Ref. Ares(2022)6038225 - 31/08/2022

+Horizon 2020 – project number 952219
Research and Innovation Action Topic FETPROACT-EIC-05-2019

112CO2

Low temperature catalytic methane decomposition for COx-free hydrogen production

Deliverable D7.21 – First Social Impact Analysis

List of Participants

Participant No.	Participant organization name	Country
1 (Coordinator)	UPORTO || Universidade do Porto	PT
2	CSIC || Agencia Estatal Consejo Superior de Investigaciones Científicas	SP
3	DLR || Deutsches Zentrum für Luft- und Raumfahrt	DE
4	EPFL || École Polytechnique Fédérale de Lausanne	CH
5	QTIS || Quantis	CH
6	PW || Paul Wurth	LU
7	PV || PixelVoltaic	PT

Start date of the project: 01/09/2020 **Duration of the project:** 42 months **Period covered by this report**: from 01/02/2021 to 31/08/2022 **Nr. pages**: 22	**Project coordinator name**: Adélio Mendes **Institution of the Project coordinator:** UPORTO **WP Reference**: WP7 **WP leader name:** Michael Graetzel **Institution of the WP leader: EPFL** **Institution of the Responsible:** UPORTO

History of Changes

Version	Date	Summary of Changes
V1	26/02/2021	First Version
V2	31/08/2021	Second Version

List of Contents

1. Introduction

The IS-UP team is the responsible for tasks regarding Social Impact Assessment included in work packages 6 and 7., We start from the proposal of responsible research and technology (RRI), as defined in regulation n. 1291 of the European Union, published in 2013, which considers that the acceptance of technology by the various stakeholders, as well as by society in general, is decisive in the co-construction of solutions for the energy transition in general and, specially, the hydrogen paradigm. From a sociological point of view, we seek to evaluate the societal impact of the technology developed at ***112CO2***, aiming to obtain information on the perception that society has about it and its potential acceptance or rejection, but at the same time disseminating the project to promote a debate about it and promoting critical participation in the co-construction of future solutions. It is therefore the motto for the discussion on the energy transition in general and the hydrogen paradigm. Our main objective, in the spectrum of sociological analysis aimed at the perception of social impact, is 1) **to identify external stakeholders**, classify them and outline a strategy for their participation in the research of Social Impact Assessment, and 2) **to understand how the perceptions of the stakeholders risks and benefits**, in relation to the hydrogen paradigm, are socially constructed and can influence the acceptance of hydrogen technologies. These objectives result in an *ex-ante* assessment of the societal impact, within the scope of an approach of *Responsible Research and Innovation* (RRI), taking into account the societal risks and benefits that the energy transition places on the societal agenda. It is intended to produce a reflection capable of going beyond the economic interests that underlie this type of business that moves international political agendas, making visible the most hidden aspects that technology disguises under the appearance of neutrality of choices. From a sociological perspective, the identification of conflicts between stakeholders with divergent interests in the energy transition and their clarification in terms of contributions to make complex and unclear issues visible to the public and to local and regional authorities in particular is an important goal in the co-construction of the new energy paradigm.

Deliverable D7.21 entitled “First social impact analysis” describes our methodological strategies for mapping, identifying and consulting stakeholders with the main aim to co-construct, in a participative way, the future of hydrogen paradigm and the energetic transition. The content of this text will demonstrate the evolution and current state of the work of the IS-UP team, responsible for the application of sociological methods and techniques to respond to the social impact assessment.

