PORTUGAL

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1. OVERVIEW OF THE REGION

According to the last Census results the North Region of Portugal has a population of 3,689,682 inhabitants and covers an area of 21,286 km² (density of 173 inhabitants per km²). The North Region is one of the five regions of Mainland Portugal, according to the NUTS II subdivision and includes the 8 NUTS III sub-regions shown in *Figure 1*. It is bordered in the North and East by Spain, in the South by the Central Region and in the West by the Atlantic Ocean.

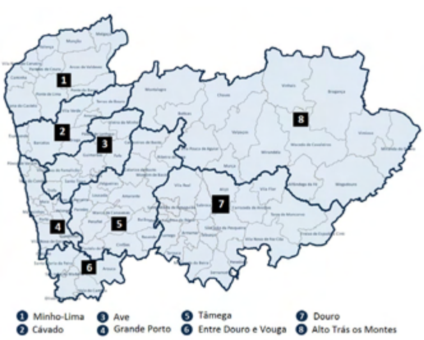

Figure 1 – North Region – NUTS III

For each of the five administrative regions of Mainland Portugal, there is a Regional Coordination and Development Commission, which is a decentralised body of the central government not an authority in itself since, besides municipalities, there is no other intermediate level authority in Portugal.
The North Regional Coordination and Development Commission (CCDR-n) is a decentralised body of the central government established in the North. Its mission is to promote the conditions to develop integration and sustainability of Portuguese North Region (NUT II), thereby contributing to the national cohesion and competitiveness.

CCDR-n, is a body that has administrative and financial autonomy, is tasked with coordinating and promoting governmental policies with regard to Regional Planning and Development, Environment, Spatial Planning, Inter-Regional and Cross-Border Co-operation and also supports Local Government and Inter-Municipal Associations. Its fields of intervention also concerns the management of regional operational programmes financed by European Union (EU) funds, as well as other regional development finance instruments, including structural funds.

The GDP of the North Region, in 2010, represented 28 % of the Portuguese GDP, with €48,542 million, corresponding to €13,000 per capita (*Figure 2*).

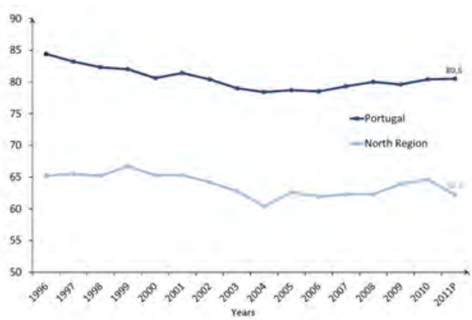

Figure 2 – Evolution of GDP per inhabitant in PPP (EU27 = 100 index) (CCDR-n, 2013)

In the sector of agriculture, the region has a leading position in milk and wine production. Port wine, produced in the region, is the main national agricultural export.

In industrial sector, the traditional branches of textiles, footwear and other leather products, wood and furniture and cork are concentrated in North region. Food industry has also a significant expression in North Region, representing around 30% of the national total. With respect to the employment, a scenario of economic crisis is revealed with quickly growing unemployment rates across all Portuguese regions.

	1stQ-2012	2ndQ-2013	3rdQ-2013
Portugal	**14.9**	**16.4**	**15.6**
North	15.1	17.2	16.6
Centre	11.8	11.5	11.2
Lisbon	16.5	19.3	17.9
Alentejo	15.4	17.2	16.1
Algarve	20.0	16.9	13.8
Azores	13.9	16.1	17.7
Madeira	16.1	18.8	17.3

Table 1 – Unemployment rate (%) by region for NUTS II (INE, 2013)

However, as *Table 1* reveals, for the North Region, in the second and third quarters of 2013, the unemployment rate is slightly decreasing and was about 17.2% and 16.6%, respectively.

Regarding the employment rate, for Portugal and as it can be observed in *Figure 3*, it has decreased below 50% but, over the last three quarters, has shown a small recovery to 51%. Concerning the North region, the trends are the same, reaching a minimum in the 1st quarter (49.5%) and recovering to an employment rate of 50.4%, being 56.2% for men and 45.1% for women, since the 2nd semester of 2013.

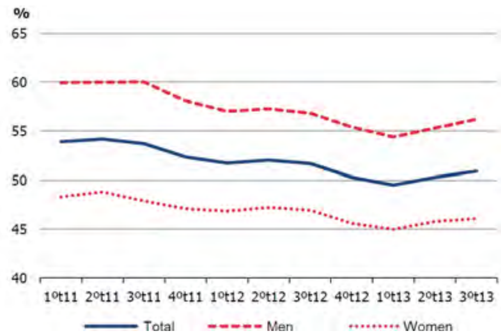

Figure 3 – Employment rate (%) for Portugal, by trimester, since 2011 (INE, 2013)

Energy demand and supply of the Region
The data for total final energy consumption by activity sector and by energy source are not available for the regions but only for the whole country, although they can be expected to be very similar in terms of percentage distribution. In *Figure 4*, it is possible to see a consistent trend, since 2005, regarding a decrease in energy consumption for all sectors of activity.

