CHIST-ERA-19

SEEDS Project

[D3.1 Report on the background research]
[D3.2 Design Artifacts - Personas, Interactive scenarios]

January 2022

Author:
Debora Conceição Firmino De Souza (TLU)

Note about contributors:

The contributors offered advisory support or/and assistance throughout the inquiry research and participatory activities.

Contributors:

Ilja Šmorgun
David Jose Ribeiro Lamas
Joanna Agata Rutkowska
Gabriela De Moraes Beltrão
Silvia Keerd
Girish Srinivas Rao Nalawade
Yi-Ting Yeh

Content

List of figures

Executive Summary

This report covers Deliverables 3.1 and 3.2 of the SEEDS project WP3 - Participatory design of the web interface for energy system modeling. The purpose of WP3 is to capture insights into the needs and predispositions of project stakeholders for specific user interface implementations. The research question addressed at this stage was: (1) What are the needs and predispositions of stakeholders towards the future energy system modeling tool?

The report is divided into two parts:

- *D3.1 Report on the background research, development of the initial design concept*, explains the execution of the conduct contextual inquiry in the form of desk research, and interviews with beneficiaries and energy system modeling experts.
- *D3.2- Initial Design Concept, Personas, and Scenarios,* describes how the background research and first workshop participatory exercises were combined to define personas and interaction scenarios providing input on user preferences for the energy system model.

The research reported here was conducted over six months, from Augusto 2021 to January 2022. This phase of the design project was meant to generate concepts and insights used throughout the development of the final product proposed. The present report offers an outlook of the procedures and findings disclosed by the initial research on the SEEDS project scope and activities.

1. Introduction

The long-term framework for the transition to a renewable energy-based energy system in Europe aims to tackle climate change issues by promoting sustainable and renewable energy alternatives to reduce greenhouse gas emissions. It requires, nevertheless, socio-economic adjustments and changes in the way that energy is generated, distributed, and consumed.

For that reason, efforts have been applied in experimenting with models to explore possible configurations in the future. Nevertheless, those models have focused on assessing scenarios that overlook social issues and environmental sustainability, often pushing the people affected by the implementations of these scenarios out of the decision-making loop. Although there is considerable knowledge about how the social and political aspects impact the transition, the offered solutions focus on cost minimization and techno-economic worldviews.

Using Portugal as the case study, the Stakeholder-Based Environmentally-Sustainable and Economically Doable Scenarios for the Energy Transition (acronym SEEDS) aims to help the local energy sector reduce GHG emissions and achieve carbon neutrality by 2050.

The original component in this endeavor is the project accountability for democratic participation and the socio-economic and environmental aspects entangled by the carbon neutrality strategies and energy transition policies. The SEEDS tool relies mainly on two frameworks (Calliope and MUSIASEM Checker) associated with the participatory process outcomes to generate optimized scenarios for the energy transition and assist different stakeholders in negotiating feasible options.

The SEEDS project facilitates stakeholder engagement following Participatory Design, Generative Design Research, and user-centered design methods.

2. Methodology

The present phase of the project employed Participatory Design, Generative Design Research and User-Centered Design methods. For the novelty and complexity of the tool envisioned by the SEEDS project, the mixed methodology was considered a fruitful approach to developing an energy modeling tool that accounts for the experience and expertise of the participants in the conceptual and development phases.

Task 3.1 was executed into three iterative phases of desk research, expert interviews, and stakeholder interviews, ensuring the understanding of the project scope and framing its development.

This phase of the research was divided into two levels. The internal level involved the domain experts, researchers, and scientists of the project, and at the external level, the stakeholders.

Participatory Design is a collective creative process through which the users of an under-development system or service are engaged as co-creators during the conceptual and development phases of the design process. The approach of Participatory Design focuses on actively including the people who are being served by the designed artifacts, ensuring that the result of functionalities and features match users' goals and needs. Generative Design, in its turn, pertains to an area of research focused on methods to "empower everyday people to generate and promote alternatives to the current situation"(Sanders & Stappers, 2012) by facilitating communication, either visually or directly to each other, of their ideas, dreams, and visions for the future.

The designer's role in both approaches is to facilitate creative expression by creating a collaborative environment, developing the 'generative tools', and mediating the creative process during the co-design sessions. Afterward, from the expressions shared by the participants on the process, data analysis methods are applied to attain the insights and drive the further phases of the design.

Task 3.2 was executed by analyzing, reflecting, and interpreting the data collected from the initial research phases. The inquiries and co-design activities performed at both levels provided the necessary information for developing the User-Centered design artifacts, namely Personas, Interactive Scenarios, and Design concepts.

Tools and techniques of User-Centered design were applied to make sense of the gathered information about the preferences and profiles of users. The iterative approach has shaped the design process and generated the artifacts delivered by this report.

The diagram below (Fig.1) illustrates the mixed methodology dynamics, depicting the levels and phases of the task development, the participatory design activities facilitated, and the design artifacts generated.

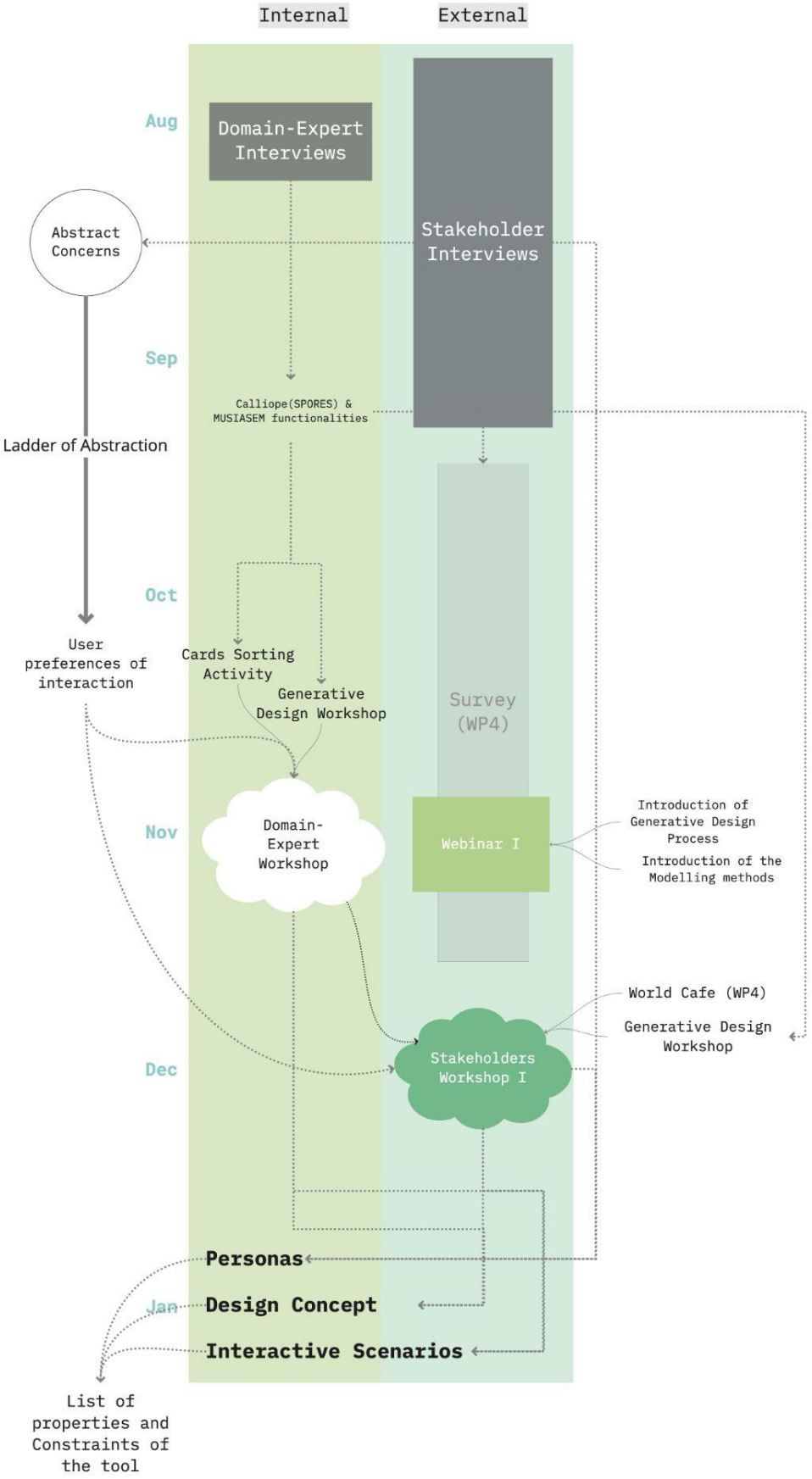

Fig. 1 - Task 3.1 overall methodology

3. Report on background research and development of initial design concept (D3.1)

3.1 Desk research

Desk research was developed during July, August, and September to review relevant literature on Participatory Design, stakeholder's value elicitation, energy systems modeling, and transition to renewable energy sources.

Besides scoping the design activities, the desk research informed the structure of the interviews and the two levels of participatory design activities. The research was rather iterative and exploratory for the novelty of the human-computer co-creation loop proposed in SEEDS.

The review included journal articles from databases such as 'Science Direct' and 'ACM', including textbooks on design methodologies and design artifacts. The iterations happened as the interviewers were suggesting topics to be researched. Such an exchange provided knowledge about previous case studies on energy modeling systems involving participatory methods and alternatives and challenges of the decarbonization of economies. Furthermore, relevant newspaper articles from Portugal were reviewed to better understand the energy transition context.

The European Union released 2011 a roadmap decarbonisation of Europe by 2050 (European Commission, 2011). The document outlines possible actions to enable greenhouse gas reductions and milestones towards the target, policy challenges, investment needs, and opportunities in different sectors. Each of the union members has also issued their national plans and target goals aligned with the 2050 long-term strategy, which include, among other aspects increasing renewable energy production, building new infrastructure, and replacing the use of fossil fuels energy sources.

Portugal has established a carbon neutrality plan and advanced with the transposition of new EU directives to national law (Campos et al., 2020) regarding the energy power generation sector. The plane presents alternative options to

achieve the carbon neutrality goals that affect multiple stakeholders in different social and economic areas.

The scenario of the Portuguese energy transition configures a complex transformation or an "unstructured problem", as suggested by Mingers and Rosenhead (2004). The transition entails reaching a consensus among multiple actors who see the problem from multiple perspectives and hold different interests and values regarding the process.

Within the scope of the energy transition, as Gunnarsdóttir et al. (2021) point out, the discussion with stakeholders and community representatives is highly beneficial for deciding the paths of the future energy systems and grasping a better understanding of what means sustainability within a particular setting. This way, the involvement of stakeholders enables identifying what is encapsulated in the desirable future scenarios. Therefore, the information retrieved from the desk research was structured to facilitate the dialogue between design researchers and stakeholders regarding the vocabulary of the energy systems, the technologies available in Portugal and its alternatives, and aspects of Europe's decarbonization targets and plans.

Nonetheless, acknowledging that "different stakeholders have diverging interests and opinions on how the energy transformation should take place" (Höfer & Madlener), the research also focused on investigating facilitation tools and design strategies to create a unique arena for co-designing interventions.

3.1.1 Mapping the stakeholders and context

The involvement of stakeholders was led by the SEEDS WP4, which employed the Multi-actor Perspective framework (Avelino and Wittmayer, 2016) for understanding the categorization of actors regarding different levels of aggregation, and the existing power relations in the transition process. Four categories are identified, namely: the state, which includes Policy and Regulators from national and regulatory bodies alongside municipality agents; the market, which includes energy services ranging from consulting companies to industrial associations; the community, which were included community groups and citizen’s participation forums; and the third sector,

from academia and research institutions to non-governmental environmental associations and renewable energy cooperatives and associations.

Accordingly, WP1 also identified for scoping the project three critical dimensions of the Portuguese transition context. The themes refer to: the structure of the energy system (how do decentralized distributed and centralized configurations come together?); the dynamics of the system (how do flexibility and storage shape social practices and system functioning dynamics?); and the speed of the transition (how does systems' transformation develop over time and what can be the resulting social, cultural, economic, environmental and political outcomes?).

3.2 Inquiry research

The inquiry research phase aimed to understand the contextual aspects of the Portuguese case study. In both Internal and External stages, the contextual inquiry (T3.1) was conducted in interviews with the project experts and beneficiaries and energy system modeling.

3.2.1 Domain-Expert Interviews

During the first fortnight of July, interview sessions were conducted with each of the project work packages participating in SEEDS, resulting in four interviews with researchers from social sciences, data sciences, and engineering. The goal was to draw an overview of each approach brought in by the team collaborators and understand the context of the energy market in Portugal concerning the propositions of the SEEDS project.