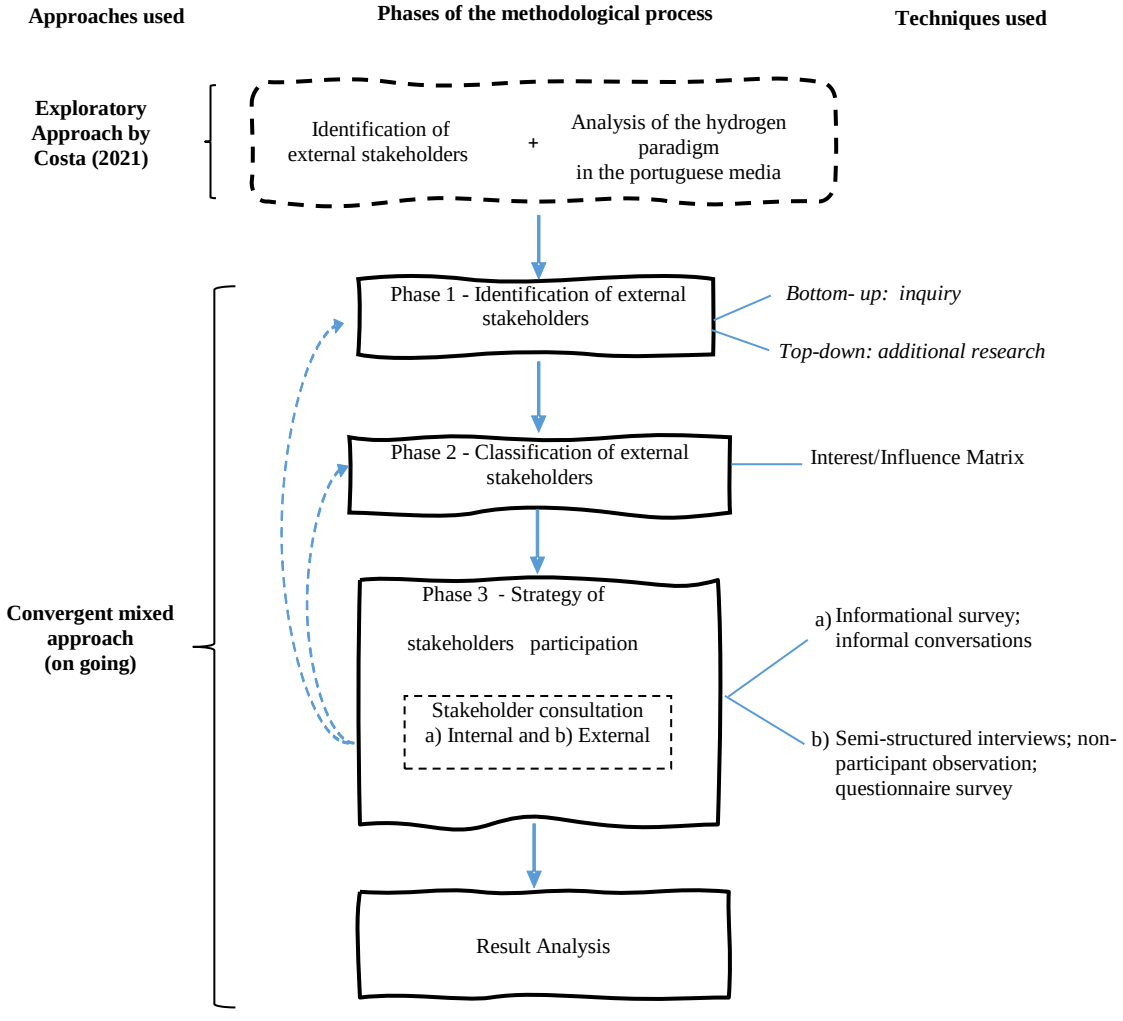
2. Strategies for mapping and involving of stakeholders

2.1. Research Strategy

Throughout the course of the project, it was necessary to identify stakeholders for the dissemination and communication of the project, as well as to capture the influence of civil society for the eventual co-construction about the future of the Hydrogen paradigm, and to do an *ex ante* assessment for social impact based in people perception of the hydrogen paradigm.

The *ex-ante* assessment of the societal impact of ***112CO2*** carried out by the IS-UP team is organized in two major phases, guided by a context of discovery, justified by the general lack of knowledge about the problem, as Hanush and Shad (2021) highlighted. Figure 1 summarizes our path of identifying, mapping and consulting stakeholders

Figure 1. *Mapping and Consulting Stakeholders. Source: (Teixeira, 2022)*



In the first year of the project (2020-2021) the research was guided by an exploratory approach with an analysis of the relationships between the consortium members, in which objectives, expectations and reasons for participating in the project were reviewed, as well as bridges of tension and conflict. At the same time, an analysis of the content of news on the subject in Portugal, based on the consultation of two Portuguese newspapers with a large circulation – *Jornal de Notícias and Jornal Público* – between 2015 and 2020 was done. The conclusions drawn from reading the contents of these newspapers suggest a negative position about the hydrogen, linked to disbelief in relation to the Government. Insecurity and uncertainty regarding hydrogen technologies were often highlighted. These uncertainness towards the state may hinder the transition of the energy paradigm, for which it is essential that we contribute to an informed civil society that understands the risks, benefits and urgency of implementing hydrogen technology in our societies (Costa, 2021), with due precautions and considering the different sensitivities of stakeholders. Among these are local, regional and national governments, companies and other private institutions, and organized civil society/third sector or social movements and anonymous citizens. This first phase allowed us to give broader notions about the theme, namely the strong gap identified by Hanush and Shad (2021) with regard to the lack of studies in social sciences on the theme of the Hydrogen paradigm. Therefore, after the exploratory studies, we had to outline a strategy for mapping stakeholders to understand their perceptions in relation to Hydrogen technologies as well as to disseminate the project among European actors.

In the second year, a stakeholder mapping strategy for the ***112CO2*** Project was outlined, initiating a survey of internal stakeholders with the aim of identifying and reaching potential external stakeholders. Following this approach, the first step for mapping was to follow the model presented by Reed et al. (2009) regarding the identification and classification of stakeholders (combining a top-down and bottom-up approach). In this way, we launched an informative online survey to internal stakeholders in order to capture and inventory the names and contacts of possible external stakeholders. We also had to design other strategies to capture new names that could add to our list.

