ENER MAPS

DELIVERABLE 1.1: USER STORIES AND PRIORITIZATION

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Synonyms/Acronyms

List of abbreviations	
RES	Renewable energy sources
BS	Building stock
R&I	research and innovation
JRC	Joint Research Centre
EEA	European Environment Agency
GIS	Geographic Information System
HDD	heating degree day
CDD	cooling degree day
EC	European Commission
OPSD	Open Power System Data
ESPON	European Spatial Planning Observation Network
GDP	Gross Domestic Product
NACE	Nomenclature des Activités Économiques dans la Communauté Européenne
NUTS	Nomenclature of Territorial Units for Statistics
PV	photovoltaics
RD&D	Research, Design, and Development
SDH	Solar District Heating
SETIS	Strategic Energy Technologies Information System
NZEB	Near Zero Energy Building
EDMT	EnerMaps Data Management Tool
SA	Stakeholder Analysis
SNA	Social Network Analysis
I [1, 2, 3, 4, 5, 6, 7, 8]	Interviewees

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ABSTRACT

The Horizon 2020 (H2020) EnerMaps project aims at developing a Data Management Tool that will include energy-related datasets and ensure their availability, accessibility, interoperability, reusability, as well as accuracy.

The energy transition deals and starts from data, which are important for several stakeholders, whose deal with planning, management, and policy-making processes.

This report lists the stakeholders and analyses the user stories and needs with the aim at identifying the main aspects to be considered in the development of the EnerMaps Data Management Tool (EDMT). The deliverable includes methods for proceeding in a clear and transparent way at the beginning of the EDMT development, involving stakeholders who use energy-related datasets.

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INTRODUCTION

The energy transition is one of the most relevant ongoing processes in Europe and the World. Several European funded projects deal with the energy transition and its aspects, producing energy data in the process. Energy-related, or energy, data include data directly related to the energy sector, including energy consumption and production, and data that is indirectly related to the energy sector, including socioeconomic variables. These data are fundamental in addressing the energy transition and supporting the processes of research, planning, management, and policymaking. However, in the actual context of energy transition in the European Union, data is often difficult to find and fragmented. This situation creates inefficiencies and the need to propose new innovative solutions and strengthen past activities of energy data creation and management. Since these energy data are vital for addressing, planning, and managing the energy transition, it is fundamental to promote a process for organizing and making all existing datasets accessible, and to promote the creation of new and relevant datasets.

The availability, quality, management, and use of energy data are relevant for energy and climate strategies and actions. The European Green Deal (1) declares the relevance of the data access to all the actors dealing with energy transition and climate change, facilitating evidence-based decisions and expanding the capacity to understand and tackle energy challenges. The stakeholders of the energy transition need to plan, manage, and monitor their actions for the energy transition, which usually starts having an idea on the status quo and the historical evolution of the processes and phenomena. It is relevant to know who the main stakeholders are, to be able to identify their needs, and to know how we can promote easy and clear access and use of available data.

In this context, the main goal of the Horizon 2020 (H2020) EnerMaps project is to promote energy data access for all actors dealing with energy-related issues and daily decisions in terms of planning, implementing, and monitoring of energy-related activities. This project works on the identification of existing datasets, the promotion of interactions among datasets, and the dissemination of energy data. The EnerMaps Data Management Tool (EDMT) - Figure 1 - will be developed as an ecosystem where energy data is findable, accessible, interoperable, reusable, and accurate (FAIR). At the beginning of the EnerMaps project, relevant stakeholders are identified for collecting user stories and needs for developing the EDMT, which will be effectively up taken.

For promoting an effective uptake, an innovation should be aligned “with the existing political, cultural, or economic structures” (2) and the uptake should be supported by an existing network of stakeholders (3). It is important to take immediate action, at this beginning stage of the EnerMaps project, understanding how the EDMT could be aligned with the political, cultural, and economic structures, which are the most relevant challenges on the use of energy datasets, and which potential uptake of the EDMT can be supported by a network of stakeholders. One way to define all these aspects for dealing with the development process of the EDMT is to talk to the main stakeholders, both users and creators or managers of energy datasets and software. Asking them is also a matter to open the minds collecting new viewpoints and perspectives on data access and use, in all sectors and in the energy transition process.

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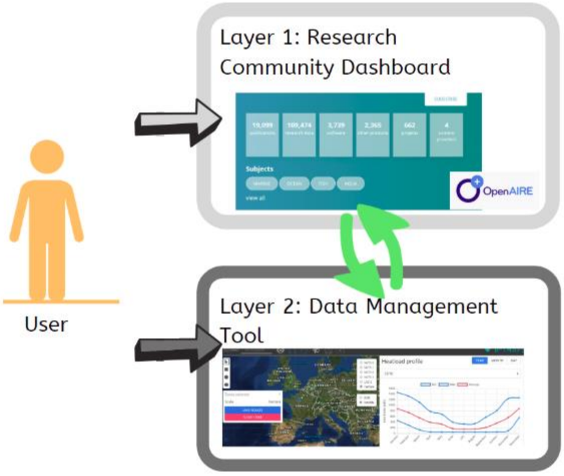

Figure 1 – The EnerMaps project will develop a research community dashboard including several existing datasets, and the EnerMaps Data Management Tool for elaborating and visualizing the energy data.

All stakeholders engaged in the energy transition can be imagined as part of a network of relationships among them. This perspective is called the relational analytical approach (4), (5) and it is interesting for investigating the shared understanding of challenges and conflicts, shared problem construction and collective solutions (3), (6). Each stakeholder has a relationship with one or more of the other stakeholders who deal with energy data. The understanding of the characteristics of the stakeholders and their network of relationships is relevant for two main reasons:

- The stakeholders have their own needs, preferences, and forms of understanding, which are usually different according to the sector (e.g. research, planning, policymaking).
- The network of relationships could be relevant to uptake the EDMT, using concepts of circulation and replication of innovations (2).

The stakeholder analysis is an important phase to ensure the involvement of all the relevant perspectives and stakeholders who have an influence (7) on the effective future use and uptake of the EDMT. There may be groups that have historically been marginalized by planning, management, and policymaking sectors and are difficult to identify or involve (8). These aspects can be addressed by the methodology of stakeholder analysis, which consists of several phases: (i) the identification of stakeholders, (ii) the categorization of stakeholders, and (iii) the investigation of the relationships among stakeholders. The stakeholder analysis identifies relevant actors for interviewing them, in order to collect and analyse user stories and needs.

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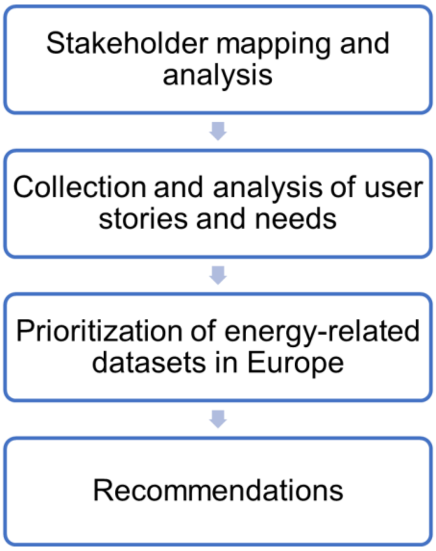

Figure 2 – Process considered in the analysis included in this report.