3.2.1.1 Procedure

The participants received beforehand a set of questions as sensitizing material. The subject of the questionnaire slightly varied depending on the expert's domain and roles in the SEEDS project; nonetheless, it covered the same topics regarding the strategy for carbon neutrality of the Portuguese economy.

The interview sessions were handled via Google Meets, with the participation of a moderator, an observer, and the interviewee. The sessions lasted one hour, and the audio of the interviews was recorded for further analysis.

3.2.1.2 Analysis

From the transcription of the interviews and notes taken by the observer, a summary of relevant topics was organized to guide the qualitative analysis.

The data collected from the sessions were analyzed by the KJ method of affinity mapping (Scupin, 1997), selecting specific categories within the data for organization and synthesis. The identified concepts were mapped in an affinity diagram organized in the shared collaborative board that remains an information artifact that can be consulted during the length of the SEEDS project. Additionally, a summary report on the Domain Experts interviews was organized to illustrate the insights and findings obtained in this research phase.

The insights obtained from the Domain Experts have facilitated the understanding of the scope of the SEEDS modeling workflow for the decarbonization transitions of the Portuguese energy system. Moreover, it offered new perspectives about the envisioned functionalities of the tool and areas for improvement, which would promote a democratic negotiation of the transitioning scenarios. Furthermore, the knowledge built upon the information shared by the domain experts was fundamental to understanding the contextual scenarios and the questionnaire's scope for the Stakeholders' interviews.

3.2.1.3 Findings

Regarding the current situation of the energy transition policies and actions in Portugal, several points were expressed by the domain experts. From the Social and Political perspective, it was mentioned that: a) The decentralization of the energy production model is referred to as a bureaucratic process, regulated by complex laws and procedures; b) Cost-oriented solutions are creating conflicts of interest among different participants of the transition process, in which private investments tend to lean towards economically favorable configuration and exchange benefits, without much consideration of the negative environmental impact and its consequences; and c) Portugal has no tradition of public participation processes, locals find that investment agreements and negotiations lack transparency and inclusiveness.

The researchers expressed that the long-term strategies for carbon neutrality have established the goals but still lack an action plan.

Regarding the importance of citizen participation and the involvement of stakeholder groups, the experts commented that currently, the involvement of big companies (oil/energy companies) in the transitioning process raises concerns from the other stakeholders regarding the transparency of the actions. This is mostly caused due to the unevenness among the stakeholders' positions in the transition process.

The modeling frameworks

Regarding the modeling of the energy system, the SEEDS tool relies on two major frameworks to output optimized scenarios for the energy transition and assist different stakeholders in negotiating feasible options. Firstly, calculations made by Calliope can output multiple ways to meet energy demands by analyzing cost-effective feasible options of energy sources and technology available. Optimal solutions are generated by linear programming; the method, however, cannot account for the social and environmental impacts caused by the given alternatives for each optimization scenario. It accounts only for low emission energy alternatives. Furthermore, to refine the results presented, an additional feature of Calliope's model called the SPORES method filters technically feasible alternatives close to the optimal cost but radically different in terms of technology (which energy source to use) and spatial aspect (where to install them). Which increases the number of optimal scenarios for a given configuration.

The second modeling framework, the MUSIASEM checker, assesses environmental aspects alongside social context aspects, adding a wider spectrum for the scenarios generated. It checks the feasibility of energy systems through the lenses of environmental performance indicators. In other words, MUSIASEM Checker will inform the consequences of each choice of scenario. For its deployment, the MUSIASEM checker relies on customizable data input for evaluating of specific impacts on specific situations (resources, employees, and working time, for instance).

The SEEDS energy modeling tool

The experts expressed their expectations for the SEEDS tool about how it should assist the stakeholders in accessing alternative scenarios for the energy transition. Pointing out that the integration of the two modeling frameworks, Calliope and MUSIASEM Checker, into a searching interface tailored to the stakeholders' needs has the potential to improve the process of decarbonisation of the Portuguese economy and empower the people involved and affected by the process.

The experts mentioned that the engagement of different stakeholders is crucial. Moreover, the participatory process can enhance awareness of social-economic benefits and opportunities, and possible impacts. Furthermore, the use of the SEEDS tool can enable users to reach a detailed understanding of the chosen energy production and distribution scenarios.

3.2.2 Stakeholders interviews

The critical themes identified by the WP4 were finetuned through the insights obtained by the domain-experts interviews, especially in terms of vocabulary and approach to foster the discussion with the stakeholders. This phase of the qualitative research was done through an interpretivist stance (McChesney & Aldridge, 2019) of the gathered data in order to integrally link the results of the analysis to the participants and the context of the research. This way seeking a better understanding of the stakeholders lived experiences from their point of view.

Six (N=6) semi-structured interviews were conducted with the Portuguese energy system stakeholders. The interviews individual with participants from each of the four actor categories previously identified by WP1 - the state, market, community, and the third sector. Stakeholders directly involved with the energy systems are more informed sources of information, and when interviewing them individually, “ a greater emphasis is placed on their expert knowledge” (Gunnarsdóttir et al., 2021). Therefore, the interviews were designed to enable access to divergent views and to understand stakeholders' different perceptions. The questions were contextualized by the desk research previously done to acknowledge expressions of the stakeholders' needs and key values.

3.2.2.1 Procedure

The interviews were handled in Portuguese and consisted of two moments. Firstly, participants responded to four ice-breaking general questions regarding their professional background and opinions about the current state of the Portuguese energy sector. Then, upon the scenario presentation, five questions were asked. Follow-up questions were made to delve further when deemed needed, enabling clarification of the answers and participants' values related to the transition themes.

A pilot was used to test the structure and scenario presentation. As the interview offered great insight on the topic and used the same set of questions, that data was not discarded but rather taken into the analysis as well.

A scenario-based structure (Beighton, 2021) was used in the interviews, designed to facilitate the articulation of the interviewee's perspectives and understanding of their values, opening up the access to a holistic and diverse investigation of the discussed topics. The scenario served as a discussion-starting tool to elicit a deeper discussion of the available options for innovating the energy sector, how the transitions should take place, and why and who should be involved. It was presented to the participants in a broad descriptive format that could allow the contextualization and foster discussions throughout the interview. The narrative was generated depicting shifts surrounding the transition of the Portuguese energy system, considering both overall objectives for the transition (e.g., decarbonization of the Portuguese energy system) and specific short-term objectives (e.g., increased RES production; increased citizens' participation).

The scenarios were presented as broad narratives about possible energy system futures to gain insight into the key objectives perceived by different stakeholders. They considered both general objectives for the transition (e.g., decarbonization of the Portuguese energy system) and specific short-term objectives (e.g., increased RES production; increased citizens' participation).

Only audio of the interviews was recorded to de-identify the information shared from the source. The data gathered is stored on the SEEDS project cloud-based drive, accessible only to the project members.

During the interviews, the participant was encouraged to explain his ideas on the topic, describe problematic aspects and offer potential solutions. No questions regarding the final web interface were asked as this would be in the scope of the later phase of the project.

The interview sessions were handled via Google Meets with the participation of the moderator, an observer, and the interviewee. The sessions lasted around forty-five minutes. The interviews were recorded, transcribed, translated to English, and anonymously analyzed.

3.2.2.2 Analysis

The results of the in-depth interviews were analyzed through an interpretivist perspective looking for emergent codes (Blair, 2015) directly derived from the collected data, which allowed insights into the overall concerns of energy system stakeholders. The data was divided into smaller parts that were deeply analyzed and received a descriptive code.

The analytical chunks of data were compared, attributing the same code to similar parts. Following content analysis guidelines (Stemler, 2000), the emergent codes were established through an immersive examination of the data, and they were not imposed by previous research on the topic. Hence, the analytical focus was placed on understanding the mechanisms and actors involved in the transition process.

3.2.2.3 Findings

The key values identified in the analysis have indicated that stakeholders are wishing for strategies that focus on innovative solutions, regulation by means of green laws and taxes, and implementation of hybrid configuration and sustainable solutions. The necessary aspects for the transition mentioned by participants included: Increase Transparency of the transition process through communication; To increase citizens participation, with particular emphasis on the role of municipalities; Enable the advent of Prosumers to maximize Energy ownership; Fight Energy Poverty; Fighting monopoly of big companies; Assess the impacts of the renewable energy alternatives; Sustainability of Hydrogen energy and Lithium exploitation; and Priority of energy efficiency on old buildings across the country.

Moreover, the stakeholders pointed out some issues that should be addressed by the transition, such as: Urgency to reduce consumption; Improvements In transport electrification, Investments in Storage; Fighting cost-oriented solutions; and decreasing PT dependence on fossil fuels.

Departing from the concepts and values identified, an objective system for evaluating the Portuguese energy transition alternatives (Fig. 2) was designed using the Höfer and Madlener (2020) framework. The authors applied the Value-Focused Thinking (VFT) method (Keeney, 1992) to determine the stakeholders' objectives in a case study that studied the transition of energy systems in Germany. The VFT method sustains that values are the basis used for evaluation. Thus people "use them to evaluate the actual or potential consequences of action and inaction, of proposed alternatives, and of decisions. They range from ethical principles that must be upheld to guidelines for preferences among choices." (Keeney, 1992). The relative willingness to accept the consequences and trade-offs is a value-based concept as well. Accordingly, the objectives decided by decision-makers are contextually evaluated based on their own values. (Höfer and Madlener, 2020)

The definition of objectives provided by Höfer and Madlener describes an objective as "a statement of something that one desires to achieve. It is characterized by three features: a decision context, an object, and a direction of preference" (Höfer and Madlener, 2020). Being that "a fundamental objective characterizes an essential reason for interest in the decision situation" (Ibid.) and guides the decision situation and evaluation of alternatives. And, the means objectives, tools to analyze decision problems and create alternatives, describing per se the means to accomplish the fundamental objectives.

The objectives system was created using the concepts acquired through the interviews by converting the expressed concerns related to the decision problem (e.g. the structure of the energy system; the dynamics of the system; the speed of the transition) into decision opportunities described through four fundamental objectives and eighteen means objectives.

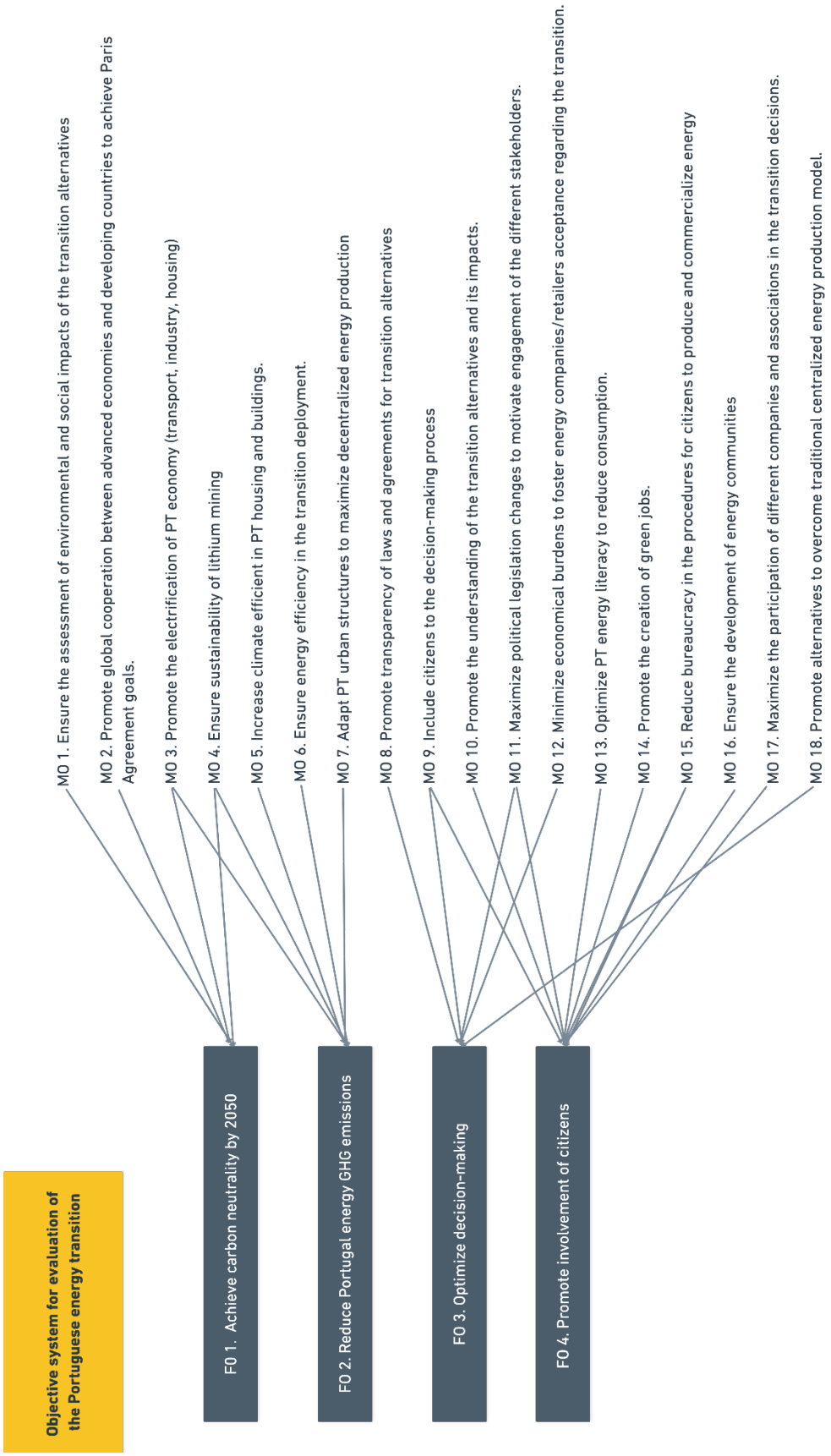

Fig 2. Objective system for the evaluation of the Portuguese energy transition alternatives

Although the small sample of participants led the analysis to a high level of abstraction regarding concerns and issues of the energy transition pathways, the results built a groundwork sense of the relationships between the identified themes and the expressions of the values among the different stakeholders.

