pudong Management Committee, Shenmei signed an agreement with Nokia Communications (Shanghai) Co., Ltd., and started to supply recycled water to Nokia. So far, the recycled water reuse system network has been formed in Shanghai Jinqiao EIP and has gradually formed a set of supporting mechanisms.

The authors have followed this project for a long time, and have taken several times of field investigation and information discussion with the relative government departments, the EIP Management Committee and the participating enterprises. We calculated the comprehensive benefits of the project (social, economic and environmental benefits), then explored the challenges for extending the project, finally we summarized and listed some possible suggestions to improve WRCU in similar EIPs: (1) build the water recycling trading market and the encouraging mechanism based on water price with the joint efforts of multiple stakeholders; (2) build demonstration projects and form the radiative effect; (3) construct a comprehensive digital supervision platform to regulate the trading market and guarantee the smooth communication between WRCU supply and demand; (4) Raise the environmental awareness of enterprises and form the circumstances of green development in the EIP.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity
4th September 2019, Wednesday 1:30 - 3:00 pm

Indicators of circularity derived from a material flow analysis of plastics in South Africa

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Plastics recycling is a core concern for advocates of a circular economy. In South Africa, industry figures claim that 43,7% of plastic waste is recovered for recycling, outperforming Europe's plastic recycling by a significant margin of 12,5%. This is in stark contrast to reported and observed plastics in the environment, with one global scientific study putting South Africa in the top 20 contributors to ocean plastics and estimating that 56% of plastic waste is poorly managed and prone to leakage into the environment. If one adds up the 43,7% headline recycling rate and the 56% of plastic waste poorly managed, one would have to conclude that only 0,3% of plastic waste is properly disposed in landfill sites. Any visual of a South African landfill site would quickly dispel this view. This study aims to provide a clear quantitative description of the situation, in the form of a material flow analysis from which key indicators can be derived.

The method used was to retrieve and inspect the available numbers of how much is produced, used, exported, imported, recycled and disposed, and build a material flow analysis (MFA). Data sources included the annually released survey of the plastics recycling industry, a government commissioned MFA the results of which are disputed but which compiled trade statistics, reported waste quantitites and national census data of waste services. The MFA was mass-balanced in a spreadsheet, accounting for recycle effects and visualised using a freeware version of the MFA software package STAN.

Results produced show that the input recycle rate drops to 40% if non-plastic items are excluded from collection quantities, but that this drops significantly when taking into account imported plastics and long-lived plastic goods. The average recycled content of plastic items produced in the country is estimated at 17%. Most recycling is open-loop rather than closed loop, with PET bottle-to-bottle recycling a notable exception. An important limitation to recycling is use of plastics in remote rural areas, too distant for economically viable return for recycling.

We conclude that much more recycling is possible and necessary, but also that a singular focus on this strategy cannot achieve a plastic-free environment. Circularity should be expressed by a dashboard of indicators, complemented by a well-compiled infographic. Interventions should seek to:

i) protect and grow the impressive plastics recycling industry,

ii) develop a national standard for materials management in rural areas (and this might have to involve packaging redesign where distance makes recovery for recycling infeasible), and

iii) do away with the small number of plastic items highly prone to littering.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity
4th September 2019, Wednesday 1:30 - 3:00 pm

eCircular: Plastic waste prevention through digital innovation

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Ecomatters

Tackling the end-of-life application of plastic-based products is major challenge. Single-use plastics are already under scrutiny by the European Commission and national policies, and certain products will likely be banned for consumer use as a result. However, demand for plastic will not disappear overnight.

The advent of new digital technologies offers new opportunities for setting-up novel end-of-life approaches for plastic material flows. Digital technologies foster traceability of materials and products, and allow for accurate information flows on product and material qualities and availability, reducing the fragmentation of knowledge and costs associated with regulatory compliance. Market transparency can be improved, search costs reduced, and effectiveness of material processing can be enhanced. Beyond these benefits the digital transformation can also enable a quicker transition towards plastic waste reduction and prevention. For instance, developing blockchain based end-of-life plastic collection schemes or implementing innovative business models to improve plastic material use optimization and waste prevention can transform linear value chains to become circular.

In 2018, EIT Climate-KIC has launched eCircular, a Flagship initiative that explores new ways for increasing circularity in plastics. eCircular brings together a strong network of research, academic, and business partners across Europe to accelerate the circularity of plastic-based material systems and dematerialising plastic demand, with the vision of a reaching a carbon-neutral material system by 2050. The programme strives to enable radical digital innovations for waste prevention and support their up-scaling. eCircular will promote smart manufacturing solutions, advanced eco-design approaches, new business models and alternative consumption patterns. Advanced policies and industry standards will be explored to scale-up innovative solutions. eCircular will explore, foster and evaluate instruments to improve waste prevention in the plastics cycle through:

- Scouting and identifying innovative ideas from industry and providing test beds
- Incubation of innovative disruptive concepts
- Knowledge sharing and capability building

This presentation will explore the eCircular initiative and the activities developed during 2018 and the first quarter of 2019. Learning points will be extracted from the projects and activities executed by eCircular, to offer a good overview of the opportunities that digitalisation enables for the circularity of plastics, and the challenges rising from the change in the business models and the implementation of new technologies. Finally, a call for action will be made showing eCircular roadmap for the digital transformation of value chains to improve plastic waste prevention and dematerialisation.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

4th September 2019, Wednesday 1:30 - 3:00 pm

Tune the world with Maezio(TM)

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Covestro Deutschland AG

Goal:

Industries require materials that push the boundaries of what is possible – to make their needs a reality. Maezio™, the Continuous Fiber-Reinforced Thermoplastic (CFRTP) Composites from Covestro, is the solution, designed for performance as well as scale. Maezio™ thermoplastic composites can be tuned to be as strong as metal, with a high specific stiffness and strength compared to magnesium and aluminum while being extremely lightweight. They sound and feel like metal, but offer designers the design freedom of plastics. Maezio™ UD tapes and sheets look amazing right off the production line but they can also be coated, embossed and even laser etched to create beautiful surfaces. At the end of their life, they can be reground and used in injection molding compounds, making them a sustainable material choice in an increasingly disposable world. Covestro is committed to the United Nations Sustainable Development Goals (SDG) and puts sustainability at the heart of its corporate strategy. The environmental impact of novel materials like Maezio™ during the complete lifecycle is assessed to ensure that these materials reduce the impact on ecological systems. Therefore, the environmental performance of a part made of Maezio™ was investigated in comparison to one made from magnesium alloy for different scenarios over the complete lifecycle. Specifically, a future recycling scenario was included to evaluate the difference between a composite material that is commonly perceived as hardly recyclable and a metal system that usually is considered to have great recyclability.

Method:

In this study a laptop cover with defined technical specifications, which is an important use case of Maezio™ composites was investigated. Magnesium alloy was chosen as the competing material because both material systems target high-end, premium laptop applications.

A comparative Life Cycle Assessment (LCA) was conducted aligned with ISO 14040/14044. Both material systems have been assessed during their life cycle including raw material extraction, production and end of life. Use phase in the case of a laptop cover was assumed to be identical for both systems and was therefore not considered. Several indicators were assessed that are suitable to evaluate the overall performance based on scientifically sound and accepted models with sufficient and reliable data sources.

Results:

The Life Cycle Assessment for a laptop cover showed that the composite material has the potential to exhibit better - in some impact categories even significantly better - environmental performance than the magnesium alloy for all investigated scenarios. Therefore, the application of composite material for a laptop cover is environmentally more favorable than the magnesium alloy. Further outcomes were that the raw materials, carbon fiber and magnesium, and the electricity consumption during production are the main levers of the environmental impacts. Process developments and usage of renewable energy will result in much lower impacts. In this session, the Goal and Scope of the study, as well as the main assumptions and data sources will be presented. Exemplary results will demonstrate the environmental performance of the MaezioTM composite compared to the benchmark system.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices
4th September 2019, Wednesday 1:30 - 3:00 pm

Environmental impacts of EU-consumption: comparing process-based LCA and Input-Output analysis towards supporting SDG 12 on sustainable production and consumption

Antoine Beylot, Sara Corrado, Serenella Sala

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JRC

Goal

The assessment of the environmental impacts generated by consumers and, more generally, by people's lifestyle, is pivotal for the Sustainable Development Goal 12 on responsible production and consumption (UN, 2015). Accordingly, it has been increasingly addressed in the scientific literature, considering the full life cycle of products and unveiling the impacts of the final consumers. Two modelling approaches have been primarily implemented so far: process-based LCA and Environmentally-Extended Input-Output Analysis (EE-IOA). Yet, existing studies have mainly implemented one of the two approaches only, either considering a limited set of products as representative for the full consumption (process-based LCA) or a limited set of footprint indicators (Input-Output Analysis). This study assesses and compares the environmental impacts of consumption in the European Union (EU), calculated both with process-based LCA and EE-IOA (considering impacts, i.e. going beyond mere pressure-based indicators). The overall aims are to: i) identify the key converging results between the two approaches; ii) discuss the differences in results from one approach to the other; iii) monitor the evolution of impacts over time in support to SDG12 assessment.

Methods

This study quantifies all the environmental impacts generated (directly and indirectly) by household consumption in EU in 2010, i.e. by the purchase and use of products and services by European citizens. As a complement, the environmental impacts of EU trade (imports and exports) are also specifically analyzed. Two modelling approaches are implemented to calculate the Life Cycle Inventory (LCI) relative to EU household consumption and trade, respectively:

- process-based LCA of representative products, selected by importance in mass and economic value, based on statistics on household consumption, trade, and stocks of products. Five key areas of household consumption are considered: housing, mobility, food, household goods, and appliances;
- EE-IOA, considering the hybrid version of EXIOBASE 3 as the database supporting calculations.

The impact assessment stage is performed considering 14 impact categories of the Environmental Footprint (EF2017) Life Cycle Impact Assessment method as the common characterization framework.

Results

The total impacts generated by EU household consumption and trade are analyzed. In order to further explore the drivers for these impacts, a contribution analysis focused on areas of consumption, product categories, substances and, only in case of household consumption, stages of the supply chain was performed. According to both the approaches, food, followed by transport, and housing, are responsible for most of the impacts associated to household consumption, and the import of fuels is one of the main hotspot of trade. Moreover, the input-output approach, allows assessing the contribution of services, which was not included in the process-based LCA and is generally below 10% of the overall impacts of household consumption. The key converging results are specifically useful i) as a support to policy-making, in order to encourage societal changes to lower the impacts of EU consumption, ii) to inform EU citizens on how changes in their lifestyles may support the reduction of the environmental impacts of their consumption.

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SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices
4th September 2019, Wednesday 1:30 - 3:00 pm

8 ton society Sweden – assessing the material footprint of sharing and circular lifestyles in housing, mobility and food

Birgit Brunklaus (RISE, Bult Environment, Sweden), Maria Schnurr (RISE Viktoria), Ulf Sonesson (RISE Food and Bioscience)

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The average Swedish household throws away 480 kg of solid garbage per year. But this amount of material is only a small share of the resource consumption that our lifestyle gives rise to. Our homes need to be built, goods produced, we are transported, and food is produced. In today's linear consumption society, every individual in the EU is estimated to have a material footprint of 29 tons/year on average – a footprint that needs to shrink to 8 tons in order to stay within “planetary boundaries”. In a circular system, products are recycled and shared leading to less resources and materials needed, but do we know how much? Which resource and material consumption is generated in Sweden? What could we achieve through a transition to a sharing and circular economy, and how would our consumption patterns look like within a sustainable material lifestyle?

The goal of this studyis to assess the material footprint of sharing and circular lifestyles in housing, mobility and food system.

"8 ton society" takes a three-level method approach:

(1) National: assessing the material footprint of sharing and circular lifestyles in housing, mobility and food systems on a national level.

(2) Municipal: Mapping material and waste streams at municipal level (for the three Swedish municipalities Göteborg, Malmö och Umeå), by which municipalities can identify opportunities for a circular society, for example by supplementing existing climate strategies and waste plans with circular action plans.

(3) Household: Combined with a household level analysis of material footprints, the project contributes to behavioral change at household level as well as strengthened decision making and innovation at national and municipal level.

The results of the study are material footprints and scenarios that are used as basis for the development of reduction measures. The scenarios describe potential “8t societies” for Sweden, meaning potential policy and societal innovations that allow for a drastic reduction of material footprint. These include sharing and circular solutions. Additionally, the project will contrast the Swedish results to similar projects that have been carried out in Finland and Germany.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices
4th September 2019, Wednesday 1:30 - 3:00 pm

INNOVATIONS FOR FUTURE-ORIENTATED FOOD CONSUMPTION - THE ENVIRONMENTAL IMPACT OF REFECTORY MEALS

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Zurich University of Applied Sciences

1. GOAL

How can consumers be motivated to choose less environmentally impactful meals more frequently? How can those in the catering industry be motivated to offer more attractive, enjoyable, less resource-intensive choices? A multidisciplinary project funded by the Swiss National Science Foundation (SNF) aimed at fostering innovation along the value chain to reduce the undesirable consequences of the production and consumption of animal foodstuffs was carried out by the Zurich University of Applied Sciences (ZHAW) along with various project partners. Part of the project involved social experiments carried out in the campus refectories, which are operated by the SV Group. The objectives of the SV Group are in line with the goals of the SNF research programme: to contribute to healthy and environmentally friendly nutrition. The goal of this subproject was to assess the environmental sustainability of 93 refectory meals including vegan and vegetarian options as well as meals containing meat or fish.

These results of the project will be used to help steer refectory-users towards more sustainable choices, provide guidance to those in the catering industry, and can contribute to a decrease in the environmental impact resulting from the production and consumption of food.

2. METHODS

We assessed the environmental impacts of these meals according to these indicators:

- Total environmental impact according to a Swiss ecological scarcity method 2013
- Greenhouse gas emissions according to IPCC 2013
- Ozone depletion, human toxicity, particulate matter, ionising radiation, photochemical ozone formation, acidification, eutrophication, ecotoxicity, water depletion, and mineral, fossil and renewable resource depletion according to the recommendation of Joint Research Council of the European Commission.

The following aspects were considered: the ingredients, including their origin, the composition of any ready-prepared components, the most relevant kitchen appliance energy and material flows, energy requirements for preparation, rinsing and frozen storage in the refectories, freezing and the transport of frozen products, as well as food waste from storage, preparation and serving.

3. RESULTS

In terms of total environmental impact according to the Swiss ecological scarcity method 2013, vegan meals are on average 32% below the average of all dishes, vegetarian meals 20% below the average and meals containing meat or fish are 24% above the average. In the category of dishes containing meat or fish, the overall environmental impact of meals containing veal or beef was higher than that of those containing chicken or fish.

The carbon footprint of the meals analysed lies between 0.7 kg CO2-eq and 4.9 kg CO2-eq, with an average of 1.6 kg CO2-eq per meal. Vegan menus are on average 40% below the average of all meals, vegetarian dishes 15% below the average and menus containing meat or fish are 23% above the average.

The environmental impact of meat- or fish-containing meals was also determined to be highest for almost all indicators of the ICLD evaluation.

These results contribute towards the development of strategies and recommendations for a healthier and more sustainable Swiss food culture and for an increase in creativity and diversity on the plate.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices
4th September 2019, Wednesday 1:30 - 3:00 pm

Sustainable Tourism Design based on a Life Cycle Assessment of Tourism Activities in Thailand

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Tourism is an important and rapidly-expanding economic sector globally. The continuous growth of international tourism has supported the global economy via job creation and export revenues. Nevertheless, the tourism activities have caused negative impacts on the environment due to the over-exploitation of natural resources and inadequate environmental controls. Eco-tourism is an option that could appeal to tourists who are not interested in conventional holidays. Small businesses in Thailand addressing these ecological aspects can profit from an increase in the number of tourists staying in their hotels and participating in their leisure activities. Conventional travel agencies can expand their product portfolio by offering conventional holidays with a lower environmental impact. To determine environmentally friendly tourism options, an analysis of the environmental impact of both conventional and existing offers is required. This work aimed to assess environmental impacts of tourism activities and to recommend how to design sustainable tourism services with lower environmental impacts throughout the whole life cycle. The case study focuses on tourism activities in Patong, Phuket, Thailand - one of the world's top tourism destinations. The functional unit was one tourist stay for one night (person.night). The foreground data were collected from one hotel, two hostels, 120 tourists (38 Thais and 82 foreigners) and Patong municipality. Tourism activities consist of accommodation (hotels and hostels), mobility (airplane, ferry, private car, motorcycle, public bus and public van), leisure activities, food consumption (local, non-local, meat, vegetarian, etc.) and waste and wastewater management. End-point environmental impacts (human health damage, ecosystem damage, and resource scarcity) were assessed by using the ReCiPe 2016 v1.1 method. Criteria for eco-tourism identified as tourism activities with shared facilities, less resource uses and lower environmental impacts were applied for assessing level of eco-tourism in the studied area. Conventional tourism with hotel accommodation; mobility via long-haul flights/private vehicles; and intensive leisure activities had higher environmental impacts than eco-tourism due to the more resource uses per person.night. The mobility had contributed to more than 85% of all environmental impacts from tourism. The impacts from long haul flights could be partially compensated by the longer period of stay at the tourist destination. Domestic flights yielded lower impacts than domestic mobility via private vehicles. Hotel and hostels have similar environmental impacts from waste and wastewater management. When compared with the foreign tourists, the local tourists had lower environmental impacts due to the shorter mobility distance and the choices of activities. The assessment showed that 43% of tourists had medium to the highest levels of eco-tourism; and 57% of tourists had low to the least levels of eco-tourism. Future improvements to reduce environmental impacts from tourism should focus on international and domestic transport services and the length of stay. The improvement of public transport systems in tourist destinations is also needed in order to shift mobility patterns. This research can be applied to allow businesses to provide tourism services in a less environmentally impactful way and to support sustainable tourism policies in Thailand and around the world.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices
4th September 2019, Wednesday 1:30 - 3:00 pm

Influence of consumer behaviour on the greenhouse gas impacts of shopping: A multi-country stochastic approach

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Goal: The online value share of “Fast Moving Consumer Goods (FMCGs)” market is rising around the world. More and more people use non-store based online shops (pure players) to purchase their FMCGs and this indicates a change in the environmental footprints of FMCG shopping. Several attempts have been made to compare the environmental impacts of traditional shopping with those of e-commerce. Some studies argue that online shopping has environmental benefits over traditional retailing whereas some others have shown the opposite. In this study, we stochastically compare the greenhouse gas (GHG) footprints associated with the last mile travel (or delivery) and the last mile packaging of traditional shopping and those of online shopping through the so called pure players. For traditional shopping, we include four countries with significantly different consumer shopping behaviours e.g. the United Kingdom, the United States of America, Netherlands and China. To assess the impact of online shopping we assessed3 scenarios namely a Large City (London), 2. city centre of a large city (London City Centre) and 3. a small region (Winchester). Inclusion of different countries and scenarios in combination with a stochastic approach provides information on the conditions where a retailing channel would have environmental preference –based on the GHG emissions- over the other channels in a specific region. Applying stochastic models increases the reliability of the decisions made by both consumers and policy makers.

Methods: We used a wide range of data sources to develop a stochastic model to account for the variability in traditional and ecommerce shopping/delivery patterns including mode of transport (where applicable), GHG emission intensity of vehicles, travel distance, volume of a products purchased, failed delivery rate and redelivery percentage. We used Monte Carlo simulation to propagate the variability in the input variables of the model to the variability in the last mile GHG footprints associated with the purchase of one product through the two considered retailing channels.

Results: Our results illustrate that it is vital to consider the consumers’ shopping travel behaviour when the environmental impacts of retailing channels are compared. Mode of transport and the number of items purchased are the key variables that determine when e-commerce would have lower GHG emissions compared to traditional shopping.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies
4th September 2019, Wednesday 1:30 - 3:00 pm

Access to life cycle-assessment data: Findings from national LCA literature searches

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GOAL: A big hindrance in life-cycle assessment (LCA) is access to data. One way to help overcome this has been through the Global LCA Data Access Network (GLAD), as part of the LCInitiative, which is looking to increase the accessibility and interoperability of inventory data between datasets. While this is a useful and welcomed initiative for LCA practitioners, the work as presented here looks at how easily a non-specialist is able to obtain LCA data based on limited knowledge of the topic.

METHOD: Over the past few years, a series of papers have been published to determine the accessibility of LCA and other environmentally related studies for different areas; including West Africa, Portugal, Brazil, New Zealand, Sweden, Austria, Indonesia and Tanzania. In this work, we review the findings of these studies and identify recurrent themes and learnings that can be applied for future research.

RESULTS: From these studies, it was found that the majority of the studies were conducted by research organisations and academic institutions – and as such may be 'hidden' in paid for academic journals. The sectors that were explored were varied (including industries such as energy, agriculture and forestry, food and beverage, financial services and automative and manufacturing), but often those that were most relevant to the country. Although the concept and implementation of LCA is relatively new for a number of these countries, there was a significant increase in the number of publications produced over the last five years, but still a small number of studies compared to what might be found in datasets such as ecoinvent or other specialist websites e.g. openLCA. While the studies focused on countries, it may be easier to obtain information on a product rather than a location.

It is recommended that in order to stimulate interest in LCA, introductory capacity building and training sessions should be developed, together with easily accessible and understandable central repositories. Furthermore, the establishment of online platforms to disseminate LCA studies and findings will contribute to making environmental data more accessible and transparent globally.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies
4th September 2019, Wednesday 1:30 - 3:00 pm

NorEnviro: Creating an Integrated LCA Data Infrastructure for Norway

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PRé Consultants

Goal:

Business associations, governmental organisations and research institutes in Norway all clearly stated they will need relevant and high quality environmental and resource data of materials, products, energy and waste systems, buildings, infrastructure, etc. in their work for a more sustainable society. A lot of these data is available in Norwegian Research Institutes but not easily accessible to users outside those Institutes.

Method

The NorEnviro Infrastructure project will establish research infrastructure for developing and providing environmental data to national as well as international research institutions, companies and governmental authorities. Society increasingly demands such data to document, develop and market sustainable products, systems and services. Life Cycle Assessment (LCA) is a method to quantify resources used, emissions and environmental impacts throughout the whole value chain of products, including, materials, processes, services, energy and waste systems.

Research institutions involved have already a significant number of research projects and proposals related to LCA and with use of LCI and LCIA data. Data generated through those projects in addition to projects already finished over the last 10 years can be made easy accessible and validated in a common format with metadata, through the NorEnviro infrastructure. A pilot will be done in early 2019 to test the platform developed by PRé as a basis for further development of the national infrastructure shown above.

Results

In the presentation the results from the pilot will be presented and shared. We will illustrate how the infrastructure will work and how it might contribute to the accessibility of data for sustainable innovation (including circular economy), life cycle assessment, marketing of green products, public green procurement, B2B relations and public policy development.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies
4th September 2019, Wednesday 1:30 - 3:00 pm

CONNECTING LIFE CYCLE MODELS INSTEAD OF EXPORTING AND IMPORTING DATASETS FROM AND IN LCA SOFTWARE - A DATABASE PLATFORM FOR PARAMETERIZED LCI DATASETS – CONCEPT AND IMPLEMENTATION

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ifu Hamburg GmbH - member of the iPoint Group

The Problem to be addressed

Life Cycle Inventory (LCI) databases like Ecoinvent reduce the efforts for life cycle assessments (LCA) dramatically. In particular thousands of result datasets map common commodities like aluminum or wheat to elementary flows and therefore to Life Cycle Impact Accessment (LCIA) methods. However, in practice appear gaps between the commodities and the raw materials of production processes.

Typically BOMs (bill of materials) contain raw material entries like “assy wiper shaft”, “acrylic resin for labels” or “capacitor, 100uF, 400V”, but these type of intermediates cannot be found in LCI databases. Databases like Ecoinvent cannot close this gap effectively, because this would result in millions of different result datasets.

The Solution to work on the problem

One possible solution for this dilemma could be to provide parameterized datasets, e.g. only one dataset for a generic screw, parameters could be type, materials, diameter, length, and origin. This would reduce the number of datasets dramatically and make it easier to find and to use them because it is not longer necessary to include parameters in the naming of datasets. Moreover, parameterized datasets may support sensitivity analyses by providing allocation rules as parameters. In other words, parameterized datasets are easy to use.

The implementation of the solution

The question is therefore how to provide parameterized datasets. From a users perspective, it would be very attractive to employ already existing LCA models as parameterized datasets by utilizing the calculated inventories. Such a database platform has to include a life cycle inventory calculation engine that recalculates the inventories and therefore the datasets as soon as the parameters change. In this contribution, we want to present the concept and implementation of such a database platform for parameterized LCI datasets. It could be also described as a platform of connected models with a cloud enabled calculation engine.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies

4th September 2019, Wednesday 1:30 - 3:00 pm

Data Management for Circular Economy Business Models

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Data collection and data management are crucial for the successful design and implementation of Circular Economy Business models in any industry. Data coming from various sources, industries and technologies (e.g. IOT, supply chain etc.), in various formats, should be combined and assessed to provide valuable business insights. In this work we create a centralized system that aims to collect data from various sources, aggregate them, update in real time with additional data, inter-operate with external sources and finally retrieve and provide data to external applications. This study proposes a uniform and flexible data representation for storage and exchange between various sources. More specifically a tree structure, containing properties in various levels, is proposed which can support a wide variety of information and is easily stored and exchanged using the JavaScript Object Notation (JSON).

The main goals of a uniform and flexible data representation structure are a) the ability to include data from various formats coming from fundamentally different contexts (electronics and agricultural industry data should be processed with a common methodology) and b) the extensibility allowing easy future data insertion without breaking backwards compatibility. In order to achieve that, we move away from the traditional record structure with predefined property fields of specific format and introduce a tree structure that allows any type of data property to be inserted on any level of the structure. The result is easily converted to and from JSON format, whose lightweight text representation is ideal for storage to databases and filesystems, for interchange between services and applications and is also readable by humans. The tree structure can represent data records and industry processes with ease and the extensibility is achieved by simply extending the tree properties in both width (e.g. number of properties in a specific level) and depth (number of branches/levels, inclusion of a complete subtree allowing merging of structures). JSON is widely adopted in modern ICT systems due to its ease of parsing and generation. To assess the best strategy for storage, various database technologies are used in order to store this new format, comparing results mainly on performance and maintainability.

Finally an aggregation layer is proposed in order to retrieve and format data to be compatible with the main LCA standards (LCA, PEF, Recipe, various models of LCA etc).

This research has been conducted as part of CIRC4Life which has received funding by European Union's Horizon 2020 research and innovation programme under Grant agreement No. 776503

SESSION T1-8 Sustainability of Agri-Food Products

4th September 2019, Wednesday 1:30 - 3:00 pm

Improving regional coverage of agricultural data in a background database

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ecoinvent

Goal:

The creation of reliable, consistent and transparent regionalized LCIs represents a core purpose of the Sustainable Recycling Industries-Life Cycle Inventories (SRI-LCI) project. SRI-LCI was a program funded by Swiss State Secretariat of Economic Affairs (SECO) and implemented by ecoinvent across Brazil, Colombia, India, Peru and South Africa. One of the key sectors improved in all regions was the agriculture sector. Different strategies were used for different regions and will be detailed in this communication.

Methods:

The project included the development of a simplified tool allowing the creation of crop producing LCIs, compliant with the ecoinvent methodology. The tool can be improved to include different emission models, depending on the region where the crop is produced.

Heavily influencing the agriculture sector, new data and assumptions for water production and supply were collected in the framework of SRI-LCI. This allowed distinguishing between different irrigation technologies, influencing the water footprint of key crops in heavily-irrigating countries.

Results:

This communication covers the results obtained for Brazil and India, picturing two different strategies for the development of a dense core of datasets covering the main crops of economic relevance in each of the countries.

A total of 46 new crop producing datasets in India were developed using the abovementioned tool. This demanded the collection of a limited set of parameters, that allowed the tool the calculation of the different emissions and inputs. The results obtained will be discussed in this presentation.

In the Brazilian case, the country was divided into states, which allowed the consideration of distinct models covering the specificities of the Brazilian states. The development of the circa 120 crop producing LCIs was done independently from the tool.

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SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 1:30 - 3:00 pm

Assessment of packaging portfolios and prospective evaluation of packaging solutions for recyclability

Dennis Bankmann, Philippe Blank, Carsten Bertram, Marcin Lapaj, Thorsten Leopold, Susanne Monnse, Nikolaj Otte, Swen Peters, Matthias Schaefer, Christine Weiss, Johannes Tolls

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Henkel AG & Co. KGaA

Recycling is a complex topic that has both an ‘inlet’ and ‘outlet’ to be taken into consideration. The ‘inlet’ defines the use of recycled materials and thus the recycled content of a solution. The ‘outlet’ defines the recyclability of the solution and plays an equally important role in the grand scheme of circularity and is strongly coupled to the design and composition of different materials into complex articles and is the focus of this presentation.

Packaging materials are required to both protect and market the products they contain. Due to the amount of packaging materials in use, packaging has gained a high visibility in political and consumer awareness. The design of packaging plays an important role in the future design of circular solutions, since the assembly of different materials to form the final packaging decides whether a solution can be recycled to higher or lower degrees. Henkel is both a user of packaging materials through its consumer business as well as a contributor to packaging solutions via its industrial adhesives business. Both perspectives will be integrated in our full value chain assessment.

Assessment of a large number (several thousands) of packaging solutions is suited to using a digital approach. Uniformity of the assessment and repeatability play a key role here, as well as the possibility for constructing different scenarios. In this way we are able to account for status, progress and future developments. We also develop a digital toolset to enable a prospective assessment of the degree of recyclability of individual packaging solutions. Thus we enable packaging designers and product developers to factor in recyclability at the time of development.

We present a system for the rule-based assessment of the packaging portfolio of an international enterprise using digital solutions as a means to quantify current status and to measure progress. The aggregate portfolio assessment is supported by a prospective assessment of individual packaging solutions using Henkel´s EasyLCA toolset, for the use by packaging designers and product developers.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 1:30 - 3:00 pm

ATISOL C2C - ECODESIGN OF A "VAPOUR AND AIR BARRIER MEMBRANE" MADE OF RENEWABLE MATERIALS

Sylvie Groslambert, Michel Getlichermann, Bernard Colson, Ine De Vilder, Antoine Tilmans, Angélique Léonard

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Liège Université

Goal

The European directive on the energy efficiency of buildings requires the members to put on the market solutions for insulation of buildings that are simple, effective and lasting, but also respectful of the environment and of the users.

To reduce energy losses and to guarantee the durability of the thermal insulation, it is necessary to have a vapor and air barrier on the warm side of the building, situated between the thermal insulation and the inside. Hence, the passage of moisture from the building is reduced, preventing condensation problems on the insulating material. Currently, the implementation of an insulation system combined with a vapor barrier presents three major problems: an important time for placing, a random durability in time (stability of tapes of junction, adherence to the existing walls, punching resistance), and finally a low disassembly and re-use level.

The ATISOL C2C project aims to develop a renewable vapor barrier, with the lowest environmental impact on its whole life cycle. The solution can be used in both new construction or during renovation.

Methods

Compared to the state of the art, the solution that is developed is unique and innovative by its simplicity in terms of materials by integration of a vegetal self-adhesive binder to the spunbond reinforcement of the membrane, the latter being also mainly constituted of renewable resources. The material is appropriate for application on the different wall coverings that can be found in a building. Due to the self-adhesive characteristics, the implementation is made easier in both common surfaces (walls, roofs and ceilings) and to the level of detail such as corners and junctions.

The constructive system can be dismantled at the end-of-life of the building and the various elements are recovered and valued in a cradle-to-cradle perspective.

Results

A first step is already carried out, the Derbiskin©. The preliminary life cycle assessment (LCA) results have supported the technical partners along the whole development and evolution of the membrane by pointing out the hotspots of the system. It helped to the choice of the components of the vegetal binder and of the spunbond reinforcement and it lead to the elimination of an acrylic coating by the modification of the reinforcing layer manufacturing.

After a first phase of Industrial Research, the project is entering its Experimental De-velopment phase. The LCA can now integrate the production steps and give a global estimation of the environmental impact of the membrane.

This project is supported by the GreenWin Competition Clusters and subsidized by the Walloon Region (BE).

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 1:30 - 3:00 pm

Shorter Product Lifespan for the Environment

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Goal:

The concept of Circular Economy (CE) is experiencing increased attention and has the goal to ensure sustainable consumption. In the center of CE is the aim to close the material loop. Prolonging useful lifetime of products in order to use the materials as long as possible is another CE principle and therefore sometimes used to measure circularity. However, this might not be the appropriate Design for Environment strategy when it comes to energy-consuming products like heating systems. Here, I will present that under certain circumstances a shorter product lifespan is actually better for the environment.

Method:

The largest part of Global Warming Potential (GWP) caused from households is due to heating. The installed heating stock in Germany is on average 17.6 years old. In general one can say, the older a boiler is today, the lower the efficiency of the used technology is. The efficiency in turn has a major influence on the environmental impact of gas boilers over their whole life cycles. In case of a gas condensing boiler, over 99% of the GWP is caused during the use phase without considering efficiency degradation. If efficiency degradation is considered, the overall GWP of a gas boiler is even 4% higher in the case of professional maintenance or 12% higher in the case of no or seldom maintenance.

This work analyzes the optimal replacement time of a boiler to minimize the overall environmental impact from heating in households. To achieve that, the decision path with optimal GWP is modelled. Input for the decision model is an efficiency learning curve of the boiler technology. Moreover, efficiency degradation of boilers depending on the maintenance schedule is taken into account.

Result:

The optimization result is that within a period of 15 years, a boiler should be replaced two to four times. It means that two to seven years is the best boiler lifespan for the environment. The environmental impact is 6% to 19% lower compared to a scenario in which the boiler is used for the full time. The optimization result mainly depends on the starting point in the efficiency learning curve (i.e. the possible efficiency improvement) and the maintenance scenario. Even if the technology is mature and no efficiency improvements are possible, efficiency degradation has such a big influence that a boiler lifespan should be in the same range as mentioned before. However, the avoided environmental impact is a little smaller than in the case with possible efficiency improvement.

As conclusion, an energy-consuming product with a significant use phase shouldn't be long-lasting to minimize the environmental impact, if the efficiency learning curve of the technology is steep or efficiency degradation has a big influence. Moreover, a shorter lifespan could result in faster replacement of the installed heating stock. This would lead to a younger boiler stock, i.e. a boiler stock with much higher average efficiency and therefore better environmental performance. Hence, a shorter lifespan of heating systems could have a great leverage to reduce the environmental impact of households.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies
4th September 2019, Wednesday 1:30 - 3:00 pm

Circularity, life cycle assessment and criticality: A holistic approach to sustainable product design

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thinkstep AG

Goal

The circular economy has become one of the defining sustainability strategies of this decade. However, there is also growing recognition that increasing circularity may not necessarily lead to the expected results on resource efficiency and reductions in potential environmental impacts. Some of the most significant challenges for the product's design in the circular economy era is effectively informing the early design and product development with a holistic approach. One that assesses improvements in material circularity alongside other life-cycle risk and environmental performance metrics. This study aims to provide an example of how a well-rounded sustainability strategy (incl. also social and economic aspects) use a variety of robust assessments such as the LCA and criticality assessments together with the material circularity indicator to inform decisions in the design and development stage.

Methods

The Material Circularity Indicator (MCI) methodology report by the Ellen MacArthur Foundation (EMF) recommends prioritizing product improvements by using the MCI in combination with complementary indicators to identify relevant risks and impacts [1]. Our proposed approach is to consider these indicators from standardized and scientifically recognized methodologies:

- In order to assess that the product design circularity principles and characteristics bring net environmental benefits, we will be using Life cycle assessment (LCA) as described in [2]. We live in a complex world and thus analyzing the potential environmental impacts of an activity or a product implies a degree of complexity. Life cycle assessment (LCA) is a thorough standardized methodology to quantify this complex reality. The following LCA indicators are chosen based on the European Commission's complementary indicator categories for resource productivity: water (represented by water consumption), materials (ADPE), carbon (GWP) and land [3].
- The criticality assessment will be performed following standardized methodology as outlined in [4]. Risk indicators based on critical material assessment include material price variation, supply chain risks, toxicity and material scarcity. The analysis results are used as a basis for formulating procurement and material strategies from resource efficiency aspects.

Results

Using a consumer electronics case study, this paper demonstrates that the eco-design strategy that has the greatest influence can vary significantly depending upon the indicators considered. The findings highlight the importance of taking a holistic approach to improving sustainability performance – one that focuses on multiple environmental and risk indicators. Only by considering circularity alongside criticality and other life-cycle environmental performance metrics will we achieve meaningful improvements in product sustainability.

References

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SESSION T3-2 LCM as a Part of Environmental Management Systems
4th September 2019, Wednesday 1:30 - 3:00 pm

Multi-country Eco-factors Based on the Ecological Scarcity Method for Application in Company Environmental Management Systems

Liselotte Schebek, Andrea Gassmann, Patrizia von Wyschetzki, Elisabeth Nunweiler, Steffen Wellge, Moritz Werthen

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Environmental Management Systems (EMS) require an organization to identify and evaluate its environmental aspects. However, the procedural as well as the methodological approach how to assess the relevant environmental aspects are largely left on the side of the individual organization as no general procedure has evolved by now. Drawbacks may be a lack of comparability and reproducibility, as the assessment may to a certain extent be dependent from individual perceptions of a group or person in charge of an audit procedure at a certain point of time.

In 2003, the Volkswagen AG introduced a systematic approach to assess environmental aspects as part of its so-called SEBU system for environmental management. This approach uses of the “Ecological Scarcity Method (ESM)”, which provides weighting factors (“eco-factors”) based on a distance-to-target approach between current environmental flows and respective environmental targets. The ESM has been developed in Switzerland and consequently its original eco-factors had been defined on Swiss framework conditions. This obviously is a point of criticism for use in site-specific assessments of EMS. Therefore, since 2012 the Volkswagen AG has launched a series of projects in order to adapt the eco-factors to those countries where VW production sites are located, starting with first projects on Germany and the countries of the EU.

We here present the development of eco-factors for 8 countries worldwide: Argentina, Brazil, China, India, Mexico, Russia, South Africa and USA. Although complying to the methodological foundations of the ESM, specific challenges arise for the derivation of current flows as well as critical flows in a global multi-country perspective: First, data for current flows have to be drawn from heterogeneous data sources, using different terminologies, definitions and procedures of accounting for environmental problems. Second, critical flows can only be assessed on the basis of political target setting: here, large differences exist between countries, as well as to the existence of political targets for specific environmental problems as on the paradigms of environmental policies and the level of ambition for target setting. The development of eco-factors thus has to bridge the gap between two countercurrent goals: on one hand, the original intention of the ESM is to mirror the individual framework condition of a country and notably to draw from political targets that have been “adopted in legally binding form or at least defined as targets by competent authorities” on the national level. On the other hand, from the societal perspective as well as from the perspective of a multinational company, eco-factors should also account for the fact that today policies on global environmental problems are more and more developed in international policy regimes, aiming at multilateral agreements and common global goals. Thus, different approaches were developed how to address these issues in developing eco-factors for different fields of environmental impacts. The presentation will outline these approaches and discuss the resulting eco-factors for the selected 8 countries.

SESSION T3-2 LCM as a Part of Environmental Management Systems

4th September 2019, Wednesday 1:30 - 3:00 pm

Sustainability Assessment of 175 years of wheat cultivation in the United Kingdom using the AgBalance™ Model

Richard van Gelder, Keith Goulding, Patricia Granados, Sarah Perryman, Peter Saling, Sebastian Schulze, Kerstin Ulrich, Markus Frank, Torsten Rehl

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BASF SE

Goal

With 175 years of continuous cereal growing, the Broadbalk experiment at Rothamsted Research represents a remarkable example of research on sustainable agriculture. As a stakeholder in the agricultural value chain, BASF maintains a partnership with Rothamsted Research in order to move sustainable development in agriculture forward. The focus of this study was the analysis of the evolution of sustainable crop production on the Broadbalk Wheat Experiment, using both mineral and organic fertilisation together with the introduction of technological innovations in arable cropping for almost 100 years from 1938 until 2015.

Methods

The cooperation between BASF and Rothamsted Research addressed the Broadbalk experiment using an innovative approach to combine long-term field trial data collection from the electronic Rothamsted Archive with modern sustainability assessment methodologies, such as the AgBalance™ method . Developed by BASF, the AgBalance™ Model is based on the principles of the life cycle assessment (LCA) framework, with special focus on primary agricultural production. AgBalance™ includes upstream and downstream processes and evaluates the interdependencies between the economic and environmental dimensions of sustainability.

Results

Focusing on the role of the different elements of the agricultural system in the sustainability assessment, the field activities are the main source of environmental impacts, implying that there is improvement potential on the farm level. Exceptions are the impact categories depletion of water, fossil and mineral resources, which are driven by the production of agricultural inputs.

If special attention is paid to amounts and application techniques of organic fertilisers, field emissions could still be reduced, making the use of manure even more sustainable. The set-up of diverse crop rotations, combining the benefits of increased output with the chance to reduce inputs for individual crops and better erosion control is a powerful tool to manage the trade-offs between economic performance and environmental impacts.

Surprisingly, the influence of technological innovations in arable cropping was more evident in the cost structure than in the environmental burdens. For example, replacing horses with tractors and the application of herbicides reduced the costs for labour demand but at expense of higher machinery and pesticide costs. Despite the recent technological innovations in arable cropping and cost minimisation, producer price and yield are more decisive factors for the profitability of Broadbalk.

SESSION T5-7 LCM and Central Eastern European Countries – the Past, the Present and the Future
4th September 2019, Wednesday 1:30 - 3:00 pm

Carbon footprint in practice – a case study of Polish youth – special presentation from St. John Kanty High School

Zofia Rogacka – Trojak, Michał Miłek, Oskar Kilianczyk, Kamil Małecki

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St. John Kanty High School

In 2018 a cooperation was established between PUT LCM 2019 team and 2nd year students of the class with extended maths, IT and physics. During several meetings and consultation an idea of environmental footprints, including the carbon footprint, was explained and discussed. A case study, encompassing the calculation of carbon footprint of daily activities of all the classmates, and also the average footprint of the whole group, was performed, to be reported at the LCM 2019 conference, as an example of involvement of Polish teenagers in the process of intensification of the environmental awareness.

Under the protectorate of the Director, Mrs. Katarzyna Kordus, and with the care of the teacher, Mrs. Anna Jaborkhel, the class representation (Zofia Rogacka-Trojak, Michał Miłek, Oskar Kilianczyk, Kamil Małecki) prepared a conference speech describing the case study performed. The presentation will be given on Wednesday, 4 September, in the session T3-2 “LCM as a Part of Environmental Management Systems” (01.30 pm – 03.00 pm).

Posters

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Methodologies on crossing LCA and LCC

Carolina da Rocha Colli, Alain Bataille

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Université d'Artois

The sustainable development is a principle of development without compromising the ability of future generations to meet their own needs. It is composed of three domains: environment, economy and social. The economic domain runs the industry. Nowadays, the environmental domain is starting to be considered, combined with the economic one in order to make the best choices in terms of economy and environment. However, there are different emerging questions to be dealt with, such as: where should be the compromise between economy and environment? The environment could be presented by many kinds of environmental indicators with different units while the economy is normally presented by a single score, which is expressed in euros. The goal of this work is to discuss the different possibilities of crossing environmental and economic results.

This work presents and discusses different ways for the normalization and for the weighting of the different environmental indicators in order to obtain a unique environmental score. The work discusses the EC-JRC Global methodology of weighting, the equal weighting method and it proposes a method taking into account the robustness of considered environmental indicators. It presents as well the environmental and economic crossing methodologies.

The methodology chosen for the combined analysis of environmental performance and of economic performances crucial to ensure the more reliable result. This is illustrated by examples drawn from our experience in building refurbishment.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

SELECTED ASPECTS OF ENVIRONMENTAL MANAGEMENT OF THE CAR TIRES LIFE CYCLE

Katarzyna Piotrowska, Łukasz Sobaszek

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Lublin University of Technology

In the era of growing societies and economies, ecology has become one of the most important challenges. It is extremely important to look for solutions that are a compromise between the growing needs of people and limiting the negative impact on the natural environment while fulfilling these needs. Man manufacturing activities has one marked direction – a cycle of production and consumption. In this cycle an energy and raw materials are in the end converted to waste and more or less dangerous emissions. Modern civilization is dependent on the automotive industry, both in terms of transport, as well as everyday life. In the near future this status will not change, and motor vehicles cannot do its task without tires. In connection with the worsening state of the environment, it’s been noted the need to determine the impact of the life cycle of car tires on the environment, ranging from the processes involved in the extraction of raw materials and production, till the post-use management.

This paper presents an analysis of the current state of knowledge and techniques in the area of the manufacturing, usage and existing capabilities management of post-use tires.

The research object consisted of two types of tires for passenger cars (the size of P205/55/R16). The first one was made in traditional manufacturing technology, the second one is called an ecological tire.

The main assumption of the work was to perform a comprehensive analysis of the lifecycle of two different types of tires (traditional and ecological) using SimaPro software for environmental life cycle assessment (LCA). Within the framework of the research performed analysis LCA life cycle of traditional and ecological car tires, with the using of methods: Ecoindicator 99, CED and the IPCC. The level of negative effects have been set for both the life cycle of the tires, and in its individual material stages (production, use, end of life). It has been evaluated of total impacts, emissions to the atmosphere, soil and water as well as the negative impact on the quality of the environment, human health and the depletion of raw materials resources. The implementation of the environmental analysis of the car tire lifecycle (LCA) made it possible to create Relative Indicator of Proecological Product with the Environment. On the basis of the values assumed by the index, it was possible to assess whether the analyzed tire of a new type is a solution that in the perspective of the whole lifecycle (or its individual phases) will help reduce the negative impact on the environment compared to the product made in the older technology.

Thanks to the research and evaluation, it was possible to create recommendations and guidelines, aimed at the more pro-environmental life cycle management of traditional

and ecological car tires.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

LCA for the PAMPLONA ROAD CLEANING CONTRACT

José Mari Sotro

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Navarra Industrial Association AIN

This is the case of using the methodology of the Life Cycle Analysis (LCA) in the realization of an initiative for a Public Administration, such as the City Council of Pamplona, the capital city of Navarra province in the noth of Spain.

The concrete application was for the PAMPLONA ROAD CLEANING CONTRACT, understanding as LCA "the procedure to evaluate the environmental burdens associated with a product, process or activity, identifying and quantifying both, the use of materials and energy as emissions to the environment, in order to determine the impact derived from the use of resources and emissions to evaluate and implement environmental improvement strategies. "

The method of calculation, the rules at national and international standards reference and calculation process, together with the corresponding tools to the LCA application, according to the principles and requirements established in the corresponding Spanish and international standards:

A LCA study comprises in four phases:

1. Definition of objectives and scope
2. Analysis of life cycle inventory
3. Life cycle impact assessment
4. Interpretation

Objective

The study considers the environmental impacts associated with street cleaning services contracted by the CITY COUNCIL OF PAMPLONA.

Scope

The purpose of this life cycle analysis is to know and inform the City Council about the environmental impact of the contracted services, and to be able to compare the evolution with real data collected during the provision of the services.

Functional unit

The provision of services during a quarter, under normal conditions.

Reference flow

Provision of service during a quarter.

Restrictions system

The system limits proposed for the LCA are considered in accordance with the services included in the contract.

Impact categories

The impact categories initially selected for the presentation of the LCA results are:

- Climate change (kg CO2-eq.)
- Toxicity (1,4-DCB eq.)
- Shortage of water (m3)

Analysis of the Life Cycle Inventory

The data corresponding to the inputs and outputs for the system processes included in the limits defined in the scope are collected in order to identify and quantify the environmental aspects or burdens throughout the service life cycle.

Impact assessment of Life Cycle.

At this point, the potential impacts to the environment are evaluated, based on the inventory of inputs and outputs obtained in the previous phase, expressed as a list of elementary inflow and outflow flows that, through characterization factors, are transformed into an environmental impact indicator, depending on the selected category (Kg CO2-eq, m3 water, 1,4-DCB eq.).

Interpretation

The main relevant processes are detailed and the contribution of different environmental burdens is analyzed with respect to the total impact for services, facilities, impact category, etc. identifying facts to which adress the measures for improvement and reduction of impact.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Environmental impact assessment for Tourism and MICE in Japan using Input Output modeling

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Tokyo City University

This study is the first phase development of sustainability evaluation for tourism and MICE (Meeting/ Incentive Travel/ Convention/ Exhibition and Event) in Japan. This time we introduce the study framework and examine the analysis results of priority check using Hotspots Analysis (HSA) based on Life Cycle Assessment（LCA）.

Tourism and MICE industry is said to have significantly higher growth speed than other industries and expected to have a high economic ripple effect. A recent study pointed out that the global tourism industry has a great negative contribution to climate change. In addition, international targets such as Sustainable Development Goals (SDGs) encompass not only focusing on climate change, but also considering some other topics. Therefore, our opinion is multiple criteria evaluation is needed in this industry.

It follows LCA method can evaluate and analyze multiple effects and use assessment based on the Input-Output Tables (I/O). By using the HSA method, it becomes possible to confirm the important sources of environmental Impacts before each event.

Here is a summary of our results. Calculations of the environmental impact and CO2 emissions were made to show characteristic of Tourism and MICE in Japan. Results showed domestic tourism is found to have a large impact on land use, climate change and air pollution. Life Cycle Assessment (LCA) from CO2 emissions shows domestic tourism is the highest contributor. In addition, impact of air transportation and accommodation services is found to be high. Percent impact from souvenirs such as cosmetics and confectionery is also high. Total impact of tourism and MICE showed calculated CO2 emission result is 7.54% of the whole of Japan (2015). This research shows in the future it is possible to make trial calculations easily for each update of the survey data on the amount of consumption provided by the JAPAN TOURISM AGENCY (announcement of the latest year edition).

We were able to show the same trend as in a recent study. Our study found not only air transportation and accommodation services, but also cosmetics and confectioneries such as souvenirs were found to contribute to the environmental impact and CO2 emissions in tourism and MICE in Japan.

It is necessary to consider ways to reduce environmental burden from transportation as well as accommodation services and souvenirs.

Therefore, this study will become part of the foundation for the Japanese tourism and MICE industry to achieve world sustainability.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Comparative Life Cycle Assessment of Nickel Metal produced by Pyrometallurgy and Hydrometallurgy process

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Beijing University of Technology

Goal : Nickel is widely used in stainless steel and chemical industries, especially in nickel-based high temperature alloys which are used in aerospace and automotive, however, the nickel production process not only consumes a lot of energy and resources, but also produces serious pollutant emissions and environmental issues. Generally, the production process of nickel metal can be classified as hydro-metallurgy and pyrometallurgy process. In accordance with the technical framework of life cycle assessment, the aim of this research is to find out the environmental hotspots, such as the most important environmental issues, the key phase led to environmental burdens, and make suggestions for improvement the life cycle environmental impacts of nickel product.

Methods: The pyrometallurgy process of nickel is defined as six phases, namely, mining, mineral processing, transportation, flash furnace smelting, converter blowing and pyrometallurgical refining, moreover hydrometallurgy process is divided into five phases as mining, transportation, crushing and acid leaching, extraction and electrolysis. The environmental impact analysis for each phase of nickel production was carried out based on life cycle assessment in accordance with ISO14040 and ISO14044, and the environmental impact is performed based on ReCiPe model.

Results: The main environmental impacts of nickel produced by the pyrometallurgical process are MDP (metal depletion), FDP (fossil depletion), HTP (human toxicity) and GWP (climate change), their contributions to the total environmental impact are 35.49%, 25.08%, 16.30% and 13.24% , respectively; while PMFP (particulate matter formation), AP (terrestrial acidification) and POFP (photochemical oxidant formation) are relative small. Moreover, regarding each phase of mining, mineral processing, transportation, flash furnace smelting, converter blowing and metallurgical refining, their environmental impact account for 57.56%, 6.39%, 4.44%, 5.45%, 2.34% and 23.82%, respectively. However, for hydrometallurgy process of nickel production, the major environmental impacts are MDP, HTP, FDP and GWP, accounting for 41.73%, 26.13%, 15.84% and 11.07% to the total environmental impact, respectively; The main contribution processes to the total environmental impact are mining, acid leaching, extraction and electrolysis, which account for 50.76%, 18.11%, 7.95% and 20.84%, respectively. Finally, compared the energy consumption of pyrometallurgical process with hydrometallurgy process of nickel production, the former is 2.63 times than the latter. Meanwhile, the energy consumption of pyrometallurgical process is 6.15 times than that of hydrometallurgical process at the raw material acquisition phase, and is 1.55 times at the smelting phase.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Sustainable Regional Development in the Construction Sector - Linking Life Cycle Tools and GIS for Decision Support

Christian Dierks, Maximilian Guntrum, Liselotte Schebek, Hans Joachim Linke

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Goal

The construction sector has a strong regional focus, as many low-value, high-density materials (e.g. concrete) are used. This raises the question as to how far certain secondary materials can be transported before the transport-related environmental impacts outweigh the advantages of their reuse or recycling. Although building materials are already well-categorised, the transport-related emissions are often neglected or calculated based on generic assumptions. Our goal is the coupling of a geographic information system (GIS) and life cycle tools in order to allow for case by case decision support regarding the reuse and recycling of building components and materials on a regional level. The district Darmstadt-Dieburg in Hesse, Germany, serves as a case study area.

Methods

The scope of the project "WieBauin – Wiederverwendung Baumaterialien innovativ" (innovative reuse of construction materials) covers a wide range of aspects such as the development of a value chain for reusable components and materials, a building and material cadaster for the identification of these components, approaches to address owners in order to gain access to structurally empty or improperly used real estate and the development of teaching materials for architects, builders and authorities.

One main contribution will be a regionally differentiated material flow model intended to track and portray relevant stocks and flows of the construction sector in and between the different sub-areas of the region. This model will be interlinked with a GIS-based building and material cadaster, which supplies relevant input data through building typology. This data will be supplemented by a scenario analysis investigating relevant regional drivers such as population growth, urbanization rate, legal framework conditions, developments in the building sector and demand for secondary materials. Field surveys will take place to assess the number of reusable components and to detect the correspondent spatial location. This information will be saved in an appropriate database, allowing for a spatial analysis of material flows.

Further input data for the material flow model regarding possible developments in the case study area is generated using scenario analysis. For this, factors such as demand for residential and commercial floor area, predicted demolition activities, strategies for value chains as well as legal and practical framework conditions regarding e.g. waste management, road construction and regional planning are taken into account. These parameters will be analyzed in cooperation with project partners and other stakeholders and merged into scenarios. The model will serve as a basis for the assessment of the implementation of the value chain developed in "WieBauin" within an LCA framework.

Results

This project has both scientific and practical implications, as the results will be applied in the case study area within a two-year implementation phase. In addition to assessing the potential environmental consequences of implementing the value chain, the combination of a GIS-based building and material cadaster with MFA and LCA is intended to aid in decision making regarding the most environmentally friendly use of secondary components and materials in a regional context by adding the spatial dimension to existing assessment tools. LCA results are intended to be fed back into the cadaster in order to identify secondary components and materials that can be reused or recycled ecologically feasibly depending on their spatial availability and potential transport distances.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

LCA in the Space sector: what has been done so far?

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ArianeGroup

The space sector is a new area of development for Life Cycle Thinking and Life Cycle Assessment (LCA) studies. Space industry deals with strong particularities which complicate the use of LCA. One of the most important is that space industry related systems (i.e. launchers and satellites) are the only human activity that crosses all layers of the atmosphere and stays “out” of the natural ecosystems. Consequently, life cycle steps occurring into the near-Earth orbital environment are not yet characterized by the LCA methodology.

Besides, space facts are getting more and more out of the space community, receiving interest from large public audience, especially diffused by the media (movie on space debris, use of social network by astronaut, media launch from competitors, etc.) and, as all industry, it has to take into account environmental issues.

In this context, LCA has been identified as the most appropriate methodology to evaluate the environmental impact of space activities by the European Space Agency (ESA), ArianeGroup and others actors of the space industry. In this context, strong efforts have to be done in order to characterize the complete life cycle of space systems and solve methodological issues (mainly related to environmental impact on space), from the extraction of raw materials to the post-mission disposal.

The priority has been given for the harmonization of practices among the actors of the European space industry. The goal is to establish a common framework to be used by European space agencies and industries when performing spacecraft design, including the development and implementation of dedicated databases and tools for space activities. Guidelines and good practices helping to perform LCA studies have been released by ESA with a dedicated Handbook: “Space System Life Cycle Assessment guidelines” in 2016.

In addition, based on the ESA LCA studies already performed, a dedicated database, the “Space LCI Database” (2017) has been developed by the Agency. It includes a large amount of dataset dealing with specific aerospace materials and manufacturing processes, including space propellants.

As a leading industrial stakeholder, ArianeGroup is involved in the current efforts made by the European space sector in term of eco-design and LCA developments. The company is carrying out a Life Cycle Analysis of the future European launcher Ariane 6 in order to bring additional environmental parameters for decision making as long with the design-to-cost approach. In addition, ArianeGroup enhances the current methodological developments related to a specific Life Cycle Impact Assessment (LCIA) framework for the space sector. In this way, a dedicated LCA space debris indicator is currently being developed to compare several missions and post-missions disposal scenarios to study potential trade-offs between environmental indicators.

The presentation will propose a state-of-art focusing on the application of eco-design and life cycle thinking within the space industry, ESA and ArianeGroup pioneering this field since 2011. A common framework will be presented as well as key developments and case studies aiming to adapt existing methodologies to the space sector particularities.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Improving Sustainability in Textile Industry

Cristina Luján-Ornelas, Leonor Patricia Güereca, María-Laura Franco-García, Michiel Heldeweg

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The textile industry is currently one of the manufacturing industries with a greatest influence in the world economy, but also, one of the most polluting industries with many social concerns, as well. In the current production scheme, large organizations often hire suppliers in developing countries to generate products that will be sold in other countries, where products should comply with higher environmental and quality standards than the supplier countries. This can be a problem for suppliers without sufficient resources to meet those standards, putting at risk their competitiveness and permanence in the market.

For this reason, a literature review was carried out to enlist tools, methodologies and certificates to measure sustainability -defined as the balanced state of a system, resulting from the integration of three dimensions: environmental, social and economy- in textile organizations which were afterwards analysed by using content analysis techniques to identify common features among them. Some of the reported evaluation tools are: Carbon Disclosure Project, Business Social Compliance Initiative, Corporate Social Responsibility Standards, AA1000, SA8000, Organisation and Product environmental footprint, ISO, LCA thinking, GRI, Cost-benefit analysis, OEKO-Tex and SMART Sustainable Textile Standard, among others.

Even further, several studies to determine the environmental impact generated by the textile industry were found. Some tools estimate the sustainability performance at product level or from the design perspective. On the other hand, large textile organizations have issued “The Higg Index” to measure their sustainability level, but since it is not a public tool, textile SMEs cannot freely use it.

Through the content analysis, here some of the most common features observed in the analysed tools, methodologies and certificates: i) they focus only on one sustainability dimension; ii) intensive training is necessary to use them therefore it is often necessary to hire external services; iii) membership to large clusters (mainly conformed by large or transnational organizations) is a requirement and consequently a barrier for SMEs; iv) a certification process is demanded which represents an economic and technical burden, in some cases, certifications are difficult to achieve.

Derived from this analysis, we found that the integration of the three sustainability dimensions can offer an opportunity to increase the competitiveness of the textile industry representing an important innovation niche. Moreover, it was found that by adopting sustainability strategies at local and international levels, textile organizations might be regarded as more competitive. It is necessary the textile sector be monitored and evaluated in order to achieve its objectives and deploy in-depth knowledge including the SMEs and be able to improve its sustainable performance.

For this reason, we recommend to assess the sustainability performance in the textile value chain through an environmental and social Organizational Life Cycle Assessment. Different case studies will be evaluated to identify key indicators and hotspots, to subsequently develop strategies for continuous improvement. In further research, we aim to develop a tool for easy access and application, based in life cycle thinking to guide textile SMEs during their sustainability performance evaluation as well as their relationships with the community and government.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Eco-design as a New Lever to Enhance the Global Value Proposition: from Space to Corporate

Kévin Le Blevennec, An Vercalsteren, Katrien Boonen

Corresponding author: Kévin LE BLEVENNEC

VITO

Companies key decision makers have increasingly highlighted the transition towards a circular economy as a determining factor of their sustainability performance. Environmental strategies and subsequent environmental commitments are becoming more and more ambitious. Product design is key to enabling circularity and reaching those commitments. For Vito, the integration of environmental parameters into product design processes no longer has to be considered as a constraint but as a new lever to enhance the companies' global value proposition. Actuation of this lever is possible only if such integration is in line with existing companies' practices and is compatible with current processes. It also requires an efficient internal and external collaboration as well as an early stage integration. Specificity and challenges of some industrial solutions lie in their complex evolving environment. Long development life cycles and concurrent engineering activities have been developed to translate those customer specifications into functional requirements. Multiple highly-specialized experts ensuring the critical compatibility of those functional requirements are also characterizing those constrained engineering environments. Complex systems are part of highly competitive markets in which value creation is at the heart of the concerns. Driven by performance and technological considerations, the complexity of the solutions itself associated to the one of the organizations, did not lead most actors of the development to collaborate and anticipate the integration of environmental parameters into their current activities. In order to reduce the risk of inactions, divergent or unfinished actions, Vito perceived the need to facilitate the organization of the integration of eco-design approaches into current design processes of complex engineering systems.

Being the archetype of a constrained engineering environment, the Space sector is pioneering for dealing with such integrations. Within the framework of the GreenSat project initiated by the European Spatial Agency (ESA), Vito has firstly peformed a life cycle assessment of the Proba-V mission for QinetiQ. A close collaboration between QinetiQ and Vito has then allowed to identify and select eco-design options for this space mission. Due to the challenges faced in this project and as part of its eco-design activities, Vito has secondly studied the approach used in this project from a value creation perspective. Interactions and exchanges among actors have been scrutinized in order to identify the individual contribution of each of them to the global value proposition. Necessary actions ensuring the compatibility of customer, environmental and industrial sources of value creation originate from this analysis.

Based on those identified actions, a methodology facilitating the creation of a common language and enabling the translation of environmental commitments into functional requirements has been developed. This action step methodology especially targets environmental experts in charge of organizing the integration of an eco-design approach into current design process of complex products. Understanding of individual value creation processes, their connection through the tailoring of existing tools, intelligibility of delivered outcomes, are essential steps characterizing it. Arising from an efficient external collaboration in a specific sector, this methodology is transposable to other industrial sectors and applicable to internal collaboration at a corporate level.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Moving to a Circular Economy: taking advantage of the cross-fertilization between life cycle assessment and eco-innovation

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Ecological crisis is directly related to climate change, depletion of natural resources, high generation of environmental impacts and so on. A review in industrial practices is a necessary condition to confront this crisis, considering this fact, some proposals have emerged, including the life cycle assessment (LCA) methodology. It encompasses the entire production chain: the extraction of natural resources, transport, production process, consumption and disposal of products (waste), measuring each phase of a production chain, providing opportunities to identify critical points for environmental innovations – or simply eco-innovations. In addition to the widely known and discussed role of LCA as a decision making supporter, there is another of critical importance, its role as a generator of eco-innovations. It is then understood that there is a cross-fertilization between LCA and eco-innovation. The discussions underline the need of integrating these two axes of the literature, considering the huge potential to provide new means to tackle the ecological crisis. Considering this crisis, the circular economy - CE is a disclosure proposal alternative to the traditional linear approach, proposing a model based on "reuse-repair-renew-recycle" existing materials and products, in brief, CE take as a premise that resources are kept in use for as long as possible, value creation is maximized in the use phase, the production process is appropriate to the environmental needs, there is the use of renewable energies and products and materials are recovered at the end of each service life, thus proposing that inputs and products need to be managed in a more eco-efficient way throughout their entire life cycle, including here the waste generated. Taking into account these elements and this senario, this study seeks to point out and clarify the interrelation between these three knowladge areas – LCA, eco-innovation and circular economy. It is a bibliographic research is a addressing the three themes added to a field research that has been released through the life cycle initiative website, where 106 LCA specialists from 33 different countries reinforced the understanding concerning this cross-fertilization between LCA and eco-innovation, being perceived by 90.7% of them. To summarize: (i) LCA allows to find critical points in the product life cycle; (ii) eco-innovation is the type of change to be developed to improve a product in the critical points. (iii) the cross-fertilization between LCA and eco-innovation should promote better opportunities facing the ecological crisis, supporting, in this way, the transition to the circular economy. The study demonstrated this important interrelation between this three axes of knowledge, pointing out that the co-evolution of these axes promises fruitful results and suggest new applied research to demonstrate this findings.

SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Zera - An innovation Home Appliance that turns Food Waste into Fertilizer in one day

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Whirlpool Corporation

Goal:

An average US household generates approximately 3.5 kg of food every week. Most of this food-waste ends up in landfills where they produce one of the most potent greenhouse gases, methane. Whirlpool created Zera™ Food Recycler, a truly sustainable home appliance that converts your food waste into fertilizer!

Method:

To make Zera™ Food Recycler a truly sustainable alternative to throwing away food-waste in a landfill, we had to make sure that sustainability principles were applied at every stage of its design process. Life cycle assessments were performed to help make decisions regarding where the product should be manufactured, what materials can be used in the product as well as in packaging, what technology to use for the functioning of the machines and what changes can be made to improve the quality of the fertilizer.

Results:

The results of the study considered environmental indicators including non-renewable Primary Energy Demand, Global Warming Potential (carbon footprint), Acidification Potential (air pollution), Eutrophication Potential (water pollution) and Smog Potential.

The Global Warming Potential of disposing food waste using Zera™ Food Recycler is on an average lesser than the carbon footprint of disposing food waste in a landfill. When impacts over a period of 20 years are considered, the disposal of food waste in Zera™ Food Recycler has 25% less global warming potential than disposal in landfills.

Therefore, from a life cycle perspective, disposing of food waste using the Zera™ Food Recycler is not only useful for the owner's garden but also has other significant benefits over other methods of disposal such as landfills.

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SESSION T1-1 Complex Product Systems and Services - Design, Improvement and Innovation

Methodological Approach for the Integration of Heterogeneous Data Sets in Life Cycle Assessment – Case Study on Power-to-Liquid

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A key conclusion of the special report by the Intergovernmental Panel on Climate Change (IPCC) is that ways must be found as quickly as possible to reduce greenhouse gas (GHG) emissions in order to avoid significant impacts on humans and nature. In addition to the energy supply sector, the consumption sectors must also make their contribution. For the transport sector, alternative fuels, electrification and increased efficiency offer diverse possibilities for reducing energy consumption and integrating renewable energies.

Goal:

The diversity of measures poses a great challenge to classic life cycle assessment (LCA). The evaluation of new technologies with different structures is only conditionally compatible with fixed system boundaries and depths of detail. The aim of this paper is to introduce an adaptation of the classic LCA that allows to maintain the content scope of LCA while responding to changing input data.

Methods:

In a methodology was presented which takes into account the temporal dynamics of the electricity composition in the production of alternative fuels. The underlying modularisation is now used to handle the challenges of different levels of detail and changing system boundaries. The example of a Power-to-Liquid (PtL) process is used to outline the concept. For this, on the one hand, the LCA can be carried out for the whole process which contains two subprocesses (electrolyser, synthesis). On the other hand, the LCA could be made for the two subprocesses. For the latter, higher data availability must be ensured. The procedure is used to compare the results of the LCA of demonstration projects with those of reference PtL processes generated based on literature and simulations. Eventually, the change in comparison to the reference can be used to evaluate the improvement due to the integrated process. In addition, the results can be compared with the conventional reference and other alternatives.

Results:

As a result, the method is shown presenting two different quantitative examples. A complete PtL plant as well as an electrolyser are integrated into the PtL reference life cycle to show the handling of different depths of detail. A comparative analysis regarding the GHG emissions is carried out for the examples. Finally, the influences of the different levels of detail of the input data as well as the chosen e-fuels reference life cycles on the results will be investigated.

SESSION T1-2 LCM for Electric and Electronic Products

Critical Review of Life Cycle Assessments in the Domain of Information and Communication Technology Devices

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Fraunhofer IZM

Goals:

Life Cycle Assessments see an increasingly widespread use in the electronics sector and for consumer ICT devices in particular. More than 25 years after the first kind-of Life Cycle Assessment of a complex electronics product (Micro and Computer Technology Corporation: Environmental Consciousness: A Strategic Competitiveness Issue for the Electronics and Computer Industry, Austin TX, 1993) a thorough assessment of a server, laptop, or mobile phone is still a challenging exercise. This poster is supposed to summarize the state of the art of Life Cycle Assessments for electronics.

Methods:

The authors' insights in current LCA practice in the ICT domain are derived from almost 100 critical reviews of LCA studies of wearables, audio equipment, VR equipment, laptops, personal computers, servers, smartphones, smart home applications, and many more, following ISO 14.040 / 14.044 and ETSI ES 203 199: Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services. This allows for a comprehensive overview of current data sources, data reliability, variances in assumptions, appropriateness of chosen impact categories, and transparency of LCA documentation.

Results:

Frequent practice in Life Cycle Assessments of electronics products is still a reengineering of a given device and plotting of components on generic datasets. We observe a high level of confidence among LCA practitioners in generic datasets from the usual databases, but a closer look unveils some major shortcomings. The availability of datasets for electronics is good, but with some gaps, which are not properly or not at all modelled in most frequently used databases, such as specific semiconductor materials (GaAs, InP and similar), which are increasingly used in today's devices, semiconductor packaging technologies, such as wafer level packaging (WLP), which are around already for a while, or OLED (organic light-emitting diodes) technology, which is likely to dominate the market for small displays in the near future. Even brand name OEMs face major difficulties to get hold of primary inventory data from suppliers. At best, only a minor share of the components – although some with a comparingly high contribution to overall impacts – are assessed with primary first or second tier data in the end. The LCA results therefore largely depend on chosen background databases, proper plotting of components on individual datasets, including scaling where needed, worst case assumptions in case of uncertainties, such as suppliers' process yields. Under these conditions LCA results established by different manufacturers or different LCA experts are hardly comparable. For cradle-to-gate carbon footprints of ICT products we estimate the accuracy of results to be +/- 20%, even when considering state-of-the-art in LCA. Only if very standardized and closely framed approaches, such as PAIA are applied, a certain level of comparability is given, but with some other shortcomings. Updates of some commonly used generic datasets is urgently needed, as technology is in the meantime several generations ahead of the modelled data and for some emerging technologies no appropriate data is available at all.

SESSION T1-2 LCM for Electric and Electronic Products

Water footprint of Electrolux products: a life cycle based study

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GOAL: Electrolux is committed to reduce and control the use of water across its factories globally, as well as to address the growing need for enhancing the water efficiency of products. This paper is aimed at illustrating how we applied a life cycle assessment (LCA) based approach to analyse the water footprint (WF) of a group of products considering the potential impacts due to changes in both water scarcity and degradation over the entire life cycle of products (raw materials, product assembly, use and end of life).