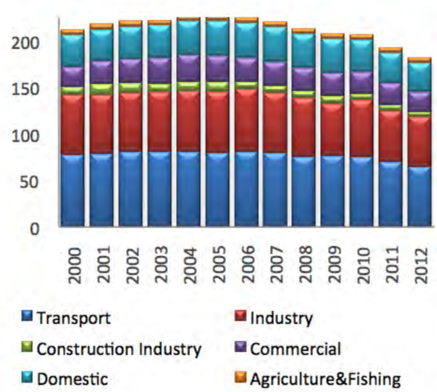

Figure 4 – Total final energy consumption for Portugal, by activity sector, for 2000 – 2011, in thousands of GWh, from(DGEG, 2013)

The final energy consumption in Portugal was 181,293 GWh in 2012, 15.1% less compared to 2008. It is emphasised that the decrease observed in 2011 (-6.8%) and 2012 (-5.6%) were the most significant in the period, corresponding to the beginning of the economic crisis.

Regarding the structure of final energy consumption by sector, it remained unchanged between 2008 and 2012, and the sectors of transport (35.5%), industry (29.6%) and residential (17.0%), showed the highest final energy consumption.

With the negative evolution of the national economy, from 2011 all sectors of activity showed a decrease in final energy consumption. It is stressed the negative variation in 2011, compared to 2010, of industry sector (-11.4%) and of transport sector (-6.8%), as well as the one observed in 2012, compared to 2011, in construction (-21.3%) and transport (-8.6%) sectors (INE, 2013).

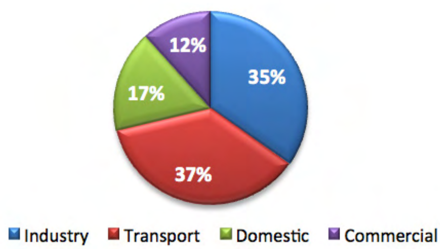

Figure 5 – Total final energy consumption, by activity sector, for 2011 (DGEG, 2013)

For the year 2011, *Figure 5* shows with more detail the partition of the total energy consumption (191,954 GWh) amongst the most relevant activity sectors, where it is observed that transport and industry are the most demanding sectors.

Regarding the total final energy consumption, by energy source, it is obvious when observing *Figure 6*, that oil is still the prevailing source of energy followed, at great distance, by electricity.

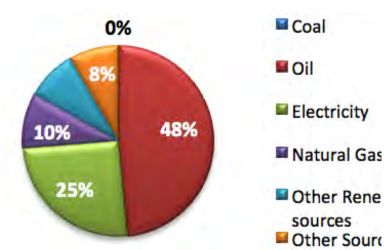

Figure 6 – Total final energy consumption by energy source, in 2011 (DGEG, 2013)

The total electricity consumption in the North Region of Portugal, in 2011, was about 15,226 GWh, distributed by the different sectors as shown in *Table 2*.

Sector	GWh	
Residential buildings	4,834	32%
Non-residential buildings	3,491	23%
Industry	5,377	35%
Agriculture	145	1%
Streets lighting	566	4%
Indoor lighting of State Buildings	775	5%
Others	38	0%

Table 2 – Total consumption of electricity in the North Region, in 2011 (INE, 2011)

For the nominal indoor conditions considered by the Portuguese Energy Performance Certification Scheme and for a reference scenario considering an energy tariff of €0.10/kWh, the fuel poverty rate for mainland Portugal was estimated to be of 92% (Magalhães & Leal, 2012).

This very high level of fuel poverty is related to the high current prices of energy, to a low energy efficiency of the housing stock and to a low income of the households. However the realism of the nominal indoor conditions is questionable and there is a significant variation of the energy bill depending on the tariff scenario.

For the electricity production and the share of energy sources, management is undertaken at a national level and so there are no specific figures available for the North Region (*Figure 7*). However, in the case of wind and hydraulic sources, it was possible to derive those values from the information available. In 2012, the north of Portugal accounted for 34.6% of the total electricity produced, with 21% from large dams and about 14% to wind power.

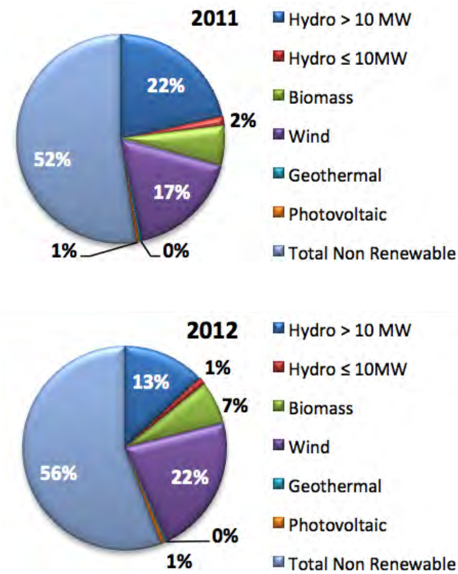

Figure 7 – Share of energy sources for national electricity production (2011 and 2012) (DGEG, 2013)