Delving into the body of data, the analysis facilitated observation of the context regarding the identified critical themes and the relationships between the expressions of the values among the different stakeholders. This understanding was organized on a mapping of concepts and values shared with the research team for validation.

3.3 Participatory Design Workshop

For the development of the initial design concept, two co-design workshops were organized on both internal and external levels. The decision opportunities identified with the objective system for the evaluation of the Portuguese energy transition alternatives were instead centered on the abstract level of ideas. Although detailed in contextualizing the transition process, the data gathered was not in the correct format to be translated into aspects of the interactive interface.

Seizing the opportunity of the Participatory Design stance of the project and acknowledging that within this approach, "the designer must view interaction from a holistic rather than specific perspective and seek to understand user's everyday practices and the prior knowledge they bring to a situation" (Frauenberger, Good and Keay-Bright, 2010), the co-design sessions were planned to narrow down the abstract concepts gathered during the interviews and investigation into concrete concepts that could be applied for the development of the SEEDS tool.

Thus borrowing from the Ladder of Abstraction approach, we found guidelines for proposing the participatory activities to involve the participants in the initial definitions of the interactive aspects and actions of the interface.

The Ladder of Abstraction is a mental model that describes varying levels of abstraction and concreteness to explain the way people think and communicate (Doblin, 1980). The upper part of the ladder represents higher levels of abstraction.

And the lower parts correspond to the concrete idea. Taking such a lead (Fig.3), we structured a path of actions down the ladder to achieve the concrete imagery of domain experts and stakeholders, aiming to understand how the definitions of the tool should assist the users in performing tasks and making decisions.

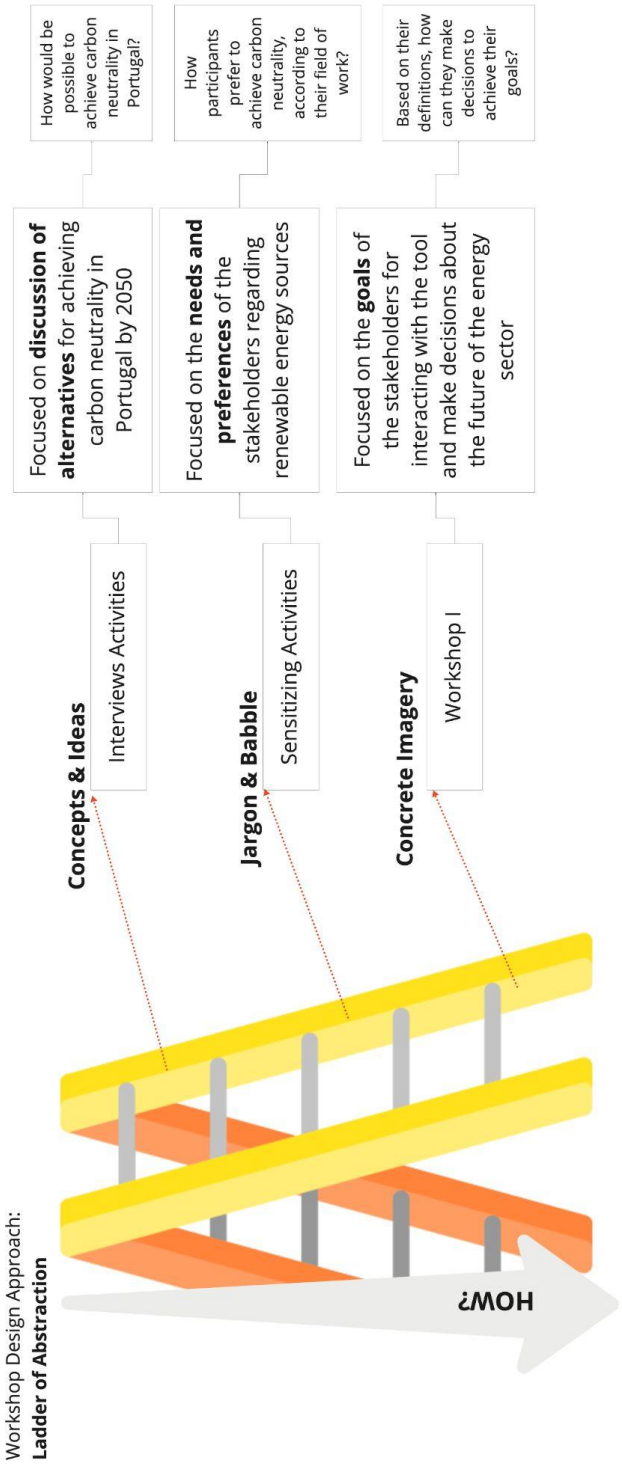

Fig.3 Illustration of the Ladder of Abstraction approach used to design the workshops

3.3.1 Internal Workshop

On the 15th of November 2021, the online workshop was held with the participation of experts and researchers of the SEEDS project to discuss their expectations about the energy modeling tool. Two activities were proposed, the first being a card sorting activity in which the participants reflected on the content that should be presented by the interface of the tool. And at the second, the group work on the design of the interface wireframes.

Overall, there were no issues with the session. Although the groups had expressed different goals and expectations for the tool, the discussion brought valuable and informative insights to the project development. Moreover, the results of this activity were the basis for the collaborative session proposed in the external workshop. The process and outcomes are presented in the following session.

Seven of the SEEDS project members joined the collaborative activity. The primary goal of the session was to generate the initial features and functionalities of the interface according to the experts' point of view.

3.3.1.1 Card sorting activity

The participants firstly performed a card-sorting activity in which they expressed their understanding of how the SEEDS tool filtering and searching functionalities should be structured.

The activity was done individually, and in which the participants were invited to perform a cards categorisation and grouping activity. Each participant created groups with cards representing how the search parameters should be presented on the interface based on their expectations.

Using 64 cards with the name of energy production technologies, types of impacts, units of measurement, and interface functionalities, the participants were asked to create and organize groups representing the search functionalities and metrics, the presentation of generated scenarios, and additional interface components that the tool should make available for its users.

3.3.1.2 Co-design of the interface

A design brief was prepared based on the results of the inquiry research. The SEEDS tool should be developed attempting to offer a tool for users to make decisions about the pathways for transition in the Portuguese energy system, considering renewable energy sources as alternatives that can help Portugal achieve carbon neutrality goals. The tool should enable searching features, as well as access to documentation, impacts assessment, sharing information, and rating of options.

Departing from a design brief and building upon the previous classification activity, participants used a given initial wireframe to sketch the items and interactions that serve as the main elements of the SEEDS interface.

The activity was done in three groups using Balsamiq. The choice for this collaborative environment was due to its library of ready-to-use user interface items.

Participants received a toolkit of items and pieces of a web-based interface focused on elements of searching engines. Additionally, the groups offered customizable wireframes containing the initial elements as a starting point.

A team of designers from Tallinn University assisted and facilitated the group activities providing shortcuts and straightforward explanations about the Balsamiq tools.

The "make part" lasted forty minutes. Afterward, the groups had twenty minutes total to explain and add considerations about their choices.

3.3.2 External Workshop

The focus of the participatory approach is to actively involve beneficiaries and stakeholders in the design process so that the results align with the intended use and needs of the participants in that process. During this phase of the research process, all the activities and contact with stakeholders were handled in Portuguese.

The Stakeholders Workshop aimed to facilitate the co-design of the SEEDS interface with the actors and beneficiaries of the Portuguese energy system transition to learn from their experience how it should be framed in the development of a web tool for searching and selection of optimized and feasible energy alternatives. Moreover, that would be aligned to their needs and expectations.

In the first moment, coordinated by WP4, the stakeholders discussed local concerns on energy poverty, renewable energy, and self-consumption adoption objectives, the source of resistance or acceptance of energy infrastructure projects, and their understanding of prototype visualizations of alternative energy system scenarios.

3.3.2.1 Sensitizing activities

A process of sensitisation and awareness-building was coordinated prior to the workshop to guide participants on a deeper understanding of their needs, wants, hopes, and dreams (Sanders & Stappers, 2012) to identify criteria and opportunities for the project. These activities aimed to gradually encourage participants to reflect on the project's themes, evoke new ideas, and create space for the creative process.

The dynamics of these activities were structured in order to create weekly moments of reflection, carrying out an activity every four days. In this way, gradually encourage them to reflect on the theme of the project. Activities were structured to guide participants through a 'path of expression' (Sanders & Stappers, 2012), proposing tasks that would help participants to a) Observe the Present, in the activity I; b) Recall past experiences, in the activity II; and c) Imagine and Create future, done by activity III and IV.

In Activity I, participants reflected on their preferences regarding the energy transition in Portugal by marking in a word list important items to be considered in order to help Portugal reach the energy sector decarbonization goals.Extra space was also provided for adding other important factors that did not appear in the list that could be added.

In Activity II, participants reflected on past experiences considering how they positively collaborated or negatively caused impacts in three instances: a) management of the energy system in their region; b) in the energy consumption of their region; c) in the production of renewable energy in the country;

In Activity III, participants were invited to imagine the future of the Portuguese energy system and to represent with images how the system will be configured in the next 5 and 10 years;

In addition to the images, the participants briefly expressed the reasons why they imagined Portugal's energy system in such way. Two questions were asked to help the participants to reflect. a) What will the energy system of the future look like? b) What types of social and/or industrial needs should the energy sector meet?

Finally, in Activity IV, participants performed the same tasks as in Activity III however considering the time frame of 15 and 30 years. Fig. 4 illustrates the activity setting offered for the sensitization of participants.

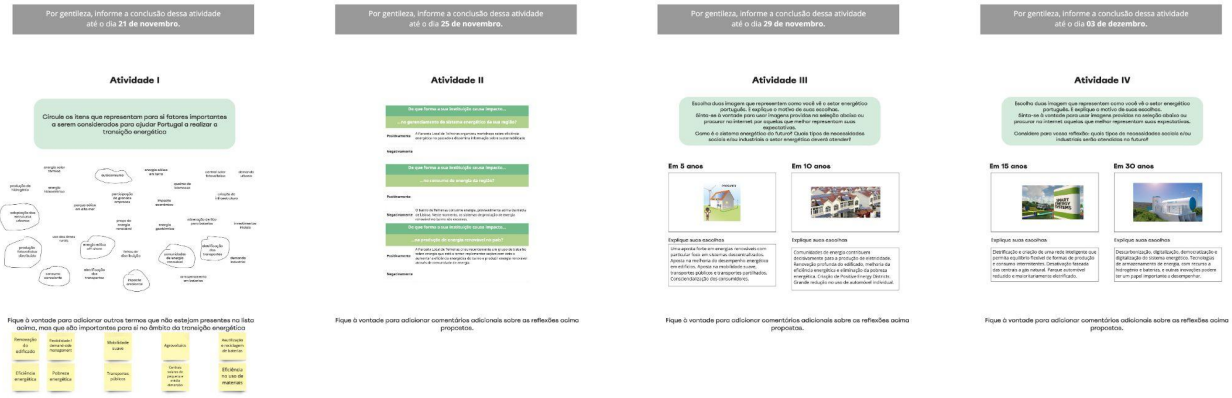

Fig. 4 - Set of activities used in the awareness-building stage

Individual Miro boards were created for each of the 60 people that confirmed participation in the workshop activities. They received a toolkit and detailed instructions on how to develop the task. A specific pace of one activity per week was suggested that should facilitate the development of the task and minimize the time consumption; nonetheless, the participants had also the opportunity to perform the task all at once.