In an effort to complement the list of contacts, the IS-UP team carried out an additional investigation in cyberspace; we have also participated in workshops and communications who taught us about strategies to engage stakeholders. One of the most important workshops was the EMBRACE Project workshop, held online in May 2022 and then in Brussels in June 2022. It was useful as a tool to learn more about the strategies for stakeholders engagement and to discuss what we have done in this dimension. Other fundamental events who helped us to increase our stakeholders list was a meeting organized by the Portuguese Non-fundable Governmental Organization ZERO (Sustainable Terrestrial System Association) in July 4th 2022 and July 14th 2022, which focused on the role of civil society in the hydrogen economy, having participants from several countries, namely German and Polish organizations. This meeting gave us access to the list of companies, organizations and public authorities financed by EUKI (European Climate Initiative). This list allowed us to increase our possibilities of contact with European stakeholders, mainly from Germany, Poland, Italy, Belgium, Austria, *etc*. In July 2022, we had a total number of 304 internal and external stakeholders that might have some interest or influence on the Hydrogen paradigm at the present time. We have also designed an online survey, which was launched to all the external stakeholders. As for the interviews, it is important to highlight the predominance of the presence of Portuguese

stakeholders, which results from the inherent difficulty of the IS-UP team to conduct interviews outside Portugal. On the other hand, the survey was successful in attracting respondents outside Portugal, although these numbers are still insufficient.