For investigating the characteristics, preferences, challenges, needs of the stakeholders as well as the shape of the current network of relationships between stakeholders, this report presents a mixed-methods research approach, including stakeholder analysis and qualitative analysis of user stories and needs. The combination of quantitative methods of network mapping and qualitative methods for content analysis are also used to understand emerging discourses and storylines (9), (10), (11) useful to address the development of the EDMT. Using this combination of methods, we are not only able to identify the potential users and experts of energy datasets but are also able to analyse relationships among them and identify the core actors dealing with energy data in Europe.

This report aims to propose the key aspects to be considered in the development of the EDMT, and to listen and understand the viewpoints of stakeholders and consider their user stories and needs. This report is structured in four chapters. The **first chapter** explains the stakeholder analysis method and describes each stakeholder group, including their main sectors in the energy world and what their relationship is to the other stakeholders. The stakeholder analysis permits a select number of central stakeholders to be interviewed to collect user stories and needs and create an in-depth understanding of the current challenges and problems that are to be addressed in the EDMT. The **second chapter** synthetizes the user stories and needs collected through interviews to stakeholders, emphasizing some aspects to be developed in the EDMT. This chapter synthesizes – analysing the contents of interviews (12), (13) - user stories and needs, the most relevant existing energy datasets that could be useful for the development of the EDMT, new energy datasets that could be created. The **third chapter** addresses the major topic of existing energy-related datasets and attempts to prioritize a selection of them. Fifty energy-related datasets are included in a table along with a description and other relevant information. The **fourth chapter** proposes some key aspects on the main needs to be considered in the EDMT development, synthesizing the previous chapters.

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1. STAKEHOLDER ANALYSIS

This chapter is divided into four sections. First, an introduction describes the evolution of the stakeholder concept in the scientific literature over the years. The second section explains the relevance of the stakeholder analysis at the beginning of planning, development, management, and decision-making processes. The third section describes the methods for stakeholder analysis used in the EnerMaps project. Finally, the fourth section reports the results of the stakeholder analysis.

1.1. Evolution of the stakeholder concept

Over the years, stakeholders have been significant in the planning and management of activities in different fields, such as economic, social, and energy fields, due to the interdisciplinary aspects of these fields (14).

There are different definitions of the concept of stakeholders that emphasize the involvement of interdisciplinary perspectives. For this reason, the following paragraphs refer to the contribution of Reed et al. (15), who attempt to make a brief explanation on how this term has changed over time and the relevance that has been attributed to it. In particular, the recent definitions of this term refer to the one elaborated by Freeman (16) that identifies stakeholders as individuals who are influenced or affected by a decision or action.

What is neglected in this definition is the influence that stakeholders can have in some contexts. Decades before Freeman, in a corporate context where stakeholders were viewed in a different light, they were defined as those groups or individuals that are fundamental to make organizations exist (15). In 2015, in the international regulatory field, stakeholders were defined as interested parties, persons, or organizations that can influence, be influenced, or perceive themselves as influenced by a decision or activity (ISO 14001/2015).

In particular, the current debate on an interdisciplinary definition of stakeholders is held back by the lack of a definition of common criterion to identify who is entitled to participate in a planning or management process. The following sections highlight how stakeholder analysis can be used to define who is entitled to participate and who are the stakeholders.

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1.2. Identifying, categorizing, and investigating relationships

The stakeholder analysis (SA) is one the most used techniques aimed at identifying all those who are entitled to participate in a process. Before proceeding, we will briefly clarify SA and its limitations. The SA is a research method used to define actors that have influence in a certain context (17). According to Reed et al. (15), the SA: "(i) defines aspects of a social and natural phenomenon affected by a decision or action; (ii) identifies individuals, groups and organizations who are affected by or can affect those parts of the phenomenon (this may include non-human and non-living entities and future generations); and (iii) prioritizes these individuals and groups for involvement in the decision-making process". Precisely, because SA is used in different contexts and with different purposes, it is not considered as a single tool but as a set of different methodologies to investigate the interests of stakeholders (18). The main problem with the SA is the definition of the aspects of the system on which research is intended. The limitations of the SA can sometimes be related to the little knowledge of the processes and to a categorization of the stakeholders based on a subjective evaluation for the purposes of research or personal prejudices (17).

In addition, the selection of subjects to focus on is very challenging because you can face different problems: there may be groups which have historically been marginalized by planning and management sectors and which are difficult to identify or involve; there may be conflicts between the different social groups which restrict participation by some of them; and there may be a lack of representativeness due to the fact that decision-makers are a small group compared to the whole (8). A mistake at this stage of the methodological process for identifying stakeholders has the potential to marginalize important groups, to influence results, and to compromise profitability and support of the process (15).

The first step in the stakeholder analysis is the **identification of stakeholders** (15). This phase is important because experts or researchers have potentially much to learn from stakeholders. They possess important information for the simple fact of being part of the context or process to be analysed (19). An in-depth knowledge could improve the processes as it adds different points of view that characterizes each interested party (20). The next step suggested by Reed et al. (15) is to differentiate and classify the stakeholders. This step will help us understand how the different stakeholders are incorporated into the process, how they can influence the process, what might satisfy them, and their personal and professional preferences (20).

The second step is the **differentiation and categorisation of stakeholders** (15). It takes place through different methods: (i) top-down analytical categorizations and (ii) bottom-up reconstructive methods (15).
There are different types of classification that can be considered. This report briefly explores the one developed by Lindenberg and Crosby (21), which considers interest and influence as important elements. An important part of planning the best development of a new management process, for example in environmental fields, is to understand the opinions and needs of each interested party. To this end, it is essential to integrate the opinions of stakeholders. To do this, we must understand the real power that has every stakeholder in processes and in the use and diffusion of a new tool – such as the EDMT – based on the role it plays as an interested party (22).

The last step is the **investigation of relationships between stakeholders** (15). Understanding the relationships between the different social actors can be important for two reasons. First, it helps to know the present relationships and the work on them e.g. using them for spreading a new technology or tool. Secondly, understanding interactions also helps to improve interdisciplinarity, which will be useful in designing the EDMT

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to be practical for several sectors and actors. The integration of multiple forms of knowledge (19) into a new data management tool will ensure a more appropriate and specific development of the tool based on the reference context of datasets in Europe.

The purpose of identifying, categorising and investigating the relationships between stakeholders within the EnerMaps project was to integrate the knowledge of researchers and partners of the project with the knowledge in possession of those stakeholders who use energy-related datasets and software. Being unable to interview all stakeholders, it was decided to identify 10 experts through the stakeholder analysis. This list of stakeholders is not exhaustive and is not representative of all the European stakeholders. However, it permits to collect an initial idea on the user stories and needs.