METHOD: The LCA methodology is applied for assessing the WF of four domestic appliances (washing machine, dishwasher, fridge and oven), from cradle to grave, taking into account the ISO 14046:2014. The functional unit of each product is expressed according to its function, e.g. in case of the washing machine a defined washing cycle with detergent, water and electricity, repeated several times annually over an expected lifespan. The system boundaries include all life cycle stages from cradle to grave. The manufacturing and the use phase of the products group is modelled in several countries (EU, US, Brazil, etc.) to verify the influence of regionalization on the WF results. Washing water from the washing machine and the dishwasher is disposed to a sewerage system, where it undergoes treatment and then is released into the aquatic environment. In countries where appliances are not connected to the sewerage system, washing water is discharged into the environment with a pollutants load. Ecoinvent datasets are chosen as the background data for the electricity, gas and water consumed. Finally, the end of life phase is modelled assuming an EU scenario reflecting corresponding recycling rates for different materials. The impact assessment methods for the WF are selected to cover both impacts on water availability (scarcity) and quality (degradation). We selected mid-point water scarcity indicator (Boulay et al, 2011; m3 freshwater–eq). For degradation, the freshwater eutrophication (ReCiPe method) and freshwater ecotoxicity (USEtox method) indicators are chosen.

RESULTS: Among the studied products, the washing machine shows the largest impacts in water scarcity category, followed by the dishwashers, taking into account that both products use water, electricity and detergents during the use phase. Water scarcity is mainly caused by water consumption for the washing machine and the dishwasher, while for the fridge and the oven it is mainly associated with cooling purposes in electricity production. Therefore, the use phase largely dominates the impacts on water, which are highly dependent on the location and on how the use pattern is modelled. Washing water discharged into the sewerage system contributes the most in terms of ecotoxicity and eutrophication impact. Consumption of powder detergent during the use phase is responsible for sizeable ecotoxicity impacts. The inventory data from available database show that it is feasibale to have an overview of the impacts on water, as well as to identify critcial hot spots, along the whole life cycle of studied products.

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SESSION T1-2 LCM for Electric and Electronic Products

Environmental profile of electric and electronic appliances valorization schemes: re-use vs. recycling

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EnergyLab

Waste of electric and electronic equipment (WEEE) is becoming an issue to tackle. The release of the Directive 2012/19/EU was the framework regarding WEEE management in the European Union. In order to achieve the established goals for re-use, recycling and materials recovery, the Directive was transposed into national law by Member States. The adoption of this new framework for WEEE implies the adaptation of current municipal waste management systems. In this sense, the municipal collection points shall be modified to comply with the provisions regarding WEEE management and separate collection.

The ESTRAEE project is focused on the adaptation of municipal collection points to the Directive in the Galicia (Spain) and Northern Portugal cross-border area. Hence, the project aims to increase valorization rates and to improve the environmental performance of WEEE collection and treatment in the cross-border area.

To do so, Life Cycle Assessment was applied to evaluate the environmental performance of WEEE disposal, taking into account re-use and recycling schemes in order to shed light on the potential benefits and drawbacks of each scheme.

The results obtained showed that re-use scheme did not always attained lower environmental burden for all impact categories when comparing with recycling scheme.

SESSION T1-2 LCM for Electric and Electronic Products

Comparative life cycle assessment of power supply units for stationary and mobile personal computers

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Goals

The objective of the research is to compare the environmental profiles of two different variants of power supply solutions for personal computer and to determine the more environmental friendly type of product. The research is oriented on types of generated impacts on environment caused by both variants of product. The possible outcome of the study is also an indication the key environmental feature of product and recommendation for consumers on selecting and using power supply devices.

Methods

The research is supported by the life cycle assessment Impact'2002 metchod, computer software SimaPro for calculations and the ecoinvent 3.0.1 environmental database for inventory data. The data on material flows in life cycle are collected in power supply units inventory analysis and technical assessment that led to defining appropriate assumptions simplifying the assessment and enabling comparative study. Additionally, external resources and experts' opinions are used in order to define appropriate framework, system boundaries and functional unit for the study.

Results

The results of the conducted research are presented with regard to the specificity of the impacts generated by both compared devices. The interpretation is focused on differences between the two power supply units while environmental impacts are concerned. The results are presented in way to show consumer perspectives and potential recommendations for selecting power supply units and using it in order to minimize environmental pressures. The interpretation of the results lead also defining selection criteria for different types of use of personal computers with different power supply solutions.

Additionally, some significant differences characterizing the use phase of mobile personal computers in relation to their stationary counterparts were also observed indirectly. The results form the basis for further research that will allow to formulate environmental recommendations of the specific computers types application. In addition to environmental gains, they could also allow to determine economic benefits of using appropriate sets of devices for the enterprise.

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SESSION T1-2 LCM for Electric and Electronic Products

Quantitative environmental impact assessment for agricultural products caused by exposure of artificial light at night

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In recent years, it became clear that the brightness of artificial light at night has been increasing year by year, and its scale is expanding. According to Science Advances, it is reported that from 2012 to 2016, the artificially illuminated outdoor area increases by 2.2% per year and the annual radioactivity total radiance increases by 1.8%. Light pollution is described as the situation in which these lights are obstructing or having damages through their leaks, a common example is the outdoor lighting. Light pollution has various effects on human activities, wild animals, plants, agricultural crops and livestock.

Rice is also one of the crops affected by light. Rice is a short day plant where flower buds begin to form when the light exposure becomes longer than the critical dark period, which is the minimum requirement time needed for flowering. However, today road and sign lightings are increasing with the countryside urbanization. Therefore, the influence of light pollution on rice is expected to increase due to the increase in artificial light at night. Although the influence for each region and each type of rice must be considered, the evaluation in Japan as a whole has not been done. Growth of rice is hindered by night lighting, and light pollution has become a problem as a type of pollution causing heading delay.

It is known that the degree of damage by the exposure of light differs depending on the type of light source. Numerous studies have been done on the effects of climate change due to conversion from incandescent lamps to LEDs, but quantitation on the effects of light damage has not been made in LCA studies, and the relationship between climate change and light damage has also been discussed yet.

In this research, we aim to develop a method for life cycle impact of artificial light pollution. This study focused on the impact on rice production as a part of significant endpoint of social asset. The method can be divided into several steps; fate analysis, exposure analysis and damage analysis. Fate and exposure analysis were developed by the utilization of existing research related to light pollution. Damage analysis was carried out by applying of statistic data. Characterization factors was expressed by monetary unit per a unit of electric power.

Furthermore, we carried out case study of LCA for road light installed at road. The scope of the assessment included climate change and light pollution. The results obtained through these studies are expected to contribute to the design and installation of lighting equipment with a comprehensive viewpoint.

SESSION T1-2 LCM for Electric and Electronic Products

Environmental assessment of domestic electric water heaters

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In Europe, the energy used for water heating in the residential sector accounted for 15% of the total energy consumption in 2016. About 19% of this energy consists in electricity that is consumed in appliances such as electric water heaters and heat pumps. Given the current concerns of achieving a circular economy, it is important to evaluate the environmental performance of these appliances in order to identify opportunities for reducing environmental pressure and resource consumption.

In this context, his study carries out a comparative cradle-to-grave life cycle assessment (LCA) of an electric water storage heater (EWS) and a heat pump for water heating for domestic purposes (shower and/or cooking). This assessment aims to determine the largest contributions of each household appliance to the environmental impact, providing relevant information to the manufacturer on how the impacts could be more effectively reduced. Besides, the comparative analysis between the two appliances will provide a general outlook about the less aggressive electric water heater for the environment, thus, supporting decision making by consumers.

A cradle-to-grave approach was adopted considering the following stages: raw materials production, use over 15 years (including water and electricity consumption according to the EU Regulations 812/2013 and 814/2013 during use and maintenance), and end-of-life (recycling of water heaters components and/or landfill). The manufacturing stage was excluded as it is expected to have a minor contribution to the global impacts as indicated by a previous study for gas water heaters. The functional unit is the provision of 1 litre of heated water with a temperature of at least 45ºC and considering 15 years of lifespan for the appliances. Primary data supplied by the producing company, located in Portugal, contribute for achieving accurate life cycle inventories that were modelled in SimaPro 8.5.0 complemented with data from Ecoinvent 3.4 database. The ReCiPe 2016 Midpoint V1.01 methodology at the Hierarchist perspective has been used to estimate the environmental impacts.

The LCA results show that the main contribution to the environmental burdens of the two electric water heaters comes from the electricity consumption during the use stage. Thus, this stage plays an important role in minimizing the environmental impacts associated with these household appliances. It is also important to note that the environmental burdens vary considerably according to the electric mix of the country where the water heater is used.

The comparative LCA between both systems, indicates that the EWS heater has higher environmental impacts - in terms of atmospheric and water emissions and fossil resource depletion - than the heat pump due to its more intensive electricity consumption. However, the heat pump has associated greater mineral resource depletion because of its higher material requirements.

This study is part of a wide work in which several domestic hot water production systems are being developed. Practical implications of this work will enable the manufacturer to achieve better levels of environment-friendliness and to improve its awareness of the sustainability of new electric water heaters that will be developed. Therefore, it is essential to optimize the EWS and the heat pump and reduce their electricity consumption during the use stage, for instance, through the increase of the energy efficiency and the reduction of thermal losses in the storage tanks. Moreover, it also helps householders to identify and select the least damaging alternative to the environment.

SESSION T1-2 LCM for Electric and Electronic Products

Methodology to Assess the Circularity of Product Design for Smart Mobile Devices

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Goals

Circular product design refers to different design measures which aim to extend the use time of products and components for as long as possible, thereby preserving materials and minimising environmental impacts over the whole product life cycle.

The objective of this research was to develop method to assess the circularity of product designs of smart mobile devices (such as smartphones, tablets, etc.) and will guide the user towards a circular product. This method will be later integrated into a web-tool that is simple in its application, is widely applicable to assess and evaluate smart mobile devices, and determines strengths and weaknesses of the product design.

Methods

In order to assess product designs first of all it was necessary to distinctly define the so-called “D4R strategies” (Repair, Reuse, Remanufacturing and Recycling) based on academic literature and standards. Although there is a long history of D4R strategies, there is significant change in the product technologies, which needs to be considered, but also some innovative developments in 4R processes, such as robotics for disassembly.

Secondly, a criteria catalogue, with a set of specific design measures related to the 4Rs and specifically relevant for smart mobile devices was defined (e.g. Accessibility of spare parts for manual and automated access). This catalogue is the basis for the assessment method.

The next step was to develop the assessment method behind the tool. Further the developed method was tested on several devices (smartphone, digital voice recorder…), to adjust the assessment scale and test the method with its underlying criteria according its usability.

Currently the developed and proofed assessment method will be translated into a web-tool.

Results

The resulted assessment method consists of:

1) Criteria catalogue of specific product design measures.

2) An assessment scale evaluates the degree of fulfilment for each design criterion. The scale is based on the guideline VDI2225-33 which describes a method to evaluate different product variants concerning their technical and economic value.

3) A defined quantifier for every single criterion, which weights each criterion in terms of its importance related to the particular end-of-use strategy (Repair, Reuse, Remanufacturing and Recycling).

4) Improvement strategies: According to the fulfilment of each strategy the strengths and weaknesses can be identified and possible design strategies for further improvement selected.

5) Related Business Models: In order to fully capture the value of the circular product design, an adaption of the business model often becomes necessary. Therefore the paper describes how the criteria relates and enables predefined circular business strategies.

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SESSION T1-2 LCM for Electric and Electronic Products

Life Cycle Environmental Benefits of a Novel Smartphone Waterproofing Technology

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ERM

What is the environmental impact of dropping your smartphone in the sink? We can prevent water damage to electronic items with novel technologies, but to what extent do the impacts of these technologies themselves counterbalance the benefits that they offer?

Using LCA, environmental consultants ERM and one of its clients assessed the full life cycle environmental impact of an innovative waterproofing nanocoating that protects smartphones from water damage. This new technology is expected to be superior to conventional waterproofing methods, which rely on O-rings and gaskets to create an airtight seal. The study compared the environmental impact of the innovative nanocoating with a conventional waterproofing technology, taking into account expected changes in damage rates.

The results show that the waterproofing nanocoating has a significant net environmental benefit and demonstrate the value of life cycle thinking.

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SESSION T1-2 LCM for Electric and Electronic Products

Tool sharing platforms and sustainability: Managing sharing services from a life cycle management perspective

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Collaborative consumption has been promoted as an important step in transforming consumption patterns toward more sustainable consumption and production practices. Expectations of the sharing economy are generally positive, though few studies have analyzed the environmental implications of sharing services. This study aims to analyze the potential environmental

impacts of a product sharing platform (rental box system) for gardening tools by a leading Swedish manufacturer, Husqvarna. Furthermore, the study follows the life cycle management practices from the producer to develop more sustainable solutions based on pilot studies and a developing proof of concept. Results suggest that the sharing platform can have significant environmental benefits compared to linear consumption models. The analysis also suggests that important aspects for the environmental impacts include the location of rental system, transportation method for renting the products, maintenance and models used to ensure availability and sustainable waste management of batteries. The study also follows the development of the sharing service offered by Husqvarna and the business models, production, sourcing and changes to the system implemented toward more sustainable practices. The results and mapping provide an important addition to the LCA and LCM literature for circular business models.

SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM

Life Cycle Assessment of Flame Retardants: LIFE-FLAREX project

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Goals

Flame retardant (FR) textiles are extremely important since they offer human, property and environment protection against fire. In recent years, increasing concerns about the toxicological and environmental consequences of using such FR chemicals on textile substrates have been raised. Many of these chemicals are now recognized as global contaminants and are associated with adverse health effects in animals and humans, including endocrine and thyroid disruption, immunotoxicity, reproductive toxicity, cancer, and adverse effects on fetal and child development and neurologic function.

In order to contribute to the mitigation of the environmental and health impacts on European ecosystems caused by toxic compounds of FR textiles additives, the LIFE-FLAREX project was proposed in the LIFE Environment and Resource Efficiency Programme.

LIFE-FLAREX project aims to evaluate from an environmental point of view 3 harmful FR and 6 non-toxic or environmental friendly alternatives. A Life Cycle Assessment (LCA) has been performed to compare the different FR and identify the environmental benefits of the new FR textiles and technologies.

Methods

Life Cycle Assessment (LCA) has been developed based on ISO 14.040 and ISO 14.044; following the four interrelated steps: goal and scope definition, life cycle inventory analysis, life cycle impact assessment and interpretation of the results.

During the goal and scope task, the following aspects have been defined:

- The objective of this LCA is to compare the environmental impact of environmental friendly alternatives with conventional FR in different types of textile.
- Functional Unit: 100m2 of textiles finished with FR.
- System boundaries: life cycle stages included in the system boundaries are raw material extraction, production stage, use and end-of-life. Also the transport is included in the assessment.

For LIFE-FLAREX project, the LCA methodology selected is the ILCD impact assessment method, released by the European Commission, Join Research Centre in 2012. The impact categories selected to express the environmental performance are: Climate change, ozone depletion, human toxicity (cancer and non-cancer effects), acidification, freshwater eutrophication, freshwater ecotoxicity and mineral, fossil & renewable resource depletion.

Results

There is limited information available about the environmental behaviour and toxicological properties of FR, and their potential impact on the environment is still difficult to be assessed in an accurate way. Literature reveals that the major differences between FRs of concern and their proposed alternatives in terms of human health and environmental impacts are the potential for bioaccumulation and CMR (carcinogenic, mutagenic or reprotoxic) effects.

From an environmental point of view, the most promising alternatives HFFRs are Ammonium polyphosphate (APP), poly[phosphonate-co-carbonate], Magnesium hydroxide, Aluminium hydroxide (ATH) and Aluminium diethylphosphinate (Alpi); because they present generally low-acute ecotoxicity and low bioaccumulation potential. For other substances such as Phosphinic acid-aluminium salt and nanocomposites, there are large data gaps and lack of data to assess their hazards.

LIFE-FLAREX will provide more data to know the environmental performance of specific FR. Despite at this stage of the project there are not final results to show, it is expected to present preliminary results during the coming months.

SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM

The Life Cycle Thinking adherence and contribution of the chemical industry to improve ecoefficiency of home care products: Sokalan HP56 case

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BASF - FUNDAÇÃO ESPAÇO ECO

The consumer demand for more sustainable processes is decisively influencing the business choices of the chemical industry. Since decades, BASF creates new solutions that contribute to the sustainability needs of its customers and evaluates the sustainability performance of its portfolio to actively steer offerings towards more sustainable solutions. (GOAL) Is BASF Latin America making use of Life Cycle strategies for achieving this issue?

According to Nielsen trend research (2016) 74% of Latin America consumers use a washing machine and indicate high efficiency (61%) and color preservation (48%) as attributes required.

Realizing this consumer demand, BASF's Care Chemical business, has developed a portfolio that offers practicality and economy in home care solutions, composed by actives, which when added in cleaning products, provide benefits that allow consumers to optimize everyday household tasks such as cleaning the house and washing clothes. The innovations allow the reduction in the consumption of natural resources and some of them are developed in accordance with vegan certification. (METHOD) In this sense, the present study carries out an Ecoefficiency Analysis of Sokalan HP 56, an additive for laundry detergent that reduces the consumption of electricity, water, time and costs because it allows cleaning the same volume of clothes in fewer washing cycles. This cradle to grave analysis considered all the processes since the extraction of raw materials to the treatment of effluents for laundry processes when using regular detergent and detergent with SOKALAN HP 56 considering a 4 people residence which washes an average of 8 kilograms of clothing per cycle, including white, black and colorful. (RESULTS) In general it was found a reduction of environmental and economic impact of 20%, mainly due to the reduction of consumption of water and electricity consumed in the process and, consequently, decrease the amount of water to be treated in the sewage treatment plant. The most relevant environmental impact categories for the study are: Freshwater Eutrophication, Global Warming Potential, Acidification and Water Depletion. Summed up, they correspond to more than 80% of the total environmental impact caused by the analyzed system. The results of this study permitted BASF Care Chemicals to understand the role of the chemical in question in the laundry chain putting in practice the Life Cycle Management in the business activities. Communication materials focused on SOKALAN HP 56 ecoefficiency attributes were developed and had a great repercussion. The results of this study aroused BASF Care Chemical managers interest in evaluating the sustainability performance of others solutions for home care like dishwater and surface cleaners. The scope was mainly proposed by the involved people, who was able to identify the ecoefficiency potential of each solution (e.g. reduction in transportation stage, raw materials with high vegetalization index, among others). This movement demonstrates the adherence of this business unit to Life Cycle Thinking. These new studies are in progress and the expectation is to boost the company value chain by making good use of LCM strategies.

SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM

Demonstration of an innovative recycling scheme to increase the water efficiency in the petrochemical industry

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GOAL

Clean water is a vitally important natural resource, but increasingly under stress. European industrial sector is the second larger consumer of water, using 22% of the freshwater of the world. Petrochemical industry in Europe represents over 27% of the European chemical industry, and it is a major water user mainly for cooling purposes, and for productive processes. In that sense, the ongoing LIFE + REWATCH project focuses on increasing water efficiency in petrochemical sector by implementing an innovative water-recycling scheme based on biological and separation processes. The project is taking place in DOW Chemical Ibérica and DuPont España chemical facilities in southern part of Ebro River, Tarragona. An LCA study is being conducted in the frame of the project in order to assess the environmental benefits of the technology.

METHODOLOGY

The LCA is focussed on the environmental gains and drawbacks of each water recycle scenario. The FU is one cubic meter of freshwater consumed by the petrochemical industry at the entrance of the cracker. The LCA is modularly constructed and performed accordingly to the ISO 14040 series following a “from cradle to grave” approach. The study relies on the principles stated at the Environmental Product Declaration: “Wastewater collection and treatment services”. The system is based on three initial scenarios: The first one is based on the initial situation of the system, where no water reuse is performed (92% of the water comes from the Ebro River, 8% is ultrapure water). Industrial wastewater treatment plant (IWWTP) is within the system for treating cracker wastewaters. The second scenario implies the installation of the current centralized water reclamation plant, (CWRP) reducing the Ebro uptake to 67% by introducing 25% of the water needs of the cracker. The third scenario studies the implementation of REWATCH plant, which treats wastewaters from cracker, and produces 36% of its water inputs: it avoids external ultrapure water production, IWWTP and reduces water consumption from CWRP. Depending on the technical performance of the plant, more scenarios may be added for achieving a more realistic environmental profile.

RESULTS

Preliminary results point to high environmental impacts from IWWTP in all assessed categories (70% on average), especially in water consumption(WC) (95%). In terms of global warming(GW), the whole process accounts on 2 kgCO2eq/m3, and 17.81 m3/m3 of (WC). On its behalf, water intake from Ebro River has an average contribution of 25% of the impacts, motivated mainly by pipeline transportation. When CWRP is introduced in the second scenario, GW decreases to 1.93 kgCO2eq/m3, while (WC) remains in 17.80 m3/m3. This effect is caused by the fact that IWWTP is still receiving the cracker wastewaters. The gains from partially water reuse are almost counteracted by the installation of CWRP. Regarding the REWATCH scenario, the fact of avoiding production of ultrapure water let the impacts drop to 0.75 kg CO2 eq. and 0.79 m3/m3. The main gain is driven by the fact that in this scenario all ultrapure water production is avoided, as well as the IWWTP is not active due to the REWATCH plant operation.

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SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM

Environmental Impact Assessment Model for Substitution of Hazardous Substances Using Life Cycle Approach: A Tool for Sustainable Regional Development

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Goal

Environmental management in the Baltic Sea Region has improved during the last decade, resulting in a considerable decrease of emissions. Despite this progress, most parts of the Baltic Sea still is classified as “disturbed by hazardous substances”. Environmental policies (such as REACH, 2006) on chemicals management have so far been formulated mainly to reduce emissions of hazardous substances. Nowadays, the public authorities have a big issue of ensuring better environmental status of the Baltic Sea Region waters and to strengthen the resource-efficient growth. An environmental impact assessment model dedicated for the substitution of hazardous substances using Life cycle approach with streamlined, easy to implement environmental and occupational Life cycle assessments found to be necessary to address this issue. The proposed model has been developed to guide chemical substitution in industrial companies, and model can be useful for green public procurement.

Methods

Alternatives assessment frameworks by OECD, EU, EPA and various other organizations cover a wide range of issues. However, they lack life cycle occupational safety, total CMR/physical hazard/PBT/vPvB evaluation and fugitive/accidental emission considerations along the supply chain. The model for evaluating the environmental impact of substitution of hazardous substances using life cycle approach consists six methods: simplified life cycle assessment (simplified LCA), work environment characterization factors (WE-CFs) method, LCIT method, modified life cycle inherent toxicity (modified LCIT) method, emissions/usage amounts and risk assessment (RA). WE_CFs method has been adopted for the EU region, with derived DALYs per unit of production for various industry sectors (NACE Rev. 2). The DALYs per unit of production have been multiplied with the product flows of representative top 40-50 processes concerning occupational safety. These methods selected to be complementary in scope and to have the optimum balance between simplicity, accuracy and comprehensiveness. Model includes environmental impacts from regular/accidental/fugitive emissions, occupational impacts due to fugitive or accidental emissions into work places and accidents along their supply chain.

Results

The developed model has been applied to a several case studies in the Baltic region. Simplified LCA (Recipe Endpoint), WE-CFs method, and modified LCIT method gave a combined score of 3.7E-5 in baseline situation and 2.2E-5 for the alternative situation. LCIT method gave an increase in cancer impacts on workers, from 5.4E-7 to 1.0E-6, but a decrease in non-cancer impacts from 2.7E-6 to 1.4E-6 disease cases per kg of substance. Emission/usage amounts indicated that there was an increase in highly flammable/explosive/reactive and reprotoxic substances although there was a decrease in ‘suspected carcinogens’ along supply chain. RA gave unacceptable risks to the environment in both situations. Indicators proposed by the methodology covered a wide range of issues, such as intermediate carcinogens in supply chain and worker’s health along life cycle, that are recently being ignored in chemical alternatives assessments.

Regional authorities can benefit from the model as policy instrument for environmental improvement, resource efficiency in industry, infrastructure development, services in health and sanitation, transport, etc. The main mechanism for this would be by necessitating the use of the model in public procurement of chemicals or products.

SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM

Life cycle sustainability assessment and life cycle engineering to evaluate banana/plantain fiber biocomposite materials

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Companies of many industrial sectors have begun to use sustainable designs in their product development processes, promoted by concerns about CO2 reduction, climate change and sustainability. Entities involved in the production of materials are actively searching for non-oil derived products, using renewable resources and considering environmental impacts during their life cycle. However, some of the alternative options are very expensive compared to the synthetic ones. Biocomposite materials (BM) reinforced by natural fibers (NF) from local and renewable resources offer a much more environmentally friendly option to substitute petroleum-based composites. However, most of researches are devoted to evaluate the technical performance and economics, and the analysis of the environmental and social implications including the integration of these dimensions continues to be scarce (1).

The aim of this study was to measure the sustainability of beverage cup lids manufactured by different blends of BM with respect to the conventional synthetic polymer ones, based on technical, economic, environmental and social indicators selected by the stakeholders. This methodology could provide to the local plastic companies, tools and new data for reflects the quadruple bottom line (QBL) as an accounting framework to go beyond the traditional measures as support of multicriteria decision making for sustainable BMs. The use of these materials holds a great opportunity for social and economic progress of small-scale farmers and low-wage workers who produce NF.

Methodology and Results

The life cycle assessment LCA and ISO 14040-44 series was fundamental for the evaluation of QBL and during all the stages of life of a BM. The identification of the most relevant stakeholders related to the supply chain to collect data by interviews (2) was another important step. Technical, economic, environmental, and social dimensions were based on BM properties, Life Cycle Cost (LCC), LCA and Social Life Cycle Assessment (SLCA) (3-5). The inventory data were modelled using primary information by direct process and/or stakeholders, literature sources from BM assessments mainly focused on Colombian cases.

The Fig. 1 shows the life cycle process of lid production, the recognized stakeholders and some of the identified indicators. The system's boundary was performed on a cradle-to-grave approach.

The results showed that among the different aspects, the lids with the largest amount of synthetic polymer have greater benefits in terms of cost, performance and processability due to research, logistics, machinery and production have been focused for years on polymer processing. Unlike the environmental assessment, where the use of synthetic polymers shows a high environmental impact due to the fossil depletion compared to the use of NF in the impacts generated in land use and climate change. Regarding the social aspect, farmers have the greatest benefit when natural fibers are used at the industrial level, among which it is highlighted the inclusion of women's work in their extraction. When an integral evaluation is made, the alternatives with superior NF content presented the best option with respect to those with a high percentage of biopolymer.

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SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM

Strategies to Reduce the Global Carbon Footprint of Plastics

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Over the last four decades, global plastics production has quadrupled. Continuing this trend, the greenhouse gas (GHG) emissions from plastics would reach 15% of the global carbon budget by 2050. Strategies to mitigate the life cycle GHG emissions of plastics, however, have not been evaluated on a global scale. Here, we compile a new dataset covering the life cycle GHG emissions of ten conventional and three biodegradable plastics. We project these emissions through 2050 under various mitigation strategies and their combinations. Our results show that the global life cycle GHG emissions of conventional plastics in 2015 was 1.7 Gt CO2e, which, under the current trajectory, will grow to 6.6 Gt CO2e by 2050. However, alternative feedstocks, energy, and end-of-life management strategies have the potential to reduce the emissions by up to 76% by 2050. Our results show that reducing life cycle GHG emissions of plastics below the current level requires an aggressive decarbonisation of energy combined with extensive recycling. Our study demonstrates the need for integrating energy, feedstock, and end-of-life management strategies to curb the growing GHG emissions from the life cycle of plastics.

SESSION T1-3 Towards Sustainable Chemicals and Materials by Mainstreaming LCM

Sustainability hotspot scan: life cycle assessment for SMEs in the chemical sector

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Goal:

To make lifecycle assessment mainstream for the chemical industry TNO together with CSR the Netherlands and a group of SMEs - developed a simplified life cycle assessment tool; the sustainability hotspot scan (SHS).

Methods:

For SMEs within the chemical sector sustainability is a driver, one that is increasingly a requirement. But where do you begin? Where do the opportunities lie? And what are the risks? For this tool, first an analysis of the methods already available to SMEs revealed that most of these methods are too time-consuming, too expensive or not tangible enough for SMEs. Large chemical companies are often able to develop their own methods. This is not so easy for SMEs. Knowing this, and on the basis of a number of manuals for sustainability assessment, the hotspot scan was developed specifically for SMEs. The manuals on which the SHS is based are the WBCSD social metrics handbook, the Life cycle metrics of the WBCSD, People + Handbook, the OECD sustainable manufacturing handbook and LCA expertise. The SHS combines social databases such as the ILOSTAT database, global slavery index, child labor databases, incident registration and REACH to assess the social impact. For the environmental impact databases for scarcity, Worldbank data, EUSES and the blue water footprint are combined to estimate the environmental impact based on your own production data.

Results:

This results in an assessment tool which can be used in the chemical industry to scan the strengths and weaknesses in the supply chain of a chemical product.

SESSION T1-4 Sustainable Health Management – Performance of Health Services

Pharmaceuticals in Hospitals – Are they relevant?

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1. GOAL

Healthcare was determined to be the fourth most relevant consumer sector in terms of environmental impact in an analysis of Swiss Environmentally Extended Input-Output-tables. A wealth of studies have been carried out on the three most relevant (nutrition, housing, mobility). However, thorough analyses of the healthcare sector remain scare and many knowledge gaps still exist.

Some studies suggest that pharmaceuticals may play a significant role in the total environmental impact of the healthcare sector. For example, approximately 9% of the carbon footprint of the National Health Service in England is due to the provision of pharmaceuticals. Other publications focus on active pharmaceutical ingredients (API) in the effluents of hospitals. The proportion of total emissions emitted by hospitals varies significantly depending on the substance: from less than 10% of the total emissions for common substances originate from hospitals to well over 50% for hospital-specific substances.

The goal of the multidisciplinary “Green Hospital” project is to analyse resource consumption and efficiency in Swiss hospitals from an environmental, economic, and logistical perspective. As no such comprehensive studies have been carried out to date, a number of relevant questions have been raised. For example, how relevant is the environmental impact of pharmaceuticals in hospitals? How can this impact be quantified? Is there significant improvement potential? The Zurich University of Applied Sciences is attempting to answer these questions.

2. METHODS

Data collection for the project occurred in three main steps. Firstly, a rudimentary questionnaire was sent to several hospitals in Switzerland in order to provide data for a preliminary LCA to determine which areas within a hospital are responsible for the majority of the environmental impact. Collaboration with the Fraunhofer Institute for Material Flow and Logistics helped identify which of the most environmentally relevant areas have significant improvement potential from the perspective of process optimisation. Based on this preliminary analysis, detailed questionnaires were sent to two partner hospitals in order to collect comprehensive data in these areas, which included pharmaceutical provision. Lastly, additional data concerning the provision and logistics of pharmaceuticals within hospitals were collected on site during process analyses. A comprehensive LCA is being carried out to determine the environmental impact.

3. RESULTS

It is expected that drug procurement and related energy demand will contribute significantly towards the total environmental impact of Swiss hospitals. Research shows that energy related impacts of pharmaceutical production often range from 90%-95% of the total footprint, while impacts of process chemical emissions are found to represent only 5%-10%.

Formulation of the API into a ready-to use drug marks the final step in the production of medicine. On the overall industrial level, studies showed that API production was responsible for the majority of cumulative exergetic resource consumption. As a result, the dosage of the API in the final product is expected to have a strong influence on the overall environmental impacts from a resource point of view.

Identifying hotspots will help in the development of best practice recommendations and contribute towards a more sustainable healthcare system.

SESSION T1-4 Sustainable Health Management – Performance of Health Services

DOAR: an inventory management system able to avoid blood waste.

Breno Barros Telles do Carmo, Daniel Faustino Lacerda de Souza, Paulo Gabriel Gadelha Queiroz, Vanessa Elionara de Souza Ferreira, Itágores Leandro Bezerra de Lira, Amim Alleff de Souza Silva

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Goal:

Blood Centers are responsible for delivering blood products to hospitals, such as packed red blood cells, platelets and plasma, among others. These products present different shelf-life and storage requirements, making complex the establishment of an effective strategy for donor recruitment and inventory management.

Managing blood products stocks is a global problem. Coordinated efforts are needed to avoid shortages of these products as well as waste. The use of inventory management techniques is able to overcome this problem and provides a way to balance donors recruitment and blood products distribution. Defining blood collection campaigns targets is one of the challenges of Blood Centers. As such, this research presents a software able to establish weekly targets for each blood type in order to attend blood products demand, avoiding the waste related to excessive stocks.

Methods:

This abstract presents a software developed for this purpose, called “DOAR”. The base idea of the system is to favor smart blood collection, balancing supply and demand, maximizing the availability of blood products while avoiding waste. Based on the analysis of the demand historical data, it is defined the statistical behavior in order to establish the parameters used for the maximum stock levels definition for each blood product. Considering these stock levels, the system defines the need of each type of blood to be collected at the respective week. The system was designed through two modules: (i) inventory management and (ii) donor management. The first one seeks to establish optimum stock levels for each blood component and, from this information and current stock levels, establish a collection target for each type of blood and which blood products should be produced from the bags collected.

The second module aims to promote contact between the Blood Center and the donors, considering the type of blood and the time between donations. This module allows the Blood Center social worker recruit the donor when a blood type is needed and schedule the donation, considering the availability of the donation beds per shift, in order to optimize blood collection activity. The system was developed in a web platform and it was programmed through JavaScript. The web modeling was done at AngularJS environment and Node.js.

Results:

DOAR is able to promote a good balance between the supply of blood bags and the demand for blood products, allowing high availability of blood products with a low waste. It is a system that promotes the efficient inventory management. Thus, the system contributes to improve collection costs, since only what is needed is collected, as well as to promote a better level of service in the care of people who need these blood products and blood donors. As such our system promotes sustainability when collecting blood, considering that it optimizes the collection campaigns, reducing potential blood waste.

SESSION T1-4 Sustainable Health Management – Performance of Health Services

Pathologists' interest towards techniques to reduce environmental impacts in medical pathology operations: case study on Turkey

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Goal: There is sufficient literature discussing potential impacts of climate change on industries within the 21st century, including the medical profession. With growing public support towards limiting impacts and emissions, the medical industry can be expected to undergo certain changes as it is one of the largest contributors to emissions in developed economies. Studies relating climate change to the medical field have taken the approach of trying to quantify environmental impacts of standard operations in various specialties, or of entire hospital buildings, or even for national healthcare systems. Studies that compare anesthesiology procedures in operating rooms, gynecology procedures, or surgical laparoscopy modalities may be given as examples analyzing specific procedures. As for commonly used products, most studies indicate the need for reuse as compared to single-use consumables. As awareness and public interest on environmental issues grow, it is expected that the medical field will also need to implement changes in its operations to minimize environmental impacts. The knowledge and perception of decision-makers, from physicians to hospital management, who are often physicians themselves in developing countries, is crucial in adoption of novel techniques and systems that aim to reduce environmental impacts. Thus, this study aims to determine the attitudes and approach of pathologists in Turkey towards environmental impact of healthcare operations

Methods: An online survey was conducted as part of the study to assess current knowledge and potential interest towards adoption of techniques and materials that reduce environmental impacts of pathology operations. Such alternatives explored through the questionnaire included applicable green laboratory techniques, material alternatives with less toxicity, material recycling programs, reusable equipment, and digital pathology.

Results: Results shed light on the current knowledge level and interest of physicians in the area, and outlines next steps necessary to improve environmental impacts in pathology operations. From an environmental perspective, a life cycle approach is necessary to identify hidden impacts as most alternatives were found to require tradeoffs.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

THE CONCEPT OF SUSTAINABLE DEVELOPMENT IN BUSINESS MANAGEMENT FROM THE FOOD INDUSTRY

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1. Goal

Bearing in mind the regular industrialization and the degradation of the natural environment based on it, there is an increasing number of controlled exemptions. The effects of one deepened study on the tool impact of human products - technical objects, and in the interests of devices and the environment. In the case of problems related to technology, e.g. a quantitative limitation generated by environment innumeration.

2. Methods

The proposed analysis in its scope will include the PET bottle blowing process on the example of two different technologies. As a functional unit of the system, a PET bottle with a capacity of 500 ml and a weight of 23.5 grams was adopted. For the analysis, the Impact 2002+ method was chosen, which was a combination of four LCIA methods: IMPACT 2002+, Ecoindicator 99 / E, CML and IPCC. This method groups similar categories of intermediate points to endpoints. The unitary processes were adopted abroad: preforms for the furnace, heating of preforms, stretching and lengthening of the hot prophora, blowing out ready preforms. The purpose of the analysis is to indicate which technology has less negative impact on the natural environment. The results of the analyzes have been included in the following categories of damage: human health, ecosystem quality, climate change, depletion of resources.

3. Results

The paper includes presentation and discussion of the results that are specified levels of hazard impacts on the environment of the different stages of the life cycle of PET bottle. Analyzing the distribution of environmental impacts to individual environmental categories and groups of these categories, it is possible to conclude an impact of impacts related to the impact on the quality of the ecosystem and depletion of natural resources. In the process of taking cold preforms to the heating furnace, the highest level of harmful effects was noted for the natural environment. This process is associated with the collection of a large amount of electricity. In the process of heating preforms, the greatest negative impact was noted for the area of resource depletion and climate change. However, in the stretching proces and the prolongation of the hot preform the greatest damage was noted for climate change.

Each product affects the environment, and the life cycle of most products is long and folded. Therefore, it is advisable to strive to minimize the product's impact on the environment in all phases of its life cycle, especially in the phases in which this impact is greatest, and to undertake actions in this scope in the most effective manner possible. Significant use of the amount of electricity needed for the life of machinery, causes strong environmental impacts. It is necessary to conduct meticulous ecobusiness analyzes focused on the stages of machine operation. Which goal should be to assess manufacturers' declarations in relation to reliable analysis of collected data from research objects or service units.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

AN IN-COMPANY CIRCULAR ECONOMY CASE STUDY: LCA OF PLASTIC COMPOUND SHEETS VERSUS EUCALYPTUS WOOD SHEETS

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UNESCO Chair in Life Cycle and Climate Change (ESCI-UPF)

GOAL

GCR Group, producer of mineral-based masterbatches for plastic processing industry in Tarragona, Spain, was using the eucalyptus wood sheets to separate loaded pallets during the storage of the final product in the company. However, the company was not satisfied with their use, as they had no long lifetime and were damaging the plastic film covering the final product. And, they decided to replace the sheets by the plastic compound ones; which are composed of virgin PP (54.6%), recycled PP (23.5%), Granic 1522 (1.8%) and Granic 1081 (20.1%) (talc and calcium carbonate-based masterbatches produced by the company itself) and have longer lifetime. These plastic compound sheets, instead of wood going to landfill, will be recycled in the recycling facilities of the company at the end-of-life, contributing to application of circular economy in the company. Therefore, the goal of this study is to perform life cycle assessment (LCA) of the use of plastic compound sheets against eucalyptus wood sheets.

METHODS

Environmental impacts were identified by performing a cradle-to-grave LCA, following the ISO 14040 and ISO 14044 standards. For the identification of the impacts, ILCD/PEF recommendations v1.09 were used and the following environmental impact categories and indicators are evaluated: acidification, climate change, freshwater eutrophication, marine eutrophication, ozone depletion, photochemical ozone formation and human health, resource depletion, mineral, fossils and renewables, resource depletion water, primary energy from non-renewable resources and primary energy from renewable resources. The functional unit of the study was identified as “105 uses of the sheet, which is able to separate and protect the final product during storage, either by eucalyptus wood or plastic compound sheet”. The LCA was performed in GaBi software, by using the Thinkstep professionals and Ecoinvent databases.

RESULTS

Results of the LCA study showed clear advantages for plastic compound sheets in most of the impact categories evaluated. The impacts of plastic compound sheets varied between 0.1 - 1.4 % of the impacts of wood sheets. Only, in the case of primary energy from nonrenewable sources, the impact of plastic compound sheets reached to 14% of the wood sheets. On the other hand, for the impact categories of water depletion and resource depletion mineral, fossils and renewables, wood sheets performed slightly better.

The reasons for the plastic compound sheets perform better than the wood ones for the majority of the impacts were identified as follows:

- The higher number of reuses and lower weight (35 times reuse against 3 times)
- The use of recycled PP and mineral masterbatches (forms 76.5% of the composition)
- The end-of-life recycling in the company (minimizes transportation and assures a second life).

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

ENVIRONMENTAL FEASIBILITY ANALYSIS OF REVERSE LOGISTICS OF PLASTIC PACKAGING CONTAINING REMAINING OF LUBRICANT OIL

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Goal

This study aims to analyze the environmental feasibility of applying reverse logistics packaging plastic containing the remaining lubricating oil.

Methods

In order to fulfill the main purpose two situations were compared through Life Cycle Assessment (LCA): scenario 1, applying reverse logistics to the packages containing the remaining oil, involving a recycling system, and scenario 2, by disposing of them in a landfill.

For the first scenario, we collected data regarding the processes involved by contacting reverse logistics companies working with oil packaging. The second scenario is a critical setting, unsuitable for disposal of plastic packaging containing lubricating oil, but predominantly used in Brazil, case study site. For this scenario, we used secondary data obtained in the Ecoinvent database.

We defined as functional unit, the amount of 1,000 containers containing 1-liter remaining lubricating oil. It is assumed to be high-density polyethylene containers with approximately 62g and a highly refined remaining oil with a density of 0.9kg/l. The remaining oil is estimated at 13g per package, which corresponds to the approximate amount of oil, which is discarded with each package.

Through the system, a comparative analysis was performed, evaluating Scenario 1 and Scenario 2 according to the following impact categories: depletion of abiotic Resources, acidification, eutrophication, global warming, ozone layer depletion, human toxicity, freshwater, marine water ecotoxicity, terrestrial ecotoxicity, photochemical oxidation, land occupation and total accumulated energy. The impact categories are characteristic of the CML 2001 method, with the addition of the category of impact total energy demand to the detriment of the need of interest in analyzing the energy demand of the scenarios. We chose to use this method because it presents lower subjectivity of the results, since it presents environmental impact values in categories, which are characterized by established methodologies, such as the characterization of greenhouse gases by the Intergovernmental Panel on Climate Change (IPCC), used to estimate the amount of emissions for the global warming impact category, with CO2 emission equivalent emitted as an environmental impact indicator.

Results

Scenario 1 remained more environmentally valid for the following categories: abiotic resource depletion, acidification, eutrophication, global warming, ozone layer depletion, human toxicity, freshwater ecotoxicity, photochemical oxidation, and accumulated total energy. Scenario 2 remained more environmentally effective for the categories: seawater ecotoxicity, terrestrial ecotoxicity, and land occupation.

In this type of analysis, SimaPro assigns 100% of the environmental impact under each impact category to the highest contribution scenario, and the relative share to the other scenario.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

Analysis of large-scale implementation of circular innovations for the plastic packaging value chain

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Circular economy principles have been developed and implemented since 90s with regards to the changes of production and consumption patterns under the climate change conditions with increasing population trends throughout the world. Circular economy, in that sense, breaks the rules of linear production and consumption patterns via promoting reusing, repairing, remanufacturing, refurbishing and recycling by creating possible closed material and energy loops on the value chain.

Petrochemical production patterns of plastic materials and total amount of waste generated by overconsumption of plastic products (especially in packaging) have caused serious environmental and economic burden throughout the world. In 2015, each inhabitant in the EU has generated 166.3 kg of packaging waste in average, mainly composed of cardboard and plastic material and total accumulation of packaging waste have reached up to 15.9 million tonnes of plastic packaging waste per year.

In response to emerging environmental issues related to plastic packaging waste, CIRC-PACK Project (Towards circular economy in the plastic packaging value chain, GA#: 730423) strives for a more sustainable, efficient, competitive, less fossil fuel dependent, integrated and interconnected plastic packaging value chain through (i) plastics from renewable resources, (ii) eco-friendly packaging design, adn (iii) enhanced sorting and recycling schemes.

This study aims to develop an assessment framework for analysing the combined benefits of innovations with regards to circular value chains over the entire life cycle of the packaging products. The framework involves assessment of

- cross-sectorial industrial symbiosis potentials establishing links between plastic packaging value chain with other value chains,
- the extent of decoupling and rebound effect created by the CIRC-PACK innovations,
- the between circular plastic packaging value chain and urban circularity.

The evaluation of industrial symbiosis between value chains is carried out by investigating the cross-sectoral synergies and mapping the relations between different value chains. Also the possibility of applying the Material Circularity Indicator on a multiple value chain basis is investigated. The work on decoupling focuses around utilization of decoupling indicators on a quantitative basis to analyse weak, strong, and recessive decoupling with the value chain innovations. The framework further investigates the use of Environmental Rebound Effect (ERE), which is combined with Life Cycle Assessment (LCA) for analysis of rebound effect. Finally, the impact of a more circular plastic packaging value chain on urban circularity is studied by the use of urban metabolism concept. One widely utilized method for quantification of sustainability indicators through urban metabolism approach is to employ Material Flow Analysis (MFA) and LCA. In fact, life cycle approach is the component of the framework that combines different aspects of analysis on the larger scale implementation of circular economy principles on plastic packaging value chain.

This study is conducted based on the project CIRC-PACK: Towards Circular Economy in the Plastic Packaging Value Chain (GA No: 730423) which is funded by European Union’s H2020 research and innovation programme.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

GHG emission profiles of plastic waste treatment and LCA in the strategic development of a global energy company

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GOAL

The goal of the project was to investigate and compare the climate impact of plastic waste management through pyrolysis. The analysis was performed for a global energy company that are exploring how they can introduce solutions to global plastic waste challenges and find new supply chains for their petroleum refineries.

The project is still ongoing. Together with the use of LCA it includes material flow analysis of global plastic waste and a more detailed study to identify where in Europe plastic waste handling with pyrolysis can be viable with respect to the volume of plastic that needs better handling and EU and local policies.

METHOD

The assessment used life cycle assessment (LCA) methodology to compare the potential climate impact for four different plastic waste treatment options: Material recycling, landfill, incineration and pyrolysis. The systems were studied from the point where plastic waste was ready for end-of-life (EoL) treatment and to the point where the carbon in the plastic is stored in a material or emitted to air as greenhouse gases. The functional unit was the EoL treatment of 1 kg plastic waste.

The client did not specify the mass- and energy balance of their pyrolysis process, where in the world it would be situated or exactly what plastic waste it will handle. To cope with these "unknowns" the assessment was performed as a set of sensitivity analysis that investigated the results when the most important parameters change. That included assumptions on substitution effects (consequential aspects).

RESULTS

The results showed that for almost all cases/sensitivities material recycling and landfill have the lowest climate impacts, this was expected from studies of the established "waste hierarchy". Pyrolysis showed results that were similar to incineration, but for most cases pyrolysis was the preferable solution. Especially when the pyrolysis oil is used as a raw material for new materials, thus that the carbon in the plastic is stored rather than emitted as a GHG. The incineration vs pyrolysis comparison is especially dependent on how substitution effects are included, what types of heat and electricity it is assumed that the incineration output replace. Here pyrolysis has the advantage of the freedom to be situated where there is a need for more plastic waste treatment capacity, but without the need for a local energy/heat demand to defend the climate impacts it causes. Another important positive feature of the pyrolysis route is the ability to make all types of plastics from the waste (all qualities).

A comparison of the carbon footprint of oil from plastic waste pyrolysis with crude oil was showed that plastic waste pyrolysis oil can compete with the average crude oil used in Europe today.

The project had two main outcomes: 1) The comparative assessment of the carbon footprint of different plastic waste handling methods. 2) Better understanding of how a big global company can use LCA at a early stage do discover important environmental and sustainability aspects of their option and strategies.

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

A circular business model for SMEs in the fishing gear industry

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Goals

Globally, oceans continue to accumulate debris in all forms making them possibly the biggest landfills on the planet. Marine littering, defined as the introduction of solid refuse into the marine environment through human activity, poses a major threat to the ocean environment and is a growing concern for authorities. Plastic is seen as an important material in our economy and our daily lives, but too often the way plastics are produced, used and discarded fails to capture the economic benefits of a more 'circular' approach and harms the environment. Due to immature value chains most of the discarded nets end up in landfills or incineration plants instead of being recycled or upcycled. Most of the companies exploring waste fishing nets, ropes and components (FNRCs) to develop new resources, are micro-SMEs which operate within a regional or local market, where the demand is limited and product costs remain too high.

Our goal is thus to create environmentally and economically viable circular business models for SMEs in the fishing gear industry. One element of this is to develop marine plastic waste solutions through methods of prevention and remediation. Another goal is to help small and medium-sized enterprises (SMEs) offering products and services within fishing gear recycling solutions in the NPA region to attain a greater market reach.

SMEs studied, are SMEs involved in the recycling of fishing gear (including those collecting, processing and recycling FNRCs) and SMEs that produce products which has recycled nets, ropes and components as input into their production processes, and finished products. Identification of market opportunities for products created from FNRCs. Market expansion and 'go to market' models/templates to be produced to provide support to SMEs in the NPA region. For example, how SMEs can make use of the newly produced marine plastic eco-labels to assist in market expansion, branding and product promotions.

Methods

The context of this study is a project the authors are involved in that aims to set up a multi-level cluster to connect and catalyze SMEs in remote environments of Northern Europe. The cluster formation will be used as a hub, multiplier and network enabler where knowledge and experience is developed and shared. Cluster establishment and operation will be done in collaboration with academia, industry and government agencies following a triple helix approach. The Triple Helix thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies (Etzkowitz & Leydesdorff, 2000: 109). With regard to the branding of recycled products from fishing gear, data are collected through semi-structured interviews with SMEs that are making products from FNRCs.

Results

The results are not clear yet, but will be very soon and will be included in the final write-up submitted in May (if abstract is accepted).

SESSION T1-5 Towards Cradle to Cradle - Plastic Product Circularity

Preliminary results on a comparative assessment of alternative feedstock for plastic articles

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European Commission - Joint Research Centre - Circular Economy and Industrial Leadership Unit

Goal: The European Strategy for Plastics in a Circular Economy (COM(2018 28 final) proposes a vision where innovative materials and alternative feedstocks for plastic production are developed and used when evidence shows that they are more sustainable compared to traditional fossil-based alternatives. Under the framework of the European Strategy for Plastics, the JRC is currently developing a comparative environmental sustainability assessment of alternative feedstock for plastic articles production in comparison to current fossil-based feedstocks. Recycled plastic waste, biomass, biowaste, and CO2 can potentially be used, but their availability, the economic viability, and the potential environmental impacts along the entire supply-chain need to be properly assessed.

The paper will provide a general overview of the main purposes of the ongoing JRC study, which consist of the elaboration of a consistent and appropriate LCA-based methodology and its application to a number of LCA case studies. Furthermore, the paper will include a more detailed description of a set of criteria defined for the selection of relevant plastic articles, made of different polymers obtained from either fossil-based polymers or alternatives feedstocks, to be compared from an LCA perspective.

Methods: The different aspects considered in the development of an appropriate methodology for the selection of relevant plastic articles will be described. Criteria such as policy priority, market potential of alternative feedstock plastic polymers or articles, including market trends and criticality, the different market sectors where polymers or articles are used, the promise for deployment, the availability and quality of techno-scientific data needed for the LCA analysis and the relevance of End of Life scenarios, are considered for the development of a scoring model. Moreover, additional criteria were applied to the entire set of articles to achieve a balanced group of case studies allowing a good coverage of the relevant scenarios regarding aspects such as the coverage of single use items, and biodegradable products, short lived articles vs long lived articles.

Results: Based on the application of the selection criteria and on further considerations on the potential scenarios to be analysed, a preliminary list of candidate articles for the final LCA case studies will be obtained. An overview of the main information sources, including market studies and research projects, together with the identification of the main data gaps will also be included.

Finally, in order to provide an example of the ongoing comparative assessment carried out by the JRC, some preliminary results of a case study targeting durable plastic articles (e.g. insulation board) will be presented, including the learnings from applying the Product Environmental Footprint methodology and the options to be explored for further improvement.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

Eco-Design in European granted projects: H2020 EFFECTIVE case study

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LCE

Goals

Life Cycle Assessment is widely considered a fundamental element in many of the European Commission sponsored projects. Its relevance is not only linked to the environmental impact analysis of already existent products, but also to the development of new ones, carried on with the specific aim to reduce negative environmental impacts along their life cycle. This is commonly referred as eco-design of products.

The goal of this poster is to introduce the case study of H2020 EFFECTIVE project [H2020, BBI, N.745746], where eco-design is applied to carry out the technical feasibility and sustainability assessment of different solutions towards a new generation of polyamide and polyester-based products which embrace circular economy.

Methods

EFFECTIVE project was launched in 2018 with the aim of demonstrating innovative and economically viable routes for the production of bio-based polyamides and polyesters from sustainable renewable feedstock (sugars and vegetable oils) towards the obtaining of fibres and films with enhanced properties, market competitiveness and increased sustainability.

These materials will be applied into eco-designed large consumer products targeting different markets, such as construction, automotive, packaging and textile.

The project will address each stage of products life cycle in order to increase the sustainability of the whole value chain. First, eco-design measures will be developed to increase the recyclability of products, then evaluations of resources and energy efficiency measures will be carried out, together with the assessment of the environmental, economic and social impacts.

The project sees the participation of several companies in different sectors, making it one of the broadest industrial-driven efforts to reshape entire product value chains and drive economic growth. The presence of such kind of participants is expected to facilitate the adoption of the sustainable solutions developed, helping the transition to a circular economy system.

Expected Results

The project will end in 2022, so no results are available nowadays.

The main expected impacts of EFFECTIVE are the creation of new bio-based value chains thanks to new interconnections among sectors which usually do not cooperate. Specifically, sustainable feedstock will be used to create polyamides for garment, carpet, primary packaging products, and polyesters for secondary packaging products. Moreover, the creation of new bio based materials with improved performances, sustainability and marketability is expected.

The implementation of the EFFECTIVE innovations will allow a significant reduction of GHG emission, which will be possible thanks to the innovative value chains for the production of bio based polyamides and polyesters. In this way the project will provide a relevant contribution to the decarbonization of the polymers production system.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

Prospective life-cycle assessment of end-of-life options for traction batteries

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IMDEA Energy

Goal: The rapid growth of complex traction batteries technologies arises fundamental questions regarding their sustainability and the appropriateness of applying conventional policies or regulatory frameworks. Policy development requires a good knowledge of the technology itself (how efficient is it or will it be?), of its probable implementation (e.g. how much lithium will be needed?), its impact (e.g. will it reduce the environmental impact of transport?), and its behaviour (what new policies are required – if any?). In order to answer these questions, this work proposes a robust methodology integration framework, based on the generation of prospective scenarios for the calculation of dynamic inventories, which would be able to provide a realistic outlook on the potential impact of batteries over their whole life-cycle, with a specific regard on their end-of-life, i.e. recycling of batteries elements or repurposing for second uses, such as stationary storage of electricity.

Method: The proposed integrated approach is based on the methodological framework of Life-Cycle Assessment (LCA) since this methodology is key to understand the environmental performance of electric vehicles. However, LCA results are not representative of the actual impact when inventories are characterised on the same year for all the life-cycle stages, which in reality take place at very different times. We propose to evolve the inventories of batteries life-cycle through three main mechanisms: (i) the prospective electricity generation mix under several scenarios and calculated by Energy Systems Modelling (ESM), (ii) the mass and energy balance variation for the manufacture, remanufacture, and recycling technologies, especially of those materials with a high influence on the life-cycle impact and with a high potential for improvement and (iii) the evolving performance of batteries and electric vehicles, modelled with learning curves. The main methodological challenge in this work lies in the proposal of robust inventories for LCA, which should be harmonised for comparison and for use in the different prospective scenarios, especially regarding those assumptions related to the deployment of the traction batteries and the prospects of future electricity markets.

Results: In the first phase of the study, the data gathered from life cycle inventories of different studies confirms substantial differences in the methodological approach, showing a remarkable heterogeneity in some of the main assumptions. Three main conclusions can be derived: (i) generally, most of the recycling processes assessed have a very low influence on the overall impact of a battery life-cycle, except for those categories related to the mining of raw materials, (ii) existing inventories for recycling have a low degree of representativeness of the industrial practice, and (iii) the emerging character of the involved technologies shows an important improvement potential. On the other hand, repurposing is proved to reduce the greenhouse gases emissions associated with the batteries, but with a great uncertainty in terms of feasibility and costs.

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SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

Life Cycle Assessment of Innovative Paper Recycling Technology Developed in Japan

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A new 'dry paper recycling technology' that creates new paper from used paper at office have been developed. The developed technologies consist three technologies ; 'defibration technology'' for decomposing used paper into pulp fiber, 'sheet forming technology' for forming fibers again into a uniform sheet, 'pressing and binding technology' for increasing fiber density and bonding pulp fibers each other to create new papers. By doing these in dry processes, a small sized and low power consumption paper making machine (named PaperLab) to be able to create on-demand paper recycling system have been realized. This recycled paper can be used to print as a PPC paper and so on. This study aimed at evaluation

of environmental aspects of this technology using the framework of product life cycle perspectives. The scope of our assessment includes raw material extraction, transportation, manufacturing, usage and recycling. The assessed inventory items are carbon dioxide and water use and integrated environmental impacts. We used LIME3 method to evaluate total environmental performance of this system. According to the tentative result, this new system is revealed to contribute the reduction of 90 percentages of water consumption, because it enables us to avoid the water usage in making pulp for recycling paper.The results revealed that this innovative product have high potential to realize circular economy internationally.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

Organic waste from biogas plant as agricultural fertilizer: risk analysis

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The goal of the article was an in-depth analysis of the possibilities of using waste from agricultural biogas plants, after biogas production. Such waste is digestate (waste received after fermentation of organic waste). A biogas producer can dispose of it, however, it is very expensive. The sale of fermented mass to the producer of agricultural fertilizers would be a better solution as digestate contains large amounts of nutrients (minerals) that (in the form of fertilizers) can support the cultivation of agricultural plants.

This solution is also beneficial for the economy and the environment. The economy will benefit from it multiple times. First of all, the costs of waste digestion disposal in the landfill will disappear, so the producer will stay longer in business.

Secondly, he will earn money selling the waste. Thirdly, the use of the waste in the next production process will be in line with the idea of a circular economy. The idea is becoming more and more popular in many countries and has various benefits. We can also list many other advantages.

The proposed solution is also beneficial for the environment. Firstly, the areas occupied by landfills will be limited. Thus, they can be used in many other ways and bring further gains. Secondly, greenhouse gas emissions (coming from landfills or incineration) will decrease. This is very important because such emission intensifies the greenhouse effect and climate changes. There are other environmental benefits too.

Another goal of the research was to analyse hazards associated with the production of fertilizers using digestate. The conducted research was based on a review of scientific literature, an analysis of technological processes in agricultural biogas plants, and an analysis of regulations and legal norms regarding fertilizers and soil fertilization in agricultural crops. As a result of it, we could indicate such key risks as investment, operating, seasonal, social and legal; a loss of quality of the finished product; risk associated with the delivery and storage of raw materials; market risk (concerning price or interest rate); a loss of liquidity and profitability; and bankruptcy risk.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

The Environmental Benefits of Circular Business Models in the Home Appliance Market: The case of Washing Machines in Europe

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Goal:

Due to recent innovations in sustainable businesses for home appliances, we aim to estimate the environmental benefits of the introduction of archetypical circular business models in the European market of washing machines.

Methods:

We use a methodological framework that combines diffusion and life cycle assessment to estimate the environmental impacts and benefits due to the adoption of emerging circular business models from 2015 to 2040 under different scenario of adoption rates.

Results:

All scenarios show environmental benefits towards 2030, but it is clear that the speed of adoption is the main driver of such benefits. Business models that incorporate lifetime extension and use intensity reduction report the largest benefits while those that only incorporate reuse or reuse sibling activities report the smallest benefits.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

Remanufacturing, but only when technology is mature!

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Goal:

The concept of Circular Economy (CE) is experiencing increased attention and has the goal to ensure sustainable consumption. In the center of CE is the aim to close the material loop. Remanufacturing is the process of restoring a used product to like-new condition. Hence, it is a recovery strategy to close the material loop on low entropy level in order to minimize the employment of exergy and the associated environmental impact. This work deals with the question if remanufacturing of energy-consuming products like heating systems is a good Design for Environment strategy, especially when considering future efficiency developments. General guidance for an environmental favourable End-of-Life decision will be given here.

Method:

A Circulation pump is the main electricity-consuming component in gas boilers and is used to circulate the heating fluid in the system. To analyse the environmental potential of remanufacturing, circulators with different efficiencies are examined here. Moreover, the remanufacturing process is compared to a primary production process.

Based on a case study of a remanufactured low-efficiency circulation pump, general process rules for remanufacturing are derived (e.g. which parts have to be replaced) in a first step. Those rules lead to a parametrized LCA model for remanufacturing with which the environmental impact of different systems is then assessed in a scenario analysis.

Result:

In case of circulation pumps, the remanufacturing process is causing a smaller environmental impact than primary production. However, the biggest environmental impact is still caused during the use phase. The efficiency in turn has a major influence on the environmental impact of the use phase. The conducted scenario analysis shows that a remanufactured low-efficiency circulation pump only has a better environmental performance over all life cycles if the substitute has an energy consumption higher than 55 Watt. This is not the case if a potential substitute is a high-efficiency pump. Upgrading the low-efficiency circulator should be favoured then.

The results show, that when assessing remanufacturing of energy-consuming products the potential substitute must be well defined. Whether a substitute has the same efficiency or can be upgraded to a higher efficiency has a big influence on the system to be preferred. As conclusion, one can say in general that remanufacturing makes sense when an energy-consuming technology is mature.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

Smart parking – life cycle assessment for ecodesign

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Purpose:

Smart parking system is a response to the growing problem of parking spaces deficit in the cities. The continuous increase number of vehicles, high land prices, costs of building an underground garage make smart parking an alternative to traditional, large-area solutions. The question of life cycle oriented design phase is: How to make parking not only smart but environmentally friendly as well. The paper focuses on analysis of environmental aspects of the smart parking through the life cycle at the design phase.

Methods:

The analytical part is based on the life cycle assessment of the design solution. Data collection was based on primary (for production) and secondary data (for other than production - life cycles stages). The SimaPro software tool is utilized along with databases, mainly ecoinvent.

Results:

The spatial and functional structure of the cities is characterized, among others, by insufficient number of parking spaces in city centers, especially in the vicinity of public facilities. For this reason, the results of this analysis can be important step towards developing appropriate solutions, including environmental aspects in the life cycle. The results of the analysis are presented for the stages of the smart parking life cycle. At the stage before the production, the acquisition of raw materials and materials needed for the production of smart parking was included. The production of the smart parking unit and its assembly was taken into account at the production stage. The use phase refers to the use of the smart parking - renovation, maintenance, etc. within a specified period of time. The management of post-consumer waste includes the management of waste associated with the decommissioning of the smart parking (including materials for recycling, repair, reuse).

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

INNOVATION THROUGH CIRCULAR ECONOMY IN HIGHER EDUCATION: IMPLEMENTING A MULTIDISCIPLINARY COURSE ON PRODUCT DESIGN

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Designers are keyplayers in the entire process of the product-service chain and are relevant actors in the linear economy model of consumption. The growing unsustainability of this model challenges the design methodology to deal with the new environmental, social and economic reality as a holistic approach to problem-solving, for a more sustainable production-consumption paradigma. Designers have the opportunity and responsibility to foster transition towards Circular Economy (CE), where the value of products, materials and resources is maintained as long as possible in the system.

However, in the industry, there are several professionals involved in product-service Design, like engineers, marketers, environmental experts, or business and innovation managers.

The authors believe that it is crucial to rethink Design Education, and that by providing specific education in CE within the curriculum at higher-education institutions will empower students with tools and skills for CE, and sustainability concepts in the product-service design system, also developing competences to explore new ways to create products with resilient, long-lasting value.

This paper will present the launching and implementation of an innovative multidisciplinary curricular unit: Product Design within Circular Economy, intended for Master's students at the University of Aveiro, not only from Design but also from areas such as Economics, Management or Engineering.

A detailed description will explain the contribution of different areas and teachers for the overall structure, contents and organization of didatic activities, where students contacted with CE concepts through specific modules.

With the promotion of project-based learning, students worked on the proposal of a furniture product within multidisciplinary groups, with supervision of the Design area.

The paper will provide remarks on the first round of this implementation, along with data on the student's projects and reports, stating their insights about CE integration in the project development and the impact in the prosecution of their Master's research.

SESSION T1-6 Circular Economy and Design - Approaches, Challenges and Case Studies

Circular solutions for rubber waste

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The tire production is a complex process, which is constantly evolving almost around the word. The tires have more than 12 components, and the production covers the following steps:

• production and mixing of raw materials (rubber, carbon black, sulphur, and other materials),

• preparation,

• tire building,

• curing and after-curing.

During the production, companies generate - beside the market ready tire - a lot of different waste. These are mineral-based non-chlorinated engine, gear and lubricating oils; spent waxes and fats; wooden packaging; wastes from processed textile fibres; waste plastic; bulky waste; carbon black; non-ferrous metal; ferrous metal; wastes from additives containing dangerous substances; absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances; end-of-life tyres, etc. The aim of our research focused to circular economy find new waste management possibilities for a tire company site in Hungary. The research was based on life cycle assessment (LCA) and life cycle cost analysis (LCCA) in order to compare the environmental impact of the applied waste management practice (BaU – "business as usual") and a circular economy (CE) solution. The LCA, as an environmental management method on the one hand is very useful for companies to analyse their environmental impacts during the whole product life cycle (from cradle to cradle). On the other hand, LCA is also useful to find new possibilities in order to reduce the environmental impacts.

In this paper we do not investigate the environmental impact of the tyre production, only the waste treatment. The function unit is 1 kg rubber waste that is sent to burning. During the LCA the first step was the reconnaissance of the technologies of tyre production on site, than the identification of the main waste streams and recognize the currently solution of waste neutralizing. Second step was the selection of waste flow incenirated (mainly rubber waste, without steel wire) and data collection for this process, on based of annual materials flow, what had been named the BaU model; The third step was itself the Environmental Life Cycle analysis (PEF/EF analysis). The fourth step was the modelling of the circular solution (CE) concerning of the main waste streams and the Environmental Life Cycle analysis (PEF/EF analysis) of the circular solution, and the comparison of the BaU and CE technology. Finally the interpretation of the results.

The main results are the following: almost all of impact categories, the transport and the recovery processes have dominant effect and regards to only two – but the most important - categories has a role of the disposal. The results do not contain the tyre-manufacturing phase, only the disposal with transport. The previously defined impact assessment method is PEF (product environmental footprint) with 16 different impact categories. The results shows that the incineration of the waste has lower impacts on the environment, but the cause of it that only 1,7% of the waste is disposal in this way. The biggest improver of the impacts is almost in same of the transport and the recovery stages, depends on the impact categories. It has to emphasize that some recycling process (utilization at cement factory and devulcanisation) are not in the model, because in that case the waste goes to base/additional material at the other processes. The research is going on and at the end of the project the LCA helps to define the best waste management technologies from environmental view.

SESSION T1-7 Sustainable Mobility

Harmonised life-cycle indicators of hydrogen fuel options

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IMDEA Energy

Motivation and goal:

A future sustainable transport sector is expected to look significantly different from the current one. For instance, a significant penetration of battery and fuel cell electric vehicles is anticipated. In particular, hydrogen could play a key role as a transportation fuel. However, among the relatively high number of hydrogen fuel options that could be available in terms of technology pathways, only those with a suitable life-cycle performance would be ultimately supported. This suitability is typically determined by comparative LCA (life cycle assessment) studies. In this regard, in addition to benchmarking studies against conventional hydrogen (currently represented by fossil-based hydrogen produced through steam methane reforming), comparative studies between alternative (mainly renewable) hydrogen fuel options are required. Within this context, the goal of this work is to provide a sound database of life-cycle indicators for a wide range of hydrogen fuel options, which is intended to be used in robust comparative LCA studies.

Method:

Building a thorough database of robust life-cycle indicators of hydrogen fuel options is a challenging task. This work relies on the application of the protocols currently available for the computation of harmonised life-cycle indicators of hydrogen. In particular, current protocols allow analysts to harmonise three life-cycle indicators: global warming, cumulative non-renewable energy demand, and acidification.

Results and conclusions:

The effective application of the protocol involves 71 case studies of renewable hydrogen as well as a reference case study of conventional hydrogen from steam methane reforming. Thus, a sound database of harmonised life-cycle indicators of hydrogen is now available. It should be noted that, while the database includes harmonised carbon and energy footprints for the whole sample, the harmonised values for acidification refer to approximately one third of the sample. Nevertheless, this database is expected to grow progressively through its application by LCA practitioners addressing hydrogen energy systems. In this respect, a smart tool for the computation of life-cycle indicators of hydrogen will be soon released in order to facilitate the application of the harmonisation protocols.

SESSION T1-7 Sustainable Mobility

Enhancement of Sustainability Performance of Maritime Transport by Adopting Emission Control Areas

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International shipping industry has expanded during the past ten years and played an important role in the global trade and economy. The maritime transport activities have not only contributed to economic development but also the increases of the negative impacts on human health, environment and ecosystem due to greenhouse gas emissions and air pollution. In order to ensure the sustainable growth in this sector, emission control areas have been endorsed to limit the air pollution under different international regulations. In order to ensure that the additional costs of operation from the stricter controls will not affect business competitiveness, the assessment considering both internal and external costs under life cycle perspective could be used for supporting decision. This research aimed to assess the enhancement of sustainability performance of maritime transport by adopting emission control areas (ECAs). The sustainability performance was measured in term of total environmental and economic costs. The functional unit was the overall ton-miles generated by world seaborne trade as of 58,098 billion tons in 2017 estimated by United Nations Conference on Trade and Development. Four main technological systems were considered. The reference system is maritime transport with conventional fuel (heavy fuel oil) and technology in the areas without emission control. The three technological systems in the ECAs based on the MARPOL Annex VI and the European Union Sulphur Decree (decree 2005/32/EC) are maritime transport systems with heavy fuel oil (1%S) using a scrubber (S1); with low Sulphur fuel (marine gas oil, 0.1%S) (S2); and with the low Sulphur fuel and selective catalytic reduction (S3). The environmental and economic costs of 100%, 50% and 0% ECA adoption scenarios for world seaborne trade as of 58,098 billion ton-miles in 2017 were assessed. The 100% ECA adoption scenario includes only the systems under the ECAs (equal integration of S1, S2 and S3); whereas the 0% ECA adoption scenario includes only the reference system. The environmental costs were estimated by monetarizing life cycle environmental impacts of the world seaborne trade. Life cycle environmental impacts were assessed by using the ReCiPe 2016 v1.1 method. The economic costs include fuel and equipment costs. The data were collected from international journals and scientific reports supplemented with background LCI databases. If including only the economic costs, the costs of the 100% ECA adoption scenario will be 43% higher than those of the 0% ECA adoption scenario. When considering both environmental and economic costs, the 100% scenario could reduce the total costs up to 46% (207,381 billion USD cost reduction) from the scenario without emission controls. The emission control area adoption using different fuels and/or abatement technologies will be very beneficial if environmental costs are taken into account. Nevertheless, inclusion of environmental costs or externalities in practice is very limited. To improve sustainability performance of global maritime transport by adopting ECAs, it needs strong collaborations among policy makers, industry and stakeholders in developed and emerging economies. Future research should be improved by including various types of the vessels, fuel efficiencies, costs and weighting factors for monetarisation.