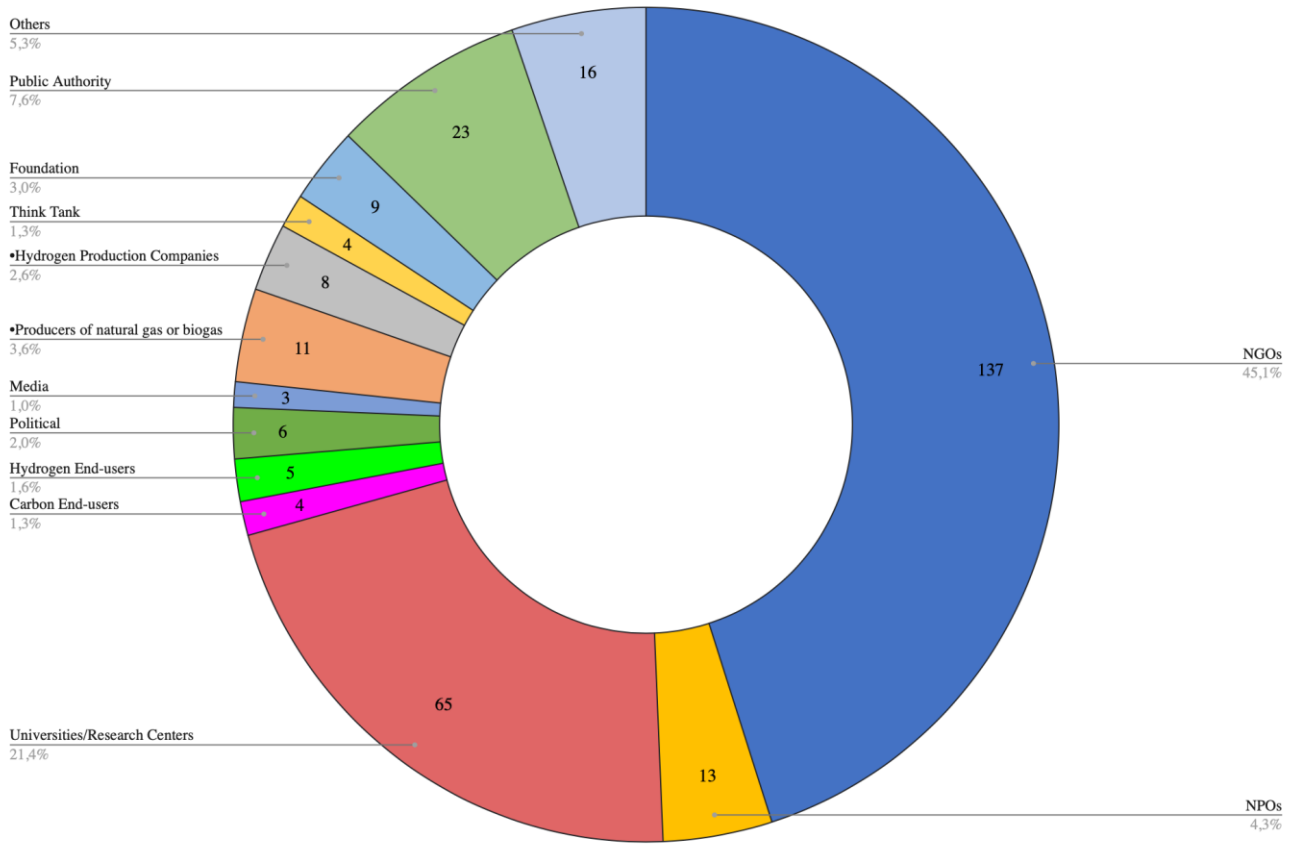


Figure 2. *Stakeholders identification. Source: Authors*

In this research, sectoral associations and environmental NGOs were highlighted. It should be noted that the stakeholder mapping process is dynamic and it is intended to continue to expand it throughout the duration of the 112CO2 Project, either with indications from the surveys launched or independent research carried out by the team. Once the stakeholders have been mapped, the next step refers to the study of risk and benefit perceptions. To this end, a methodological strategy anchored in a mixed convergent approach was applied which, according to Creswell (2014), aims to collect and process qualitative and quantitative data simultaneously, with the application of the online survey to all identified stakeholders and interviews with national NGOs, aiming to a convergent and integrated analysis of a complex social phenomenon such as the risk in the energy transition to Hydrogen. The interviews addressed a group of Organized Civil Society/third sector stakeholders who appeared in the media, either as supporters or with lobbing and advocacy activities in the face of Hydrogen. Given its exploratory nature, the research assumes an inductive logic and incorporates a constructivist perspective, concerned with understanding the social construction of meanings, guided by a pragmatic perspective, which combines different methods and techniques to study the object of study (Ibidem). The convergent mixed approach aims to compare the objective results by the different techniques, in the following dimensions: perceptions of the risk and benefits of Hydrogen;

sustainability values; prior knowledge; trust in science, political institutions and the media. Finally, it is important to mention that the techniques were used to identify new possible stakeholders, expanding the list of contacts based on a snowball sampling method.

2.2. Interviews and online survey

The interviews started to be applied on April 7th, 2022 and, a month later, we developed the survey applied during the month of July and August 2022. We currently have a total of 7 interviews, all applied to Portuguese stakeholders in the Organized Civil Society sector. The interviews were semi-structured, giving space for the interlocutor to develop their ideas so that we could better capture their perceptions. We divided it into six major dimensions of interest and analysis:

1) ***Culture of the NGO/Association***, based mainly on the association's perspective and how the organization could play a role in the energy transition. The main objective of this dimension was to understand how stakeholders located Hydrogen within the paradigm energetic;

2) ***Knowledge about Hydrogen***, in which we asked about the perception in the sense of the associations that the stakeholder made with the word Hydrogen, how they were familiar with what types of Hydrogen and the means of obtaining information. The objective of this section was precisely to map general knowledge and familiarity, in addition to the opinions and means of information of these agents;

3) ***Trust in Institutions*** focused on the perspectives of public policies and the role of science and technology in society, we seek to uncover how much stakeholders trusted institutions for the energy transition and the perceptions about public policies in this area;

4) ***Perception of the benefits and risks of Hydrogen***, where the questions revolved around understanding the bonuses and burdens of applying Hydrogen as a source of energy and whether or not this entailed any danger, and whether it was worth risking for the general benefit.

The objective of this fourth dimension is based on Risk Theories and how fear can (or not) influence the acceptance of Hydrogen;

5) ***Acceptance and Support***, in addition to the previous dimension, we asked the interviewees how they would define themselves in relation to the Hydrogen paradigm, in order to make some correlation with the previous questions;

6) ***Identification of external Stakeholders***: finally, we asked the interviewee to introduce himself some socio-demegraphic data (age, level of education, history of the Association/NGO) and we also asked for the indication of other possible stakeholders. In this way, with snowball process, we could substantially expand our list of stakeholders. For more information, check Annex I

However, so far and due to budgetary impossibility and the availability of allocated human resources, the interviews are restricted to the Portuguese case, although they are applied to organizations and actors with strong international relations. This approach was strongly anchored in a Master's thesis in Sociology (Teixeira, F. S., in completion), without a homologue at the level of the other countries belonging to the consortium, which constitutes a limit to the analysis and dissemination intended with the social impact assessment.

The interviews, together with the survey, are part of a convergent mixed methodology, as mentioned before. The aim is to take stock of the perceptions of the Hydrogen paradigm. The interview would complement us with more specific and detailed information on the subject, being able to help us in the matter of speeches. The justification for choosing this methodology is based on three pillars: first, we would have a complexification of the data on perception, enriching the analysis; second, from the experience of the first year, it was discovered that only one instrument for collecting the material would bring little result, as the response rate is usually low, as also perceived in our research; and, finally, the online survey would allow for faster and easier dissemination to stakeholders across Europe, thus increasing the chances of more responses.

Our main objectives with the survey are: understand what risks external stakeholders associate with the hydrogen paradigm; identify which dimensions may have greater influence on the social construction of risk regarding the hydrogen paradigm; understand the role of risk perception in the acceptance of hydrogen technologies; classify and identify new external stakeholders.