1.3. Methods for stakeholder analysis

Table 1 shows the different methods, that Reed et al. (15) point out for each stage of the SA.

Table 1 – Steps and methods for defining stakeholders through stakeholder analysis, used in the EnerMaps project.

Step	Methods
1. Identification of stakeholders	Focus groups
	Semi-structured interviews
	Snow-ball sampling
2. Differentiating and categorizing stakeholders	Analytical categorisation (top-down)
	Reconstructive categorization (bottom up)
3. Investigating relationships between stakeholders	Actor-linkage matrices
	Social Network Analysis
	Knowledge mapping

In this work, it was chosen to use the snow-ball sampling for the first step, the reconstructive categorization (bottom up) for the second step and social network analysis for the last step. It was chosen to use snow-ball sampling giving the possibility to know more closely the relationships and interactions between the different stakeholders as each of it indicates a person who for various reasons is in contact with the stakeholder. The reconstructive categorization (bottom up) was chosen because this method allows to leave to the categorization directly to the stakeholders, in such a way that everyone inserts the different people they want to indicate based on their own criteria. This method is considered the most correct to identify the different views, which as previously pointed out are very important (23). In the last step we chose to use the SNA because, among the three shown in the table, it is the most efficient method to know and measure relationships within a social network. In particular actor-linkage matrices allow to create only a matrix with the various relationships but not to know and measure them, while knowledge mapping is usually used as a support to the SNA and not as a single method.

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The snow-ball sampling method was used to identify stakeholders in the EnerMaps project (Table 1). For the first step in our case, we decided to start with the partners of the EnerMaps project. The partners were sent an Excel file and were asked to indicate persons and/or organizations that could be important to effectively address the development of the EDMT. The reference sample to which the file was sent was made up of 23 people. After 10 days from the sending of the first e-mail we sent a second e-mail to the stakeholders. 8 out of the 23 people returned and filled the file. The SA identified 49 experts in total.

Most stakeholders have identified more than one person relevant to the research objectives, distributed in the different target groups (Table 2). The stakeholders that were identified the most belong to the research and policy makers categories. This can be justified with the figure covered in the working field of the initial stakeholders, who work mainly for research institutions and with researchers and policymakers. This limit can be resolved by asking more stakeholders to indicate new persons. Social Network Analysis (SNA) was used in the following step to investigate the relationships between stakeholders. The SNA is defined as an approach that, by referring to techniques related to mathematical graph theory and using matrix algebra, analyses the relationships between actors, using both qualitative and quantitative methods. The actors are linked to each other through meaningful social relationships (17), (24).

Table 2 - Number and type of stakeholders identified by project partners.

Target group		
Lead user	**Absolute values**	**Relative values**
Research (staff in universities and non-university research organisations	11	22,44%
Industry (in particular, renewable technology industry)	3	6,13%
Energy managers	2	4,08%
Energy planners	2	4,08%
Energy utilities	4	8,16%
Energy consultants	3	6,13%
Public administration officers operating in the energy field (those address	6	12,25%
End users		
Civil society (addressed by social innovation experts - lead-users): civil	4	8,16%
Data providers	3	6,13%
Policy makers	11	22,44%

In this specific context, for the EnerMaps project we have chosen to use the SNA to have the opportunity to understand what the existing relationships between the different stakeholders are. The partners of the project were asked to indicate the people who according to them were relevant for each category of stakeholders and to express, with a value of 1 to 10, how important their contribution could be. Subsequently, a data matrix was created with all the indicated stakeholders. It was not possible to consider the importance of the contribution of each stakeholder because not all partners indicated this value. Once obtained the data matrix, a graphical representation of the relationships between the different stakeholders was prepared. The relational approach, if further depth, will allow to understand the dynamics and the relationships between the different stakeholders and understand if there are some categories of stakeholders who are more excluded than others from the process of the EDMT development.

There are some limits in this SA. The first limit is in the identification of stakeholders. It is impossible to understand the influence on each expert, because it was not indicated by the stakeholders who filled the Excel

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file. The second point that limits a wider analysis is that we do not have a significant value for the SNA, because, as indicated below, only 8 stakeholders had returned the filled file. It is important to note that at this stage of the development of the SA in EnerMaps it is not yet possible to talk about snow-ball sampling as the file has not been sent back to the stakeholders indicated in the first selection.

The following section presents a graphical representation of the relationships among the identified stakeholders. Before proceeding to a more detailed analysis of the chart shown below (Figure 3), we would like to make some clarifications. For a matter of privacy, all the names of the people involved in this SNA have been encoded. The encodings where a “0” appears (e.g., A0) are those who filled the list of relevant stakeholders. The data were included in a data matrix which subsequently was important to graphically represent the relationships using relational software.

1.4. Stakeholder analysis in the EnerMaps project

This section focuses on a descriptive analysis of the graphical representation emerged from the collected data. The total number of nodes (or stakeholders) is 57, while the total number of edges (or relationships) is 59. B0 and C0 have indicated the same stakeholders. This occurred because these two experts belong to the same organization. This also happened for node D1, which was indicated by G0 and D0.
Everyone has indicated more than one relationship (except F0, of which we will then indicate the reason). Table 3 shows the relationships that emerged from a first administration of the Excel file, where it is possible to notice outdegree and indegree. In particular, it emerges that E0 is the stakeholders that has a fairly high outdegree value, this indicates that this stakeholder has a good disposition towards others and a high degree of membership in the group (Chiesi, 1999).

Table 3 - Indegree-outdegree-degree.

Label	indegree	outdegree	Degree
A0	0	3	3
A1	1	0	1
A2	1	0	1
A3	1	0	1
B0	0	9	9
B1	2	0	2
B2	2	0	2
B3	2	0	2
B4	2	0	2
B5	2	0	2
B6	2	0	2
B7	2	0	2
B8	2	0	2
B9	2	0	2
C0	0	9	9
D0	0	13	13

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D1	2	0	2
D2	1	0	1
D3	1	0	1
D4	1	0	1
D5	1	0	1
D6	1	0	1
D7	1	0	1
D8	1	0	1
D9	1	0	1
D10	1	0	1
D11	1	0	1
D12	1	0	1
D13	1	0	1
E0	0	9	9
E1	1	0	1
E2	1	0	1
E3	1	0	1
E4	1	0	1
E5	1	0	1
E6	1	0	1
E7	1	0	1
E8	1	0	1
E9	1	0	1
F0	0	1	1
F1	1	0	1
G0	0	6	6
G1	1	0	1
G2	1	0	1
G3	1	0	1
G4	1	0	1
G5	1	0	1
H0	0	9	9
H1	1	0	1
H2	1	0	1
H3	1	0	1
H4	1	0	1
H5	1	0	1
H6	1	0	1
H7	1	0	1
H8	1	0	1
H9	1	0	1

This indicates that there would be an expansive potential network among stakeholders, if we continue asking for new lists identifying stakeholders and applying a wider interpretation of the snowball sampling. This highlights

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that there are stakeholders who can be further identified, and it would be interesting to know in depth the dynamic relations among them.