3.2.2.2 Co-design of the interface

On the 3rd of December 2021, the stakeholders were invited to an online workshop that followed a similar approach. During the workshop, the stakeholders will have the opportunity to debate and negotiate with other participants on the best choices to create an interface for filtering and selecting optimized and feasible transition alternatives for the Portuguese energy sector.

Due to the COVID-19 situation, the workshop, originally planned to happen in Lisbon, was held online. The activity was presented collaboratively by the WP4 and WP3 because both work teams were interested in the outcomes of the first official

encounter and discussed it with the stakeholders. Firstly, the participants took part in a World Cafe activity proposed by WP4. Later, after a break, participants were invited to a group co-design activity inspired by the results of the internal workshop.

The primary objective of the stakeholders' collaborative design session was to engage them in the ideation and design process, facilitating tools and a proper environment where the prototyping activity could facilitate the expression of their needs and expectations for an energy modeling tool. Fostered by the sensitizing activities and previous discussion, the activity was planned to engage stakeholders in a collaborative creative moment, in which they could define interactive objects and actions in the filtering interface according to their preferences.

Participants were divided into three groups with up to four people. Each group received a Miro board and a toolkit to play with. The groups also received a design brief explaining the goals and features of the SEEDS tool. Then, departing from the design brief and examples of wireframes, the participants had 30 minutes to sketch the items and interactions they would like to see on the SEEDS interface.

Although the time was relatively short, there was no wrong placement for the bits and pieces of the interaction. Thus, participants were instructed to follow their expectations of the final tool to negotiate with their group where and what items should be present. The groups were divided into ZOOM breakout rooms, and the activity was monitored by the design researcher from TLU with the assistance of a Portuguese speaker volunteer.

Customizable wireframes containing the interface's initial elements and toolkits were offered to the participants as a starting point, reducing the effort of planning the structure of the interaction and driving their attention to the important requirements of the interface design that would attend to their needs in order to improve the filtering of the energy transition scenarios.

Afterward, the groups had 25 minutes in total, to explain and add considerations about their choices. The discussion was recorded, transcribed, and translated to English, alongside the design artifacts created by each of the stakeholders' groups.

3.3 Results

3.3.1 Internal workshop activities

The card sorting activity used the open cards categorisation approach, which allowed the participants to create and name the groups. Because of that, some categories needed to be merged to consolidate the similarly named groups into the analysis. They were merged and named according to the initial concepts of the tool functionalities to facilitate the understanding of primary aspects such as input and output, taking into consideration that during the discussion it was noticed that part of the researchers' participants sees the interface as a profiled filtering tool, as others expressed the features of the tool to serve generalization.

As it is shown in the examples below (Fig. 5, Fig. 6, Fig. 7), the majority of participants agreed in the position of the technologies for energy production in the category filtering as options of filtering.

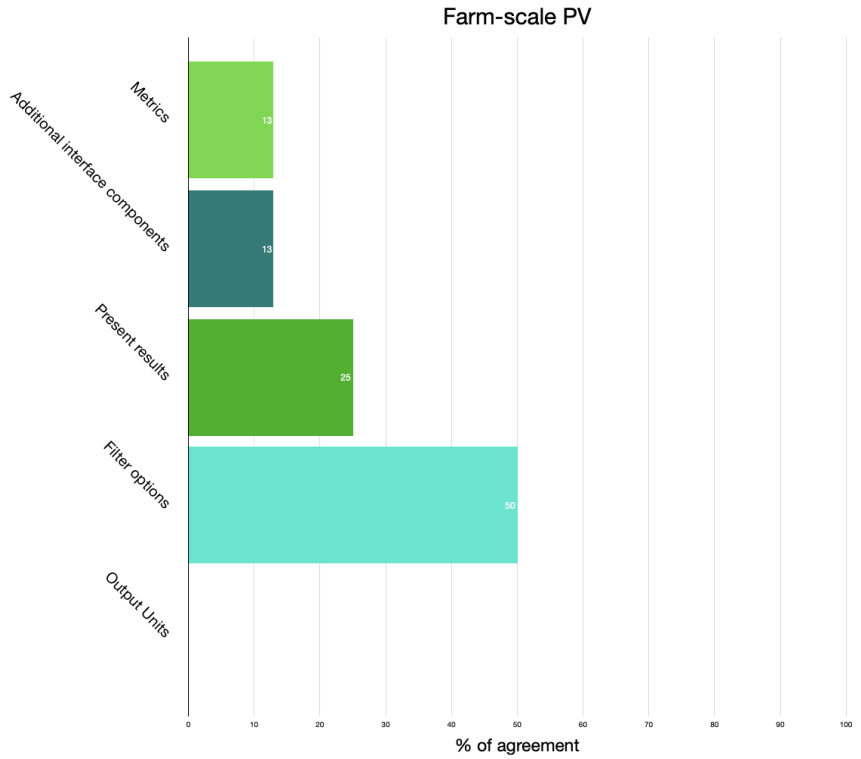

Fig. 5 - The percentage of agreement regarding the position of the card Farm-scale PV

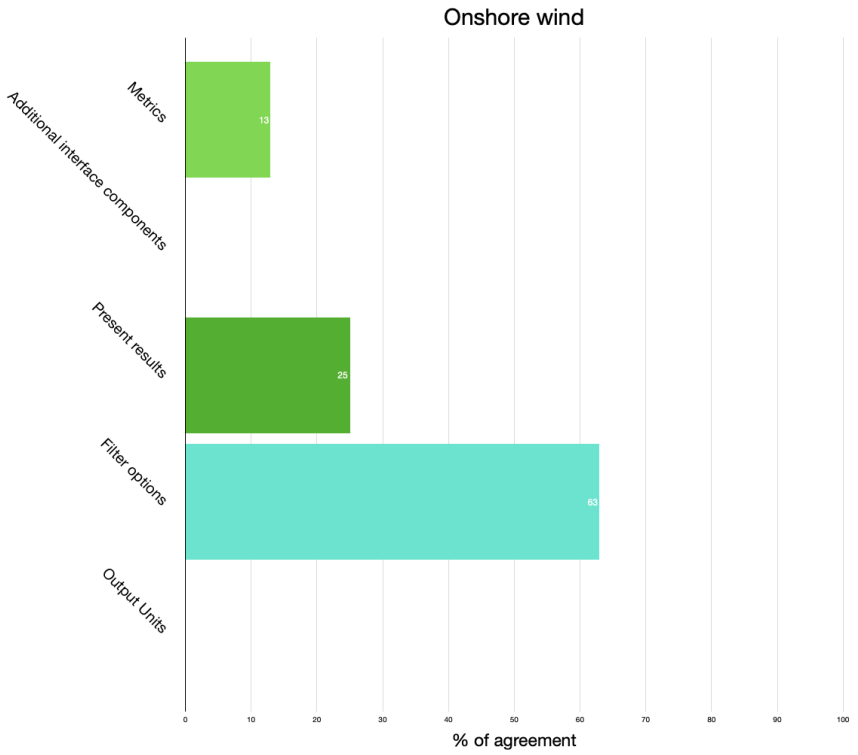

Fig. 6 -The percentage of agreement regarding the position of the card Onshore Wind

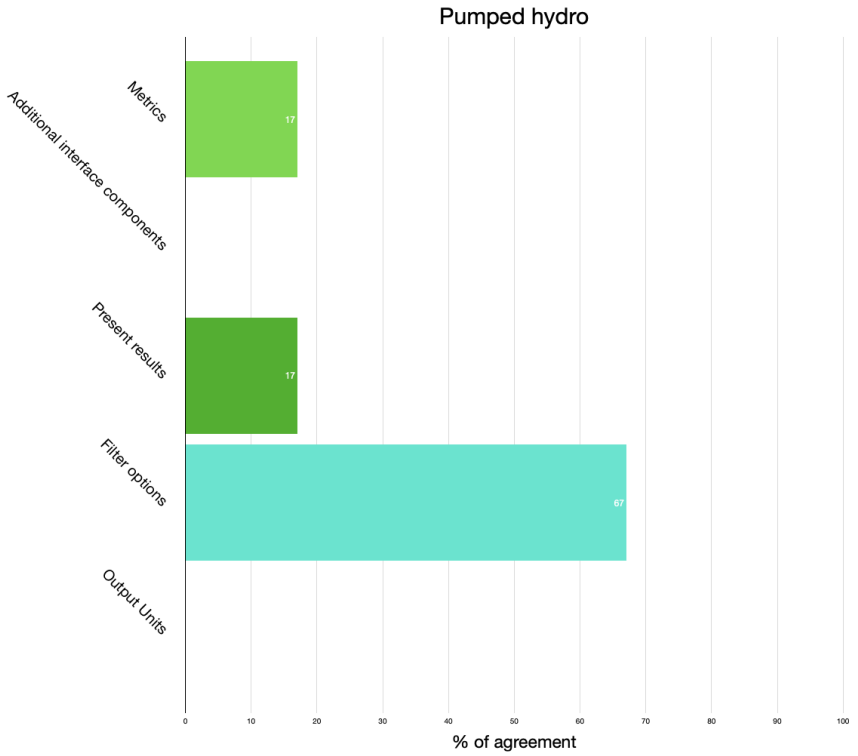

Fig. 7 - The percentage of agreement regarding the position of the card Pumped hydro

However the levels of agreement regarding the position of Installation Capacity and Geographic region on the searching interface is still inconclusive as it is shown by Fig. 8, and Fig. 9 below.