With respect to the total GHG emissions, according to the Portuguese Environmental Statistics released in 2013, the total for 2011 was 68,452 ktCO2eq, from all sectors combined or 63,132 ktCO_2eq if was also considered the influence of LULUCF (Land Use, Land Use Change and Forestry) (INE, 2013). Based on the last Portuguese National Inventory Report on Greenhouse Gases, 1990 – 2011 (APA, et al., 2013) and considering emissions data of 2009, the Northern Region contributes with 24% of total GHG emissions of the country. In terms of GHG emissions per area, the North is above the national average, with 808 against 773 tCO_2eq/km^2, although, regarding emissions per capita the situation is the opposite with 4.7 against 6.7 tCO_2eq per capita.

The *GHG emissions factor* for electricity from the grid, produced exclusively in Portugal, was at approximately, 0.375 kCO_2eq/kWh for 2009, obtained from the data collected by DGEG (Directorate General for Energy and Geology) (APA, 2011). It is intended that the GHG emission factor for the reference scenario, in 2020, decrease to 0.132 kCO_2eq/kWh (ADEPorto & CMPorto, 2013).

Considering energy related technology, in August 2013, Portugal had 10,887 MW of installed capacity for electricity production from renewable sources (RES). The share of RES in gross consumption of electricity for the purposes of the Directive was 45.6% in 2012, considering only the Continent. In 2012, Portugal was fourth in the European Union (EU15) for generating renewable energy (DGEG, 2013).

A priority for national investment includes the construction of seven out of the ten new hydropower plants in the country to be built in the North. This corresponds to an increase of more than 50% of the current potential.

Wind power has been an important national strategic focus over the past decade particularly in the North Region, having gone through a strong growth in the region. This has included various sectors of industrial activity contributing to the “wind cluster” and constituting a field of continuous technological innovation, given the purpose of energy optimisation.

The encouragement of the energy production from biomass, in line with the National Strategy for Energy - “ENE 2020” and with the National Strategy for Forests, should also be mentioned as it represents about 7% of the electricity produced.

Regarding wave energy generation, there are technological developments on the way, and it can be expected that it can become an option in the near future. In the North Region, two priority areas for potential installation of wave energy parks were identified(CCDR-n, 2011).

2. CURRENT SITUATION: TARGETS RELATED TO ENERGY POLICY

Promoting a more sustainable environment and, in particular, the containment of the growth in greenhouse gas (GHG) emissions, is one of the priority areas for action defined by the United Nations and the European Commission.

For the Northern Region and with regard to Environment, Energy and Sustainability the main concerns include promoting a low carbon economy, reducing the specific energy consumption through energy efficiency, increasing the share of renewable energy, improving air and water quality, the treatment of municipal solid waste and the preservation of biodiversity. The region takes an important role in the national context, particularly in the domain of renewable energy, presenting a high potential, mainly in hydropower and wind power, and in addition, biomass, solar radiation and wave energy.

Concerning the existence of targets for energy demand and supply, those are set at national level and involve the National Strategy for Energy 2020 (ENE2020), National Action Plan for Energy Efficiency (PNAEE2016), the National Action Plan for Renewable Energy Sources (PNAER2020) and the National Program for Climate Change (PNAC2020). Each region must contribute for the national targets but there are no specific regional targets defined.

These legal instruments (ENE2020, PNAEE2016, PNAER2020 and PNAC2020) intend to ensure the compliance with the commitments made by Portugal in the context of the related European policies under Energy-Climate Package 20-20-20.The end purpose is to achieve by 2020: a reduction of 20% in emissions of GHG in relation to 1990 levels; 20% share of energy from renewable sources in gross final consumption and 20% reduction of primary energy consumption. For Portugal and for 2020, was established a general goal of reduction in primary energy consumption of 25% and a specific goal of 30% reduction, for the Public Administration.

Similarly, to other European countries, Portugal is taking actions regarding energy and climate change whose purpose is to achieve lower targets of GHG emissions over the years, higher energy efficiency and a stronger participation of renewable sources on energy production.
In the present year of 2013, Portugal approved action plans for energy efficiency and renewable energy sources (PNAEE and PNAER, respectively) establish the following targets for the next years:

PNAEE2016 targets:

- for 2016, an estimate of savings of 17,442 GWh, corresponding to 8.2% reduction of energy consumption,comparing with the average consumption 2001 – 2005;
- for 2020, a decrease of 91,860 GWh in primary energy, comparing with the energy demand projection of PRIMES model from European Commission (26% of 348,837 GWh).

The expected impacts, in terms of CO_2 emissions, are expressed in *Table 3*, by sector of activity, with respect to the energy efficiency policies and show a reduction of about 5.1 $MtCO_2eq$ by 2020.