Another interesting aspect that emerges from the relationship between stakeholders, which is explained in greater detail in Table 4, is the geographical proximity of the expert indicated as relevant.

Table 4 - Distribution of stakeholders by work area relative to the responding expert.

Label	Stakeholders working in the same country (%)	Stakeholders working in another country in (%)
A0	30	60
B0	100	0
C0	100	0
D0	7,7	92,3
E0	100	0
F0	0	100
G0	0	100
H0	87,5	12,5

As is evident in the Table 4, three experts (B0, C0, E0) only indicated stakeholders who work in the same geographical area. As mentioned above, A0, F0, D0, H0 and G0 work in the same institute. However, the majority of the stakeholders indicated by H0 come from the same geographical area whereas the stakeholders indicated by A0, F0, D0, and G0 come from other geographical areas. F0 and G0 only indicated stakeholders that come from other geographical areas. One possible reason might be that for work reasons they have more relationships within the country where they work.

The first data and results are interesting to define a list of stakeholders to be interviewed. However, there is potential to follow up the analysis and to further enlarge the network represented in Figure 3. Each of the stakeholders indicated by the partners of the project could indicate additional stakeholders, indicating an even wider network of stakeholders using energy-related datasets and software. A further analysis could be very important at this stage of the project as it could allow us to learn more about the existing relationships and improve the relationships between the different stakeholders for ensuring the uptake and use of the EDMT.

Starting from the list of experts emerged from the stakeholders, we highlighted 10 relevant stakeholders to interview. The criteria we used to choose these experts were:

- Geographic distribution: 8 different European nationalities.
- Gender inclusiveness: 50% women.
- Interdisciplinary expertise: lead and end users.

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These criteria were considered valid because at the base of these features there is a lot of transversal information to consider. Like the different cultural background that characterizes each geographical area, and therefore the different use of the instrument by people from different locations. We have chosen to select experienced women to avoid the risk of excluding part of society that might be more difficult to achieve. Ultimately, having different points of view can bring important information, which is why the third parameter considers interdisciplinary expertise.

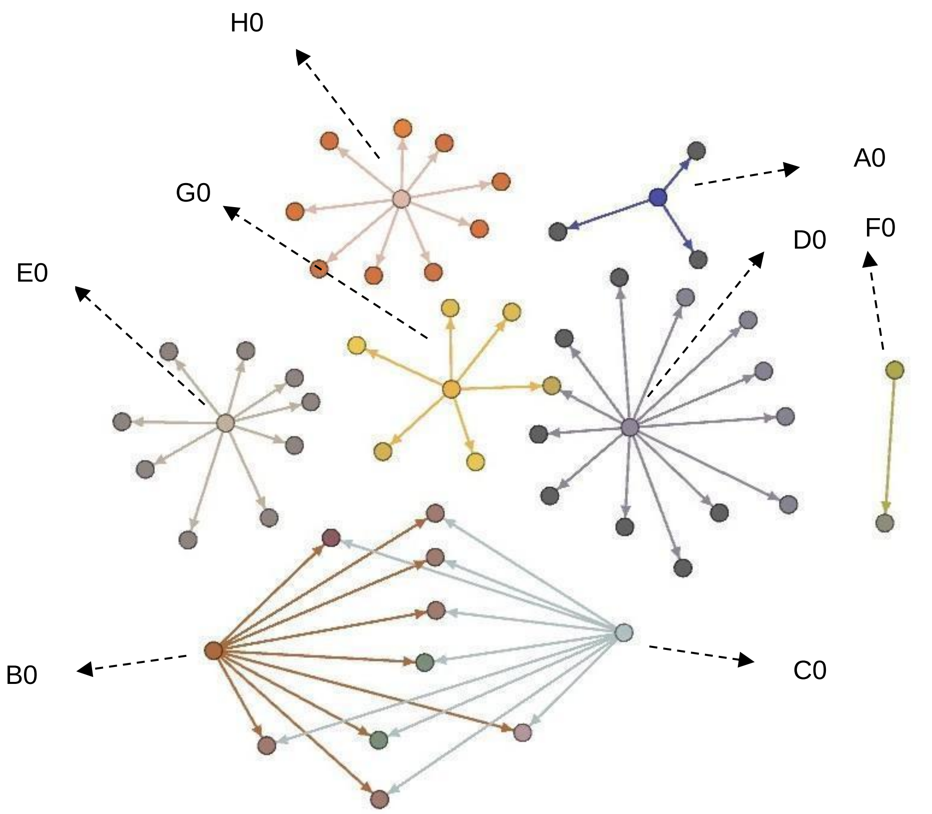

Figure 3 - Social Graph (SG). The graph includes a representation of the relationships among identified stakeholders. The node's label is indicated only for the 8 stakeholders who first filled the Excel file.

One of the limitations that is important to highlight was due to privacy issues (see F0 that indicates only a relationship). In many cases, it has proved difficult to abled or allowed to indicate the contact of a person who is deemed important. Without this availability or consent and due to a matter of sensitivity, we could not consider and analyse several data.

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2. USER STORIES AND NEEDS

This chapter presents the results of the expert interviews carried out within the context of the EnerMaps project. These interviews were collected in order to create an exploratory analysis with the aim of supporting the development of the EDMT. The chapter is divided in the following way: first, a brief methodological section introduces the criteria of selection of the interviewed experts, emphasizing some choices done in Chapter 1, and the structure of the interview; second, the data of the interviews are analysed according to some categories of user stories and needs.

2.1. Methodological introduction

The qualitative data presented in this study were collected through eight phone interviews with experts within the energy field. As explained in Chapter 1, the experts were selected through a process of stakeholder analysis with the aim of achieving a sample with three main traits: wide geographic distribution, gender inclusiveness, and interdisciplinary expertise. The eight experts selected are equally divided between men and women and come from six different European countries. Regarding the interdisciplinarity issue, we selected the sample in order to include experts working in various types of public institutions and private companies active in the energy field. The sample group includes an energy researcher, an energy planner, an energy consultant, an officer from a public administration operating in the energy sector, a data provider, and a member of an energy research community. Regarding the academical background, six of the experts graduated in energy-related masters and PhDs while other two are specialized in social sciences.

Ten experts were contacted directly through e-mails and eight interviews[1] which, due to obvious distance issues arising as a consequence of the international nature of the sample, were conducted and recorded by phone using an online software. We acknowledge that the use of phone interview is controversial in the literature of qualitative methodology (25) due to the loss of elements such as non-verbal communication, which are usually considered important in the process of interpreting the result. However, we also believe that this method is justifiable in the case at hand since, as Christmann (13) suggests, the method is not suited for generating new theory, but it remains a valid tool for focused exploratory researches within the context of a broader project.