The survey was divided into 5 major dimensions of interest and analysis:

i) ***Environmental Values***, valuing the degree to which each individual cares and values the issue of energy transition; this way we will be able to map the perceptions, concerns and actions of the company/organization regarding the sustainable energy transition;

ii) ***Knowledge***, trying to understand the familiarity with hydrogen technologies and policies and sources of knowledge (scientific journals, blogs, radio, etc.);

iii) ***Trust***, to understand if there is trust in the decisions made by governments and science regarding the hydrogen paradigm, as well as the information disseminated by the media, with the aim of understanding how trust in the various institutions can influence the perception of risks and acceptance of the paradigm of Hydrogen;

iv) ***Risks***, that is, the risks perceived by individuals regarding the paradigm, the objective of analysis is to understand the risks associated with hydrogen technologies, as well as the degree of concern with them;

v) ***Acceptance and Support***, would show us the degree of support and acceptance of technologies and associated risks; the objective of this dimension is to understand the degree of acceptance of Hydrogen technologies and how the previous dimensions determine their support. For more information, check Annex II.

The application of the online survey opened an opportunity for us to receive greater feedback, especially with a considerable number of stakeholders. However, we still get low response rates, with an average of 10% of all respondents. There will be, nevertheless, new applications in order to absorb as many responses as possible. Biweekly reinforcements have been applied, which started on July 17th 2022 and continuing until the end of September of the same year. We currently have 36 surveys answered. Furthermore, considering the scale of the project, we intend to further expand our list of stakeholders through a network analysis carried out on digital platforms. Thus, we have been able to outline some discoveries and difficulties within this field of analysis, which will be exposed in the next section.

3. Interviews and survey and results: a preliminary analysis

In this moment, having 34 answers, through interviews and the inquiries, it was able to draw some preliminary results from an ongoing research process, which will be discussed below. It can be seen in Table 2 the sociodemographic characterization of stakeholders as a result of the responses we have been able to collect so far (August, 2022).

Table 1. *Sociodemographic characterization of stakeholders*

	Interviews N(%)	Survey N(%)	Total N(%)
Sex			
Male	7 (100)	18 (66,7)	25 (73,5)
Female	0	9 (33,3)	9 (26,5)
Total	7 (100)	27 (100)	34 (100)
Age			
< to 35 years	1 (14,3)	6 (22,2)	7 (20,6)
36 to 45 years	1 (14,3)	10 (37,0)	11 (32,4)
46 to 55 years	2 (28,6)	7 (25,9)	9 (26,5)
56 to 65 years	2 (28,6)	3 (11,1)	5 (14,7)
over 66 years	1 (14,3)	1 (3,7)	2 (5,9)
Total	7 (100%)	27 (100%)	34 (100%)
Education			
Under Postsecondary	0	0	0
Bachelors	2 (28,6)	3 (11,1)	5 (14,7)
Masters	4 (57,1)	17 (63,0)	21 (61,8)
PhD/Post Doctorate	1 (14,3)	7 (25,9)	8 (23,5)
Total	7 (100%)	27 (100%)	34 (100%)
Institutional belonging			
Civil Society /Third Sector	7 (100)	12 (44,4)	19 (55,9)
Political Sector		2 (7,4)	2 (5,9)
Media		1 (3,7)	1 (2,9)
Hydrogen Producers		0	0
Hydrogen Consumers		0	0
Solid state carbon consumers		0	0
Universities/Research Centers		6 (22,2)	6 (17,6)
Producers of natural gas, biogas, or synthetic natural gas		0	0
Other		6 (22,2)	6 (17,6)
Total	7 (100%)	27 (100%)	34 (100%)
Country			
Germany	-*	4 (14,8)	4 (11,8)

Bulgaria	-	3 (11,1)	3 (8,8)
Czechia	-	1 (3,7)	1 (2,9)
Slovenia	-	2 (7,4)	2 (5,9)
Estonia	-	1 (3,7)	1 (2,9)
Greece	-	1 (3,7)	1 (2,9)
Hungary	-	2 (7,4)	2 (5,9)
Lithuania	-	1 (3,7)	1 (2,9)
Poland	-	3 (11,1)	3 (8,8)
Portugal	7(100)	6 (22,2)	13 (38,2)
Romania	-	3 (11,1)	3 (8,8)
Total	7 (100%)	27 (100%)	34 (100%)

Source: (Teixeira, 2022)

* Interviews were not applied

The main findings about the hydrogen technology are the following (Teixeira, 2022):

i) There is a relative lack of knowledge about turquoise hydrogen production technologies, the one being developed within the ***112CO2*** Project, with 33.3% (n=9) of respondents saying they are totally unaware of these technologies, 18.5% (n=5) say they have little familiarity with it and 11.1% (n=3) revealing having some familiarity. However, the remaining 37% (n=10) claim to have a deep knowledge of these technologies. It was relevant to understand the degree of acceptance of the technology under development and its self-assessment about its interest and influence. To this end, a short text was presented in the questionnaire survey that summarizes the purposes of the project and briefly explains the hydrogen production process.

ii) The survey data show that 88.8% (n=24) of the stakeholders express an interest in the technology, with the Universities/Research Centers group being the most interested (22.2%, n=6) and the SCO group the most critical (11.1%, n=3).