Reducing GHG emissions (tCO_2eq)savings		
	2016	**2020**
Transport	227,273	422,441
Dwellings and Office buildings	1,400,941	2,543,735
Industry	399,504	890,765
Public buildings	489,647	1,108,715
Agriculture	92,571	123,541
TOTAL	2,609,936	5,089,197

Table 3 – Impact of PNAEE2016 on CO_2 emissions (PCM, 2013)

PNAER2020 targets:

- incorporating 10% of Renewable Energy Sources (RES) on transport;
- for 2020, the share of RES in gross final energy consumption is 31% – the fifth highest in the EU.

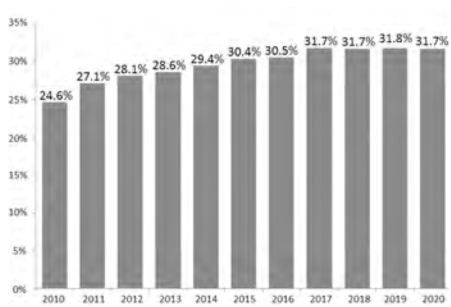

Figure 8 – Pace of expanding renewable energies

Regarding CO_2 emissions, the compliance with PNAER2020 will provide an estimated reduction of 28.6 $MtCO_2eq$, by 2020, which corresponds approximately to €286 million (CO_2 = 10 €/ton).

The recast Directive (Directive 2010/31/EU) on the Energy Performance of Buildings (EPBD), published on 19th of May 2010, was integrated in the Portuguese legal framework in 2013, with the DL 118/2013, which also includes the Building Energy Efficiency Codes (BEEC) for Dwellings and for Commercial & Office buildings.The implementation of the former directive and former BEEC, promoted the use of innovative technologies to improve buildings efficiency and provided incentive to the use of RES for efficient generation and usage of heat.

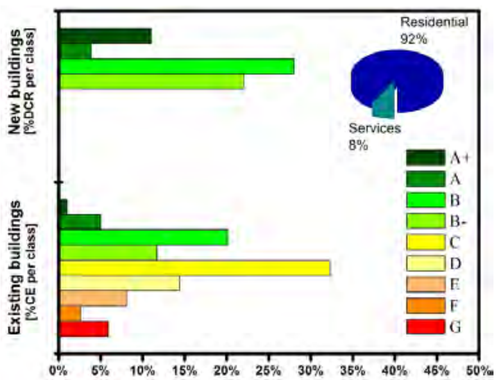

Figure 9 – Energy label distribution for new and existing buildings (Gonçalves, et al., 2013)

Following the requirements of the BEEC, since 2007 until December 2012, more than 555,000EPCs (Energy Performance Certificates) were issued, about 80% of these correspond to existing buildings, upon sale or rent. The results of those certificates, according to the energy label are visible in *Figure 9*.

Other Regional targets, barriers and drivers

It must be pointed out that, in terms of building energy efficiency, the old part of the building stock in the North Region and the existence of many historical places with severe restrictions for renovation actions constitute a barrier for the improvement of energy efficiency. On the other hand the Western part of North Region is one of the most populated zones in the country with a large housing stock where significant renovation actions can be implemented mainly in a large number of buildings that were built in the 70's and 80's, when no building energy efficiency code was into force.

With an important concentration of the construction industry and construction working force in the North some efforts have been made lately in what concerns training for energy efficiency. Specific training programs on subjects like insulation technics, solar collectors' installation and efficient windows were launched.

Concerning *climate-friendly mobility,* the new PNAER gives continuity to the Mobi.E project which led to the creation of the Electric Mobility Network, an integrated network linking various stations in Portugal that enable electric vehicles to recharge, using a charge card.

It is estimated that the number of electric vehicles in Portugal will grow at an average annual rate of 44% between 2011 and 2020, totalling 33,663 electric vehicles, including passenger cars, goods vehicles, buses and motorcycles, as shown in *Figure 10*.

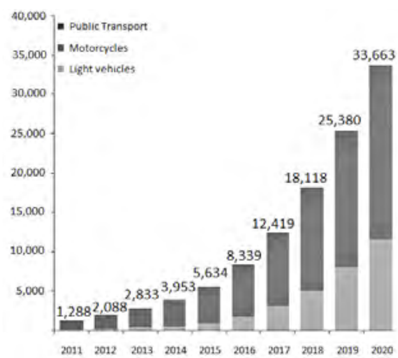

Figure 10 – Estimated evolution of electric vehicles in Portugal (PCM, 2013)

Improving access to *Information and Communication Technologies* (ICT), as well as its use and quality, corresponds to one of the thematic objectives set by the European Union for the period 2014 – 2020. Also, "Digital Agenda for Europe" is one of seven flagship initiatives of the Europe 2020 Strategy, aimed at promoting smart, sustainable and inclusive growth.

The coverage of basic broadband (which allows access to the Internet of at least 2 MB/s) was already very close to universal coverage in the Northern Region, in 2011, in line with EU targets set for 2013.

Broadband coverage of new generation (at least 30 MB/s) at regional level is quite high but shows significant intra-regional disparities. In areas of lower population density, the coverage of this type of service does not exceed 35%. With the exception of Greater Porto and Entre-Douro and Vouga, the sub-regional North territories present values are still far from 100% global coverage targeted by the EU for 2020.