The interview schedule is written with consideration of the guidelines provided in their methodologic paper regarding expert interviews by Meuser and Nagel (12). In particular:

[1] Two out of ten persons were not available to be interviewed.

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- The interview follows a flexible schedule divided in thematic guidelines rather than a rigid list of questions. This scheme allows the chance to address unforeseen aspects of topics which could be utilized in subsequent interviews.

- The wording of questions aims at the supra-personal level of knowledge and relates to the institution/company where the expert is employed. This kind of questions helps to understand how the official institutionalized reality of the expert is structured, as well as to what extent the expert acts in a field of conflict between perceived institutional directives and his personal interpretation of rules.

- In addition to questions strictly related to EnerMaps, the interview tries to contextualize the expert in its job environment. This operation aims to investigate the non-explicit knowledge (26) typical of the affiliated organization of the expert, namely, collectively shared experiences, incorporated knowledge, rules of thumb, organizational routines or informal rules of prejudice.

Since the objective of this exploratory research is to support the development of the EDMT, the interviews focused mainly on two aspects of the experts' work process: user stories and user needs. The former refers to all the formal and informal procedures related to the use of data, often presented in a narrative form. The collection of this information may help the EnerMaps developers to understand in which part of the experts' work process the new software results are useful. On the other hand, the user needs indicate all the instruments needed by the experts to properly analyse the data. An overview of these needs may prove fundamental in deciding which features must be included in the EDMT.

2.2. User stories

This section analyses narrative excerpts from the interviews, which may be useful for the development of the EnerMaps tool. In particular, this section focuses on two main elements:

1. Common problems in data handling reported by the experts in the narration of their work and research processes, which may be overcome thanks to the EDMT.

2. Previous experiences of the experts with software to aggregate and elaborate different datasets, which may highlight problems or difficulties to be avoided in the EnerMaps tool.

2.2.1. COMMON PROBLEMS IN DATA HANDLING

In most of the performed interviews, the first reported problem regarding data handling is related to the acquisition of datasets. This process is particularly delicate, and the problems may arise from a wide variety of sources. One of the foremost is the legal regulation of databases:

"So, we have this problem: data attracts copyright if it is sufficiently selected and arranged, and here we have a second problem. There is a thing call the Database Directive. That's a thing that partakes databases. It came in 1996 and it is that if a public database has substantial investment, then there are restrictions on how you can use that data, and this causes us endless problems. […] So, this is not being traditionally a problem for closed

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research groups, but anyone who works for open source models of research, with Open Science has to confront this problem of license." (Interview 2)

The expert is referring to the Directive 96/9/EC of the European Parliament which sanctioned the intellectual propriety of databases. Obtaining the proper licenses may not be a problem for a research centre or public authority, but it is far out of reach for single researchers working with open source tools. A similar problem may arise due to market reasons:

"Market sensitive data, meaning that this is data that the utilities or the data providers are not willing to provide because this data may present some challenge for their market realization. For example, if they say the number of customers they have in a city, this may be used by other companies in the same sector. Or the quantities of energy they sell or the quantities of energy they generate, somehow." (Interview 1)

This problem is relevant only when the experts deal with private data providers, but it creates again the same scenario: researchers without company authorization or substantial funding have great difficulties in meeting the requirements to obtain databases for their research.

The problems regarding data acquisition are not limited to simply obtaining data but may also involve how data are sent:

"There are also sometimes technical problems in the way you get the data, because you have range of possibilities. They send you a file, you can download the file. Nowadays, that's my point of view, it should be better using APIs or these kind of technologies in which you can ask the system what you need. […] This also helps you for interoperability issues." (Interview 5)

API in this excerpt means Application Programming Interface, a computing interface which defines interaction between multiple software intermediaries. Using this kind of tool, as suggested by the interviewed expert, may also help a software like the EnerMaps tool in harmonizing different datasets.

The second problem faced by many of the experts we interviewed is the quality of the data. Datasets often do not present sufficient level of detail for research purposes. The problem may be related to data segregation (the process in which all the information gathered into clusters with some homogenous or similar properties), data granularity (which refers to the size in which data fields are subdivided), or both. One of the experts stated that in their country the data tend to be lacking on both issues:

"What is difficult in data collection here in X is that usually data is not segregated. It is very difficult to split the data by sectors or by different time frames and when we are requesting data, we have to officially ask the data provider to give us the data in a certain format. For example, we asked the electricity utility to provide us with data of households of one year back separated by day and night tariff." (Interview 1)

"We have problems sometimes with the granularity of data, meaning that sometimes data is not collected on a certain level. For example, in X energy data is not collected on apartment level. It is collected on building level mostly. This is very true for the heating data; it is collected on building level. We have sometimes trouble with data that it is not collected at all. I mean, there is no such data collected." (Interview 1)

Another quality related problem is related to data normalization:

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"The problem is also the normalization of the data: depending if you get the data from the local, regional or national agency they don't always have the same format." (Interview 5)

This issue can usually be solved through a slow and meticulous work or harmonization between datasets, but it becomes more serious when paired with low data transparency. When the measurement units or the definitions used to create the data are unclear or absent, it becomes impossible to merge different datasets without mistakes.

The last reported problem in data handling is related to representation of the data. Energy technical issues are particularly difficult to understand for people without a specific preparation, and therefore some of the calculations produced by the experts we interviewed may not be easily understandable for all the companies or public administrations which could be interested in the results:

"We have many different datasets for different fuels, but let's say that our final product is the energy balance for a country. This combines all fuels together and uses different international conventions to present all this information in a matrix way and this is usually difficult to understand for people. It is relatively complex." (Interview 8)

This difficulty is not only caused by the audience, but it may also be due to a problem of the experts, who lack the communication skill needed to present their findings to a broader public. Others, like the expert who narrated the following excerpt, may have difficulties to translate abstract concepts into action guidelines:

"What is difficult is the ideological goal. […] I mean when you communicate people don't understand exactly what we have to do to reach the goal. It is just nebulous. […] It is difficult to find actions that we can really do to reach these goals. I mean it is difficult to estimate numbers, results of each action that we do." (Interview 4)

2.2.2. PREVIOUS EXPERIENCES WITH COMPARABLE SOFTWARE

Most of the experts we interviewed stated that they already have experience with software based on the elaboration and aggregation of datasets. Some of the experts process their data using internal software owned by the company/institution where they work. This software is usually centred on merging different datasets, performing calculations or energy modelling, and creating graphs or other representation of the data. The remaining experts stated that they perform these tasks using general-purpose programming languages, in particular Perl or Python or other open source software. The software that experts indicated as particularly useful was Enercoach, a Swiss free software created for energy planning on the local level[2], and SHARES[3], a software created by EUROSTAT for the harmonized calculation of shares of energy produced with renewable sources.