iii) Regarding the level of influence of our stakeholders, 55.5% (n=15) consider having little or no influence on the project, with the most influential stakeholders from the Civil Sociey/Third Sector (7.4%, n=2) and from the political sector (3.7%, n=1)

iv) However, respondents have a positive expectation about the technology in terms of environmental impact, since 74% (n=20) consider that the technology will have a positive environmental impact.

v) Furthermore, with regard to the social and economic impact and expectations about the safety and costs of the technology, the opinion of the stakeholders tends to be positive, but there is a greater positioning in the intermediate levels of the scale, which could translate into a lack of opinion about these categories. It is concluded that the environmental, social and economic benefits of the ***112CO2*** Project may be more significant than the possible perceived risks. With regard to blue or turquoise hydrogen, the one that is intended to be produced in the ***112CO2*** Project, despite being shown interest in the technology, there is a great lack of knowledge about this type of emerging technologies, although a tendency to accept them is demonstrated.

Regarding the perspectives of stakeholders about the energy transition and the hydrogen paradigm, we can conclude that there is a consensus among stakeholders that the energy transition is necessary and that, above all, green hydrogen is seen as a viable bet to comply with this transition and accelerate decarbonization.

It was also possible to identify the importance of public participation in the speeches of stakeholders. It is expected that this will be presented throughout the energy transition process, but it was perceived as still insufficient, both in politics and in science, as the gap between the transmission of knowledge has not yet been overcome (Teixeira, 2022).

On the one hand, the benefits essentially have to do with economic, environmental, technical and social benefits. In the interviews, the properties of the hydrogen molecule were underlined, due to its inexhaustibility, storage capacity and its ability to be burned in a non-polluting way, allowing for the decarbonization of various sectors where direct electrification is not possible and, thus, representing a possible replacement for fossil fuels. In this way, consequent benefits are related to the possibility of strengthening and complementing the national energy system in terms of renewable energies, increasing the security of energy supply and creating a new value chain with (green) hydrogen production at competitive costs.

The assessment of the perceived risks associated with the hydrogen paradigm has allowed us to identify four types of risks (Teixeira, 2022):

i) ***Technical or technological risks*** associated with technical and human failure, uncertainty in the implementation of these technologies on a larger scale, handling of hydrogen, accidents and problems in the transport of hydrogen;

ii) ***Environmental risks*** regarding a possible depletion of natural resources (mainly water) and impacts on biodiversity, still unknown;

iii) ***Social risks***, which refer to the possible public rejection of hydrogen technologies, pressure from economic and political interests to invest in certain technologies and give rise to conflicts of interest, dependence on political will, misinformation about the risks and benefits of hydrogen technologies, the creation of new needs, occupation of the territory without well-defined criteria, and decisions that make the use of hydrogen inefficient;

iv) ***Financial risks***, related to large investments in emerging technologies and infrastructure, as well as continued energy dependence for the production of gray or blue hydrogen. The factors that underly the construction of these perceptions are related to context issues (macro level), group issues (meso level) and individual issues (micro level). These factors trigger processes of amplification or minimization of risks, which translate into different types of acceptance of hydrogen technologies, with a greater tendency towards the acceptance of technologies for the production of green hydrogen.

We can summarize the results and conclusions as follows:

1. Stakeholders are experts with a greater familiarization with green hydrogen projects;
2. There is a general ignorance about turquoise hydrogen production technologies;
3. We can perceive some resistance to these technologies due to the perception of dependence on natural gas, confining it to favorable technologies for a time of transition and for niche sectors;

4. In general, the stakeholders surveyed (N=27) are interested in the ***112CO2*** Project;
5. Finally, they do not have a strong opinion/expectations about the safety, environmental impact and cost of the technology. However, overall expectations are positive.

4. Limitations and future research

Throughout the research process, it was encountered some specific limitations that projected us to think more carefully about the next steps of the research. On the one hand, one of the main concerns was: **1) *the low response rate***: on average, we only had 10% of respondents overall. We know, however, that the months in which we applied the survey were vacation months for some stakeholders, which may have influenced this rate. Another major concern that surrounded us was **2) *the perception of the technicality*** involved in the discourses on the Hydrogen paradigm. The experience obtained in the first and second years of the project showed us that the more involvement of civil society, the better the successes in the energy transition, due to social acceptance. As long as the discourse is concentrated on academic and technical layers, the transition will be made in a top-down direction, which is exactly what some of the NGOs we had contact with want to avoid. Finally, in the bibliometric analysis carried out by the team, it was discovered that **3) *there are very few articles and studies carried out in the field of social impact analysis of the energy transition with Hydrogen***. Again, a reality shown by Hanush and Shad (2021) of the lack of social studies in this area and the high technicality of the discourses involving Hydrogen is corroborated.