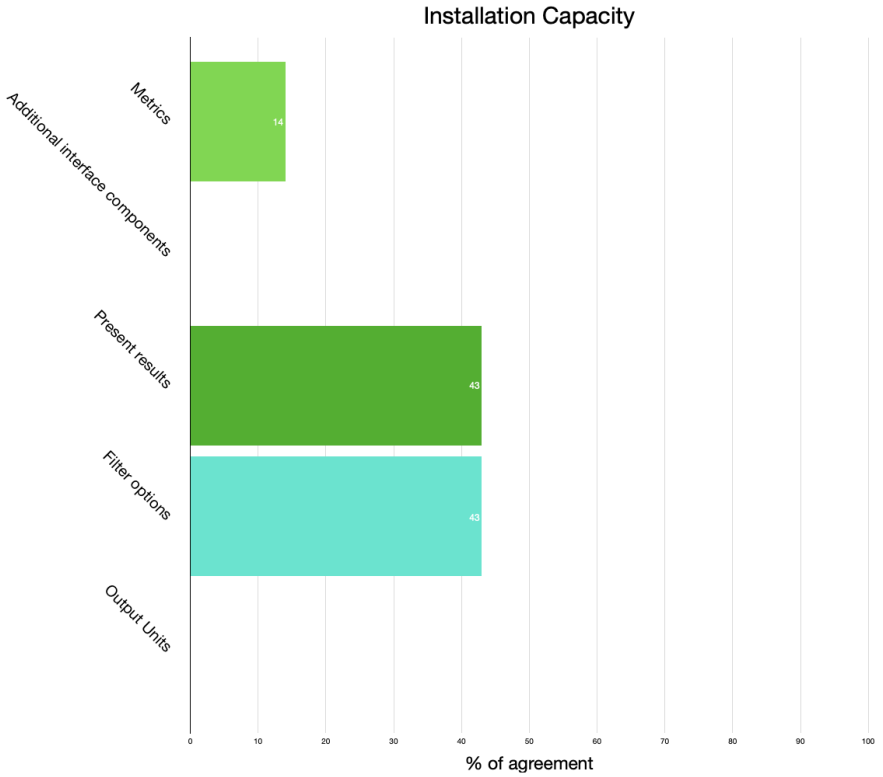

Fig. 8 - The percentage of agreement regarding the position of the card Diagrams

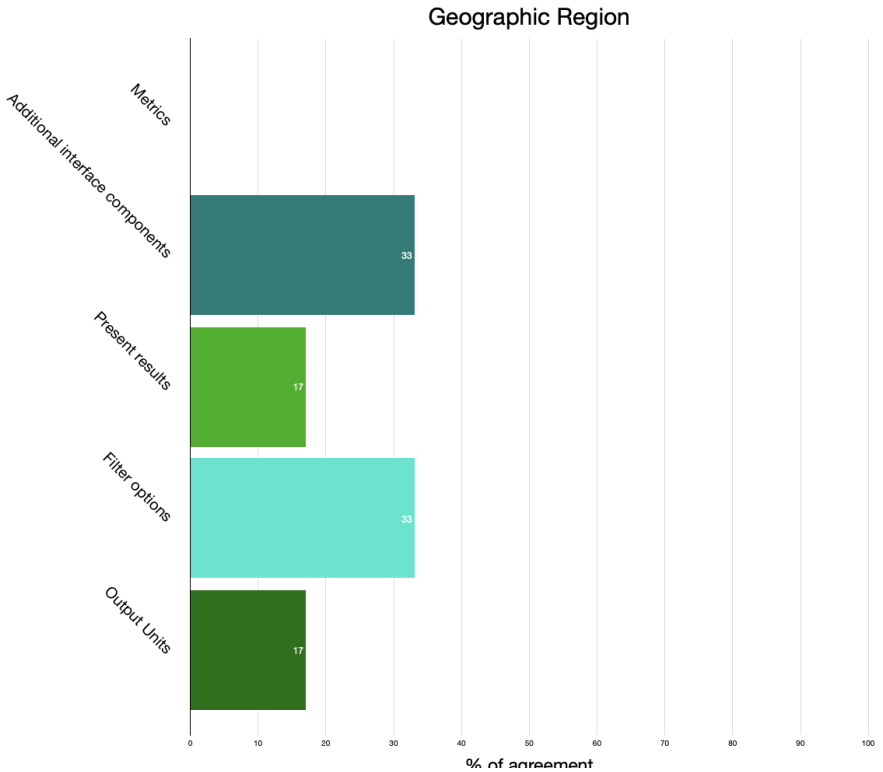

Fig. 9 - The percentage of agreement regarding the position of the card Distribution Maps

Overall the data illustrated the disparity of views of the domain experts in regards to the options available to the future users of the SEEDS tool, nonetheless demonstrating that participants have high levels of agreement in regards to the components of the search and aspects that users can filter, as well as to how the results should be presented to the users. Yet, aspects mentioned among the stakeholders' concerns such as adaptation of old infrastructure (Existing Infrastructure) and Initial Investments are not covered by the design concept; therefore, further investigation is required to define such properties of the search and filtering features.

This has an impact on the delay of the taxonomy of properties of the SEEDS tool once the task requires detailed descriptions of the functionalities and interactions with the search engine under development.

On the other hand, the collaborative design activity resulted in three design artifacts followed by a productive discussion about the main functionalities of the SEEDS tool. The session’s outcomes, as well as the transcribed discussions, were analyzed using the KJ affinity mapping method (Scupin, 1997) and demonstrated that:

- Authentication should be required from users that want to have full access to the resources of the tool. However is not necessary to log in to perform general searches
- Tutorials of use and documentation should be available on the landing page of the interface
- Filtering should be divided into multiple steps or tabs in which the users would customize technological, geographical, and environmental aspects.
- The unities of search should be presented in the form of sliders or interactive UIs
- Items of the search could be customized either by user profiles or on/off functions in which of the parameters
- There should be an environment for users collaboration
- Download of the generated scenarios should be available to users containing the respective documentation, tables, and graphs
- Users should be able to share their generated scenarios with other users

- Information about users behaviors, such as downloads, saved items, and preferred scenarios should be recorded as metadata for later could informing research and eventually policy-making

The results of the activity alongside the design created by each of the domain-expert groups (Fig. 10), were used to inspire the creation of the example wireframes of the Stakeholders' workshop toolkit.

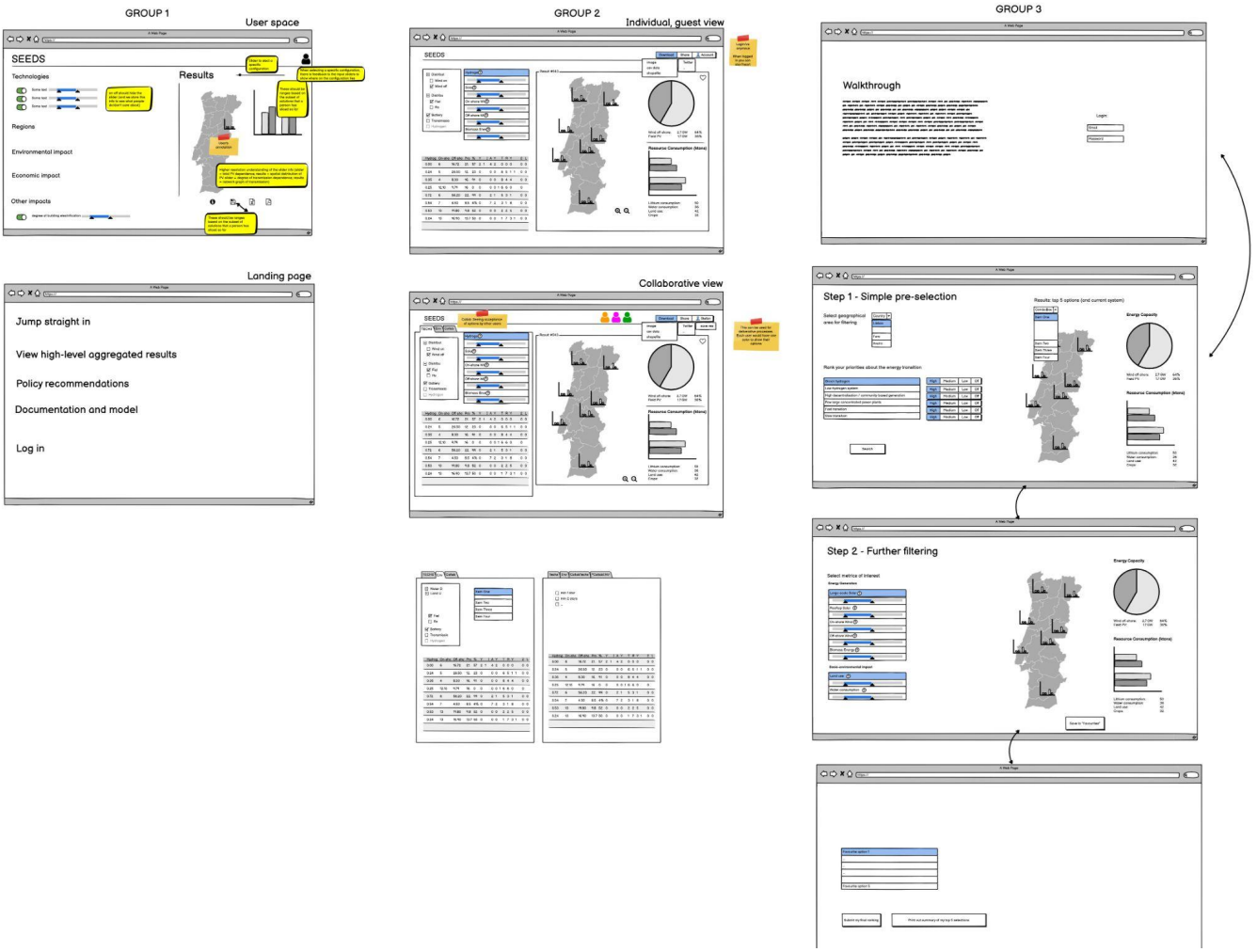

Fig. 10 - Wireframes of the three designs created by the domain-experts groups

3.3.2 External workshop activities

The attendance rate of the sensitizing activities was very low. From the sixty participants invited, only eight performed the tasks on the Miro board. Additionally, some participants gave up on the activity conclusion, as can be seen in Fig.11, which shows the board of Participant 52.

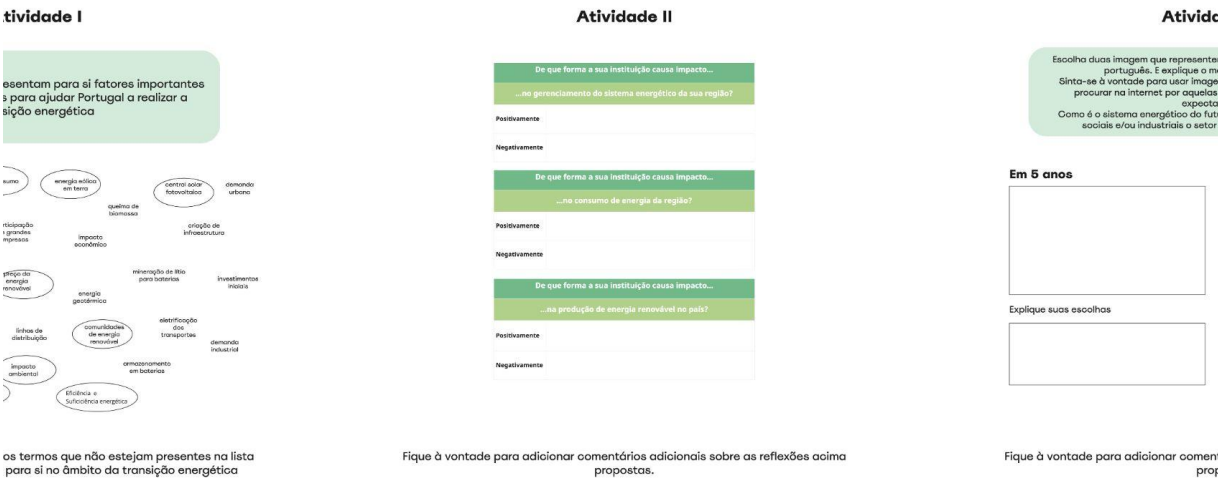

Fig.11 - Sensitizing activity interrupted by Participant 52

Although the data could not be explored for further insights, the answers collected were used to complement the Personas development of task 3.2. For that, participants were anonymized, and their inputs were translated to English to enable the understanding of the project members.

As pointed out by van Rijn & Stappers (2008), in the practice of Participatory Design, "although users are seen as partners, they have different motivations than designers for involvement in design". That was reflected also by the lack of participation and engagement noticed during the co-design activity, when a few participants left in the middle of the session, resulting in a shorter discussion session due to the fact that two of the groups had one member remaining.

Also, one of the groups informed in the discussion moment that they have not created any artifact because they "didn't feel like joining the co-design" activity; nonetheless, they instead have used the time to discuss the challenges of modeling scenarios for the Portuguese energy transition. During the discussion, just one participant of the group remained to summarize the topics discussed.

All things considered, the session was productive and resulted in two wireframes that are presented in Fig. 12 and Fig. 13. Participants were anonymized for the analysis phase. Furthermore, as the session was handled in Portuguese, the collected data and artifacts were translated into English.