[2] EnergieSchweiz. Energy accounting. [Online] 2020. https://www.local-energy.swiss/arbeitsbereich/energiestadt-pro/werkzeuge-und-instrumente/energiebuchhaltung.html#/

[3] Eurostat. SHARES (Renewables). [Online] 2020. https://ec.europa.eu/eurostat/web/energy/data/shares

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One of the experts also shared with us their experience with the HotMaps Toolbox[4]. This software is an open source tool for mapping and planning on a European scale in the field of heating and cooling. This narration is particularly important in our research because HotMaps provides an approximate idea of what EnerMaps will be at its release.

"My main problem is that it is difficult, and I believe that this a problem for many of the local authorities who attended the trainings. It is very difficult going from the level "I do the exercise because you asked me to find this data" to "I understand what I am doing". […] I can perform the calculations, but I do not really understand the mechanism behind them." (Interview 3)

The interviewed expert explains that although learning the main functionalities of the software is pretty straightforward, it is particularly difficult becoming an autonomous user. The software is able to present results efficiently; but at the same time, it does not seem to be clear enough in presenting which kind of process, called by the developers "scenario toolchain", is the source of these results. The expert also points out that the software has an intricate interaction with other programs:

"It is also very complicated when you have to work on the data outside of the toolbox. You have the Excel sheet, which you have to fill yourself, and you have to upload again the results. I believe it is a bit clunky, it would be preferable doing these operations directly within the system and then getting the result." (Interview 3)

2.3. User needs

In this last section of the chapter we analyse needs expressed by the experts during the narration of their work procedures and their interaction with quantitative data. In particular, we focus on two groups of elements:

1. Dataset-related needs of the experts.
2. Software-related needs of the experts.

2.3.1. DATA-RELATED NEEDS OF THE EXPERTS

During the interviews, the experts were asked to address two traits of the dataset used in their job: the topic of the data and the technical features.

Regarding the data topics, several macro-areas were mentioned by more than one expert:

- Energy consumption data, with particular interest in the division between industrial and residential sectors and the types of buildings using energy.
- Energy production data, with a focus on the division between renewable and fossil fuel sources, type of power plant, and type of energy transport.

[4] HotMaps Project. HotMaps. [Online] 2020. https://www.hotmaps-project.eu/

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- Meteorological data, where experts usually ask all the information about a typical meteorological year (rainfall, solar insulation, sunshine, …). In this field, it was often mentioned the NCEP datasets[5] as textbook example.
- Decentralized energy production and consumption, especially regarding the category of “prosumers”, private citizens or organizations who produce by themselves the energy they consume. In this field, great emphasis was placed in chance of getting information regarding off-grid energy producers who are particularly difficult to analyse due to problems in the data collection.
- Socio-economic data (e.g. population, demographics, economic status, status of the building stock) useful to contextualize the energetic analysis.

Regarding the technical features of the datasets, the main issue is clearly the quality of the datasets:

“Highly reliable data is data collected at each floods of origin and not based of estimation. It has to be original data. Ideally it has to be collected by smart equipment like energy meters, heat meters and so on, and transmitted to a central server. This data should be validated very well by the data provider so that it doesn’t have gaps or wrong data in it, wrong pieces of data in it. […] It should be data with good granularity, meaning that for example you have values for each and every hour, each and every day or week, and so on. It should be segregated by sectors, by transport, household, public sector and so on. It should be segregated by energy carriers: for example, electricity, heating, biomass… Oil, coal, liquid gas, natural gas and so on. Should be split like that as well.” (Interview 1)

As this excerpt suggests, high-quality datasets have some important features: they are collected and not based on statistical estimation, they are validated by the data provider, and they present satisfactory levels of segregation and granularity. In addition to these features, it is also important for the quality of the datasets to consider the transparency:

“It is important when you get the data that you get the clear explanation of what each dataset means. Also, because sometimes you can find mixing units and if you want to use these data for something and you are not aware the you are using different units for the same variable you are in trouble.” (Interview 5)

Lastly, especially regarding the weather data, it is important for the expert that the datasets cover a sizeable span of time in the past in order to spot trends in the data:

“We need actual and historical data of the weather in our location in order to predict what is going to happen in different horizons.” (Interview 5)

“There should be a history of data, a couple of years back, at least.” (Interview 1)

[5] Kalnay et al.,The NCEP/NCAR 40-year reanalysis project, Bull. Amer. Meteor. Soc., 77, 437-470, 1996, in https://psl.noaa.gov/data/gridded/data.ncep.reanalysis.html

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2.3.2. SOFTWARE-RELATED NEEDS

When asked about the feature of the software, most the experts insisted of creating opportunities to combine datasets:

"Sometimes it is not easy to combine data from different sources, I know because we use data from different sources to make comparisons and see whether they combine with other organizations data and sometimes it is difficult because methodologies are different. I guess I would need to know more about the methodology that is underlying a certain tool to judge how much credible it is." (Interview 8)

The necessity to harmonize the measurement units and method of production of different datasets should be lynchpin of this kind of software, without it any form of comparative research would be impossible. This topic is linked to another need expressed by the expert: the importance of data semantics.

"When one person calls something a "coal power plant", someone else has to use the same concept when collecting their data or presenting it. […] So, we have a definition of "coal power plant" and what "coal" means. Does it include lignite? Does not include lignite? […] So, if you are talking to me about mixing data, the first thing I would ask is: "what are you doing for semantics? How are you treating the semantics?". What I call "coal power plant" must be the same thing person b has used, because if they don't have the same meaning, then is any troubles ahead." (Interview 2)

Any software based on complex operations of datasets should have a glossary of all the common terms employed and an easily accessible wiki which can be used to answer the doubts of the analyst.

Finally, the last feature the experts mention as important for a software is the effort from the developers to create and support a community of users:

"If there is a community around the software, people are correcting it, pointing out mistakes and working on how to improve it. Yes, feedbacks forms traffic lights for quality, indications of efficiency, all this kind of things." (Interview 2)

"I have a very simple definition of community and it is what happens when there is some problem, what is the response. That's my simple definition: it is people that get together to solve common problems, really. You know, people put a lot of effort into solving common problems, it is very gratifying for me to see." (Interview 2)

An active community is usually related to a high-quality software since the users debate on the related forums regarding new ways to overcome difficulties and may develop interesting mods[6] which can be included in the original software adding new functionalities.

[6] Mods are packages with further functionalities programmed by users and open access.

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3. ENERGY-RELATED DATASETS IN EUROPE

Europe is a leader in energy research, and is one of the frontrunners in energy research, development, and demonstration (RD&D) spending (27). As a result, European institutions at the EU, national, and local levels all produce energy data, much of which is open access. However, despite the availability of open datasets, finding and accessing energy data is often a cumbersome process. Data is scattered in various repositories, many of which require the creation of an account to access them or require applications that are not intuitive to users. In addition, many of these datasets are not well-advertised or optimized for search engine results and can be overlooked by the public. In the case of many Research and Innovation (R&I) projects, where data is created but its dissemination is not a main objective of the project, the data is often not readily available for download.