Regarding broadband penetration and Internet use by citizens, the Northern Region stands out negatively, both in the national and European levels. Less than half the population of the North uses the Internet on a regular basis (at least once a week) and the same applies to the use of e-commerce.

3. THE GREAT METROPOLITAN AREAOF PORTO: AN APPROACH TO CLIMATE-FRIENDLY MOBILITY

The city of Porto is located in the Northern region, has an area of 41.66 km² with a population of 237,591 inhabitants and a density of 5,703 inhabitants per km², according to the last census (2011). The city is the capital of the Great Metropolitan Area of Porto (GMAP), which comprises 17 municipalities, within an area of 2,246 km² and with a population of 2,381,595 inhabitants. The geographical situation of GMAP within the northern region is shown in *Figure 11*.

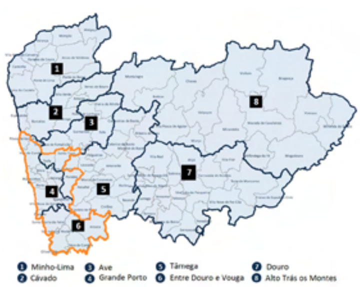

Figure 11 – Great Metropolitan Area of Porto in the Northern Region of Portugal

Although this metropolitan area only covers about 10% of the entire region, its population is almost 2/3 of the total and the contribution for the regional GHG emissions is about 50%. This highlights the economical relevance of GMAP in not only the industrial sector but also regarding the transport sector (density of roads, traffic), residential sector, etc.

In *Figure 12*, some figures are presented that emphasise Porto as the capital city of the metropolitan area, providing all the primary institutional services, major education and health facilities, polarising commuting movements, namely, a high population density, a strong production of GHG emissions per area unit, but an average CO_2eq emission significantly below the national average.

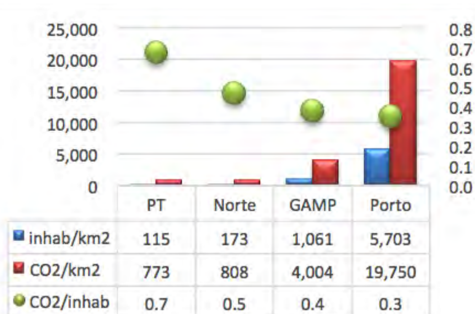

Figure 12 – Density parameters for population and GHG emissions (in tCO_2eq/km^2 and $tCO_2eq/inhab$) for different geographical levels

As Porto has such relevance in the regional context, it was considered that any intervention developed in this city could have the potential to engage a regional change. With this purpose,the Municipality of Porto, through the creation of the Energy Agency of Porto, in 2006, began an innovative journey in the approach to the subject of energy within the city. The most relevant milestones of the agency action were:

- the elaboration of the Energy Matrix of Porto in 2007, reported to 2004;
- the signature of the Covenant of Mayors in 2009 and;
- the approval of the 2010 Plan of Action for Sustainable Energy for the city of Porto (PAES-P).

The Porto Strategy for Sustainability was based on a diagnosis and on an energy strategy for urban sustainability, meeting the objectives of the European Commission for 2020, taking action on not only specific energy systems and vectors but, mainly,with interventions on the scale of city activities and energy users sectors, like buildings and transport. In what concerns CO_2 emissions the PAES-P aims to go even further, reducing them by about 45% in 2020. The main "stakeholders" of the city were consulted throughout the process and were called to evaluate the planned actions in their areas of responsibility, such as EDP – Gas; LIPOR – Inter-municipalities Waste Management of Greater Porto; Metro of Porto and STCP (Society of Collective Transport of Porto).

As stated in the energy matrix of Porto for 2004, the transport sector is the most demanding, in terms of final energy consumption and, together with office buildings, it is responsible for more than 2/3 of the GHG emissions in Porto. In this context and making use of the opportunity provided by the construction of a new Metro network in recent years (since 2003); it was considered that the analysis of environmental implications (GHG emissions) of the modal shift towards the Metro offered great interest.

Initial conditions and local situation

As a starting point, one should consider the situation without the influence of the Metro system. Unfortunately, the data available on GHG emissions does not allow going back that far. Meanwhile, considering the information included on PAES-P and related documents (AdEPorto, et al., 2008), (AdEPorto, 2009), it is possible to compare the years 2004 and 2008, as shown in *Figure 13*, regarding CO_2 emissions, not only at local level but also with the influence of indirect CO_2 emissions.