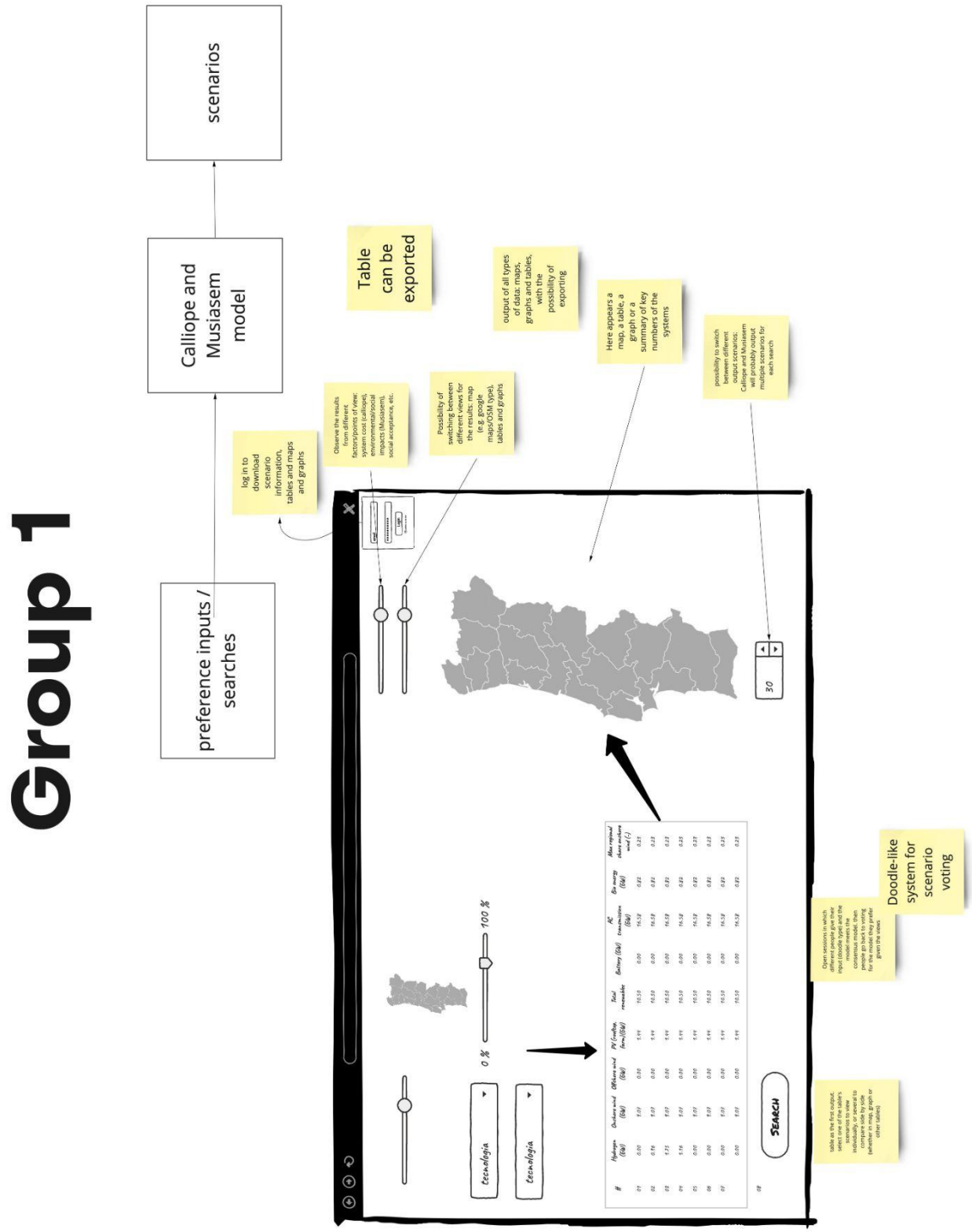

Fig. 12 - Design artifact created by group 1 with translated notes.

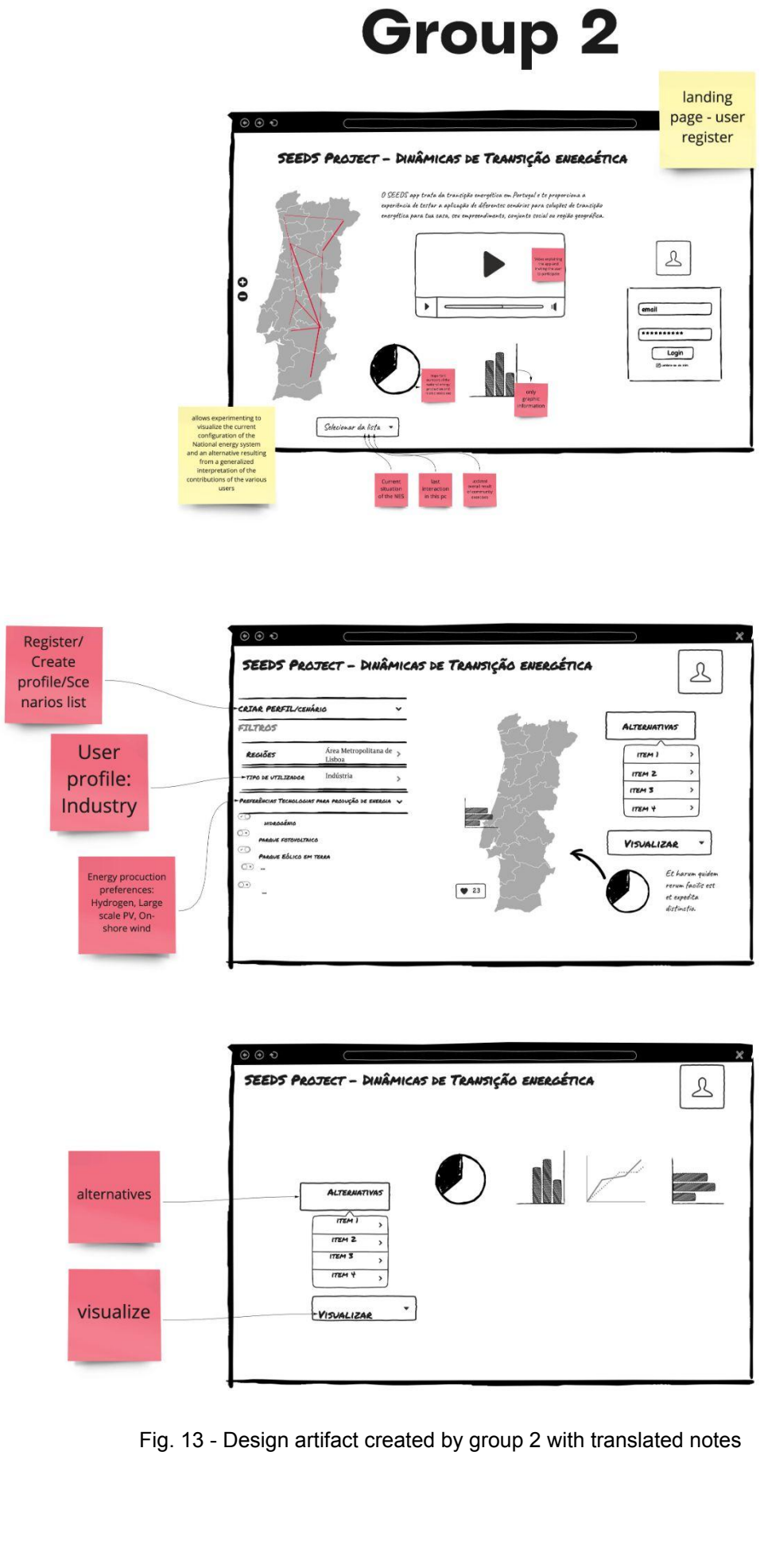

Fig. 13 - Design artifact created by group 2 with translated notes

The topics of the discussion were analyzed using the KJ affinity mapping method (Scupin, 1997) and returned results similar to the domain-experts co-design activity. Namely, a) Tutorials on the landing page; b) multi-stage filtering divided into sessions; c) possibility of unauthenticated search; d) sliders or and on/off interactive UIs; e) full access to the resources after user authentication; f) collaborative environment; g) sharing and downloading of the generated scenarios.

Nonetheless, the stakeholders expressed wishes to have additional features not mentioned in the previous phases of investigation:

- Users prefer visualizations over tables, due to the complexity of the data used by the tool
- Metadata of previous users should be available on the landing page to show the application functionalities
- The indices calculated by the application should be connected to the EU climate targets;
    - Temporal dimension to visualize and compare the outputs of the SEEDS calculations with the real data from the past
- Users should be able to create profiles of use and one user could have more than one profile for strategic views
    - Scenarios of optimal solutions should be connected to the presets for each profile, facilitating the search
- Users should be able to select scenarios for comparison, either analyzing them individually or side by side
- User should be able to mark some points on the map or in the filters and then see these information highlighted in the tables they downloaded

4. Conclusions and Recommendations

The review of literature and inquiry research facilitated the understanding of the surrounding context of the energy transition in Portugal and the possible design interventions that can be addressed by the SEEDS project.

The data retrieved from the desk research enabled the dialogue between the design team, researchers, and stakeholders in terms of the specific vocabulary of the energy systems, the technologies available in Portugal, and its possible scenario configurations. At the same time, it integrated information from Europe's decarbonization targets and plans by 2050.

The insights obtained at the level of the Domain-Experts interviews have presented the aspects of the energy transitions in Portugal and its characteristics. The knowledge built upon the information shared by the domain experts was fundamental to understanding the contextual scenarios pertaining to the socio-technical innovations and the scope of the possible interventions in the transition to renewable energy sources.

At the internal level, the participatory activities enabled the SEEDS experts and researchers to express their expectations and collectively create the concept of the SEEDS modeling tool. The results brought valuable and informative insights, besides providing the primary definition of the functionalities and content of the interface under development.

However, the activity demonstrated that the domain experts still have different assumptions about the components of the search and aspects that users can filter, as well as how the results should be presented to the users. This has an impact on the definition of the taxonomy of properties of the SEEDS tool once the task requires detailed descriptions of the functionalities and interactions with the search engine under development.

Aspects mentioned among the stakeholders' concerns such as adaptation of old infrastructure, temporal spatiality, costs and initial investments are not covered by the design concept; therefore, further investigation is required to define such

properties of the search and filtering features. The taxonomy of properties for interacting with the tool will be constructed alongside the development of the prototypes, due to the need for definition customizable options in both models that can be used by the users as parameters for searching and filtering scenarios.

From the Stakeholder's interviews, we gathered new perspectives about the areas for improvement, especially focused on how to promote a democratic negotiation of the transitioning scenarios by including the citizens in the decision-making process. The key values and the critical points accessed at this phase of the investigation included: the need for communication and transparency of the transition process; actions to reduce energy poverty; ensuring the assessment of the new configuration impacts; ensuring the sustainability of hydrogen energy and lithium exploitation, and prioritize energy efficiency of the existing buildings across the country.

The stakeholders pointed out some issues that should be addressed by the transition, such as support for the advent of Prosumers to maximize energy ownership; the urgency of reducing consumption levels; improvements in transport electrification; investments in the storage of RES-based energy; and decreasing PT dependence on fossil fuels.

The dialogue, however, had flaws. First, the data collected was leaning toward common views, which was considered to be a bias due to the limited number of people interviewed. Second, due to the lack of concrete information about the stakeholders' needs regarding the energy modeling tool and interface functionalities.

To sort out the abstractness of the data, the expressed aspects were refined through an objective system using the Höfer and Madlener (2020) framework, and afterward, the Ladder of Abstraction approach was used to drive the focus to the stakeholders' goals for interacting with the tool and making decisions about the future of the energy sector. Which allowed the participatory activities to be designed as a hands-on experience to shape concrete definitions for the design of the tool.

At the external level, the participatory activities facilitated a connection with the beneficiaries of the project and structured the ideas used for the development of the design concept, as well as informed the content used for creating the Personas and Interactive Scenarios (D3.2).

A few issues have been identified that need to be tackled by reviewing the planning of future workshops. As participants had already spent one hour and a half on the discussion groups proposed by the first activity (World Cafe), they afterward demonstrated tiredness to perform the online prototyping activity.

Although it affected attendance and engagement, the co-design session allowed the stakeholders to express their predispositions and needs regarding the energy modeling interface, pointing out additional features not mentioned in the previous phases of the investigation.

It is known that participatory projects are uncertain and risky (Huybrechts et al. 2014), so efforts were required to mitigate the mishappenings and extract meaningful contributions from the participants who attended the activities proposed. Regarding the bias of the data, still, the co-design participants seemed to have converging views regarding the transition. Thus, to create diversity among the Personas of the project, information from the desk research and the participatory activities was condensed to cover different world views.

Focusing on keeping in contact and fostering the stakeholders to participate in the upcoming activities of the SEEDS project are the most important recommendations to be made. Throughout the second year of the project, further interviews or focus group activities might be needed to validate the design concept. We foresee iterations of Personas and Scenarios as well. But, as the project unfolds the aspects not addressed by the first phase of the project can be iterated.

5. Initial Design Concept, Personas, and Scenarios (D3.2)

The initial design concept was based on the data gathered from the desk research, inquiry investigation, and co-design activities. Besides the information retrieved in the research, insights were withdrawn from the affinity maps and design artifacts created by the workshop participants.

5.1 Initial Design Concept

Based on those findings, the SEEDS energy modeling tool should allow users to make decisions about the pathways for transition in the Portuguese energy system, considering renewable energy sources as alternatives that can help Portugal to achieve carbon neutrality goals. The tool should enable searching features, as well as access to documentation, impacts assessment, sharing information, downloading, and rating of options.

In regards to the searching engine, the application could use a combination of Parametric and Faceted search. Within the parametric search, users specify parameters within a discrete list of values using "a variety of controls such as checkboxes, pull-downs, and sliders to construct what effectively is an advanced Boolean query" (Morville & Callender, 2010). This way the interface allows the users to modify multiple parameters before query execution.

As the possibilities of outputs from the SEEDS modeling calculations are immense, the users could use the Parametric Search combined with the second stage of Faceted Search. Faceted search is composed of multiple filters that describe a set of content (Whitenton, 2010). It provides users with visible options for clarifying and refining queries. It offers an integrated, customizable search and browsing experience that allows the users to formulate sophisticated queries by taking a series of small, simple steps.