The decentralised nature of regional and country level research efforts means that European energy data is often restricted to individual countries, regions, and cities, rather than Europe as a whole. The best sources for EU-wide data are from the European Commission, including EUROSTAT, the European Commission's Directorate-General dedicated to statistical data, and the Joint Research Centre (JRC), the European Commission's science and technical knowledge research body. Most EU-wide data is available at the country level (NUTS0), however, datasets that have been harmonised (for example, by Eurostat (28)) may be available with greater granularity (NUTS1 or greater).

3.1. Energy-related datasets

Some key criteria need to be taken into account and satisfied in order for a dataset to be considered for the H2020 EnerMaps project. Since the data in EnerMaps will be available for dissemination to its users following FAIR data principles (findable, accessible, interoperable, and reusable), it is imperative that the data is openly accessible. Therefore, one of the most important criteria for a dataset to be considered is that the data needs to be either:

- Available online with an open license (so it can be integrated into EnerMaps without issue).
- If it is private/not available to the public, then the permission for its use in the project (which would render the data open access) needs to be received from the owner of the dataset.

In terms of thematic criteria for selecting the data, three main areas are emphasised:

1. Renewable energy sources (RES) data, including data related to wind, solar, hydroelectric, and geothermal. This can include both resource potential data as well as generation and power plant data.
2. Energy efficiency/Building data, including data related to building stock and building energy consumption.

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3. Data from publicly funded Research and Innovation (R&I) projects, since one of the goals of EnerMaps is to promote lesser known data.

Another point of emphasis was to focus on datasets that covered as much of the entire European region as possible (more specifically, EU27+UK). If data only covers a portion of the region, it limits the usefulness of the data in conducting EU-wide research. In addition, datasets from individual countries may have different assumptions and methods in their collection that render them incomparable without undergoing rigorous harmonisation processes.

Based on these previous considerations, a list of 50 datasets was built at the beginning of the EnerMaps project and can be found in Annex 1. Currently, 13 of the datasets are related to RES, 11 are related to energy efficiency/building stock, and 15 are from R&I projects. Other datasets include: RD&D spending, electricity costs and capacity, energy consumption and expenditure, and emissions data. Finally, datasets were included that are not directly energy-related but are important in energy analysis, including socioeconomic data (i.e. population and GDP) and climate/meteorological data that can be analysed with, for example, RES potential and energy consumption. Information on the spatial level and granularity of each dataset is also provided. This is not intended to be an exhaustive list, but rather a "jumping off" point for data to be included in the EDMT.

3.2. Prioritization

The list of datasets, included in Annex 1, was shared with interviewed stakeholders who integrated it with further relevant datasets and who prioritized the most relevant ones. Three activities were asked to the interviewed stakeholders:

1. To select at least three datasets among the ones enlisted in Annex 1, considered particularly useful for the institution where the interviewee is working.

2. To include additional energy-related datasets that may be included in the list.

3. To list some aspects to be considered for having high-quality datasets.

The prioritization of datasets is relevant for the choice of which datasets should be included in the EDMT[7]. Considering the most relevant datasets, interviewees identified 23 out of 50 datasets already included in the Annex 1 and reported in Table 5. All the datasets included in Table 5 have the same importance, except for HotMaps: Building stock analysis and the Electricity prices for household consumers, which received two votes.

Table 5 - Datasets identified as relevant for the eight interviewed stakeholders.

Dataset with Hyperlink	Description	Level	Granularity
EDGAR CO2 emissions	Timeseries 1970–2018 of CO_2 emissions by country and sector (Buildings, Power Industry, Transport,	Worldwide	NUTS0

[7] This process to identify the final list of datasets is ongoing and a final list will be delivered in next months.

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	Other industrial combustion, Other sectors) in Mt CO_2/year.		
Heat demand densities	Heat demand densities of the residential and service sector (delivered energy)	Several EU countries	
Energy dependence	The indicator shows the extent to which an economy relies upon imports in order to meet its energy needs. It is calculated as net imports divided by the gross available energy.	EU27 + UK	NUTS0
Energy consumption in households	Share of final energy consumption in the residential sector by type of end-use	EU27 + UK	NUTS0
EDGAR CO2 emissions	Timeseries 1970–2018 of CO_2 emissions by country and sector (Buildings, Power Industry, Transport, Other industrial combustion, Other sectors) in Mt CO_2/year.	Worldwide	NUTS0
Photovoltaic power potential	Photovoltaic power potential for Europe	EU27 + UK	
S2BIOM: Biomass supply	Estimated supply of biomass resources in Europe	EU27 + UK	NUTS0
HotMaps: Building stock analysis	This dataset contains building stock analysis data for EU28. Data is available per country and are organized by residential and service sectors, addressing specific types of buildings and time periods.	EU27 + UK	NUTS0
H2020 SET-Nav*	Strategic Energy Roadmap datasets containing scenario data for energy demand.	EU27 + UK	
H2020 HEART*	Energy consumption of the EU building stock	EU27 + UK	
INTERREG recharge green*	RES potential in central Europe	several EU countries	
FP7 SINFONIA*	Space heating, cooling and domestic hot water consumption in buildings	several EU countries	
TABULA	Building typology data	several EU countries	

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EPISCOPE	The EPISCOPE project focused on the energy refurbishment of houses in 20 European countries. Among the collected information, data regarding the construction period (different classes are defined in each country) and the building type (single-family, terraced house, multi-family house and apartment block) may be useful for risk assessment of large geographic areas.	several EU countries	
ODYSSEE: Building stock data	Building stock data including floor area of dwellings, consumption by source, and stock of appliances and dwelling	EU27 + UK	NUTS0
ENTRANZE: Building stock data	Building stock data including floor area of residential and non-residential buildings, heating/AC system data, and energy use by sector	several EU countries	NUTS0
CommONEnergy: Building stock data	Building stock data including building sector data and final energy demand data for non-residential buildings	several EU countries	NUTS0
Zebra2020: Building stock data	Building stock data including data for energy efficiency trends in buildings as well as data for NZEB buildings	several EU countries	NUTS0
Electricity prices for household consumers	Electricity prices for household consumers - bi-annual data (from 2007 onwards)	EU27 + UK	NUTS0
EEA: Share of gross final consumption of renewable energy sources	Approximated estimates for the share of gross final consumption of all renewable energy sources.	EU27 + UK	NUTS0
EMHIRES: Wind power generation	High resolution RES generation time series data of wind power capacity factors at NUTS 2 level	EU27 + UK plus Cyprus, Iceland, Balkans countries	NUTS2
EMHIRES: Solar power generation	High resolution RES generation time series data of solar power capacity factors at NUTS 2 level	EU27 + UK	NUTS2
Energy supply and use by agriculture activities	Energy supply and use by NACE Rev. 2 activity (in this case, the agriculture).	EU27 + UK	NUTS0

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The interviewed stakeholders suggested some more datasets to be considered:

- Complete energy balances.
- Production of electricity and heat per type of fuel.
- Disaggregated final energy consumption in households.