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SESSION T1-7 Sustainable Mobility

Electricity or electrofuels for a future short sea shipping without harmful emissions?

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Chalmers

The shipping sector is facing a period of large investments to reduce environmental impact and reach carbon dioxide (CO2) reduction targets. It is urgent since the sector is growing fast and the ships that are built in the coming years will, statistically, be used until 2050. Electricity in the form of battery electric propulsion or electrofuels are two interesting options. Electrofuels are carbon-based fuels, such as diesel and methanol, produced from carbon dioxide (CO2) and water, with electricity as the primary source of energy. Electrofuels are also known as power-to-fuels and are of interest for all transport modes but may be especially interesting for ships due to their long-life length and costly retrofits. Furthermore, the interest in electric/hybrid propulsion on ships is increasing especially for coastal and inland vessels. These two alternatives for short sea shipping have the potential for substantial reduction of CO2 in line with the targets set by the International Maritime Organisation.

Prospective life cycle assessment is in this paper used to assess the life cycle environmental and cost performance of a RoPax ferry operating between Gothenburg and Frederikshavn using either (i) electrofuels in combination with combustion engines and exhaust abatement equipment or (ii) electricity, electric engines and batteries. The comparison is assessed based on state-of-the-art production processes for renewable electricity, electrofuels and battery production and the time horizon for the assessment is 2030 and 2050. All parts of the life cycle of the ship energy system that are different between the two cases is included in the assessment. The software tool openLCA and the International Reference Life Cycle Data System’s recommended characterization methods is used.

Preliminary results indicate that battery electric propulsion has lower environmental impact, but higher cost. However, the result is sensitive to several parameters including type of electricity used, size of batteries, future prices, CO2 source and efficiency of the electrofuels production process.

SESSION T1-7 Sustainable Mobility

Towards Integrated Sustainability Assessment of Electric Mobility Scenarios

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Goal: From a socioeconomic point of view, transport sector occupies a major place in terms of employment, operation services and costs for users and society. Furthermore, it is considered as a major source of greenhouse gases and other pollutant emissions, mainly due to fossil fuel's high consumption, thus contributing to environmental impacts such as acidification, eutrophication and climate change. There is an increasing need for promoting alternatives with lower environmental burdens. Among these alternatives, electric mobility is gaining attention from both governments and industrials to ensure a transition and lift this challenge facing our world.

A fair evaluation of the electric mobility systems sustainability requires accounting for the three dimensions of sustainable development, namely environmental, societal and economic dimensions. This work presents a new decision-support framework based on Life Cycle Sustainability Assessment (LCSA) methodology.

The objective is to identify the most significant phase(s) of the product's life cycle in terms of impacts. This will allow highlighting the benefits of the deployment of electric alternatives according to multiple use scenarios (personal, sharing services, etc.).

Methodology: To conduct this evaluation, we propose a holistic approach that combines environmental and social Life Cycle Assessment (LCA), jointly with Life Cycle Costing (LCC). The approach can be applied to different scenarios of electric mobility systems to identify and quantify the impacts generated throughout the entire life cycle.

As a first step, we need to select the most significant impact categories for each dimension. Relevant literature of existing studies on electric mobility sustainability assessment was reviewed. This stage includes existing LCA frameworks applied on the automotive sector, company reports, research papers and guidelines from relevant institutions (e.g. European Commission, UNEP/SETAC).

The LCC will be used for the economic dimension to allow the quantification and compilation of each phase costs for a specific stakeholder. For the environmental dimension, a set of criteria are commonly recognized with a wide consensus which is not the case for the social dimension. To set the social impact categories, we have proposed two supplementary steps to complete the selection and refine the list of criteria identified from the previous studies. A risk analysis using a social hotspot identification was suggested, as well as a stakeholder consultation process that consists on interviewing different affected stakeholders (e.g. workers, local communities, users) or involved in the product's life cycle (e.g. suppliers, local authorities, NGOs). The aim is to prioritize a set of criteria according to a scale-based approach (from low to high risk), allowing the identification of the most relevant impact categories for the evaluation.

Results: Through the current study, we propose a framework for the definition of a set of sustainability indicators which could then be applied to achieve a quantitative assessment of electric mobility scenarios.

As a perspective of this work, LCSA approach could be coupled with a multi-criteria decision- Analysis (MCDA) to constitute a decision-making tool. MCDA is a relevant methodology that based on a weighting process contribute to a consistent way of interpreting the evaluation results.

SESSION T1-7 Sustainable Mobility

Development of electromobility from a life cycle perspective

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A goal

In Poland government actions are aimed at increasing the use of alternative fuels and supporting the electromobility development . The Act of 11 January 2018 on Electromobility and Alternative Fuels came into force on 22 February of this year. It establishes a system of incentives for the promotion of the vehicles use powered by alternative fuels, mainly e-mobility. Electromobility and alternative fuels are the future of road transport in Poland and offer potential for reducing environmental pollution and increasing life comfort, especially in crowded city centers. The development of electromobility is a big challenge and opportunity for Poland. The automotive industry needs tools like life cycle assessment that support decision making regarding the development of mobility with alternative fuels and technologies in vehicle's life cycle. Life cycle assessment is tool used to support decision-making on environmental aspects.

In the paper will be carried out LCA of the introduction of alternative fuels according to the guidelines of Electromobility Law in Poland. The goal of the article will be to present the challenges of life cycle perspective and circular economy guidelines for support sustainable mobility on the example of Polish conditions. The article will show the results of LCA of electromobility development in Poland and coupled with smart grid.

Methods

The LCA will be conducted in accordance with the ISO 14040:2006 guideline. The goal and scope of the study, including the functional unit, system boundary, and basic assumptions for analyses, will be defined. For a multi-dimensional environmental impact assessment LCA will be made using the SimaPro v. 8 with the Ecoinvent v. 3 database. Based on the LCA analysis using the most appropriate Life Cycle Impact Assessment (LCIA) methods for electromobility, environmental indicators will be obtained in terms of impact categories.

Results

The most important environmental impact categories of electromobility development and alternative fuels in Poland will be presented, and the main sources will be identified. The article will show the results of identification of environmental burdens related, both directly and indirectly, to the life cycle of vehicles in Poland. The article will show the results of greenhouse gas emissions, fossil fuel depletion and others impact categories. The paper will present the main determinants of environmental burden and the most important impact categories of electromobility in Poland.

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SESSION T1-7 Sustainable Mobility

Social Life Cycle Assessment of Mobility Services: State of the Art

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Goal:

Continuous efforts to mitigate climate change and to improve quality of life in cities result in new mobility solutions based on collective use as well as connected autonomous cars. In order to better understand the implications for cities, society and the automotive industry, it is essential to evaluate these different new mobility services against the three pillars of sustainability. The present work focuses on the implementation of social life cycle assessment methodology to mobility as a service and on the development of a set of indicators to be able to assess positive and negative impacts.

Whereas the use phase plays an important role for the assessment of mobility services, the evaluation of the use phase has been underrepresented in previous S-LCA case studies. The goal of this work is to contribute to this current lack of scientific research by developing a suitable set of indicators to assess the social impact of the use phase with a particular attention on mobility services.

Methods:

In order to develop a suitable set of indicators to assess the social impact of mobility services, a review on the current state of the art of S-LCA of mobility services has been carried out. This has been done in a top-down as well as a bottom-up approach to understand which indicators exist and how they can be measured. In that way, existing stakeholder groups as well as corresponding indicators are analyzed. In addition, indicators that need to be adjusted to the specific needs to assess social impacts of mobility services are identified.

Results:

The results of the review on the current state of the art of S-LCA of mobility services outline a huge variety of different indicators and established frameworks to assess urban sustainability as a whole. However, the literature review clearly reveals shortcomings regarding the assessment of use phase social impacts of mobility services, as no universal set of indicators exists so far. The top-down as well as the bottom-up approach identify four stakeholder groups with four to eight indicators each to assess use phase social impacts of urban mobility. However, as the indicators are designed to assess social sustainability of urban mobility in general, the indicators need to be adjusted to the specific needs of mobility services. It is recommended to adjust the identified indicators in order to develop a suitable set of indicators for the assessment of use phase social impacts of mobility services. In a final step, the developed set of indicators need to be verified and validated by applying them to mobility service use cases. In this final step, it is also essential to critically discuss accuracy and reliability of the developed set of indicators.

SESSION T1-7 Sustainable Mobility

Alternative Fuels in the Maritime Sector – Comparative Life Cycle Assessment of a Hydrogen Ferry

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Climate change became relevant for the shipping sector rather late mainly due to a more obvious local pollutant sources, its omission from national inventories under Kyoto Protocol, its importance in globalisation and its reputation as energy efficient transportation mode. However, global shipping CO2 emissions represented 2.6% of the global CO2 emissions in 2015. Additionally, shipping contributes to 15% of the global NOx and 13% of the global SOx from anthropogenic sources. Although international shipping is excluded from the Paris Agreement, the International Maritime Organization agreed in 2018 to cut the CO2 emissions by 50% by 2050 and acknowledged the use of low and zero carbon fuel as short, mid, and long term measures to reach this goal.

Within this context, the European funded project of HySeas III has emerged with the main aim of building and testing the first RoPax ferry using hydrogen fuel cells and compressed hydrogen as propulsion mean operating on the route between Kirkwall and Shapinsay on the Orkney Islands in northern Scotland. The implementation of this ship might prove the technical feasibility of using this technology in the marine ecosystem. However, the environmental impacts of this new prototype must be considered from a holistic point of view in comparison to a conventional-propelled fossil-fuel ferry, including aspects from all the life cycle steps. Hence, a life cycle assessment of the HySeas III prototype is conducted. Some previous studies focused mainly in global warming potential of alternative fuels, but do not consider other life cycle steps. However, the inclusion of the effects of other life cycle steps and the operation phase must be taken into account to give a more realistic idea of the impact effects that new technologies might bring to this sector.

We performed an LCA of the prototype of RoPax ferry which is developed in the project of HySeas III compliant with the ISO 14040 standard, considering her manufacturing and operation using hydrogen. For this purpose, we collected primary information from the project partners to complete the inventory. Additional information gathered from literature and secondary data from databases complemented the data collected in the first step. After completing the inventory, we conducted the impact assessment using the CML impact assessment method, going beyond global warming potential, to give a broad view of the impacts.

We contrasted the results from these calculations with results obtained for a similar conventional-propelled fossil-fuelled ferry in order to show the higher or lower impact of the prototype throughout the different impact categories. The final results are interpreted to draw conclusions and identifying hot spots which might lead to improvements in the near future. After doing this assessment, we can obtain a more comprehensive picture of using alternative fuels in the maritime sector and in the conditions of operation proposed for this inter-island ferry allowing to give more solid statements of this innovative application.

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SESSION T1-7 Sustainable Mobility

Environmental impacts of energy consumption of the human body on mobility activities

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Every activity causes consumption and loss of energy by the human body, but few LCA studies have considered this fact in the assessment of mobility activities. Based on this, the objective of this work was to verify the environmental profile of transport habits when considered the energy consumption of the human body. Given so, consumption scenarios were elaborated in order to verify the effects of energy consumption of the human body in mobility activities, e.g., sitting in a bus or train, walking, pedaling, and driving a car. A dataset named "Caloric Expenditure" was created, consisting of a basket of food that make up a commonly consumed meal in Brazil. When consumed, this meal provides the human body with available energy to perform the mobility activities. Based on this, a fraction of the available energy was assumed to be directly used by the consumer to move to his or her destination. The system boundaries include the consumption of food and the means of mobility only, i.e., car, bicycle, bus. Elements associated with the practice of mobility activities, such as apparel, accessories, and drinking water were not considered in this study. Likewise, intangible elements such as health benefits of walking to work or a greater availability of free time for the car user were not assessed in this study. The software SimaPro v. 8.5.2.0 and secondary inventory data from the ecoinvent database v. 3.4 – cut-off modeling – were used for the life cycle impact assessment, along with the ReCiPe midpoint (adapted) and endpoint 2016 method v. 1.1 (World ReCiPe H). The results show that the environmental impacts of transport habits in which the consumer uses bicycle or goes on foot varied substantially in relation to the Baseline scenario. This was due both to the greater time required to move (in minutes) in comparison to when driving a motor vehicle, and to the higher caloric rate (kcal/min) of walking or cycling activities. At the endpoint impact categories, the greatest quantitative variation in environmental impact was verified in Ecosystems quality, followed by Human health and Natural resources. In the latter impact category, the practice of walking habits was more impacting even than the use of motor vehicles in some lifestyles. However, due to the lack of data, potential benefits of walking or cycling in a lifestyle, such as health benefits, increased life expectancy, and reduced use of medicine were not quantified.

SESSION T1-7 Sustainable Mobility

LCA of seaweed-derived biofuels – Challenges in developing 3rd generation biofuels

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Environmental Resources Management

Seaweed is an attractive biomass for the development of a low-emission transport sector because it contains high levels of sugars, is fast growing, and requires no land for cultivation. Technologies for converting seaweed to biofuels have received considerable interest in recent years but are still at an early stage of development. Nevertheless, an important part of evaluating these technologies for further development should be considerations in terms of sustainability and economic competitiveness. This paper analyses the environmental impacts of biofuels production as part of the MacroFuels project, a Horizon 2020 funded initiative that seeks to move the production of biofuels from seaweed further along the development path to industrial scale production through rotational crop cultivation, automated harvesting and innovative conversion methods. Life cycle assessment is used to evaluate three production pathways generating the biofuels ethanol, butanol and furanics, respectively. Industrial-scale production is considered to take into account economies of scale, and for each pathway several alternative production scenarios are considered in order to maximise the benefits and minimise trade-offs in environmental performance. The results show that seaweed-derived biofuels can provide a net reduction in climate change factors through optimised production and utilisation of co-products. Considerations to configuration of the in-water cultivation set-up is important as a major hotspot in the value chain is the cultivation stage. Increasing biomass productivity and reducing materials required for cultivation, or increasing their lifespan, can help minimise the impacts from this stage. Farm sighting in areas not too exposed to ocean elements and avoiding over-specification are other considerations to take into account. At the refining stage, high rate of sugar extraction and utilisation of residues for energy production ensure optimal production. The study shows that seaweed derived biofuels can contribute to a low-emission transport sector and provides valuable insight which can help direct future initiatives for supporting such biofuels reach large-scale production.

SESSION T1-7 Sustainable Mobility

Hybrid life cycle assessment and life cycle costs of battery electric busses: a German case

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#Goals: The transport sector emits roughly 20 percent of total greenhouse gas (GHG) emissions alone in Germany and showed no clear declining trend in the last years (Wietschel et al., 2015). Electro mobility is seen as major alternative to fossil fuel based combustion engines in order to mitigate these emissions. The mobility sector and (local) governments have experienced a strong societal pressure for such change as air quality in cities reaches levels risking serious health issues. Commercial fleets, above all public bus networks, suit well to be substituted with electric busses. Battery electric busses (BEV) attract the highest attention and have already been successfully tested worldwide in demonstration projects.

Yet, BEV including eligible charging infrastructure face obstacles. To lower market entry barriers, BEV are not only required to show an equal operational performance, but also stronger results in comparative sustainability assessments than its conventional alternatives. This paper provides a state of the art on techno-economic optimized planning to match the first requirement. Second, this paper indicates current research gaps in life cycle assessments (LCA) on BEV and presents an improved hybrid LCA methodology. For the case of German cities, we preliminary analyzed GHG emissions, resource-efficiency, and operational efficiency. The paper intends to quantify potential reductions of resources and environmental impacts for transforming the public transport towards BEV.

#Methods: We used a systematic literature review and content analysis to scrutinize relevant articles upon current state of the art in techno-economic and life cycle assessment of BEV. Following Tranfield et al. (2013), we established a starting point for our own hybrid LCA approach and collected generic data. If necessary, we will draw analogies to research on electric cars. We will then use GaBi software to model results and scenarios. We will include these result as data lists within an existing simulation tool based on MatLab to optimize battery size and charging infrastructure within German cities.

#Results: We identified the following patterns within existing studies: fossil fuels and power generation is often the only fully analyzed subsystem (e.g. Jwa et al. 2018). Its GHG emission factor is rarely differentiated over time (per day), but used as constant average. LCA of the battery and chassis are either ignored or less scrutinized (because use phase of conventional vehicles contributes roughly 70 percent of total environmental impact, Gradin et al., 2017). Ageing of battery is less modelled for predicted service life time. Uncertainty modelling is mostly done by sensitivity analysis.

For the baseline scenario, we preliminary show that energy consumption and GHG emissions of BEV is better, but depends on the power generation mix, the cooling or HVAC loads, the loading behavior, the drivers' driving behavior, and the chosen battery technology (e.g. NMC). Resource-efficiency provides no clear picture.

Our findings provide reason for city planners, regulators, and end users currently considering to introduce BEV within their fleets. We further nudge the discussion on temporary government funding to overcome existing market entry barriers.

SESSION T1-7 Sustainable Mobility

Comprehensive Assessment of critical raw materials for BEV and FCEV

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(1. Goal)

Battery electric and fuel cell electric vehicles (BEV and FCEV) are both considered as highly promising technologies for decreasing the environmental impact of the mobility sector. This can be achieved through an increasing use of renewables in BEV and FCEV. However, both technologies require certain raw materials, for which concerns are often raised. These concerns address a variety of aspects, e.g. the potential depletion of such materials and short-term supply restrictions, increasing dependence on certain countries relevant for the supply, risks of increasing material prices, and environmental as well as socio-ethical issues related to the supply of these materials. To assess this broad number of relevant topics related to the raw materials for BEVs and FCEVs, this comprehensive study was conducted.

(2. Method)

In a first step, a “criticality assessment” for raw materials was used to identify the most relevant materials for both applications. This method characterises a certain material according to the risk of supply shortages on one hand, and the severity of those on the other hand. While a standardised procedure based on geological and market statistics was used for quantifying the risk of a supply shortage, the severity of a shortage with respect to BEV and FCEV technology was quantified based on interviews with experts from industry and academia.

For the identified “critical materials” a set of relevant aspects was assessed within the study: these include the supplying countries and the structure of the global supply situation, the temporal evolvement of mine production and reserves, the development and the volatility of prices and the expected future ratio of supply and demand, environmental and socio-ethical issues related to the raw material supply as well as the recycling potential of these materials. The focus is set on the individual raw materials but also on the total amounts required for BEVs and FCEVs in the future.

(3. Results)

Three raw materials resulted to be critical for BEVs and FCEVs from the criticality assessment. These are lithium, cobalt and platinum. Three additional materials were considered for the subsequent analyses, namely nickel, rare earth metals and copper. The assessment of potential raw material demand for BEVs and FCEVs in the future shows that a physical depletion of deposits is rather unlikely. Nevertheless, current production volumes of some raw materials need to be increased significantly to meet future demand. This does not only pose a risk towards volatile and rising material prices, but also emphasises the necessity to overcome environmental and socio-ethical challenges related to the mining activities. Several recommendations of how to address these issues in comprehensive raw material strategies and how to make the use of BEVs and FCEVs a viable pathway to sustainable mobility in the future were derived as conclusion of the study.

SESSION T1-7 Sustainable Mobility

Zero Footprint for Car Mobility, Utopia or Reality?

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renault sas

Introduction and goal of our proposal

Car mobility will face more changes in the 5 coming years than in the past twenty ones. So was saying Renault-Nissan-Mitsubishi CEO at CES 2018. Electric vehicles are one pillar of these transformations.

Aiming to zero environmental footprint car mobility is one current utopia. How to measure the so called zero footprint in face of a changing world ? What is the current status of automotive product ?

Our goal with this submission is to propose a return on experience and shared practices in order to build a factual opinion whether a zero footprint car mobility can become a reality.

Method

We would like to approach the topic under two angles: life cycle calculation methodology in one hand and results of key results in the other hand.

Regarding the LCA methods, several methodology studies has been carried. We analyse methods for impact regionalisation based on two methods (ImpactWorld+ and Lime3) with the support of key researchers. The company also contributed to common research with other industrial companies and French EPA to discuss best practices regarding topics such as circular economy, product second life, and impact regionalisation.

Results

As concrete examples we will share the results of applying regional impact factors to the Electric Vehicle Battery production, calculation of the benefits of a second life for batteries and experimentation of electrifying mobility on islands.

Finally, we will discuss if a zero footprint car mobility is an utopia or if we can see it real and under which conditions.

We hope this proposal will meet your intention in order to prepare the best sustainable mobility session. We would like to underline also that authors have experience regarding giving oral presentations in several LCM, SETAC and EcoBalance conferences.

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SESSION T1-7 Sustainable Mobility

Identification of minimal life cycle greenhouse gas emissions of various powertrain concepts for the future long-range mobility in Germany

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After 20-years-stagnation of the greenhouse gas (GHG) emissions of the German transport sector, changes are currently taking place. New innovative powertrain concepts for short- and long-range mobility, aiming for reducing life cycle GHG emissions of vehicles, are developed and introduced to the market. The minimal life cycle GHG emissions of these innovative powertrain concepts are not known yet for the case of an optimal design. So far life cycle assessment (LCA) studies regarding different powertrain concepts are based on the knowledge of vehicles which are already available on the market. These existent vehicles may not have been designed for mitigating GHG emissions but rather for fulfilling the standard consumption of the certification process, the sporty performance or the brand image. Therefore, the mitigation potential of the powertrain concepts, which could be achieved if the concepts were optimally designed for the investigated scenarios, remains unclear. For this reason, current LCAs show a research gap regarding the assessment of various powertrain concepts aiming to identify the potential minimum GHG emissions per driven kilometer. Therefore, the objective of the German funded research project “FahrKLang” was the development of an overall optimization environment for the comparative assessment of the life cycle GHG emissions of vehicles with various powertrain concepts for the evaluation of long-range mobility in Germany.

To this end, eight different powertrain concepts were compared for the long-range mobility: one conventional combustion engine (ICEV), one mild-hybrid (mHEV), two battery electrical (BEV), one series plug-in (sREV) and three parallel plug-in hybrid (PHEV) powertrain concepts. These powertrain concepts were dimensioned based on real fleet driving data within Germany which was recorded in the metropole region of Frankfurt. The developed optimization environment was used to determine the optimal parametrization and an adapted operating strategy for each powertrain concept. The objective function of the optimization consisted of the GHG emissions over the entire life cycle of the vehicles. For each powertrain concept, the minimum GHG emissions were determined through the optimized parametrization of the components, creating an equal evaluation basis for a proper comparison of the powertrain technologies. For the final evaluation, different scenarios of external factors were examined. The baseline scenario was based on real data from 2018 and was compared to the future long-range mobility scenarios of the years 2030 and 2050.

Regarding long-range capable vehicles, the results of the baseline scenario show that the BEV concepts have the highest GHG emissions per driven kilometer with 230-246 g CO2-eq./km, followed by the sREV and ICEV in 2018 in Germany. The mHEV and PHEV concepts have the lowest impacts with around 171-172 g CO2-eq/km in 2018. The fuel supply and the driving emissions have the highest contributions. In 2030, the results look similar, only the impacts of the PHEVs decrease to 163 g CO2-eq/km. The impacts of the BEV are also reduced by around 17%. In 2050, the impacts of the BEVs and PHEVs are decreased further with around 135 g CO2-eq/km and 127 g CO2-eq/km, respectively. The main contributor of the BEVs and PHEVs changes from the fuel supply and driving emissions to the production phase of the vehicle components and in particular to the battery production.

In overall, PHEV concepts are found to robustly achieve a good mitigation potential in all investigated scenarios for a long-range capable vehicle.

SESSION T1-7 Sustainable Mobility

Environmental life cycle impacts of autonomous e-shuttle busses and consequences for assessing future mobility systems

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The presentations provides LCA results on using autonomous electric shuttle busses in public transportation, highlights specific challenges of conducting such assessments, and draws conclusions for more life cycle and sustainability assessments of future mobility systems that include such vehicles. An attributional LCA study is carried out as part of the EU Horizon 2020 project AVENUE (Autonomous Vehicles to Evolve to a New Urban Experience). Based on these results and on a comprehensive literature review, the requirements and challenges for future mobility system assessments are explored with a consequential LCA mindset. Results highlight the importance of including the sophisticated hard- and software landscape for autonomous vehicles into LCA studies, the specific challenges of defining adequate functional units and reference flows in public transportation systems, and the difficulties of incorporating technology (non-)readiness into the assessment.

Hints:

- The contribution is for Session T1-7 Sustainable Mobility (the submission systems moves it to T1-1 for no particular reason)
- The contribution might also work as poster presentation
- The work is ongoing and to be finished in summer, which makes it difficult to state final results at present

SESSION T1-8 Sustainability of Agri-Food Products

Water Footprint of European agricultural imports: trends and development in the context of water scarcity

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Goal: In the year 2016, the European Union (EU-28) imported 132 million tons of agricultural products. This means an increase of more than one third compared to the year 2000. To fulfil this growing demand, the cultivated land is being continuously expanded in the producing countries and thus, the amount of irrigation water applied to fields is increasing as well. The irrigation water is then exported as the so-called "virtual water" via agricultural goods. The impacts associated with the irrigation water consumption strongly depend on water scarcity in the producing countries and can be quantified using the water scarcity footprint (WSF) assessment as per ISO 14046:2014. The goal of this study was to calculate the WSF associated with the EU agricultural imports. Further, the contribution of the EU virtual water imports to local water scarcity in the exporting countries was estimated.

Methods: Overall imports of nine commodities including 104 products were analysed for a reference year (2015). In the first step, the blue water consumption (i.e., irrigation water) was calculated by multiplying the blue water consumption of imported goods with their import mass. Then, the results of this first step were multiplied by the AWARE country-specific water scarcity characterization factors of the exporting countries to obtain the WSF per analysed product and country.

The EU contribution to local water scarcity was estimated for the five countries with the largest WSF associated with the EU imports. For this, the consumption-to-availability (CTA) ratios between 2000 and 2015 with and without the water consumed for the EU imports was calculated and compared.

Results: The blue water consumption of the EU agricultural imports amounts 11 km3 and the related WSF corresponds to 409 km3world-eq. The highest WSF occurs due to the product categories cotton and yarn (31% of the total WSF), nuts (21%) and rice (18%). Despite the large import share (36% of the total imports) the category soybeans is responsible for less than 6% of the WSF. Conversely, the category nuts amounts to less than 1% by mass, but to 21% of the total WSF. On the country level, the highest impacts arise in the USA (18% of the total WSF), Turkey (16%) and Pakistan (15%). The 2000-2015 time series shows the growing trend in the water scarcity in all evaluated countries except in the USA. The largest contribution (5%) of the EU imports to water scarcity is in Turkey, where a high fraction of the cotton and nuts consumed in Europe are produced. The EU contribution to the water scarcity accounts to 1-2% in the USA, Pakistan and Egypt and to less than 1% in India. However, these are country-average values and the shares can be higher for particular regions. This study identifies water-footprint hotspots arising due to the EU agricultural imports on a country and product level. It was also demonstrated that the highest WSF does not necessarily result from high import amounts, but is associated mainly with water-intensive crop production and high water scarcity in exporting countries.

SESSION T1-8 Sustainability of Agri-Food Products

Evaluating the environmental sustainability of legume-modified rotations: exploring LCA methods

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Agriculture faces major challenges to increase food security whilst reducing environmental impact and adapting to climate change. On one hand, modern technologies have been adopted to more precisely apply inputs including fertilisers and water, producing crops more efficiently and reducing waste within "conventional" systems. On the other hand, there are efforts to break the current state of technological lock-in of intensive mono cropping by promoting more complex cropping systems that may include more biological nitrogen fixation by legumes, extended rotations and intercropping. Such "agroecological" intensification could mitigate some of the environmental hotspots linked with agriculture, including high dependence on finite resources such as phosphorus fertilizers and fossil energy, greenhouse gas (GHG) emission, loss of reactive nitrogen and soil degradation.

Incorporating legumes into cereal rotations is a promising form of ecological intensification for Europe. Legumes are an important source of plant protein and have the ability to fix nitrogen from the atmosphere biologically. Legume residues can provide a significant quantity of nitrogen to following crops, reducing mineral fertilizer requirements and consequently decreasing GHG emissions (Watson, et al 2017) across entire rotations. Currently, only 1.5% of European arable land is planted with legumes, compared to 14.5% worldwide. Meanwhile, a deficit of protein-rich plant products in Europe is compensated by importing soybean from other countries where its production may drive deforestation (Watson, et al 2017). Fully accounting for the environmental consequences of introducing more legumes into European rotations requires careful delineation of system boundaries to capture nitrogen carry over and break-crop effects alongside changed crop product outputs, possibly incurring crop displacement and product substitution. Previous legume studies have often focussed only on GHG emissions and nitrogen leaching, with a few exceptions looking at a wider suite of pertinent impact categories (Nemecek et al., 2008). There is an urgent need for more holistic LCA to evaluate the environmental sustainability of legume interventions in Europe, using complex functional units such as nutritional density (van Dooren 2016) or population needs (Costa et al 2018) across entire rotations, or more sophisticated biophysical allocation across crop products (Brankatschk and Finkbeiner,2014), or a consequential approach.

Following a review of important gaps in previous legume LCA studies, we present novel results of advanced LCA application, including exploration of aforementioned approaches, to legume modifications within four major arable cropping typologies in the UK. Regional baseline farm rotations are characterised using national statistics, and paired with legume rotations characterised from a survey of legume growers. Attribution LCA is applied to the legume systems at crop and rotation level, applying different functional units and allocation procedures combined with the latest Product Environmental Footprint impact categories (JRC, 2018). Then, consequential LCA is applied to evaluate the environmental burden changes arising from conventional baseline rotations being modified into the legume rotations, exploring potential crop displacement and substitution effects linked to various macro-economic narratives.

Key words: legumes, functional unit rotation systems, allocation rotations, consequential scenarios

SESSION T1-8 Sustainability of Agri-Food Products

Management of Life Cycle of Cargill Tomato Products - Ecoficiency Analysis Case

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Fundação Espaço ECO

This study aims to discuss how different changes in production process of tomato products contribute to life cycle impacts associated to the service of the suppling bottled and packed tomato products in terms of its environmental performance, besides the economic costs. Cargill is responsible for an operation of different tomato products in Goiânia (Brazilian state of Goias). The eco-efficiency analysis (EEA) compared performance of 4 (four) alternatives in reference years (2014, 2015, 2016 and 2017) and allowed to determine conditions of operation in this supply chain. System product modelling followed a cradle to grave approach and its frontier is defined from the extraction of natural resources for tomato cultivation, through harvesting and transport activities to (and from) the industrial unit, besides packaging production, use and disposal. Primary data came from several operational sources and seeks to provide the most representative assessment of Cargill operation. Environmental and economic aspects were associated to life cycle stages of each year alternative sought the greater completeness for all the analyzed scenarios, besides adopting conservative assumptions in which there are no benefits for any of the alternatives or scenarios. As a representative check, the results from the EEA10 method suggest greater attention to the same impact categories recommended in Type III Environmental Labeling. In the context of climatic atipicities increasingly recurrent to each harvest, the search for other management solutions and sources of inputs becomes strategically important, reducing the dependence of seasonality to a single cultivation window. The impact from the industrial phase has an important contribution, mainly due to the consumption of water and biomass for steam generation, but it is also determined according to the agricultural production and its window. At this industry stage, environmental performance is dependent on water consumption and selection of biomass for steam generation. The Cargill unit is also responsible for the packaging and distribution of tomato products in the form of 3 (three) types of packaging: Steel can, Tetrapak and Plastic Pouch. Packaging (steel can). Tetra Pak packaging is potentially the most eco-efficient option, however it is recommended to use the results as support for the definition of R&D actions in new packaging in order to show the improvements made each harvest year.

SESSION T1-8 Sustainability of Agri-Food Products

Synergies of ecosystem services and productive model of renewable raw material contributing to the carbon foot print of industry

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Fundacao Espaco Eco

Nowadays global discussions around Climate Change points out an urgent need to reduce emissions. This common objective is shared by country leaders, global and local companies and specific activity sectors such as agriculture, responsible for around 14,5% of global GHGs emissions. The efforts aimed to assure quality of life to population estimated at 7.6 billion people are huge, but the challenge becomes even bigger when we think of 11,2 billion people expected by 2100. Industries with value chains highly dependent on renewable raw materials such as Food and Personal Care industries, have a huge challenge and opportunity. These companies can act reducing their emissions not only on production level, but also looking closer to their supply chain and prioritizing raw material coming from productive models less impacting. These models can be motivated by a certification that looks forward improving the emissions of the plantation or by the origin of the product. This second option considers raw material coming from regions where legislation is based on the requirement of environmental conservation areas in the property. This model mitigates the emissions of agricultural activity compared to a conventional farm that does not include a conservation area located next to the production area. This was verified for commodities produced in two different production models in Brazil: one respecting local legislation (50% of the property is preserved) and another model doesn't respect legislation (does not preserve any area). A comparative study of the valuation for dependence and internal impact, considering the necessity of the productive units of the company in South America, in relation to the ecosystemic provision of commodities was performed. To calculate the valuation, the Replacement Cost Method (CRCM) was used. With the results of this study it was possible to understand that traditional (without considering the conservation area) commodity is the economically cheaper option. However, when considering the environmental aspect, the certified product presented greater environmental value. This is because, in Brazil, the Forest Code requires that rural properties have a minimum of 50% of the rural property area covered by native vegetation in the municipalities located in the Amazon Biome where there is economic-environmental zoning, and forests are active contributors to the sequestration of CO_2 from the atmosphere. From this case we can see how important is to look at the productive unit in the context of the landscape at the ratio of 1:1 between agricultural management area and forest area. From this study we can conclude how important is to identify synergies between Agriculture and Ecosystem services, how important is to trace the raw material companies by and how they can induce with strong supply policies supply chains that will reduce the company carbon footprint that will at the end attend future society and company needs.

SESSION T1-8 Sustainability of Agri-Food Products

Manure Management in pork production value chain

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BASF SE

Since the agricultural sector is known to exert impacts on the environment, several LCA studies have focused on the environmental impacts along the value chains of livestock production. While these studies aim to optimize the feed recipes, they show that the management of manure also causes noticeable impacts of up to 70% for Acidification Potential (AP), 50% for Global Warming Potential (GWP) and 55% for Freshwater Eutrophication Potential (FEP). Due to the relevance of these impact categories in the recent political discussion (Nitrate Directive and National Emission Ceilings Directive), insights into manure management are crucial to assess effective reduction strategies.

Since previous studies do not apply an integrated approach focus on manure management as part of the pork production process, this study examined the whole value chain considering a real-life manure management system including a manure separation process and biological treatment of the liquid manure fraction. The key topics of the study were the assessment of the specific manure management system and the integration and relevance evaluation of manure management in the whole pork production value chain. These insights are used to identify levers for significant reduction of environmental impacts in the production of pork.

Preliminary results show that the examined manure management systems with separation and biological treatment achieves a better environmental performance compared to a traditional manure management of about 30% (for AP). Both feed optimization and manure management improvement could effectively reduce the environmental impact. However, an optimization of diets towards lower nitrogen and phosphorus contents tends to lead to a lower effectivity of the manure management improvement, the least environmental impact is assumed to be achieved by a combination of both. The accomplishable improvement of such a combination compared to pork production without nitrogen and phosphorus reduced pig diets and a traditional manure management system will be assessed in further investigations.

SESSION T1-8 Sustainability of Agri-Food Products

Consequential and Attributional Life Cycle Costing of Agri-Food Products towards Sustainable Agriculture and Food Production

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Agriculture and food production has played an important role in the global economy. One of the main approaches to increase the productivity of agri-food production in emerging economies is the use of agricultural chemicals including chemical fertilisers, herbicides, insecticides and fungicides. The potential impacts on human health, eco-system and resources from the use of these chemicals are needed to be taken into considerations. Moreover, there are other processes throughout the whole supply chain of agri-food production which may adversely affect the environment and society. The varieties and intrinsic complexities implicitly point to the need for holistically determining the potential impacts on the environment, economy and society and to take them into consideration when developing and implementing sustainable consumption and production policies. In order to capture the holistic environmental and economic impacts from the whole supply-chains of agri-food products/production systems, life cycle based decision support tools such as life cycle assessment (LCA) and life cycle costing (LCC) considering the inputs, outputs and potential environmental impacts as well as costs under life cycle perspective could be applied. For assessment studies, the modelling choices significantly affect the conclusions. Two main modelling choices which have been widely applied for LCA studies are consequential and attributional LCA (CLCA and ALCA). Consequential and attributional modelling approaches are valid not only for LCA but also for other life cycle based assessment tools. In order to provide comprehensive decision support, this study assesses conventional and environmental LCC of agri-food products in Thailand by using consequential and attributional modelling approaches. The conventional or economic/financial LCC includes only internal costs whereas the environmental LCC considers externalities. The agri-food products being considered as the illustrative cases are oil palm and sugarcane. Different agricultural practices are compared in order to provide relevant policy recommendations on how to produce agri-food products in Thailand more sustainably. The environmental LCC is conducted by monetarising the environmental impacts derived from CLCA and ALCA. Different cost definitions based on the two modelling choices are also applied in this assessment. Finally, the research could be applied for decision support under various policy contexts and relevant modelling choices.

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SESSION T1-8 Sustainability of Agri-Food Products

Environment impact analysis in plants cultivation systems in urban areas: LEDs lighting as an alternative to increase production

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Alternatives to support the demand for food keep growing in response to rising population. Due to severe climatic changes inducing variation in sunlight intensity, temperature and humidity, plants development and growth can be decreased and consequently their biomass production. Indoor or vertical greenhouse and urban rooftops are such as crucial alternatives for plants cultivation systems. These cultivation systems have greater environmental control, especially those using artificial lighting to supplement or replace natural light. In consequence of this and to better understand the mechanism of the wavelengths and their intensities regulating the development of plants, we built an indoor greenhouse using Light Emitting Diode (LED) systems as a source of energy for the plants photosystems and photoreceptors. The range of the LEDs wavelengths can vary between 380 to 780 nm (including part of UV, blue, red and far-red wavelengths), the temperature and humidity are also controlled parameters. To evaluate the effects lighting technologies on the growth and flowering plants stages light parameters will be tested in tomatoes plants, considering the application of different wavelengths and intensities. Results of the data analysis will be performed in the next months. Through the results compilation, the greatest parameters will be optimized to try to achieve greater conditions of plant development and growth rate. A life cycle approach analysis in control conditions will be performed comparing the optimized adjustments of the LEDs light systems used in the greenhouse.

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SESSION T1-8 Sustainability of Agri-Food Products

Environmental efficiency of human nutrition from chickpea pasta versus durum wheat pasta

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The food sector faces two major challenges: 1) environmental concerns around intensive agricultural practises to meet growing food demand, notably fertiliser use and animal-related GHG and ammonia emissions and 2) health concerns around excess fat, sugar and calorie consumption linked to an increase in various diseases. Legumes provide a sustainable solution to these issues, minimising greenhouse gases (GHG) and reducing the need for synthetic nitrogen fertilisers (SNF) by virtue of their symbiosis with N2-fixing bacteria and addressing other ecosystem services, while providing a rich source of nutrients and improving health. However, current legume consumption in Europe represents a mere 1.5% of arable land and 1% of daily energy intake, respectively. Providing a legumes-based substitute of a staple food could reverse unpopularity of legumes. European consumption of durum wheat pasta amounts to around 3.4 thousand tons a year. Substituting durum wheat flour with pulses flour in pasta production could dramatically expand legume cultivation and consumption in Europe, with associated environmental and nutritional benefits.

Most LCA food studies used weight-based functional units (FU) for comparing different foodstuffs, omitting the key nutritional role of the products involved. Often, GHG emissions were the only impact category analysed, limiting the environmental significance of results. In this study, we conducted an attributional LCA of novel chickpea pasta, using the Nutrient Density Unit (NDU) as a functional unit, and assessed fourteen impact categories following the new Product Environmental Footprint Category 2 Rules Guidance. Primary data were collected from Clicks Ltd, a Bulgarian manufacturer of Variva® chickpea pasta, from field to fork.

Per 250 grams of product, chickpea pasta had a higher environmental impact than durum wheat pasta over 7 impact categories out of 14, and required 2.5 times more land, whereas per NDU, chickpea pasta had a considerable smaller environmental impact across all impact categories but a toxicity-related one, highlighting the importance of selecting a relevant FU. For example, per NDU, chickpea pasta produced 0.20 kg CO2 eq., 2.19 MJ, and consumed 0.14m3 water, representing 66% less GHGE, 65% less fossil fuels, and 75% less water than durum wheat pasta. Therefore, to provide the same nutrition, durum wheat pasta had a considerably higher environmental impact overall than chickpea pasta. A second goal of the study was to identify improvement opportunities for sustainable chickpea pasta production. Chickpea cultivation was the major hotspot in the chickpea pasta life cycle, emphasizing the need for adequate agricultural practices. This included substituting the use of SNF with inoculated seeds with N2-fixing bacteria, saving 30.30kg of nitrogen fertiliser per hectare of arable land without affecting yields. Other hotspots included transport to international markets and packaging, due to the use of cardboard packaging.

SESSION T1-8 Sustainability of Agri-Food Products

Developing a sustainable production and consumption model based on sustainability: the Barilla's experiences

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The food sector is characterized by a larger variety of products but also diversity in the customers, needs, perspection and large data variability in order to understan environemtnal impacts along the lifecycle.

The sustainable developement goals (SDGs) must push up a new strategic sustainability pattern for the food production and chain that take into consideration social, economic and environmental subjects, the climate change problems and the sustainable development.

The Barilla Double Pyramid represents in a synthetic and graphically effective way the combination of environmental impact of food and a balanced diet from a nutritional point of view. It is built starting from environmental indicators of Life Cycle Thinking (LCT) and from the nutritional / nutritional ones suggested by the international guidelines inspired by the Mediterranean Diet. Currently, the research work contains more than 1000 data collected from more than 400 sources (BCFN, 2018).

Achieving the 12 SDGs goal requires a solid sustainability model. It must include both production practices and correct consumption methods. The use of the LCT approach allows the validation of this model through the support of performance improvement tools with particular reference to sustainable agriculture.

The LCA analyzes used for the quantification of environmental impacts have been developed for Barilla brand durum wheat semolina pasta, produced in Italy and packaged in cardboard box (the classic formats of semolina, the small ones, the specialties and the regional ones). For the agricultural phase, the provenance was assumed (for 80% from the Mediterranean area and 20% from the North American area), the semolina is produced by milling the durum wheat (of the total 70% is produced from mills owned and the remaining part comes from external mills), are then included the mixing phases of the semolina with water, the extraction of the mixture in the desired format, the drying of pasta with hot air produced by gas-fired plants natural, packaging. In Italy, Barilla dedicates 3 factories to the production of this product: Foggia, Marcianise and Parma.

Climate change in precipitation and temperature cycles are affecting various ecosystems including forests and farmland, mountain regions and oceans. Global carbon dioxide (CO_2) increased by more than 50% between 1990 and 2012 (UN, 2018).

The contribution resume the expernce of Barilla best practices, and in particular the analysis focus the attention on the Objective SGDs 12 which requires to guarantee models of sustainable development of production and consumption. The Final results shows the generical model for life cycle management applied to food chain and including all factor and variables.

SESSION T1-8 Sustainability of Agri-Food Products

Economic and Environmental Feasibility of wine glass packaging reuse scenarios in Catalonia.

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The chosen waste management system is a key component to the overall impact of packaging in the production chain. Reusability of glass bottles was used during decades in Catalonia and Spain, but it was replaced during the decade of 1980 by the current one-way system of a single use of the packaging and posterior disposal. European legislation on waste management, and subsequently Catalan legislations, prioritizes reduction of waste production, followed by the adaptation to reusability, then recyclability, energetic valorisation and safe disposal or landfilling. Products and packaging in particular, should be designed for the waste management system present in the location where they are produced, to be adaptable and produce minimum affectation to the environment.

This paper aims to analyse the feasibility in environmental and economic of a wine glass packaging reuse scenarios in Catalonia

All information related to this study was gathered in Catalonia, which is worldwide famous for its production of wine and cava. Two scenarios are proposed, having technical differences between company models such as the business model (big company or cooperative) and the transportation distance for bottles (local or regional level of operation). Both scenarios have been carried out during the demonstration phase of LIFE+ project called reWINE (more information in: http://www.rewine.cat/en

Life cycle assessment based on ISO14040:2016 and Carbon Footprint assessment (CF) and economic assessment were conducted with the data obtained after performing 10 reuses of a limited sample of wine bottles for both scenarios, then comparing those results to the production of the equivalent new bottles and among scenarios.

Results show that the proposed system is proven to be mechanically and environmentally feasible for the scenarios proposed. After the second reuse, the process is already feasible and performance improves upon more reuses for both cases. When comparing one-way bottle with reusable bottles for 10 uses, carbon foot-print emissions are reduced from 38.4% (Scenario 1 – BW) and 19.3% (Scenario 2 MW). The optimal number of reuse points is at least seven times. Avoided impact is recalculated into extra distance (ED) allowing the wineries to enlarge their boundaries and distribute their products longer distances. Under this study's conditions, this distance is equivalent to expand 150 extra km (+250%) their current distribution reach for local level for scenario 1 – BW and expand 95 extra km (+63%) for regional level in scenario 2 – MW.

The provision of a neuralgic network of bottle collection centres all over the region and the standardization of eco-designed bottle models for all DOs would be a solid proposal to apply for an improved future system of reusable bottles.

SESSION T1-8 Sustainability of Agri-Food Products

Prefectural-level life cycle inventory dataset of vegetable and fruits production in Japan

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Inventory databases of agricultural products have been developed with country-level data. Despite these data will be useful and suitable for background data of life cycle assessment, it is insufficient to use inventory data as benchmarks for consumer product choice. For example, conventional agriculture is very varied by production area, when considering its detail of practices. Seasonal variation of inventory data would be high if target products are grown in greenhouse with heating. Benchmarks of consumer product choice are required to contain regional- and seasonal-level inventory data to compare with other type of practice in same area and season.

This study developed life cycle inventory data of vegetables and fruits produced by prefectural level in Japan, considering standard practice of each area. We formulated inventory data of around 40 products by collecting standard farming practice and production cost model issued by prefectural governments. Functional unit is 1kg of products and production of one thousand Japanese yen. Life cycle greenhouse gases emission was calculated. Statistical approach, such as data envelopment analysis (EDA) and multiple regression analysis, was applied to analyze relationship between environmental load, areal condition, and detailed practices, cost efficiency, and yield.

Result of tomatoes indicates that the amount of life cycle greenhouse gases (LC-GHGs) of products in highest area and season, is over 30 times more than the lowest area and season. As for winter season, the difference between highest and lowest LC-GHGs is over twice than the lowest. The majority of reasons for variation of LC-GHGs is greenhouse heating, while effect of fertilizer is large in outdoor cultivation. The dataset developed can be used to estimate potential of improvement of agricultural practices considering existing practices in each area.

SESSION T1-8 Sustainability of Agri-Food Products

How to compare the impacts of our food choices? Proposing a new approach

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UNESCO Chain in Life Cycle and Climate Change (ESCI-UPF)

To overcome the global challenge of designing food systems that can satisfy the food demand of a growing global population, but do not threat the environment, has been usually focused on how to improve food production, for example, through intensification (Garnett et al., 2013). However, food choices play a significant role. For instance, Bajželj et al. (2014) show that changes in dietary patterns towards a “healthy diet”, as well as the reduction of food waste, are the best strategies to ensure food security by 2050 while reducing current GHG emissions by 45%.

Facing this significant role of food choices and eating patterns, more research analysing the impacts of diets with a life cycle assessment (LCA) approach has been published in the last decade (Hällstrom et al., 2015). However, methodological issues remain a challenge, especially in defining diets’ function, and subsequently on selecting the functional unit (FU) of the system under study. While most studies use a mass- or energy-based FU, this study proposes a new approach to account for the energy and nutrient content within the FU of a diet. This approach allows to compare the environmental impacts of diets independently of their caloric and nutritional content, and it is applied to the Spanish context, as a case study.

SESSION T1-8 Sustainability of Agri-Food Products

Life Cycle Analysis improvement in the ethanol chain: using geoprocessing to estimate the variation of soil carbon stocks

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Atvos

Goal: Land Use Change (LUC) has great relevance for Brazilian overall CO2 emissions. Considering its relationship to agricultural production, especially for biofuels and biomaterials production, it becomes paramount to understand and replicate improvements on the methodologies to measure LUC in the ethanol chain. The objective of this work is to reduce uncertainties and to ensure traceability in the calculation of the variation of carbon stock in the soil and Biomass, during the ethanol production process in Brazil aiming at a complete LCA of the product. In this sense, Braskem, the world's largest producer of biopolymers, Atvos the largest supplier of ethanol, Embrapa (Brazilian Agricultural Research Company) and Quantis (Swiss sustainability consultancy) joined together to experiment a method of estimating LUC emissions, which will feedback the process to help to develop a LUC accounting guidance.

Methodology: The methodology used prior to the study utilized as a database the factors of the IPCC and the data of previous use of the soil informed by Atvos team. In the present work, the methodology applied for the estimation of LUC associated with the ethanol production obtained more accuracy and traceability mainly due to be based on satellite imagery data. The soil maps data were analyzed and combined with carbon stock data from Brazilian literature, in a GIS environment. From this, the type of soils and the occupation of the farms were obtained by gathering images from 20 years prior to the study´s base year. Together with this framework, it was possible to synthesize the estimates needed to account for changes in carbon stocks (SOC, AGB and BGB). The area used for the study represents more than 170 thousands hectares of sugarcane production, which correlates to the actual image processing sample of 22 thousand hectares from real Atvos production units supplying sugarcane for ethanol mills that supply chemical grade ethanol for Braskem industrial units.

Results: The results indicated that in the past 20 years, most sugarcane expansions happened on agricultural land or pasture land leading to net carbon capture of 2.3 tonne C ha-1 in the base case. Annualized over 20 years and applying a conversion from C to CO2 based on the molecular weight leads to carbon capture of 0.4 t CO2 ha-1. Using the average sugarcane yield of 58.2 tonne sugarcane ha-1, the CO2 carbon capture due to LUC is 7.1 g per kg sugarcane. In the case of Atvos, there is a high probability of a significant increase in the carbon stock of the sugarcane plantations over time, given the change in the practice of harvest without burning and expansion over previously anthropized areas, mainly occupied by grazing in sandy soils pasture. The study may support decision-making of future agricultural expansions of Atvos aiming at maintain or increase the carbon stock in the soil and consequently reducing the carbon footprint materialized in the LCA.

SESSION T1-8 Sustainability of Agri-Food Products

Monitoring the environmental impacts and the economic performance of wine production with a single management tool

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Goal of the study:

The wine industry faces two major environmental challenges. From the production point of view, vineyards should adapt to climate change because of the increasing recurrence of climate disasters. From a consumer point of view, awareness associated with environmental impacts of wine production is raising (eg., pesticide use) and transparency on this issue is requested.

In this context, the goal of this study is to equip wine estates with a tool assessing their economic and environmental performance at both the production system and product levels. The purpose of the tool is to provide to decision makers valuable information for the sustainable management of their companies.

Methods:

The tool is built on the coupling of two reference methods: Activity Based Costing and Life Cycle Assessment.

The application of Activity Based Costing requires the identification of the different activities conducted within an organization and enable the assignment of cost to the different activities and to the products using allocation keys. The cost amounts are retrieved from the general accounting system of the company, while the keys are defined using the resource consumptions of each operation constituting an activity.

The application of Life Cycle Assessment uses operational data to constitute the Life Cycle Inventory, that is then analyzed to evaluate the environmental impact of the production.

The common ground of the application of the 2 two methods is therefore the collection and the treatment of the operational data that are reported by the wine estates in their existing management systems. This enable the display of cost and environmental impact information broken down by product, by activities and by operations constituting these activities. The different level of information can facilitate the selection of appropriate technology and technical options considering their cost and environmental impacts.

The coupling of the method has to respond to constraints specific of the wine sector, mainly composed of SMEs of various size. These constraints are:

- the variability in the level of digitalization of the companies, and therefore the variability in the availability and the quality of data;
- the production of a wine bottle mixes agricultural and industrial activities, and the technical options for each activity are numerous;
- the necessity to automatize as much as possible the data collection through existing sources: accounting, traceability and inventory information.

To adapt and cope with these constraints and to calibrate the tool, cases studies are conducted on 2 different French wine estates. In these cases, the accessibility of the data are assessed, different impact assessment method, namely ReCiPe and the recommendations of the Product Environmental Footprint for still and sparkling wine, and their influence on the results are tested.

Results:

The results of the case studies will be presented. This includes the environmental impact assessment, the cost analysis of the different products, and the recommendations provided to wine estates: technical options to optimize their production system and management processes to report and store data, in order to improve the tool and the fineness of the calculations.

SESSION T1-8 Sustainability of Agri-Food Products

Environmental footprint of zinc supplementation in animal nutrition

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Animine

Available Life Cycle Assessment (LCA) studies have shown that feed production significantly contributes to the environmental footprint of edible animal products and therefore an important element to take into account when considering mitigation options. For this reason, the Product Environmental Footprint Category Rules (PEFCR) of animal feed was approved by the EU commission in 2018, the feed industry being the first sector to have its PEFCR. However, for feed additives such as trace minerals, the models of their production process are still being improved. In this line, feed industry's commitment to generate high-quality data on feed additives will be important in the near future. Therefore, the objective of this study was thus to develop a high-quality dataset for the potentiated zinc oxide source named HiZox® (Animine, France) in compliance with PEFCR requirements. The PEF study was based on the method as described in the PEFCR Feed for food-producing animals, and the experimental unit was 1 kg of zinc used in animal nutrition. The system boundaries were from cradle-to-plant, and the environmental indicators included all PEF impact categories, as well as the toxicity ones. The modelling was performed in the SimaPro version 8.5 and the latest PEF datasets and the EF method were used. The results showed an impact on climate change of 4.32 kg of CO2-eq. per kg of zinc supplied in the diet. For acidification (terrestrial and freshwater), the impact was calculated as 0.10 mol H+-eq. For freshwater and terrestrial eutrophication, the impact was 1.84E-04 kg P-eq. and 7.52E-02 mol N-eq., respectively. The impact on freshwater ecotoxicity (EcotoxF) was 12 CTUe per kg of zinc supplied in the diet. For resource use - mineral and metals (ResUse), the impact was 1.45E-03 kg Sb-eq. Metals are, in general, the greatest contributors to EcotoxF and ResUse impacts of a total feed, which make important the assessment of those categories by the trace minerals industry. However, as highlighted at PEFCR report, measuring the impacts associated with the production of feed and with the farm performance is necessary to achieve meaningful LCAs of food-producing animals. For this reason, the next step of our study will be to account for the animal production system in the boundaries of our LCA. In conclusion, now Animine could provide a high-quality PEF related dataset to be used by the feed industry in the PEF assessment. As perspective the speciation of zinc in animal wastes could be accounted in the LCA, because of the high contribution of metal speciation to the toxicity impact.

SESSION T1-8 Sustainability of Agri-Food Products

Influencing Sustainable Food Consumption through the use of Sustainable Procurement Criteria

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IVL / KTH

Goal:

Population growth and urbanization has led to an increase in resource intensive and energy rich foods, where the public sector accounts for a large share of food consumption. This requires implementing measures across the food value chain, in order to realize a transition to a sustainable food system. One such measure is the use of public procurement to influence the purchases of food from the public sector. However, there are many challenges to implement procurement criteria in the public sector to guide purchases, calling for an increased understanding of the criteria employed. This study aims at reviewing the use of sustainable public procurement (SPP) as a tool for more sustainable food production and consumption, by analyzing and reviewing the influence of sustainability criteria in public procurement of food throughout the life cycle; this includes all three pillars of sustainability (economic, environmental and social sustainability).

Methods:

This study analyses the use of life cycle based criteria that can be used in public procurement within Sweden, to influence sustainability of food consumption and production. A mapping of the use of the criteria nationally was performed to investigate how the sustainability aspects are represented within the available criteria for different food groups; conducted through the use of a survey and interviews with municipal procurers. The sustainability criteria at different levels were reviewed and categorized into social, economic and environmental sustainability criteria for the different foods. Thereafter, the food groups, and their relevant criteria, were categorized to understand the importance of criteria. Finally, a series of stakeholder dialogues were held to understand how to improve the criteria for promoting more sustainable choices.

Results:

The results point to an overwhelming number of criteria available for animal based foods. However, these cover only a limited set of sustainability criteria in the three pillars. Economic aspects are nearly absent in the current criteria used. Criteria relevant for social criteria are also relatively difficult to find, although many criteria for ethical handling of animals are available, which may fall outside the current guidelines and recommendations from the scientific community. Finally, while the criteria are applied for foods throughout the life cycle, we found there is an overwhelming focus on the production phase for foods. The procuring municipalities, also suggest that while a large number of criteria are available for use to guide choices, these are not always used to their potential. This is due to the difficulty in finding producers which can meet demands. We have thus found a divergence in the use of life cycle based criteria availability and use. The stakeholder dialogue also suggests that creating new criteria to promote more sustainability may alleviate some concerns, but will be difficult to implement along the supply chains.

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SESSION T1-8 Sustainability of Agri-Food Products

The Influence of Socioeconomic Aspects to Environmental Impact for the Maize Production in Indonesia

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Life Cycle Indonesia

Maize is one of the most important cereal crops in the world. Its application is wide from staple food for certain areas in the world, poultry feed, raw materials up to renewable bio-energy. Indonesia is an agricultural country with its main animal protein is sourced from poultry. As maize is one of the main components of poultry feed, maize production is crucial in supporting the provision of protein-based nutrition for the country. The biggest producers of corn in Indonesia are in East Java (20%) while West Nusa Tenggara (NTB) is plotted to be the center of corn production by the Ministry of Agriculture (2018). Currently, there is limited information regarding the environmental impact of maize production in Indonesia. The goal of our study is to identify the impact of traditional maize plantations in various areas in emerging Indonesia. The relationship of socioeconomic aspects, such as economic condition, cultural traits, and agricultural practice knowledge, to environmental impact, are explored.

Our study was conducted for maize production in 3 provinces, i.e. East Java, West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT), that was spread into 5 islands. Life Cyle Assessment methodology is applied in our study. The functional unit of the study is 1 kg of dried maize kernel. Primary data from more than 300 farmers around the selected areas were collected for the life cycle inventory. The system boundary of the study is from the planting of the seed to the market of dried maize kernels at distributor. ReCiPe Midpoint (H) impact assessment method was used to assess the life cycle impact. Two impact categories are selected, i.e. GHG emission and water depletion.

The average production yield in the 3 provinces varied from 0.5 to 6 ton per cycle with the GHG emission of 1 kg dried maize kernel in all the locations range from 0.07 to 6.65 kg CO2-eq. The economic condition in East Java with their higher GDP compared to other location do not show high productivity yield per area with only 1 ton per cycle. Instead, East Java contributed to the highest GHG emission (6.65 kg CO2-eq) due to their extensive use of chemical fertilizers. Meanwhile, the application of good agricultural practice in NTB has shown some benefit with the highest yield among the others (6 ton per cycle) and significantly low GHG emission of 0.54 kg CO2-eq per kg of dried maize kernel. Additionally the type of soil for plantation is affecting water consumption. There are generally three types of soil identified in our study area, i.e. mineral soils, clay soils and rocks. In NTT, the maize are planted in rock soil. To produce good yield in NTT requires a large amount of water which causes water depletion impact of over 117,000 m3. Nevertheless, the common traditional practice in that area is without any irrigation due to economic constraints, which explains the low productivity yield. These findings suggested as sustainability aspects may contradict, things that are environmentally sustainable may not be socioeconomically sound. This highlighted the importance of life cycle and sustainable supply chain perspective in decision making.

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SESSION T1-8 Sustainability of Agri-Food Products

Improving the performance of sustainable development goals for maize plantation: a case study of the Indonesian maize

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Indonesia is one of the potential countries for maize plantation. This plantation spreads from the western to the eastern part of Indonesia due to the high demand for maize in the market worldwide. Its application is wide from staple food for certain areas in the world, cattle and poultry feed, beverages, sweeteners, up to renewable energy.

The aim of the study is to identify the impact of maize plantation in various area in emerging Indonesia including East Java, West and East Nusa Tenggara (NTB and NTT). Ten different scenarios were analyzed in some aspects such as machinery, and application of Good Agricultural Practices (GAP). Maize plantations are usually located in drought areas that usually identical with poverty. Therefore, this study focuses on two potential environmental impacts, namely water depletion, and carbon emission. These two impacts are two of 17 parameters that stipulated by Sustainable Development Goals (SDGs).

This study applies a Life Cycle Assessment (LCA) method and involved approximately 300 farmers in three provinces, namely East Java, West and East Nusa Tenggara (NTB and NTT), in Life Cycle Inventory stage. The system boundary for the study is cradle-to-gate, from the land preparation to transportation of the dried maize kernel to the market. In the case of data are not available from study sites, representative data are used from commercial database and/or from relevant literature. Specifics of the data quality used is specified in the life cycle inventory process by using the Pedigree Matrix.

The results showed that pre-and post-intervention's impact assessment to global warming potential were varies from 156.90 kg CO2-eq to 8,329.73 kg CO2-eq per yield, however, the highest carbon footprint variance (96%) between pre and post intervention was generated by scenario 3MEC due to its better management on fertilizer application. Meanwhile, the increase of water usage ranges from 3,979 up to 458,049 m3 and the highest environmental impact of water depletion was generated by scenario 2MEB with the amount of water depletion was 511,930 m3 due to land preparation technology applied. The scenario that generated a better environmental performance should be maintained and developed while the others scenario should be improved by re-evaluating its three bottom lines of sustainable development: economy, social and environment.

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SESSION T1-8 Sustainability of Agri-Food Products

Life Cycle inventory for Indian textile Sector

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FICCI

Background: Fast fashion, technological development and expanding economy have helped the global textile industry to grow tremendously. The world textile mills market is forecast to reach a value of $ 842.6 billion in 2020, a rise of 26.2% since 2015. It accounts for 14% of the total industrial production and constitutes around 15% of total exports from the country. Indian textile market is currently estimated to be around US$ 120 billion, and is expected to reach US$ 230 billion by 2020.

This increase will lead to a rise in associated environmental impacts in the form of energy water and land use, global warming and ozone depletion etc. Therefore, it is an urgent requirement, to study the factors in textile production, which are responsible for these impacts. Such analysis requires good quality life cycle inventory, which is geographically, temporally and technologically representative. Life Cycle Inventory (LCI) of Indian textile products and activities, as presented in EcoInvent v3.5 does not completely represent well, the highly varied textiles produced in India.

Goal: This work was carried out under Sustainable Recycling Industries (SRI) programme, led by Ecoinvent, with the main goal to establish regional Life Cycle Inventories (LCI), that can be used in Life Cycle Assessment (LCA) studies, environmental product declarations, carbon foot-printing and similar assessments. This project covers; 30 inventories for various processes related to textile production in India.

Methods: This work covered multiple processes and sub processes related to textile production beginning from raw material production; agriculture and fibre processing (retting and dressing), yarn production (spinning), fabric production (weaving and knitting) and finishing (mercerizing, bleaching and dyeing). Data was collected was broadly classified into agricultural and industrial data. Data collection covers domestic textile production between 2014-2017 and majority of data is primary data, collected through site visits and interviews with farmers, scientists and manufacturers. The impacts of agricultural processes were calculated using EcoInvent LCI calculation tool for crop production. The data generated was critically reviewed according to EcoInvent guidelines.

Results: Despite the many difficulties faced during the data collection, this work successfully generated life cycle inventories of around 30 textile processes through mostly primary data and created a basis for building up further research, addressing many sustainability aspects of textiles life cycle. This work covered multiple processes and sub processes related to textile production. The collected and processed data represents resource consumption and environmental impacts of agricultural technologies used for textile production in India and the industrial processes for converting raw material into usable textiles as well as some finishing processes. The creation of reliable, consistent and transparent LCIs can be useful to designers, manufacturers and consumers by to providing a basis for informed decisions in raw material selection and production technology.

SESSION T1-8 Sustainability of Agri-Food Products

LCA of aquafeed diets: analysing experimental diets to feed gilthead seabream

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Goal(s) Aquaculture appears as a good option to supply world fish demand however it still relies heavily on fish-derived products for aquafeeds production, which compromised the sustainable aquaculture growth. To solve this fish-derived ingredients dependency, fish nutrition researchers found two good alternatives, that assurance, at the same time, a good growth rate to fish and a good immunologic status: (i) replacement of fish-derived ingredients by plant feedstuffs ingredients, and/or (ii) partially replacement of dietary protein (P) content by carbohydrates (CH). However, to the authors knowledge, no study evaluated the environmental impacts associated to aquaculture diets with different P/CH ratios and, at the same time, different protein sources. This study assess and compares the environmental impacts of four experimental diets to gilthead seabream. The diets were made either with fish meal (FM) or plant feedstuffs (PF) as main protein sources and with dietary protein (P) to carbohydrate (CH) ratios of P50/CH10 and P40/CH20.

Method(s) The present study applied the Recipe Endpoint method, hierarchist version (V1.13; Europe recipe H/A). The functional unit used was 1 kg of experimental diet. The studied boundaries included aquafeed ingredients production (S1), compound aquafeed production under laboratory conditions (S2), and transportation between S1 and S2 locations. The background data was collected from Ecoinvent database and related literature. For each aquafeed ingredient used was accounted either the agriculture production or fishery activities, the processing unit, and transportation between the production and processing locations. Ingredients mixing and processing were done at the Marine Zoology Station (MZS) located at Porto, Portugal. It was also taken into account the road transportation of aquafeed ingredients between a commercial company and the MZS.

Results Regardless of dietary protein source or P/CH ratio used, all diets present a similar single score index. S1 was the system with the largest environmental impact. On the other hand, S2 is the lowest environmental contributor to all formulated diets. The exception is for P50/CH10 diets, where transportation of ingredients to MZS presented the lowest environmental impact. Fisheries-derived ingredients were the largest contributors to environmental impact. As FO (fish oil) from fisheries ‘by-products was the aquafeed ingredient with the largest environmental contribution in all diets, this study included two different hypothetical scenarios, which replace this ingredient by FO from Peruvian anchovy or by soybean oil (SBO). In these hypothetical scenarios, the replacement of FO from fisheries by-products by FO of Peruvian anchovy fisheries or by SBO lead to diets with lower impacts. Results show that the replacement of FO by SBO is the best environmental alternative. Those scenarios also highlighted that PF-based diets lead to lower environmental impact scores when compared to FM-based diets. At the end, studying the replacement of FO from by-products to FO from Peruvian anchovy or by SBO allowed to understand the importance of selecting ingredients to the purpose of the environmental sustainability to the aquafeed sector.

SESSION T1-8 Sustainability of Agri-Food Products

PRODUCT ENVIRONMENTAL FOOTPRINT OF SUPPLY SERVICE FOR SCHOOL MEALS: APPLICABILITY AND CHALLANGES

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Ecoinnovazione

The catering sector at EU level counts over 600,000 employers across Europe and de-livers over 6 billion meals every year. The total size of the foodservice market in Italy is about 6.2 billion euro, among healthcare sector (hospitals, clinics, nursing homes), schools and workplaces. The most important environmental impacts produced by the col-lective catering stemmed from food primary production and processing (e.g. energy, wa-ter), packaging, logistic and food waste. Therefore, the development of detailed guidance to assess them in a transparent, comprehensive and coherent way is fundamental to support the identification of improvement strategies, and to support the implementation of the product-related policy, such as the Green Public Procurement.

Among the methods for the evaluation of the environmental impact, the Product Envi-ronmental Footprint (PEF) stands out as the recommended method for the quantification and communication of the environmental impacts of products (goods or services). Build-ing upon existing approaches and international standards, the aim of the PEF is to set the basis for better reproducibility and comparability of the results.

The applicability and effectiveness of the method to evaluate the life cycle environmen-tal impacts of products has been tested during the PEF pilot phase of a set of products from different sectors. However, the services were not among the applications tested in the pilots and, to our knowledge, no applications of the PEF methodology on a service are available in the scientific literature.

This paper shows the outcomes of the first example of a PEF applied to a service, in particular the contracted supply service for school meal has been assessed, with refer-ence to the functional unit of one daily meal for one year (considering 200 school days). The application is the supporting study for the development of PEFCR for the school meal service, developed in the framework of the LIFE project EFFIGE.

The impact assessment results showed that the most relevant categories are eutrophi-cation and water depletion, followed by resource depletion, acidification and global warm-ing. The main responsible life cycle stage is the food production (meat and dairy prod-ucts), whose contribution ranges between 80% and 40% of the whole life cycle stage. Transport of food and consumptions in the kitchen (electricity and heat) are the second largest contributors.

Results will be shown and discussed in relation to the following main aspects: 1) granu-larity of the PEFCR, 2) capability of capturing the variability - in the environmental profile - of the food products, 3) identification of the most relevant processes characterizing the service life cycle; 4) the complexity of the services, which in most cases are tailored to customer requirements and needs, and thus the comparability is questioned.

SESSION T1-8 Sustainability of Agri-Food Products

Life Cycle Management of marine aquaculture seafood products

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WeLOOP

Consumption of seafood, including shellfish and seaweed, has been increasing with an average rate of 3.2% in the last 50 years. The high content of valuable nutrients such as proteins, carbohydrates, vitamins and minerals make seafood products an interesting alternative to animal nutrient sources.

The demand of seafood is expected to continue increasing in the near future, thus, sustainable solutions are needed to be provided by producers. Life Cycle Management (LCM) approaches can be used to identify hotspots in the production of seafood to decrease the overall environmental footprint of aquaculture products.

In the present study, marine nearshore and offshore mussels and nearshore seaweed and oysters' environmental impacts are studied by Life Cycle Assessment (LCA) methodology. The study is conducted in the framework of Value@Sea (nearshore) and Edulis projects (offshore) projects.

Primary data from pilot cases in Norther Western Europe (NWE) have been used to provide and extended overview of the environmental impacts of commercial scale cultivation designs. All the life cycle stages are included (cradle-to-grave study) and the assessment considers different production technologies, potential upscaling of the processes and different product packing solutions.

The aim of this presentation is to provide an extended overview of the life cycle environmental impacts of commercial scale cultivation designs at pilot scale. Hence, some recommendations for cultivation infrastructure designers are highlighted. Further research topics are recommended to endorse these results for commercial scale cultivation infrastructures.