This way, the SEEDS tool could allow navigation in a simplified manner that offers customizable parameters. Users start by filtering the most apparent attributes of the energy modeling tool, such as types of technology, geographical location, and

impacts generated. After that, a refined search through the given results should be enabled to clarify the user queries.

The state transition diagram below (Fig. 14) describes the significant steps envisioned for this interaction.

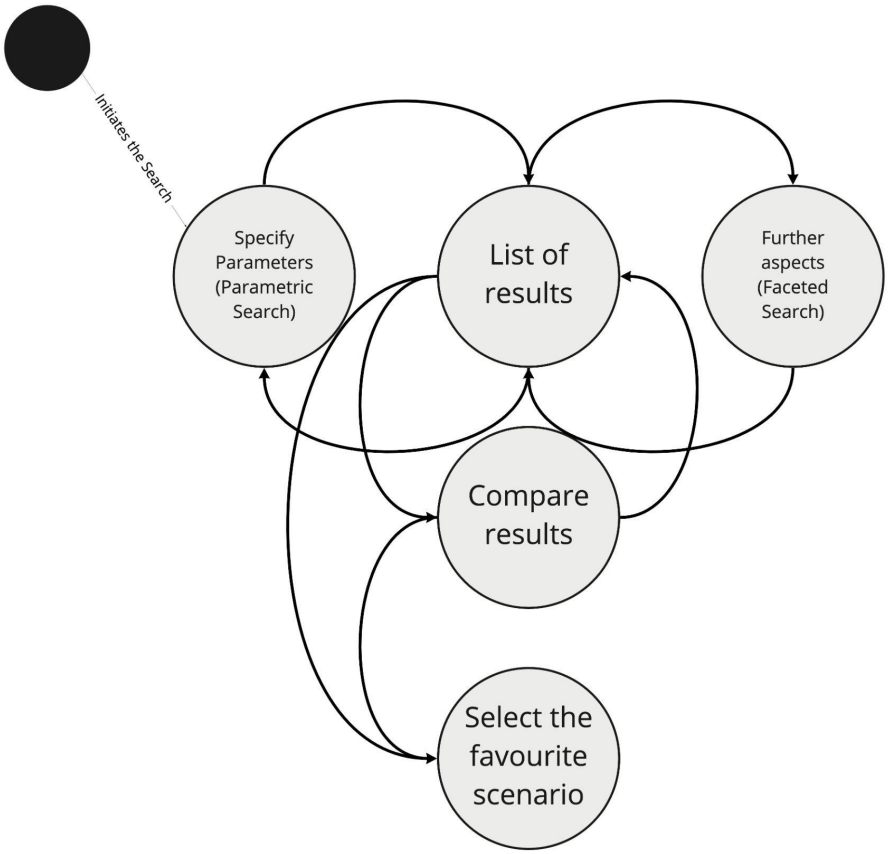

Fig. 14 - State transition diagram of SEEDS searching tool

When the user reaches the Landing page and initiates the search, firstly, parameters are presented for choice. The first search provides a list of results for the best fit of scenarios obtained (suggested number of 5 best scenarios calculated). The scenarios are either refined and customized through additional filters or compared. At this stage, users should be able to: a)use sliders to navigate among the obtained results; b) establish comparisons analyzing simple graphical representations side-by-side. The selected scenario can be analyzed through the interface by visual representations of the data alongside textual descriptions. Users can also download the reports containing the detailed data (spreadsheets, charts, respective documentation) used for generating the chosen scenario.

From the generative design activities, profiling aspects were ideated to facilitate dealing with a great number of search parameters. The profiling stage could be implemented as a short survey used before the parametric search. Nonetheless, the creation of profiles requires a thorough understanding of the groups and intentions of the user, which is still under development. Profiles should be considered and embedded in the design as additional interface components. The concept of this feature, and suggestion for implementation, is explored in the description of the Scenarios of interaction.

5.2 Personas

Part of the User-Centered design methods, ‘Personas’ is a popular interaction design technique in which the abstract user representations are used to assist designers in communicating within the teams. "A persona is a fictional, yet realistic, description of a typical or target user of the product. A persona is an archetype instead of an actual living human, but personas should be described as if they were real people"(Harley, 2015). The technique helps to prioritize audiences and place the focus of the development on the most important audience.

The Persona posters use a template of the Nielsen Norman's Group (Harley, 2015), with pictures of the webpage This Person does not Exist (https://thispersondoesnotexist.com/), a platform that provides images of people generated by a generative adversarial network. Three personas were created, attempting to represent the demographic and biographic information of the project's stakeholders. The approach of the Role-Based Perspective of personas suggested by Grudin and Pruitt (2002) was implemented to grasp both qualitative and quantitative insights from the research to supplement the persona descriptions.

The primary persona is Emília Cavalcante, who works for the municipality of Porto. She represents the stakeholders of the Policy and Regulators group. Additionally, research enabled the creation of two secondary personas. One is Yuri Barcellos, who represents the stakeholders from Academia and Non-governmental organizations. And the second is Walter Diniz, who represents the Agriculture Associations and Civil Society.

Emília Cavalcante

52 years old

Renewable energy consultant

Porto, Portugal

"The current rooted system does not prevent the implementation of a new system. And it should be hybrid not totally centralised, not totally distributed, it will be possible to have both systems."

About

She is a Renewable energy consultant at the executive office of Porto Metropolitan Region. Emilia holds a BA in Environmental Engineering and MA's degree in Sustainable and Renewable Energy Management. She coordinates a team that deals with sustainability at public level, advising and consulting on energy and environment development and managing projects.

Behavioral considerations

- Daily reviews and report on renewable energy projects
- Deals with funding proposal and projects for renewable energy at the municipality level
- Actively participates in national boards for sustainable energy development representing Porto
- Is skeptic about the hydrogen energy, but believes it to be an essential ingredient to eradicate the use of fossil fuels
- Sees a great potential for Portugal as a leader of renewable energy production in Europe

Goals

1. Straightforwardly transition plans for the renewable energy configurations
2. Review demands of her region per field of actuation
3. Forecast production capacity of different configurations for renewable energy alternatives
4. Access impacts caused by implementation of new energy RES-based configurations
5. Demonstrate the potential of hybrid energy configuration solutions

Tasks

- Gather information on energy demand, weather conditions, technology costs and performances for transition
- Generate cost effective scenarios for renewable energy use
- Access to diversity of solutions in order to facilitate negotiation with industry and policy makers
- Generate simplified visualisations for the transition configurations to share with non technical audience

Expectations

- Be able to provide informed solutions for energy transition challenges
- Keep up a good relationship with the executive associates of her work actuation region
- Help her region to take benefit from the increasing innovative energy plans and climate targets management that the European committee have been funding

Frustrations

- Most of the renewable energy reports are focused on site specific cases, making unfeasible to apply generalized metrics of success
- metrics of the Global calculators are too complex to be shared with executive policy makers and non technicians
- Important decisions regarding implementation lack evidence support
- Traditionally the goverment leans towards economic values disregarding social and environmental needs

Fig. 15 - Primary Persona: Porto's Renewable Energy Consultant

Yuri Barcellos

43 years old

NGO Environmental Technician / Researcher

Lisbon, Portugal

"The transition projects must be planed in another way because the citizens participation is extremely important, and they need to be involved in the projects happening in their regions."

About

Yuri is the Environmental Technician and Project Manager of a Portuguese environmental NGO. He holds a MA in Biology and Environmental Systems and a PhD in Applied ecology and Environmental Engineering. Currently, he teaches at a university in Lisbon and leads a research team on topic of *ecodesign*, energy efficiency and nature conservation.

Behavioral considerations

- Engaged on environmental activism since the1990s
- Keeps up to date with the governmental propositions for decarbonisation of the Portuguese economy
- Assists private and community renewable energy projects with a strong attention to conservation policies and law enforcement
- Frequently interviewed by the local news about environmental impacts of different governmental projects

Goals

1. Thoroughly assess the impacts of the ongoing and upcoming renewable energy projects in PT
2. Review the cutting-edge energy models to benefit his research teams
3. Contribute to an sustainable transition of the national energy system, addressing environmental, social and economic aspects
4. Increase energy literacy and citizens participation on the energy market to support cooperative energy communities

Tasks

- Research and model efficient energy systems for transition
- Foster bigger participation of citizens and energy communities in planning the transition
- Enable information access and decision power to private and community consumers
- Integrate different RES-based solutions on a robust transition model

Expectations

- To minimize the impact of the energy sector on the environment from source to use
- Access clear and well detailed information about future energy configurations
- Demonstrate efficiency and reliability of distributed energy configurations (energy communities)

Frustrations

- The country needs to speed up the transition in practical terms
- Citizens are not empowered by the current energy policy
- A few big companies keep the shares and profit of the PT energy
- The goverment tends to favour big companies investors in detriment of the environmental assessment and citizens will.

Fig. 16 - Secondary Persona: NGO Environmental Technician and Researcher

Walter Diniz

63 years old

Land owner and Wine producer

Reguengos de Monsaraz, Portugal

"Alentejo is a region with the highest sun sunstroke in the EU, so it has a high photovoltaic potential. We'd take great benefits from facility scale energy production in the region"

About

Walter is a land owner and wine producer. Since 1990, he runs a family-owned wine business. His owns properties on different regions regions of Alentejo where his vineyards are located. Walter meticulously takes care of quality and costs of his products. And lately his main focus has been on bridging technology into the traditional methods of his winery.

Behavioral considerations

- Daily deals with management of tasks and workforce.
- He has a sharp analytical view of his business
- Believes that a competitive market on large scale production of RES-based energy would reduce the prices
- His an associate at the Alentejo Wine Producers group where he has been seeking for cost-effective solutions
- He's a strong supporter of the wine industry technological development

Goals

1. Get to know about the alternatives for energy transition in his region and its costs of implementation
2. Reach a strategic view of RES-based options available
3. Gather information to support cooperative development towards industrial energy prosumers
4. Forecast production capacity of his region for different renewable energy sources
5. Reach cost-effective solutions for the technological upgrade of his winery

Tasks

- Strategically review the RES-energy sources available to him
- Review cost-efficient solutions
- Inform his and the neighbours upcoming investments on sustainable energy
- Assess the energy use impact of his machinery or region in order to inform the sustainable development of his product (carbon footprint)

Expectations

- PT should import the less energy from EU
- Help her region to take benefit from the increasing innovative energy plans and climate targets management that the European committee have been funding;
- Mitigate expensive energy bills during the high consumption season

Frustrations

- Society generally do not account for the needs of the industry regarding energy when discussing transition alternatives
- There's a high level of energy inefficiency on the industrial sector
- Alentejo has a great energy potential that have been under explored due to retrograde policies and enterprises

Fig. 17 - Secondary Persona: Land owner and Wine producer

5.3 Scenarios

A second technique applied in this phase of the research was the generation of scenarios. These are narratives that designers use to organize, justify, and communicate ideas. The scenario is applied as a tool to present and situate solutions, as well as to illustrate alternatives, and potential problems. The Anatomy of a Scenario is usually centered around one task that is key to the product and includes an actor, a motivation, an intention, the action, and the resolution.

As pointed out by Nielsen (2019), "the strength of the scenario is its ability to make design ideas concrete", because it helps to maintain focus on the specific context, use, and user, while providing the opportunity to relate to both current and future conditions and issues.

With that in mind, the scenario narratives were focused on the descriptions of the personas' relationship with the SEEDS tool within their imagined workflow or everyday life, concerning the focus area: modeling scenarios for the Portuguese energy system transitions.

Additionally, the scenarios describe steps of the interaction based on the data collected from the co-design activities.

Each persona has one scenario describing their interactions with the tool based on a given goal. The three scenarios are presented below:

Scenario 1 - Collaboratively creating feasible transition scenarios

Persona: Emília Cavalcante - Municipality Renewable energy consultant

Goal: Working on a team, develop alternatives for renewable energy in her region with a focus on the energy capacity of the different configurations and impacts assessment of its implementation.

Emília will represent her region in the national forum "The energy transition in Portugal and its contributions to carbon neutrality." She was asked by the major to prepare a plan and discuss it with him before the forum. Representatives of all municipalities will deliberate novel solutions for the energy configuration.

She called her team to work on an innovative plan for the metropolitan region of Porto. Her team used the SEEDS tool to forecast a list of actionable alternatives to implement renewable energy production. Now Emília will review them.