In this sense, the future steps to be carried out by the IS-UP team seek to resolve/minimize these three issues. In the case of the low response rate, we will **1) *increase the list of stakeholders for more responses and continue with the survey*.** To expand the list of stakeholders, we will outline an online strategy for mapping stakeholders through the analysis of networks on digital platforms, such as LinkedIn. The network of contacts of each stakeholder that we have in our base will be analyzed in order to diversify and reach other names based on the connections that these people/organizations have. Regarding the technicality of the theme, we will seek to **2) *get involved in citizen science plans***, trying to bring the very recent discourse of Hydrogen closer to civil society, in partnership with the aforementioned stakeholders. Finally, in the process of research in the 112CO2 Project, we will seek, at the root of social studies, **3) *to produce articles that fill the gaps found***, thus feeding sociological studies within the theme of the Hydrogen paradigm.

References

Costa, C. (2021). *O Envolvimento de Stakeholders no Projeto 112CO2*. [Unpublished Master's Thesis]. Universidade do Porto. https://repositorio-aberto.up.pt/handle/10216/137001

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (4th Ed.). Sage

Hanusch, F., and Schad, M. (2021). Hydrogen research: technology first, society second?. *GAIA – Ecological Perspectives For Science And Society*, *30*(2), 82-86. Doi:10.14512/ gaia.30.2.5

Reed, M., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., & Morris, J. et al. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal Of Environmental Management*, *90*(5), 1933-1949. Doi: 10.1016/j.jenvman.2009.01.001

Teixeira, F. S. (in completion 2022). *Mapeamento de stakeholders e perceções sobre o paradigma do hidrogénio: um estudo exploratório a partir do projeto 112CO2*. [Unpublished Master's Thesis]. Universidade do Porto

Annex I

SEMI-STRUCTURED INTERVIEW

I. Culture of the NGO/Association

1. Regarding the topic of sustainable energy transition and energy decarbonization, how does (name of Association/NGO) see this transition?
2. What impact can your Association/Organization have in this transition?
3. (IF YOU DO NOT MENTION HYDROGEN) Getting into the hydrogen paradigm, how does your Organization foresee the role of hydrogen in this transition?

II. Knowledge about hydrogen

4. Moving on to the hydrogen paradigm dimension: What is the first word/phrase/image that comes to your mind when you hear the word hydrogen?
5. Considering that there are different modes of hydrogen production, are you familiar with any of them? Which/Which?
6. IF YOU KNOW HOW TO DIFFERENTIATE BETWEEN TYPES OF HYDROGEN: Overall, how do you think turquoise hydrogen is currently perceived?
7. Do you feel that the perception of people, more precisely economic, industrial and political agents, in relation to hydrogen, has changed over the last few years? If so, what might have triggered this change? Because?
And if not? Because?
And the general public, can you have that perception?
8. By what means do members of (name of NGO/association) seek information about the hydrogen paradigm?

III. Trust in institutions

9. Now let's talk a little bit about public policies related to hydrogen. Is (name of NGO/association) familiar with current national and European policies related to Hydrogen? If yes, what is the position of (name of the NGO/Association) in relation to these public policies?
10. How does (name of NGO/association) view the role of science and technology in society?

IV. Perception of the benefits and risks of hydrogen from (name of NGO/Association)

11. What benefits do you associate with hydrogen as an energy carrier?
12. On the other hand, what risks do you associate with hydrogen as an energy carrier?

13. If not developed in the previous answer: What reasons lead you to enumerate these risks?
14. Do you consider that these risks are known?
15. What is your opinion on the way in which the media present these risks?
16. What impacts or consequences do you think these risks could trigger?
17. How do you think these risks can be mitigated?
18. Do you consider these risks to be acceptable?

V. Acceptance and Support

19. How do you define yourself in relation to the Hydrogen paradigm? For, against, indifferent, with doubts. Because?

SAW. Identification of External Stakeholders

20. In the last section: you can briefly introduce yourself regarding your age, level of education and career in (name of the Association/NGO).
21. Finally, and because we are mapping the stakeholders, I would like to ask which other associations/organizations, institutes, companies, political or media bodies do you think it is appropriate to contact on these matters. It can indicate names, institutions, ..

We're done. Thank you so much for your time and attention!

Annex II

Online Survey

Stakeholders' perceptions of hydrogen paradigm

SECTION I) Sustainability

I) Please indicate to what extent you agree or disagree with the following statements on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree):

1. My organization/company is concerned with sustainable energy transition issues
2. My organization/company has behaviors/actions that promote sustainable energy transition

SECTION II) Knowledge

II) Please indicate to what extent you know the following concepts on a scale of 1 (I don't know at all) to 5 (I know extremely well):

1. Grey hydrogen;
2. Green hydrogen;
3. Blue hydrogen;
4. Turquoise hydrogen.

III) Indicate to what extent you know the hydrogen paradigm with regard to the dimensions listed below on a scale from 1 (I don't know at all) to 5 (I know extremely well):

1. Hydrogen production Technologies
2. National and european public policies within the scope of the hydrogen paradigma

IV) Please indicate to what extent you find information about hydrogen technology in the following sources on a scale from 1 (Never) to 5 (Always):