SESSION T1-9 Other (not mentioned above)

Potential contributions of agri-food products to the SDGs

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Goals. In 2015 the United Nations adopted the Sustainable Development Goals (SDGs) (UN 2015). The 17 goals and their 169 targets are based on a global participatory and political process with the claim of a holistic framework of goals for global sustainable development. Intended for state-level, besides politics, companies and societies are called to contribute. Amongst others, it is necessary to find ways to integrate the SDGs into sustainability assessment frameworks. The aim of this study is to identify how the SDGs can be used to assess an agri-food product's or services' potential contribution to sustainable development along the product's life cycle. For this, the first question is to which SDGs and targets agri-food products and companies can potentially contribute.

Methods. The chosen approach was to identify on the targets' level to which SDGs agri-food products can potentially contribute. For this purpose cases for potential contributions of products and services have been defined. It has to be beard in mind that products and services are produced and offered by companies and thus, both on the level of products and on the level of the involved companies contributions are possible:

- Case 1 (C1): The product or service itself contributes along its life cycle
- Case 2 (C2): The product or service contributes through the activities of the companies involved along the life cycle

Results. A potential contribution of agri-food products could be identified to 16 out of the 17 SDGs and to 54 out of 169 targets. Only for the SDG 11 no relation could be identified. For seven SDGs only C2-relations could be identified, for the remaining nine SDGs both C1- and C2-relations have been determined. For 115 of the targets no relation to agri-food products could be identified.

The identified C1-relations comprise impacts through emissions on ecosystems, land and soil quality, global climate and human health as well as impacts through the use of resources like energy, water and resources, the disposal of waste, but also the resulting yields and incomes.

The C2-relations include potential impacts through the payment of adequate & equal wages, social security support, sustainability (risk) management, protective clothing, apprenticeships and trainings, equal chances, availability of drinking water & adequate sanitation, waste water treatment, fulfillment of the conventions of the International Labour Organisation, inclusion of small-scale suppliers in supply chains in particular from developing countries, investments in Research & Development, sustainable use of ecosystems, sustainability reporting, use of sustainability labels & standards, and engagement in multi-stakeholder processes.

Discussion. The analysis showed that agri-food products and companies cannot directly contribute to all targets or SDGs. This is mainly due to the fact that the SDGs have not been designed for sustainability assessment of products or companies. However, a contribution to almost all SDGs is possible. These contributions cover all sustainability dimensions: the social, environmental and economic dimension and also governance aspects. Thus, the results of this study can be a starting point for further research on the integration of the SDGs in sustainability assessment frameworks.

SESSION T1-9 Other (not mentioned above)

Identification of indicators to measure agri-food products' contribution to the SDGs

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Goals. The Sustainable Development Goals (SDGs) adopted by the United Nations (UN) in 2015, are the first detailed and comprehensive goals that differentiate the more general Brundtland (1987) definition of sustainable development and show clearly the direction for development in the future. In a previous study (Eberle & Schmid 2017) the SDGs and targets to which agri-food products, incl. services, potentially could contribute have been identified. Based on that work, the aim of this study is to identify what has to be measured to enable the assessment of an agri-food product's potential contribution to the SDGs.

Methods. For the identification of indicators suitable to measure the potential contributions to the SDGs, the proposed indicators of the "Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development" (here from referred to as GIF-SDG) (UN 2017) as well as indicators proposed for the assessment of products and services in Life Cycle Assessment (LCA) have been analysed regarding their suitability. For the latter the indicators proposed by the European Commission in the Product Environmental Footprint (PEF) process (EC, 2012; EC, 2013; EC, 2018) and indicators common in Social LCA (sLCA) (Kühnen & Hahn, 2017) have been taken as a basis. The analysis has been undertaken separately for contributions that are either caused through the products or services themselves (C1) or through the activities of the companies involved along the life cycle (C2).

Results. In total 58 indicators have been identified. These indicators have been separated into the two described groups. To the C1 indicator group belong all indicators that are directly related to the product/service itself. These are mainly indicators which are directly related to the material flows like the impact indicator Global Warming Potential. To the second group (C2) belong indicators that are related to the activities of the companies involved along the product's/service's life cycle, e.g. inventory indicators like the average worker's wages in the lowest income category. There are 26 C1-indicators of which 16 are impact indicators. Seven impact indicators have been derived from PEF, two from the GIF-SDG and PEF, three from GIF-SDGs (adapted) and PEF, one from PEF and sLCA (adapted), and three have been adapted from the GIF-SDG. Ten indicators are inventory indicators, with two of them only relevant if small-scale producers from developing countries are involved along the life cycle, and one only relevant for products containing ingredients of marine origin. All inventory indicators have been taken from GIF-SDG or have been adapted therefrom. For C2-contributions 32 indicators have been identified. Thereof 31 could be derived from GIF-SDG, most of them had to be adapted, but two could be taken directly. Two of the 31 indicators could also be traced to sLCA.

Discussion. The GIF-SDG was designed to measure achievements on a national level, and not to measure possible contributions of products and services. Thus, most indicators had to be adapted. The indicators proposed in the PEF framework are quite suitable as C1- indicators and no adaption was necessary. However, environmental LCA today does not cover all impacts relevant to cover with respect to the SDGs, i.e. biodiversity impacts or marine acidification are not yet proposed in PEF (EC 2018), although impact assessment methods are under discussion in LCA community. Further research includes the need to validate and discuss the proposed indicator set within a broad stakeholder dialogue.

SESSION T1-9 Other (not mentioned above)

ProScale: Human toxicity assessment in LCA

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BASF SE

Goal

Although regulatory requirements are in place to ensure the safe use of chemicals in their application, the ambition to reduce the environmental impacts of products along their life cycle is often combined with an ambition to identify and reduce hazards and exposures. As there is currently no methodology available to compare hazard and exposure performance along the lifecycle and identify priorities for improvement, requirements are often based on purely hazard-based lists for priority substances without evaluating their risk in specific applications.

LCA is widely used to quantify the overall environmental impact of products along the life cycle but the models for toxicity impacts are focussing on the indirect impact of chemicals emitted into the environment. As a performance-based indicator for the application in LCA; ProScale assesses hazard and direct exposure potentials from chemicals along their life cycle. It can be integrated in LCA to compare human toxicity potentials of alternatives. Furthermore, Environmental Product Declarations ("EPDs") and Product Environmental Footprints ("PEFs") in life cycle thinking, a risk-based approach for product assessments can be applied.

Several companies from the Industrial Sustainability practitioner network (ISPN) were involved in the method development and applying the method in LCA.

Methods

The ProScale methodology is a function of the four parameters (1):

- Hazard Factor (HF) – Describes the hazard of a substance, reflecting health effect, severity and potency based on hazard statements (also called H-phrases) and acceptable concentration levels (e.g. OEL, DNEL).
- Exposure Concentration Factor (ECF) – Describes the exposure concentration of a substance based on exposure modelling using the ECETOC TRA Tier 1 exposure model.
- Person-Hours Factor (PHF) – Number of person-hours of exposure per mass unit of produced product or service.
- Mass Flow (MF) – Describes the amount of a substance needed per functional unit of a product.

Figure 1 Illustration of the ProScale methodology.

The Hazard Factor, the Exposure Concentration Factor, the Persons-Hours Factor and the Mass Flows are calculated for each substance and each unit process and then combined to establish the ProScale score.

Results

Insulation boards aggregates were assessed in a cradle-to-gate approach together when the final insulation boards are produced.

The results can be shown in different ways. One option is to show all the product contributions linked with the pre-chain, another option is to list the results product by product. Table 1 shows all summarized ProScale factors including the pre-chain. Polystyrene is the most significant material due to the high input to the boards. It is followed by the pentane impact and the flame retardant.

Table 1 ProScale PSP in toxicity points of the insulation materials test case

	Polystyrene	Pentane	Graphite	Flame retardant	Neopor beads	Pentane (board prod)
Inhalation	1,56E-01	9,16E-03	0	1,61E-03	0	9,59E-03
Dermal	1,54E-03	7,91E-05	0	6,37E-06	0	7,91E-05
Oral	0	0	0	0	0	0

Table 1 shows, which materials along the life cycle have the highest impact. That is oil production, followed by the Naphtha input and the Benzene. Polystyrene as material has no direct impact, because it does not have an H-phrase as a material.

SESSION T1-9 Other (not mentioned above)

LCA on P3HB production from UCO

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The cosmetics industry has been using plastic additives for a long time in a variety of products, such as soaps, shampoos, anti-wrinkle creams, etc. These are non-biodegradable and water-insoluble synthetic plastic particles made from fossil polymers. After the application, most of these products end up in wastewater system. Even if wastewater passes through conventional municipal wastewater treatment plants, only a portion of the microplastics can be removed from it by existing technologies. In an effort to use waste for the development of new materials and with the ambition to reduce the environmental impact of microplastics, Nafigate Corporation along with Brno University of Technology and the Institute of Microbiology of the Academy of Sciences developed a biotechnology called Hydal, which represents a unique way of producing biopolymers Polyhydroxyalkanoates (PHA) from waste vegetable oil. This technology uses a special kind of bacteria that are an organic part of ecosystems to transform used cooking oil (UCO) into PHB biopolymers that serve as a reservoir for their internal energy. The resulting product is a poly-3-R-hydroxybutyrate (P3HB) biopolymer, known for its high quality and biocompatibility.

The LCA method was used as a tool for the development and optimization of Hydal biotechnology. The range of the assessed system was determined from cradle to gate, i.e. from raw material extraction including UCO collection to P3HB production. Neither the manufacture of cosmetics nor the phase of the products use was included in the LCA study due to various applications of P3HB biopolymer. Furthermore, the end of life of P3HB biopolymer after flushing cosmetic products into wastewater or natural recipients was not included due to lack of knowledge in this field and missing characterization factors for calculating the results of impact category indicators. Due to these limitations, not a functional but declared unit was set as 1 kg of cosmetics ingredient. During the inventory analysis, specific production data of 1 kg of P3HB were collected. The software SimaPro version 8.5.3.0 and the Ecoinvent 3 database were used for calculating results. LCA results were used as a basis for reducing the technology's environmental impacts.

Since the results of LCA studies are inherently relative – based on a functional, in this case declared unit, it is difficult to assess the significance of study results without the possibility of comparing them with the results of LCA products performing the same function. For this reason, the LDPE polymer made from crude oil, which is commonly used in the cosmetics industry in the form of microplastics and which has the same properties and function as P3HB biopolymer, was chosen for the comparison purposes. Both polymers are fully substitutable in cosmetics. The scope of the system for LDPE was the same as for P3HB, as the production and use of the cosmetic product is identical in both cases.

The comparison of the results of selected impact categories showed a significantly lower impact of P3HB compared to LDPE in all assessed impact categories (CML 2001 method). However, with the current level of knowledge, the LCA study failed to assess the environmental impacts of the end-of-life of both polymers. The main reason was the question of their biodegradability. Many studies have confirmed the excellent biodegradability of P3HB biopolymer, but a number of testing set unrealistic standards with unreal parameters. Therefore, Nafigate Corporation started to cooperate with a specialized institution – Institute of Chemistry and Technology of Environmental Protection, Faculty of Chemistry, Brno University of Technology, which became the topic bearer. In 2017, the first calibration tests were initiated. Comparative biodegradability studies have been ongoing since 2018. The fresh water biodegradation test has demonstrated full biodegradability of P3HB biopolymer. Hence, from the point of view of production and biodegradation in fresh water, the suitability of using P3HB biopolymer in the cosmetics industry has been clearly demonstrated. The optimal end of the life cycle is decomposition in a wastewater treatment plant or natural recipient. Specifically, the substance in the wastewater treatment plant biodegrades in about ten days; in nature within 60 days.

Significantly slower decomposition occurs in marine water. Although the biodegradation of biopolymers is likely to occur over a period of 2-3 years, at this stage of the research, salt water does not appear to be a suitable end to the life cycle of a P3HB biopolymer cosmetic product.

In conclusion, LCA study and biodegradability tests have confirmed the environmental benefits of P3HB production from used cooking oil. The production of P3HB from UCO significantly reduces environmental impacts in all assessed impact categories. Moreover, it is a concept that is in line with the principles of the circular economy, as it uses UCO as the source of energy in addition to using waste material in order to produce new products.

SESSION T1-9 Other (not mentioned above)

A new workflow for improving raw material characterization exponentially

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Geological Survey of Finland GTK

Goal: With exponential increase in the amount of battery-powered devices – from smartphones to electric cars –high quality characterization of geomaterials becomes increasingly important. This is true for primary raw materials (ores) as well as for recycled materials (batteries). There is a growing need therefore to be able to characterize the economic potential of such materials accurately and comprehensively.

Methods: Traditionally, such analysis of geological samples is done with bulk or 2D surface methods applied directly to the sample surface or the surface of a carefully prepared thin section. Automated analysis tools, such as QEMSCAN (Quantitative Evaluation of Minerals by SCANning electron microscopy) with SEM-EDS (Scanning Electron Microscopy – Energy Dispersive X-ray Spectroscopy), have become quite efficient and convenient, while more interactive tools, such as EPMA (Electron Probe Microanalyzer) or LA-ICP-MS (Laser Ablation – Inductively Coupled Plasma Mass Spectroscopy) provide unparalleled accuracy on elements covering almost the entire periodic table. The main drawback with 2D surface methods is knowing a priori where to section a 3D sample in order to obtain the best representative analysis. Contextual knowledge of the sample material can help a lot, but an economically significant part of the sample may nevertheless remain unexamined. We have therefore developed a workflow which takes away most of the subjectivity and chance of preparing 2D slices from 3D objects, such as rocks. The process begins with a non-destructive XCT (X-ray Computed Tomography) scan of a complete sample. Efficient scanning of samples at the drill core scale and larger (up to 30 cm in diameter) has only recently been made possible in Finland with the installation of GTK's new XCT equipment. The resulting tomographic image shows the internal structure, along with the heterogeneities, and can be used to locate areas of specific interest to the analyst. Thin sections, both optical and polished, are then prepared so as to deliberately intercept the features of interest observed within the 3D volumes. The first step of the workflow, XCT, is non-destructive and can later be used as a map for all subsequent analyses. GTK has a unique facility in Finland with XCT and advanced 2D mineralogical, geochemical and isotopic analysis systems in the same laboratory, with the researchers working in close collaboration.

Results: We present results where this workflow has been successfully applied to the discovery of minerals in exploration samples of commercial importance, efficiently combining XCT with QEMSCAN. We also present preliminary results from similar workflow on other types of materials, such as batteries, that includes trace element analysis by LA-ICP-MS. We show that expanding from 2D to 3D, improves exponentially the scientific and economic evaluation of a sample. We are also able to upscale our findings in-house, from laboratory-scale enrichment experiments to pilot plant scale, where the sample sizes can be in the order of kilotons.

SESSION T1-9 Other (not mentioned above)

Assessing the environmental performance of green and sustainable finance products: an LCA approach

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[Goals] In recent years, an increasing number of “green” and “sustainable” investment products have become available on financial markets. While these products represent a praiseworthy effort towards a more responsible financial sector, the lack of a general framework, let alone a standard, regarding their actual environmental and social performance may run the risk of undermining their credibility and increase the risk of greenwashing. For these reasons, both institutional and retail investors demand increasingly clear, robust and transparent metrics to assess sustainable and green financial products. Developing these metrics is a challenging exercise because of (i) the diversity of financial products (e.g. equity funds, index funds, speciality funds, corporate bonds) (ii) the lack of information necessary to link the financial products with their underlying economic activities (iii) general lack of data about the activities themselves. Here we aim at developing two assessment frameworks addressing these challenges to assess the sustainability of green funds and bonds, respectively, as accurately as available data permits.

[Methodology] In order to overcome the three challenges listed above, we propose to apply life cycle assessment (LCA) methods to assess financial products. In particular, we develop a methodology to evaluate the environmental and social performance of both sustainable and traditional equity funds based on input-output data, extended with environmental and social satellite accounts, as well as financial and economic data. Secondly, we design a methodology to assess the so-called “handprint” of green bonds by using LCA datasets to quantify the gap between the expected environmental footprint of the business-as-usual and that of the projects financed by the bond’s proceeds. This handprint is calculated by developing parameterized life cycle inventories proxying potential green bonds-funded projects, as well as the conventional alternatives that they aim at substituting.

[Results] Assessing the environmental and social performance of funds marketed as “green” or “sustainable” – with reference to traditional funds – highly depends on the underlying hypotheses regarding regions and sectors in which the fund is investing. As a general tendency, the positive gains in terms of environmental and social performance vary depending on the type of management strategies, namely active (in which fund managers apply a given investment strategy themselves) vs. passive management (in which funds replicate an existing index that follows, in turn, a third party methodology). Additionally, using LCA datasets, our method makes it possible to compute the “handprint” of green bonds. Our method yields a first-order, systematic estimate of the cost-effectiveness of different green bond investments, providing quantitative information to identify where a euro invested in these activities is more beneficial from an environmental standpoint.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?

Smart device for solid residues sorting

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The Brazilian Solid Waste Policy (2010) aims to guarantee the sustainability principles having as one of its instruments the application of selective collection, reverse logistics systems and other tools related to the implementation of shared responsibility for product life cycle.

This work demonstrates how the creation of a Smart Bin system is capable of identifying, sorting and storing solid residues (glass, plastic and metal) in an autonomous way, allowing a big contribution to lowering the necessity of human intervention in a very common activity in Brazil: the waste picking.

Using simple and easy to find parts in the market, the Smart Bin was engineered using Arduino, an open-source electronics platform based on accessible hardware and easy to code software, so that it can be fully replicated.

The Sorting process starts in the bin material sensor, detecting an object placed in the common discard receptacle.

Another set of sensors installed in the common discard receptacle acquires information about the material about to be sorted, according to its material density.

The acquired information is processed and compared to several different materials in a database, and after the comparison process, and the material is determined, the object is directed to its proper section of the bin, plastic, metal, glass or paper, without any human intervention.

When the smart bin is full, a sensor emits an alert to a responsible company to remove the sorted material, so it can be reinserted in another products lifecycle.

This first prototype has a lot of space for personalization according to the user necessities, assimilating technologies like solar energy, new kinds of sensors to sort new kind of materials and everything that the community might create according to its needs.

A job that has become increasingly common in Brazil is that of garbage pickers, an informal employment that provides no kind of physical or social security for the workers. The garbage pickers in Brazil, usually work in an unhealthy environment with no individual protection equipment, being constantly exposed to serial health risks due to the toxic, chemical and biological wastes exposition.

In this worrying scenario, the smart bin is an innovation that helps to mitigate social and environmental risks, thus contributing to the achievement of sustainability and reverse logistics, improvements are expected in the future, so that more classes of residues can be sorted, and so the precision level of the sorting process increases by applying more modern sensors and new revisions in the software code.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?

Assessment Roadmap for Emerging Bio-based Technologies – Identifying Sustainability Prospects with Multiple Perspectives

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Many bio-based technologies are emerging technologies, with the characteristics of being radical and fast growing. The 2018 Nobel prize in chemistry is based on enzymatic bio-based conversion as a green alterative for several conventional technologies. Overall, the transition to a bio-based economy is seen as a mean to reach sustainability, energy independence and economic growth. Bioeconomy strategies have however also been criticized for focusing too much on economic growth and too little on sustainability. Assessing potential life cycle sustainability risks and benefits early in the development of technologies – when still at lab or pilot scale – provides valuable insights about how to prioritize research activities and to potentially avert unintended consequences. The lack of knowledge and high uncertainty in early development however also makes such assessments challenging. On the social sustainability side, bio-based technologies create new jobs, while the social acceptance can hinder the market growth even in an innovation country like Sweden. Emerging technologies like for example artificial intelligence might reduce jobs and gene therapy in medicine might bear risk for coming future generation. The questions and risks are manifold. Therefore, it is essential to have a roadmap for guidance that takes a holistic approach to sustainability with a life cycle perspective. To add to the complexity, the possibilities for assessment approaches are extensive. Different perspectives can be assessed in numerous ways and with many different methods. The goal of this study is to contribute to a sustainable transition to the bioeconomy, by serving as a roadmap for research and innovation (R&I) on emerging bio-based technologies.

To suggest a general roadmap for holistic and interdisciplinary assessments, this study identifies, and describes the use of multiple perspective assessments in selected R&I projects on emerging bio-based technologies. The projects include virgin and waste raw materials, biotechnology conversion processes and products such as bio-based chemicals, building materials, soil amendment, and pellets for heat. The findings are, in combination with existing frameworks on biomass- and bio-product prospect models, used to suggest an assessment roadmap for identifying sustainability prospects of emerging bio-based technologies.

The result consists of an “assessment roadmap” including the perspectives resource-, economic-, environmental-, social- and market potential. Each perspective is accompanied by questions targeted to identify benefits and risks, such as “What valorization routes currently exists, and are under research, for the feedstock?”; “Is the feedstock available, also in the future?”; “Is the production technology socially accepted?”. The roadmap for bio-based emerging technologies also provides advice on the procedure for sustainability assessments, such as organizing an initial workshop with expert knowledge and highlight the importance of scanning before allocating resources for in depth analyses.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?

Integrated Innovation and Sustainability Analysis of Pulsed Electric Field Treatment (PEFT). Scenarios, Preliminary Inventory and Impact Data of an Emerging Technology in Industrial Processes.

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Goal: In order to bring new promising technologies into existing well established industrial processes, there has to be an attractive innovation idea, a feasible way to implement it and a good business model. However, what else can be the barriers, drivers and risks of emerging technologies?

The analysis of the environmental impact of products and services over the whole life cycle (LCA) can be done well for existing or quite far developed products and services. Nevertheless, when the product and its production and logistic processes have not been fixed yet, it is not that easy to carry out.

There is a dilemma: The uncertainties regarding market conditions like, regulatory frameworks, competing technologies and the knowledge regarding environmental impact are large. Yet, also the possibilities to influence the design and development of the new technology are large.

The goal of the Integrated Innovation and Sustainability Analysis is to determine economic and environmental guiding parameters and optimization suggestions for the technological R&D. It is applied on the PEF treatment , a novel technology to reduce the number of microorganism (MO) in process water and liquid paint in an industrial application. It is a potential substitution to the conventional process based on chemical biocides.

Method: The mentioned analysis is conducted within the publicly funded collaborative R&D project DiWaL and is done in close collaboration with the project partners: a plant manufacturer, a car manufacturer, paint suppliers and other research institutes. The methodological approach of stakeholder involvement within the Integrated Innovation and Sustainability Analysis (IISA) is described in the following:

The first step is Stakeholder Analysis (SA) to take a holistic view of the value chain in terms of the life cycle perspective. For this purpose the following (successive) methods are used: a) stakeholder mapping, b) interest/influence portfolio, c) illustration in the life cycle perspective.

Stakeholder mapping is used to identify stakeholder groups and analyse their relationships in order to gain a better understanding of the system, the flow of information and the dynamics of the system. The relevance of the stakeholder groups is assessed by classifying them in an influence/interest portfolio. This results in an indication which stakeholder groups are suitable for further dialogue or integration and how communication with the other stakeholder groups will be continued. Finally, the life cycle perspective is analysed (also using results of the two previous methods) and then illustrated. Depending on the available resources different levels of effort are possible for the SA. The analysis can range from low (own experience, internet research) or medium (discussion in the company/project group, selected interviews) to high effort (multiple interviews, surveys). For assessing environmental impacts, a scenario-based LCA is applied to reflect and manage uncertainties occurring at early innovation phases.

The second part of the IISA complements the previously described part of stakeholder involvement with sustainability assessment. For decision support on the implementation of emerging technologies and technical innovations these have to be evaluated against incumbent technologies or other alternatives regarding many different characteristics, including sustainability aspects, at the beginning of the innovation processes.

In order to get the 'whole picture', it is vital to extend current life cycle thinking to encompass all three pillars of sustainability: (i) environmental, (ii) economic and (iii) social. This means carrying out an assessment based on environmental, economic and social issues – by conducting an overarching life cycle sustainability assessment (LCSA). The following paragraph shortly describes how we approached this target.

There are different types of so called ex-ante LCAs which take several aspects of "future" into account. They are all varieties of analysis which can be seen as explorative LCA. The LCA combine several of these aspects (prospective and anticipatory assessment). Potential environmental impacts are estimated via material flow analyses and life cycle assessment approaches. The environmental assessment of the innovation is based on a parameterized energy and material flow model. This model delivers life cycle inventory data (LCI) such as energy demand and material used e.g. in production phase but also in up- and downstream processes. Applying a mixture of streamlined LCA using expert guess for assumptions, scenarios and hotspot analysis, allows an evaluation of the potential environmental impact of the innovation early in the development phase.

The assessment of the economic sustainability is done based on the "Total Cost of Ownership" (TCO) approach. In analogy to the life cycle assessment, investment and operation costs occurring during all life cycle stages are taken into account.

An actual social-LCA, corresponding to current state-of-the-art recommendations has not been conducted up to now.

The innovation analysis has a focus on integrating the various stakeholders of the technology and their requirements, in order to determine and assess specific barriers, drivers and risks of the technologies. Results are used to support the project partners in their R&D activities by feeding back potential future outcomes of the technologies into the innovation process.

Results: The alternative technologies have a very different mechanism of action. Therefore, the impact pathways are quite different, too.. On the one hand, the PEFT has the potential for saving water consumption, but needs electricity for the application, which will cause energy-supply related environmental impacts. On the other hand, the corresponding biocides are chemicals which have a rather high toxicological impact potential, but only if released to the environment. The evaluation of the potential effects of the investigated chemical biocides is based on USEtox, characterizing human and ecotoxicological impact. Since the substances are used within a closed system no impacts were calculated.

The assessment of several scenarios showed that PEFT could have relative high environmental impacts, if current electricity mixes are assumed. On the other hand, if a future electricity mix is assumed, the environmental impacts, especially, from climate change will be much lower, but the costs may be higher than today.

SESSION T2-1 Emerging Technologies - Sustainable Future or Rising Risks?

LiSET: a lifecycle screening method for emerging technologies

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Goal:

Technologies at low readiness levels present a dilemma: such technologies are still free from lock-in effects for design changes improving environmental performance, yet lack the data required for an LCA to inform such changes. The aim of this work was therefore to develop a method that identifies environmental benefits and pitfalls of a large number of technological candidates using a lifecycle perspective such that the most environmental sustainable technologies are adopted.

Methods:

The lifecycle screening of emerging technologies (LiSET) method presented here is applied at early development phases, i.e., lab- or pilot-scale, to screen technological candidates for lifecycle environmental performance. Typical LCA data are often unavailable at these stages, and there are often many possible technological candidates to evaluate, rendering a traditional LCA difficult or impossible to perform. LiSET is an iterable screening-to-LCA method, which may be used to follow technological development. In its earliest form, LiSET screening results are presented in matrix form with a 'traffic light' color grading system. This format allows the quick comparison of many technological candidates while also communicating the high levels of uncertainty in the results such early development stages. As development progresses, more data become available and candidates are eliminated: the assessment approaches a traditional LCA. The method described in LiSET aims to preserve objectivity and transparency in all steps of the analysis, which earlier attempts at formalizing screening and streamlined LCAs have neglected.

Results:

The resulting LiSET method allows the screening the environmental impacts of emerging technologies for which traditional LCA data are not yet available due to low readiness levels. The strengths of LiSET are many: the ability to iteratively transition to a full LCA as the technology matures and more data become available; the focus on objectivity and transparency; the leveraging of non-traditional LCA data; the ability to map a large number of technological candidates and to pinpoint hotspots of environmental concern from a lifecycle perspective.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Energy systems modelling and prospective life cycle assessment of the penetration of battery and fuel cell electric vehicles in Spain: a focus on the fuel production mix

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Introduction and goal:

The path towards a sustainable future is highly conditioned by the effective development of an appropriate energy system. In this sense, sensible energy planning strategies should take into consideration not only techno-economic aspects but also other sustainability aspects such as environmental and social indicators. Since energy systems models are typically used to support energy planning, their enrichment with life-cycle indicators of the embedded technologies would allow analysts to further assist energy planners in making sound decisions. In fact, the endogenous integration of life-cycle indicators into energy systems models constitutes a field of research of growing interest. However, the number of sustainability-enriched energy systems models is still very low, with the most relevant ones focused on the power generation system. On the other hand, transport models are affected not only by the lack of endogenous life-cycle indicators but also by a poor inclusion of fuel technology options. Within the framework of a national project for Spain (ENE2015-74607-JIN AEI/FEDER/UE), the goal of this work is to develop a technology-rich model for the sustainability-oriented planning of the Spanish road transport sector.

Methodological framework:

In particular, this work focuses on the combined use of Energy Systems Modelling (ESM) and Life Cycle Assessment (LCA) in order to prospectively assess a number of separate energy scenarios on the low, medium or high penetration of battery and fuel cell electric vehicles (BEV and FCEV, respectively) in Spain. The focus is laid on the long-term evolution of the electricity/hydrogen production mix and the subsequent evolution of a set of life-cycle indicators characterising each scenario.

Results and conclusions:

A technology-rich transport model endogenously provided with life-cycle indicators is now available to support the sustainability-oriented energy planning of the Spanish road transport sector. Its application to scenarios of BEV and FCEV penetration led to discuss the evolution of the electricity/fuel technology mix under techno-economic and socio-environmental aspects. For instance, wind power plants were found to play a key role in meeting the increased electricity demand associated with BEV penetration. Furthermore, BEV penetration was found to slightly affect the national power generation sector while significantly reducing the life-cycle impacts otherwise associated with conventional transport technologies. A similar finding was found for FCEV penetration in terms of a favourable life-cycle performance. In this regard, renewable electrolysis was identified as a key hydrogen production technology. Despite the proven potential of this type of ESM + LCA initiative, further efforts are still required to continue enriching the model with additional technology options, sustainability indicators, and energy scenarios.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Comparative Life Cycle Assessment of a novel Al-ion battery cell and the current Li-ion technology

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Goals

Given the major concerns about Li-ion batteries, such as supply risk of Cobalt and high production impact, recently different chemistries have been proposed as substitute (Nitta et al. 2015) . ALION, an EU funded project, aimed to develop a novel Al-ion battery cell for stationary applications, where the lack of Cobalt and Lithium is expected to overcome some major concerns among policy makers and stakeholders. The goal of the study was to assess whether the novel technology has the potential of replacing the state-of-the-art Li-ion chemistry, and what trade-offs might arise, under an environmental perspective. In order to have a comprehensive overview, we performed a cradle-to-grave study of 18650 cells and a cradle-to-gate LCA of pouch cells. For the End-of-Life treatment we were provided with primary data by a German recycling industry (Accurec Recycling GmbH), thus we investigate different approaches commonly used in the LCA framework, namely the recycled content, cut-off, and allocation at the point of substitution (APOS) (Steubing et al., 2016).

Methods

To assess the environmental impacts of both the Al-ion and Li-ion cells, we performed an attributional process-based life cycle assessment with focus on different impact categories. The inventories compiled for the studies are largely based on primary data, regarding the production phase, and fully based on primary data for the recycling phase. The assessment was undertaken for 2 different functional units –per cell and per kWh-, and both an uncertainty and sensitivity analysis were performed with regards of key parameters.

Results

The impact assessment reveals that currently the production of Al-ion battery cells, either in the 18650 or pouch format, outperform the reference Li-ion cells, when the assessment is carried out on a per cell basis. Indeed, the Global Warming Potential score of the Al-ion cells is 0.71 and 2.28 kgCO2-eq, for the 18650 and pouch format respectively. On the other hand, the chosen Li-ion reference cells have impacts of 1.32 and 8.82 kgCO2-eq (Ellingsen et al. 2014).

However, currently the Al-ion chemistry has a lower energy density compared with a Li-ion cell, with 4 Wh/kg against 170 wh/kg. Thus, when the results are normalized on a per kWh basis, there is a wide gap between the two chemistries, regardless of the format. At the moment, the pouch format shows higher potential for breaking-even with the current Li-ion technology, under a GHG perspective. The results stemming from the recycling phase show that the choice of the right allocation method is crucial for studies focused on recycling. Li-ion batteries show the greater variety in the results, mainly due to the relevance of the recovered copper which can lead to negative scores impact several impact categories, when the APOS is applied. Regardless of the technology, the energy used for the manufacturing phase is the major driver of CO2-eq emissions, meaning that great benefits can be achieved with its reduction.

Finally, at the moment Li-ion batteries are still the best option for stationary applications, and the ALION battery is not yet ready as a replacement.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

PRO-ENVIRONMENTAL EVALUATION OF PHOTOVOLTAIC POWER PLANT MATERIALS AND ELEMENTS FOR THEIR SUSTAINABLE MANAGEMENT

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1. Goal

Modern civilization is almost completely dependent on energy. Economic and social analyzes indicate that civilizational changes are exacerbating this dependence. Due to the need of greenhouse gas emissions reduction, the need to increase energy independence of countries and the progressive depletion of fossil fuel resources, modern societies have begun to use more and more alternative sources of energy, including solar energy. Proper use of both non-renewable and renewable fuels requires not only financial and social costs but also the solution of many important issues in ecology, sociology, technology and security. Therefore, the essence of the present research was environmental testing of life cycles of plastics, materials and elements of photovoltaic power plant for improving the possibility of creating the sustainable methods of their post-consumer management.

2. Methods

The analysis was carried out for 1 MW photovoltaic system, located in northern Poland and capable of producing (950-1100) MWh per year. Basic elements that make up the relevant photovoltaic power plant are: support structures, photovoltaic panels, cables and connectors for the electrical system, cubicle substation with inverters. The panels are made of glass, aluminium, silica, EVA, PVB, cadmium, lead, copper, nickel, selenium, and silver. Other materials are: galvanised copper, cross-linked polyolefin, tin-plated copper, polyvinylidene fluoride and polyamide PA6, silicone, neoprene, modified polyamide PA12, steel, concreate.

The proceeding will be a classic LCA process that will determine the size of the negative impact on the environment. The functional unit was defined as the production of 1000 MWh of electricity by the installed plant during the year. Impact Assessment (LCIA) was performed using the SimaPro. The Eco-indicator 99 method was used based on the endpoints of the environmental mechanism.

3. Results

The paper includes presentation and discussion of the results that are specified levels of hazard impacts on the environment of the different stages of the life cycle of photovoltaic power plant. Different processes of post-consumer management was selected: landfill and recycling. The impact of the life cycle of power plants in the three impact areas: human health, environmental quality, raw materials was also analyzed. The highest level total of negative impact on the environment was the stage of production: 37770 Pt and post-use disposal in landfill disposal: 4691 Pt. Recycling of power plant components at the end of its life cycle would reduce the negative impact of the life cycle by a total of 23804 Pt. The highest level of harmful impact in each area was the production stage (from 3366 Pt for environmental quality to 21593 Pt for raw materials). The most negative impacts were recorded for the depletion area (total 9759 Pt) and the lowest for the ecosystem (3980 Pt)

Based on the research conducted, it is proposed to reduce the negative impact on the environment of production processes, which are the life cycle stage with the greatest harmful impact on human health, environmental quality and raw material depletion, by implementing modern technologies with lower energy consumption, material consumption and emissivity of harmful substances.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

DEGREEN project: Life Cycle Assessment of electrical energy generation by Dielectric Elastomer Generators (DEG)

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With its energy program, the Bavarian state government wants to cover around 40 percent of the Bavarian electricity demand by 2025 from domestic renewable energies. The Fraunhofer Institute for Silicate Research ISC is pursuing an innovative approach to regenerative power generation in the DEGREEN project, focusing on hydropower and using extremely stretchy, wafer-thin elastomer films that function like a capacitor, so-called dielectric elastomer generators (DEGs). If water flows through a pipe construction (Venturi nozzle), a negative pressure arises in a riser pipe. Due to this negative pressure, the stretched elastomer films bulge inwards. By closing a valve and venting the vacuum, a periodic cycle is established. For this new technology, the Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS worked out the present Life Cycle Assessment study. The aim of the study was to estimate how environmentally friendly the electricity generation by the developed DEGs is in comparison to conventional small hydropower plants and the average German electricity generation market (electricity mix of Germany).

The elastomer generator technology converts mechanical energy directly into electrical energy. The environmentally friendly, robust system does not require any rotating or moving parts and therefore the shoals of fish are not endangered. In addition, the operation of the system is silent and components of conventional electric generators like rare earths and metals can be spared.

The study compares the environmental impacts of the generation of 1 kJ of electrical energy from DEGs with small hydropower plants and the Germany electricity mix. It will be shown that the production of polyvinyl chloride, polyethylene and silicone are the three dominant environmental factors in DEGs. The DEG films themselves are responsible for about 30 % of the GWP impact. The results of the sensitivity analysis advice that the DEG foils easily influence the environmental performance. Increasing the number of periodic strain from 10 million to 200 million cycles the climate impact will decrease from 4.6 · 10-6 kg CO2eq to 3.2 · 10-6 kg CO2eq. That corresponds to a saving of about 17 % GWP.

The major part of the environmental impact of DEG (70 %) occurs during the manufacturing of the plant. In order to minimize the effects of this phase, it is recommended to reduce the amounts of materials with particularly high environmental impact (e.g. polyvinyl chloride and polyethylenes) and to test the possibility of substituting these materials. In addition, we recommend the identification of appropriate capacities and further developing of the technology to improve environmental performance.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Benefits from decentralized power generation of marine plastic waste

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Approximately 5 billion people still lack access to basic waste services such as collection or controlled disposal. Uncollected waste, in particular plastic waste, is burned, dumped or discharged to waterways, damaging human health, the environment and ecosystems at local and global level. Decentralized, small-scale and modular solid waste treatment facilities which can be coupled with power generation provide an adjustable solution for communities along near coastal areas to establish initial waste management capacities.

The present comparative LCA study evaluates different types of decentralized power generation systems such as a diesel generator and a module for energy recovery from plastic waste and their effect on the common fate of plastic debris for instance landfilling or uncontrolled combustion. By considering local conditions and waste compositions different scenarios are assessed. The results show that the use of plastic waste as an alternative fuel for power production could contribute not only to reducing plastic pollution but also to reducing air emissions and resource depletion.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Quantifying the Impact of Low Emission Bus Incentives on the Life Cycle of Alternative Bus Fleets in the UK

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Goals - To increase uptake of low and zero emission bus technologies, bus fleet operators are offered financial incentives to reduce capital and operational costs. However, there is uncertainty about the most environmentally and economically sustainable method of delivering these incentives and the impact it could have on the procurement, operation and wider life-cycle implications of new technologies. The first goal of this study is to develop a framework to quantify the life cycle cost, carbon footprint and risk of alternative technologies. The second goal is to conduct an initial investigation into the impact that low emission bus incentives have on the total cost of ownership for low carbon technologies.

Methods – The life cycle framework developed comprises a fleet sizing model, vehicle energy consumption models and a hybrid-LCA model for quantifying the life cycle cost and carbon footprint of conventional diesel, micro-hybrid, mild-hybrid and battery electric bus fleet scenarios for a London based case study. Three incentives scenarios currently under consideration by the UK bus industry are modelled: business-as-usual, a revised proposal offering higher relief for zero emission technologies with future reduction in operational incentives, modelled with and without capital cost support. Probabilistic simulation is conducted, and the results of each scenario are interpreted over a range of possible outcomes.

Results – Analysis of stochastic results are ongoing, and the final submission will present the life cycle cost, total carbon footprint and cost-effectiveness implications of each incentive scenario in the form of a technology roadmap. However, it can be concluded that the life cycle framework developed enables support for the decision-making process, even accounting for external factors (i.e. policy changes), for the implementation of new bus fleet technologies. The model created for the framework presents a novel capability for making comparative assertions about life cycle impacts over a comprehensive system boundary on a fleet level.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Sustainable and best use of biomass for electricity, fuels and chemicals in the European Union: a network life cycle optimization approach

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Vegetable biomass resources, unlike other renewables resources, present a wide range of alternative production and environmental profiles, providing one of the most promising options for replacing fossil-based resources in the transition towards more sustainable energy, transportation and chemical sectors.

A large amount of biomass processing routes are already available in the literature while finding new technologies is still a major focus of research. Nevertheless, this wide assortment of potential production pathways, along with the limited availability of the biomass and increase competition for those suitable feedstocks between sectors, hinders the identification of best use for biomass resources. This situation calls for new approaches capable of systematically identifying the most sustainable biomass utilization strategies to support the decision-making process.

Here, we present a novel Life Cycle Optimization (LCO) approach which allows determining best strategies for biomass utilization considering both economic and environmental criteria. We first generate a biomass superstructure containing hundreds of biomass conversion technologies to electricity, fuels and chemicals while taking into account simultaneously other technical, resource availability or demand satisfaction constraints. The biomass network includes eight alternatives for biomass feedstocks (i.e, dedicated bioenergy crops in marginal land and residues from agroforestry) and 224 technologies and 175 compounds (e.g., pre-treatment, mechanical processes, chemical conversion, intermediate products) to satisfy demands for electricity, biofuels and ethylene. The environmental performance of the production pathways is characterized through the application of a Life Cycle Assessment (LCA) approach that allows evaluating all cradle-to-gate environmental impacts associated through a set of midpoint and endpoint indicators referring to single environmental problems as well as to areas of environmental protection (i.e., ReCiPe methodology).

To illustrate the capabilities of our approach, we apply it to the European Union considering that the demands for electricity, transport fuels and ethylene can be only satisfied with indigenous biomass resources. We solve the EU biomass network following a multi-objective optimization approach which allows exploring the trade-offs between the economic and environmental objectives. Broadly speaking, our results show that there is a clear trade-off between the costs and the environmental impacts and that significant benefits could be attained by replacing conventional fossil-based technologies by biomass-based routes. For example, the Climate Change impact could be reduced as much as 1.81 Gt CO2eq (52% compared to the current EU situation) at the expense of increasing the cost by 49% which highlights the role that biomass can play to achieve the EU commitments such as the 2030 targets for renewables or the Paris Agreement goals. Indigenous biomass resources are found to be insufficient to fully cover the total EU demand for ethylene, transport fuel, and electricity, so that biomass resources should be prioritised for power generation and biofuel production while ethylene should continue to be produced through conventional means (i.e., derived from naphtha).

Overall, the proposed methodology aims at facilitating the identification of sustainable optimal biomass utilisation strategies taking into account local conditions and limitations. The approach presented generates valuable insight to aid decision and policymakers on how to use biomass resources sustainably.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Emissions of electric vehicle charging in Europe in 2 °C-consistent scenarios

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Goal

Switching from petroleum-burning vehicles to electric vehicles powered by climate-friendly electricity is an important strategy to stabilize the climate. Understanding the current and future emissions associated electric vehicle charging is a key component to formulating effective electric vehicle strategies. At the same time, developing such an understanding is a challenge: Among other things, this is because of the the location- and time-specific character of both electricity generation and vehicle charging, and to uncertainty surrounding future electricity generation mixes. The importance of time can be expected to increase in the future as electricity generation from variable and weather-dependent energy sources (i.e., wind and solar) increases.

We explore the greenhouse gas emissions of electric vehicle charging in Europe in different scenarios consistent with 2 °C climate stabilization. In particular, we explore the effects of vehicle charging time (time of day) on emissions in 2 °C-compatible scenarios.

Methods

We combine climate stabilization scenarios that describe long-term evolutions and aggregated characteristics of power systems, detailed power system modelling that determines energy balances (supply, consumption, trade, losses) at an hourly time resolution and with consideration of inter-annual variability of weather, and future-oriented life cycle analyses that quantify direct and indirect emissions of electricity with consideration of future technological progress. We quantify emissions for three hypothetical charging regimes (fixed charging, home charging and workplace charging), and one 'smart' regime where charging follows solar electricity generation. We explore a range of electricity generation scenarios that rely with different degrees on wind, solar, nuclear and natural gas energy. We account for emissions of electricity in consumption-based terms, meaning that we track how electricity demand in a country causes emissions elsewhere due to inter-country trade of electricity (such trade is a model outcome of the detailed power system modelling). We consider both average and marginal emissions from electricity.

Results

Results will be available for the conference. We investigate questions such as: What are the emissions of electric vehicle charging in future scenarios for Europe? How do the emissions vary depending on time of charging (time of day) and country? Does the consideration of time of charging increase or decrease emissions estimates, compared with quantifications that do not consider time of charging? What combinations of electricity mixes and vehicle charging profiles yield the lowest emissions footprints of charging? Finally, what are the emissions reduction opportunities of 'smart' charging regimes, such as charging at daytime when solar electricity generation is at a maximum?

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Prioritisation of bioenergy systems for residential heating in Portugal

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Goal;

The effects of climate change and the continuous depletion of fossil fuels require a wide deployment of renewable energy systems, promoting a change to a global bioeconomy. The implementation of processes based on the production, supply and processing of biomass can boost that change. In particular, bioenergy options based on wood feedstocks emerge as a sensible solution for residential heating. In order to prioritise the best bioenergy options among the currently commercial technologies, this work proposes the application of a set of multi-criteria decision analysis (MCDA) tools to common wood-based alternatives for residential heating in Portugal.

Methods;

Five different systems based on the combination of three technologies (pellet, wood stove and traditional fireplace) and the use of two different feedstocks widely available in Portugal (eucalypt and maritime pine species) are evaluated. Eight criteria are used for the assessment of wood-based alternatives, covering the three dimensions of sustainability: global warming potential, terrestrial acidification, freshwater eutrophication and ozone formation (environmental dimension); annualised capital costs and annual operation and maintenance costs (economic dimension) and, working hours and number of days of absence due to non-fatal accidents during the biomass feedstock production (social dimension). Regarding the multi-criteria analysis, four MCDA techniques for the prioritisation of alternatives are applied: Weighted Sum Method, TOPSIS, ELECTRE, and PROMETHEE.

Results and conclusions;

The calculation of the sustainability performance indicators and the application of the MCDA tools identify the wood stove system with combustion of maritime pine logs as the best alternative. This alternative is positioned first in the four MCDA rankings included in the analysis, although scores are similar between the two wood stoves alternatives (with exception of the application of ELECTRE method). Thus, both alternatives could be considered as appropriate bioenergy systems for residential heating in terms of sustainability performance, showing a relative good profile for each of its dimensions. Regarding the worst alternative, the system based in the use of fireplaces with combustion of eucalypt logs is positioned last in three of the four MCDA rankings obtained. This fact is linked to the unfavourable environmental performance of fireplace systems as well as their relative high annual operational costs and days of absence due to non-fatal accidents. This work shows how an appropriate selection of bioenergy alternatives in terms of sustainability is proven to be relevant for paving the way to a future widely deployment of the European bioeconomy sector.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Life cycle assessment of shale gas production in Spain

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1. Goal

Even though the environmental impacts of shale gas have been extensively discussed in the scientific literature, most studies only evaluate single environmental impact categories. To fill this gap, this work assesses the impacts of natural gas (NG) from shale formations (or shale gas) making use of the life cycle assessment (LCA) methodology. The study focus on a shale gas project located in the Cantabrian basin, in the province of Burgos, Spain (BNK, 2014).

2. Method

A cradle-to-gate system was evaluated, considering the pre-production and production phases. The functional unit is 1 MJ of processed NG. Unprocessed NG has a lower heating value (LHV) of 41.4 MJ/m3 and a density of 0.86 kg/m3. The processed gas has a LHV of 42.2 MJ/m3 and 0.80 kg/m3, following the transmission requirements in Spain.

The inventory analysis used SimaPro 8.4.0.0. The Ecoinvent 3.1 database was employed as the main source of background data (Wernet et al., 2016). Other data sources include the specifications for the evaluated project (BNK, 2014) and statistical distributions obtained from data available in a variety of sources. The CML-IA Baseline version 3.02 method (CML-IE, 2016) was used to assess the impact categories. The sensitivity of results was assessed considering relevant parameters.

3. Results

The results show that the most critical phases in the life cycle of shale gas are well casing and cementing, hydraulic fracturing, NG production, gathering, and processing. The consumption of diesel, water, and chemicals used in hydraulic fracturing, besides the emissions of raw NG to the atmosphere are the major contributors to the environmental impacts. Operations with lower contributions to the total environmental impacts are the well completion, and the transmission and distribution. Well abandonment is the phase that contributes less to all environmental impact categories.

The sensitivity analysis showed that parameters affecting more than three impact categories were the total recovery of NG, the length of the gathering pipeline, the penetration rate of the drilling rig, the water use in hydraulic fracturing and the number of workovers. The comparison of results with similar studies demonstrates relevant differences in the toxicity related categories. However, results converge in the assessment of global warming potential and abiotic depletion potential of fossil fuels.

This study identified relevant data gaps for the life cycle of shale gas in Europe, which is related to the immature stage of exploration of this resource. Therefore, several uncertainties of the environmental impacts of shale gas production remains. As a consequence, a future shale gas exploration in Europe should be conducted carefully, considering the environmental and social costs of extraction.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

An environmental comparison of centralized and decentralized wood pellets production for residential heating

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The Portuguese national action plan for renewable energy under Directive 2009/28/EC promotes the use of forest biomass, namely wood pellets for residential heating, as a key environmental strategy to achieve GHG benefits compared to fossil-fuel alternatives. Portugal is the tenth producer of wood pellets in the European Union. In Portugal, wood pellets are usually produced in industrial pellet production plants. However, wood pellets can also be produced at sawmills or at households.

This study applies life cycle assessment (LCA) to quantify and compare the environmental profile associated with the burning of wood pellets from maritime pine for residential heating, considering centralized and decentralized production of wood production. Three scenarios were considered: (1) industrial wood pellets production, where wood pellets are produced at an industrial pellet plant; (2) wood pellets production at sawmill, in which the sawdust from sawmill is transformed into wood pellets using small pelletisers, and (3) wood pellet production at households, in which householders produce their own wood pellets, pressing the sawdust from sawmill into small pelletisers. System boundaries include forest management, wood pellets production, distribution and thermal energy generation into pellet stove, wood stove and fireplace. The functional unit is 1 MJ of thermal energy generated for residential heating purposes. Inventory data are representative of the current typical technological systems of wood pellets production and burning in Portugal. Environmental impacts were calculated for seven impact categories from the ReCiPe 2016 midpoint method: global warming, fossil resources scarcity, terrestrial acidification, freshwater eutrophication, marine eutrophication, ozone formation (human health) and ozone formation (terrestrial ecosystems).

The results showed that the industrial pellet production scenario presents the worst environmental profile, while pellets production at households presents the best environmental profile. The worst environmental profile from the industrial pellet production scenario results mainly from the burning of logging residues to produce heat for drying biomass and from diesel combustion to feed the feedstock to the grinder, during the industrial pellet production stage. These activities do not occur in the other scenarios considered. The pellets production at households presents the best environmental profile because less transports steps are required, i.e. only a unique transport of sawdust to households occurs. In fact, the main difference between the pellet production at sawmill and households scenarios are related to the transport of feedstock material.

In addition, a sensitivity analysis has been performed to evaluate the effect of changing the distances travelled to distribute pellets to stores and to transport sawdust to households. The results reinforce the importance of transport to global warming and fossil resources scarcity. It was observed that for these categories, the pellet production at households scenario has the best environmental performance up to a distance travelled to transport sawdust to households of 63 km and 60 km, respectively. For higher distances, the industrial pellet production scenario arises as the best alternative. Important aspects to consider in further research include the increase of energy efficiency during the pellet production stage, including the increase of pelletiser capacity.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Environmental benefits of an EU second-generation bioethanol production network designed by integrating LCA and supply chain network optimization

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Decoupling the global economy from fossil fuels and shifting towards the use of renewable resources is the main objective to limit global warming to 1.5°C. Second-generation (2G) bio-ethanol is a promising substitute for fossil resources in applications like solvents, intermediates in the chemical industry, or fuel. In the EU, the first commercial large-scale 2G biorefinery is currently being realized and expected to be online by 2020. Agricultural residues, one of the most promising feedstocks for upcoming biorefinery concepts, exceed a bioeconomic potential of 110 Mt (corresponding to about 1.925 PJ) and could increase to 125 Mt by 2030. This work roadmaps an upscaled biorefinery network in the European Union, designed by the integration of Life Cycle Assessment in supply chain network optimization. In this work, we are dealing with the question of the optimal design of a European second-generation bioethanol network that maximizes environmental benefits under the satisficing goal of competitive biofuel prices.

By means of mixed integer linear programming (MILP), a second-generation bioethanol production network is designed under optimization of environmental benefits and satisfaction of specific production cost. The multi-criteria model design includes 21 ecological objectives (18 midpoints and 3 endpoints, based on ReCiPe 2016) optimize the environmental benefits compared to 1G bioethanol and to fossil based fuels. To assure the competitiveness of 2G bioethanol, specific production costs are implemented as satisficing goal. The model design further allows an assessment of the sensitivity of the results and the network size to changes in the parameters and the model itself, such as a variation of the economic satisficing goal or the available feedstock potential. Another aspect is a sensitivity analysis regarding the choice of the method for allocating environmental impacts to crops and straw respectively, using mass allocation, energy allocation or economic price allocation. The functional unit of the model is MJ. The system boundary is cradle-to-tank, which considers feedstock cultivation, provision and distribution, ethanol production and the end-product distribution.

The first results show, that a maximum production 2G bioethanol volume of 22 Mt today and 25 Mt in 2030 could be realized. This volume corresponds to about 650 PJ of energy that could be used from agricultural residues without compromising the regional demand for agricultural residues. When directly substituting fossil based fuels in the transportation sector, over 40 Mt of CO_2 could be saved, which corresponds to 1 per cent of today's European Union's annual GHG Emissions.

SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Parameter model to calculate EPDs for run-of-river power plants

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Goals

Main goal of this work is to provide insights for the optimization of run-of-river power plants. It also enables stakeholders to make a rough comparison for electricity purchases of the client's existing and prospective power plants.

The model provides results for the two functional units: kilowatt-hour electricity, produced in a run-of-river power plant, “at power plant” and “at final customer”. For electricity at customer, also transformation to low voltage and transmission trough different grids is included.

Methods

Modelling is done according to latest available Product Category Rules (PCR CPC 17 2018). Data collection is based on run-of-river power plants without reservoirs already modelled for Switzerland (Flury & Frischknecht 2012; Frischknecht et al. 2007; Itten et al. 2012). For the impact assessment, besides required impact categories according to PCR for EPDs also an assessment with the Swiss-specific ecological scarcity method is implemented to simplify communication with Swiss stakeholders.

The model is implemented in excel and allows exchange of parameterized data in the Ecospold v1-format.

Result

For one exemplary run-of-river power plant, it is shown that infrastructure and, in particular the distribution networks cause the major part of environmental impacts in most impact categories.

The greatest potential for improvement therefore lies in the downstream infrastructure, i.e. the electricity distribution networks. Decisive factors are, for example:

- Use of materials in the construction of the electricity supply network (e.g. copper for the low-voltage network)
- Power losses in the grid and in transformers
- Use of construction-materials for run-of-river power plants, e.g. concrete and reinforced steel.

Some lessons learned during this work:

- The choice of the correct LCIA indicators is often difficult because PCR lack details about the methods to be used.
- When distinguishing between upstream, core and downstream module, relevant aspects for optimisation were hidden in background-data. Getting transparency using unit processes from ecoinvent was helpful for this goal.
- There are no indications on how to set findings in perspective. With bare numbers on several single emissions, the values give no order of relevance and little encouragement for improvement.

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SESSION T2-2 Roadmapping Sustainable Energy Technologies and Systems

Life cycle assessment of forest biomass residues direct gasification for electricity production

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The progressive depletion of conventional fossil fuels and increase of greenhouse gas emissions lead to a growing demand for alternative and "greener" energy sources. Biomass is considered a renewable fuel and its thermochemical conversion into energy vectors is considered to be carbon neutral. In this context, the use of biomass for the production of heat, electricity and fuels is increasing, becoming a global strategy. The Portuguese government has been adopting different strategies and targets concerning electricity production from renewable sources, through the implementation of power plants supplied by forest residues (FR). Moreover, the use of FR promotes the optimization of forest cleaning, thus reducing the risk of forest wildfires.

Traditional biomass combustion is the process most widely used for the production of heat and electricity. However, nowadays, gasification appears as an alternative in order to obtain more efficient, versatile and value-added energy vectors. The biomass gasification process consists of converting a solid biomass to a gaseous fuel (that can be upgraded to synthetic gas), through the reaction between the solid biomass and a gasification agent (air, oxygen and/or steam) at elevated temperature.

The objective of this study is to evaluate the environmental performance of direct gasification (using fluidized bed reactor) through life cycle assessment and its comparison with the environmental impacts of combustion (using fluidized bed and grate furnace reactors) previously assessed by da Costa et al. (2018). One kWh of electricity produced based on the gasification or combustion of FR from eucalypt forestry operations was established as functional unit. The boundaries include: a) forest management, b) biomass collection, processing and transportation and c) electricity conversion. The assessment of the life cycle impacts was modeled using ReCiPe 2016 Midpoint method for the following seven impact categories: global warming (GW), ozone formation, human health (OFHH), terrestrial acidification (TA), freshwater eutrophication (FE), marine eutrophication (ME), mineral resource scarcity (MRS) and fossil resource scarcity (FRS). The results obtained for the environmental assessment of gasification reveal that most of the impacts are associated with forest management (mainly in ME and MRS) and electricity conversion (mainly in OFHH, TA and FE). In the electricity conversion stage, the largest contributions come from the raw gas cleaning process, mainly caused by the end-of-life treatment of the residues produced (mainly the ashes disposal in sanitary landfill and the hazardous waste incineration process chosen for tar disposal). A sensitivity analysis was performed using characterization factors recommended by the ILCD System. Despite the differences expected, justified by the number of substances and characterization factors that were considered, the results obtained with both methods showed the same trends. From the comparison of gasification and combustion technologies, it can be concluded that the combustion in fluidized bed features better and more efficient fuel conversion conditions, compared to the combustion in grate furnace, and the gasification in fluidized bed presents the best environmental performance in more than half of the categories studied.

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SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

Assessing the environmental impacts of wood waste cascading in Germany: exploring future scenarios

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Goal:

Wood-based materials have multiple advantages compared to non-renewable counterparts: they are renewables, able to sequester carbon, and have the potential to substitute primary wood and non-renewable resources. With all those benefits, at first, it looks that wood-based materials could contribute to reducing climate impacts. However, wood resources are limited, and there is a growing concern about the future availability of wood. This fact causes the utilization of the secondary source of wood, or cascaded wood waste, has attracted more interests during recent years.

In Germany, around 1.5 million tons (Mton) of wood waste are cascaded into particle board (PB) production annually, represents 44% of share in total PB production volume. Theoretically, another 1.5 Mton/year of wood waste potentially can be utilized as cascading sources. However, enhancing wood waste uses as materials are hindered by the wood waste quality and separation costs, stiff competition from the wood-based energy sectors, and consumers' negative attitude regarding recycled wood. From the supply side perspective, the future wood use for materials may also be limited by the German Biodiversity Strategy to promote more deciduous forest, which implies the softwood supply, or the primary wood for materials use, can be expected to drop by 14–18% in the next decades. Therefore, it is important to address to which extent wood waste utilization will benefit the fulfillment of future materials and energy demands as well as climate mitigation effort under different wood availability and energy and materials utilization scenarios.

Methods:

Previous life cycle assessment (LCA) studies generally emphasize the environmental benefit of wood cascading. Nevertheless, there are still limitations on those studies that need to be resolved. Most importantly, no studies took into account the future availability of wood and wood waste, including the effect of forest management strategies to the prospective wood supply and the influence from the wood waste use competition between materials and energy sectors. Furthermore, there was no consideration of the current in-use wood stock to estimate the potential future source for cascading. Future scenario parameters were also often simplified such as constant energy mix and product demand.

This work will combine a dynamic wood flow analysis with the prospective LCA of wood cascading. The use of wood waste in different future scenarios will include the change of the German energy mix, wood and wood waste supply and availability based on the German forest development and timber resource modeling (WEHAM) and dynamic stock modeling, respectively, and changes in wood-based energy and materials demands. The cascading steps scenarios will include the cascaded wood use in other wood-based products and material substitution, by taking biogenic CO2 effects into consideration.

Results:

Preliminary results from our simplified wood cascading case study in German domestic buildings show approximately 1.1–1.8 Mton/year of CO2 emission savings can be achieved when the full cascading potential of wood waste is implemented. Further assessment will display the prospective carbon emission reduction from wood waste cascading in entire German wood use sectors from the current year until 2100 and beyond.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

Prospective LCA modelling for innovative water optimization strategies applied to process industry

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Goal

Due to climate change and socio-economic development, water resources, largely used by process industry, are under increasing stress. Within the SPOTVIEW project*, companies and research organizations are developing technology solutions to optimize water use and recover valuable substances or energy from water. The proposed strategies (including membrane filtration, elevated pressure sonication, capacitive deionization or electrolysis) are tested and demonstrated for four industrial case studies: hot rolling of steel, production of cardboard, of tissue paper and processing of dairy products.

The implemented solutions are expected to decrease the water and the carbon footprints of the target sectors. These impacts are quantified using the life cycle assessment (LCA) methodology. Since these novel technologies are only partly deployed in the market, the evaluation is applied on prospective scenarios defined at the 2030 time horizon when full-deployment is expected to be achieved in Europe. The study aims at understanding how prospective LCA of the studied production processes, with and without water optimization strategies, can affect the modelling of life cycle inventory (LCI) and impact assessment (LCIA).

Method

Prospective LCA of innovative technologies usually focus on adapting the foreground LCI data, i.e. evolution of infrastructures and operating parameters with higher readiness level (learning curve, scaling effects). However, the economy (or technosphere) and the environment could also change and eventually adapt during the studied time period. In order to understand which LCI and LCIA parameters should be adapted in priority, contribution analysis and prospective data review are performed.

For the contribution analysis, a preliminary LCA for the current situation is carried out. LCI data are collected for the innovative water technologies (from testing results) and for the reference production processes (from industrial project partners and European reference documents). The carbon and the water footprints, the latter including water scarcity, freshwater/marine eutrophication and freshwater ecotoxicity, are characterized following the European Commission recommendations and the consensus method “Available Water Remaining” (AWARE) for water scarcity.

Regarding prospective data review, forecasts results from well-known prospective modelling tools are screened and classified depending on their covered sector, environmental stressors, spatial and temporal resolution, as well as the used socio-economic drivers.

Results

Preliminary results show that the environmental profile of the tested technologies is mainly influenced by the electricity consumption and the removal/recovery efficiency. The energy consumption is also driving the LCA results of the four reference production processes, while the process water consumption contributes significantly to the water scarcity results. The prospective data review highlighted that several prospective models used the same Shared Socioeconomic Pathways (SSPs), i.e. climate scenarios based on various storylines, to simulate future energy supply and water resources, which are key contributors. The related data will be therefore used to adapt the prospective background LCI for energy sector and the characterization factors for water scarcity. Prospective foreground LCI will be based on upscaling data and realistic implementation scenarios determined with project partners.

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SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

Development of a conceptual framework and its associated indicator to take the dissipation of non-energetic abiotic resources into account within Life Cycle Assessment (LCA)

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GOAL

Build a conceptual framework to assess the impact of abiotic resource use within life cycle assessment (LCA) with a dissipation approach.

METHODS

In order to gather most relevant actual information on (i) Natural Resources AoP, with a focus on mineral resources, (ii) on recommendations and literature reviews for LCA methodologies for mineral resources, and (iii) on methodologies for mineral resource LCIA, a primary research is led in Google Scholar using different combinations of the following keywords: Life Cycle Assessment, Minerals, Metals, Abiotic, Natural Resources, Area of Protection, Life Cycle Impact Assessment. A secondary research is led within referenced documents gathered during the primary research phase in order to cover all the relevant literature which exist to our knowledge. Peer-reviewed articles are the main source of information. Additional filtering of the gathered literature is applied in order to be in line with the most actual knowledge about Natural resources in LCA.

Through a critical literature analysis, a state of the art overview for non-energetic abiotic resources in life cycle assessment (LCA) is realized. "Key elements" to be integrated in a conceptual framework and its associated indicator for resource use in life cycle assessment (LCA) are identified. Current relevant methods are analyzed in face of most actual knowledge.

RESULTS

“Key elements”, such as dissipation occurring during extraction, production and use, quality limits (e.g. physicochemical limits, including thermodynamics, after which the resource will be permanently lost as an emission or as a final stock within mine tailings or end of life discharge), resource occupation in the technosphere, recycling rates and quality loss are defined in order to make this approach functional. Approaches to measure or evaluate such key elements, and the way their implementation within Life Cycle Inventories (LCI) or Life Cycle Impact Assessment (LCIA) can be done, are presented. Feasibility of the implementation of these elements within the LCA methodology is evaluated and planned future works based on this initial framework are presented.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

An early integration of life cycle and techno-economic assessment to evaluate water as promising alternative for homogenous catalyst recovery in continuous processes

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Goal: The assessment of ressource intensive chemical technologies at a low maturity stage is challenging, especially when integrating life cycle (LCA) and techno-economic assessment (TEA). Goal of this contribution is to provide a suitable approach for method selection and integration of TEA and LCA for early technology developments in the field of homogenous catalysis (requiring intensive amounts of precious metals). The focus lies on recent research revealing the high potential of water as alternative solvent in conventional organic synthesis. By adding surfactants to an oil-water mixture, micellar solvent systems are generated, that enhance the solubility of lipophilic reactants in the water phase, thereby increasing the reaction rate with a water-soluble homogenous precious metal catalyst. The temperature-induced switchable phase behavior of these systems can be used to gain both environmental and economic benefits, such as: Prevention of tremendous amounts of organic solvents ending up as waste, energy efficient process conditions and nearly quantitative recycling of the active catalyst precious metal complex. A suitable assessment methodology needs to be developed to evaluate process alternatives and resulting ressource efficiencies at at an early stage of development.

Methods: In this contribution, the performance of micellar solvent systems is being evaluated by conducting LCA and TEA of two very different process scenarios. Case study A assesses the application of micellar systems in a small-scale batch process of the fungicide Boscalid, a high-value fine chemical requiring homogeneous palladium catalysts in consecutive reaction steps. Data is mainly based on scale-up of laboratory experiments. In contrast, case study B assesses micellar systems in a large-scale continuous hydroformylation process of long chain C10 olefins as low-value base chemicals. Data for case study B is largely based on successful miniplant operation demonstrating mild reaction conditions and continuous Rhodium catalyst recycling.

Results: In both case studies the processes with micellar solvent systems are being compared to the conventional benchmark systems as described by industrial patent literature to evaluate, whether environmental and economic benefits are gained.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

Is cultivation a hot spot in LCAs of lignin-based products? The case of lignin-based carbon fibers

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Goal

As abiotic resources are getting scarcer and the greenhouse effect increases, industry needs to swap their fossil-based products with bio-based replacements. One source for such replacement could be lignin. Lignin is a macromolecule that provides stiffness in wood and is often described as the world's most abundant polymer. Historically, lignin has mostly been utilized for its energy content in pulp mills but is now increasingly being extracted for external use.

Lignin is increasingly attracting attention as a novel green alternative in applications such as batteries and carbon fiber reinforced composites. However, little is known about the life cycle environmental impacts of lignin, and especially on how this could vary depending on the lignin origin. The goal of this study is to investigate if the cultivation is a hot spot in life cycle assessments (LCAs) of products based on lignin, and gain insight into the required efforts to be put in the life cycle inventory of this activity. To achieve this, the issue of what to assess and how to assess it first needs to be solved/handled. This contribution therefore discusses what impact categories to assess and how to assess them and illustrates in a rough LCA on lignin-based carbon fibers the importance of the cultivation activity for the LCA results. In particular, how to assess the impact category of biotic resource use is explored.

Method

A literature review is made to (1) map the most commonly used environmental impact categories in assessing lignocellulosic biomass and (2) gather information on other potentially important impact categories for lignin production with a focus on biotic resource use. Selected impact categories are then assessed in a rough LCA that aims to illustrate the importance of the cultivation activity in relation to other life cycle activities for the case of lignin-based carbon fibers.

Results

Results include an environmental evaluation of lignin from different sources from a life cycle perspective. The results show that biomass cultivation can be an environmental hot spot but that this depends on which impact categories are employed and on other LCA methodological choices, e.g., the allocation method. It can be concluded that lignin production can be a potential hotspot in the lignin-based carbon fiber life cycle and likely also many other lignin-based products. Recommendations are provided on how to best assess biotic resource use in LCA, with a focus on the special case of lignin.

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SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

Integration of supply risk indicators into Life Cycle Assessment: A critical review

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The supply of goods and services covers consumer needs and supports human well-being, but also contributes to environmental, economic and social impacts such as diverse environmental influences, resources exploitation and social change. Along the often complex and non-transparent supply chains, impacts occur locally and, due to international trade, as well globally. The supply risk of the commodities is determined by taking into account a set of factors and indicators. Life Cycle Thinking and Assessment may provide an important contribution to address the supply risk of the materials involved in the production process and to design a sustainable supply chain. The aim of this paper is to reflect the state of the art concerning the combination and/or integration of meaningful supply risk indicators into Life Cycle Assessment (LCA), with a special focus on indicators utilized for crucial resources applied in key functionalities within our service-oriented economy.

As a first step within a Swiss national research project assessing the environmental and social drivers and resource related risks of Swiss production and consumption (project called OASES), we currently perform a critical review of existing raw materials criticality assessment approaches regarding indicators used for supply risk assessment. A focus is being set on the identification of indicator-specific data requirements along the supply chains of components and products exemplarily within the information and communication, energy provision and storage, and mobility sector. All identified supply risk indicators are evaluated with a special focus on their applicability in combination with databases developed in the area of the LCA methodology.

Available literature reveals several supply risk indicators with various, individual aggregation and scoring methods and different data sources, often using data from the United States Geological Survey (USGS), the World Bank or the United Nations Environment Programme (UNEP), but also applying specific national databases. The focus in the reviewed studies is predominantly on the supply risk of metals included in innovative applications such as wind turbines, photovoltaic, smartphones, batteries or electric vehicles. Although the existing supply risk indicators can be applied along the entire supply chain of metals in these applications, most of the criticality studies emphasize the material extraction and production stage. Regarding the integration of these supply risk indicators into LCA, first suggestions and approaches are identified in the reviewed literature. Some of these attempts use characterization factors in order to reassess existing and establish new midpoint, Area of Protection and endpoint impact categories.

Based on our review results, we conclude that LCA does not yet adequately implement resource criticality and an agreement on a common methodology is lacking. Additional research is required for properly addressing the supply risk of relevant resources and products for key economic functions. The research both will have to consider a huge variety and amount of indicator-specific data and require alterations in life cycle data inventories and impact assessment to adequately integrate supply risk indicators under the Life Cycle Sustainability Assessment (LCSA) framework.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

Closing product cycles for existing products as part of a circular economy strategy

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Products and organisations that are designed for circular economy consider requirements that allow for recovery of values from entire products, components and materials through reuse and reprocessing. Products that are part of the stock in use today are not necessarily ready and suitable for a similar approach. As examples. disassembly is challenging, and existing products can contain higher concentrations of hazardous substances that what not identified at the time of production, but have subsequently been recognised. However, they often also contain higher concentrations of valuable substances and are a rich source for resources that become increasingly scarce. Strategies for existing products therefore have to be developed in parallel with design of novel products and services. The aim of this paper is to develop a framework based on indicators that guides producing companies in identifying options to close product cycles and choosing among different variants.