She logs in to her account on the SEEDS tool webpage. She goes to the collaborative environment where the members are ordered by the recent activity. They worked collaboratively on a list of 5 possible, which Emília sees as an interactive map alongside graphs and legends. She moves across the different alternatives created, sliding through them until she reaches one highlighted by the team as the favorite. But reviewing that, she disagrees. That condensed scenario makes her skeptical, so she decides to open a new search and see why the choices lead to that path.

She goes to her userspace and enables all filters to make her decisions on the go of the task. Starting by activating the technologies that she thinks are suitable. She later toggles the percentual deployment of the chosen technologies and balances the options. She sees the consequences of her changes displayed on a map in real-time. She reviews several until reaching a satisfactory alternative: it outdoes the demands, nonetheless highly demanding new distribution lines bringing power from the South. Emilia marks it as a favorite overall; it seems to her a good alternative.

So it's time to compare. Emília selects the two favorite scenarios, one from her user space and the other from the collaborative work, and enables comparison mode. Having two interactive maps side-by-side, she now observes in detail the consequences of each choice, noticing that the alternative of her team actually brings less environmental impact and can generate more jobs throughout its implementation. She makes improvement remarks on teamwork, calls for more distributed opportunities, then shares a notification with her team asking for their review.

Satisfied, Emília downloads both reports for close inspection while scheduling the team meeting to decide on the alternatives to be presented.

Fig. 18 - Scenario of interaction of the Porto's Renewable Energy Consultant

Scenario 2 - Review the cutting-edge energy models to benefit his research teams

Persona: Yuri Barcellos - NGO Environmental Technician / Research

Goal: Review the novel energy model solutions to support energy community implementation

It's lunchtime. Yuri sits on his desk to quickly check out a modeling tool his colleague commented about. He's leading an energy community project in the south of Lisbon, for which he also has a research interest. He has been playing with different modeling strategies that should account for the community's demand coverage and energy sufficiency and support impacts assessment once the community is in a protected area.

He reached the webpage and is already engaged in watching the tutorial video. Meanwhile, he has been looking through the interactive map that shows the production levels of renewable energy around his region against the current demand.

Aware of the extra features that he might be able to play with, Yuri jumps straight to the Create an account link. He inputs the regular information, his name, professional status, etc., and performs a quick profile test of three multiple-choice questions. That's been done. He is taken to the search page, where he notices that few options are set to some specific values and that the number of technologies available is much less than the ones he is aware of.

Profiled as a researcher, Yuri sees a preset of options that match his role description and intention of use. Nonetheless, Yuri wants a broader picture and more options to play with. So, before starting the filtering of options, he goes to the Menu and clicks on Enable all parameters.

Yuri sets the Regional area to the Metropolitan Region of Lisbon, goes back to the tab Technology, and sees the list of technological options has increased. So one by one, he starts toggling on and off the types of energy production he wants to consider for this first trial. Later, as he checks Environmental impacts, he notices that many of his NGO's topics of concern are listed there. "It's a good opportunity for me to catch some measurements!" he thinks.

After performing his choices, he clicks on Search. Quickly, a map of the selected region with the respective distribution of power generation sources shows up, accompanied by graphical information regarding capacity, types of technology, and social and environmental impacts. Alongside the map, is a menu listing the 5 scenarios that match Yuri's expectations. Before going further to review them, Yuri jots down in his notebook: "Invite research group to test."

Yuri looks at the clock and remembers that his meeting starts in five minutes. So he saves his Search to review the results later. Closing the page, Yuri switches his tasks.

Fig. 19 - Scenario of the interaction of the NGO Environmental Technician and Researcher

Scenario 3- A strategic view of RES-based options available in Alentejo

Persona: Walter Diniz - Land owner and Wine producer

Goal: Research available cost-effective options and gather information to discuss energy efficiency for his winery

Walter met with his cooperative colleagues to discuss energy efficiency in their region. People criticized the government's initiatives of building big photovoltaic power stations in the south of Portugal, but Walter defended it. The opinions disagreed so much that the talk was left for another moment. When Walter arrived home, he decided to research the topic.

He reached the webpage of this modeling tool called SEEDS and found that he could simulate feasible, cost-effective energy plans. Walter watched the page tutorial, and perceiving the interaction easy, he gives a try.

Walter clicks on Begin to create his plan. Straightaway he's led to a page that presents three questions with multiple choice answers. The first is about his actuation area, for which he chooses the Wine Industry. The second is about the geographic location he wants to search, and he selects the Alentejo region. The third asks him about the aspects he wants to take into account for his search, for which he selects Economic Impact, Ecotoxicity, and Land Use. Based on his choices, the tool provides him a set of technology options that he can edit.
He skims through the list of technologies and sets off some of the options. Also, he starts tweaking the percentage values of some of them. Walter then clicks on search. A new screen appears, and Walter sees the parameters he edited listed on the right alongside an option to refine his search. Seeing the map of the Alentejo region, he reviews the data of the five scenarios listed until he finds a good alternative.

The numbers are satisfactory, but an exclamation signal on the Environmental histogram calls his attention. Clicking on that graph, a detailed review of the data is expanded on his screen. Walter notices that his choice has affected water toxicity and Land use indices, which can compromise his vineyards in the future. Concerned, Walter goes back to the map screen and updates his research by tweaking the options he left untouched. Focused on fixing the environmental impact of his previous simulation, he reaches an unexpected solution: small unities of energy generation across the winery region would give them an advantage in supplying the current demands. "I need to show this to José", he thinks, reaching the Save button.

At this moment, Walter sees a pop-up that asks him to create an account to save his preferences. He fills up the requested information. Logged in, he then saves that worth sharing scenario and downloads the report.
While he prints the results and detailed tables, Walter sends a message to José informing "I found something very interesting for our energy demands. Let's meet this week to resume our talk!"

Fig. 20 - Scenario of interaction of the Landowner and Wine producer

6. References

Bodker, S. (1999). Scenarios in user-centered design-setting the stage for reflection and action. *Proceedings Of The 32Nd Annual Hawaii International Conference On Systems Sciences. 1999. HICSS-32. Abstracts And CD-ROM Of Full Papers*. https://doi.org/10.1109/hicss.1999.772892

Carroll, J. (2000). Five reasons for scenario-based design. *Interacting With Computers*, *13*(1), 43-60. https://doi.org/10.1016/s0953-5438(00)00023-0

Doblin J. (1980). A structure for non textual communications. In: Kolers P.A., Wrolstad M.E., Bouma H. (eds) Processing of Visible Language. Nato Conference Series, vol 13. Springer, Boston, MA. https://doi.org/10.1007/978-1-4684-1068-6_7

European Environment Agency NEWS. EU achieves 20-20-20 climate targets, 55 % emissions cut by 2030 reachable with more efforts and policies. https://www.eea.europa.eu/. (2021). Retrieved 27 November 2021, from https://www.eea.europa.eu/highlights/eu-achieves-20-20-20.

Felder, F., Unel, B., & Dvorkin, Y. (2021). Modeling strategic objectives and behavior in the transition of the energy Sector to inform policy making. *The Electricity Journal*, *34*(8), 107009. https://doi.org/10.1016/j.tej.2021.107009

Frauenberger, C., Good, J., & Keay-Bright, W. (2010). Phenomenology, a framework for participatory design. *Proceedings Of The 11Th Biennial Participatory Design Conference On - PDC '10*. https://doi.org/10.1145/1900441.1900474

Gunnasdottir, I., Davidsdottir, B., Worrell, E. (2021) It is best to ask: Designing a stakeholder centric approach to selecting sustainable energy development indicators, *Energy Research & Social Science*

Grudin, J.T., & Pruitt, J.S. (2002). Personas, Participatory Design and Product Development: An Infrastructure for Engagement.

Harley, A. (2015) Personas Make Users Memorable for Product Team Members. Retrieved 16 December 2021, from https://www.nngroup.com/articles/persona/

Harvey, W. S. (2011). Strategies for conducting elite interviews. Qualitative Research, 11(4), 431–441. doi:10.1177/1468794111404329

Höfer, T., Madlener, R.(2020). A participatory stakeholder process for evaluating sustainable energy transition scenarios. Energy Policy 139, 111277. https://doi.org/10.1016/j.enpol.2020.111277

Huybrechts, Liesbeth, Cristiano Storni, Yanki Lee, Selina\ Schepers, Jessica Schoffelen, Katrien Dreessen (2014). Participation is Risky. Approaches to Joint Creative Processes. Amsterdam: Valiz.

Katrina McChesney & Jill Aldridge (2019) Weaving an interpretivist stance throughout mixed methods research. *International Journal of Research & Method in Education, 42:3, 225-238,* DOI: 10.1080/1743727X.2019.1590811

Komatsu, Tamami, Manuela Celi, Francesca Rizzo, and Alessandro Deserti. (2016). A case based discussion on the role of Design Competences in Social Innovation. *Design Research Society 50th Anniversary Conference, Brighton UK.*

Liebe, U.; Dobers, G. (2019). Decomposing public support for energy policy: What drives acceptance of and intentions to protest against renewable energy expansion in Germany?. Energy Research & Social Science, 473, 247-260. https://doi.org/10.1016/j.erss.2018.09.004

Libório, A., Furtado, E., Rocha, I., & Furtado, V. (2005). Interface design through knowledge-based systems. *Proceedings Of The 4Th International Workshop On Task Models And Diagrams - TAMODIA '05*. https://doi.org/10.1145/1122935.1122961

Lucero, A., Vaajakallio, K., & Dalsgaard, P. (2012). The dialogue-labs method: process, space and materials as structuring elements to spark dialogue in co-design events. *Codesign*, *8*(1), 1-23. https://doi.org/10.1080/15710882.2011.609888

Mingers, J., & Rosenhead, J. (2004). Problem structuring methods in action. *European Journal Of Operational Research*, *152*(3), 530-554. https://doi.org/10.1016/s0377-2217(03)00056-0

Moallemi, E. A., Malekpour, S. (2018). A participatory exploratory modelling approach for long-term planning in energy transitions. Energy Res. Soc. Sci. 35, 205–216. https://doi.org/10.1016/j.erss.2017.10.022

Morville, P., and Callender, J. (2010). Design Patterns: Faceted Navigation. Retrieved 23 December 2021, from https://alistapart.com/article/design-patterns-faceted-navigation/

Naranjo-Bock, C. (2012). *Creativity-based Research: The Process of Co-Designing with Users*. UX Magazine. Retrieved 7 November 2021, from https://uxmag.com/articles/creativity-based-research-the-process-of-co-designing-with-users.

Nielsen L (2019) Personas in use. In Personas – user focused design (pp. 83–115). Springer, London. https://doi.org/10.1007/978-1-4471-7427-1_5

Pruitt, J., & Grudin, J. (2003). Personas. *Proceedings Of The 2003 Conference On Designing For User Experiences - DUX '03*. https://doi.org/10.1145/997078.997089

Sanders, EBN., & Stappers, PJ. 2012. Convivial toolbox: Generative research for the front end of design. Bis.

Santamouris, M., & Vasilakopoulou, K. (2021). Present and Future Energy Consumption of Buildings: Challenges and Opportunities towards Decarbonisation. *E-Prime*, 100002. https://doi.org/10.1016/j.prime.2021.100002

Scupin, R., 1997. The KJ Method: A Technique for Analyzing Data Derived from Japanese Ethnology. Human Organization 56 (2): 233–237. doi: https://doi.org/10.17730/humo.56.2.x335923511444655

Süsser, D., Ceglarz, A., Gaschnig, H., Stavrakas, V., Giannakidis, G., Flamos, A., Sander, A., & Lilliestam, J.(2020). The use of energy modelling results for policymaking in the EU. Deliverable 1.1. Sustainable Energy Transitions Laboratory (SENTINEL) project. Potsdam: Institute for Advanced Sustainability Studies (IASS).

van Rijn, H.,& Stappers, PJ. (2008). Expressions of ownership: motivating users in a co-design process. In: Proceedings of the Tenth Anniversary Conference on Participatory Design 2008 (PDC '08), Indiana University, USA. 178–181. DOI:10.5555/1795234.1795266

The European Commission. Roadmap for moving to a competitive low carbon economy in 2050. The European Commission, 2011. URL:

https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52011DC0112&from=EN

Yndigegn, S., Malmborg, L., & Brandt, E. (2018). Codesigning with public partners. *Proceedings Of The 15Th Participatory Design Conference: Short Papers, Situated Actions, Workshops And Tutorial - Volume 2*. https://doi.org/10.1145/3210604.3210651

Whitenton, K. (2010) Filters vs. Facets: Definitions. . Retrieved 13 December 2021, from https://www.nngroup.com/articles/filters-vs-facets/