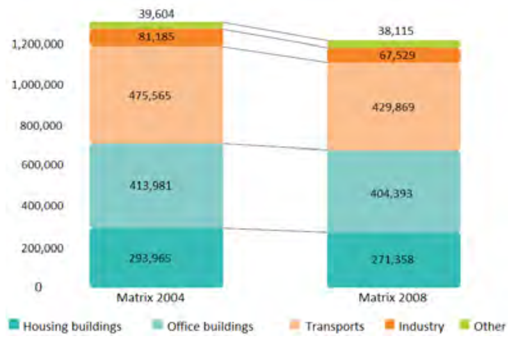

Figure 13 – Energy matrix 2004 vs 2008: CO_2 emissions, in tCO_2eq, by activity sector (ADEPorto & CMPorto, 2013)

These indirect emissions result from converting primary into final energy, which does not occur in Porto, and represent about 30% of those CO_2 emissions, according to differences detected in data from APA (APA, et al., 2013) and AdEPorto (ADEPorto & CMPorto, 2013), respectively, emissions produced locally and global emissions (local plus indirect). This CO_2 emissions decrease reflects a reduction on primary and final energy consumption by, respectively, 11% and 12%. Those changes,which in housing means a decreased of 6.2% in final energy and 7.7% in CO_2 emissions for the period 2004/2008, are in part due to the loss of population, but probably also to the transfer from electricity to natural gas.

With respect to transport, there was a reduction in final energy consumption by 10.5%, corresponding to a 10% decrease in CO_2 emissions, most likely due to the opening of new Metro lines in 2005, the reformulation of STCP network (part of the fleet runs on natural gas) and the continued migration of people from Porto to the neighbouring municipalities. In general terms, there was an average reduction on CO_2 emissions of 7.1%, with a particular focus on industry (17%) followed by the transport sector (9.6%) and dwellings (7.7%).

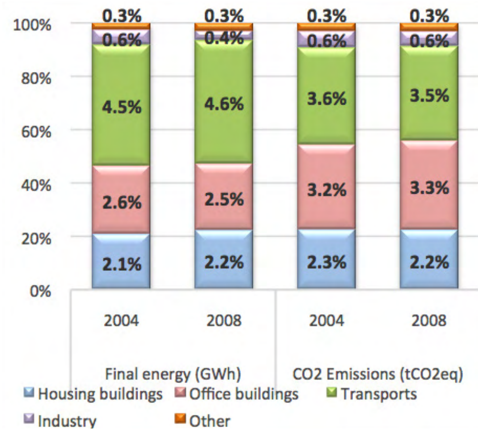

Figure 14 – Energy matrix 2004 vs 2008, distribution by activity sector, adapted from (ADEPorto & CMPorto, 2013)

As it is possible to observe in *Figure 14*, transport and buildings account for 90% of CO_2 emissions, from which 36% are related to the transport sector. In 2004, from the perspective of the “supply”, the energy matrix of the transport sector is dominated by diesel (57% of energy and 58% of emissions) followed by petrol (39% energy and 38% of emissions). The individual weight of the remaining energy vectors (natural gas, LPG and electricity) is not significant, although about half the STCP fleet runs with natural gas. The matrix of transport is dominated by road transport headed by individual transport (55%). The public transport represents only 7% of primary energy for mobility, being 1% by rail (train and metro) and the remaining 6% by road, provided by STCP, where the energetic weight of natural gas is higher than diesel.

In PAES-P some benchmarking indicators for Porto and for Portugal are provided, regarding the use of primary energy per capita for transport, which are indicated in *Table 4*, showing that in Porto, for 2008, the consumption is higher than the national average by 10% and with a greater use of petrol.

Benchmarking demographic indicators (2008)		
	Porto	**Portugal**
Population density (hab/km^2)	5,786	114
Number of inhabitants	238,954	10,529,255

Benchmarking indicator for energy and CO_2				
Emissions	Energy	Emissions	Energy	Emissions
Total of primary energy in the transport sector (MWh/inhabitant) | (tCO_2/inhabitant)				
	7.74	1.99	7.01	1.82
Final energy in the transport sector (MWh/inhabitant) | (tCO_2/inhabitant)				
Diesel	4.34	1.16	4.66	1.24
Petrol	3.03	0.76	2.19	0.55
Electricity	0.05	0.02	0.05	0.02
Natural gas	0.26	0.05	-	-

Table 4 – Benchmarking indicators for the transportation sector (ADEPorto & CMPorto, 2013)

A particular attention will be given to the Metro of Porto (*Figure 15*), as the chosen case study, since it represents the most used public transport mode and along the first 10 years (Dec 2002 – Dec 2012) it transported about 380 million customers and registered, in 2012, 54.5 million trips (journeys/ validations).

The fleet consists of 102 vehicles, driving 9000 persons per hour and per line with an average speed of 28 km/h. This is clearly higher than the average speed of the private transport in the centre of the city, very much conditioned by traffic lights, bus stops and bus lanes, crosswalks and traffic congestion, mostly in rush hours. In peri urban areas, however, private transport speed can reach the one of the Metro and can often exceed it, as there are less circulation constraints.

Figure 15 – The Metro of Porto (source: Photographer António Chaves - Metro do Porto, S.A. Archive)

Presently, the Metro of Porto has a network with 6 lines and 66 km of extension, along which there are 81 stations both on surface or underground, according to the Metro profile, which has been constructed along the years as indicated in *Table 5*.