Closing the loop strategies have been developed for manufacturing industry in the Nordic countries, considering characteristics of developed performance economies with specific transport distances and participation of users in separating and collection goods for closing the loop. Based on literature review, tools for decision support have been developed that include technical properties such as feasibility and viability of re-processes as well as organisational and institutional aspects such closed-loop supply chains and legislatory barriers. Decision support is guided through a series of product specific questions that also take into account the value and quality of products made from secondary resources and its suitability for multiple further loops, thus emphasising a life cycle perspective. Tools are further developed with co-creation partners from in different sectors of the Nordic industry and further validated with an additional set of companies. Results are coordinated and consolidated with additional focus areas such as product development, business model configuration and information technology.

Closing product and material loops is beneficial and a contribution to sustainable development when it decreases the resource use compared to primary and linear production, and the effort to collect and process used goods is lower. Similarly, strategies which provide a higher net benefit as regards resources are preferable. Results are exemplified for products with different levels of complexity, including electric and electronic equipment and textiles. Conclusions for product development and further circular economy focus areas are highlighted.

SESSION T2-3 Maintaining the Value of Resources - Transitions to Sustainability and Their Challenges

Valuing resources and managing the risks for a successfull environmental transition

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renault sas

Car mobility will face more changes in the 5 coming years than in the past twenty ones. So was saying Renault-Nissan-Mitsubishi CEO at CES 2018. Automotive industry is committed to reduce its carbon emissions. To achieve this mutation, new materials will be engaged. A sustainable use of materials is a key question for these transformations.

How electrification of cars will change the material profile of vehicles ? What are the consequences in term of supply / demand risk and social impact ?

Method and results

We conducted a detailed assessment of materials needed in order to electrify a vehicle.

Then, we adapted the criticality matrix from the EU commission to our specific needs. This allow to point out key materials.

Finally, we will discuss how the value management of the resource.

We hope this proposal will meet your intention in order to prepare the best "value of resources" session. We would like to underline that authors are business actors with management science background. They have experience regarding giving oral presentations in several LCM, SETAC and EcoBalance conferences.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

CCU at alternative production routes of succinic acid

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goal: comparison of alternative production of succinate acid with LCA. Evaluation of CCU potential

Methods: Comparison of scenarios using fossil feedstock and waste glycerol as feedstock using a LCA cradle-to-gate approach.

Two production routes of succinate were compared. Fossil based production from butane via malic anhydride and genetic engineering of microorganisms, such as Yarrowia lipolytica or other fungi, having high-yielding, commercial production potentials.[1] Global production of succinic acid is estimated at 16,000 to 30,000 tons a year, with an annual growth rate of 10%.[2]

The evaluated bioengineering route was based on glycerol instead of well-established glucose used in many other projects. The process takes up CO2 as part of the feedstock as side-product from the biodiesel production.

Results: From both effects – direct uptake of CO2 and exchange of the fossil feedstock the effect on Global Warming Potential was assessed. Additionally side effects like energy efficiency and burden shifting could be addressed from the results.

The carbon footprint of bio-SA was 16,68 kg CO2-Eq/kg and seven times higher than the carbon footprint of fossil-SA with 2,30 kg CO2-Eq/kg. Also, in all other impact categories the LCIA factors of bio-SA process were higher than the fossil-SA process. Although electricity represents a high percentage of the environmental consequences in fermentation and downstream processes, the GWP-level of fossil-SA could even not be reached by the use of electricity based on renewable wind energy. Further hotspots driving these results are sodium carbonate as a regulator for pH during fermentation and organic solvents used in the downstream process.

Literature

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SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

Effects on CO2 emissions from fattening pigs with microalgae in comparison to the traditional diet with corn

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goal: comparison of alternative diet for pig under special aspects of CO2 uptake and the Evaluation of CCU potential

Methods: Comparison of scenarios using corn and microalgae as pig diet.

Results: Whereas the total carbon uptake per nutritional value is comparable between microalgae and corn, emissions from fertilizers and land use account for large advantages for microalgae.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

Determining the carbon footprint of a chemical industry based on CO2-utilization using a novel LCI database

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Goal

The chemical industry is expected to become the largest driver of global oil consumption by 2030. A widely discussed strategy to reduce the oil consumption and the resulting greenhouse gas (GHG) emissions is capturing carbon dioxide from industrial point sources or ambient air and using it as an alternative carbon feedstock for chemicals. Although climate benefits have already been demonstrated for individual Carbon Capture and Utilization (CCU) technologies, the total climate change mitigation potential of CCU in the chemical industry is still not fully understood. The goal of this work is therefore to determine the carbon footprint of a chemical industry based on CCU and the maximum climate change mitigation potential of CCU in the chemical industry.

Methods

We construct a bottom-up model of the chemical industry covering the production of 20 large-volume chemicals, which account for more than 75% of the industry's GHG emissions. The model builds on engineering-level data for more than 160 production processes from a newly compiled Life Cycle Inventory (LCI) database for the chemical industry. Therefore, flows of energy, material and emissions can be determined at a high level of detail throughout entire production chains. Our model includes both conventional and CCU-based production technologies. For CCU technologies, we consider two scenarios: a high-TRL scenario including only CCU technologies at Technology Readiness Levels (TRL) of 7 and higher, and a low-TRL scenario also covering CCU technologies at earlier research and development stages. The choice between technologies is determined by minimization of GHG emissions, enabling the computation of the maximum climate change mitigation potential of CCU compared to conventional production.

Results

Our results show for both scenarios that CCU in the chemical industry has the potential to reduce GHG emissions on a gigatonne-scale. Exploiting this potential, however, requires large amounts of low-carbon electricity for the production of hydrogen, which is used as co-reactant by many CCU technologies. The low TRL CCU technologies could substantially reduce the electricity demand of CCU. Still, the required amounts of low-carbon electricity largely exceed current production estimates for the next decades in both scenarios. Hence, low-carbon electricity generation represents a major challenge for a large-scale CCU implementation. Furthermore, most CCU technologies are found to use low-carbon electricity less efficiently for climate change mitigation than other large-scale uses of low-carbon electricity including e-mobility and electric boilers. Nevertheless, once and where these other uses are unavailable or exploited, CCU could efficiently contribute to climate change mitigation.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

Environmental impact of CO2 capture technologies: GENESIS project

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Goals

Greenhouse gases are a global concern, since they are the main cause of Global Warming. With the aim of reducing the CO2 emissions different countries are applying strategies like the Carbon Capture and Storage (CCS). New technological solutions to improve the CCS technologies are under development. The GENESIS project aims to develop and upscale some of the most promising materials for CO2 capture and demonstrate their performance, durability and reliability in industrial environments.

Two membranes have been developed (IPOSS and MOF membrane systems) and these technologies are to be up-scaled in the project to achieve at least 90% of CO2 recovery in pre-combustion and post-combustion applications.

A Life Cycle Assessment (LCA) is conducted with the aim of giving insight of the environmental costs and benefits of the membrane systems developed during the project. Moreover, the LCA allows the comparison of the systems in order to identify the main environmental benefits of each technology and the critical points.

Methods

The LCA methodology is based on ISO 14.040 and ISO 14.044; following the four interrelated steps: goal and scope definition, life cycle inventory analysis, life cycle impact assessment and interpretation of the results.

During the goal and scope task, the following aspects have been defined:

- The main goal of this LCA is to assess the environmental performance of the nanotechnology enhanced membrane systems developed to capture CO2 in pre-combustion and post-combustion applications.
- Functional Unit: 1 m3/h of CO2 at the inlet of capture system
- System boundaries: life cycle stages included in the system boundaries are the construction phase and the raw materials used to manufacture the membranes, the installation and maintenance of the membranes, use phase (including CO2 captured), and end-of-life.

For the GENESIS project, the selected LCA methodology is the ILCD impact assessment method, released by the European Commission, Join Research Centre in 2012. The impact categories will be selected considering the needs of the project and the main impacting areas. A first selection of the impact categories has been done. The most important categories are climate change, ozone depletion, human toxicity (cancer and non-cancer effects), acidification, freshwater ecotoxicity and mineral, fossil & renewable resource depletion.

Results

The LCA of the GENESIS project assesses the potential environmental impacts in a holistic view, including direct impacts as well as supply chain impacts and it ensures that climate change benefits as a result of reduced CO2 emissions and the potential offsetting effects from other stressors are being compared between the nanotechnology enhanced membrane systems. The overall health benefits from the systems can be assessed and stakeholder decisions can be made on a holistic and informed basis.

The GENESIS project aims to provide more data to know the environmental performance of specific CCS strategies. At this stage of the project there are not final results to show, but it is expected to present preliminary results during next months.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

Comparative cross-sectoral systems analysis of production, use and recycling of CO2 based products

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In general, when CO2 is transformed into hydrocarbons this requires high energy inputs. An environmental benefit depends on the provision of renewable electricity, which is still a scarce resource. We compare different routes of CO2 use with regard to their environmental performance, including chemical products and transport fuels. The analysis also allows to evaluate which purpose of using renewable power is associated with higher benefits, including e-mobility.

CO2-based chemicals such as methanol and methane, and derived polymers such as polyoxymethylene (POM) are compared with their fossil-based substitutes. Various CO2 sources, including cement kilns, biogas plants and DAC are considered. Electrolysis is assumed to be supplied by wind power, which is increasingly available in Germany.

Comparative life cycle analysis determines the benefit of CO2-based routes with regard to GWI (Global Warming Impact) and input indicators such as RMI (Raw material input), TMR (Total material input), CED (Cumulative energy demand) and water input.

Each route is considered on a cradle-to-cradle basis. Earlier studies [1] on a cradle-to-gate basis showed a trade-off between GWI benefits and higher requirements of raw materials. We extend the system in order to consider also subsequent recycling routes. CO2 based production enables different recycling options, such as mechanical or material recycling, to keep materials in the recycle loop and reduce new material input and increase resource efficiency.

CO2-based chemicals such as methanol can be used in the chemical and polymer industry or as fuels in the transport sector. The life-cycle impacts resulting from the use of 1 MWh of renewable energy for CO2-based chemicals and polymers are compared to a use of that energy in e-mobility. Scenario analysis is used to vary relevant parameters, such as electricity mix, electrolysis technology and recycling options and quantities.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

LCA OF METHANOL PRODUCTION FROM BLAST FURNACE GASES: THE EUROPEAN PROJECT FRESME

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Goal

Iron and steel industry represents a significant source of CO2 emissions. Especially in integrated steel mills, a high quantity of CO2 is emitted from the power plant, where carbon-rich blast furnace gases and other residual gases are burned to produce electricity. Integrated steelworks are well suited to the application of carbon capture, storage and utilization of CO2, technologies that contribute to the achievement of the European Community objectives concerning the reduction of emissions in 2030. The FReSMe (From Residual Steel Gases to Methanol) project, funded by the European Union’s Horizon 2020 research and innovation programme (grant number 727504), deals with this topic. The project aims to demonstrate the feasibility of CO2 and H2 capture from residual steel gases and their use for the production of methanol. A Life Cycle Assessment (LCA) has been carried out to evaluate the environmental performances of the new technology.

Methods

The FReSMe project started in 2016 and will finish in 2020. It includes the following phases: laboratory analyses to support the technology improvement, both for the CO2 and H2 capture and for the production of methanol; modelling and simulations to optimize the processes; construction of a pilot plant in Sweden, where the steel mill is located; LCA of the process to evaluate the effective reduction of environmental impacts compared to traditional technologies; final demonstration of the use of methanol produced for the feeding of a passenger ferry. Specifically for the LCA, the ISO standards, the Product Environmental Footprint guide and the Techno-Economic Assessment & LCA guidelines for CO2 utilization (TEA/LCA Guidelines 2018) were considered to set up the analysis. The definition of the functional unit (FU) was challenging as the FreSMe project has different aims: 1) to find a way to reduce the impacts associated with the production of steel 2) to find an alternative way of methanol production 3) to demonstrate a new technology for the integrated production of steel and methanol and 4) to demonstrate a new technology of capture and utilisation of CO2. Different scenarios have been defined, depending on the percentage of gases that is sent to the new technology of CO2 capture instead of to the power plant, and on the percentage of captured CO2 that is used in the production of methanol instead of being simply stored.

Results

The aim #4 has been selected as the main objective. Consequently, the FU has been chosen as the treatment of 1 t of process gases. This is a different approach compare to the one reported in TEA/LCA Guidelines 2018 where the FU is defined in terms of the new product. The chosen FU has allowed to apply the zero burden approach and thus the system boundaries start with the treatment of the process gas (i.e. the processes that generate the gases are not included). The methanol production has been considered as a co-function: the multi-functionality of the system has been solved by applying the "system expansion with substitution" approach. LCA preliminary results will be shown for the different analysed scenarios.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

Keeping a food eco-label attractive: The case of the 'Ladybird Beetle' of IP-SUISSE

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Agroscope

IP-SUISSE is the largest farmer organisation in Switzerland with almost 20.000 members. Approximately half of them produce for the association's own food eco-label "IP-SUISSE Ladybird Beetle". After having started a biodiversity scheme, which was applied on all label farms, some of the member farmers approached the association's leadership with their wish to extend the label's requirements in the area of sustainability, e.g. human well-being or climate change.

The aim of the presented project is to put into work a point-based system for climate mitigation measures (CMM) aiming at reducing the greenhouse gas emissions (GHGe) by 10% on 10.000 farms in 2022 compared to 2016. IP-SUISSE wanted the CCM to be assessed with Life cycle assessment (LCA) methodology as it is their belief that it is important for their label not to create trade-offs and being consistent within all types of CMM. The project's cornerstones are an independent scientific steering, a financial contribution by the Federal Office of Agriculture and a close collaboration with farmers.

We performed an LCA on farm level for 33 pilot in accordance with the SALCA (the Swiss Life Cycle Assessment) methodology developed by Agroscope (Gaillard & Nemecek, 2009).

The data retrieval, the calculation of the Global Warming Potential (GWP) as well as the calculation of the expected reduction in GHGe according to the planned CMM showed a twofold picture: On the one hand, it is encouraging to witness how well the suggested CMM have been accepted and sometimes already applied by the participating pilot farmers. On the other hand, the forecasted reduction of 2.2% less GHGe in 2018 compared to 2016 is below expectations. This calls for a sound analysis of its reasons.

By the time of the conference GWP-calculation of the pilot farms for the agricultural year 2018 will be available as well as the analyses of those results compared to the results from the agricultural year 2016 (without CMM). This will allow to present results on whether the application of a set of measures on a real farm resulted in the same quantity of GHGe reduction as the computed GHGe reduction resulting from the addition of the potential GHGe reduction of single CMM.

The results will allow us to check and accordingly adjust the amount of GHGe reduction (CO2-eq.) with regard to the different CMM. Furthermore having tested and applied the point-based CMM system on a pilot network is a prerequisite of introducing it on an organisational level, meaning on approximatively 10.000 IP-SUISSE-Label-farms from 2020 onwards. Assuming this initiative will be successful, it will further the label "IP-SUISSE Ladybird-Beetle" and strengthen their position on four levels: i) among their supplying farmers, ii) opposite to their purchasers, i.e. retailers and the food industry, iii) as against to the climate policy actors within the agricultural administration, as well as to iv) the consumers and society.

Witnessing the origin of the scheme coming from farmers this illustrates that LCM is not only of importance for multinationals but also for SMEs.

SESSION T2-4 LCA and LCM on Carbon Utilization Processes in Chemical Industry and Others

CO2 as raw material for chemical industry – new methodological considerations for allocation and related results

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(Goals:)

Since a couple of years the use of CO2 as feedstock for carbon compounds in the chemical industry is intensively investigated both from a conceptual and a technological point of view. The connection of capturing fossil CO2 emissions from production processes and using these molecules as raw material input for new products is considered as a double benefit by reducing GHG emissions and providing a new raw material basis. Life Cycle Assessment is needed to prove this hypothesis and substantiate potential positive environmental performance.

Combining two processes leads to an allocation issue if environmental impacts have to be attributed to newly developed chemical compounds based on CO2. The choice for an allocation methodology is highly significant for the environmental profile of this product or the related product life cycle. Hence a new approach shall be discussed here that could probably help to provide an acceptable solution for this kind of coupled production processes. A close-to-reality example shall shed light on the proposed allocation approach and its related results.

(Methods:)

The specific character of CO2 in the coupled production systems can be regarded in three ways. The generation of CO2 from the first system can be viewed as an emission to atmosphere (1), the production of a raw material as input into a second system (2) or a waste stream that must be recovered or be disposed of (3). The identification of CO2 as a waste stream is a newly proposed approach that opens up the methodological toolkit to treat CO2 in analogy to any solid waste stream. Environmental impacts of using waste material for recycling is normally attributed to the waste generating system and the waste recovery system by approaches like cut-off, 100:0, 50:50 and 0:100 providing a life cycle result for the waste recovery system.

The modelling of these approaches will be presented for CO2 from an industrial process like ammonia production going into the production of a polymer based on polyethercarbonate polyol. Instead of applying allocation rules to CO2 as a co-product of the first system the waste approach has to identify and assign impacts from the common production and end-of-life processes related to CO2 as waste. The 100 : 0 approach describes the situation that the waste delivering ammonia system stays responsible for all production and end-of-life steps associated with this product while a 50:50 approach distributes the environmental impacts of the common processes equally to the waste generating and the waste recovery system.

(Results:)

The convention of allocation methodologies for waste prefers a 100:0 approach for systems that consist of a predominant offer of waste material compared to the waste recovery activity. By contrast, a balanced offer-demand scheme of recyclable material lead to 50:50 or even 0:100 approaches. As a consequence the 100:0 approach should be followed regarding the overwhelming offer of CO2 to be recovered in present times. This might change considerably in a low carbon society when the demand for carbon compounds in chemical industry will be in the same order of magnitude as the CO2 sources. Then the 50:50 approach should be used. Results will be shown for both cases.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges

Life Cycle Assessment of new innovative hydrometallurgical processes: a case study

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The demand for metals is expected to follow an exponential increase in the years to come to satisfy an ever-growing market for manufactured goods. In the meantime, the depletion of metals-rich deposits requires to develop new beneficiation and extraction processes in order to recover metals from low-grade/complex ores. In addition to technical and economic performances, the environmental sustainability of such new techniques must be assessed. For this purpose, Life Cycle Assessment (LCA) is a widely accepted tool that allows the assessment of a product/process “environmental performance” along its life cycle.

The present case study focuses on a copper open-pit mine owned by Cobre Las Cruces (CLC) in Spain. The deposit comprises copper sulphides containing different metals in addition to copper. The mine site is equipped with “Mine-to-Metal” (M2M) technologies allowing on-site ore processing and downstream metals recovery through the implementation of a newly developed hydrometallurgical process: Silver Catalyzed Atmospheric Leaching (SICAL). The goal of this study is to assess, by use of LCA, the potential environmental impacts induced by the recovery of different metals (copper, zinc, silver and lead) through SICAL. The functional unit is “process-specific” and is calculated based on the material balance of the process. It is defined as “the co-production of 1 ton copper cathode and 6 tons zinc cathode, combined with the further recovery of 2.65 tons lead and 0.045 ton silver under precipitates forms”. The system boundaries include all the steps from the run-of-mine (ROM) ore input (0.99 % Cu, 3.35 % Zn, 2.42 % Pb, 57 ppm Ag) to the output metals: Mineral processing (including comminution, flotation, thickening); Tailings disposal (impoundment); Atmospheric leaching (SICAL); Copper recovery by SX-EW (solvent extraction – electrowinning); Zinc recovery by SX-EW; Lead and silver recovery (including Pb/Ag leaching, silver cementation, lead precipitation).

The foreground system is modelled by use of on-site data at pilot scale, while the background system is modelled by use of the ecoinvent v3.4 database. The LCIA (Life Cycle Impact Assessment) calculations are performed using the SimaPro v8.5.2 software, considering nine midpoint impact categories recommended by the ILCD.

The LCIA results show that most of the impacts in terms of climate change, ozone depletion, photochemical ozone formation, acidification, terrestrial and marine eutrophication are generated by the lead and silver recovery steps. In terms of toxicity-related impacts, tailings disposal is responsible for the largest share of the environmental burden. The contributions analysis highlights that these toxicity-related impacts are caused by potential metals emissions to ground and surface waters from the tailings pond. Regarding the other impact categories, the consumption of reagents such as sodium hypochlorite (NaClO) for Pb/Ag leaching or oxygen for atmospheric leaching appears to be the main contributor to the impacts.

As a conclusion, this study assesses the environmental burden induced by the newly developed SICAL process and identifies the main environmental hotspots on which the effort would need to be focused with respect to a future eco-design approach.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges

Environmental impacts analysis of titanium sponge production using Kroll process in China

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Goals:

China has been ranked as the top titanium producer in the world since 2007. In the year of 2014, China contributed 34% of the titanium sponge produced globally, with the total production capacity reaching 150,000 tons per year. Current researches concerning titanium supply chain mainly focused on the environmental issues such as resources consumption and specific pollutants emission during the production of titanium and TiO2. Nonetheless, the environmental impacts analyses of titanium sponge production in China associated with technical potential for saving energy and reducing emission have not been reported. Therefore, we aimed to build a life cycle model for the titanium sponge production using Kroll process in China, and calculated the life cycle inventory and analyzed the environmental impacts, and identified the energy-intensive processes and environmental hot spots according to the ISO 14040/14044 standards. Furthermore, the environmental improvement potential for titanium sponge production in China was also predicted through screening advanced technologies and equipment and comparing the effects of advanced technologies implementation.

Methods:

Life cycle assessment of titanium sponge production using Kroll process in China was conducted based on ReCiPe method. Based on the mass allocation method, the energy consumption associated with the titanium concentrate production process was calculated in accordance with the quality of the desired product in each sub-process. The life cycle inventory and environmental impacts of the main processes was calculated. The main factors and sources that cause environmental pressure were identified. In addition, sensitivity analysis of the allocation scenarios for energy consumption in the V-Ti magnetite ore mining and dressing and main auxiliary materials and power consumption were discussed in detail.

Results:

The results indicated that the electrolysis of magnesium chloride and the smelting of titanium slag accounted for 39.6% and 22.4% of the total impact of Kroll process, respectively. The accumulative energy consumption of the titanium sponge production in China was 423GJ/t. Electric power accounted for 66% of the accumulative energy consumption. The sensitivity analysis showed that the scenario based on the mass of the target products in ore mining and dressing process was more feasible. The allocation scenarios based on the mass of iron or titanium dioxide exerted negligible impact on the final results. The electricity consumption exhibited the highest sensitivity among all the environmental impact categories except for the metal depletion. Toward cleaner technologies implementation in China titanium sponge production, the potential and effectiveness of the effort were quantified. In particular, the electric power consumption and the characterisation results for particulate matter formation and photochemical oxidant formation were reduced by 17%, 54% and 28%, respectively. The overall environmental impact decreased by 21%. The adoption of advanced and mature techniques and equipment is of a greater practical significance to the cleaner production of titanium sponge.

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SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges

Environmental life cycle assessment for laser additive manufacturing

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AIMEN

Goal

Environmental life cycle assessment was performance in order to evaluate new laser additive manufacturing processes for advance metallic components. Additive manufacturing technologies allow the production of controlled deposition of material (layer by layer), providing material exclusively where it is needed.

Additive manufacturing represents one of the most promising technologies, especially in terms of flexibility and productivity. This technology is specially considered in industrial sectors with a high demand for differentiated and customized products by consumers. Additive manufacturing has been considered as one of the key aspects in the so-called third industrial revolution.

Method

A prototype was defined in order to define and optimize laser manufacturing process. A mould from automotive industry was considered due to high requirements and lightweight needed. Environmental impact for current metalworking process were evaluated and compare with new LASMEC process requirements.

A “cradle to door” approach was considered in order to evaluate raw materials and energy requirements for additive manufacturing process. Functional unit was defined as “one prototype component manufactured” in order to compare both process.

Environmental life cycle assessment was performed using SIMAPRO 8.2 and EcoInvent 3.3 database. CLM-IA impact categories were evaluated.

Results

Aluminium alloy raw material is the main environment impact for prototype manufacturing both in current and new LASMEC project.

Comparing with current metalworking processes, raw material reduction (aluminium alloy) in LASMEC process can reduce the environmental impact by half, as it accounts for 75% of the impact on greenhouse emissions of the manufacturing process.

Although energy consumption is higher in laser additive manufacturing, reduction in raw material needs balance carbon footprint. Results in other analysed impact categories were similar.

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SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges

PRODUCT ENVIRONMENTAL FOOTPRINT OF AN INNOVATIVE TECH-NOLOGY FOR PRIMARY ALUMINIUM PRODUCTION

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Ecoinnovazione

Goal

The production of primary aluminium is an energy intensive process, responsible for around 1% of global Greenhouse Gasses emissions. GHG are mainly related to electricity production, used along the processes, and carbon-based anode reaction during the elec-trolysis process. Aluminium is consumed across a wide range of sectors and its demand is expected to grow up; therefore, the reduction of energy consumption and GHG emissions is fundamental to cut down environmental burdens and costs (e.g. EU ETS cost).

This study concerns the application of Product Environmental Footprint (PEF) as a methodology to evaluate the advantages of an innovative technology for the production of primary aluminium. Such technology, developed within the AGRAL (Advanced Green Alu-minium Anodes) project, consists of the use of an inert anode to replace the current carbon one, thus with the potential of significantly improving the environmental profile of the prima-ry aluminium. The inert anode is based on a cermet, mix of oxides as the major compound and metallic compound, coated on a metallic substrate. The development of the inert an-ode enables to cut the direct CO2 emission from the electrolysis reaction (those due to the carbon anode consumption) and also to increase life duration of the anode, thus represent-ing a leap forward for the aluminium industry and the European Environment policy targets to decrease global CO2 emission by 20% until 2020.

Method

In order to measure and quantify the potential environmental impacts and benefits of to the innovative technology compared to the carbon-based one, a Product Environmental Footprint study of the primary aluminium produced with the inert anode has been carried out according to the PEF methodology, which aims at setting the basis for better reproduc-ibility and comparability of the results.

Results

Overall, the results show that the inert anode performs better than the carbon one in terms of global warming potential and other environmental impact categories but eutrophi-cation freshwater, ozone depletion and resource depletion. A trade-off among the life cycle phases is observed; in particular, the better environmental performances of the inert solu-tion are achieved at the expenses of an increased impact in the raw materials phase and a strongly reduced impact in the electrolysis phase.

Results will be presented and discussed, focussing on the role of life cycle methodolo-gies in promoting eco-innovation and in supporting the early design phase of new techno-logical systems. In addition, the main methodological and technical issues affecting the overall results will be discussed such as the maturity of the technology, data availability for raw materials, and the applicability of the PEF methodology.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges

Responsible sourcing of copper: Comparing the environmental performance of global supply chains of primary copper

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Empa

Goal

Copper plays a crucial role in society, yet its mining and processing often causes significant environmental damage. Processing requires large amounts of energy, while the disposal of tailings poses a long-term pollution risk. Copper is commonly produced through pyrometallurgy in three stages, mining and concentration, smelting, and refining, with the products of each stage (concentrate, anode, and cathode, respectively) traded via global markets. While the quality of these products must be consistent, irrespective of the country of production, their environmental burdens may vary depending on geographic factors, such as climate and technology. Here, using a regionalised MFA-LCA approach, we compare and rank the environmental performance of global supply chains of primary copper.

Methods

A combined MFA-LCA approach was adopted. Major producing countries of each copper product were identified and regional copper production systems were modelled using MFA to calculate the mass flows of copper (and other metals) in each country. Distinct LCI process models were developed for each stage of production and country-specific LCIs were developed, considering important regional factors, such as smelting technology mix, electricity grid mix, average ore grade, and climatic conditions. We then calculated the characterised potential impacts of all possible supply chains for primary copper.

Results

The environmental burdens of copper vary widely depending on its global supply chain. Mining and concentration were found to contribute most greatly to climate change impacts. Hence, copper produced using concentrates from countries with high ore grades and/or renewables-based electricity mixes (e.g. Kazakhstan and Canada) incurred the lowest climate change burdens. Similarly, with tailings disposal identified as the greatest contributor to toxicity-related impacts, the lowest toxicity-related burdens were associated with copper produced using concentrates from countries with low precipitation rates and/or high ore grades (e.g. Kazakhstan and China). The wide variability in our results highlights why such regionalised LCAs are necessary, as they can improve the accuracy and representativeness of studies. Outcomes from this and related research should help companies in establishing better environmentally performing material supply chains.

SESSION T2-5 Metals Industry in a Sustainable World - Chances and Challenges

Life cycle assessment of primary and secondary copper production rout – a comparative study

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The article analyzes and discusses potential environmental impacts and benefits associated with a primary and secondary copper production rout. In case of primary resources smelting technologies for refined copper production were assessed including flash and shaft furnace. Using generic data from the smelting facilities in Poland, this study employs LCA to compare the environmental impacts of shaft and flash furnace-based smelting technologies. In case of secondary rout of copper production generic data from different Polish companies engaged in collection and processing of waste electrical and electronic equipment were used.

The process of metals recovery from WEEE is similar in all analyzed companies and embrace mainly the following steps: removal of the materials and hazardous components and their disposal, disassemble of components for reuse and their storage; transfer of secondary raw materials to recycling plant, own process of recovery. The differences between this companies are mainly related with equipment used for disassemble e.g. shredding and technology lines for different fraction recovery as cable, picture tubes, etc. The LCA in this case was conducted within the boundaries including collection, processing, recovery and recycling of secondary raw materials.

For primary production LCA results show that for most impact categories the flash-based technology can achieve significantly lower environmental impacts, than a shaft furnace, i.e. to produce 1 t Cu generates on average a 24% lower overall impact. For climate change, transitioning from shaft furnace-based copper production to more efficient flash furnace technology leads to decreasing GHG emissions of 29%.

In the case of WEEE main environmental benefits are associated with the recovery of non-ferrous metals, ferrous metals and plastics. It's related with replacing virgin materials by secondary one, which helps to avoid production of emissions and waste at the stage of primary production. For metals benefits are mainly related with avoided emissions of inorganic compounds as SOX and NOX and particulate matter, affecting the category of respiratory distress, and carbon dioxide, having an impact on global warming. In addition, the production of non-ferrous metals causing high emissions (to water and air) of heavy metals, affecting the category of terrestrial ecotoxicity.

SESSION T2-6 Eco-Innovations and Circularity in Non-Ferrous and Precious Metals Industry

International cooperation in the area of rational management of mineral resources and the circular economy - ACADEMIC INTERNATIONAL PARTNERSHIP PROGRAM

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The aim of the article is to present a project "International cooperation in the area of rational management of mineral resources and circular economy within the framework of the International Academic Partnership Program", managed in the years 2019-2021 by the Division of Strategic Research at the Mineral and Energy Economy Research Institute, Polish Academy of Sciences and financed by the National Agency for Academic Exchange.

Together with the Project Partners, which are leading research centers from Germany, Norway, Sweden and Latvia, an analysis will be made, and as a result, methodology of the economy's demand for mineral raw materials in Europe will be developed, at the same time increasing the mobility of young scientists, establishing and maintaining international cooperation and making public the obtained research results.

The final result of the project provides for the development of a method for determining the demand for mineral resources including: changes in the domestic economy (among others: assessment of demand by selected industries, development of innovation and new technologies, planned changes in the country's development), European (e.g. megatrends and assessment of raw material flows based on material system analysis and material flow account), security of supply incl. guaranteeing the development of advanced high-tech technologies. The analysis of trends and dynamics of demand development will be carried out in the short and long-term perspective. The elaborated methodology will allow predicting the demand for selected mineral resources and developing scenarios depending on trends in the European economy and the conditions on the international raw materials market. Mineral deficiency is a particularly worrying problem for the European Union (EU) - countries depend on the import of metallic ores and metals needed for high-tech productions. The rapid development of the global economy requires the defining availability of primary and secondary mineral resources necessary for the functioning of individual sectors of the economic. Lack of appropriate standardization and methods to manage the flow of materials is a barrier to the effective use of raw materials on the European market.

The results of the project will have a considerable importance for the implementation of development strategies and EU raw materials policy. The project's effects will contribute to the promotion of innovative technological solutions, which requires the involvement of interdisciplinary teams promoting solutions and products at home and abroad.

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SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels

Dynamic Ecological Assessment of Different Kinds of Renewable Energy Based Synthetic Fuels in Comparison to Fossil Fuels and Electric Vehicles

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Already today, the global mean temperature is 0.9°C higher than in the last century, and it continues to rise steadily. Therefore, limiting global warming to a maximum of 1.5°C, as stated in the Paris agreement, is the key goal for meeting climate protection. The largest contribution to global warming can be attributed to the persistently high proportion of fossil fuels of approx. 80% used in energy conversion. Approx. 20% of the share of total consumption is represented by the transport sector and in contrast to other sectors, emissions have increased by 20% compared to 1990. This is based on the effect that more fuel-efficient engines has been more than offset by larger and heavier vehicles and by more kilometres driven.

Goals

Therefore, the production of synthetic fuels like methane, hydrogen etc. (power-to-fuel) out of renewable energies represent one key factor in decreasing the emissions in the traffic sector. In this context, synthetic fuels also have the advantage of using excess surplus renewable electricity while offering better storing capabilities in contrast to electricity for EV and thus, of increasing the stabilization and flexibility of the energy system.

In order to know more about the ecologic and economic impacts of synthetic fuels, in the current project “BEniVer – Accompanying Research on the energy turnaround in transport” funded by the German BMWi, different methods to produce and apply synthetic fuels have been investigated and evaluated. The fuels considered include among others hydrogen, methane, synthetic diesel and petrol, ethanol, and kerosene and have been compared with conventional fuels and electricity.

In this contribution, we would like to present the ecological assessment of the application of synthetic fuels in cars in comparison to internal combustion engine vehicles and battery electric vehicles.

Methods

Within the assessment, we focused on the holistic methodology of Life Cycle Assessment (LCA) according to ISO 14040 and compared different fuel options.

Continuously we focus on the application phase and have pursued a tank-to-wheel approach with impacts according to CML-categories to give a comprehensive overview. Furthermore, we decided to use a dynamic approach because a static approach merely reflects the situation at a certain point in time. As a new approach, we modelled the application phase of the assessment in MATLAB to offer the possibility to include other energy system models and to account for e.g. temporally resolved CO2-emission and a prospective approach. The necessary data for the LCA are directly provided by the project partners and are incorporated into our reference cycles.

Results

As a result of our study, we would like to show a comparative LCA of synthetic fuels with conventional fuels and battery-powered concepts with a tank-to-wheel approach.

In this context, we will present a dynamic approach with MATLAB allowing a holistic view on synthetic fuels.

Therefore, we can describe to what extent electricity-based fuels can contribute to CO2-reduction and to other environmental impacts in order to know more about the role such fuels will play in a future energy system.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels

LIFE CYCLE ASSESSMENT OF SECOND GENERATION BIOETHANOL PRODUCTION FROM SWEET SORGHUM BAGASSE CULTIVATED IN THE STATE OF VERACRUZ, MEXICO

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There have been alternative proposals to promote the use of renewable energies and biomaterials as a request that helps clean development; however, there are questions regarding the non-renewable sources included in the production of bioresources. The life cycle analysis (LCA) is a tool that evaluates the potential environmental impacts of a product or process during its life. The objective of the present work was to evaluate some probable environmental impacts, in addition to energy efficiency through the fossil energy ratio in the production of bioethanol. It was considered second generation ethanol from one ton of sweet sorghum grown in the state of Veracruz, Mexico. Three stages of the production process were considered: agricultural phase, transport process and industrial conversion. The LCA calculations were made with SimaPro 8.5 considering the environmental impacts according to the CLM 2 methodology with baseline V2.05; On the other hand, energy efficiency was determined by the Cumulative Energy Demand V1.08. The results showed that the agricultural phase is affected by the use of nitrogen fertilizers that cause emissions into the atmosphere. Regarding the industrial phase, the emissions consisted of three impact categories: Global Warming Potential, Human Toxicity Potential and Fresh Water Ecotoxicity. According to the specific information of SimaPro 8.5, the GHE were caused by the use of hydrogen peroxide, which is an input in alkaline hydrolysis. The Fossil Energy Ratio was 1.3, however some alternatives must be taken during the process to achieve a more sustainable result and a higher value in this parameter.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels

Bio-isobutene: Life Cycle Assessment of an emerging technology for biobased fuels and materials

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Goals

The goal is to evaluate the environmental performance of biobased isobutene for a 1st generation sugar route and a 2nd generation sugar route. Each route has its specific challenges concerning Life Cycle Assessment such as allocation procedures, scenario development or considering the carbon cycle of large scale fossil reference systems versus the emerging value chain under development. These challenges are identified and in a next step potential solutions are developed. In the case of bio-isobutene the differentiation in application, if the product is used as precursor for chemicals or as precursor for biofuels, is open. The commitment to a specific product route can have a crucial impact on the methodological options in LCA structure and on the final LCA result as well as on the conclusion. However, the current LCA study points out these impacts in order to achieve a better understanding of LCA and associated methodological choices among the biofuels and biobased materials community. Besides that, scenario based analysis provides important implications for further process development and sustainability performance analysis of relevant value chains.

Methods

There are two methods applied: LCA according to ISO 14040 and the greenhouse gas calculation methodology given in the Renewable Energy Directive (RED 1009/28/EC; RED II). Due to a change in perspective LCA is conducted for bio-isobutene as a biofuel precursor and a biobased material precursor. Developed scenarios for bio-isobutene production differing in process energy mix as well as the crop utilized for sugar production backed by experimental validation in demo-scale and foresight on up-scale and commercialisation. The fossil reference product for comparison of biobased isobutene is fossil based isobutene in the case where it is used in the biobased product market. In the case where bio-isobutene is used to synthetize ETBE as drop-in biofuel the fossil comparator is gasoline. For ISO 14040 LCA the LCA software GaBi ts 8.0 and the ecoinvent v 3.5 database are used. The system boundaries are defined to be cradle-to-gate. The Life Cycle Inventory consists of industry data on bio-isobutene production. Data gaps are closed using literature results. CML 2001 methodology is applied for Life Cycle Impact Assessment.

Results

Biobased isobutene is a promising alternative to fossil based isobutene for the product market from greenhouse gas perspective but also in other environmental impact categories. As a precursor for biobased ETBE it also contributes to greenhouse gas mitigation in the fuel sector. Sugar crop and sugar feedstock as well as process energy generation are the two main parameters influencing the environmental performance of 1st generation bio-isobutene. Based on a carbon balance for the isobutene production system it can be discussed how to deal with the CO2 sequestered in sugar crops and the final product if bio-isobutene is used in the biobased product market. System boundaries and time horizons require special attention in this context. There is a bandwidth of results achievable by altering assumption and it requires diligent reasoning and decision making on which results are representative and relevant for communication to stakeholders.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels

Environmental impacts of second generation ethanol considering its learning curve and complementary metrics

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Biofuels have been considered a powerful climate mitigation option for temperature stabilization scenarios and energy polices. Expanding biofuel consumption with increasing share of second-generation ethanol is a key point to reduce emissions in Brazil, while other environmental impacts are to be properly managed. A new policy, so-called RenovaBio, might foster biofuel deployment by providing monetary bonus to biofuels producers that are proportional to its mitigation potential in relation to fossil fuels, measured using global warming potential with a time frame of 1000 years (GWP100). However, many authors alert for the underlying scientific assumptions and implicit value judgements of using a single climate metric. Comprehensive analysis requires a broader understanding of contributions of a diversity of climate stressors with differing radiative effects and atmospheric lifetimes. In addition to greenhouse gases, bioenergy systems releases a different mix of short-lived climate pollutants (SLCPs) to the atmosphere (e.g. black carbon leading to warming and SOx leading to cooling), whose impacts are sensitive to emission location. There are also many other environmental impacts from bioenergy that should be added to this analysis, since climate is only one of the many interconnected environmental challenges that our society is facing.

We focus our analysis in the first and second generation ethanol from sugarcane in Brazil, using emission inventories compatible with different technological learning curves envisioned for both technologies, complemented with life-cycle inventory of SLCPs emissions. We add a novel perspective to the biofuel assessment in Brazil by jointly applying expected technology improvements with recent advances in climate impact assessments, which include the multi-metric approach recommended by the UNEP/SETAC. This set of metrics explicitly addresses short-term (a few decades) and long-term (about a century) climate impacts for both greenhouse gases and SLCPs. Other impact categories from updated life cycle assessment methods are also used to address the comparative impacts of biofuel technology options in land use, biodiversity and human health.

Results show that the second generation ethanol will contribute to decrease most of the considered environmental impact categories, mainly when expected process improvements are considered. Our analysis emphasizes the important contribution of SLCPs in the short-term impacts of biofuels. However, longer time scales, more in line with climate stabilization time scales from climate policy, highlight the climate mitigation benefits of biofuels in comparison to fossil fuels. These results support the need of complementary environmental impact categories to support more assertive biofuel polices.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels

The environmental performance of a fossil-free fuel propulsion system with onboard carbon capture: The HyMethShip Concept

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Today's shipping fleet is highly specified and adapted for a variety of tasks resulting in a scenario where decarbonizing the maritime industry will only be feasible if a range of technical solutions is applied. One such potential future solution is the "HyMethShip - Hydrogen-Methanol Ship propulsion system using onboard per-combustion carbon capture" system.

The HyMethShip system combines a membrane reactor, a CO2 capture system, a storage system for CO2 and methanol, as well as a hydrogen-fueled combustion engine into one system. The proposed solution reforms methanol to hydrogen, which is then burned in a conventional reciprocating engine. The CO2 reduction is a result of using renewable methanol as the energy carrier and implementing pre-combustion CO2 capture and storage on the ship. The renewable methanol fuel bunkered on the ship is produced on-shore from the captured CO2, so-called electrofuels, thereby closing the CO2 loop from the ship propulsion system.

The goal of this study is to assess the environmental performance of the HyMethShip propulsion system and identify critical performance aspects.

Life cycle assessment is used to assess the environmental impact. The functional unit is one round trip on a case study ro-ro vessel traveling from Gothenburg, Sweden, to Kiel, Germany, as well as transportation of 1 ton cargo 1 km. The study is conducted as a cradle-to-propeller system consisting of the fuel life cycle, including raw material accusation, fuel production, distribution, storage, bunkering and combustion in ship engines.

The system is compared to today's main liquid maritime fuels and methanol produced through biomass and natural gas, as well as an alternative where methanol from biomass is combined with direct air carbon capture on shore. This poses methodological challenges related to system expansion and allocation. The International Reference Life Cycle Data System's recommended characterization method is used together with the LCA software tool openLCA.

Direct use of hydrogen has been indicated to have economical and environmental benefits compared to electrofuels. However, hydrogens lower volumetric energy density poses a challenge for the maritime industry.

The outcome of the study indicates how the HyMethShip concept in a future scenario where electricity is produced from renewable sources would significantly lower the environmental impact compared with fossil alternatives. A key aspect for the performance of the HyMethShip system is the start-up time and flexibility of the membrane reactor which will affect how much CO2 that can be captured and when hydrogen is available for propulsion. This together with losses of CO2 in the circular system are the main influencers on the total environmental performance of the system.

The HyMethShip concept has the potential to lower the environmental impacts regardless of methanol source if combined with storage of CO2, mainly due to the altered exhaust emissions when burning hydrogen.

SESSION T2-7 LCA of Biomass- and Non-Fossil Conversion-Technologies for Liquid Fuels

The environmental and economic assessment of biomass conversion to sustainable energy in the agricultural biogas plants

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The decrease of fossil fuel consumption in the energy sector and replacing it with energy from renewable sources is an important step towards a more sustainable world. On a global scale, fossil CO2 from energy production by combustion is responsible for 65% of total greenhouse gas emissions. This can be achieved by increasing the share of renewable sources. The Polish energy sector is based for more than 90% on burning fossil fuels. According to data from the International Energy Agency, many Polish power plants are old and damage the environment in a significant way. Poland as any other European country must fulfill its obligations regarding increasing the share in the production of energy from renewable sources. By 2020, this share for Poland is to amount to a minimum of 15% of green energy consumption in final gross energy consumption. Poland has significant biomass potential so it seems that the most promising technology that could develop in Polish conditions is producing energy in agriculture biogas plants. Operating an agricultural biogas plants offers the potential to provide a stable, clean, renewable and diversified energy source. In the same time it is also a good opportunity to reduce the amount of organic waste by converting it into a high quality natural fertilizer. The objective of this study is to evaluate the main environmental hot spots of operating agricultural biogas plants and costs of electricity based on Levelized Cost of Electricity (LCOE) methodology. In this article the environmental impact assessment of four agricultural biogas plants differing in the way the feedstock is provided will be presented. The analyzed biogas plants are representative examples of particular types of agricultural biogas plants. The environmental life cycle assessment was carried out from “cradle to gate” using the SimaPro software the IMPACT 2002+ methodology. In this survey all 15 impact categories distinguished in this method to which 4 damage categories are assigned were taken into account. The assumed functional unit was defined as production of 1 MWh of electricity with standard parameters in the biogas plant. The boundaries of the system included cultivation of energy plants along with transport to a biogas plant, provision of feedstock, energy production, storage and application of digestate. The analysis of the obtained results shows that the highest environmental impact is induced by feedstock transport. The structure of distributed energy production cost indicates a substantial share of feedstock supply costs in the total value of the LCOE ratio.

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SESSION T2-8 Negative Emission Technologies (Net)

Life Cycle CO2 Assessment of a Carbon Capture and Storage System to Be Added on Existing Coal-Fired Power Plants

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Carbon capture and storage (CCS) is a promising technology due to a high potential to sequester anthropogenic CO2 from fossil fuel-based industries. However, the captured and stored CO2 is inevitably offset by the CO2 directly and indirectly generated from energy and material consumptions for CCS construction and operations. Currently, a new CCS system using ammonia as an absorbent is being developed to improve existing monoethanolamine (MEA)-based CCS systems. Thus, this study is intended to evaluate the net CO2 reduction performance of an ammonia-based CCS system and to identify high CO2 emitting processes that need to be improved with priority.

A process-based life cycle CO2 assessment on a model system is performed to evaluate CO2 emissions from processes consisting of the system.

The LCA results showed that the net CO2 reduction of the CCS system is 72%, which is 23% lower than the CO2 capture ratio of 95%. The high CO2 emitters were CO2 capture and wastewater treatment processes. This study can provide valuable information needed to develop high performance ammonia-based CCS systems.

SESSION T2-8 Negative Emission Technologies (Net)

Influence of spatial differentiation in impact assessment for LCA-based decision support: Implementation of biochar technology in Indonesia

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Goal: Spatial differentiation in evaluation of environmental impacts in life cycle assessment (LCA) may give more accurate and realistic results, especially in cases where impacts occur at a local or regional scale and where sensitivity of receiving ecosystems differs from generic conditions. However, from a decision maker's perspective it is of interest to investigate whether the use of spatially differentiated impact assessment methods in addition leads to better decisions. Biochar production and agricultural utilization in Indonesia is an example of a micro-level decision-support case where spatial differentiation could be relevant. Methods: To study the influence of spatial differentiation on management recommendations for implementation of biochar as a waste management strategy and the choice of best performing biochar production techniques, agricultural utilization systems and geographic locations, comparisons were made between four communities living on different Indonesian islands, three biochar production techniques and two types of fertilizer. Results: Results showed that the differences in impact scores between generic and spatially differentiated impact scores were an order of magnitude different for some of the considered impact categories. These differences influenced the identification of which system performed best when considering total damage to human health, which was mainly due to differences in accounting for impacts arising from water use. By contrast, trade-offs between impact categories combined with relatively small contribution of some spatially differentiated impacts rendered spatial differentiation less relevant with regard to total damage to ecosystems. Total impact scores were influenced to a greater extent by variations in inventories determining environmental burden and benefits, than by differences between generic and spatially differentiated characterization factors. Hence, irrespective of the scenario and type of damage considered, both generic and spatially differentiated assessments showed that implementing biochar technology in Indonesia is expected to bring environmental benefits. It was shown that spatial differentiation in impact assessment did not necessary lead to better decisions in this case study. This may suggest that depending on the goal of the LCA, practitioners should consider potential benefits of implementing spatially differentiated life cycle impact assessment methods as opposed to potential benefits from collecting site-specific inventories

SESSION T2-8 Negative Emission Technologies (Net)

Utilisation of Captured CO2 in a Shale Gas Fracturing Process – Life Cycle Assessment

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GOAL AND SCOPE: Exploitation of shale gas in Poland is at a very early stage of several dozen exploratory drilling. First estimates done by U.S. Energy Information Administration (April 2011) suggested potential resources of 5,3 bln m3 – enough to supply Poland for next 300 years – but even with the latest estimates of 346-768 billion m3 conducted by Polish experts (Polish Geological Institute) that would be enough for 40 years. Regardless of the obvious uncertainties in the recoverable reserve size, shale gas could clearly be a 'game-changing' resource that could transform the Polish energy market and contribute significantly to the national supply security of. However, while the economic potential is obvious, its environmental and social implications are currently unknown, making it a controversial issue.

PURPOSE: The presented research aimed at comparing environmental impacts of shale gas extraction made by using two technologies differing in a medium used as a fracking agent: conventional hydraulic fracking – using water, and a new patented CDOF method – using a carbon dioxide, captured from CO2 sources.

METHODS: A Life Cycle Assessment (LCA) methodology has been used to assess and compare the life cycle potential environmental impacts. A goal and scope; an inventory analysis - including different scenarios for dealing with multifunctionality; an impact assessment and an interpretation have been made and reported.

RESULTS: The research showed that both compared technologies differ considerably, both from an inventory and an impact assessment perspective. The system of shale gas production with using of CDOF technology needs to be modeled as a multifunctional system, which is specific for CCU technologies. The conventional hydraulic fracking is assumed as a mono-functional system. Both tracking agents differ in cradles (the CO2 is "born" during the production of the main product made by CO2 sources; the water is taken from nature) and in production facilities (the conventional hydraulic fracking involves intensive land occupation and transformation and calls for construction of water storage devices and wastewater treatment).

SESSION T2-8 Negative Emission Technologies (Net)

Life cycle assessment of biochar systems: key methodological aspects and recommendations

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GOAL.

Biochar is a negative emission technology (NET) of interest primarily because it sequesters carbon in a more stable form than organic matter in vegetation and soils. It is of environmental interest for its mitigation potential of various sources of pollution. Direct economic interests arise from the biochar's value as a product. The pyrolysis co-products also have an inherent economic value either for energy or in industrial applications. Biochar systems are already being deployed in different parts of the world and at different scales, despite very limited policy support. For stronger integration in climate policies and financial mechanisms for climate action, a better quantification of the life cycle climate impacts of biochar is needed. Trade-offs and synergies with other environmental impacts and human uses of biomass must also be understood. The goal is to describe key methodological aspects for quantifying the climate impact of biochar as a NET in life cycle assessments (LCA). Other key sustainability aspects to consider in assessments of biochar are also described.

METHODS.

The key LCA methodological aspects are identified based on a review of published biochar LCAs and the experience of several on-going biochar LCA case studies. These case studies include large (city district heating) and small scale (household cooking and heating) systems, in two different countries (Sweden and Kenya). Specific biochar applications such as soil remediation or urban greening are also analysed. Recommendations and needs for further development are included.

RESULTS.

One key aspect is to treat biochar as a special case of biorefinery LCA, with biochar and pyrolysis co-products as the outputs of a multifunctional system. Another is to define and analyse several alternative systems, considering different biomass feedstocks, co-product uses and biochar uses. The choice of alternatives depends on the scale of the production unit, the feedstock's physical and economic properties, and the local context. In prospective or large-scale assessment, it is recommended to investigate several contrasting alternatives and future developments of the LCA's background system.

Further, the use of biochar in agriculture has complex biogeochemical and biogeophysical effects on agroecosystems. Biochar can alter soil organic carbon levels, nitrous oxide and methane emissions, surface albedo, soil roughness and evapotranspiration. Including these effects in climate impact assessments requires explicit modelling that can vary in complexity and uncertainty, often with limited availability of experimental data. Thus, biochar climate assessments tend to include few biogeochemical factors while biogeophysical ones are mostly excluded. Temporal aspects of carbon cycles and biochar stability in soils are also essential for robust assessments. Biochar use is not limited to agricultural applications. Whether it is in construction or filter applications, explicitly describing the fate of the biochar over its life cycle is essential for taking into account carbon sequestration and substitution effects.

In biochar LCA, the main interactions with other sustainability aspects relate to air pollutant emissions during production and handling, nutrient use and leaching in agriculture, and land use change.

SESSION T2-9 Sustainability in the Construction Sector

Sustainability in Construction: the thought of the life cycle guiding the journey of an important product manufacture of waterproofing in Brazil

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Several factors motivate companies to incorporate sustainability into their business strategy. Whether it is for convenience, embarrassment, or sense of guilt, the fact is that this theme has many possible ways to be developed, but they often stay superficial because they do not take a more systemic view of understanding the value chain neither see opportunities for innovation that can range from business models, products, services and processes. According to the relevance of sustainability topics in the construction market, some governmental politics are boosting the adoption of sustainable practices in the value chain. Allied with its vocation to innovation, Vedacit was motivated to intensify its action in this journey. Vedacit is a 100% Brazilian company and for over 80 years has played an important role in the national construction sector, where it participated in major infrastructure projects such as the Itaipu Power Plant (PR) and the Museum of Tomorrow (RJ), both in Brazil. It is a leading brand of clients and professionals (architects, builders and engineers) in the waterproofing membranes sector. In 2018, along with Espaço ECO Foundation (FEE), Civil Society Organization of Public Interest (OSCIP) and specialized consultancy to promote sustainability in the business environment through life cycle thinking, started the project to understand their value chain and defines objectives, targets, the structure and management model of sustainability in the company. The life cycle thinking guided the project, which took place during six months in 2018. Starting with the mapping of the value chain, a perception study based on interviews with the main stakeholders, followed by the definition of its material themes. The second stage consisted of interviews with employees to map and identify pre-existing actions in the company and a benchmark study on the positioning of the main competitors regarding material topics, where in the end the company defined 07 priority themes by 2025, following the Simon Zadek's Matrix. The third and final stage resulted in the construction of the sustainability management model and the definition of short, medium and long-term objectives and targets. Immediate results highlight the challenges and opportunities for the company to continue to differentiate itself in the market in which it operates: highlight the role of the Vedacit Institute as an important player in stimulating innovation and harmony among people, housing and urban spaces focusing on the Cities of the Future; start of a project regarding reverse logistics of product packaging; possibility of development and/or improvement of processes and services being more assertive in the delivery of value to its clients; integrated and transversal vision of the theme in the company and development of the intellectual capital, especially of the high leadership, to incorporate this vision in the decision making. Today the responsibility of sustainability strategy implementation is shared among all areas of the company. It was defined that life cycle assessment (LCA) will be the tool to be adopted to ensure continuous improvement of products and the goals of the strategy will be reported in the Global Report Initiative (GRI) standards.

SESSION T2-9 Sustainability in the Construction Sector

Rebond Effects on Housing LCA Results

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In France, 20% of the climate change impacts are due to the building sector. A share of 65% of this sector is composed of buildings constructed before 1975, with no thermal regulation. Those buildings have an average energy consumption of about 300 kWhPE/m2.yr. In order to decrease the energy consumption of the building sector, a refurbishment of those buildings shall be proposed systematically. Following refurbishment of a building, the energy consumption must have decreased but it is in fact highly dependent on the inhabitant behavior. The goal of this work is to assess the balance between the environmental benefits drawn from a decrease of energy consumption after refurbishment and the increase of the environmental burden due to different inhabitant energy consumption behavior.

The presented case study considers such a refurbishment of a single-family house located in the North of France, built in 1939 and refurbished in 2014-2016, with a living area of 60 square meters. In order to create the inhabitant behavior scenarios, a deterministic approach has been chosen. The calculated energy consumption after refurbishment is 110 kWhPE/m2.yr. This value is the reference scenario in terms of inhabitant energy consumption behavior. Other scenarios are created by varying this behavior.

The results have highlighted the importance of the building use phase on the whole life cycle environmental burden. The potential environmental variation due to inhabitant energy consumption behavior has been compared to the potential benefits drawn from alternative construction products. It is shown that inhabitant energy consumption behavior is crucial. Indeed, it can reduce or even cancel the environmental benefits achieved by energy efficiency refurbishment.

SESSION T2-9 Sustainability in the Construction Sector

LCA supported development of innovative building materials

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Introduction and Objective

Construction and buildings have a significant impact on the environment through several sectors of the industry. Interference with the natural environment also affects the resources of the raw material mining and the exhausted resources. Looking at a life cycle approach, one of the greatest environmental burdens is the production of building materials, in particular due to the high energy demand and carbon dioxide emissions. The impact of the construction sector on the environment and especially on the greenhouse effect could be exactly determined by material flow analysis, tracking each component of flows from cradle to grave / cradle and aggregating environmental impacts. In 2016 with the aid of the Economic Development and Innovation Operational Program and following the Quadruple Helix model, ÉMI Nonprofit Llc. (ÉMI) as a R&D&I knowledge center has started the establishment of a joint research network of the Higher Education - Industry Cooperation Center (FIEK). Consortium partners are the University of Miskolc, BorsodChem and Bosch in the project. The aim is to map research, development and innovation needs of industrial companies using advanced technologies and to provide market-based service.

Method

The Life Cycle Assessment (LCA) methodology aims to enable a correct assessment of the environmental aspects and potential impacts associated with a product. A life cycle approach can help to make choices in the building and construction sector, knowing that from raw material extraction to decomposition of waste, each phase of the life cycle requires energy and is associated with carbon dioxide emissions. It implies that everyone in the whole chain of a product's life cycle, has a responsibility and play a role taking into account all the relevant impacts on economy, environment and society. Beside LCA which is an internationally accepted and useful tool to assess the environmental impact of products, the project includes the preparation of a Life Cycle Sustainability Assessment (LCSA), as it covers not only environmental (E-LCA) but also economic (LCC) and social (S-LCA) effects. Combining the aspects listed above, LCSA can be used to compare the products.

Results

The project is based on taking into account market needs, so the economic viability of the R&D&I results is a key issue. Therefore, the project aims to reduce the number of construction technology steps to create products with higher added value and to increase the final technical quality of the buildings being realized. Research directions of the project:

- Development of innovative and environmentally friendly, plastic-based insulating materials, products and technologies;
- Material and technology research to establish intelligent building management systems;
- LCA-based development of innovative and environmentally friendly concrete components.

The environmental impact of the properties and technology of patented plastic-based insulating materials developed during the research were investigated by life cycle analysis. The novelty content lies in the product composition and production technology. The analysis from cradle to gate system boundaries were evaluated using the GaBi software according to the CML method. 5 PUR-based insulation materials combined with different materials were developed. As a reference, we have chosen 1 kg of pure PUR insulation material. In this respect, impact category indicators, thermal conductivity and costs were also considered 100%. The characteristics of the developed prototypes are expressed as a percentage of these values. As for the environmental profile and thermal conductivity, the PRT_3 sample was the best and from viewpoint of economic, the best is the PRT_5 sample.

In the intelligent building management system based on development of sensors (inside outside), and will be analyzed by LCA. Environmental savings achieved during one year of operation of built-in sensors compared to a building without a sensor with the same function. In addition, other aspects of the sensor are important: sensing accuracy of a sensor, operational safety of a sensor, power consumption life.

In the present phase of the research, the environmental impact of the sensor installation was examined. The global warming potential is connected to the transport and PVC.

In case of light weight concrete development, we have 9 experimental samples and were analysed by LCA. From the analyzes carried out so far, the change in environmental impacts depends on the environmental profile of the cement and the cement content of the samples. The higher the cement content results greater acidification potential, abiotic depletion potential, and the gobal warming potential.

Conclusion

The experimental results proved that the samples are worth developing and the resulting products can be the first steps towards sustainable large-scale manufacturing of the unique product, which is another important element of Industry 4.0.

SESSION T2-9 Sustainability in the Construction Sector

GREEN PUBLIC PROCUREMENT AND BUILDING SUSTAINABILITY ASSESSMENT TOOLS: AN ANALYSIS APPLIED TO THE OFFICE SECTOR

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Goal

Each year, the public authorities of the European Union (EU) spend the equivalent of 16% of the EU Gross Domestic Product in the purchase of goods, services and works. Taking into account this context, green public procurement (GPP) can guide the production and consumption trends, since a significant demand from public authorities for greener products and services will create or expand markets that respect the environment and also improve the use and efficiency of resources.

The building sector is one of the greatly responsible for the main environmental and sustainability problems affecting our society. Therefore, the incorporation of environmental requirements into public tender documents of the building sector can significantly boost the increase in the sustainability of buildings. With this aim, the European Commission has developed GPP criteria for buildings, and specifically, for office building design, construction and management.

In parallel, different tools to evaluate the sustainability of buildings have been recently developed. They allow a holistic assessment of buildings, including aspects such as energy, water, pollution, waste, transport, materials, indoor environmental quality, site conditions, management and innovation. Many of these aspects are strongly related to the criteria covered by GPP. However, other aspects covered by these sustainability tools are missing in the GPP criteria.

The aim of this study is to analyse the relationship between the GPP criteria for the sector of office building design, construction and management, and the criteria covered by the building sustainability assessment tool BREEAM (Building Research Establishment Environmental Assessment Method).

Methods

On one hand, EU GPP criteria for office buildings are analysed considering selection criteria and award criteria for two ambition levels: core and comprehensive. On the other hand, sustainability criteria included in BREEAM tool are also analysed and compared against the GPP criteria to assess the level of GPP fulfilment and to identify possible gaps and missing issues. In addition, the improvement in the BREEAM rating is assessed by applying both selection and award criteria.

Results

The comparison of both criteria used in GPP and BREEAM allowed three main results to be obtained:

- Analysis of the scope of GPP and the level of coverage of BREEAM criteria.
- Estimation of the percentage increase in the rating of BREEAM when applying selection and award GPP criteria.
- Identification of missing sustainable criteria in GPP and proposal of its inclusion in public tender documents.

The results of the study may assist public authorities on providing guidelines to integrate environmental performance, social and cost considerations according to their needs and ambition level to include in their tender documents for the office building sector.

SESSION T2-9 Sustainability in the Construction Sector

MODEL OF ENVIRONMENTAL DECLARATION OF BUILDINGS AS INSTRUMENT FOR THE SUSTAINABLE CONSTRUCTION OF HOUSING IN COLOMBIA

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This article is the result of the first phase of a research project on the opportunities of the implementation of a model of environmental declaration of housing buildings in Colombia. It has been taken as theoretical references; the sustainable construction in the Colombian context, the existing territorial and sectoral regulations; Life Cycle Assessment (LCA) applied to buildings; Environmental Product Declarations (DAP), regarding environmental labeling type III.

According to the above, two phases are proposed for the development of the research. The first seeks to provide the information base in Colombia around the subject and the second one is to define a model and explore with stakeholders its implementation, from a simple holistic case study approach, using a research-action design method.

This research has the expectation of generating discussion regarding the application of LCA in buildings, using methodological bases of the EDP as a contribution to the evaluation of the entire building. It is expected that from the main characteristics of a EDP such as the reliability to be verified by an independent third part, the definition of product category rules (RCP), and the standardization of the functional unit and system limits, allow the development of a model for reliable communication of environmental impacts.

In order to comply with the above, as a result of the first phase, valuable contributions of the literature as well as methodological and conceptual doubts are identified, around the idea of the application or use of the Environmental Declarations of buildings, as a strategic resource to reduce their negative environmental impacts, in the whole construction process, considering the materials and processes involved in the building.

Finally, it is worth noting that this article is the result of the diagnostic phase that is the basis for the development of the following of the investigation.

SESSION T2-9 Sustainability in the Construction Sector

Consequential life cycle assessment methodology applied to the construction sector

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Goals. Nowadays, the most widely used tool to assess environmental impacts is the Life Cycle Assessment (LCA), generally using the attributional methodology. While this approach assesses the environmental profile of a product or system in a defined instant “t”, Consequential Life Cycle Assessment (C-LCA) can be very relevant for quantifying large-scale changes. This is because C-LCA evaluates the environmental impacts as a result of the consequences of the changes based on scenarii of different decisions.

The construction sector is an important contributor to key environmental issues such as energy consumption, greenhouse gas emissions, and waste generation. The sector recognizes the need to implement strategic policies and market incentives to reduce their impacts by taking a life-cycle approach. In this context, C-LCA may have an important role in supporting decision-makers of the construction sector by giving a wider comprehension of the environmental impacts associated to the changes caused by their decisions, including the market effects induced by these changes. For example, if a renovation work of a set of buildings increases the demand for a constrained material A, then this induces an increase in demand for a substitute material B to satisfy the demand of other consumers of A.

Despite the increased interest in the consequential approach over the past 10 years, C-LCA methodology is not yet standardized and the methodological framework remains under development. This research aims at proposing a methodological framework for conducting a consequential LCA useful for the construction sector.

Methods. Consequential Life Cycle Inventory (LCI) modeling must include all the processes that are affected by the studied changes, considering the market effects. The major difficulty lies in identifying those processes and the economic models can be helpful on this matter.

This project reviews the economic models used in C-LCA. Although linear models are conventionally used in LCA, nonlinear models (e.g. computable general equilibrium) have increased their use in C-LCA because they can include important market aspects neglected by linear models.

We propose a 6-step iterative method to define the C-LCA methodology, which must be general and apply to any system in study, defined as:

Step 1 proposes a general C-LCA methodology, considering the literature review and economic models.

Step 2 defines a simple case study and collects data for consequential LCI.

Step 3 applies the proposed methodology to the case study of step 2.

Step 4 gathers data for a more complex case study (by adding elements to the step 2 case study, for example).

Step 5 adjusts the methodology and reapply it to the step 4 case study. There may be iterative loops between steps 4 and 5 until the methodology is adjusted.

Step 6 compares the consequential and attributional results for the final case study.

Results. The expected results are the following: the development of a consequential LCA methodology; a set of rules to help identify and select data for consequential LCI; collected data for a case study on construction sector; and a concrete case study comparing the attributional and consequential LCA approaches.

SESSION T2-9 Sustainability in the Construction Sector

IDENTIFYING HOTSPOTS IN EXISTING WATER INFRASTRUCTURE BY APPLYING A LIFE CYCLE PERSPECTIVE

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Today's world population is approximately 7.5 billion and is expected to continue to increase until the end of the century, where current estimates place the then population at about 11 billion. On one hand, an increase in population combined with rising living standards leads to growing consumption of resources over time. On the other hand, we have started to observe the limits of natural systems to absorb human impacts and thus topics such as climate change will continue to be important factors during decision-making in the future affecting engineering together with most profession. One impact of climate change is being observed through changing precipitation patterns. Such a change poses an immediate challenge for civil engineering structures and infrastructure specifically. Applying a life cycle perspective indicates that infrastructure most exposed to effects of a changing climate are vulnerable. The existing water infrastructure built in past years by using the previous 50-100 years or more worth of data is no longer relevant for today, and thus civil engineering is designing infrastructure for the past century and not for the future. As design input change, so must the engineering design. This study analyzes the existing water infrastructure in Turkey as a case study and aims to identify hotspots through applying a life cycle perspective. The study aims to determine where changes are needed and their magnitude to continue to provide sufficient service. Asset management of infrastructure, which is based on the principle of life cycle management, will grow in importance as countries struggle to keep up with rising upkeep demand of an ageing infrastructure. The study, with its scope and methodology provides guidance for applying life cycle management to analyze existing infrastructure components and to forecast need areas. Population, water consumption, infrastructure capacity, and future predicted impacts were considered as variables in the study to form conclusions

SESSION T2-9 Sustainability in the Construction Sector

Rainwater harvesting potential for rooftop greenhouses irrigation and CO2 reduction in cities using airborne hyperspectral remote sensing

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Currently, 55% of the world's population is living in urban areas. Urbanization, population growth, and global climate change represent pressure on natural resources. Water is a finite resource and its demand has already exceeded local capacities in many cases. Currently, agriculture consumes 70% of water worldwide. Besides, by 2050 the global demand for food production will increase by 70%. In recent years, urban agriculture has emerged as a sustainable strategy for food production in cities. In this sense, rooftops can be used as productive spaces for food, water or energy production. Rainwater harvesting systems are a strategy for improving urban water management. Rainwater collected can be used for irrigation, decreasing the consumption of potable water. The aim of this study is to quantify the rainwater harvesting potential for rooftop greenhouses (RTGs) irrigation and to calculate reductions in CO2 eq emissions that occur from substituting harvested rainwater instead of public water supplies for irrigation.

For this purpose, image data of the selected study area was acquired in March 2018 using hyperspectral airborne sensors: AisaEagle 2 (400-1000 nm) and TASI-600 (8000-11500 nm). A rooftop classification and validation were performed. Data for LiDAR (Light Detection and Ranging) sensor was also used, to identify rooftops characteristics. For quantify the potential, different rooftops parameters were considered such as area, slope, and the rooftop material. Our case study is based on a Mediterranean municipality with a population density of 3,952 inhabitant/km2. Different surface material classes were identified, including metal, gravel, asphalt, and clays rooftop surfaces, among others. The first findings indicate that 3.07% of rooftops can be used for RTGs. Rainwater can be collected in a total area of 1.7 km2, this means complete self-sufficiency (100%) irrigation for tomato crop. The excess of water could be used for laundry and flush. The use of rainwater for this purpose would reduce the public water supply in 50847, 23 m3/year and would save 16 tones CO2 eq/year and 1198 tones CO2 eq/year for tomato production.

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SESSION T2-9 Sustainability in the Construction Sector

Integrating LCA in planning, design and construction practices for new multi-family residential buildings in Sweden

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Goal:

The Swedish housing authority has proposed a mandatory introduction of LCA-based climate declarations for the construction of new multi-family residential buildings in Sweden. The housing authority aims with these climate declarations to improve the sector's understanding on how to reduce climate impacts of buildings. The mandatory introduction of these declarations is expected to lead to a certain reduction of carbon dioxide emissions in the construction sector. However, LCA-based climate declarations can only improve building environmental performance when they inform changes in building life cycle practices. If climate declarations remain isolated from the operational, they risk becoming little more than an expensive paper trail.

Currently, the integration of LCA in building life cycle practices is understood poorly. There is a knowledge gap explaining how and where LCA may lead to changes in the decisions made during each stage of a building project. While we believe in the value of LCA and LCM, it is no secret that many well executed life cycle studies do not lead to the changes that their results recommend.

In this study, we focus on the integration of life cycle concerns in the planning, design and construction of multi-family residential buildings. The goal of the study is to find out how and where LCA may be integrated in the planning, design and construction practices of multi-family residential buildings in order to effectively improve the environmental performance of these buildings.

Method:

A development process in a large Swedish contractor is taken as a study object. During the process, twenty different stakeholders – ranging from architects to sales managers – collaborate to develop a new building product. Using a longitudinal ethnographic approach, we follow the development process during the program, systems design, detailed design, and construction stage. Data collection takes place through a combination of participant observation and semi-structured interviews. These research methods are used to produce a rich description of stakeholder actions and organizational context, as well as the legitimations that stakeholders give to justify the direction in which the environmental performance of the product travels during each stage in the development process.