1. Television/Radio
2. Social media and blogs
3. Newspapers/ Large circulation magazines

4. Technical magazines
5. Scientific articles
6. Conferences
7. Information from national and community authorities

SECCTION III) Trust in Institutions and Public Participation

V) Indicate to what extent you agree with the following statements regarding the hydrogen paradigm as an energy alternative on a scale from 1 (Strongly Disagree) to 5 (Strongly Agree):

1. The success of the hydrogen paradigm depends on political will
2. The hydrogen paradigm is a familiar topic for citizens of my country
3. Decisions made by politicians on hydrogen technologies are safe and responsible
4. There is room for public participation in national decisions on the hydrogen paradigma
5. The risks linked to new technologies are temporary problems that will eventually be solved by science
6. I trust the information released by the media about the hydrogen paradigma

VI) Indicate to what extent you consider it important to consult and involve the following agents in decision-making on the hydrogen paradigm in the context of energetic transition on a scale from 1 (not at all important) to 5 (very important):

1. Scientists and technicians
2. Businessmen
3. Politicians
4. General population
5. Social movements
6. Industry associations
7. Environmental NGOs

SECTION IV) Risks and Benefits

VII) Of the risks you associate with hydrogen paradigm, indicate your degree of agreement about each one on a scale from from 1 (Strongly Disagree) to 5 (Strongly Agree):

1. Insecurity
2. Technical/human failures

3. Hydrogen handling and transportation
4. Depletion of natural resources
5. Non-efficient use of hydrogen
6. Dependence on political will
7. Disinformation
8. Energy dependence
9. Scalability of technology
10. Infrastructure

VIII) Of the benefits you associate with hydrogen paradigm, indicate your degree of agreement about each one of them, on a scale from 1 (Strongly Disagree) to 5 (Strongly Agree):

1. Strengthening or complementing renewable energies
2. Replacing fossil fuels
3. Creation of a new value chain
4. Competitive cost of hydrogen production
5. Hydrogen can be produced in a green way
6. Use of hydrogen in sectors such as industry and mobility, where electrification is not possible
7. Hydrogen storage capacity
8. Hydrogen can be burnt without emitting greenhouse gases

SECTION V) Acceptance and Support

IX) Please indicate to what extent you agree with the following statements, on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree):

1. I am in favor of investing in hydrogen technologies in my country
2. Using hydrogen as an energy source is good for the environment
3. The consequences of using hydrogen are acceptable for future generations

X) Indicate your position on hydrogen production modes and its production costs on a scale from 1 (totally against) to 5 (totally in favor):

1. Hydrogen must be produced from exclusively renewable sources even if this implies higher production costs

2. Hydrogen must be produced from renewable and non-renewable sources in order to reduce production costs
3. Hydrogen must be produced from exclusively renewable sources, but only if there is no increase in production costs

112CO2 TECHNOLOGY

The following text presents the technology to be developed in the 112CO2 project:

The EU-funded 112CO2 project offers an innovative process for decomposing methane (also known as methane pyrolysis) running at low temperature for cost-effective production of carbon dioxide-free hydrogen. It employs cyclic reactor regeneration along with carbon removal for storage. The reactor developed will be suitable for mobile and stationary applications. This invention was filed under a patent (WO2020121287) owned by Pixel Voltaic and is currently protected in Europe, North America and Asia. The sustainability of the 112CO2 solution is not only environmental, but also economic and social.

XI) Indicate your degree of INTEREST in the 112CO2 project, which aims the production of clean hydrogen by decomposition of methane:

1. Interest - (Not at all interested to Extremely interested)

XII) Indicate your degree of INFLUENCE in the 112CO2 project:

1. Influence – (Not at all influential to Extremely influential)

XIII) Indicate your expectations about Environment, Safety and Cost, regarding this technology on a scale from 1 (negative pole) to 7 (positive pole).

1. Environment - (Very negative impact to Very positive impact)
2. Safety – (Very dangerous to very safe)
3. Cost – (very expensive to very cheap)

SECTION VI) Characterization and identification of stakeholders

XIV) Indicate the sector in which your institution operates:

1. Political
2. Sectorial or Business Associations

3. NGO
4. Media
5. Hydrogen End-Users
6. Hydrogen Production Companies
7. Universities/Research Centers
8. Carbon End-Users
9. Producers of natural gas, biogas, or synthetic natural gas
10. Others

XV) Indicate the country in which your institution is located:

1. Open Answer

XVI) Indicate your age

1. Open Answer

XVII) Indicate your gender

1. Male
2. Female

XVIII) Indicate your level of education

1. ISCED 1-2 (9 years of school or less)
2. ISCED 3 (12 years of school or less)
3. ISCED 4-5 (Post-secondary non-tertiary education or Short-cycle tertiary education)
4. Bachelor's Degree
5. Master's Degree
6. PhD/Post-Doctoral Degree

XIX) To continue our research, we need to identify companies, research centers, state agencies, organizations/associations or individuals who are interested in and/or can influence hydrogen technologies. Please provide us with some contacts:

1. Contact 1: Name and Adress
2. Contact 2: Name and Adress
3. Contact 3: Name and Adress