Metro Network (31/12)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Length (km)	12	16	35	59	59	60	60	66	66	66
Number of stations	18	23	45	69	69	70	70	80	81	81

Table 5 – Development of the Metro of Porto

The majority of customers of the Metro of Porto are obviously resident in the 6 municipalities covered by the network: Póvoa de Varzim, Vila do Conde, Maia, Matosinhos, Porto, Vila Nova de Gaia e Gondomar. From Porto come 27.1% of the customers, followed by Vila Nova de Gaia (20.9%), Matosinhos (14.2%), Maia (10.1%), Gondomar (9.6%), Vila do Conde (4.8%) and Póvoa do Varzim (1.7%). However, the percentage of customers living in locations not served by Metro also has some expression (11.3% of total), especially for residents in Valongo (1.6%) and Espinho (1.0%).

Objectives and methods

The objective of the presentation of this case study is to illustrate, whenever possible in a quantified way, the impact of public policies and investments in reducing GHG emissions, not only at local level but mainly, with a regional or even larger geographical focus.

As previously mentioned, when studying the emissions related to transport modal split it is important to consider not only the emissions emitted locally by the different transport modes but also the emissions associated to the transformation of the primary energy sources in the final energy to be used by those transport modes. Given the environmentally friendly nature of light rail, it was necessary to perform the calculation of the emissions avoided by this mode of transport as an alternative to more polluting ones.

For those calculations a modal shift was assumed from other forms of transportation to the Metro obtained from inquiries conducted in the study: "*Assessment of the Global Impact Project Phase 1 of the Metro of Porto*"(FEUP & U.NOVA, 2008). According to that study, the inquired population was considered to be representative of the average users of Metro and was captured from other modes as follows:

- 23.6% from Individual Transport (IT);
- 65.4% from Public Transport (PT) (includes travel by train and bus);
- 11% from Non-Motorised Transport (NMT) (includes walking and cycling, for example).

Some knowledge on CO_2 emissions from individual transport, buses and trains was also needed. Regarding public transport, STCP and CP (Comboios de Portugal, the Portuguese railway operations company), the companies operating those services, were consulted and they provided that information.

With respect to the individual transport, the update of the emission factor depends on the particular characteristics of the fleet and the use profile of vehicles, information quite difficult to access. The alternative consisted in using a factor estimated from average rates of increase/decrease of CO_2 emissions from road transport published for the last 4 years in INERPA - the National Atmospheric Emissions Inventory. The emission factors used in these calculations are indicated in *Table 6*.

	2007	2008	2009	2010	2011	2012
STCP	98.46	98.46	94.39	99.33	109.60	106.16
CP	29.41	29.41	29.41	29.41	29.41	29.41
TI	724.45	724.45	724.45	719.7	712.7	703.8

Table 6 – CO_2 emission conversion factors for PT (STCP and CP) and IT, in gCO_2eq per passenger of Metro

The estimation of the emissions avoided locally from IT and PT is included in *Figure 17*. The number of passengers travelling by metro is another essential piece of information. That information was provided by "Metro do Porto", together with the "loads by section", presented in *Figure 16*, which correspond to the number of passengers who travelled between each pair of stations. The urban sections exhibit values more than ten times higher than those at the extremities of the Metro network.

Figure 16 – Passenger flows by section in both directions, adapted from (Metro do Porto, 2013)

Results

Since 2003, when the first line of Metro started to be operated, environmental and social benefits were emphasised by the company as one of the most important achievements for the city, at that time, and later for the entire GMAP.

In social terms, the implementation of the Metro system brought identifiable benefits,such as a decrease in travel time, a reduction in the number of road accidents, a lower pressure on parking and a reduction in operation costs of other transport companies. Moreover the inter-social-class character of the Metro and its territorial coverage contributed, more than any other way of transport, to the connection and integration of different urban areas which present sometimes significantly contrasted social matrices (Pinho and Villares, 2009).

Apart from environmental issues like resources, water and waste management, historical and architectural preservation, landscape, etc., energy management and the contribution for the reduction of national and local/regional GHG emissions were the most referred contributions for the society and the environment.

Following the methodology expressed in the previous section, from 2007 until 2012 – the figures for 2013 are not available yet– it was possible to quantify the savings provided by the development of the Metro network.

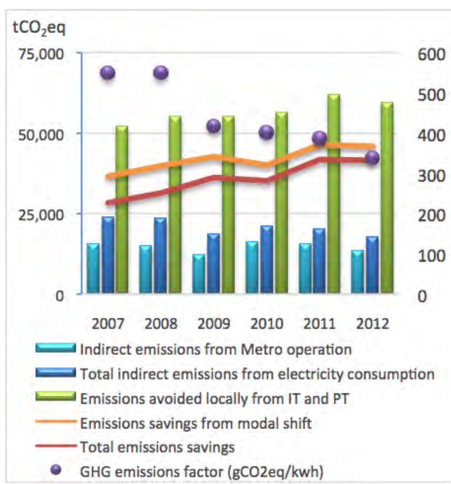

Figure 17 – CO_2 emissions and saving derived from Metro operation

Data was gathered from several Metro do Porto "Sustainability Reports" (Metro do Porto, 2008 to 2012), from DGEG (Directorate General for

Energy and Geology) and the results of those calculations are summarised in *Figure 17*. It is interesting, although expected, to notice that the emissions avoided locally have been increasing until 2011, suffering a slight decrease in 2012 that might continue in 2013. This decrease is related with the economic crisis the Portuguese are facing that firstly arose in individual vehicles use but also arrivedat public transport. According to the latest statistics of INE, Metro do Porto and STCP, there was a reduction in the number of persons using public transport.