Results:

The study allows us to identify environmentally relevant decisions at the various stages in the building development process. In addition, an explanation is presented for why certain configurations for improving the building environmental life cycle are successfully integrated in the development process while others are not. These results allow us to identify where and how LCA-based climate declarations may inform LCM practices that improve the environmental performance of a building's life cycle.

SESSION T2-9 Sustainability in the Construction Sector

Greenhouse gas emission scenario analysis for zero-emission neighbourhood projects: Methodology and case study

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Buildings represent a critical piece of a low-carbon future and their long lifetime necessitates urgent adoption of state-of-the-art performance standards to avoid significant lock-in risk. So far, LCA studies have assessed buildings, mobility and energy systems mainly individually. Yet, these elements are closely linked together, and to assess the nexus of housing, mobility, and energy associated with human settlements by aiming for minimized greenhouse gas (GHG) emissions in Zero Emission Neighborhood (ZEN) projects gives a unique chance to contribute to climate change mitigation.

In Norway, the Research Centre on ZEN in Smart Cities (https://fmezen.no/) has as a goal to enable the transition to a low carbon society by developing sustainable neighbourhoods with GHG emissions. The Centre aims to (1) develop neighbourhood design and planning instruments while integrating science-based knowledge on GHG emissions, (2) create new business models, roles and services that address the lack of flexibility towards markets and catalyze the development of innovations for a broader public use, (3) create cost effective and resource and energy efficient buildings by developing low carbon technologies and construction systems based on lifecycle design strategies and (4) develop technologies and solutions for the design and operation of energy flexible neighbourhoods.

In this study, we developed and applied an LCA-based model for estimating GHG emissions from a ZEN project over the future 60 years based on a modular structure with five physical elements; buildings, mobility, open spaces, networks and on-site energy infrastructure. As a proof-of-concept the model was tested for Ydalir, a pilot project of the ZEN Centre, in Norway.

The analysis reveals that regardless of which scenario considered, the ZEN Ydalir project does not manage to achieve its ambitious goal of zero emissions with the present plan, although this is far more ambitious than current building codes. However, the neighborhood's solutions and GHG emission results represent an important step towards a zero emission society, highlighting several crucial measures for further improvement on the field zero emission neighborhoods. The results demonstrate that the mobility during 60 years of operation is the major source of GHG emissions, accounting for 57-61% of the total. When considering emissions embodied in materials, the buildings is the largest contributor representing 51% of all GHG emissions from materials in both scenarios. Thus, operation stage of mobility and the material stage of buildings represent the obvious targets for future improvements, despite this is also where the main focus has been in the recent past.

The model and data used in this work is associated with several uncertainty factors. Parameters assumed to have significant uncertainties or are large contributors to the environmental impact are included in a sensitivity analysis and have been calculated and discussed. The study suggests a methodology that is well in line with relevant standards for GHG emission calculations as well as the analytical demand for structure, transparency, and contribution and sensitivity analysis, aiming mainly for decision support in the early stages of the planning process for a ZEN project.

SESSION T2-9 Sustainability in the Construction Sector

Developments towards mainstreaming LCA in the Belgian construction sector: online tool supporting decision-making for building solutions linked to a national EPD database

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Different stakeholders work together to make sustainability more mainstream in the Belgian construction sector. This is done by creating a platform for building designers to assess the environmental performance of different buildings and building elements variants and by enabling manufacturers and sector associations to upload their Environmental Product Declaration (EPD) to the platform.

In February 2018, the web-based calculation tool TOTEM ("Tool to Optimise the Total Environmental impact of Materials") became available to the public. The tool enables building level environmental impact assessments and was developed as part of a collaboration between the three regional Belgian authorities. The tool focuses on use by building designers and other stakeholders and aims at being transparent and objective. The basis for the tool is an LCA method and export model called MMG ("Environmental profile of building elements"), developed with the aim to consistently conduct an environmental impact assessment of building elements and buildings in Belgium.

At this moment, TOTEM is based on generic environmental data from the Swiss ecoinvent database (version 3.3), adapted to the Belgian context. Preparatory work has however started to include Environmental Product Declarations (EPDs) in TOTEM. The EPDs must be registered in the national database established by the Belgian federal government for specific environmental data of construction materials used on the Belgian market (B-EPDs). Some additional requirements for integration of specific EPDs in TOTEM have been defined. This ensures a fluent workflow with minimal delays for manufacturers who are in the process of creating B-EPDs. The MMG method and TOTEM comply with the EN 15804+A1 standard (CEN, 2013) and currently considers production, use and end of life of the product (including transport). For certain modules, specific Belgian scenarios were defined in a horizontal PCR (NBN/DTD B 08-001:2017). To motivate manufacturers to create B-EPDs for their products, a penalty will be added to the generic data used in TOTEM. On top of the environmental indicators required by EN 15804+A1, the MMG method considers additional indicators based on the recommendations of the International Reference Life Cycle Data System (ILCD) Handbook (EC-JRC, 2011) and Product Environmental Footprint (PEF) Guide (EC, 2013). Additionally, monetisation factors are applied to express single score results. This ensures easy use of TOTEM by the tool user and supports decision making. At this moment the use of TOTEM is not legally enforced. After the launch in February 2018, the tool has been optimised and tested. Its use is encouraged and monitored by the three Belgian regional authorities and might form the basis for a legislative framework in the future. Additional features of TOTEM that are being investigated are linking of the energy use simulation to the EPB calculation tool for energy performance and indoor climate, establishing reference values (benchmarks) and the inclusion of circularity (reversibility of building elements).

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SESSION T2-9 Sustainability in the Construction Sector

EEAH Tool: Environmental and Economic Assessment on Housing Refurbishment - A simplified tool

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The worldwide context is the increase of the global warming due to the climate change. In France, 20% of the climate change impacts are due to the building sector. A share of 65% of this sector is moreover composed of buildings constructed before 1975, with no thermal regulation. The corresponding energy consumption is of those buildings is on average of 300 kWhPE/m2.yr. Refurbishment is considered to be crucial to decrease the building contribution to climate change. Nowadays, the decision making of refurbishment alternatives has to take into both economic and environmental criteria. The goal of this work is to present the ongoing development of a simplified tool taking into account those two criteria for refurbishment operations of single-family houses in the North of France. This tool must be free of charge, prompt use and within easy results interpretation.

In order to develop this tool, two case studies of single-family houses were chosen, located in the North of France. Life cycle assessments and life cycle costing were realized according to the standards EN 15 978 and ISO 15686-5, respectively. The environmental hotspots and economic hotspots were found out. Those hotspots compose the foundation of the simplified tool. In order to promote the quick use, only the most impacting construction products and life cycle phases are considered by the tool. The data come from the French environmental construction product database INIES and the French economic database BATIPRIX 2018. All choices made for the simplified tool will be detailed in the article.

Thereafter the environmental and economic result visualization followed the eco-efficiency methodology and the ratio one. Graphs are used to choose a win-win situation and ratios are used combined with the graphs in order to allow a choice when there is no win-win situation. The tool is easy to use (excel sheets) and quick. The first results allow the project managers to take a decision between construction products.

SESSION T2-9 Sustainability in the Construction Sector

Mainstream use of EPDs in buildings and construction in the context of decision-making

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WeLOOP

Sustainable buildings are the fabric of sustainable lifestyles. Whilst public and building industry understand the importance of energy efficiency, the environmental impacts of the building products and materials are remained less known. For an energy-efficient house, the embodied energy in the construction represents more than 75 years of heating in equivalent energy. To assess environmental impacts of a building, it is necessary to consider the overall building lifecycle.

The construction industry is one of leading sectors in Life Cycle Assessment (LCA). LCA has been used to assess the environmental impact of construction products and buildings. EPDs are available for a wide range of products in different EU countries. EPDs can be used in the context of decision making. EPDs are used today in case of new buildings and renovations. In some countries, EPDs are related to benchmarking approach at product or building level (ex. shadow cost approach in Netherlands permitting monetarization of impacts). European Product Footprint (PEF) of European Commission is another ongoing initiative that aims to provide the possibility to benchmark products based on LCA.

Although EPDs are well developed in the European context, their use is limited and challenging. Several challenges are identified on the use of EPDs:

First major issue is the complexity of EPDs and lack of knowledge of different key actors to use them. Although LCA and EPDs are used in building and construction, there is a need for awareness rising, training, and simplification of EPDs for these key actors. E.g. in France our major challenge is to train real states owners: public and private on the use of EPDs. Missing regulation is another barrier to use EPDs in wider context.

The second major issue is the lack of equal opportunity for different companies and products to use EPDs. Availability of EPDs are still very limited. As consequence of the cost, small and medium size companies are realizing less EPDs. The missing EPDs for the companies with limited resources is a discriminatory aspect.

The next aspect is that EPDs are developed as information for building assessment to be used only at building level for B2B and B2C communication. Therefor the information provided at product level (or even at application level) cannot be used in a context of decision making and benchmarking. At building level, the mechanism to converge EPDs to the building needs to be further assessed. Simplified tools are crucial to mainstream the use of EPDs at this level.

The aim of this contribution is to highlight the use of EPD in European context and discuss challenges for a wider application of the EPD worldwide. Also to highlight and exchange with participants on some potential solutions.

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SESSION T2-9 Sustainability in the Construction Sector

Environmental benchmarks for LCA-based decisions in the construction industry

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Goal: Decisions based on Life cycle assessment (LCA) in construction usually involve comparing different products based only on average environmental impact values for each alternative. However, literature data show that impact variability among manufacturers of the same product is high, which implies an improvement potential that is being ignored by most LCA studies. This work aims to present how sector-based benchmarks can indicate the potential reduction of environmental impacts in the manufacturing of construction materials, as to encourage improvements in the sector. This will be illustrated by a case study of the Brazilian concrete block sector. Method: The product assessed is one concrete block with a characteristic compressive strength of 4 MPa. The system boundary goes from cradle to factory gate. Data for the concrete block production process were collected from 25 factories, which together correspond to approximately 50% of the national production volume. The production of raw materials (cement, sand and gravel) was modeled using average Brazilian data gathered in another study, while other upstream processes were modeled using the ecoinvent database (version 3.4). The global warming potential (GWP) indicator was calculated for each factory. To quantify the total GWP mitigation potential within this group of factories (in one year), three scenarios were considered, in which factories above a certain GWP level reduce their impact to that level, namely: 1) the average GWP of the sample; 2) the GWP corresponding to the 25% best performers of the sample; and 3) the minimum GWP of the sample. Results: the average GWP is 0,80 kg CO2,eq/block, varying from 0,60 to 1,34 kg CO2,eq/block. The total GWP of the 25 factories is of 27.206 t CO2,eq/year. Half of the factories (13) perform worse than the average; if they reduce their impact to the current average GWP (scenario 1), the total reduction would be of 1.874 t CO2,eq in one year, or 7% of the total GWP. In scenario 02, seven factories show a GWP equal or lower than 0,68 kg CO2,eq/block; if the 18 remaining factories would reduce their impact to that level, the total reduction would be of 4.635 t CO2,eq/year (17% of the total GWP). In scenario 03, the total reduction increases to 6.877 t CO2,eq/year (25% of the total GWP). Differences in the cement content among manufacturers are the main reason for GWP variability; therefore, mix optimization is a promising strategy to reduce the environmental impact, which can also be cost effective – cement is on average 6% of the mass, but 32% of the materials' cost of a concrete block. Since similar variability levels can be expected for other cement-based materials, which represent a significant share of the construction industry's GWP, great impact reductions can be achieved if manufacturers improve their processes. Companies are therefore encouraged to select their suppliers based on environmental performance. The results demonstrate that benchmarks can be a powerful tool towards reducing the environmental impacts of construction. Further research can include the consideration of multiple environmental impact indicators in the development of these benchmarks.

SESSION T2-9 Sustainability in the Construction Sector

Importance of building energy efficiency towards national and regional energy targets

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Goal: In the EU, buildings are responsible for approximately 40% of energy consumption, and 36% of greenhouse gas emissions. Currently, almost 75% of the building stock in the EU is reported to be energy inefficient. There is urgency towards further action as the EU has a 2020 strategy of making new construction nearly zero-emission buildings. While existing building energy codes and regulations are a step forward in the right direction, they have not proven to be sufficient to achieve desired efficiency gains. The goal of this study is to identify whether the EU can reach its building energy efficiency targets and assess whether the existing policies and codes are sufficient for that purpose.

Methods: Total energy consumption together with the building sector's share has been analyzed together with forecasts for the near future in line with EU Directives timeline. A multi-parameter residential building energy efficiency analysis was carried out to identify potential energy savings of techniques when applied to residential buildings. The total life cycle impacts and savings have also been calculated.

Results: Results indicate that intended EU energy-efficiency goals cannot be met if the best available energy-efficiency measures are not applied when existing dwellings undergo renovation during their lifetime. While existing building energy codes and regulations are a step forward in the right direction, they have not proven to be sufficient to achieve desired efficiency gains. The problem is complex, requiring input and close collaboration between the architecture, engineering, construction, owners and operators (AECOO) sectors, which traditionally act as separate entities with their own sphere of influence. However, life cycle management of the problem could yield efficient solutions but require policies and management techniques with increased collaboration among the affected industries.

SESSION T2-9 Sustainability in the Construction Sector

Life cycle assessment of potassium chloride as clay soil stabilizer in road construction projects

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Asplan Viak

Goal:

The safe construction of new roads requires thorough examination of soils and appropriate handling of potential issues. One of the issues identified in road construction in the area around Trondheim, Norway, is clay soils. Clay soils require soil stabilization. The stabilized soil materials have a higher strength, lower permeability and lower compressibility than the native soil. Soil stabilization can be accomplished by several methods that fall into two broad categories: mechanical stabilization and chemical stabilization. By mechanical stabilization, soil stabilization can be achieved through physical processes by altering the physical nature of native soil particles by either induced vibration or compaction or by incorporating other physical properties such as barriers and nailing. By chemical stabilization, soil stabilization depends mainly on chemical reactions between stabilizer and soil minerals to achieve the desired effect. Through soil stabilization, unbound materials can be stabilized with cementitious materials (cement, lime, fly ash, bitumen or combination of these). In this study, we evaluate the environmental impacts associated with the production and delivery of a chemical stabilization agent, namely potassium chloride.

Method:

The environmental impact of potassium chloride was evaluated in terms of five categories: climate change, acidification, eutrophication, photochemical ozone formation, and accumulated energy use. The inventory was compiled using the attributional, process-based method with ecoinvent 3.2 as the databse. The impacts were calculated from the hierarchical perspective with the ReCiPe method

The potassium chloride salt (white 62% K2O) is extracted through traditional mining in the Perm region in Russia. The finished product is packed in polypropylene bags that contain 25 kg potassium chloride. From Perm, the packed salt is transported by freight train to St. Petersburg, where it is temporarily stored until it is transported by ship to Haugesund, Norway. In Haugesund, the salt is temporarily stored until it is shipped by boat to Trondheim, Norway. Once arrived in Trondheim it will be used as soil stabilizer.

Results:

We find that the cradle-to-gate processes contribute with about 25-80% of the total impacts, while the transport from Perm to Trondheim contributes with about 15-60% of the impacts. The impact associated with the storage units contribute are miniscule, about 1-3% of the totals.

Looking at climate change impact in particular, we find that the total impact is 0.43 kg CO2-eq/kg potassium chloride. The cradle-to-gate impact is 0.19 kg CO2-eq/kg, where the plant contributes with 0.07 kg CO2-eq of these. The packaging bags contribute with 0.10 kg CO2-eq/kg. Transport by freight from Perm to St. Petersburg contributes with 0.10 kg CO2-eq/kg. The total shipping from St. Petersburg to Trondheim emits kg 0.03 CO2-eq/kg. The storage buildings including electricity use for heat and lighting contribute with 0.02 kg CO2-eq/kg in total.

In the study, we discuss what actions can be taken to reduce the environmental impact of the production and delivery of stabilizing salt. We also compare how the salt performs compared to other soil stabilization alternatives.

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SESSION T2-9 Sustainability in the Construction Sector

Sustainability potential from the application of the Urban Mining principle in the construction sector – a case study for Switzerland

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Modern cities have become one of the main accumulators for primary materials. Recovery of these materials after building demolition, but also the utilization of untapped waste materials in landfills offer a secondary material stream that could relieve pressure from primary resources. Such a more circular approach dealing with our existing resources is called Urban Mining and its application is of paramount importance for the creation of a truly sustainable built environment. This study is based on the Urban Mining and Recycling (UMAR) unit - a research project, established with "circular" materials and installed within the NEST building of the Swiss Federal Laboratories for Material Science and Technology (EMPA). UMAR aims to demonstrate how a responsible approach in order to deal with our natural resources can go hand in hand with high functionality and an appealing architectural form. The present study estimates the sustainability potential that stems from the application of this concept at a country level for the whole Switzerland.

Methodological approach: In a first step, data on the Swiss residential building sector (type and number of buildings) have been collected from statistics of Switzerland for the estimation of the net change in the built environment during the reference period chosen in this study (i.e. the years 2012 to 2016). In parallel to this, rectangular buildings according to the UMAR principle (i.e. a wooden building) as well as conventional construction techniques (i.e. a concrete building) with different External Side Ratios (ESR) and different number of floors have been formed. They have been analyzed using the LCA framework, in order to estimate, how and to what extend geometry variation, as well as the number floors, influence the building's environmental impact in terms of Cumulative Energy Demand (CED), Global Warming Potential (GWP), as well as its overall environmental impact, measured with the Swiss Eco-points (so-called UBP-method). Finally, the results from this building level analysis and the residential building statistics are combined in order to assess the overall sustainability potential of the UMAR concept for a country like Switzerland.

The results show that at the building level the impacts of a wooden single family house are about 20% lower than for a similar, concrete-based construction – and this for all LCA indicators considered. Hence, on a country level, this leads to substantial environmental benefits for a sector, being reputated of contributing to large parts to today's environmental loads.

SESSION T2-9 Sustainability in the Construction Sector

Simplified LCA tool for ambitious upgrading of wooden dwellings

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SINTEF Building and Infrastructure

GOAL

Norwegian dwellings consume 48 TWh of energy annually, which is more than half of the total energy use in the Norwegian building stock. Residential buildings in Norway are largely wooden houses, and approximately 25 % of these are detached houses that have been built between 1960 and 1990. This part of the building stock is now rapidly reaching a state where major renovations are needed. However, we know that only half of the renovations that take place in Norway include energy renovation. Furthermore, when a building has been upgraded, it can be a significant amount of time before the next upgrading opportunity comes along. To avoid energy lock-in it is necessary to significantly increase the number of upgrades that include high energy ambitions. An architectural competition will be organised in order to demonstrate that upgrading to a near zero-energy building (nZEB) with a high architectural quality can be achieved also for wooden dwellings. The goal of this study is to demonstrate how a simplified and parametric LCA tool that can be used in such an architectural competition.

METHODS

A simplified and parametric LCA tool requires the development of a life cycle inventory that is adapted to the upgrading of wooden dwellings, and that includes inventory data for relevant technical systems such as balanced ventilation, heat recovery and solar energy production. By combining the results of a mapping study of existing house typologies with studies on upgrading concepts, it is possible to identify the elements (materials, components, processes) that must be included in the life cycle inventory. However, the inventory must also be parametrised in a manner that matches the architects' tools without significant additional effort, with the added challenge that it is expected that participants in the competition typically will be from small and medium sized companies. Workshops with architects are used to identify input parameters that meet the architects' needs and requirements for a simplified tool for architectural competitions.

RESULTS

The outcome is a prototype of a simplified and parametric LCA tool specifically adapted for calculating the environmental footprint of wooden dwelling upgrades. The main users of the tool are intended to be practitioners with little to no experience of LCA. The results of the tool should contribute to identifying upgrading options that have high architectural quality, are energy-efficient and have a low carbon footprint. Finally, the validity of the tool is analysed by performing a sensitivity analysis in SimaPro to evaluate model choices and value choices.

SESSION T2-9 Sustainability in the Construction Sector

A framework for life cycle management of road pavements

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Road pavements are complex and dynamic systems which need to be properly managed during their whole life cycle to ensure they deliver their function to society. The use of life-cycle management techniques (LCM) is even prescribed by the European standard CEN CWA 17089:2016 “Indicators for the sustainability assessment of roads”. This is probably the first effort globally aiming at standardising the definition of sustainable roads and identify indicators to develop sustainable practices for the design, construction and management of road pavements. Hence, stakeholders recognise the need of introducing sustainability at core of pavement engineering practices, however road authorities as well as asphalt producers/contractors are also aware that nowadays life cycle Assessment (LCA) exercises are very much dependent on the analyst‘s work and assumptions. In turns, this often lead to differences amongst methodologies and in some cases finally makes results incomparable from one case to another. Hence this study wants to present a frameworks to perform LCM of road pavements and asphalt mixes respectively and provides guidelines targeted to road authorities and asphalt producers/contractors. As a result, the different groups of stakeholders should be able to use these frameworks to carry out sustainability assessment of each system independently as well as understanding interdependencies towards a much needed dialogue and collaboration.

This work is being developed within the “PavementLCM” project funded by the Conference of European Road Director - CEDR call 2017: New Materials

SESSION T2-9 Sustainability in the Construction Sector

Facilitating EPD creation according to EN 15804 through more effective data collection

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PRé Sustainability

Goal

Construction companies are often SME's which have limited experience with EPDs and life cycle assessment (LCA) and therefore often outsource the process to an LCA expert. Since creating an EPD is time consuming and labor intensive, construction companies and LCA experts are looking for a solution in a credible software to carry out their EPDs more time and cost efficient. In the past years, VITO and PRé Sustainability worked on the data collection part of the life cycle assessment and created a user friendly data collection tool with a direct link to the software.

Method

VITO has developed in cooperation with PRé Sustainability, a life cycle online assessment and data collection tool on the SimaPro SaaS platform, which is quick and easy to use with an attractive interface. The tool generates life cycle assessment results for construction products in the format prescribed by EN 15804, which can then be used for EPD studies. It guides businesses through all the steps of the EN 15804. Businesses can enter the data for manufacturing sites and life cycle stages and they can upload relevant information such as a flow diagram of their production process. Users can select raw materials and emissions directly from inventory libraries. Only the relevant processes, materials or substances are shown to the user, which were preselected by the LCA expert. The selected processes, materials or substances by the user are automatically uploaded in the LCA model, where they will be reviewed by the expert. Once finished with the data collection and modelling, environmental impacts can be calculated using the appropriate method. Additionally, the tool enables online in-tool support from an LCA expert. The platform is made flexible in its architecture and design, allowing easy data upload and format changes by the LCA expert.

Results

Within this project, EPDs are created for various Belgian construction products by different manufacturers. The first pilots started at the end of 2018. The findings and learning points from one of these pilot projects with a manufacturer, as well as the desired steps forward in the future, will be shared.

The platform enables construction companies to work independently and efficiently, while still being ensured of support from VITO. On the other hand, it allows VITO's LCA experts to manage data collection more easily and create EPDs more efficiently.

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SESSION T2-9 Sustainability in the Construction Sector

¿How to evaluate the sustainability of a housing construction in Colombia?

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This article is the result of the first phase of a research project on the opportunities for implementation of the Life Cycle Assesment (LCA) in housing buildings in Colombia. It seeks to answer the questions: How to evaluate the sustainability of a housing construction in Colombia? What methodology adjusts to the technological, cultural, social, environmental and economic context?

According to this approach, this research is addressed in two phases. The first seeks to identify theoretical references in the literature such as concepts for the development of sustainable construction, existing territorial and sectoral regulations at national and international level and the research carried out with respect to the LCA in buildings, to see its applicability to the country context. The second is the validation of a methodological model through a multiple holistic case study, which includes the implementation of LCA in buildings as a strategic resource to reduce the negative environmental impact throughout the life cycle of the building, and which additionally includes the search for competitive advantages for stakeholders in its implementation.

It is worth noting that this article is the result of the diagnostic phase as the basis for the development of the following phases of the investigation. In this way, this study has the expectation of contributing to the discussion regarding the application of LCA in buildings, making a critical review of the applicability of concepts, theories and regulations to developing countries such as Colombia, where research and data availability is limited, and finally offer a proposal of methodological model for the evaluation of sustainability in housing buildings.

SESSION T2-9 Sustainability in the Construction Sector

Life cycle assessment and management of a newly-developed solar cement kiln

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Cement production generates 5% of the global anthropogenic carbon dioxide emissions. About 40% of these emissions are caused by the combustion of fossil fuels, which provide the thermal energy necessary for the calcination of limestone. This study focuses on an innovative and sustainable design of the kiln, which aims to reduce the use of fossil energy and the associated combustion related emissions. The proposed system utilises solar thermal energy instead of fossil fuels for the calcination of limestone. To ensure 24 h/day operation, a hybrid production system, which combines 5 MWth solar kiln and petroleum-coke fired rotary kiln is proposed. In this system the solar kiln operates during daylight hours (8 h/day) and the rotary kiln operates for the rest of the day.

A life cycle assessment was conducted to compare the benefits of the hybrid system over the current petroleum-coke fired rotary kiln. A cradle-to-grave approach was followed for the assessment and, therefore, the system boundaries include the construction, operation and end-of-life management of the solar plant. Furthermore, scenarios based on current and future regulations regarding end-of-life management of the proposed solar plant are considered.

The results show that the hybrid production process can reduce the climate change impact and fossil depletion by more than 20%. Similar levels of reduction were also observed for particulate matter formation, terrestrial acidification and terrestrial ecotoxicity. For the solar system, the production of additional components (solar kiln, heliostat and reception tower) increased the toxicity-related impacts by around 20% and metal depletion by 30%. In particular, the heliostat field showed larger contribution to the environmental impacts compared to other components, such as the solar kiln or the tower. This is because of the materials used for the construction and maintenance of the heliostat field. The analysis of different end-of-life management strategies showed that the environmental impacts related to the heliostat field can be reduced depending on the recycling rate considered. Overall, this analysis demonstrated that the proposed hybrid production system can potentially mitigate the environmental impacts of limestone calcination and limit the use of non-renewable resources. Moreover, further optimization of the solar thermal production process is expected with further development in solar technologies.

SESSION T3-1 Life Cycle Thinking from the Purchasing Organization's Point of View

Utilization of EPD in the Norwegian and Chinese construction industry

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This paper summarizes the output from a study performed to evaluate the drivers and barriers, challenges and opportunities of utilization of environmental product declarations (EPDs) in the Norwegian and Chinese construction industries. The study was performed with a total of 72 respondents using questionnaire, consists of restrictive and open-ended questions, and face to face or skype interview. The respondents represent two main EPD user groups in Norway and China. The first group covers producers and providers of building products. The second group covers building industry employees, including academicians', architects, environmental consultants, project managers and EPD developers. Most of the respondents from both countries believed that having a better performance in building certification system was the main driving force behind market needs of EPD. The results show that EPD has been more developed and recognized in Norway, and Norwegian customers are more likely to buy products with EPDs than Chinese ones. Compared with Chinese customers, Norwegian customers have better familiarity and understanding of EPD. For e.g. in China, EPD is often misinterpreted as a green label to claim the product with EPD as environmentally friendly. Lack of information or knowledge to understand the results presented in EPD, high cost of EPD development process (specially for small and medium sized enterprises) and lack of digitalised EPD format are considered as the main obstacles for the utilization of EPD in both countries. Surprisingly, many of the same obstacles are still found in Norway even though Norway has a more developed EPD market. Most of the respondents from both countries believed that participating in EPD platform, sharing and promoting EPD with other manufacturers were the most important measures to increase the acceptance of EPD by different end users. The results from this study provides valuable insight in how the construction industry in Norway and China experiences the use of EPDs. It also discussed the issues that are needed to be addressed and proposed a recommendation for different stakeholders who play major role to promote the development of EPDs.

SESSION T3-2 LCM as a Part of Environmental Management Systems

CIRCULAR ECONOMY IN ORGANISATIONS: AN EXPLORATORY ANALYSIS FROM SUSTAINABILITY REPORTS

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Goal

The interest of organizations towards circular economy (CE) has grown in recent years. However, the application of the CE framework at the company level (micro level) is still under development. Significant advances have been done for developing indicators to measure the circularity level of products, although the research field for measuring the performance of companies in their transition towards circularity is still open.

Companies concerned about sustainability, voluntarily, make public their corporate report, including annual information related to its environmental, economic and social behaviour, and also their sustainability strategies and practices, which often can be considered circular strategies.

In addition, and from the government perspective, the Spanish strategy of circular economy (2018-2030) proposes measures for the following lines of action: production and design, consumption, waste management, secondary materials, water reuse, research, innovation and competitiveness, awareness and employment and training. For companies to be successful in their transition to circular economy, their sustainability strategies should be aligned with these national strategies.

Taking into account this context, the aim of this study is twofold. On the one hand, to explore if aspects related to the principles promoted by the circular economy framework are being considered and communicated by organizations to create value through their products, processes, services or businesses models. On the other hand, to analyse if this effort is aligned with the national strategy of circular economy.

Methods

The methodology followed in this study consists of four stages:

- Systematically selection of corporate sustainability reports and environmental declarations from public online databases for Spanish companies.
- For each report, collection of information related to the sustainability indicators and its metrics with any relation with the circular economy principles: inputs of water and material resources and its origin and characteristics; energy consumption, use and/or generation; characteristics of the solid waste generated and its management; waste recovery practices; suppliers characteristics; research, development and innovation efforts; practices on training and employment, including creation of new business opportunities; product and organisation certifications; etc.
- Consolidation of the collected information in order to identify which circular economy indicators are being already measured by companies.
- Relationship of the circular economy indicators identified with the lines of action and measures of the action plan of the Spanish strategy of circular economy

Results

The analysis of the information included in corporate sustainability reports of Spanish companies and its relationship with the Spanish strategy of circular economy allows three main questions to be answered:

- What are companies giving value in relation to circular economy?
- Which lines of the Spanish strategy are being taken into account by companies and which ones are not?
- Is there any alignment between the effort made by companies and the prioritization of the proposed Spanish strategy lines of action through its budgets?

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SESSION T3-2 LCM as a Part of Environmental Management Systems

ENVIRONMENTAL IMPACT OF CHANGING ENGINE PISTONS FROM ALUMINUM TO STEEL

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The automotive industry, as characterized by very serious development, has undergone a significant metamorphosis in recent years. Many of the challenges that the industry is currently facing result from the increasing legal requirements related to emissions, but also from the market expectations in terms of increased energy efficiency of vehicles. This article presents the impact of the new piston production technology on the environment, which plays a key role in the aspect of transport emissivity and is part of the current discussion on the importance of LCA testing of engine components.

PURPOSE

The article presents comparative results of a detailed LCA analysis of two types of pistons: (1) aluminum, on which the construction of the EURO 5 series engine was based, and (2) steel, the basis of engine construction for a vehicle meeting emission requirements in accordance with the EURO 6 standard. The research subject was chosen due to the fact that for many engine designs there has been a marked change in material preference: abandoning aluminum - lighter and easier to machining, in favour of heavier steel, which however opens up new possibilities. These components definitely vary in their diversity of production process and the environmental impact of the production phase, which has been discussed in detail in the present article.

METHODS

As part of the research conducted, the production phase of aluminum and steel pistons was analyzed in detail. The production processes covered by the study were divided into: main processes (directly shaping the physical characteristics of the piston) and supporting processes (performing an auxiliary role to the main processes and indirectly affecting the quality of the final product). The study included about 200 material as well as energy inputs and outputs that characterise the processes analysed. The piston usage phase was examined on the basis of a simplified model focused on fuel consumption and gas emissions. In order to assess the impact on the environment the Impact 2002+ method was used as well as SimaPro software.

RESULTS

During the research phase there were differences noted in the scale of environmental impact of the compared pistons in both the main and auxiliary processes. Taking into account only the production phase, aluminum pistons are characterized by a lesser impact on the environment. On the other hand, when considering selected aspects of engine operation, it was recognized that if a steel piston was used, the lower fuel consumption and reduction of emissions into the air reduces the differences in environmental impact at the stage of production of compared pistons.

The article opens discussion about the quality and detail of environmental data in the LCA research phase of production in dynamically developing production processes. It shows how a seemingly small change of material and technology can influence the environmental impact and the level of awareness of the premises for a detailed analysis of other components; not only engine parts, but also other vehicle components (not solely combustion vehicles).

SESSION T3-3 New Types of Organizational LCA

About adapting O-LCA to decision makers

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Goal:

We aim to reason about how environmentally more effective understanding of management could be reached by extending the organizational LCA developed by the Life Cycle Initiative (here called standard O-LCA) to include studying human actions.

Method:

We compare standard O-LCA to a well-tested socio-material flow methodology. The socio-material methodology has been used in product life cycle based case studies that our comparison builds on. The cases cover bread and metal packaging product life cycles.

Results:

Both standard O-LCA and the socio-material flow methodology aim to enable better environmental management of product life cycles. An ISO/TS defines standard O-LCA as "a compilation and evaluation of the inputs, outputs and potential environmental impacts of the activities associated with the organization adopting a life cycle perspective". The socio-material flow methodology complements this approach with a focus on how nets of actual interactions between humans, within and between organizations, determine the environmental performance.

In the metal packaging case, the management of and technical processes along metal packaging flows determined the life cycle environmental impacts of different organizations: packaging producers, fillers, and waste management organizations. We applied the socio-material flow methodology to metal packaging flows in Sweden and the Netherlands. The study, among other, led to a finding about complementing recycling via source collection with recovery from ashes. Such recovery can be performed on the waste that has passed through municipal waste incineration. The ashes were not considered, however, because an earlier government agency policy had dis-encouraged incinerating non-combustible materials. The policy was abandoned, but this had not been communicated to the waste management procurers. A standard O-LCA would cover the product life cycles passing one organization. For example, if that study covered the waste management procurement organization, the study would cover four packaging types in addition to metal packaging. This O-LCA would produce both more coarse results and less knowledge on important organizational links between different organizations.

Communication was also found to be of relevance for the product life cycle of bread. We studied three Swedish bakeries and their product flows. We found, among other, in the flows related to one of the bakeries, high levels of bread discarding at retailers. The discarding at the retailers had increased over time because of a growing bakery that had extended the number of retailers from one to six without assigning more time for coordination of production and sales. A standard O-LCA would both be coarser because it would include the bakery's many different patisserie products and have less focus on the organizational processes.

The bread and packaging case findings put emphasis on interactions between humans and the material flows. Flows are considered thoroughly in standard O-LCA. How the hotspots can be changed in practice could be pointed out by using our socio-material flow methodology. The methodology captures the organization of flows both within and across different organizational entities, which extends the one-company focus in O-LCA. This points to different meanings of the term 'organization'.

SESSION T3-3 New Types of Organizational LCA

O-LCA: Fostering the transition towards a Circular Economy

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Nowadays the world is is experiencing an unprecedented ecological crisis. This crisis translates into serious challenges for humanity, which require radical changes in the way we live, especially how we produce and consume. The current economic model has had serious consequences that endanger the living conditions of the world population and other living beings, not to mention the inequalities in the appropriation of natural resources. The concept of circular economy arises from this search for solutions to face the current ecological reality and its future prospects. The main objective of the circular economy is to maximize the environmentally sustainable use of natural resources, seeking to reduce waste and organize economic activities, in a continuous process of feedback. The successful transition to the circular economy requires tools and methodologies that assist in dealing with the trade-offs, both to provide the information base for the decisions to be made and to validate the eventual environmental benefits gained. In this sense it becomes necessary to have available effective environmental information supporting the decision making of organizations, few of the organization-wide environmental approaches consider the full value chain, such as WRI and WBCSD (2013) and ISO / TR 14069 (ISO 2013), however, these approaches focus only on a single environmental aspect. On the other hand we have a proposal derived from life cycle assessment - LCA that is the leading method for comparing and quantifying environmental and social impacts. Traditionally, LCA has been focussed on the sustainability performance of products and services, but this proposal the Organisational Life Cycle Assessment (O-LCA) identifies organisations' environmental and social issues, it can be understood as a LCA with an organization perspective. O-LCA is used to map and quantify risk and impacts for the whole organisation – supply chain, operations as well as products and services. The complete value chain of products and services are global and complex, the top-level screening O-LCA methodology uses categorisation of all suppliers based on their sector and country, providing a global and precise picture of the supply chain. This proposal is also supported by ISO 14.074 that provides requirements and guidelines for the O-LCA. Assessing various impacts and adopting a life-cycle approach can offer innovative and applicable environmental impact reduction solutions that are applicable to a more sustainable business model, and have the potential to assist in the transition towards a circular economy. The challenge of circular economy is to develop an innovative and sustainable approach to overcome the current trade-off between our model of incessant economic growth and the environmental crisis. In this context, could O-LCA contribute to build this approach? How can O-LCA collaborate with this necessary change versus the current linear approach? What is the role of ISO 14074 in this transition? The present study intends to shed light on this discussion through a literature review analyzing both the O-LCA and the use of ISO 14,074 to promote the transition toward the circular economy, demonstrating that effective use of O-LCA has promising prospects for this expected and necessary transition to the circular economy.

SESSION T3-3 New Types of Organizational LCA

Organisational LCA (O-LCA) for activities in the Norwegian Defence sector

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1. Goal - The Norwegian Defence sector has annual revenues of approximately 5 billion US$ and employs over 20.000 people. The activity of the sector is diverse and the organization may affect the environment in several ways; i) indirectly through purchasing of good and services, ii) directly by using resources and creating emissions to the environment and, iii) through waste handling and end of life activities. This paper aim to conduct an organisational LCA of the sector in order to investigate main contributors to emissions through the value chain. 2. Method - Organisational LCA (O-LCA) is a compilation and evaluation of the inputs, outputs and potential environmental impacts of the activities associated with the organisation adopting a life cycle perspective. Organisational LCA (O-LCA) is a compilation and evaluation of the inputs, outputs and potential environmental impacts of the activities associated with the organization adopting a life cycle perspective. The O-LCA was in this case, delineated to assess the carbon footprint (CF).

O-LCA has been used to determine the greenhouse gas emissions from the Norwegian defence sector, during 2016, covering emissions in scope 1-3. Life cycle emissions for scope 1 and 2 data were achieved through process LCA, combining the physical data from the present greenhouse gas account with emission characterisation factors of relevant unit processes given in the Econinvent 3.3 LCA database. For life cycle emissions of scope 3 data we combined the economic data of various procured goods and services with corresponding emission characterisation factors identified previously. 3. Results - The emissions from process data were calculated to 420 000 tonnes CO2-eq, and the emissions from economic data accumulated to 560 000 tonnes CO2-eq. The total CF was estimated to be 800 000 tonnes CO2-eq with adjusted economic values to avoid double accounting. The largest contribution (44 % of the total CF) origins from transport related activities, while building and construction is the second largest contributor (25 % of the total CF).

The results showed that when only the direct emissions were included, the greenhouse gas emissions were dominated by fossil fuel use and particularly the use of fossil fuel in aircrafts and in naval operations. However, the overall results showed 60% contribution from indirect emissions originating from producing goods and services for the sector. Most important was the emissions relating to building and construction activities.

The study showed that O-LCA might be a valuable contribution to assess the life cycle impacts for a diverse organisation. By using a hybrid approach with both process and economic data, the O-LCA becomes more comprehensive. The limitation may be increased uncertainties due to use of generic emission factors for the economic data.

The findings confirms the present focus on reduced use of fossil fuel and energy savings as effective means of reducing the environmental impact. Interestingly, the study in addition finds that impacts from indirect emissions upstream in the value chain heavily influences the CF.

SESSION T3-3 New Types of Organizational LCA

Communicating the positive environmental impacts of R&D activities: A corporate approach

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Goals: Communicating the positive impacts of corporate activities is at the heart of business marketing. Usually, positive impacts are communicated by means of ad-hoc communication strategies with little to no scientific base. Generally, companies build these strategies on the environmental gains of innovative products, or develop narratives around successful actions taken at corporate level, such as corporate responsibility actions or diverse forms of philanthropism.

However, these initiatives are seldom based on robust environmental information, which is in high contrast to the formalised modalities of B2B and B2C communication, like EPDs or Eco-labels. Moreover, positive corporate impacts are generally communicated by means of narratives built with little to no participation by the sustainability experts within firms. Still, the main obstacle for the disclosure of the positive contribution of corporate activities on the environment is the lack of a systematic approach to the collection of environmental information on actions that can be then translated and interpreted as positive impacts in a consistent way. We present an experimental approach for the calculation of the 'net positive environmental impacts' of corporate activities. Our method is based on life cycle thinking and is in compliance with existing LCA and reporting standards. Impacts are calculated using the ReCiPe impact assessment method.

Method: Our methodology is based on a systematic data collection involving various data points. These include: (1) information retrieved from the corporate management system at project level; (2) information delivered by the Quality Department at corporate level; (3) data retrieved from life cycle databases (currently Ecoinvent v 3.x). The net positive impacts are computed at project level by subtracting the negative environmental impacts occurred at development stage by the estimated positive impacts under a conservative scenario of technology diffusion (or product penetration). The net positive impacts at corporate level are then calculated by aggregating all marginal project impacts.

Result: The method has been developed and tested at Tecnalia R&I as one of the building blocks of its sustainability strategy that is currently under elaboration. A web tool has been developed to collect and process all the data points. Our tool also allows to generate different indicators on the environmental performance of our technologies and produces graphical outlies that can be used for communication purposes. Once tested, the tool will be adopted for standard project management practice. The calculations will be used for corporate communication. Future developments will focus on social and economic impacts and on the adaptation of the tool to other business sectors.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

The important role of the Paulista Irrigation and no-tillage planting Association (ASPIPP) promoting Sustainable Agriculture

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In 1975, the Alto Paranapanema region, located in the southwest part of São Paulo State (Brazil), was known as the "Hunger Branch" due to the low human development index, given the unfeasibility of agricultural production in the region, due to sandy soils, low water availability and climatic conditions. In the early 1980s, the first agricultural projects with irrigation and no-tillage planting technology, promoted an increase of the diversity of agricultural production, boosting local development and transforming the region's economic scenario increasing value generation. In January 2001, ASPIPP was founded with the objective of increasing agricultural production through irrigation and no-tillage planting, encouraging the development of the sector in a sustainable way. However, with the advent of the water crisis in 2014, the theme has caused different perceptions among environmental licensing bodies, research bodies, basin committees and the community in general. In addition of that it is known that water is a finite resource and according to the National Water Agency (ANA), irrigation is responsible for 72% of the use of this resource in the country (EMBRAPA, 2016). In this context, in 2016 ASPIPP, with the support of the Holambra Cooperative, BASF and the Espaço Eco Foundation (FEE), Civil Society Organization of Public Interest (OSCIP) and specialized consultancy to promote sustainability in the business environment through life cycle thinking, started the project with the purpose of studying the real benefits and impacts of irrigated agriculture and no-tillage planting technology, in order to support the association in her strategic positioning revision, reinforcing the discussion of the theme in the region. Good practices of water and soil conservation and compliance with environmental legislation were carried out by the ASPIPP members, ASPIPP stakeholders' perception of irrigated agriculture and no-tillage planting such as the identification of material themes for the organization, strategic planning of the institution and modeling of water dynamics and soil. So far, it has been observed that the associated producers have good agricultural practices and meet legal environmental requirements. From the stakeholders' point of view, it was highlighted that irrigated agriculture is fundamental to ensure productivity in the region, emphasizing in the same time the importance of good practices for soil and water conservation. In addition, water modeling shown that the adoption of good agricultural practices associated with the maintenance of native vegetation, have the best performance for soil and water conservation. In addition, water modeling shown that the adoption of good agricultural practices associated with the maintenance of native vegetation, have the best performance for soil and water conservation. The stakeholders' inputs also subsidized the review of the organization's strategic planning, enhancing its performance, fulfilling its purpose and establishing an active communication plan with several players in order to promote sustainable agriculture. The project continues in 2019 with a life cycle assessment that will compares the economic environmental performance of farming practices and irrigation in the Southwest region of São Paulo.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

The strategic use of LCM to promote sustainable development, build strategic partnerships, and to disseminate critical life-cycle thinking in Society

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Fundação Epaço ECO - BASF S.A.

Considering sustainability issues in corporate strategy is not an obvious or simple task, and several challenges and dilemmas that are faced by all the actors involved in this process. Examining in more depth the nature of these challenges, the importance of mapping the problems, not only within the companies / industries, but also in the environment and in the society in which it is inserted, outside the walls of the company, is perceived.

Understanding this as a value, two business institutes have signed a partnership to develop a Social Responsibility project that could disseminate the concept of life cycle. This project aims to enable and take advantage of this knowledge in practice, to a resource management work in an expanded way, reaching public agencies and schools in the region where some automotive factories are located in one of the companies.

Two specific knowledge of each organization were applied. On the one hand, a Japanese methodology for the survey of opportunities and operational excellence, capable of reaching proposals for sustainable solutions. On the other hand, the Life Cycle Assessment (LCA) methodology assists in understanding and scaling the impacts generated in each decision making.

The most diverse civil society groups were involved, such as civil servants from the environmental secretariats, prefectures, schools, municipal parks and community stakeholders. These hearings were encouraged to identify opportunities to reduce wáter, receiving training of a team specialized in process analysis.

The most diverse civil society groups were involved, such as civil servants from the environmental secretariats, public works, prefectures, schools, municipal parks and community stakeholders. These hearings were encouraged to identify opportunities to reduce water, resources, and waste in their work and living spaces. They received training from a team specializing in process analysis, problem detailing, and discussed possible solutions to converge on an action / project.

From the life cycle database it was possible to evaluate this 29 projects that had main objective to reduce water. The environmental and economic impacts caused throughout the water production and distribution chain were mapped. According to the study, the volume of water saved, throughout the chain, equals 3.4 million cycles of a laundry. That is, enough volume to wash clothes of more than 268 thousand people. In atmospheric emissions, responsible for the Global Warming Potential, the reduce is equivalent to 4 minutes of vehicular emissions São Paulo State (fleet of almost 30 million vehicles). In relation to the energy reduction, is the equivalent to the consumption of 476 residences a year.

The people involved went beyond what the paper can show, they were transformation agents in their places of conviviality and could be part of the solution of the problems, were able to understand the indirect impact of natural resources consume, reducing the risk of water shortage and using the public resources in a more efficient. In addition, this saving in water consumption results in a reduction in the use of chemicals for water treatment, pumping energy and water distribution. emissions from these steps.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

Sustainable Farm Award: a life cycle thinking based method for promoting innovation on agrobusiness

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BASF Fundação Espaço ECO

Goal:

Evaluate how Life Cycle Thinking is applied along with other indicators for sustainability perception

Methods:

Consultation of materials and documents of all editions and analysis of related publications

Results:

Life cycle thinking allows the award to associate other indicators and possible evaluations in order to define which farm was the most sustainable.

Increasingly, Brazilian agribusiness has been seeking sustainability. Being one of the world's largest producers and exporters of food, fiber and biofuels, brings the country the responsibility to comply with environmental legislation and certification in several chains. In addition, the perception that the use of technology combined with good socio-environmental practices increases productivity and consequently the profitability of crops, stimulates an increasingly competitive environment in the current scenario.

This movement, in large part, occurs due to external stimulus such as awards and recognitions. The Sustainable Farm Award (SFA) is one of those, developed through a partnership between Rabobank, Globo Rural magazine and Fundação Espaço ECO (FEE), the award presents a way to unite in a single evaluation different aspects of sustainability.

Throughout the 5 awards editions, it was possible to perceive an evolution of maturity regarding sustainability. This maturity happened on both sides: internal, that is, in the elaboration of the public notice of the award and external - profile of the participants that subscribe.

Regarding the analysis of the socio-environmental profile, responsibility of the FEE, significant changes took place from the first to the last edition of the award. The production impacts are measured in comparison of national average in addition to economical and social evaluation. But the Life Cycle Thinking has always remained the same. A major breakthrough observed was the inclusion of aspects of gender equality, distribution in structure company levels (workers, administration, CEO) and open questions to capture sustainable initiates.

Life-cycle thinking enables a systemic analysis of the agricultural production, through the LCA, initiatives related to sustainability, qualitatively captured, indicators of gender equality and their distribution in the hierarchy of work (owner, administration and operation).

The methodology of the award goes beyond the environmental and economic character, which allows the commission to evaluate the best practices and to foment the discussion of which presented itself more sustainable. Suggestions for improvement are captured for the next editions with the commission and given trends in the market. As an example of the digitization, which is increasingly present in the field and was suggested by an evaluator to be addressed in the next editions.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

Estimating climate impact and energy use of earthworks in early planning

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Goal: Construction of roads and railways involve large-scale excavation and transport of rock and soil. These activities have a significant contribution to the climate impact and energy use of construction projects. To reduce the climate impact of infrastructure construction, the Swedish Transport Administration (STA) places climate requirements in procurement of new construction, maintenance, and construction materials. The climate impact and energy use of construction, operation, and maintenance of road and rail infrastructure is calculated with the model Klimatkalkyl developed by the STA.

The need for earthworks and the energy use for earthworks vary significantly between different construction projects and are difficult to estimate in early planning. At the same time, early planning involves the biggest opportunities to reduce the climate impact and energy use of earthworks. Currently, Klimatkalkyl includes generic data (such as volume of excavated rock and soil and volume of diesel used in excavation) for a specific type of road or railway. The quality of these generic data is significant for the validity of the results.

The aim of this study is to improve Klimatkalkyl concerning climate impact and energy use from earthworks in early planning of road and rail infrastructure.

Methods: The study contains a literature review to synthesise knowledge from previous studies suggesting methods to assess climate impacts and energy use of earthworks in early planning and to identify key aspects that are most significant for the results of the study. The literature review will be complemented with analysis of data from previous construction projects and interviews with contractors to find which parameters in Klimatkalkyl that differ most from practical experiences in construction. Additionally, the study will analyse whether other existing models, some which are used for other purposes at the STA, can be used together with, or integrated with, Klimatkalkyl to improve calculations of earthworks.

Results: The main outcome of the study is recommendations to the STA how Klimatkalkyl can be further developed concerning rock and soil excavation. The study will suggest new generic data for volume of excavated masses in construction, transport distances of excavated materials, amount of diesel and explosives used in excavation, alternatively identify the need for new generic data – but where data is not yet available – to further develop the model.

This will lead to improved knowledge on assessment of climate impact of earthworks in early planning and possibilities for more efficient work at the STA to reduce climate impact and energy use of construction projects. The STA will have improved estimates for base lines when placing climate requirements in procurement, which improves the possibilities to measure the actual emission reductions, and improved precision of calculations for projects in the national plan for the transport system.

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SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

Verification of future maintenance in procurement of new construction

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Goal: The Swedish Transport Administration (STA) places climate requirements in procurement of new construction projects. The contractor winning the bid has to reduce the climate impact of the project compared to a predefined base level calculated using the model Klimatkalkyl, developed by the STA. The contractors may suggest measures to reduce climate impacts of the construction phase; however, future maintenance of the project is calculated using generic, non-project specific data that the contractors cannot modify.

If future maintenance cannot be modified, there will be little incentive to design infrastructure will less intensive maintenance. Since the design phase determines the service life of the infrastructure and opportunities for resource efficient maintenance, this may lead to sub-optimisations, not reducing the total life cycle impacts of a construction project. To provide incentive structures for reduced impacts of future maintenance, further method development is necessary to find a consistent, practical process for verification of project specific data in future maintenance.

The aim of this study is to develop a method that could be used by the STA to verify project specific data for future maintenance in procurement and to suggest how Klimatkalkyl could be further developed to enable use and verification of project specific data for maintenance activities.

Methods: A literature study – including previous life cycle assessments (LCA) and life cycle cost (LCC) analyses of transport infrastructure, other LCA and LCC models, standards such as the EN 15804, and environmental product declarations – will be conducted to identify methods and data that could be used to verify infrastructure life length and its connection to future maintenance requirements.

A case study with the STA and its contractors will provide a link from the literature study to practical implementation at the STA by first assessing how the climate impact of future maintenance could be reduced in the project by changes to construction design and then to evaluate how the methods and data identified in the literature can be used by the contractors and the STA to verify the claims of reduced climate impact of future maintenance.

Results: The main outcome of the study is a suggestion on how to verify future maintenance in procurement of new construction projects and how to construct LCA based calculation models to enable use and verification of project specific data for future maintenance.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

LCA IN FIELD OF SAFETY AT WORK: A NEW ENGINEERING STUDY SUBJECT

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Goal: Life cycle assessment (LCA) has been in education process at the University of Novi Sad for more than 20 years, since the foundation of the Department of Environmental Engineering at the Faculty of Technical Sciences. The starting point was a teaching topic within the Environmental Engineering study program, the subject Mechanical engineering in environmental protection. Today, LCA is studied in several courses at bachelor, master and PhD levels of environmental, safety at work, mechanical and civil engineering study programs. The result is a growing number of bachelor, master and PhD theses in the field of LCA, eco-labelling and eco-design. Considering the importance of occupational safety in engineering and aiming to fulfil the expectations of organisations operating on the labour market, beside the environmental engineering, since 2010 safety at work study program has been established at the Faculty of Technical Sciences. The goal is to develop a new study subject on a master study program of safety at work in order to assess the impacts on workers' health and safety with LCA approach.

Methods: Beside environmental LCA, life cycle costing and social LCA emerge in order to provide sustainable LCA, where social LCA is the youngest methodology. Within the social LCA, impact on workers' health and safety during the life cycle is a group of stakeholder impact categories that can provide information on accident rates at workplace (non-fatal and fatal), occurrence of various diseases and injuries, disability-adjusted life years, presence of safety measures, etc. Mastering these methods enable students to perform and develop skills for LCA of product's and process's impact on worker health and safety.

Results: The new subject "life cycle assessment in field of safety at work" on a master study program of safety of work has been developed and is currently applied for the accreditation programme for the new 2019/2020 academic year. The goal of the subject is acquisition of knowledge, competences and academic skills in field of safety at work and product's life cycle. The new subject aims to develop creative capabilities, academic and practical skills for implementation of LCA of processes and products from aspect of impact on the worker.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

12 x LCM. The many versions of life cycle management.

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GOAL: Life cycle management (LCM) is often discussed in terms of specific and successful cases of LCM (e.g. Sonnemann and Margni, 2015), or in terms of a general concept. However, reported cases on LCM display a scale of different types of LCM, and different ways in which LCM comes about. Also, LCM seems to serve different purposes in different contexts.

METHOD: In this study, we explored how the life cycle logic has resulted in such diverse variety of LCM logics that exist in industry and in society. This was done by a practice review, where we systematized a number of LCM cases. The aim of the systematization was to take a few first steps towards theorizing LCM practices, through classifying and typologizing cases of LCM. The collection of LCM cases was assembled by purposive sampling for difference (Seawright and Gerring, 2008; Emmel, 2013), which generated many and different types of LCM cases. The cases were then compared and analyzed, resulting in several types of LCM. These types were then analyzed with regard to reasons for change towards LCM, as a way of identifying the logics to each type of LCM.

RESULTS: The practice review of LCM cases resulted in twelve types of LCM: 1) Company domino; 2) Bricolage; 3) Chance encounters; 4) Parallel product offers; 5) Strategic brace; 6) Product chain roundtable; 7) Building from scratch; 8) Mining waste; 9) PSS; 10) Consumers as prosumers; 11) Policy patches; and, 12) Product chain governance.

As an example, LCM as Strategic brace can be characterized by a company starting to collaborate with an external actor. This external actor then govern the coordination of the product chain towards a more sustainable one. In this case, governance also includes first the identification and assembly of specific actors relevant for the reorganized product chain. This type of LCM may start as traditional B2B management, a company seeks to certify a product (or category), by collaborating with an external actor, who identify, and grow to assemble, and govern a chain of actors in the reorganized product chain. The business logic that comes to the fore in these organisational efforts is the securing of resources for the initiating company.

In all, the study showed that LCM takes place in many different business and governance practices. This also means that LCM comes into being through a variety of processes where the life cycle idea becomes aligned with various organisational logics present in practices in business and in society.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

How to successfully utilize new technologies to scale up the use of Life Cycle Information

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PRé Consultants

Goal

Technologies like block chain, Big Data and the Internet of Things provide new opportunities for embedding LCM into existing business practices, like improving and scaling up the collection of (LCI) data. The cloud allows for sharing and collaborating based on one underlying mode, that is constantly fed and used by a broader audience. Unfortunately, these new technologies are not fully adopted so their potential is not fully exploited. The objective of this session is to show how technological innovations can contribute to embedding LCM into daily decision making at a mass scale. Social innovation is needed to seize the opportunities these new technologies can provide.

Method

A case study will be presented that shows how 10.000's of footprints were generated. The case study will explain how the project was approached, how stakeholders were involved, how LCM was integrated in the existing way of working and how the results are used. It focuses on the large scale collection of data, which is fed to a cloud based LCA model, allowing dissemination of footprints at an unprecedented scale. New technology facilitated more than 10.000 individual footprint calculations, using only one LCA model. The study will also go into the reasons why technology alone is not sufficient.

Result

The result of the case study is real life, large scale data collected and the calculation of a huge amount of individual footprints. To achieve this it was important to identify what users can contribute and to link their activities to the value it brings to them and to consider how a balance can be found between effort and result. The case study brought forward two key success factors to achieve this: 1) make it easy to integrate the data collection in their daily work and 2) show the benefits to them so they are motivated to participate. The pragmatic approach, as described in the case study, can be applied to other situations to accelerate the adoption of new technologies to improve data collection at scale and, as a result, the availability of high quality data.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

Feasibility, usefulness and acceptance of an LCA-based sustainability indicator framework in Swiss agriculture

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Agroscope

Aims:

Roesch et al. (2016) published an LCA-based indicator framework for assessing the sustainability of farms, covering all three dimensions (ecology, economy and social aspects) and intended for use in the business relationship between farmers' organisations and the purchasers of agricultural goods. The aim of the present study was to test the feasibility, usefulness and acceptance of this framework under real-life conditions.

Methods:

We selected 15 commercial farms representing the following four typical Swiss production types: arable farms, animal-intensive farms, mountain farms, lowland dairy farms. The test was conducted in two phases – in 2016 and 2018 – with repetition for 15 farms. Thirteen environmental indicators were calculated using the Swiss Agricultural Life Cycle Assessment methodology (SALCA; Gaillard and Nemecek, 2009), including global warming potential (GWP), eutrophication, and ecotoxicity. Six economic indicators were analysed: two each from the categories of profitability (income per family labour unit and return on capital), liquidity (cash-flow ratio and dynamic gearing ratio) and stability (investment intensity and capitalisation ratio). For the social pillar, we considered the following three indicators: workload, human well-being, and visual quality of landscape.

The farmers' feedback was collected by means of a detailed questionnaire covering the following five topics: validity of the entire evaluation procedure, farmer's general knowledge and understanding of the topic of sustainability, data acquisition, support, and impact of the study on their daily work in the medium and long term.

Results:

Results from the first test in 2016 showed that the implemented data-flow process allows reliable calculation of the sustainability indicators. However, data acquisition must be further automated and the plausibility control needs to achieve greater efficiency. There was only slight correlation between the sustainability indicators, underscoring the necessity of retaining most of them in order to achieve a good overall picture of the farm's sustainability. Synergies between economic indicators and environmental impacts were extremely rare. On the whole, greater workloads did not lead to increased economic success.

Evaluation of the farmers' feedback revealed that they considered sustainability in agriculture to be important from the environmental and economic perspective of a farm.

We therefore conclude that this sort of LCA-based sustainability indicator framework can be used by associations and retailers in their business relationship with purchasers, provided that high efficiency is achieved in the data-flow process.

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SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

Are four views better than one? - Embedding Life Cycle Management in the organization through a Four-lens approach

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Goal: This contribution explores characteristics of current approaches of integrating environmental Life Cycle Management work in companies. It draws upon findings from general management, where a so-called “four-lens view of organizations” is found to provide a rich understanding of different sets of factors influencing the integration of new approaches in organizations. A key point is that the Four-lens view embraces both an organization’s formal functioning (through a “structural lens”) as well as its informal functioning (through “human”, “political” and “symbolic lenses”). On this basis, this contribution aims to explore the extent to which the Four-lens view of organizations may support the integration of LCM in companies.

Methods: As an example of LCM, this explorative study uses experiences with ecodesign integration captured during fifteen interviews at seven manufacturing companies in Denmark and Norway. Other methods include literature reviews in related fields.

Results: Key results include, that all four lenses could be identified in the measures mentioned by the case companies. The “Architect’s perspective”, provided by the “structural lens”, seemed necessary in order to establish an official scene for ecodesign in the organization and to help prioritizing it in relation to other activities in the organization. The three informal lenses, providing a “Catalyst’s”, “Advocate’s”, and “Prophet’s perspective”, respectively, seemed necessary in order to facilitate or complement the Architect’s perspective. Companies also indicated potential dedicated further application of the Four-lens view in order to make integration work more effective in their organizations.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

Approaches and experiences in embedding sustainability aspects in Life Cycle Management for fostering business success

Peter Saling, Dirk Voeste

Corresponding author: Peter Saling

BASF SE

Goal

BASF has one clear ambition looking ahead: Our customers should have a new experience with BASF. By combining our unique expertise in chemistry with our customers' competencies, we will jointly develop solutions for society and the planet that are both profitable and responsible. In this way, we will grow profitably and create value for society. This is what we do best: We create chemistry for a sustainable future. Tackling sustainability trends early on is essential for a business strategy which will be successful in the long term.

What are Sustainability Business Trends and standards that will drive this sustainable transformation towards 2030 in specific industries? Which capabilities will companies need to develop to be successful in this transformation of economy, society and environment?

Methods

With an extensive study we investigated together with the management consultancy A.T. Kearney in detail which trends will change at what pace in the industries in scope: Agriculture and Food, Automotive and Transformation, Consumer Goods and Retail, Energy and Utilities, Engineering and Construction, High Tech and Electronics, as well as Pharma and Health. The answers are concrete and industry as well as region-specific. BASF will integrate the derived insights into sustainability trends of its customer industries, their development as well as the risks and opportunities in its future strategy.

The inclusion in sustainability indices and rankings is a confirmation of our performance concerning environmental and social issues. Rating agencies have particularly highlighted our community engagement, employee relations, sustainability reporting, business ethics and the development of sustainable products.

Though several different measurement and valuation methods exist, most of them are focused exclusively on ecological aspects, i.e. impact on climate, forest decline or water. However, methods developed on that basis reflect only a small part of what sustainability is all about: balancing environment, society and economics. The aim of BASF´s analysis methods is therefore to quantify corresponding aspects and to contribute to support the new strategy. For example, the new Social Hot Spot Assessment identifies impacts to the Sustainability Development Goals (SDG)

Results

As a learning from the different initiatives and approaches we made, we carry out our corporate purpose, "We create chemistry for a sustainable future," by pursuing ambitious goals along our entire value chain. In this way, we aim to achieve profitable growth and take on social and environmental responsibility. We are focusing on issues where we as a company can make a significant contribution. It is important for the market to show that the shares are particularly attractive for investors, which incorporate environmental, social and governance criteria into their investment decision.

In the strategy development we defined commitments for sustainability along the value chain. We want to contribute to a world that provides a viable future with enhanced quality of life for everyone. We live our corporate purpose "We create chemistry for a sustainable future" by

- Sourcing and producing responsibly,
- Acting as a fair and reliable partner,
- Connecting creative minds to find the best solutions for market needs.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

Setting internal price of environmental criteria, the good way to transform organisation ?

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renault sas

Car mobility will face more changes in the 5 coming years than in the past twenty ones. So was saying Renault-Nissan-Mitsubishi CEO at CES 2018. Environmental and social performance integration are two pillars of these transformations.

Companies are now committing to science based targets, reporting to external analyst on a yearly based. But is this sufficient to guaranty an effective change in product portfolios ? Is it enough to ensure that all decisions will be taken on a mid term environmental perspective level versus a short profit purchasing ?

Our proposal after one year of PhD study is to hack the company with its own economical tools. How ? By introducing sustainability in economical accounting.

Method

We carried a Delphi 2 rounds Survey other the 15 companies among the most advanced regarding the introduction of monetary environmental information in their business. Based on this analysis, we defined the suitable methods and approaches for an international automotive company.

Then, we applied the methods on key environmental topics, calculating life cycle impact and life cycle cost including externalities assessment. This is done through an on-going PhD, taking place in the company itself, in order to analyse its feedback on these new proposals.

Finally, we will discuss the impact on the organisation.

Results

As concrete feedback we will share the results of the Delphi Survey. Key findings are 6 motivations factors, 3 operational way to build the tools, and various benefits.

Then we will show how various methods could be implemented on technologies (eg: lightweight, recycling) and products types/engine strategy (electrified vehicle). We will show environmental cost/benefits of various solutions for the company, for the customer and for the society.

Finally, we will discuss the hurdles and the benefits for the organisation to set up such internal economical tools at different decision levels.

We hope this proposal will meet your intention in order to prepare the best "business practice" session. We would like to underline also that authors are Professor, Doctor and PhD in management science, they have experience of research in situ, in the companies. They also have experience regarding giving oral presentations in several LCM, SETAC and EcoBalance conferences.

SESSION T3-4 Success Factors for Embedding Life Cycle Management into Existing Business Practices

NEW EDUCATION PROGRAMS AND PROFESSIONAL SKILLS FOR STAFF DEVELOPMENT FOR CIRCULAR ECONOMY AND DIGITAL DRIVEN SYMBIOSIS

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This article is about the transformed educational programs for the staff development to provide the Circular Economy by needed retrained specialists and experts to support digital driven symbiosis.

Nowadays in the territories of different countries around whole world tremendous of the solid waste amount from household, industrial and agricultural materials accumulate. According the World Bank's statistics the global annual waste generation is expected to jump till 3.4 billion tones over the next 30 years it means can increase by 70 percent on current levels by 2050. In the turn, municipalities are responsible for solid waste removal and storage. Incorrect municipality waste management can cause great harm to the human health, local environments and lead to problems associated with the climate change as well. Due to above mention it is important to have plenty of good retrained specialists having new professional skills could be work with understanding new situation, digital and eco technologies on the all levels and provide cooperation between companies, universities and all level authorities. Article shows the importance of creation new transformed training courses for all level of specialists including specialists from companies, enterprises and authorities to organize joint cooperation and support digital driven symbiosis. The article has a look on the advantages and disadvantages of the knowledge and new retrained programs for staff development to support Circular Economy rules and competents.

SESSION T3-6 Sustainable Product Portfolio - Best Practice and Tools for PP Management

Influence of metal speciation on soil ecotoxicity impacts in life cycle assessment

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Goal: Development eco-innovative solutions considering productions and processing of metals must consider metals' potential to cause harm to terrestrial ecosystems through ecotoxic effects when metals are emitted or lost to the environment. This potential depends both on the magnitude of metal emission flows and on the magnitude of metal-specific indicators of terrestrial ecotoxicity, which are referred to as comparative toxicity potentials (CTP). Currently, metals dominate terrestrial ecotoxicity impact scores in life cycle assessment (LCA) studies, mainly because their CTPs are higher when compared to those of organic substances. It is unknown, however, whether metal remain important contributors to terrestrial ecotoxicity impact scores in LCA when solid- and liquid-phase speciation are considered in environmental fate, exposure and effects.

Methods: Here, new speciation-based method for calculating comparative toxicity potentials (CTP) of 23 metallic elements (Cs, Be, Sr, Ba, V, Cr, Mo, Mn, Fe, Co, Ni, Cu, Ag, Zn, Cd, Hg, Al, Tl, Sn, Pb, As, Sb, and Se) in soils was compared with two other widely used methods which do not consider speciation (IMPACT 2002+ and ReCiPe 2008) for nearly 13,000 life cycles of unit processes taken from different sectors.

Results: Differences in impact scores were driven either by differences in characterization models (ReCiPe 2008) or both by differences in characterization models and substance coverage (IMPACT 2002+). Strong correlations ($r>0.98$) and seemingly constant shifts in impact scores were found for those processes where one or few substances (usually metals) contributed most to total impact and there were large differences in CTPs between methods for these substances. Weaker correlations but often better agreement in impact scores were found for those processes where various organic substances were dominant contributors. As for the majority of unit processes (~80%) differences in CTPs between individual elements propagate to total impacts at the unit process level when speciation was considered, metals are expected to remain important contributors to soil ecotoxicity impacts in LCA. Our results stress the need for considering metals as important contributors to terrestrial ecotoxicity when developing eco-innovative solutions concerning production and processing of metals.

SESSION T3-7 Sustainability as a Part of Supply Chain Management in Organisations

Footprinting at Supply Chain level: Insights in the carbon footprint of raw milk from all Dutch dairy farms

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PRé Sustainability

The Dutch dairy sector has the ambition to reduce her GHG-emissions by 20 percent in 2020 and to grow climate-neutral. Additionally, a growing number of customers of dairy farmers are distinguishing themselves with sustainability in the dairy sector and would like to have insight in carbon footprint of their suppliers. Through the sustainable dairy chain initiative the Dutch dairy sector works on mitigating greenhouse gas (GHG) emissions from the Dutch dairy supply chain. Reduction of GHG emissions at dairy farms is one of the building blocks in the sustainable dairy chain program. Mitigating GHG emissions from dairy farms can be facilitated by insight in GHG emissions at individual dairy farms. Therefore a model and a tool was developed to monitor GHG emissions, i.e. carbon footprint, per kg raw milk production at individual Dutch dairy farms.

Aim

An automated system to monitor individual carbon footprints of raw milk produced at all Dutch dairy farms. With this tool sustainability in a supply chain with many actors can be supported and ensured.

Methods

An LCA model was developed to calculate carbon footprints of raw milk from individual Dutch farms. The model was developed in compliance with the Product Environmental Footprint guidelines for dairy (EDA, 2016) and IDF guide to standard life cycle assessment methodology (IDF, 2015). LCI data were retrieved from a national database containing data of all Dutch dairy farms. From 2018 onwards this model has been connected to the Dutch database to automatize yearly monitoring, thus enabling automated calculation of LCA results via robust LCA software for the entire Dairy chain.

Results

The carbon footprint of milk from 12200 farms was calculated with the developed model. Analysis of results shows that the developed model produces robust results. Variation in GHG emissions per kilogram of milk is observed between farms. GHG emissions vary based on multiple farm characteristics, such as ration composition, feed efficiency, mineral efficiency and soil type. Furthermore results provide insights in mitigation options that have potential to reduce the carbon footprint of milk from individual dairy farms.

Conclusion

From 2018 onwards an automated yearly monitoring of carbon footprints of raw milk is available for all Dutch dairy farms, enabling all farmers to take tailored measures to reduce GHG emissions at their farm. Next to that it gives the LCA expert insight in the spread of results for 12.200 farmers, identify the best performers in the chain and the reasons for their performance, the worst performers and opportunities for those farmers to take action to improve their carbon footprint.

SESSION T3-7 Sustainability as a Part of Supply Chain Management in Organisations

Lifecycle costing for an economic sustainability-oriented materials technologies assessment

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Goals -

Supply chains in manufacturing industries, such as aerospace, are challenged with increasing pressures of costumers, governments and society, to achieve sustainability. The introduction of composite materials technologies has been used to answer several sustainability challenges. However, their adoption faces high barriers, namely in the increase of supply chain complexity, which often is translated into significant acceptance delays. Cost is one of the most relevant barriers of composite materials' development and introduction into the market. Looking for answers to this context, this study intends to show how product life cycle costing can be used as a tool for supply chain sustainability decision-making, as it seeks to derive maximum benefit from critical resources as well as reduce the risk associated with an investment.

Method(s) -

The methodology employed in this work is the Product Life Cycle Costing (PLCC) approach, which assesses the economic pillar of sustainability for a life cycle (LC) sustainability assessment. A case study methodology has been applied, in order to assess a tier 1 manufacturer risk-sharing model, for a sustainability-oriented supply chain, which apply three different production technologies. To deal with the general cost effectiveness of the referred scenarios, a deterministic economic engineering model is developed, being supported by an analytical and conceptual approach, that cover two cost systems, - the manufacturer system and the aircraft owner system, as well as four LC phases, - the development, the production, the operation and the end-of-life is performed

Results -

As a result, it will be sought to know which of the three referred scenarios is the most feasible in terms of cost, i.e. in terms of its economic sustainability, and therefore, to identify which scenario allows a faster economic return, thus having the lowest risk.

Acknowledgments

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SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

Software to spatially and temporally characterize regional flooring waste generation and related environmental impacts; application to the city of Esch-sur-Alzette, Luxembourg

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Goal(s):

Society has abundant building materials in use. The European Directive 2008/98/EC prescribes that when part of these materials will become waste, 70% of its non-hazardous component should be recycled by 2020. A main issue is nowadays the lack of knowledge on the amounts currently in use (looking beyond single brands), when they will be wasted, where exactly and what the related environmental impact will be. Geographical Information Systems (GIS) coupled with life cycle assessment (LCA) can help to answer these questions through a geospatial mapping of building stocks and assessing the impacts of their treatment. Our study focuses on flooring and in particular on those present in Luxembourg. From a methodological point of view, we intend to go a step further by also considering the lifetime of the flooring as such and its installation and uninstallation over time, allowing to temporally differentiate the associated impact of waste handling.

Method(s):

A tool, named FLOREC SPATIAL, has been developed to characterize flooring amounts and related waste over time, this for a particular flooring type (e.g. PVC flooring). As a first step, the tool quantifies flooring amounts per building, based on: (a) 3D-maps of the city with building volumes, and (b) building characteristics (e.g. thickness of the walls). Second, an initialisation step, provides a random distribution of a selected type of flooring (e.g. PVC flooring) and their age distributed across the previously calculated amounts, this based on (c) the share of that flooring type, (d) a minimum installation amount and (e) flooring lifetime (e.g. 10 years). Third, the model is run with a certain time step to simulate the processes of installation and uninstallation, given: (e) lifetime of flooring, and (f) building lifetime. This all, results in flooring waste amounts generated over time. Subsequently, using (g) chance of recycling versus incineration (h) a minimum year after which flooring is susceptible to be recycled, the total share ending up being recycled or incinerated per year can be defined. Related transportation distances can also be derived if (i) a map on transportation distances and (j) location of waste handling sites are provided. Finally, the output on flooring waste amount, their handling and transportation distances, can be translated into environmental impact amounts when using (k) LCA-results for waste handling and transportation processes.

Result(s):

The model was test run starting from 2018 until 2033 for a Luxembourgish city with a focus on PVC flooring, using the following values for key parameters: (c) 15% of flooring considered as PVC, (d) minimum amount of 10 m2 installed, (e) flooring lifetime of 10 years and (f) building lifetime of 70 years. Provided waste flooring amounts ranging from 83312 to 225596 m2 over 15 years. When additionally considering (g) 50% chance of recycling and (h) that from the year 2013 onwards flooring can be recycled, over the full 15 years 34.6% is recycled and the average transport distance is 3.96 km. The coupling with LCA results, resulting in environmental impact over time, will be provided at the conference.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

A Framework for LCA of Advanced Recycling Technologies of Future Circular Economy

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The notion of circular economy implies as a common understanding that recycling of waste will return value raw materials into the economy, which lowers the demand for primary raw material as well as the environmental impacts and energy demands associated to primary raw materials extraction. In today's circular economy, there are established examples, which confirm this notion, e.g. the recovery of paper or glass, which provide indispensable sources of raw materials for the respective industries. However, it can be observed that on-going major technological, economical and societal changes have far-reaching impacts on the outline of current products which will be the waste of tomorrow: As to consumer-products, the digital transformation leads to more integration of electronics in "conventional products", like cars, household appliances or even shoes or clothes; the individualization of life styles calls for more convenience products or smaller and lighter products "to go", which are based on high-performance material composites. As to infrastructures of society, notably the transformation of the energy system introduces low-carbon technologies like photovoltaics or electro-mobility. All these products are increasingly based on composite and novel functional materials often based on so-called critical raw materials like rare earth elements (REE). Their future recycling requires the development of advanced recycling which one hand comprises single innovative technologies for recovery of specific materials or elements, but on the other hand the integration of several technologies to intelligent process chains to account for the separation, recovery and valorization of multiple material flows from complex advanced products.

This poses also new challenges for LCA of recycling technologies: where for conventional recycling, one route for one primary raw material is compared to one route for a specific secondary raw material, in the case of advanced recycling technologies multiple material inputs from diverse product streams contribute to the recovery of multiple secondary raw materials. The presentation will discuss the issues of an LCA framework accounting for this overarching characteristic of advanced recycling technologies. For systems boundary and the product system, different perspectives can be followed: the view of the product, e.g. an electric vehicle, which covers the assessment of all material flows, vs. the view of single materials or (critical) raw material flows, e.g. REE for magnetic materials, which touches interconnected material cycles of raw materials. Next, the time perspective plays a crucial role. In contrast to established material cycles, the stocks from which secondary raw materials can be retrieved will assemble only in the decades to come. This means that the relation of demand and supply of secondary materials will be different depending on the point of time of recycling which has to be investigated on the basis of scenario analysis. For impact assessment, the focus can be discussed as to energy vs. non-energy impacts, where for the latter the impact of the release or re-use of hazardous materials during end-of-life processes has to be investigated. These possibilities to address these questions will be pointed out using concrete examples from the development of advanced recycling technologies.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

Application of Life Cycle Assessment as decision-making tool in Circular Economy

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Circular economy is a noble approach for achieving resource conservation, waste minimization and extending the utility of natural capital. Applying the principles of circular economy entails promoting sharing of resources, prolonging the life of products by maintenance, refurbishment and reuse and reducing the dependence on virgin materials through remanufacturing and recycling. There are several tools which aid in decision-making by quantifying the extent of circularity for any given product. Such tools take into account the percentage of input materials which are reused / recycled and recovery that happens after the end-of-life of the product. However, use of such tools only provides screening-level guidance on circularity. To gain deeper insight, it is necessary to inspect the product value chain holistically and factor in the impact of other externalities.

Life Cycle Assessment (LCA), is an established and accepted methodology for accounting the environmental impacts for any product system over its complete life. Adopting LCA in conjunction with other circularity evaluation tools will serve as robust tool in taking effective decisions by comparing the overall positive or negative impact. An evaluation from a life cycle perspective can shed light on the quantum of benefits. It is also possible to account burden from associated activities such as transportation, repair and recycling processes, etc., which helps in identifying the overall impact.

The objective of this paper is to apply LCA approach to the circular economy principles in order to evaluate the environmental impacts of recycling / reuse / refurbishment choices. Such evaluation provides deeper insight into how recycling approach compares with the use of virgin materials and identification of scenarios wherein decision to recycle and reuse provides a clear advantage in reducing environmental impacts.

A framework for evaluation and quantification of circularity guided by robust approach of life cycle assessment is proposed. The proposed framework is validated against a case study for solid waste generated in optical fibre manufacturing industry. Circularity routes are evaluated and scenarios have been modelled to understand the impact of choices and hot spots which contribute to the environmental impacts. Adoption of circular economy in waste management has been evaluated for its extent of circularity by using approaches such as Material Circularity Index (MCI) developed by Ellen MacArthur Foundation etc. Comparison of these routes is made with the LCA results by evaluating impacts over the complete value chain.

It has been understood that, adoption of circular economy principles guided by lifecycle perspective can provide a holistic view of the environmental burden over the complete life cycle and it has proven to be robust approach for conserving natural capital while minimising the adverse impacts on the environment. This multi-dimensional approach factors in not just the quantity of material being recycled/recused, but also the material attributes, transportation considerations and energy/material inputs for carrying our recycling process. Also, it has been concluded that design for reuse may result in increased impacts due to material choices, weight, manufacturing techniques, etc.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

An analysis of assumptions and trade-offs in Circular Economy business models

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Circular Economy initiatives are drawing considerable attention in sustainability discourses of the day. Considering that business has a critical role in injecting circularity into the economic system and the fact that the dominant business paradigm remains profit maximization, the case for Circular Economy is being built on a promise of competitiveness and high profitability. Having been positioned as both economically and environmentally beneficial, there is a general endorsement of the concept by both business managers and sustainability practitioners. The proverbial devil-in-the-detail lies in its implementation modalities. The goal of this study is to identify the open issues in proposed business models for Circular Economy and shed light on the nuts and bolts of how this revolutionary change can deliver net benefits. In order to identify the open issues, we followed a methodology consisting of four steps to undertake the analysis described in this submission: identification of case studies on Circular Economy business models, content analysis of the models, categorization of model characteristics, and elaboration of problematic aspects. Put together, results of the analysis show that while business models such as Circular Supply Chain, Product Life Extension, Sharing Platforms, Product as a Service, etc. represent solutions for reducing waste in the hands of end consumers, the delivery of net benefits rests on several assumptions and there is inadequate attention to trade-offs across impacts. The trade-offs remain unclear in the absence of life cycle based analysis of the business models. The submission concludes with a suggested framework for evaluating Circular Economy business models to reduce the risks of unintended trade-offs that might creep in without an appreciation of their life cycle impacts. The framework also brings out the assumptions underlying the business models which must be validated to ensure that they deliver net benefits and do not merely shift burdens.

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SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

A tool for combined economic and environmental assessment over time of circular economy business models, exemplified for Tarkett flooring

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Goal(s):

In light of a desired circular economy (CE), the industry is interested in introducing and evaluating CE business models. An example is the company Tarkett that is aiming to achieve circular business models for its flooring solutions. However, while in theory circular systems can be sustainable, focusing on profit and environmental benefit, this is not for sure the case in practice. In other words, there is still a need to assess these impacts and optimize CE business models. Current life cycle assessment methods fall short in certain manners. First, there is a lack in consideration of temporal effects such as limitation in amount of loops and the fact that waste flows intended for recycling may only return after a long time. This temporal aspect has a considerable impact on profitability (future cash flows are financially valued less) and environmental impact (e.g. storing carbon longer over time in products is beneficial when valuing future impact less). Second, the effect of scale is often overlooked, implying the amounts of sales over time and how they influence the handling of returned waste (e.g. what to do with excess waste?). The goal of this study is to develop a tool that tackles these latter two issues, mainly from a producer perspective, and to exemplify it for CE business models of Tarkett flooring.

Method(s):

A method is developed that quantifies the product flow and related processes (e.g. production, collection, recycling) over time for a given set of parameters: amount of loops, product lifetime, collection efficiency etc. This temporal characterisation allows then to quantify profit and environmental impact over time for input values of cost and life cycle environmental impact per process. A valuation over time is then superimposed for selected discounting and inflation rates. The environmental impact can be monetized, which is then also summed with the economic values. When it comes to the second issue, the effect of sales amounts, it is crucial to track over time the returning flows of waste and what the options are for them, given the sales amount. Two mechanisms occur: (a) these waste flows are used instead of virgin raw materials or production (b) redundant waste, that exceeds amounts needed for foreseen sales, needs to be handled (treated, stored or sold). These mechanisms are considered in the method for various waste handling scenarios. A simple excel-tool has already been developed that covers these aspects. A more complex tool will be developed in the future.

Result(s):

The excel-tool is operational and has been run with dummy values. The type of results that one can obtain are for example that (a) the total of profit and monetized carbon footprint may increase 60% for recycling compared to the reference scenario (where everything is produced anew) and (b) virgin production may decrease with 33% in total over 30 years for given sales over time when recycling if redundant waste amounts are sold. Eventually, specific values valid for Tarkett will be used and the respective outcomes will be presented at the conference.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

The decoupling discourse and the circular economy: A versatile approach to assess circularity

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Goal

The spaceship earth behaves like an isolated system where waste and pollution are the manifestations of the entropy generation. Decoupling the economic activity from the degradation of natural capital is often attached to the circular economy (CE) discourses and promises to slow down the pace of entropy generation. Some authors used the IPAT equation – suggesting that the environmental impacts (I) result from the combined effect of the population (P), the affluence (A) and the technology (T) – to quantitatively assess the decoupling process operating between Gross Domestic Product (GDP) and Green House Gas (GHG) emissions. Building on the empirical use of the IPAT, we propose to assess how much a single improvement towards material circularity contributes to an overall decoupling pathway.

Method

We develop a versatile approach to assess how CE strategies contribute to environmental sustainability as the sum of activities distinguished by region, industry, process, or any other, to the overall impact and as the sum of environmental efficiency ratios. These latter are multiplicative factors of the technological variable illustrating key drivers for CE implementation, e.g. GHG/materials and materials/ product. We use Index Decomposition Analysis (IDA) to transform the multiplicative factors composing T into additive forms to facilitate the assessment of the contribution of each variable to the overall decoupling process. The approach leaves the users the freedom to choose the key drivers for CE implementation and the system boundaries to design the decoupling assessment methodology that better suits to their context.

Results

We illustrate the approach with a recent publication from Material Economics quantifying the potential for CE opportunities to reduce GHG emissions from steel, plastics, aluminum, and cement industries by 2050 in the context of the EU when applying 3 types of circularity measures: material recirculation, product material efficiency, and new circular business models. Applying our approach reveals the progress expected from each circularity measure in each industry to reach the reported results, e.g. the contribution to reducing GHG emissions in the steel industry requires the overall environmental efficiency to improve by 67% from the baseline scenario. It also reveals the maximal increase of overall demand of each material that would offset the benefits from CE to meet the decoupling condition, e.g. an increase of 201% within the steel industry from the baseline scenario.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

Methodology development to selection a new technology or innovation solution in framework of Circular Economy

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The CIRCE2020 project (with helping of EU financed Central Europe programmes) has started since 2017. In the framework of this project the consortium developed a new methodology to measure the new technologies and innovation solutions to enforce the circularity in the waste management sector. In the framework of this project the consortium will set up 5 different pilots where it can be demonstrate this new methodology. What is the speciality in this methodology? Besides the well-known economically and environmental aspects i.e. LCC and LCA, we made a new index, TRM. The technology rating methodology (TRM) is developed to provide researchers/investors the possibility to execute a technical self-test of their projects. The TRM is a self-pointing solution where it can be measured the selected solutions by different point of views. For example: EU based TRL, market references, reliability of the technology provider, circularity level, operational experience, and technical limitations. After the weighting process of these aspects it can be calculated the TRM index for all alternatives of our selected technology. Meanwhile the determination of TRM index, we have to execute the LCA and LCC for all alternatives. Helping with TRM, LCA and LCC can be given a new decision matrix for our clients of decision makers who can choose a proper one from the alternatives. This new methodology can help for us to choose that solution which considers the concepts of circularity economy. In 2019 the Hungarian partner of CIRCE2020 project will investigate new solutions for production waste problems of tyres. In the oral presentation we will show the results of this methodology, especially for tyres.

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

What is my share? Assessing the environmental impacts of secondary consumption

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Growing interest in circular economy models where multiple agents (users) reuse the same products either in parallel (e.g., Zipcar) or one after the other (e.g., via resale on eBay) creates the need to better track the environmental impacts of each user. Recently, environmental accounting methods (e.g., LCA, footprinting) have been slowly converging towards consumption (rather than production) based approaches. Constituted on the idea that demand for new products is the key driver for primary production, consumption based approaches view agents (e.g., countries, companies, individuals) responsible for the environmental impacts associated with their purchases no matter where such impacts might accrue (Wiedmann et al. 2013; Ivanova et al. 2016 Kanemoto et al. 2016). Consumption based allocations have been instrumental in demonstrating the significant impacts of household consumption and that while developed countries have essentially outsourced pollution, yet benefit from the utility delivered from product produced elsewhere.

Critically however, consumption based approaches typically overlook the role that secondary consumers play in driving primary production. This is problematic since trade volumes in secondary markets (e.g., second hand markets, sharing economy) often surpass those of primary ones, and secondary markets can increase demand for new products (Chu and Liao 2010; Waldman 2003; Cooper and Gutowski 2017). To truly link the impacts of production to the agents driving its demand, environmental accounting methods should be refined to incorporate secondary consumers as well.

In this work we explore the following: (1) How to extend consumption base footprint principals when there is more than one user?; (2) How to divide the environmental impacts of new products that were used for very short time by the first user and were them sold to another user;

We propose a new method to allocate products' environmental impacts across all the users they might have throughout their full lifespan according to market depreciation (i.e., value loss as calculated from sales data in primary and secondary markets). Specifically, we suggest using LCA in conjunction with depreciation to equitably allocate environmental impacts among multiple agents, according to the share of utility each agent gained. While depreciation is not a direct measure of the way secondary users impact demand, in a free market context, it reflects the amount of utility (i.e. benefit) to be gained from previously owned products. As such we argue that depreciation is well aligned with the basic premise that those benefiting from consumption should be held accountable for its impacts.

We demonstrate our and quantify the environmental impacts of pre-and post-resale of products approach in two product categories (cars and smartphones). We compare our results with other methods, and discuss the advantages and disadvantages of our method. Our findings suggest that depreciation based allocation is particularly relevant for products with high production phase impacts, and illustrates the importance of accounting for secondary users' specific use patterns (such as location and use length) in LCA modelling. In addition, our analysis provides insight into the actual lifespan of product with multiple users (for example 5-6 years for cell phones compared with the 18-24 months cited in literature).

SESSION T4-1 Circular Economy and Challenges for Life Cycle Management

The Reuse for the transition to a Circular Economy. Insights from the Life Cycle Assessment of second-hand consumption

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Ecoinnovazione

The Circular Economy (CE) is an economy where the value of products, materials and resources is maintained in the economy for as long as possible and the generation of waste is minimized (COM(2015)614). The communication, in line with the Roadmap to a Resource-Efficient Europe (COM(2011)571), mentions initiatives for waste prevention as a key horizontal measure for the transition to a CE. In this context, the reuse is the strategy which most values products, materials and resources stocked in the products, and prevents waste generation. In particular, the "direct" reuse seems to be the most preferable option from an environmental point of view, not requiring for any transformation or reconditioning process.

The Life Cycle Assessment (LCA) is recognized in several environmental policies as the methodology for the quantification of the environmental performance of products and systems and is part of the Better Regulation package(COM(2015)215) to support the policy definition.

The present contribution aims to i) quantify the potential environmental benefitof "direct" reuse, i.e. the reuse option consisting in the direct resale of the product, ii) provide insights to support the setting of local sustainable CE policies, which takes into account the environmental potential of goods in the second-hand market.

An LCA study (ISO 14040,14044) has been performed on a second-hand brand operating through a number of stores across Italy. The Product Environmental Footprint methodology (Recommendation 2013/179/EU) is followed for the Life Cycle Impact Assessment method and for the modelling of material production and multi-functionality during end-of-life. The functional unit is the supply of 2 times the service life of each product in the basket-of-products (BoP) sold in the reference year (2016). System boundary is from cradle-to-grave.

Climate Change (CC), Acidification (AP), Marine Eutrophication (MEP), Fresh water Eutrophication (FE), Particulate Matter (PM) and Resource Depletion (RD) have been identified as the most relevant categories, following the normalization and equal weighting, and selected for the results analysis. The reuse benefit, representing the potential benefit achieved from purchasing a used product instead of a new one, is reported for the whole BoP sold in 2016. Higher benefits are achieved in RD (35%) and PM (21%), where main contribution is from the "wood objects and furniture", 19 and 34% respectively, and depends on the flow mass relevance.CC, AP, MEP and FE account for 12, 14, 10 and 8% of the benefit respectively, with "synthetic clothing" playing the main role (39 to 51%), due to the high impact per kg of product.

The main limitation of the study is the simplification adopted for modelling the over 5,000 items, which allowed only to account for major differences in material composition.

As a next step, the model should be further deepened to take into account also possible rebound effect, i.e. the potential increase of the overall consumption as a consequence of the environmental efficiency intervention (reuse) occurring through a price reduction. Indeed, in this study, it is assumed that a reused good substitutes a new one and no rebound effect arises from cost saving of buyers/income of sellers.

SESSION T4-2 Integration of Sustainable Development Goals Assessment and Bottom-Up LCA

Assessment of Social Hotspots linked to Sustainability Development Goals within the SEEbalance®

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BASF SE

Goal

With SEEbalance® being introduced in 2005, BASF for the first time presented a methodology designed to evaluate all the three pillars of sustainability – environment, society and economy. This methodology has now been fundamentally revised in terms of assessing social aspects: qualitive factors will from now on be increasingly spotlighted. SEEbalance® is valuable when it comes to identifying relevant topics and opens up new opportunities on how to improve sustainability along the value chain.

SEEbalance® thus enables a direct comparison between different alternatives. Apart from obtaining precise statements on the alternative with the best results in each category, customers also receive information on the potential for optimization of each of the three dimensions which can be derived separately, with the goal of increasing sustainability along the value chain.

Methods

The Social Hot Spot Assessment is performed to highlight specific life cycle steps with detailed information. It follows several steps to find relevant Hotspots for every alternative that is assessed in the study. The method identifies impacts to the Sustainability Development Goals (SDG) and is displaying the results with the most significant SDG effects. A specific overview reflects all information identified and enables the support of strategic decision-making.

The SDG and the structure how they are defined are used for identifying the right key words for the detailed desktop research and the assessment of the information identified in different sources. The method is flexible and can be applied for all relevant products and sectors to enable industries the identification of social hotspots.

Results

The questions which needed to be answered in the development of the method were on one hand how to assess social impacts in a meaningful way by utilization of relevant information. Furthermore, how to identify relevant social topics for companies, countries with a meaningful set of social indicators. Thirdly the question needed to be answered, how the different types of information can be combined in an overall result for the Social Analysis and how to link an integrate it with results from the environmental and costs assessment.

Key findings of the study are translated to goals and targets which are defined in the SDG. With the matching process a SDG is identified where the alternative of the study conflicts with. This will be assessed in the previously identified area of Hot Spots. It will be identified and highlighted, if and how life cycle activities and actors conflict with the SDG. A high-level rating and a low-level rating is defined by using different types of information. Against these scale, the alternatives in the study are reflected and transferred in an assessment matrix. For further groupings, a scale-based approach is applied ending in a color code for the dedicated life cycle steps.

SESSION T4-2 Integration of Sustainable Development Goals Assessment and Bottom-Up LCA

Linking the UN Sustainable Development Goals to life cycle impact frameworks

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PRé Consultants

The UN 2030 Agenda for Sustainable Development provides 17 Sustainable Development Goals (SDGs) and 169 accompanying targets, with so far 230 indicators. Two years after their publication, they are still not widely implemented into business practice, and the sheer number of targets and indicators implies an obvious risk of cherry-picking and sub-optimised decision-making. In contrast with this top-down goalsetting processes, the Life Cycle Community has developed much knowledge, data and experience to assess products and systems in a bottom-up mode. The community has developed as something unique a large repository of data that describes all major relevant supply chains throughout the world, and it has combined this with a number of methodologies to translate this data into a number of social and environmental category indicators, in different levels of aggregation.

Project objectives, scope and expected impacts

The key problem with the SDG's is that they are developed for governments, so for instance the performance indicators to measure the progress towards SDG 13 on climate talk about subsidies and programs, but there is nothing tangible there for companies. Our literature review shows that numerous global organisations and the largest consultancy firms have tried to create a better link to report against SDG,s and this has indeed brought some progress. However, these efforts fall short of understanding how to create a link between environmental and social LCA.

With support from the UNEP Life Cycle Initiative a project has been started to link the top-down of SDGs and the LCA bottom-up approach. The objective was to develop a clear linkage between the top down process that led to the creation of the SDG's and all the bottom-up knowledge, data and methodology in the Life Cycle Sustainability Assessment area. With this link specific decisions can be related to the goals.

Our initial round of stakeholder consultations confirms that top management often develop policies on how to contribute to a number of SDG's, but they are not clear on how to measure this, and this leaves the LCA team in the company with a challenge; In order to be meaningful the LCA outputs should somehow measure the progress a company is making towards reaching the selected goals.

Results

This presentation presents the initial results from the various approaches we have used to link LCA to two selected SDG's, and also presents the challenges. The aim of presenting this is to (1) make LCA practitioners aware of the urgency to link their work to the Sustainable Development Goals and (2) to get inputs from the audience in the question and answers. In the following phases the linking approaches will be refined and applied on the remaining SDG,s and we will work with companies to develop case studies as well as develop training materials.

SESSION T4-3 LCA in EU Policy

Ecodesign policy targeting household washing machines consumption and behavioural decisions to contribute to the European Green Deal

Alicia Boyano, Nieves Espinosa, Alejandro Villanueva

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Joint Research Centre, European Commission

Goal

Due to their energy consumption behaviour, households are responsible for approximately 72% of global greenhouse gas emissions (GHG) in Europe. Thus, it is a key area to be tackled to reach the goals under the Paris Agreement. The sector of cleaning services where household washing machines are included represents a 6% of it. However, the potential energy savings in households has not yet been fully reflected in policies, nor do households receive sufficiently high priority in current climate and energy policy strategies. This work investigates how reductions in energy consumption and therefore GHG emissions of household washing machines can be achieved through a better reflection of the user behaviours in the regulations applied in EU. We then conclude with further recommendations for EU Ecodesign policy.

Methods

A model has been created to estimate the overall stock of washing machines in EU 28, based on the number of households and the penetration rate. Several policy scenarios were assessed and some core results from the impact assessment study for household washing machines are presented, which investigated and reflected how the introduction of the household preferences for laundry in Europe can shape the regulations. This work relies on four major points: the identification of the mostly used programme by consumers, a change in the testing portfolio to bring it closer to the current use of the washing machines, a limitation in the programme duration to make it more attractive to consumers, and finally an energy efficiency optimization of the testing programme by the manufacturers based on past experience.

Results

The total real electricity consumption, water consumption and GHG emissions released from the EU28 stock of washing machines is calculated for all the assessed policy scenarios. A change in the consumer behaviour where they are motivated or incentivised to increase the average laundry loading per cycle, would achieve the highest energy savings. This scenario was however considered not feasible because it would rely on a deep consumer behaviour change and this is outside the scope of the regulations. A change in the testing portfolio to bring it closer to the actual consumer behaviour would be feasible and realistic and would achieve an annual energy saving of 2.75TWh and 0.6 million tons CO2eq in 2030. Therefore, the recommendation is for policymakers to take into account the user behaviour information found out in this study into the revision of the EU Ecodesign and Energy label regulations for household washing machines.

SESSION T4-3 LCA in EU Policy

How should Food Waste Energy be Managed?

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Cantabria University

Goal:

Food waste represents a significant loss of resources invested in their production. Thereby, it is already a central issue in the European political debate, leading to the development of numerous food waste reduction strategies. At the same time, a larger share of renewable energy for greenhouse gas emissions (GHG) mitigation are stated by the new global energy strategies. In this framework, food waste reduction strategies aimed at simply halving the amount of waste generated might hinder energy policies seeking to expand bioenergy production as means for GHG emissions mitigation.

By taking a holistic view of the food waste system, this work aims at testing this hypothesis above by (1) quantifying the potential reduction of food waste in the agri-food system under different waste reduction strategies, and (2) assessing its implications for bioenergy generation and GHG emissions mitigation.

The study is performed from cradle to grave, considering the phases of agricultural production, processing, distribution, consumption and waste management, in the Spanish food supply chain. Regarding the latter, four different waste management alternatives have been considered: landfill, incineration, recovery and anaerobic digestion coupled to composting. Incineration technology is based on energy recovery. Recovery refers to recovery other than energy recovery, e.g. value added processing.

Methods:

In order to analyse the climatic merits, i-e- reduction in GHG emissions, of alternative scenarios of food waste generation and utilization, a new consequential life cycle assessment (cLCA) method is developed, which links the Life Cycle Assessment runs to the European Energy System model developed at UCL, ETM-UCL. Future energy service demands are projected using appropriate drivers (population, diets, etc.) and respective elasticities. To set European Union climate targets consistent with the Paris Agreement, ETM-UCL is run with European Union carbon budgets estimated by TIAM-UCL, a global integrated assessment model. Food waste production and consumption supply chains are implemented in GaBi v7, based on the result from the material flow analysis and using Thinkstep´s Basis data. The effect of waste reduction strategies is quantified in terms of total amount of food waste potentially available for energy, its associated costs, i.e. collection, treatment and/or disposal, and its associated GHG and non-GHG emissions. These results are then implemented in ETM-UCL, which finds new cost optimal low carbon energy systems under different European Union carbon budgets.

Results:

Results suggest that stages of consumption and agricultural production contribute to half of the Spanish food waste generation. Its reduction as a result of current waste strategies, and potential redirection to other processes, could increase pressure on the of other biomass resources generation, potentially leading to increased GHG emissions and exacerbating the food – energy competition for land. A holistic approach to food waste strategies in combination with low carbon pathways in the energy sector allows to identify national strategies which could meet both waste and overall GHG emissions reduction targets. While optimistic that representation of food – waste – energy trade-offs and synergies can be modelled in a multi-disciplinary framework, our work identifies several aspects requiring further research.

SESSION T4-3 LCA in EU Policy

Product Social Footprint as the next frontier?

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PRé Sustainability

In 2011 the Commission announced the EF footprint pilots as part of the effort to support a common market for green products. This initiative was greeted with some enthusiasm by industries, as over 120 industry associations volunteered to be part of the pilot, and only 27 could be accepted. Companies like to have a level playing field so they can compete using reliable green claims. While the dust is settling around the EF initiative, a new challenge seems to be emerging and that is how to compete using claims on social impacts.

Goal

While admittedly highly speculative, this paper investigates, if, when and how the commission could support a level playing field for companies that want to disclose the social impacts occurring along the value chain.

Method

The input for this paper came from discussions with companies and some policy makers over about half a decade.

Results

There are a number of observations from the discussions:

1. As often understood, most companies do not really applaud additional regulations and certifications.
2. At the same time companies need a level playing field. For instance: companies that ensure workers are adequately paid and treated can have a cost disadvantage against competitors that use forced labour slaves, and this creates an unfair competition.
3. Like in the case on green products, there are numerous claims and labels that try to inform the consumers on social issues, with various levels of credibility, and this is problematic.

From these discussions and from discussions with experts in the area, we also see a number of important challenges:

1. It is not likely there will be a reliable secondary database on social impacts, like the EU commission delivered for the PEF.
2. There are at this stage no mature methodologies for social LCA .
3. There are already some initiatives already organised under ISEAL and others. What could their role be, even if they usually only focus on one step of the lifecycle and tend to ignore the rest.

This paper speculates on the possibilities for the commission to develop a Social Footprint Initiative and tries to provide some suggestions on whether, how and when a pilot could be organised.

SESSION T4-3 LCA in EU Policy

A novel way to make large-scale benchmarking feasible and everlasting

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PRé Sustainability

Goal: Life cycle assessment (LCA) has general methodological rules as those stipulated in the ISO standards 14040 and 14044. Currently there is also a rise of sector specific or product specific rules, e.g. the Life Cycle Metrics for Chemical Products published by the WBCSD. Judging by the enthusiasm around the Environmental Footprint rules initiative of the European Commission, it seems desirable to have a wide coverage of products with rules specifically developed for a product category (product environmental footprint category rules – PEFCR). For developing a PEFCR, the model of a European representative product (RP) per product category needs to be determined. According to the current PEFCR guidance, the modelling of the representative product should be done either with a real product or on basis of a virtual product modelled on basis of the EU market shares of various products. Whereas the latter is more appropriate for the purpose of developing an average model, it might be impossible to collect so much and so detailed information if a bottom-up approach is used. In this abstract I propose a top-down approach for modelling representative products to represent highly diverse product groups.

Method: The RP is primarily aimed at i) identifying the hotspots, ii) at determining the data needs, and iii) at calculating the benchmark. When a product group is very complex and diverse, I propose the following approach:

1. Involve the product manufacturing organisations that contribute to at least 51% of the EU market share.
2. Carry out an organisation environmental footprint (OEF) study for each of those organisations covering the complete value chain to identify the most relevant impact categories, life cycle stages and processes.
3. Compile the hotspots from all OEF studies; each hotspot that occurs at least once will be listed in the draft PEFCR.
4. Carry out supporting studies trying to cover as many variations as possible to make sure no hotspot has been overlooked.
5. Calculate the benchmark results per (sub-)category using the yearly turnover/production volume of each of the participating organisations. At this point, all information related to the RP and required for the PEFCR is available.

With the first PEFCR in place, we can also streamline the process for the update of the PEFCR in the future by

1. Collecting data from the manufacturing companies, only for the hotspots identified. CEPE, who coordinated the paints pilot, is already doing this with its member companies.
2. The average of the data collected will be the data used for the update of the benchmark later on.

Results: This approach has not been tested yet. However, I am convinced that this is an approach that can make it really scalable. Both the development of the first PEFCR but, most importantly, the approach to update existing PEFCRs. So I encourage the pilots that will soon start the EF transition phase to try it. Moreover, this approach is applicable for product group-specific LCA guidance, also beyond the product environmental footprint (PEF) scope.

SESSION T4-3 LCA in EU Policy

Using the Organisation Environmental Footprint (OEF) to improve the EMAS Sectoral Reference Documents

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Sustainability Consulting Dr. Schemmer

Goal: The EU Environmental Management and Audit Scheme EMAS (Regulation (EC) No 1221/2009) includes an obligation for the Commission to develop Sectoral Reference Documents (SRDs) in consultation with Member States and other stakeholders. As spelled out in EMAS Art. 46, these Sectoral Reference Documents include best environmental management practices, environmental performance indicators for specific sectors and, where appropriate, benchmarks of excellence and rating systems identifying environmental performance levels.

SRDs shall guide organizations who apply EMAS when identifying their significant environmental aspects, developing environmental objectives, and reporting their environmental performance (including best practices as benchmarks). SRDs are in so far legally relevant, as their consideration is mandatory when aiming for EMAS registration in a branch for which a SRD exists. Unfortunately, the SRDs available so far are not always practically relevant and often do not focus on the most relevant environmental issues. Generally, recommendations for best practices are subjective and don’t necessarily address the most relevant processes and life cycle stages. In nearly all cases, upstream activities are not covered adequately.

Methods: The contribution includes an investigation, whether mandatory application of the Organization Environmental Footprint (OEF) methodology for the determination of significant environmental aspects and impacts, as well as for assessing potential best practices, could result in a better quality of the reference documents. The advantage of using the OEF to improve the SRDs is that application of the OEF methodology would not happen at the EMAS participants’ level, but remotely by improvement of the SRD development process. This means, there is no additional burden for EMAS organizations (who don’t have to apply the OEF directly), but rather a relief, because they will get practically relevant, scientifically funded guidance.

Results: The presentation will demonstrate how applying the OEF methodology to an existing SRD could improve it and make it more relevant for organizations. The retail sector will be used as an example, because it is presently the only branch where both an EMAS SRD and an OEFSR exist. Differences and commonalities of the two approaches: EMAS + SRD vs. OEF will be outlined, and deficiencies of the present SRD development approach will be shown. Also, it will be demonstrated which parts of the SRD would change when the OEF approach was applied for their revision (or development in case of new SRDs). The proposed integration of the OEF methodology in EMAS would also lead to more credibility for the SRDs: by following the rules laid down in the OEFSR, a proper review procedure would be applied when SRDs are being developed (or revised). Overall, the presentation will show how the OEF methodology can be integrated in existing EU policies smoothly.

SESSION T4-3 LCA in EU Policy

"Comparative Life Cycle Assessment of beverage cartons with non-returnable PET and returnable glass bottles in the beverage segments juice / nectar, UHT milk and fresh milk" - a new life cycle assessment for beverage packaging in Germany

Benedikt Kauertz, Carola Bick, Samuel Schlecht, Mirjam Busch, Stefanie Markwardt, Frank Wellenreuther

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ifeu Institut für Energie- und Umweltforschung Heidelberg

Goal:

All of Europe is talking about PEF and how political decisions can be supported by PEF results. The discussion also includes topics like: who is paying for PEF Studies and where are the limits of this shortened LCA approach.

The German environmental agency (UBA) decided four years ago, that the environmental position of beverage packing has to be proofed by a full LCA study – conducted by the industry - which has to comply with minimum requirements set by the UBA (please see also presentation on LCM 2015).

On behalf of the "Fachverband Kartonverpackungen für flüssige Nahrungsmittel e.V." ifeu Heidelberg carried out the first LCA Study in compliance with the ISO standard as well as the UBA minimum requirements. The study analyses the environmental performance of beverage cartons in comparison to PET one way and glass refillable bottles in the beverage segments juice and milk. Main target group of the results are political stakeholders. The LCA results therefore shall be used in political discussions regarding Circular Economy, plastic strategy and the new German packaging law. The study should bring scientifically based arguments to an environmental debate regarding packing, which is actually driven by buzzwords such as "waste reduction" and "recyclability".

Methods:

The study includes a set of impact categories addressing resource consumptions and emissions to the environment, covering the actual scientific debate. During interpretation the study uses the optional element of grouping to derive handy results without weighting, which is forbidden by ISO 14040/44.

Results:

Results of the LCA are that the beverage carton shows lower environmental impacts than PET one way bottles in all beverage segments within the scope of the study. In comparison to the glass refillable bottles the beverage cartons show a better environmental profile in the beverage segment milk and a comparable profile in the beverage segment juice. The results are mainly driven by these topics:

1) Although, the beverage carton is a compounded packing - made from woodfiber, plastic and in many cases aluminum foil – in Germany more than 60% of all beverage cartons are recycled to secondary fiber. The plastic and aluminum parts are incinerated in a cement kiln – replacing fossil energy.

2) PET one way bottles are widely known as well recyclable –However, in Germany PET bottles containing juice or milk are typically not recycled. The bottles are collected via curbside collection and are not recycled although the bottles have a potential recyclability.

3) The refillable glass bottles are the politically intended system for beverage packing. Therefore, the new packaging law defines a refillable-quota of 70% of all beverage packing. However, this percentage is being missed since years and only a few juice fillers and even less dairy plants are using the specific bottles. Therefore the reuse rate is low.

Based on the previous discussions on the formulation of minimum requirements, this study is considered the first policy LCA since 2002. Yet, it is still unclear how the political stakeholders will take on the study.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes

IT tools and services for the Environmental Footprint data validation, checking, and sharing

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Joint Research Centre - European Commission

Several tools for Life Cycle Inventory data development, validation, sharing and registration to the Life Cycle Data Network (LCDN) have been released by the EC since 2007, and improved after the official launch of the LCDN (2014). All those tools were originally meant for the International Life Cycle Data (ILCD) scheme, Since 2013 after a specific EC Communication (COM/2013/0196) the Environmental Footprint (EF) scheme has been developed and led to significant changes in the structure of the ILCD/LCDN. During the development of EF-compliant data, the tools had to be adapted and improved to fulfill

the new requirements. Particularly the following tools and software have been changed:

- ILCD validation tool: software for the compliance assessment of datasets (format syntax, archive structure, nomenclature,

links and orphaned items, categorization, etc.)

- soda4LCA: software for distributing data based on the ILCD data format, with search and management functions, including the data registration in the LCDN

-LCDN Registry: online registration facility that can deal with data from different nodes running on soda4LCA, and meant to make available only fully compliant data (while the nodes can host also intermediate data)

- Look@LCI: new software allowing the calculation of LCIA results directly from process datasets in (XML Files) from the

The changes that have been applied can be summarized as follows:

- ILCD validation tool: additional validation profiles added for EF scheme. Checks against different parameters for Elementary Flows, location IDs, new LCIA methods, Flow Properties, Unit Groups and schemas, according to the changes made in the DB structure

- soda4LCA: new access profiles are available for data stocks. The developer can now select entire data stocks and restrict the access only to authorized users. The entire data stock can be now downloaded directly, while before it was possible only at the single dataset level. The registration form includes a statement for the use of data within the EF framework. Declaration of compliance in the registration phase and possibility of multiple registration in more than one registry at once (a

dataset can be both ILCD and EF compliant and therefore registered in

two registries with different compliances declared).

- LCDN registry: a dedicated registry has been developed for EF, with new functions. The compliance scheme is now visible (before was implicit since only ILCD was possible), possibility to register entire batches of data at once (before each single dataset had to be registered manually). Search interface improved.

- Look@LCI: the new software allows the analysis of LCI datasets directly from the database in ILCD structure, the software is capable to calculate LCIA results according to the reference EF package used, to do a relevance check within the impact categories, and the most relevant elementary flows. Some results can be also summarized within the whole stock of LCI data analyzed.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes

Framework for carbon neutral buildings and sites: How to implement embodied carbon impacts of buildings into decarbonisation roadmaps for buildings

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DGNB

Goal

The German Sustainable Building Council (DGNB) is the German and international knowledge platform for sustainable building and provides the world's most advanced sustainable building certification system. Its aim is the planning and assessment of sustainable buildings and districts. With more than 4200 pre-certified or certified projects worldwide and as a market leader in Germany, the DGNB can look back on ten years of experience in fostering and certifying sustainable buildings. Since its very beginning, the ambitious assessments have always been based on the entire life cycle of a building, including both embodied and operational carbon emissions and applying to new buildings as well as to renovations of existing building.

In order to support a significant contribution of the construction sector to limit global warming and in order to make the implementation of the Paris Agreement of 2015 measurable within certified projects, the DGNB has developed a first version of a framework for climate-neutral buildings and sites.

Method

The new framework consists of the following three elements: carbon accounting rules with consistent calculation rules for buildings and sites, carbon disclosure rules with specific rules regarding the type and the content of the communication towards the customer and carbon management rules, i.e. establishing a building specific decarbonisation roadmap which is in line with the Paris agreement, containing a detailed action plan which demonstrates the achievement of the annual limit values. In order to not only achieve carbon neutral building operations but also to contribute to a decarbonisation of building materials, the carbon accounting rules allow for two levels of ambition. The first level only accounts for energy related, operational greenhouse gas emissions, while the second level of ambition also includes the embodied emissions.

The new framework offers a wide range of possible applications as it implies an advantageous rating within the DGNB system for new and existing buildings and offers a reliable basis for decision-makers regarding the aspect of green financing. Furthermore, it can do pioneer work in order to establish appropriate regulatory instruments or serve for educational purposes, including dissemination through the DGNB Academy.

Results:

The framework's first version is currently being tested on real projects and refined afterwards. Specific definitions especially on the balancing rules and on the projection within the decarbonisation roadmap are currently discussed with expert panels and tested simultaneously. First results of applying the decarbonization roadmaps show, that a linear approach from today's status to 2050 favors measures such as improvements of the buildings envelope, on-site renewable power generation, improvements of the energy system or reductions through user behavior follow specific patterns, depending on four general building types. The general framework and these building types and the patterns will be presented.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes

Product Environmental Footprint compliant tool for dairy industry: Presentation of a case study.

Daniel Egas, Sergio Ponsá, Joan Colón.

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UVic-UCC, BETA TC

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes

HOW TO MAXIMIZE THE VALUE OF AN ENVIRONMENTAL PRODUCT DECLARATION? AN APPLICATION IN THE CONSTRUCTION SECTOR

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Ecoinnovazione

The construction sector is of strategic importance for our society, as it delivers buildings and infrastructure needed by the rest of our economy. As such, it plays a relevant role in the delivery of the EU's 'Europe 2020' goals for smart, sustainable and inclusive growth (European Commission DG Growth, 2016).

In the last decades, an increasing attention to the environmental issues is perceived by the sector and several initiatives for harmonizing the quantification and communication of the environmental performance of the constructions products have been launched, such as the Product Environmental Footprint, the EN 15804 or the Envision Protocol.

Goal

But how could these certifications and labelling schemes be effectively used by an organization? This paper presents an application of an Italian industrial group of advanced solutions to the civil, geotechnical and environmental construction markets.

Methods

Officine Maccaferri (OM) has recently obtained the Environmental Product Declarations (EPDs) for a wide range of product families, compliant with the EN 15804. It represents the first application of the EPDs in this specific sector, which is characterised by high variability of product characteristics due to their different use in the construction sector (retaining walls, hydraulic works, rockfall mitigation systems to soil reinforcement).

Results

The objective of the certification pathway was twofold:

- internal for monitoring the environmental hotspots in the manufacturing phase of their products and define medium terms reduction goals;
- external for a proper communication of the environmental performances of their products based on robust methodology (Life Cycle Assessment – LCA) and internationally recognized standards.

Regarding the first point, it should be noted that the supply chains of the analysed products are strongly connected and often overlapped. Moreover, OM has the direct control of several manufacturing phases of the supply chains which are performed in different manufacturing sites distributed worldwide. Therefore, the LCA study allowed a better harmonization of the production data managed both at production site level and at centralized level. Additionally, the EPDs will be integrated with the other company's environmental certification schemes for identifying targeted reduction strategies.

As the communication purpose, OM has clients belonging both to public and the private sectors. For the former, the EPD certification may represent a market leverage in particular in the countries more aware of the environmental issues as it is included within the award criteria for Green Public Procurement. For the latter, having an environmental certification on their products gives assurance that they are not only compliant with technical (mandatory) standards, but also pay attention to their environmental performance. This also allow to communicate to the stakeholders along the supply chain robust environmental information to be used as informative module as such or to be integrated with other ones to asses the environmental performances of wider construction works.

The main methodological issues related to the LCA studies will be discussed and presented in terms of the definition of the representative products and environmental hotspots. Moreover, the certification pathway will be presented towards company's sustainable strategy.

SESSION T4-4 LCM - Standards, Certification and Labelling Schemes

The transition from ILCD to Environmental Footprint - changes in nomenclature, LCIA and other parts of the Reference Package

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Joint Research Centre - European Commission

In 2013 (COM/2013/0196) has been established the Environmental Footprint (EF) scheme. Within this framework, the International reference Life Cycle Data system (ILCD) format, developed since 2007 by the European Commission, along with a simplified set of compliance rules called "ILCD Entry Level Requirements" has been adopted as a baseline compliance for data development in the EF scheme. However, during the different phases of development of the EF, few changes and adaptation occurred, particularly on the Life Cycle Impact assessment methods adopted, and therefore on the list of elementary flows (nomenclature) used in the EF scheme. Also some format, syntax and conceptual errors, have been fixed during the development of the EF reference packages released (so far the packages EF 2.0 and EF 3.0 have been publicly released).

Therefore, during the transition from ILCD to EF, several changes occurred in the package, this presentation will highlight the principles applied for the changes occurred in the reference packages (i.e. the packages released by the European Commission) released, form the latest version of the ILCD (August 2016) to the current version of the EF (December 2018). The presentation will explain the choices made for the changes in LCIA methods, as well as those occurred in other parts of the database (Elementary flows, flow properties, unit groups).

Among the above mentioned changes the overall amount of items modified, added or deleted from ILCD to EF can be summarized as following: 1583 obsolete or wrong elementary flows have been deleted, 53.775 new elementary flows have been created; around 63 K Characterisation factors are different, and around 50 K are new, 2298 flows have been mapped and further deleted, 134 flow properties and 34 unit groups have been erased. The impact assessment methods have been changed as well, in EF only mid-point methods are considered and among those 9 out of 16 are significantly changed, and the others have been adapted according to the changes occurred in the flow list. Among the impact categories, 4 of them have been also subdivided in sub-categories: Climate Change, Ecotoxicity, Human Toxicity Cancer and Human Toxicity non-cancer. Each of the method just mentioned, is divided in three sub-categories (fossil, land use change and biogenic, for Climate Change, and organic, inorganic and metals) plus the overall method file including all the characterization factors.

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SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

Mapping the Carbon footprint of the Norwegian Municipal Water and Wastewater Management Sector

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Asplan Viak

The Norwegian Water and Wastewater management sector is responsible for 11% of the carbon footprint of municipal services. Therefore, greenhouse gas emission management in the water and wastewater management sector, is an important aspect of environmental management of municipalities. In cooperation with Norwegian water treatment businesses, we have developed a tool to manage greenhouse gas emissions of the entire water cycle: abstraction, drinking water treatment, distribution, collection and wastewater management. Using life cycle inventories from research and the established life cycle database Ecoinvent, users can self-report data on their business, and identify the most important areas for improvement. Preliminary results from testing, show the importance of energy management, value chain management of bought treatment chemicals and the use of trenchless technologies in pipeline maintenance as important factors for reducing the carbon footprint of the municipal water sector.

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SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

Ten years of city-scale carbon footprinting in Norway

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Asplan Viak

Recent years have seen an increase in developing and implementing greenhouse gas (GHG) inventories to guide public and private companies in a more environmentally sustainable direction. The hybrid input-output model Klimakost has been used to estimate the carbon footprint of more than one hundred cities and municipalities in Norway for the past decade. The model combines the strengths of LCA and EE-IOA to cover all GHG contribution elements. In this way, the model provides detailed GHG inventories and enables local level climate budgeting and action-based climate plans for cities and municipalities. Here, we outline some of the key learnings from this work.

To provide the cities and municipalities with pertinent information regarding their carbon footprint, we have developed a 2x2 dimensional framework. The framework consists of two GHG inventories: one for direct emissions (scope 1) and one for indirect emissions (scope 2 and 3). By combining the two inventories into one inventory, it covers the provision of services at corporate level as well as the community as a whole. As such, the framework estimates the complete carbon footprint of cities and municipalities and it supplies with them with comprehensive information that can aid their GHG mitigation strategies.

By applying the outlined framework to more than one hundred cities and municipalities, we have made the following three key findings:

1) Combining several GHG inventories is required to cover both service provisions at the corporate level and community-scale GHG emissions. Our framework suggests distinguishing these inventories from one another to make them more applicable for efficient management of local climate action plans.

2) Introducing indirect GHG emissions using the carbon footprint perspective has been essential to highlight the importance of green procurement strategies. For service provisions, we find that the carbon footprint related to the purchase of goods and services (scope 3) on average contributes to about 80 percent of total GHG emissions.

3) Recently, we find that cities and municipalities are taking a more action-oriented role. Focus has shifted from strictly working on GHG inventories, to emphasizing more on climate budgeting and action plans for the future. As the inventories now also lay the foundation for future climate actions, their role and importance becomes more significant. Consequently, the GHG inventories require further improvements. In particular, EE-IOA has weaknesses in modeling changes in procurement patterns, and we rely on improvements and increased availability of LCA-based assessments at the product level.

SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

S-LCA application: suggestions for social business implementation

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The interconnection among the three sustainability pillars (people, planet and profit) has been underlined over the last time. Several studies and research refer the sustainability to the political and cultural dimension of societies. In the S-LCA context, it is possible to say that, a society is developing socially and economically within an environmentally conditioned context and this development is directed dependent by the strategical and political organization (Mazijn, 1994).

Among the activities of the joint research project between the Department of Business Studies and People Srl. with the aim of developing an innovative model to stakeholder's management based on participatory approach to improve and develop territorial networks, after a preliminary internal survey, the stakeholder categories and sub categories was defined in order to implement Social Life Cycle Assessment framework.

Social Life Cycle Assessment is a technique available to account for stories and inform systematically on impacts. May it help stakeholders to effectively and efficiently engage to improve social and socio-economic conditions of production and consumption (Unep, 2009).

People T&C is a consulting and training company based the core business in the values of social enterprise. The direct customers are all those who are interested in promoting organizational models based on cooperative culture and social responsibility.

This work aims to define the Stakeholder Categories and Sub-categories for the social business through a case study application in People T&C.

The results will be useful for the preparation of an effective business model and strategic business plan aimed at developing the company's core activities based on training and consulting services. After a literature review, a preliminary survey based of questionnaire to the internal stakeholders was constructed and conducted.

Before this analisys, a literature review was performed using the most well-known databases and considered the last five years.

A prolific stream of contributions was emerged, highlighting a wide heterogeneity and bringing out a multidisciplinary and multifaceted concept of Stakeholder Engagement (SE). SE is a process of seeking stakeholder views on their relationship with an organization in a way that may realistically expected to elicit them (ISEA 1999).

Stakeholder Analysis (SA) is a method used to facilitate organizational and policy reform processes by accounting for and incorporating the needs of those who have a 'stake' or an interest in the reforms under consideration.

Among the activities of the joint research project between the Department of Business Studies and People Srl. SE approach and SA to improve and develop territorial networks, after a preliminary internal survey, the stakeholder categories and sub categories was defined in order to implement Social Life Cycle Assessment framework.

The authors consider a first level to classify socio-economic impacts is by stakeholders' category. In particular they investigated if the socio-economic impact assessment strictly followed Guide Lines specifications, if the assessment concerned the entire life cycle and all the stakeholders' categories specific for this economic sector.

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SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

Pilot-study for the analysis of the environmental impacts of commodities traded in Switzerland

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Goals

Commodities such as metals, crude oil and products such as diesel or staple foods (e.g. coffee, wheat, etc.) are often traded by Swiss companies, without being physically transported to Switzerland. Like this, they are excluded from foreign trade statistics or input-output analyses. Associated environmental impacts have not been evaluated in former studies. A pilot-study closes this gap (Jungbluth & Meili 2018). It answers key questions for 15 selected commodities:

- What quantities are traded by Swiss companies?
- What are the environmental impacts caused by the extraction, production and transport of these commodities?
- Which countries of origin are relevant for the global production of these commodities?

Methodology

Information about the traded quantities was gathered from literature, statistics, online company reports and interviews with experts and documented in the study. Environmental impacts are analysed through a set of seven “footprint indicators”.

Results

Depending on the commodity, between 20 to 65% of global trade is traded by Swiss companies. Extraction, production and transport to market cause, per year, more than 4 quadrillion (4e15) ecological scarcity points. Commodities from the energy sector (e.g crude oil) have the highest relevance regarding mass traded, eco-points and kg CO2-eq. Most relevant are production in USA, Russia, Australia, Saudi Arabia, Brazil, Indonesia and China.

Environmental impacts caused by the production of commodities traded by Swiss companies are substantially higher than the direct environmental impacts of Swiss production and consumption. In any commercial transaction, in addition to the goods, the associated environmental impact changes hands from the seller to the buyer. Therefore, the trading sector has a direct connection to monitoring and maybe influencing large environmental impacts. If there were better steering measures for such trades, environmental impacts might be reduced. A first measure to get there would be to increase transparency on origin, production method and related environmental impacts for commodities traded globally.

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SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

Regional development, life cycle carbon impacts from different development scenarios

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Asplan Viak AS

Goal:

Planning and disposal of land and the establishment of infrastructure in regional development can have a major impact on greenhouse gas emissions. This applies both to the impact that occurs after the disposal and construction has taken place (energy use and transport) and during the rehabilitation and establishment of new buildings (materials and construction work).

In regional development, it is often uncertain what development (mix of housing, office, hotel, retail, and size and share of new construction / rehabilitation) that gives the lowest possible climate impact. The aim of this study is to investigate which mix of building type, size and new building / rehabilitation that gives the lowest possible climate impact when accounting emissions from material use, energy use and transport of users during operation.

The method is developed by using a regional development project in the city center of Oslo as an example. Four different options have been compared for the area:

Alternative 0, reference: Today's solution, 30 700 m2.

Alternative 1: Total: 67 700 m2.

Alternative 2: Total: 41 300 m2.

Alternative 3: Total: 38 700 m2

Method:

In order to compare a regional development with a reference development elsewhere, it is assumed in the reference that a new area is being built out elsewhere that fulfills the same function as the alternative that gives the highest land utilization. This means that for alternatives with lower land utilization (alternative 2 and 3), the calculations will include development both at the area that is analysed, and outside the area that Is analysed. This assures that the same functional unit is used for all alternatives.

For most types of building types, the function is assumed to scale with area, ie 1000 m2 hotel in Oslo city center corresponds to 1000 m2 hotel built "an average place" in Oslo. The exception for this scaling is the area for dwellings. When building dwellings in the center of Oslo this will only be apartments, while alternative development in the reference will be a mix of types of dwelling (40% apartments, 24% townhouses and 36% detached houses). Area per person varies with the different housing types. The method also allows for the possibility of correcting land use for office space as development in urban areas can provide more area efficiency (eg by not building canteen, greater use of office landscapes).

Results:

Alternative 1 has the largest reduction by approx. 79 000 tonnes of CO2 equivalents savings (reduced energy consumption in operation and reduced transport and material emissions). The same distribution is achieved for alternative 2, but with somewhat lower total savings (about 50,000 tonnes CO2 eq.). Alternative 3 results in a reduction of approx. 42,000 tons of CO2 eq.

The study shows that comprehensive assessment of greenhouse gas emissions in regional development will provide important input to urban planning. The method was developed for a development in the center of Oslo, but the methodology and correction of areas and reference will be valid for urban development and regional development in general.

SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

Strategies for successful promotion of EPD in Brazil

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Goal Environmental Product Declaration (EPD) is a relevant tool for environmental data transparency that has been gaining importance, particularly in developed countries. In this sense, it is essential that emerging economy countries, such as Brazil, anticipate the development of international environmental standards and labels that could become barriers to trade for producers [1, 2, 3]. There is considerable intersection between the most exported Brazilian products to the EU in terms of monetary value [4] and the list of products submitted to the pilot phase of the PEF. Those products are coffee (PEF pilot discontinued), pipes, metal sheets, intermediate paper products and soy products (mainly livestock feed), which represented 37% of Brazilian exports to the EU in 2016. Therefore, it is crucial for Brazil to anticipate and build strategies for attending the demand for EPD or EPD-like information.

Methods An analysis of the strengths, weaknesses, opportunities and threats (SWOT) was elaborated based on interviews with EPD stakeholders in the country. This analysis followed five steps: design of an open script to capture stakeholders' perceptions during interview; stakeholder mapping and selection; script application with 15 interviewees from non-governmental organizations (UN Environment, Brazilian Life Cycle Association, Brazilian Business LCA Network), exporting companies, industrial associations (Brazilian National Confederation of Industry and one state association), government representatives (IBICT, Ministry of Development, Industry and Commerce, and Ministry of Planning), a technical consulting firm, labelling programs operators (INMETRO, Vanzolini Foundation and ABNT) and one scholar; data analysis using the technique of Content Analysis [5]; SWOT matrix elaboration. Considering the principle of connecting strengths and opportunities, compensating for weaknesses and neutralizing threats the strategies for successfully promoting EPD in Brazil were built.

Results The results of this work were presented in [6]. The SWOT analysis showed that, even though there is a long path to follow in terms of understanding of EPD and consolidation of technological structures, Brazil has the foundations for this environmental label to be stimulated and promoted in strategic sectors, namely civil construction, paper and pulp, coffee, soy and livestock. Promotion strategies should focus on sensitizing and engaging different stakeholders through an awareness program about different types of environmental labelling, their relevance in global markets, their different purposes and uses. It also should prioritize the enhancement of technical capacity within the country by generating life cycle primary data for Brazilian products. EPD programs should be strengthen to boost the Brazilian internal market and Product Category Rules development. These strategies aim at the promotion of good practices in the environmental and transparency agendas within Brazil's business sector, allowing comparative environmental advantages to be converted into competitiveness. Brazilian institutions should be encourage to follow international discussions on EPD and internalize them, fostering sustainable production and consumption.

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SESSION T4-5 Life Cycle Approaches to Sustainable Regional Development

Two years of LCI Data Collation in South Africa: Overview and Insights

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Introduction / Goal: As part of the Sustainable Recycling Industries project, ecoinvent supported the building of LCA expertise and a critical core of LCI data (industrial, agricultural and other sectors) for newly industrialised countries (Latin America, Egypt, India and South Africa) in 2016-2018. The lack of regionalized data has been recognized as a major knowledge gap for globally traded commodities. We provide an overview of what was achieved for South Africa, and share some insights.

Methods: Sector-specific data collection and modelling were done by 5 teams, of which 4 were largely or wholly South African, and peer-reviewed by international experts with prior expertise in populating a leading global life cycle database. All LCI data collection projects underwent three main phases: data collection and modelling, datasets generation in EcoEditor, and dataset submission and review. Country-specific product LCI work was complemented by updates to global LCI service data sets, such as waste management, water infrastructure, agricultural irrigation, and rail freight transport.

The development of activity LCI datasets involved the collection and generation of relevant input-output data for the production stages of key commodities. Data that accurately describes production stages were obtained from different sources, mainly Company Operational and Sustainability reports, Commercial Budget Enterprises, reports of industry associations, National Reports, Censuses and statistics, focusing on biggest producers in the specific sector. Personal communications with industry experts and their interpretation of relevant literature were also used. Data often differed in formats and represents different aspects of the production stage of interest to a company. The following steps were taken in modelling LCI datasets to ensure that the data are reliable and representative of the specific sector production process:

- Harmonizing raw data in to a single figure that accurately describes the exchanges and flows;
- Estimating statistical uncertainty associated with the average single figure by selecting an appropriate statistical distribution to describe the data;
- Recording representativeness/completeness and sampling/extrapolation procedures as well as technology level, geographical and temporal resolution in the Pedigree Matrix;
- Dataset mass balancing and validation by using mandatory properties for each exchange/flow.

Results: The South African leg of the SRI-LCI project generated some 50 production and 20 market datasets, capturing estimated national average economic and environmental flows per unit of production across five key sectors: electricity, synthetic fuels, cement & concrete, precious and scarce metals and agriculture. Further, some global LCI service data sets were also updated.

A first screening of the LCIA results confirms that ‘made in ZA’ has high carbon footprints by international comparison. We argue that the new data availability should not be used to exclude South African products from the international market, but rather as a baseline against which the speed of the nationally agreed-to transition to a low-carbon economy can be measured over the coming decades.

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SESSION T4-6 Indicators and Communication in LCM

The life cycle sustainability indicators for electricity generation in Chile: challenges in the use of primary information

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The need to get an appropriate quantification of the sustainability indicators involves the use of site-specific information. This information comes from several sources and sometimes is barely systematized and highly heterogonous, being its quality and consistency a matter of concern. Due to the increasing environmental, economic and social requirements, more data are available to model the potential impacts profile. In particular, the power plants of electricity generation in Chile reports continuously their air and water emissions, as well as the hazardous waste generated from their process. Nevertheless, the results could be a source of more questions about the data quality, such the traceability, the methodological approach to measure mass fluxes, the awareness of the reporter on the importance of his/her duty, among others. In the same way, the economic profile is well-known data for experts and investors, but not always are open and available for researchers. The social indicators are still under development and the data is usually scattered. The aim of this work is to contribute to the discussion about the use of primary information reported directly from electricity generation power plants, used to build a set of eight environmental, four economic and seven social indicators, following a life cycle approach applied to 9 electricity generation technologies; coal, diesel, natural gas, biomass, wind, solar photovoltaics (PV), run of river, reservoir and geothermal in Chile. The temporal coverage includes ten years, using specific data for 2005, 2009 and 2015. The results show that the environmental indicators have the most important differences with results reported in the literature, reaching one parameter with 147-fold in one technology. The nature of these differences are diverse due to the complexity of each natural system assessed as well as the specific operational conditions. Nonetheless, is interesting notice that this type of analysis could be a source of feedback for policy-makers in order to improve the current environmental system reports. In the same sense, the results for economic indicators are closer to the literature, although the data are not systematized and desegregated by lifecycle stage. The social indicators are very specific showing an interesting profile of the national electricity generation conditions. Finally, these results are an accurate and supported critical review of the current data report system and the challenges to be tackled in the pathway to reach a sustainable electricity sector in Chile.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices

Assessing the sustainability effects of sharing sport equipment – A study of a Swedish shared service model

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Circular economy and sharing economy are two concepts that have received more attention in recent years and are seen as steps towards more sustainable development. An example of how the concepts are implemented in practice is the Swedish “Fritidsbanken”, the Leisure Bank. Leisure banks are like libraries, where people can borrow used sport and outdoor equipment, such as skis, inline skates, life jackets and much more. The concept enables increased utilization of existing resources, stimulates sharing before consumption and prolongs the life of equipment through repair and reuse. These aspects make leisure banks a shared service model that can stimulate a shift to sustainable lifestyles. The expectations of beneficial effects on the environment, health and economy are many, but there are also concerns that hinder investment in leisure banks and the risk that they do not lead to expected benefits if important aspects are not considered. The goal of this study is therefore to evaluate and clarify which benefits the leisure banks generate and what success factors the effects depend on. The evaluation and clarification could further stimulate the development and construction of well-functioning leisure banks as means of sustainable lifestyles and increased circularity.

Methods will be based on interviews, questionnaires, existing leisure bank statistics, and available data and indicators on sustainability effects. Five leisure banks, with differing organizational structure and maturity level, act as main case studies, while 75 others will be included by a questionnaire. Statistics on loans will be collected and personnel will be interviewed on matters such as collaboration and communication with stakeholders. Individuals utilizing the leisure banks will also be interviewed on their perspective. The data gathered, in addition to life cycle data on environmental, social and economic effects, will be used to evaluate the sharing service. Assumptions and methodological choices will be designed along the way, as available documented experiences of, and methods for, evaluating shared business models are still scarce.

The expected result consists of a list and evaluation of the social, environmental and economic impacts that the leisure banks have the potential to contribute to for a municipality. This knowledge will be further processed into guidance for municipalities on which elements a leisure bank requires for successful implementation. The aim is thereby to assure the quality of the concept and eliminate obstacles to expansion. Ultimately, the project is expected to generate increased knowledge of opportunities for municipalities to contribute to a change in behavior that drives sustainable lifestyles and a circular economy.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices

Carbon theatre in public spaces – using participatory and co-design methods in a museum for shaping low carbon lifestyles

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Over the past ten years, the need for public spaces to deal with burning societal issues, such as climate

change, has become even more important. Participatory theatre offers ways to meet the longing for shared forums by engaging large groups of people in exploring difficult social dilemmas. It can potentially empower participants to change their own situations and organizations. In a previous design research project Quantifying your carbon footprint, this gap was in focus. We will use the findings from the Quantifying carbon footprint project as an entry point and expand it with Life Cycle Assessment (LCA) on objects from the current museum collection and on daily life activities that have a carbon impact.

The goal of the project is to explore and understand the climate and environmental impacts of lifestyles. The method used here are participatory theatre and co-design methods and pop-up exhibitions are used to engage young citizens in negotiating social norms and understanding their possible impact on CO2 emissions. The museum collections play a crucial role in the process of understanding how LCA calculations are related to mundane objects and reflecting on the temporality of social norms that are negotiated and re-negotiated through the way we handle products and objects in our everyday life. Developing new practices for museums involving participatory methods in order to engage young citizens in climate research.

The results of the introductory meeting and study visit show that using the museum’s collection, the history and the value of things in the past centuries become clear and easier to reflect on compared to today’s unsustainable lifestyle – travelling and over consumption. Carbon Dioxide Theatre is an attempt to shape a shared space on a local level, in line with the priorities of the museum’s three years plan.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices

Comparative environmental impact analysis of laundry activities in Japan and Thailand: potential of sharing laundry machines for sustainability

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The object of this study is to explore the environmental impact of sharing the laundry machine considering consumer behaviors in the context of the Japanese and Thai socio-cultural system. The current consumption behaviors are required to become more environmentally sound and socially acceptable to respond to the challenges of the sustainable development. In particular, consumption behavior based on the concept of sharing economy are widely considered as one environmentally effective way that also meets the need of consumers. Despite sharing has a potential to depart from the framework of mass production by dividing the use of products between consumers, the question whether the consumption behavior by sharing can contribute to the decrease of the environmental burden such as Greenhouse Gas (GHG) emissions is still remaining. Moreover, environmental impact and potential of sharing in different countries need to be addressed as well. In order to answer these questions, laundry machine which is regarded as one of the important products to identify the patterns of consumption by country is selected as a research target. Japan and Thailand were selected as research areas because there are different stages of economic development and related consumption behaviors such as ownership of household appliances even though they belong to the same Asian area.

As a method of this study, firstly, questionnaire surveys were conducted on the residents who wash their clothes by themselves in two countries. Secondly, respondents were divided into five groups according to the frequency of laundromat use and the possessions of laundry machines: Home washing only group, Infrequently laundromat using group, Frequently laundromat using group, Exclusive laundromat using group while owing laundry machine, and Only laundromat using group without owing laundry machine. Thirdly, characteristics related to the laundry behavior and the use of laundry machines were compared among the groups, and finally GHG emissions were estimated from the perspective of product of Life Cycle Assessment (LCA).

As a result, there are different types of laundromats in two countries. laundromats in Japan generally have large sized (top loading) washers and dryers, laundromats in Thailand commonly have household style (top loading) washers without dryer. In addition, Japanese laundromat users usually use both washer and dryer at the same time, whereas Thai laundromat users often use only washer and dryer is rarely used in everyday life. These differences, such as the use of dryer, the capacity of machine, and ownership of machines, between the countries diversify the energy consumption and it eventually links to the increase or decrease the GHG emissions.

We can then introduce appropriate policy contexts towards sustainable consumption and production in order to support the development of new approaches to consumers having many different patterns of consumption. Comparative research to get an in-depth understanding and possibility for the sustainable laundry behaviors in two countries will be also conducted as a future task.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices

Life cycle assessment of pets

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Goals

Pets are an important leisure activity in industrialised countries. The question arises whether this development is relevant for a sustainable lifestyle from an environmental point of view. For the first time a life cycle assessment study was carried out to examine the environmental impact of Swiss pet ownership. The present study, which was carried out as part of an internship, examined six animal species frequently kept in Switzerland: horses, dogs, cats, rabbits, ornamental birds, and ornamental fishes. Aim was, to analyse the life cycle assessment of these often-kept pets, to compare them with each other, make suggestions for improvements and link the results to the Swiss consumption.

Methods

All relevant influences on the environment are recorded in the data collection. This includes feeding, housing, faeces, car journeys and other purchases related to the pet. The relevant environmental impacts were assessed using two methods: the method of ecological scarcity (eco-points) and the global warming potential. For the analysis the program SimaPro was used.

Result

It was found that the impact increases with the size of the pet (and thus the feed requirement). The larger and heavier the animal, the higher the environmental impact. Other aspects, such as housing, can vary largely depending on the species.

The study shows that specific decisions regarding the keeping of a pet can have a significant influence on the environmental impact. A key factor here is the feeding of the pet.

The average Swiss consumption of products (food, textiles, equipment, etc.) and services (travel, events, public utilities, etc.) is a burden on the environment. The keeping of an animal can have a relevant influence on this individually caused environmental pollution, especially in the case of large animals such as horses. Compared to the average consumption of a person living in Switzerland, the keeping of a horse accounts for more than one third of these environmental impacts. The proportion of a dog is one twentieth, smaller animals increase the pollution by three percent or less.