Another point that should also be stressed is related to the efforts made, not only by Metro do Porto but also by STCP (the bus public transport operator), regarding the improvement in operational efficiency, either reducing the energy consumption with more efficient vehicles, by the reformulation of the network – lately having almost a complementary network for both modes of transport.

Long term focus
Efficiency measures have encouraged modal shift from the individual to the collective transport. Those measures will have to be articulated and, as the public transport system is improved, it will be possible to introduce some restraining measures to the use of private transport. The possible actions might include:

- improvement of public transportation services: the construction of new Metro lines in 2005 and 2006 demonstrates a significant reduction in fuel consumption and incorporated: The introduction of high frequency lines and good quality of service in strategic areas that allow integration between transportation modes; the adequacy between supply and demand; the improvement of circulation conditions for road public transportation with bus corridors and traffic light systems that give them priority; and the implementation of parking areas associated to inter-modality;
- improvement of energy efficiency: with energy audit for detailed classification of energy usage, according to the type of transport, leading to rationalisation measures of consumption. In particular, the Metro of Porto has been developing studies with the industry and with university researchers (Universities of Porto and of Minho) in order to achieve a better energy efficiency in its vehicles operation;
- awareness training and information: actions to raise the awareness of transport companies and individual drivers on economic and defensive driving; High priority on reducing individual motorised transport by encouraging collective forms of transport (Metro/STCP/CP), encourage inter-modality, creating an infrastructure of cycling lanes and promoting pedestrian pathways;
- implementation of the Urban Mobility Program: in the “PNAEE” - National Plan of Action for Energy Efficiency, there is a system of incentives under the name of Urban Mobility Program, which supports the measures related to the modal and commuting needs of public transport in major cities and business areas;
- incorporation of biofuels in petrol and diesel: in the scope of “ENE “ - National Strategy for Energy, the incorporation of biofuels was approved which subsequently led to the Decree - Law 49 /2009 where a mandatory incorporation of biofuels in road fuels, up to a maximum of 20%, is established (this objective is also outlined in “PNAER” - National Plan of Action for Renewable Energy, July 2010);
- *creation of the Metropolitan Transportation Authority:* The Metropolitan Transportation Authority of Porto (AMT) was formally constituted and its duties, arising from their legal regime of the Law n. 1/2009, include the fields of planning, organisation, operation, financing, monitoring and development of public transport; One of the main proposals for achieving the objectives is the gradual modal shift in the Great Metropolitan Area of Porto from private transport to public transport; The progress of this measure, the improvement of energy efficiency and the impact on the reduction of CO_2 emissions in the city of Porto, will be recorded during the monitoring of the implementation of the “PAES-P”;
- The Mobility Shop: is an instrument of mobility management, it is a concept that has been developed worldwide and aims to reduce the volume of traffic, limiting trips made in private transport and encouraging the use of sustainable modes of transport

(public transport, cycling or pedestrian); The "Mobility Shop" arose from the participation of the Municipality of Porto in the community project "MOST" (Mobility Management Strategies for the Next Decades), having as main objective the development and evaluation of strategies for mobility management in European countries; The "Mobility Shop" is integrated within the community project Civitas Plus (www.civitas.eu) , where the Municipality of Porto leads a consortium of several institutions of the city;

- priority Measures for Public Transport in the City of Porto: The report of the Priority Measures for Public Transport in the City of Porto, which was presented in September 2008, aimed for the improvement of the speed of public vehicles and the lifting of existing constraint points in the city of Porto. This report aimed to enhance public transport, making public space more efficient and appropriate to users, taking measures to minimise the impact of the buses movement within the city and also fostering the creation of interfaces dedicated to the road transport service, promoting the concentration of services.

4.CONCLUSIONS

The data presented for the chosen case study show clearly that the Metro of Porto has contributed to the economic, social and environmental sustainability of the Great Metropolitan Area of Porto, offering a service, which has been progressively extended to a larger region and to a higher number of users. As stated before, Porto has a great relevance in the regional context and any change carried out in its area has the potential to engage a regional change due to the many regional connections to it and to its attractiveness.

The example of the Metro of Porto can certainly be replicated in other areas of the North Region and in other regions of the country, naturally with the necessary local adjustments in function of socio-economic conditions of the population, the foreseen demographic variation, the type of use of the territory and possible changes in urban occupation due to more demanding urban functions, the public equipment's in presence or to be built in the near future - as potential generators of daily movements, the existing transport network and the different mobility pattern sand also the characteristics of the territory which can restrict, for instance, pedestrian mobility and favor the use of public transport, namely, Metro.

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