However, with a view to Switzerland as a whole, the keeping of pets is of secondary importance. It accounts only for about 1.2% of the total environmental pollution caused by the Swiss consumption.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices

Impacts of income changes on the consumption of resources

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During the past three decades, the net income of German households has increased steadily and enabled household members to consume more goods and services. The consumption of goods and services however, has a direct influence on the use of resources as well as associated environmental impacts such as depletion of abiotic resources, ecotoxicity, global warming, acidification, eutrophication and others which for long have been approximated by LCA. The link between consumption of goods and services on the one hand and use of resources and environmental impacts on the other hand is widely accepted. Still, it has not been addressed on a larger scale under use of LCA for assessing implications for resource consumption on a national level in Germany.

Therefore, a research project in Germany has investigated the link between net household income and the consumption of resources under use of LCA and under consideration of socio-demographic variables such as age, place of residency as well as lifestyle to issue policy recommendations.

Statistical consumption data from an ad-hoc survey by the German Society for Consumer Research (GfK) was subjected to a cross-sectional analysis to analyse consumption patterns along different income groups. To assess the significance of the observed changes in consumption and to establish statistically significant links, between consumption and change in income, multiple regression analysis as well as other statistical methods were applied. Based on the findings, LCA studies were conducted for specific fields of consumption to approximate the corresponding environmental impacts.

The study showed a positive correlation between net household income and the use of different resources no matter how high the income increase was. For all income groups, the observed changes in consumption were positive. In most cases, the observed correlations were linear (in some cases exponential). The highest increases in consumption was observed for car use, aviation and cruises (transportation). Households with a high income consume less resources per money spent although this is set off by a higher total consumption. No correlation was observed for net household income and consumption of organic food (including meat). The authors of the study conclude that income is the main driver of resource use (more than other socio-demographic variables). No decoupling has been observed for any of the income groups: If the income increases, the resource consumption grows. The level of education induced a high resource consumption through mobility.

SESSION T4-7 Designing Sustainable Lifestyles - from Societal Structure to Personal Choices

Perception of Sustainable Development Goals in function of age, gender, place of residence and previous experience

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Goal

With the adoption of the Sustainable Development Agenda and its 17 Sustainable Development Goals (SDGs), the need and importance of education and promotion of the actions of all generations to achieve sustainable development goals increases.

SDGs are innovative tools for global sustainable development governance. SDGs have been developed in a process of deliberative participation, in which the approach of managing through objectives has been adopted.

The aim of the article is to present the results of research of the SDGs Oriented Action project,

which gained knowledge about the activities undertaken in order to implement SDGs for different generations, from students (under 25 years of age) to their parents or grandparents' generation.

Methods

As part of the survey, a full questionnaire survey was conducted among students of the Faculty of Management of the University of Warsaw in Poland and students of the Centre Européen Universitaire, Université de Lorraine in France and members of their families.

Results

The majority of respondents declared ignorance of sustainable development goals but expressed the opinion that it is possible to achieve them. In their opinion, changes in institutions in which they work/study do not contribute to improving the situation in SDGs implementation. Respondents most often pointed to positive connotations with sustainable development: saving resources for future generations, common cause, building awareness. The study revealed a cause and effect relationship between knowledge about sustainable development and the actions taken. Respondents who have knowledge about sustainable development are more likely to show resource-efficient behaviour (money, water, energy, etc.). Respondents more often perceive that they and their families live in a sustainable way than declare that the municipality or country in which they live, the world develops in a sustainable way. The results of the study show that actions concerning sustainable development are not conditioned by geography, generation, education, gender. Respondents who were confronted with resource-saving campaigns declared a change in their approach to saving resources.

SESSION T5-1 Strengthen LCM by Blending Approaches

Sustainable Guar: an integrated approach of E-LCA and S-LCA

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Solvay SA

Sustainable Guar Initiative (SGI) is a three-year long integrated program aiming at developing sustainable guar production within the Bikaner district in Rajasthan, India. This desert district is one of the larger producer of guar in India. SGI was set up by Solvay, L'Oréal, HiChem and TechnoServe (NGO), and is based on 4 themes:

- Agronomy: enhancing sustainable practices for rain-fed guar production
- Environment: groundwater-neutral approaches and best practices in guar farming, along with tree plantation
- Social impact: gender approaches, nutrition, health & hygiene
- Market improvement: traceability, supply chain and market access

Guar gum is extracted from guar seed and can be used as such, or functionalized. It is for example used as a bio-based thickening agent in personal care products.

To confirm and consolidate the relevance of the program and to identify potential opportunities for improvement, both environmental and social Life Cycle Assessment (LCA) have been conducted, comparing the guar bean production before and after SGI.

Social LCA has been conducted following already available guidance from different sources, including UNEP-SETAC Guidelines for Social Life Cycle Assessment of Products, Roundtable for Products Social Metrics and WBCSD Social Life Cycle Metrics for Chemical Products. Methodological developments have furthermore been undertaken in order to fully take into account the smallholders, for instance,

- Goal and scope: Better identification of relevant stakeholders and social aspects
- Inventory: improvement of data quality among the social aspects, stakeholders or life cycle steps
- Performance assessment: Common rating system enabling aggregation related to inventory from multiple sources

The environmental LCA shows that even in arid conditions and by using new agricultural practices such as the one developed for SGI, the benefit in terms of Guar culture yield enhancement compensates the environmental burdens due to the higher use of mechanization for land preparation.

This combined approach of the Guar culture, as well as the control of supply chain by a block chain technology, strengthens the sustainability strategy of industries and ensure traceability up to the delivery of the final product to the customers.

We expect an oral presentation of these results during LCM2019, with details of both Social and Environmental LCA followed by a Q&A session.

SESSION T5-1 Strengthen LCM by Blending Approaches

Enhancing Life Cycle Management through the symbiotic use of Data Envelopment Analysis: novel advances in LCA + DEA

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IMDEA Energy

Goal:

It is generally acknowledged that life cycle approaches could benefit from the combined use of other non-life cycle approaches in order to enrich decision-making processes. In particular, a growing interest is found in the scientific literature regarding the joint application of Life Cycle Assessment (LCA) and Data Envelopment Analysis (DEA) when assessing multiple similar entities. In this regard, the symbiotic use of DEA –a linear programming methodology to calculate the relative efficiency of multiple resembling entities– leads to enhance multi-criteria decision analysis by strengthening the capabilities of LCA for the operational and environmental management of entities. The goal of this work is to review the state-of-the-art in the growing field of LCA + DEA, as well as to present a number of novel advances in this field which are expected to boost its applicability for enhanced life cycle management.

Methods:

In particular, this work focuses on the potentials behind the implementation of specific DEA models that had never been used before in LCA + DEA studies. These unexplored DEA models include the SBM-max model for the gradual operational and environmental benchmarking of entities in terms of continuous improvement, and the use of static and dynamic network models to enhance the system perspective in the benchmarking process. Furthermore, as an additional novelty, these LCA + DEA methods are applied to entities within the tertiary (service) sector, an unexploited field of application (in contrast to the primary and energy sectors, which concentrate most of the LCA + DEA studies to date).

Results and conclusions:

The results show the feasibility of the proposed LCA + DEA methods. In particular, the application of these methods to a case study of 30 groceries in Spain allowed to (i) set gradual operational (electricity, plastic bags, paper, and waste), environmental (carbon and energy footprints) and socio-economic (labour and economic savings) benchmarks for each grocery, and (ii) extend the (eco)efficiency assessment to additional divisions such as distribution before/after each grocery, with or without a period-oriented approach. Overall, these advances in LCA + DEA lead to increase the interest in this growing field of research, with still a high number of potentials to be unveiled.

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SESSION T5-1 Strengthen LCM by Blending Approaches

Carbon footprint as a first step towards LCA usage

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Companies are still basing its economic development in the extraction and consumption of natural resources, in order to reduce this intensive and inefficient use of resources and especially the negative impacts on the environment, some initiatives have emerged in different areas. Life Cycle Assessment (LCA) by pointing out the critical steps, from the point of view of the use of natural resources and generation of impacts, has been one of the most accepted and used methodologies. LCA effective development and use also refers to the need for implementation of the life cycle thinking approach in organizations, even if this approach initially is not for the implementation of a more complex method as LCA itself. Despite this fact, there are countries where the LCA is not yet fully implemented and its use is still limited to only few companies. On the other hand, there is another approach, the carbon footprint (CF), that when based on ISO 14067 follows the same life cycle approach patterns considering the phases and steps followed when implementing the LCA. In this sense, this study proposes the carbon footprint use as an introductory methodology of the life cycle thinking in companies at countries where LCA is still not effectively in use, seeking in this way to bring the life cycle practice and approach to these companies. The proposal is conducted through a bibliographic study that clarifies the relationship between the existing methodologies and a field research that has been released through the Life Cycle Initiative website, where 106 LCA specialists from 33 different countries took part and 88,6% of them approved the proposal. To summarize, this article point out that: (i) Carbon footprint and LCA assess environmental impacts during the life cycle of products/services, the first is based on a mono category assessment (only those related to climate change) and the second with a broader approach (multi-category based), both pointing impacts not only during the production process but also during extraction of inputs, use and end of use of products and (ii) Carbon footprint can be a first step on implementing LCA in companies. The findings point to a possibility of considering the use of the carbon footprint as a first stage in the implementation of the LCA, considering that with the use of CF the companies will come to know and use the principles of life cycle thinking, thus facilitating the understanding and the implementation of LCA.

SESSION T5-1 Strengthen LCM by Blending Approaches

Methodology for the suitable identification of technical, economic, environmental, and social indicators for the holistic evaluation of a Banana/plantain fiber Biocomposite material

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Goal: Sustainability has become a strategic imperative for organizations, governments and companies concerned about long-term global development. However, among the different methodologies, there is no consensus on which approach to follow for evaluating it. After a systematic review to identify the current challenges of sustainability assessment tools, the most mentioned unsolved problems are the need of generate appropriate and regional indicators, quantitative and practical indicators for social dimension, systemic approaches, and the stakeholder's inclusion. This work explores two critical research areas and knowledge gaps relevant to biocomposite material (BM) sustainability in Colombia: First, the identification of suitable technical, economic, environmental, and social indicators. Second, the design of a quantitative methodology based on life cycle sustainability assessment and life cycle engineering. The main objective was to provide a methodology to researchers, materials developers and companies for the evaluation during the design, selection and continuous evaluation of materials, biocomposites and natural fibers to qualify them as sustainable.

Methods: Most accounting frameworks measure sustainability according triple bottom line (TBL). However, TBL is considered too limited, because the key indicators have synergistic effects throughout all three dimensions, therefore they cannot be separately analyzed. Recently, the sustainable design path has been extended to a quadruple bottom line (QBL) approach that includes the four pillars of sustainability: economic, environmental, social and technical.

Fig. 1 present the general proposed methodology that follows the procedure defined for Life Cycle Assessment (LCA) in ISO standards 14040/44. The goal, scope and functional unit definition remain the same for all dimensions, however, certain parts may fall under cut-off criteria regarding some sustainability aspects (1). The definition of quantitative indicators of every dimension were based on the literature, international and national regulations, requirements/perspectives of stakeholders and similar materials. They cover all relevant issues related to the analyzed system (2) and define the quantitative indicators which comprise country, sector, and company data as well (3).

Technical dimension refers mainly to the BM properties. Economic dimension was based on Life Cycle Cost, indicator categories related strictly to direct costs experienced by one or more actors in the product life cycle, narrowly referring just to real money flows.

Results: Fig. 1. Methodology for the suitable identification of QBL indicators for the evaluation of a Banana/plantain fiber Biocomposite.

Environmental dimension from LCA, and the inventory data were modelled using the literature sources from BM assessments, specifically in Colombian cases, primary information and Ecoinvent database. Finally Social dimension was based Social Life Cycle Assessment, UNEP/SETAC (4) and GreenDelta group guidelines (5).

The integration of the QBL used previous methods of Life Cycle Sustainability Assessment and Life Cycle Engineering, both based on Multicriteria Decision Making and communication tools like Life Cycle Sustainability Triangle- and Life Cycle Sustainability Dashboard (6) (7). The combination of both approaches provides a more holistic perspective. Moreover, these methodologies can also identify the tradeoffs between impacts process of life cycle and/or dimensions, which is essential to integrate into a decision-making process for designing, selecting and evaluating sustainable BM materials.

SESSION T5-1 Strengthen LCM by Blending Approaches

LCA based decision support tool for sustainable procurement of materials

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Sustainable development is an underlying objective for most of the developed countries and a key consideration in developing countries like India alongside the economic growth. Life cycle thinking facilitates the much needed integrated approach linking consumption, production, resource depletion, resource use, resource recycling, environmental impacts, waste generation and social impact. As a component of life cycle thinking, social life cycle assessment (S-LCA) and environmental life cycle assessment (E-LCA) are useful tools for evaluating impacts of product systems across the value chain. However, with respect to activities like procurement of direct and indirect materials, assessment of geography based risks and impacts can yield better insights. Therefore, there is a need for development of a tool to help guide the selection of environmentally and socially favoured geographical location for procurement of direct and indirect materials.

A multivariate analysis has been conducted at pilot scale, adopting aggregation approach for identifying the most sustainable geographical location for procurement of raw material, for an optical fibre manufacturing industry. Proposed approach considers environmental as well as socio-economic impacts occurring across the life cycle stages, assigning appropriate weightage to each impact indicator as well as the life cycle stage. E-LCA for raw materials has been carried out to quantify the impact indicators considering all life cycle stages from extraction to manufacturing including transportation to customer gate. Normalization approach with the help of state specific endpoint indicators such as water quality index, health index, air quality index etc. has been used to obtain geography specific values.

S-LCA approach has been adopted for determination of social hotspots across the value chain while also capturing social and regional perspective. Evaluation of socio-economic parameters has been conducted using region-specific endpoint indicators such as income index, human rights complaints, child labour risk, etc. An inclusive approach based on stakeholder engagement and interactions with key stakeholder groups has been proposed. Based on the aggregation of obtained results from S-LCA and E-LCA, geographical locations have been prioritised to determine suitable locations for procurement of various raw materials from environment and socio-economic perspective.

Environmental and social conditions of any region provide reasonable perspective on the prevalent issues. Management of such issues is greatly impacted, positively as well as negatively, by regional industrial activity. Procurement decisions to source from specific regions can improve or degrade the conditions in vicinity. Evaluating environmental and social impacts across the life cycle stages for different raw materials has provided deeper insights on the hotspots and highlighted specific environmental and socio-economic challenges. These need to be factored in the decision-making process while evaluating suppliers for direct and indirect materials based in different geographical locations.

An attempt has been made to develop a decision-support tool adopting life cycle management principles for sustainably sourcing materials. Robustness and accuracy of the results can be enhanced by sourcing granular data and extending coverage of endpoint indicators.

SESSION T5-1 Strengthen LCM by Blending Approaches

Coupling cause-effect urban dynamics with consequential life cycle assessments

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Goal: The objective of this research is to develop an integrated consequential life cycle assessment (LCA) tool based on system dynamics (SD) modelling.

Method: Consequential LCA (CLCA) models the responses of a product system related to the change in demand. In this sense, the CLCA scope is to understand the cause-effect relationships within a product system. However, CLCA is a linear approach and does not include any dynamic feedbacks. Outside the LCA domain, the approach of system dynamics (SD) modelling uses a network of feedback loops between elements of a system, which can be used to show how the consequences of a change to one part of a product system can affect related parts of the product system. Our hypothesis is that it is possible to combine SD and CLCA to provide predictive LCA models based on feeding life cycle inventory data from SD model results. Such an integrated modelling approach can be calibrated and validated using historical inventory data to provide predictive impact assessments.

We demonstrate this model advancement with a case study of an environmentally harmful product commonly used by citizens, i.e. polyethylene terephthalate (PET) cup production and consumption system in the city of Lisbon (Portugal). To broaden the system boundary to include marginal supply chains affected by the demand variation, replacement and usage dimensions typical of the CLCA approach, we consider the PET products as an urban metabolic flow. The functional unit is a single-use plastic (PET) cup and we limit the scope to three impact categories: to simplify the example marine aquatic eco-toxicity potential (MAETP) potentially disappeared fraction of species, and productive land use changes. Several reinforcing and balancing cause-effect feedback loops were identified in the product system including the induced marginal demand of paper cups, re-usable plastic cups, and non-disposable cups. This cause-effect impact assessment was compared to the traditional consequential life cycle impact assessment.

Results: Preliminary marine eco-toxicity results show that the cause-effect dynamics reveal interesting and non-trivial differences when compared to the traditional CLCA impact assessment. The SD-CLCA model is able to capture the non-linear effects for the urban metabolism context of replacing PET with paper cups, which are beneficial for reducing the fossil resource depletion and MAETP impacts, but detrimental for the loss of biodiversity in peri-urban areas. Interestingly, these trade-offs are non-linear, meaning that the more PET cups are replaced with paper cups and or recycled, the less negative impacts are recorded but not at the same peace of the positive ones. These patterns could not be observed in the traditional CLCA, where the trade-offs were linearly opposite: the less production and use of PET, the more benefits in terms of eco-toxicity potential and fossil fuel depletion and the more impacts on species loss.

SESSION T5-1 Strengthen LCM by Blending Approaches

New method for energy allocation

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Eastman

Goals

Eastman is a global specialty chemical company and is committed to creating significantly more value in the world than the resources it uses. This presentation will cover a major shift in our internal LCA methodology and will highlight some of the complexity and choices that arise at a large, integrated facility.

Methods

For around a decade, Eastman has had a team dedicated to life cycle assessments (LCA) and has developed attributional LCAs for around ¾ of the products and product families it manufactures. Eastman generates its own electricity and steam at the largest manufacturing site in Kingsport, TN. Currently the largest on-site powerplant is undergoing a major retrofit to switch from coal to natural gas. In order to capture the value of the investment in natural gas, the LCA for our utilities will differentiate between power from natural gas and coal. This new methodology allows for allocation of steam and electricity to different streams rather than being tied to an average site grid mix.

Results

Such a virtual subdivision potentially enables a stronger business case for increased investment in low-carbon technology, but it represents a deviation from traditional grid-mix approaches to public utility power generation. The presentation will detail the choices and methodology changes as well as potential ambiguity in accepted LCA standards and Eastman’s path toward implementing these changes into various internal tracking systems.

SESSION T5-1 Strengthen LCM by Blending Approaches

Social Cost of Carbon Using a Global Scale Life Cycle Impact Assessment Method

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Social Cost of Carbon (SCC) is a metric of the marginal damage from the change in climate that results from an extra tonne of carbon (IPCC WG3 AR5). SCC is also interpreted as a benefit of society from the decrease of 1 tonne of emission of carbon dioxide. Because of its potential use in formulating climate or energy regulatory policy, governments have commissioned estimates of SCC. Since early 2000s, an SCC value has been used in policy analysis and regulatory impact assessment UK and US government (Clarkson and Deyes, 2002, US Interagency Working Group, 2013). The values of SCC differ from the present ($1 to $7) and the past administration (roughly $50). That change will affects the decision making of government how many projects for mitigating the climate changes would be adopted. A standardized range of SCC values is based on simulations with IAM models such as DICE, FUND, and PAGE. But there are some of discussion to improve the quality of SCC.

We can raise the following two points to improve the quality of SCC when we use a method of LCIA.

- Application of damage assessment based on the knowledge of natural science
- Utilization of economic evaluation which convert physical damage to monetary value

LIME3, one of the most advanced method for life cycle impact assessment was developed under the financial support of cabinet office of Japanese government. This method involves damage assessment and weighting among the four types of endpoint; human health, social asset, biodiversity and primary production. Country specific damage factors have been developed for 9 types of impact categories. Weighting factors for G20 countries have been created based on the responses of questionnaire for 6,000 responses.

The result of SCC based on the framework of LIME3 is 40 – 80 US$/1ton of CO2. Damages on biodiversity and human health were involved for the evaluation of SCC. This amount is close to the SCC adopted by the administration of the former president in US. This result can be applied to cost benefit analysis for the selection of mitigation technique for climate change. In this presentation, we will introduce the details of methodology and discussions with a comparison among the existing literatures.

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SESSION T5-1 Strengthen LCM by Blending Approaches

Enabling sustainability assessment in the early stages of product design by using model-based systems engineering (MBSE)

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70% of a product´s costs are determined in the early stages of product design [1]. The same is true for the product´s environmental implications [2]. Thus, the sustainability of a product should be considered in early design stages in order to enable designing sustainable products.

Life cycle assessment (LCA) in varying degrees of detail is the most prevalent form of sustainability consideration [3]. Usually, it is carried out after all design decisions are made. Integrating LCA into the early design stages is hindered by two key problems: the time requirement of the process as well as the availability of product specifications.

Early availability of specifications could be attained by incorporating a model-based design approach. By modelling the product´s specifications based on the underlying requirements through formulae and elementary functions, their dependencies on the requirements are available in the early stages of development. The more product specifications are set, the more precise the assessment becomes, detailing along the design process. Extending the product model by modelling its life cycle enables the implementation of LCA in product development. Thus, design decisions can be supported throughout the product development process. At early concept design stages, the sustainability performance of the product can be estimated to support fundamental decisions.

Once implemented and linked to the relevant specifications of a product version, the speed of this model-based LCA is only limited by computing power. Compared to traditional LCA, the first setup of a product assessment model is more resource-intensive whereas there is no need for further adaptation of the model thereafter. Thus, the sustainability of a multitude of different product versions can be estimated rapidly. Especially if a generic LCA model applicable to the majority of model-based design approaches is available, the resource efficiency of sustainability consideration is improved heavily.

The full paper describes the opportunities and limits of model-based LCA. A basic first version of a generic LCA model, connectable to existing design models, is presented. It is applied to an exemplary design model, examining the potential of the LCA model as well as validating its functionality.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

Metal and mineral resources in LCIA – The SUPRIM project

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Goal: Over the past two decades, life cycle impact assessment methods have received extensive attention and developed into mature methods mostly reflecting the state of the art in the relevant scientific field. Despite these achievements and harmonization efforts by the UNEP-SETAC Task Force on natural resources, there is still a lack of consensus on how to assess abiotic resource use in life cycle impact assessment (LCIA). This lack of a broadly accepted method, likely attributable to the lack of a common perspective on resource use and a common understanding of the potential problem(s) related to the use of resources, was the starting point of the SUPRIM project. The aim of SUPRIM is to obtain an understanding of different stakeholders' views and concerns regarding potential issues which result from the use of resources.

Methods: The gained insights will be provided in the form of a structured overview of those different views, which will then be used as a basis for further method development. This is being achieved by 'taking a step back' to a structured discussion about potential problems with resource use, and different motivations behind resource management concepts. The project focuses on impacts which occur directly from the use of abiotic resources - more specifically, abiotic resources such as minerals, metals, and natural materials - e.g. sand or natural stone.

Results: As one of its first activities, the SUPRIM consortium developed a framework for a structured discussion of different perspectives on resource use. The framework consists of an overarching perspective, a conceptual level ("Modelling Concept"), and a practical implementation level. The framework was first used as basis for a workshop discussion with external stakeholders. Prior to the workshop, the framework was introduced to the external stakeholders by way of a discussion paper including a number of pre-defined perspectives for discussion. Next, the workshop results were adopted as basis to propose best modelling options matching the perspectives and problems identified and prioritized by the workshop participants. The SUPRIM work is currently still ongoing but expected to be finalized in Spring 2019, and we aim to present first details of preferred methods at the conference.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

Greenhouse gas reduction scenarios of corporate activities considering avoided emissions

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To date, under the company's greenhouse gas reduction strategy, the company considers only Scope 1, which is the direct emission of greenhouse gases from factories and others; and Scope 2, which is the indirect emission of greenhouse gases associated with the use of electricity and heat. The information of Scope 3, which is the indirect emission not including in Scope1 and Scope2, is not utilized. By utilizing this information of Scope 3, it would be possible for the company to formulate and work on more environment-friendly measures when formulating greenhouse gas reduction scenarios. In this research, we propose a method to formulate a scenario for reducing greenhouse gas emissions by considering the avoided emissions throughout the life cycle. In constructing the method, we examined technical problems and investigated the measures for calculating the future avoided emissions necessary for setting future greenhouse gas reduction scenarios.

We found that there are three problems in developing a methodology to evaluate future avoided emissions: consideration of future technical forecasts, allocation of avoided emissions, and setting greenhouse gas reduction scenarios. We examined the first issue with a case study of an aircraft using carbon fiber reinforced plastic, which accounts for 50% of the weight of the aircraft. Avoided emissions were calculated from the expected number of aircraft in the future using the Weibull distribution. Two scenarios to estimate future avoided emissions are defined: 1.Calculate avoided emissions from baseline product which is unchanged until target year; 2. Calculate avoided emissions with baseline products which may change depending on market share. We examined advantages and disadvantages of each scenario. We also investigated how to add up the cumulative avoided emissions in the year of introduction and how to calculate and add up the avoided emissions each year.

In this research, we examined future technological forecasts after carefully examining technical issues concerning the calculation of future avoided emissions. There was no difference in avoided emissions until 2023 when the avoided emissions was calculated without changing the baseline. However, the avoided emissions were reduced to zero in the baseline change scenario starting 2023 or 2032. Since the avoided emissions could be zero according to the setting of the scenario, it is necessary to calculate the avoided emissions by considering the future technical forecast. In addition, if we adopt a method of collecting avoided emissions together in the year of introduction, we cannot consider the change in baseline, possibly overestimating avoided emissions.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

OPEN-LOOP RECYCLING ALLOCATION: How it is being solved?

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Life cycle assessment (LCA) is an important and consolidated methodology to quantify environmental impacts in the last years. However, even though it has already been standardized for more than 2 decades by ISO, undergoing through revisions and updates in this period, some methodological aspects are still controversial in the LCA community. Thus, different methodological decisions are possible (and allowed) when conducting a LCA project. This is not a desirable feature since it may add uncertainty to LCA results, and consequently, affects the decision-making process. The allocation approach, especially in open-loop recycling, where outputs from one product system becomes inputs to other product system (following industrial symbiosis and circular economy concepts) is one of the methodological decisions that may add uncertainty to LCA. This LCA step in open-loop systems consists in divide the environmental impacts of the shared processes (raw materials acquisition, collection/transportation/recycling, and final disposal) between productive systems involved in the chain. Due to the sensitivity of allocation approaches on LCAs, "recommendations" on how to distribute the environmental loads are presented in ISO standards and scientific publishing but still with lack of consensus. In this sense, the aim of this paper was to identify which allocation approaches have been preferred by LCA practitioners when it comes to open-loop recycling systems. A review was carried out in the main scientific databases in LCA field: Scielo, Scopus, Web of Science (WoS), Springer Link and Science Direct. The sample was outlined through a set of keywords, including: "life cycle assessment", "allocation", "recycling" and "open-loop" in every possible combination. All articles were analyzed through title, abstract and keyword, and those references that were not associated with the topic were discarded. The research identified 178 articles, published between 1996-2018, from which the most applied allocation approaches for open-loop recycling are the cut-off method (75) followed by system expansion (69), which together represent more than 60% of the applications. The 50/50 method (19), economic allocation (15), number of subsequent uses (5), mass allocation (2) and others (28) complete the list (some authors applied more than one method in their LCAs for sensitivity purposes and where accounted separately in our survey). Reasons for this result are different amongst the different approaches. The cut-off method, which is not mentioned in the ISO standards, have wide application due to its simplicity. The system expansion is suggested by ISO standard allocation hierarchy, demonstrates a group of practitioners who seek to comply the standards, although the almost all the method applied by the authors for system expansion is the replace (or substitution) method. The identification of these two opposing practices confirms the complexity of the situation, and points to the need for more synergistic guidelines, which indicate the adoption of more convergent, if not unique, approaches (at least for each product category).

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

Water-Energy-Food waste Nexus under a Life Cycle Thinking Approach

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Goal.

The environmental problems caused by the generation of food loss and waste (FLW) urge to shift from the concept of linear economy to a production process focused on a circular economy perspective, showing how industrial symbiosis can move society towards zero-waste considering the reinsertion of waste into new production processes. However, the implementation of circular economy in food waste management still seems to be at its initials stages, mainly focused on recycling and recovery instead of reusing. In this sense, the evaluation of the most environmentally-friendly FLW management scenarios requires the use of environmental tools, such as Life Cycle Assessment (LCA), which have been increasingly used in recent years. However, this great concern regarding FLW management has been studied in an isolated way, disregarding interdependences with other areas. This study aims to go a step further by proposing a new procedure to assess different waste management alternatives based on the nexus approach by means of an integrated Water-Energy-Food Nexus Index (WEFNI). Currently, there is no universally recognized methodology for nexus analysis. However, a life cycle thinking approach is essential to understand the interconnections in the nexus.

Methods

The proposed procedure combines the LCA methodology and linear programming (LP) optimisation. A basket of products was selected based on the consumption data reported by the Spanish Ministry of Agriculture, Fisheries, and Food (MAPAMA). These food commodities were classified into eleven food categories: cereals, sugar, vegetable oils, vegetables, fruits, pulses, roots, dairy, eggs, fish, and meat, and considering the distinct stages of the food supply chain (agricultural production, postharvest and storage, processing, distribution, consumption). The system function is the management of a food residue to obtain protein by means of the consumption of a new food product, while the FU was described as the ‘‘management of 1 metric ton of food residues from the FSC to obtain protein”. This study considered a “food waste-to-energy-to-waste” approach assessing three FLW management scenarios; landfilling with biogas recovery, incineration and anaerobic digestion. The management of FLW generates energy, which can be employed in the production of new food. The electricity recovered is transformed into its equivalent amount of primary energy and employed in the production of new food.

Results

The current study provides a method for decision-makers to holistically assess the interdependences affecting food security based on the assessment of water, energy and food. The procedure was applied to three FLW management alternatives: landfill with biogas recovery, incineration and valorisation. Once the WEFNI was calculated, the optimised results indicated that the landfill scenario was the best alternative because it presented the lowest WEFNI value for all food categories, except to meat where incineration emerged as the best option. This results can be somewhat controversial, since European initiatives are promoting the reduction of biodegradable amount of residues disposed. In this sense, these results highlights the importance of evaluate the different management alternatives from a nexus perspective and, in addition, the imperative need to improvement the incineration and anaerobic digestion processes.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

How many LCIs are necessary for Eco-Labelling schemes? A case study in Thailand

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Sustainable production and consumption is an important starting point for changes in economic and social conditions to sustainable development. The beginning of data and informatics era has made changes to LCA applications, such as eco efficiency, eco labels, circular economy, etc. All of these require a Life Cycle Inventory (LCI) database. One of the important questions is how many data are needed to be sufficient in both quantity and quality. The answer is to have information to support the appropriate activities that have been selected or prioritized. If any country is lacking or desires to promote any aspect, it becomes a must. Thailand has attained a global trend since 90s, starting with the promotion of cleaner technology and seeking for green solutions throughout the supply chain, along with the country's development strategies that state on green growth directives over the past decades.

Sufficient for what is the most important question, there are two approaches that should be considered. The first is what customer values and followed by what is the government needs to do, both have a similar context to the view of consumers and producers which cannot be separated from each other. If customers are aware of sustainability or environment, the product should be responsive, and sometimes providing comprehensive information for forecast/foresight is crucial. For example, products A may produce and managed well in one country but sometimes bring the same story to other countries, the result may be different. Therefore, information is extremely important for country development, if the government wants to create economic growth while preserving the environment, the LCI information will be immediately relevant. However, the acquisition of LCI data takes time and costs. So, how many LCI data is enough?

Thailand has developed LCI data for more than 10 years. There are more than 1200 databases. However, it is not fully covered because the needs are varied and cannot reach 100% with some limitations. NSTDA therefore suggests criteria to develop LCI data in accordance with current needs, about 70-80% of completeness in evaluating products or services is the expected target.

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SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

Decision making considering uncertain environmental impacts – A comparison between two pulp bleaching processes

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The life cycle assessment (LCA) is the most applied methodology to support environmental decision-making (ISO 14000, 2006) and thence the reliability of the LCA results is extremely important for decision makers. As uncertainty is present in LCA, an uncertainty analysis can help gaining more confidence in the results. This type of analysis has been mostly applied in the Life Cycle Inventory (LCI) step of an LCA and applications in the Life Cycle Impact Assessment (LCIA) step have been lacking. For this reason, the main goal of this study is to apply uncertainty analysis to the characterization factors used in this last step since these are the first type of parameters used in the LCIA.

The methodology is case-study driven and comprises three main steps:

Case Study Description:

- Goal and Scope Definition – The main objectives of the study, the functional unit (a representative element of the system being study), and system boundary are defined.
- Inventory Analysis – The collection of all the inputs and outputs of the system and corresponding quantities.

Environmental Impact Assessment:

- Deterministic LCIA – Develop a deterministic environmental assessment model considering the LCIA method ReCiPe 2008 (Goedkoop, et al., 2013).
- Stochastic LCIA – Application of Monte Carlo simulation to the deterministic model using the @Risk software (Palisade Corporation, 2016).

Results Interpretation – Compare the deterministic and stochastic environmental impacts.

The methodology has been applied to two pulp bleaching processes – System A (Elemental Chlorine Free) and System B (Total Chlorine Free). The inventory of each system was retrieved from the ecoinvent v3.3 database (ecoinvent, 2018). The systems boundary considered is cradle-to-gate and the functional unit selected is 1 ton of bleached pulp. The comparison of the deterministic and stochastic results allows the following conclusions to be drawn:

1. The deterministic difference between the single score of both systems is about 2.22 Pt. A positive difference means that System A is overall worst for the environment than System B.
2. Considering the stochastic difference between the single score of both systems, there is an 99.8% chance that System B is overall better for the environment than System A. Therefore, the confidence in this conclusion is high.
3. The deterministic difference between the single score of both systems is below the first quartile of the stochastic results. This reveals that this difference is underestimated – there is 97.8 % chance that this difference is actually higher than the initial estimated i.e. switching from ECF to TCF will result in an overall improvement higher than the initial estimated (2.22 Pt).

This study showed that the conclusions reached in an LCA study are influenced by the uncertainty associated with some parameters hence the importance of always including an uncertainty analysis in these studies. This analysis will reveal an underestimation or overestimation of the results but either way it will help the decision makers to make more informed decisions.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

Measuring positive impacts in biodiversity footprints

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PRé Sustainability

Goal

Most LCA studies, carbon footprints, water footprints or biodiversity footprints report on the negative environmental impact of a product system, an organization or an investment portfolio. Sometimes positive impacts are calculated using an avoided impact approach, e.g. through avoided carbon emissions. There is still a lot of debate on when and how positive impacts on biodiversity should be quantified and included in a footprint. In this study, an approach is developed to include positive impacts on biodiversity in a biodiversity footprint for investment portfolios. The work is illustrated using different case studies, including investments in green energy, carbon sequestration, nature restoration and sustainable forestry.

Methods

The case studies are based on the Biodiversity Footprint for Financial Institutions (BFFI) method used by ASN Bank. This method is based on the multi-regional environmentally extended input-output tables published by the Exiobase consortium. Environmental impacts are calculated with the environmental impact assessment method ReCiPe 2016. The identification of positive impacts is based on an extensive literature review of initiatives and handbooks that try to define and assess a reference level beyond which an impact can be seen as positive. We found this varies from protecting a high conservation area to restoring degraded land or storing carbon in soil; indicating that so far consensus is lacking.

Results

A methodological framework to calculate positive impacts is presented. The framework includes different types of positive impacts and important methodological choices. For instance, the choice of a reference situation and guidance when pro-biodiversity investments/measures can be counted as positive impact and when they should be regarded as minimizing negative impacts. The different case studies illustrate how these methodological choices affect positive impact calculation in a biodiversity footprint for financial institutions.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

Estimating land use change greenhouse gas emissions within global supply chains. Comparison of a spatially-explicit and a statistical approach.

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Unilever

Goal: Life Cycle Assessment (LCA) studies increasingly include land use change (LUC) and associated greenhouse gas emissions (GHG) within their system boundaries. For some agricultural commodities LUC is the most significant contributor to their GHG footprint. The Greenhouse Gas Protocol and PAS 2050 standards provide guidelines on how to determine LUC emissions depending on the level of knowledge of the location and history of land use. A commonly used approach when the history of land use is unknown is to use statistics from the Food and Agriculture Organisation of the United Nations (FAO). This approach is useful when only the country of origin is known and not the precise location. However, in recent years, various voluntary sustainability initiatives have allowed companies to improve the traceability of their supply chains. Statistical approaches based on FAO data do not necessarily capture LUC dynamics at higher levels of spatial granularity, e.g. provinces, districts or jurisdictions. In this study we demonstrated a spatially-explicit approach to estimate LUC and associated GHG emissions of agricultural commodities, based on the analysis of historical satellite land cover data and carbon maps. We also compared the results to those obtained using statistical approaches.

Methods:

Data on the locations of 89 agricultural commodities sourced from 3252 farms across 43 countries for the year 2014 were used for the analysis. Data collection was done within the framework of the sustainable agriculture programme within Unilever. Farms were geolocated using Google Geocoding API: only those referenced to nearby towns or villages (as opposed to larger areas like provinces or states) were retained for further analysis (2280 observations). Areas of the likely farm location were defined around towns and villages. Land cover maps from the European Space Agency Climate Change Initiative were used to estimate changes in land cover attributable to agriculture over a 20-year period, using ArcGIS software. Associated losses of carbon were estimated using the InVEST model and biomass maps from Baccini (2012) and Avitabile (2016). Results were converted to carbon dioxide and amortised over 20 years. We compared the results to those obtained using a statistical approach based on FAO statistics.

Results:

Results show that while LUC may be reported in country statistics, these changes are not always observed at the regional or municipality level where the agricultural commodities in question are cultivated. Therefore, allocating LUC emissions based on country level data may over or under-estimate emissions attributable to a crop compared to what is actually happening at a local level.

SESSION T5-2 LCI and LCIA modelling - Approaches and Challenges

Dynamic Life Cycle Assessment Using a MBSE System Model

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Even though there are yet no obligations for companies to evaluate the environmental impact of their products, it can become an issue in the near future. Some companies may measure the carbon footprint along the lifecycle of their product, but in most cases, it is done at the end of the product emergence process (PEP). The evaluation and optimisation of sustainability considerations must be made possible in the early phases of product development. It is not yet done because the particular challenge of sustainability considerations is a very granular depth approach and an enormous number of interactions. For ecological evaluation, it is necessary to consider many product properties along the life cycle, which can interact in complex ways. Model-based systems engineering (MBSE) is a promising approach for solving the problem of complicated correlations in products and assemblies. If the environmental influences can be evaluated at the beginning of the PEP, changes due to environmental arguments can be made so that companies can, for example, fulfil environmental requirements directly through product design, take advantage of promotional measures for ecological products or prepare an ecological certification of the product.

In the presented approach, a methodology is demonstrated to support the assessment of the environmental impacts along the life cycle of a product in the early stages of the PEP using the approach of MBSE. The procedure is as follows: first the environmental influences are evaluated. Then the system architecture including the system boundaries and the interdependencies are described. Finally, an example is given of how the system model can be used to optimize sustainability. To evaluate the environmental impacts of a product along its life cycle, the life-cycle assessment (LCA), which is standardized according to DIN EN ISO 14040, was chosen. The investigation criteria for the LCA are raw material, production with the different manufacturing methods, the energy consumption, transport, use and recycling. The existing product and the LCA are modeled with the Systems Modeling Language (SysML) using a commercial Modeler-Software. The datasets are generated from a LCA database and are calculated with an external solver. The presented approach is validated with the example of a testing machine, since real data exist for this product.

With the help of the interactive system model, the components and the life cycle phase that have the highest environmental impacts can be comprehensibly determined and options for actions can be derived. The presented approach can be applied to other products. The resulting system model can be used for dynamic change management in the context of environmental design criteria in future product emergence processes in all industries [DIN EN ISO 14040].

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management

Evaluation of characterization factor models for LCA in context of marine litter impacts

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Goal

In 2017 the Forum for Sustainability through Life Cycle Innovation (FSLCI) initiated the Medellin Declaration on Marine Litter in Life Cycle Assessment and Management. The declaration emphasizes the great need for an assessment of marine ecological impacts in LCA. It calls for more research in this area and particularly for the development of regional characterization factors for different sub-compartments of the marine environment in life cycle impact assessment [3].

LCA was initially developed for land-based product systems measuring the impacts on terrestrial and freshwater ecosystems. Still only a handful of LCA impact categories are related to the marine environment [1] and there is in general a lack of focus on marine environments and particularly plastic debris [2]. In the field for Life Cycle Assessments, there are significant gaps in assessing the marine litter effects accurately. There are gaps of characterization models and methods to integrate them in the holistic approach of LCA [3].

Methods

Using literature reesults for the assessment of plastics waste and microplastics to different organismes were assessed and trasnferred into possible impact assessment approaches.

The characterization follows the structure:

- Assessment of the impacts of polymers and degraded polymers on the marine environment
- Classification of different substances and their impacts on the marine environment
- Characterization of the effects of different groups of substances with potential embedding in LCIA models for different substance groups
- Recommendations for future research focus

Marine Litter impacts from certain selected polymers are assessed by a definition of effects to species, dicsussing challenges and uncertainties for the creation of such an assessment method and preparation of test cases.

Results

The data accumulated during the literature reviews on different polymer substances in the oceans, their behavior and impacts on marine life were analysed and linked to characterized impacts to be used in LCA. The substances were classified into different groups and different impact categories. Some substances can be placed in more than one impact category. The environmental impacts of these substances or groups of substances can be characterized and weighted, based on quantitative data found in research articles, kinectics and classification of sizes in linking with different types of impacts to organisms. Propositions for characterization factors of the effect of these polymers were developed and will be improved by further research activities for potential embedding into LCIA models.

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SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management

Society`s perception-based characterization factors for mismanaged polymers at end of life

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Goal

Our oceans are, again, the stage for the most recent environmental concern hype. More often than not, the evidence of environmental impact is noticeable before scientists can properly address their root cause and even establish and understand the risk analysis pathway. In this sense, society's perception becomes - for some period - the drive to measure, remediate and ultimately solve the perceived problem. This work strives to understand how people deal with this transitory gap of knowledge and how scientific society could use this to measure society`s viewpoint through marine liter.

Methodology

The methodology was to carry out a regular Life Cycle Assessment ISO 14040 compliant comparing an iconic and very current case: reusable and single-use drinking straws. The assessment was a starting point to reach an answer to the "society`s perception based" characterization factors for mismanaged polymers at end of life. The study also explores literature cases in which society are taking action in response to the marine debris crisis, some cases treating the symptom, others trying to find the root cause.

Results

Given that the study showed that disposable straws may be a better option for the environment, the characterization factors were then calculated making the opposite math considering that society perceives the options, at least, as environmental equivalents. The results show that the "Society`s perception-based characterization factors" may reach up to twice the characterization factors of producing the polymer.

Even though this work`s aim is to present a case as an exercise and not to properly calculate a reproducible characterization factor, it gives insight about the current LCA gap of knowledge and how far an LCA result may be from public opinion. Doubtlessly science should not be nudged by any perception and real characterizations factor are still to be calculated. The lack of data, high complexity of the subject and the difficulty of proper communication between the scientific community and social influencers tend to lead people to the precautionary side and to make decisions with no data to support. In this case, society becomes very prone to suffer from rebound effects.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management

Approach to consider resource losses by plastic emissions as well as toxicological impacts caused by the release of monomers, additives or fillers

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There is increasing public, political and scientific concern over the presence of plastics in the environment. In particular, due to possible negative effects on marine organisms and the persistence of plastics, plastic emissions are seen as a relevant environmental issue. However, existing life cycle assessment (LCA) studies are not able to address these impacts. Current works mainly focus on plastic footprints which account for plastic emissions of products in their life cycle and do not consider related environmental impacts. One example is the marine plastic footprint currently under development by the International Union for Conservation of Nature (IUCN). The goal of this work, which is linked to the BMBF funded project PlastikBudget (https://www.plastikbudget.de/english/), is to discuss and to develop a methodology for LCA that addresses two types of environmental impacts of plastic emissions: loss of resources and potential toxicological impacts by additives and fillers.

In order to address losses of resources, often input-related life cycle impact assessment (LCIA) methodologies are applied which refer to the number of resources extracted from the earth and their scarcity. Our approach is to develop a method for dissipative losses of plastics. These dissipative losses do not focus on the extraction of resources, but consider losses by incineration or by spreading plastics in the environment (Zampori and Sala 2017). Apart from the methodology to account for these losses, a central challenge is to differentiate between the losses of different polymer types and to account for the feasibility of recovery. The feasibility of recovery is mainly influenced by the associated effort and costs and will depend on the type of environmental compartment.

In addition, we seek to address toxicity impacts of plastic emissions. Chemical impacts might occur from the release of substances from plastics such as residual monomers, additives or fillers. Their chemical toxicity effect can principally be addressed by the UseTox-Methodology (Rosenbaum et al. 2008). Based on a study which analyzes and quantifies microplastic emissions in Germany (Bertling et al. 2018) and information on potential additives and fillers used in different plastic types (Stenmarck et al. 2017), the presence of relevant substances in UseTox was investigated. First results show that in total about 18 % of the identified substances are covered by UseTox. In order to overcome this data gap, the Chemical Life Cycle Collaborative (CLiCC) Tool (Song et al. 2017) was used to estimate values for the endpoints human health and ecosystem quality. This approach was compared to LD50 values taken from the database TOXNET.

In summary, preliminary approaches will be presented to address dissipative losses of plastics in LCA and to address toxicological hazardous of residual monomers, additives or fillers which can be released by microplastics. In addition, toxicity hotspots of residual monomers, additives and fillers in plastic emissions will be presented considering concentration ranges of additives and fillers as presented by (Hahladakis et al. 2018).

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SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management

Addressing Marine Litter within Life Cycle Assessment

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FSLCI

In June 2017, LCA practitioners present at the CILCA 2017 Conference in Colombia came together and developed the Medellin Declaration on Marine Litter in Life Cycle Assessment and Management. The Declaration was published by the FSLCI in collaboration with the RICV last year and has since then been signed by more than 200 practitioners. It highlighted that currently Life Cycle Assessment (LCA), as one of the most widely used sustainability assessment tools for greening the economy, is not adequately addressing the impacts on the environment generated due to marine debris, such as plastics and microplastics. It also noted that there does not seem to be any LCA studies on products that include plastics and adequately addresses the challenge of marine litter. Indeed, there is still an overall need to assess marine ecological impacts in life cycle assessment in a meaningful way. Therefore, the Declaration advocates for taking action in terms of including environmental impacts linked to waste reaching the marine environment through enhanced life-cycle modelling and improved life cycle inventories.

Given the magnitude of the impacts caused by marine debris, plastics and microplastics in the oceans, which mount up to several million metric tons per year, and as a response to the public concern on these impacts echoed in recent reports published by e.g. UN Environment, the FSLCI organized an initial workshop in collaboration with the RICV in May 2018 in Brussels (Belgium). Objective of the workshop was to link different expert communities together to start a process towards addressing the issue of marine litter within life cycle assessment and management. The workshop, which convened 30 experts with a background in LCA and Life Cycle Management, as well as marine debris generation and impact assessment, opened a dialogue between life cycle and marine litter experts which is meant to result in a process that provides the basis for inclusion of marine litter in LCA. Follow-up workshops in other world regions have been organized in order to raise awareness within the LCA community on the issues highlighted in the Medellin Declaration. This presentation presents key conclusions and recommendations that derive out of these workshops, outlining next steps that have been planned and providing an overview of initiatives to address the topic of marine litter within LCA.

SESSION T5-3 Addressing Marine Litter within Life Cycle Assessment and Management

MARILCA: A proposed framework for life cycle impact assessment of marine litter in LCA

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Environmental impact pathways from marine litter are not yet covered by life cycle impact assessment (LCIA) methods, potentially compromising the robustness of decision-support provided by LCA. For example, replacing all plastic bottles by glass would indeed reduce marine litter but increase other impact categories, such as global warming, and comparing these trade-offs is not possible if those impacts are not included and characterized. Filling this research gap is a high priority for the LCIA research community, as shown by the recent Medellín Declaration, which specifically calls for impact assessment model development to account for potential damage caused by marine litter.

Here, we present the output from Phase 1 of the MARILCA (Marine Impacts in LCA) working group process; a framework for developing LCIA models and illustrating the different impact pathways associated with marine litter. The MARILCA working group operates under the UN Environment Life Cycle Initiative and the Forum for Sustainability through Life Cycle Innovation (FSLCI) and aims to foster and accelerate the development of marine-related impact assessment methodologies, starting with marine litter.

In this framework, gaps and building blocks are identified with the objective of guiding coordinated and harmonised, and therefore efficient, LCIA model developments, leading to ultimately characterisation factors for waste leading to marine litter and the associated environmental damage. The framework is centered on plastic litter and is expandable to cover other materials constituting litter in the marine environment e.g. metals, glass, organic materials.

A detailed mapping of possible impact pathways is provided, with guidance on the most important ones from an inventory perspective. Our developed framework links the generation of waste with potential damage to three areas of protection (AoP) namely ecosystem quality, human health and (the latest proposed AoP) natural heritage by describing mechanistic steps along impact pathways. We recommend development of spatially differentiated, and size-differentiated LCIA models including details on fate, exposure and effect processes.

The impact pathways from waste generation to environmental damage are complex, including multiple routes from source to the marine environment and litter properties (size and shape) that change as litter degrades, with potential consequences on effect mechanisms. For example, macro-, micro- and nano-plastics each lead to different effect pathways. Through the development of our framework, we first incorporated the complexity and evidence base for impact mechanisms leading to and resulting from marine litter. We then identified important impact modelling steps to capture the predominant flow of litter mass in the environment. Overall, we present the basis for harmonised LCIA model development that can first cover the predominant impact pathways, which together would generate a complete damage-level LCIA model for marine litter. In the longer term, this framework will help integrate the marine impacts in LCA, including those from plastic litter, in a consistent approach that is compatible with the LCIA framework.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines

SOCIAL LIFE CYCLE ASSESSMENT: MODELING HUMAN SUBJECTIVITY ON IMPACT SUBCATEGORIES CHOICE

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Ufersa

Goal:

Social Life Cycle Assessment (SLCA) is a recent approach able to evaluate positive and negative social aspects of the life cycle of a product, including from raw materials extraction phase to the final disposal. Even if this approach be based on life cycle assessment from environmental dimension, following the same general methodological steps, human subjectivity is a preponderant element in the social dimension and it is still neglected when conducting this type of study. It introduces uncertainties associated to value judgment when defining weights of subcategory indicators, translating qualitative assessments into social performances and selecting the subcategory impact indicators. The first two elements were addressed in two studies carried out by Carmo et al. (2017). For the third element, there is no scientific approach able to select the subcategories indicators among those proposed by the Guidelines for Social Life Cycle Assessment of Products. Currently, SLCA studies select subcategory indicators to represent the performance for each stakeholder dimension in an arbitrary way, without considering the value judgment of the stakeholders affected by the product life cycle. As such, this research proposes an approach able to support the selection process of the subcategories' indicators used to measure social performance for each stakeholder dimension.

Methods:

Our model is based on the value judgment of a group of representatives of the different stages of the life cycle of a product for workers stakeholder dimension in order to provide representative subcategory indicators when assessing social life cycle performances of products systems. Our approach is participatory and the model was developed based on multiple criteria decision analysis (MCDA) models. It adapts Promsort method in order to establish a set of subcategory indicators aligned to the value judgments of different life cycle stages representatives when assessing social performances. In order to exemplify how to apply this approach, this research will focus workers' stakeholder dimension.

Results:

This research presents a participatory approach to model the human subjectivity involved in the selection process of relevant subcategories indicators on social life cycle assessment. This research is currently being applied to a case study and the results obtained from the case study will be achieved on next months.

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SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines

Assessment of the social aspects in the Circular Economy models using the Product Social Handbook

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GOAL:

The growing interest on social impact assessment, together with the circular economy model is established worldwide. It also has driven a fast innovation and research in this field. The main objective of this study is to assess if the social topics presented in the Handbook for the Product Social Impact Assessment (PSIA) can be used to find points of comparison between linear and circular business models regarding social impacts.

METHOD:

This paper focuses on the analysis of the social impacts presented in the Product Social Impact Assessment (PSIA) Handbook; in particular, in three alternative scenarios of circular economy and linear business models.

RESULTS:

Moreover, the results found in this assessment show the main differences in social impacts can be found for workers in the post-use collection and refurbishment centers.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines

Social Potential Impact on Life Expectancy caused by the use of materials from different Brazilian States

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Goal: Group O Boticário, a cosmetic business organization in Brazil that includes sustainability as part of the processes, produces multiple types of products, which changes every year and aims to include in the decision-making process the information on the potential social impacts to evaluate different value chains. The goal of the S-LCA study was to evaluate the social performance of two different value chains, considering that the direct suppliers are located in different Brazilian States.

Method: S-LCA was used. The product system considered was the whole life cycle, nevertheless, as it is a comparison and there are no differences from the entry of the material in the demanding organization till the discard, these processes were not taken into account. As the material needs to provide the same amount of function for Grupo O Boticário's final product, the unit of analysis was the reference flow, that is 1 unit of material. No other characteristic was important for the organization at this point. As the two databases available provide data on country/sector level, they were used to prioritize the sectors in which data is to be collected for the subcategory Fair Salary. For each of the three main sectors, income generic data of the sector for each State were collected. The impact on Life Expectancy (LEX) caused by the income was evaluated using a correlation analysis with the data of Brazilian municipalities. A sensitivity analysis was performed with country and State references on LEX. Relating LEX to income is better than previous proposals that used GDP, as the latter is a complex indicator not available in the organization level.

Results: The results showed a small difference of the results while using material from different states. It was also possible to verify that the reference changed the results. The approach may allow to support decision making in the company. It is recommended to further develop for other subcategories and connect to specific data.

SESSION T5-4 A Global Effort: Launching the 2019 S-LCA Guidelines

10 YEARS AFTER THE UNEP GUIDELINES (2009-2019): STATE-OF-THE-ART OF METHODOLOGIES TO CONDUCT SOCIAL LIFE CYCLE ASSESSMENT

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Introduction

Sustainable development is a three-fold concept that covers environmental, economic, and social aspects. Concerns about ways to produce and purchase more responsibly have been raised in the last decades by organizations and consumers. Now more than ever, consumers are starting to demand to know the social and economic circumstances surrounding the whole supply chain of certain goods and services.

Goal

In 2006, life cycle experts underlined the importance of broadening existing impact assessment studies to evaluate not only the economic and environmental effects of certain industries activity, but also those aspects related to its social impacts. In response to that research call, in 2009 the United Nations Environment Program analyzed and provided a broad description of different practices to measure S-LCA. A methodological framework to analyze main stakeholders affected and key related impacts was then published.

The main purpose of this research is to provide a state-of-the-art analysis of different methodologies applied throughout the last ten years to conduct social life cycle assessment (S-LCA).

Methods

An in-depth literature review combined with a bibliometric analysis has been conducted to analyze and identify the main methodological approaches followed in S-LCA case studies. A list of key databases, methods, and social indicators most frequently used to assess a product or service, based on social hotspots, is provided.

Results

Out of the three-pillar approach to sustainable development (people, planet and profit), the economic and environmental aspects of sustainability have been broadly investigated in the literature and related measurement procedures are quite standardized and quantified nowadays. However, there is no harmonized approach commonly followed by all organizations identically to assess their social impacts.

This lack of consistency among the standards used to conduct S-LCA between studies might be probably due to the combination of quantitative and qualitative nature of the data employed, and to the diversity of criteria applied when assessing social and socio-economic impacts. Moreover, carrying out an in-depth data collection process is also expensive and time-consuming given its broad scope.

A few databases have been specially developed for calculating and assessing the social impacts of products throughout their life cycles, speeding up the process overall. For example, PSILCA, Social Hotspots, and soca databases contain key social indicators to address different stakeholder groups impacts. Most of these commercial databases, however, require paying a fee for its use.

Additional efforts should be invested in identifying, systematizing and unifying the S-LCA methodologies worldwide in order to develop a consistent and homogeneous open-access methodology that helps companies and stakeholders to appraise their social performance.

Moreover, an integrative approach that reflects not only the economic and environmental facets of operations and production but also the societal impacts is highly needed. Incorporating social issues into sustainability measurements is a must to better understand and track the social implications of the consumption and production of goods over their life cycle.

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The Social Organisational Life Cycle Assessment implementation in the honey sector

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The introduction of 2030 Agenda for Sustainability Development has highlighted the essential role covered by the social sustainability, which requires to develop methodologies to evaluate the social aspects to be monitored over time. In this perspective, Social Organisational LCA (SO-LCA) is a well-suited methodology, as it assesses the social performance of organisations from a life cycle perspective. Built upon the Organisational LCA (O-LCA) methodology, the SO-LCA has been introduced by Martinez-Blanco et al., 2015, which propose the adaptation of O-LCA to the social perspective. Moreover, it is also based on the framework of Social Life Cycle Assessment (S-LCA), which provides the consideration of stakeholder categories and subcategories. Until now, SO-LCA has not been implemented yet. For this reason, this study has a twofold purpose: i) to test the application of the SO-LCA methodology in the honey sector; ii) to do so by starting from an existing S-LCA case-study on a honey jar. Indeed, the main difference among SO-LCA and S-LCA is the Goal and Scope phase, thus the goal is at organisational level for SO-LCA (meant as the direct activities of an organisation and its product portfolio) and at product level for S-LCA. Furthermore, SO-LCA could overcome one of the characteristic challenges of S-LCA, i.e. the allocation of the indicators or impacts to a product level.

The analysed company is in Abruzzo, a region of Central Italy, and its business is focused on production by bees, harvesting and manufacturing of honey. Starting from the S-LCA application, a first analysis allowed to define the scope of the SO-LCA study in terms of Reporting Unit, i.e. object of analysis: the entire products portfolio; consolidation method: the company has full financial and operational control; reference period: 2017 and the Reporting Flow, i.e. the number of the products sold in the 2017. The System Boundary (SB) defined is Cradle to Gate, which includes the processes already assessed in S-LCA study and the other processes involved in the Reporting Unit, e.g. all processes involved in the products portfolio such as the production of pollen, the production of honey candies, etc. The selected Stakeholder categories and subcategories in the S-LCA honey case-study were considered also for the SO-LCA one. study. The data collection of SO-LCA study has been conducted only for the processes non-considered in S-LCA honey case-study. Indeed, the entire organisation and all processes involved in the Reporting Unit are taking into consideration in SO-LCA and, for this reason, the allocation of impacts and multifunctionality of the product do not arise.

Indeed, a preliminary analysis of the framework of indicators of S-LCA honey case-study has shown that all indicators could be used also for the SO-LCA case-study because the indicators are at organisational level and, for this reason, the assessment is focused on the behaviour of the company involved in the assessed processes. A S-LCA case-study can be a starting point to implement SO-LCA in the honey sector for the processes already assessed, while it is necessary to broaden the SB so to include additional processes that are part of the organisational boundaries. Further development of this study aims to involve the social impacts assessment for the processes not-evaluated in S-LCA study to obtain the assessment of social performance of the honey company from an organisational perspective.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies

Applying global supply chain modeling to inventory database IDEA

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Goals;

Inventory data is essential to conduct LCA of products and organizations. Currently, inventory databases are being developed in various countries around the world, and IDEA(Inventory Database for Environmental Analysis) which is developed in Japan is one of them. IDEA is an inventory database representative of Japan that references statistics, actual measurement data, literature, etc. However, in the real world, intermediate products are supplied not only from domestic markets but also from global markets. In order to assess regional conditions and impacts that are part of the actual supply chain, inventory databases must consider import/export of products as well as overseas production. In this study, we created offshore production data by adapting IDEA inventory data to reflect local conditions as much as possible. Further, we incorporated import/export data and production volume data creating market mixes that reflect global supply chain mixes. We applied this global supply chain modeling to IDEA for some metal products, aiming to go through the procedure of gathering data and implementing these models with the objective to verify the feasibility as well as challenges of this approach.

Methods;

Estimating offshore manufacturing of a product is done by replacing and/or adjusting energy flows so the situation of each country is reflected to the production unit process. Import/export trade amounts between countries are obtained from UN Comtrade statistics and mapped to IDEA's product classification. Production amounts for each country are collected from USGS and when data for a country is not available the production amount is estimated from trade statistics. Combining these data sources, production, export, import, consumption amounts for each country is calculated and thus constructing a network of processes that represent the global supply chain of a product.

Results;

We introduce the calculation results of aluminum as an example. Production processes along the supply chain of primary aluminum production such as bauxite mining, alumina production, anode production, electricity production, aluminum electrolysis and ingot casting was modeled to reflect offshore manufacturing and global supply chains. Calculation results show that the cradle to gate GHG emissions of primary aluminum ingot can range from approximately 6.0 kg-CO2e/kg to 28.0 kg-CO2e/kg. Although the modeling method of this study was applied only to some major aluminum production processes, we were able to create inventory data for major countries with global supply chains considered.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies

First implementation of the ISO 14008 standard in a database on monetary values of environmental impacts and related aspects

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Introduction

In choices between alternative products, processes or organizations, different category indicator results must often be weighed against each other. A particular problem is the trade-off between climate impacts and resource management, e.g. when comparing ICE vehicles with electrical. Then, monetary valuation of impacts gives valuable information. A new international standard, ISO 14008 offers a framework for monetary valuation of impacts from emissions and use of resources. The standard contains requirements and recommendations on defining and documenting goal and scope, on methodology and on reporting. Our goal in the work reported here is to make monetary values of environmental impacts and related aspects available by a database based on ISO 14008. Our aim is not only a technical solution, but also an implementation strategy.

Method

The technical solution is a relational database. The database consists of 17 interlinked tables including aspect definition, environmental impact factor, environmental indicator, monetary valuation factor, and information of the study that produced the data. The implementation strategy is based on experiences from the development of the ISO LCA standards. These experiences show that consensus on terminology and structure stimulates cooperation on data production and compilation. Lack of data was for long hindering LCA applications. Once the LCA standards were established, software and databases were developed and grew both in quality and volume. Other standards and guidebooks followed that gave more precise requirement and guidance. To contribute to such a development, we have initiated a Swedish project called “Natural Capital and Value Creation”, where we develop and offer an environmental damage cost price list for materials and processes to organizations, which make case studies.

Learnings, conclusions

The same progress as for the LCA standards is beginning to show for the ISO 14008 standard. Already now, several working groups within the ISO Environmental management project is developing standards, supported by ISO 14008, such as the ISO 14007 on costs and benefits of environmental management, ISO 14030 on green finance and 14097 on climate finance. A new technical committee has been started within ISO on sustainable finance.

The establishment of the relational database on monetary values of environmental impacts is a quite straightforward process, but some of the existing valuation methods lack information required by the standard. Although the standard ensures transparency in terms of traceability, the inherent complexity of monetary valuation is a challenge in communicating with non-experts.

Applications

Monetary values for environmental impacts have a very broad application in environmental management. Of particular interest here is the potential of including externalities in initiatives within the framework of circular economy.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies

How the choice of parameters impact LCIA results: the example of batteries for electrical vehicles

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Goal: Climate change remains in the coming decades the main global challenge for society. According to IPPC, transportation accounts for 14% of all greenhouse gas (GHG) emissions. Electrification of transport in combination with a greening of electricity supply is seen as the main solution to reduce in a short and mid-term GHG emissions and to contribute to a climate change mitigation in the transport sector. In this context, a wide range of studies were published over the past years, assessing GHG emissions from electrical vehicles (EVs) and comparing those with internal combustion engine vehicles (ICEs). An assessment of existing LCA studies on EV batteries shows, however, contradicting results. Aim of the study is to identify the most relevant parameters and framework conditions, to show different options available for these parameters and framework conditions - and how the choice influences the results. Special emphasis is put on life cycle data for raw materials (such as nickel) going into the production of EV batteries and how those impact the LCIA results.

Methods: We assessed a series of articles published over the past years in the context of life cycle (impact) assessment and green mobility. Special emphasis was put on battery electrical vehicles. We identified for each study those parameters mainly influencing the results of the life cycle impact assessment. Special emphasis was put on the choice of life cycle inventory data of raw materials going into the battery production of electrical vehicles. These data are often seen in those studies as a hot spot for greenhouse gas emissions. We compared the nickel life cycle inventory data used in those studies with the most recent life cycle data collected by the nickel industry as part of a study commissioned by the Nickel Institute and conducted by thinkstep for the reference year 2017.

Results: The most relevant influencing parameters identified include use patterns (i.e. mileage), upstream electricity supply (i.e. chosen national and / or regional grid mixes), life time of the car, production of battery cathode material, assessment and inclusion of potential second life of batteries, and recycling. The choice of the data set used for raw materials converted into battery cathode material has shown to have a significant impact. For e.g. nickel, there are different datasets available in public and commercial databases, some of them being old, outdated and no longer representative. There is a need for database holders to replace by more recent peer reviewed data collected and published by industry on a regular basis. Further work is required in the context of battery cathode material production, where only limited reliable and robust life cycle inventory data are available.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies

Semantic web and stadardized model interfaces for modern LCI data infrastructure: The BONSAI approach

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Building a life cycle inventory database is an enormous and complicated process. Current practice is the result of years of development, but still has a number of significant weaknesses, such as extensive subjective and possibly inconsistent practitioner judgment, and production of static inventory dataset documents that are difficult to update or adapt. In this presentation, we present the approach being developed by BONSAI, an initiative to build an open source sustainability database, as well as serving as a model for best practices in inventory data collection and processing.

BONSAI tries to solve the subjective and implicit practitioner choices by using a semantic (RDF) database that stores basic statements about the world. Such statements include data normally used in inventory datasets (e.g wind farm X produced Y kWh in time period Z), as well as other information that can be used in allocation, validation, dis/aggregation, and spatial or temporal adaptation (e.g. the GDP in country W is projected to be X in year Y under scenario Z). Specifics on the data infrastructure and models can be found on the BONSAI wiki [1]. A set of system models is then applied to this data to produce balanced supply- and use-tables. This approach introduces complexity, both in the amount and type of data being considered, as well as in the computational paradigm. However, it also brings a number of significant advantages, including global consistency, systematic and explicit handling of uncertainties and conflicting statements about the world, validation of global and regional sums, transparency about data processing, and the possibility for systematic examination of system modeling choices.

In many cases, inventory databases are specific realizations of a broader model. Such models can vary in their implementation language and level of complexity. A truly global database will often require multiple realizations of these models for different temporal, geographical, and future scenario contexts. BONSAI is in the process of defining simple standardized interfaces for such models, and best practices for building new models intended to be used in inventory development. We illustrate this idea with a new model that dynamically consumes data from the ENTSO-E grid API.

BONSAI will be a long-term project, and it will take broad community participation to realize its complete vision. In this presentation we will focus on the specific steps achieved and lessons learned during a "hackathon" to be held in Spring 2019.

[1] https://github.com/BONSAMURAIS/bonsai/wiki/

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Methodics PtP (Package-to-product)

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In this study, we focus on environmental impact of food packaging. Packaging is an integral part of most of food and beverage's products and its production is steadily growing. Food packaging represents the largest part of household packaging and the enormous amount of produced packaging is evidenced by the fact that the average European citizen produced about 170 kg of packaging in 2016. The increasing amount of packaging waste produces undeniable environmental impacts, particularly in the production phase, in the form of consumption of primary raw materials, and in the disposal phase, where most of it ends up in landfills or worse as litter.

Here, we present the methodics PtP (package-to-product) examining environmental impacts associated with all types of packaging and selected product. As a case study, we chose five most consumed food and beverage's products in the Czech Republic. The environmental impacts of the life cycle of primary, secondary and tertiary packaging are analyzed along with production of a product and environmental hotspots identified. To optimize environmental performance, different EOL treatment options were examined (energy recovery, landfilling and material recovery scenario) for each packaging type.

For a comprehensive evaluation of environmental impact of different packaging options, we used Life Cycle Assessment (LCA). LCA is performed using ReCiPe method version 1.08. For evaluation, the following impact categories are used (1) Raw material impact categories: Fossil depletion, Metal depletion, Water Consumption; and (2) Intervention impact categories: Climate change/Global warming, Photochemical Ozone Formation, Stratospheric Ozone Depletion, Freshwater Eutrophication and Terrestrial Acidification. The methodics PtP can be used e.g. by designers, environmental, waste management and retail chains managers, as a comprehensive tool for packaging waste prevention.

SESSION T5-5 Creating the Data Infrastructure for Circular Economy and LCM based strategies

CIRCULAR ECONOMY REPRESENTED IN SOME GLOBAL ECONOMY INDICES

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The goal of the paper is to find out dependences between selected global economy indices and indicators described circular economy development level for top-20 countries in the ranking and Ukraine for identification the most significant indicators among the selected global economy indices.

The paper focused to the analysis of the circular economy development level and its elements, as well as analysis of the comparison of various indices characterized human wellbeing, GDP, hi-tech export and country competitiveness. The method of the correlation and regression analysis used in the study.

The results of the study revealed a significant dependence between some global economy indexes namely the High-tech export index and Environmental Performance index (EPI), GDP and EPI, use of renewables and Global competitiveness index, Education Index and EPI. This confirmed an assumption on the significant impact of the population erudition level to the readiness of the society for resource saving, as well as it impacts the environ¬ment and energy saving know-hows implementation. Thus, the education can contribute to the rapid expansion of the circular economy concept and it can be evidenced by the knowledge economy concept provisions. The circular economy demonstrates an intensive use of innovations and know-how comparing with the same implementation in a framework of the traditional linear economy.

SESSION T5-8 Other (not mentioned above)

A LITERATURE REVIEW OF LIFE CYCLE COSTING APPLIED TO URBAN AGRICULTURE

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Objective: Nowadays, more than half of the world's population live in urban areas and this tendency is projected to increase to 68% by 2050 (UN, 2014). As a result, problems in the supply of fresh food due to increased demand can be expected. According to various authors, the development of urban agriculture (UA) may alleviate the cities' fresh food problem in order to improve their sustainability. In this regard, Life Cycle Costing (LCC) as part of the Life Cycle Sustainability Assessment (LCSA) is used for valuation of the economic aspects in many industries, but its application in UA is still limited. To fill this gap, the purpose of our research was a literature review of the use of LCC methodology in UA sector by studying its evolution since it beginning in 1995 to date (July 2018).

Methods: We performed an accurate selection of academic literature from the two main databases Scopus and Web of Science (WoS). After several refining processes, we obtained the selected references for analysis, organized into four groups.

Results: The results showed that the European region was the most productive in LCC research for UA, being Spain and Italy the lead countries. We also found that urban horticulture (edible plants cultivation) was the most analyzed type of UA. Another interesting finding was that within the urban horticulture, the building-integrated forms (indoor farms, rooftop greenhouses, rooftop gardens) gained more popularity perhaps due to the lack of available space in the cities and the developing of new technologies. Regarding the performance of LCC assessment for UA, some emerging problems were detected. At first place, almost all the papers investigated comprised both LCA and LCC analyses, but the proportion between them was very disproportionate, being LCA the predominant type of assessment. At second place, we noticed that generally only one economic indicator (total cost) was used for the costs estimation. On the basis of these findings, further research of LCC for UA is needed for: (i) balancing the disproportion between the use of LCA, LCC and SCLA analyses within Life Cycle Sustainability Assessment (LCSA) framework, and (ii) promoting the application of more than one economic indicator for costs estimation.