The suggestion is also to discover some data from the project EnergizAir, the website www.e-control.at, and the databases: Open Power System Data, Database of energy production companies, and DEDALO.

To promote high-quality datasets, the interviewee listed some aspects to be considered, such as granularity of data, availability of the data in the needed format, geographical coverage of the data, subjectivity of the data collector/dataset author, market-sensitive data, sample time, data validation, and open data access considering the owner and API. Furthermore, “official statistics (from EUROSTAT or from national statistical institutes) should be used as much as possible and non-official sources only to fill official data gaps” [I8].

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4. ENERMAPS DATA MANAGEMENT TOOL DEVELOPMENT

Within the European framework for the energy transition, data are one of the most relevant subjects with respect to designing decarbonization strategies, planning actions to increase the share of renewables and energy efficiency, and managing sustainable energy systems. The actors and institutions involved in the energy transitions are more and more e.g., industries, energy planners, consultants, researchers, policymakers, and public administrations. In this situation, the European Commission declares, within the European Green Deal, the relevance of the data access to all those actors who deal with energy transition and climate change.

The EU-funded H2020 EnerMaps project is acting to achieve the European objectives. The EnerMaps project aims at improving energy data availability, access, and use in Europe for energy transition goals. The main output of the project consists in the development of two open access instruments: the EDMT and an energy-related datasets gateway. The two instruments will provide and merge a significant number of energy datasets, based on a quality-check selection of energy-related datasets, and a useful tool for supporting the energy transition activities in several sectors such as research, policymaking, and planning at different geographical levels. The analysis carried out and described in this report suggests some key aspects to be considered (Table 6).

The future users of the EDMT are stakeholders already or potentially using energy data in several sectors and for several goals. The identification of the stakeholders, the understanding of the potential use and uptake of the EDMT, the analysis of the relationships among stakeholders, and the content analysis of user stories and needs are all relevant activities to be carried out at the beginning of EnerMaps and other similar projects. This report presents a mixed-methods approach for underling key aspects to be considered in the EDMT development and key actors who should contribute to the EDMT development.

One of the first activities to be carried out within a similar project is the definition of the main aspects to be considered within the development of the EDMT. The researchers and the partners of the project are already making the necessary considerations on how to develop the EDMT. This report underlines what should be considered in the development of the project, including the consideration of different stakeholder perspectives and viewpoints, which are sometimes different from the initial ideas. This report includes the explication and the example on how to identify the relevant stakeholders to be engaged in the project, for collecting user stories and needs. A clear and transparent methodology of stakeholder analysis is important to ensure an effective process of development, uptake, and use of the EDMT.

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Table 6 – Main recommendations on the procedure before and during the EDMT development.

To identify stakeholders, which (or who) will be future leaders and users of energy data in Europe and analyse their characteristics and relationships. There are consistent mixed methods from the social sciences and humanities to be used.	To have a wide perspective on how to develop the EDMT, stakeholders from different sectors (e.g., planning, consulting, research, policymaking), different nationalities, different individual characteristics (e.g., gender) must be engaged in the definition of the EDMT features and services.	To enlarge the network of relationships outside geographical borders.	One approach to analyse the use and uptake of the EDMT or other innovations, is to see these phenomena as a relational phenomenon. The relationships among stakeholders can be a relevant resource to promote the use and uptake of a new tool.	Collect and analyse user stories and needs of stakeholders, for having a wide perspective on how the EDMT should be developed. There are consistent qualitative methods from social sciences and humanities on how to interview experts and analyse the contents of the interviews.	Transform this first research part into a consistent list of activities in the development phase of the EDMT, engaging all the stakeholders which (or who) could contribute to improving and uptake the tool.

The stakeholder analysis is particularly relevant to identify key stakeholders for being interviewed. For having a wide perspective on how to develop the EDMT, stakeholders from different sectors (e.g. planning, consulting, research, policymaking), different nationalities, and different individual characteristics (e.g. gender) should be engaged in the definition of the EDMT features and services. This selection is important because all these characteristics have an influence on the narratives and perspectives of user stories and needs. Once the stakeholders are identified, a qualitative and in-depth analysis of the user stories and needs can be important for an effective development of software.

The spreading of energy-related data and software can be interpreted, according to sociological perspective, as a relational phenomenon (29). Energy-related datasets and software spread around Europe through professional and social relationships. A good uptake of the EDMT can be supported by stakeholders and their existing relations.

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Table 7 – User needs identified in the content analysis of eight interviews with stakeholders: common problems in data handling.

Main needs	**Key aspects of the main needs**	**Description**
Data access	Open access	The open access is faced by legal and market issues. The open accessibility should be promoted as well as new ideas on how to overcome legal and market issues.
	Technical aspects of the data access e.g., API issues	There are several ways to obtain data, while the development of API could harmonize the data acquisition.
Quality of data	Data segregation	Data are often difficult to split by sectors or by different time frames.
	Data granularity	The main challenge of data granularity is that data at building level are difficult to find.
	Data normalization	The format of datasets should be homogenised, for promoting comparison and links between datasets.
	Sizeable span of time	Several energy sectors need to access historical data for calculating trends.
	Transparency	Datasets, calculations, and representations are not always clear and are not presented with all the information behind the data collection and processing.
Data representations	Easy understanding of the representations and graphics	The representations of data and data results should be understandable by all stakeholder groups, behind their expertise.
	Wiki with a clear data semantics	In the energy sector and talking about energy, we should all use the same semantics.
Action guidelines	Transformation of the contents (e.g., data, representations) into action guidelines.	The transformation of data and data results into actions is challenging and the EDMT could be the opportunity to promote a training or preparation on how to deal with this process.

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Which are the most relevant aspects to be addressed in the EDMT development? Considering the conditions of its uptake, the EDMT should be aligned "with the existing political, cultural, or economic structures" (2). For example, the European copyright rules (Directive 96/9/EC of the European Parliament) and market reasons for an open access of the data is a current issue related to energy-related data. This issue should be addressed in the EDMT for its effective uptake. According to the user stories and needs (Chapter 2, Table 7), the open access of energy datasets, dealing with copyright and market issues, should be increased. **The identification of legal and market solutions to promote the open accessibility of data would benefit several stakeholders who deal with energy transition.** The data access is also a technical matter and **common ways to structure and save data would reinforce the availability and usefulness of created datasets.**

To tackle research and other kinds of energy transition objectives, **a work for harmonizing the existing energy-related datasets** would improve the accessibility, interoperability, reusability, and accuracy of the energy data. A harmonization process should also be promoted before the creation of a dataset. The usefulness, effective use of the energy datasets, and effective uptake of the EDMT pass throughout its communication, and also throughout the **capacities to clearly present and represent the data and all information included in the EDMT to several groups of stakeholders and sectors.** The objective of using energy data for some stakeholder groups, such as policymakers or planners, is to transform those data and related analysis into policy guidelines or actions. The EDMT could include some parts explaining how to use this data and how to transform them into policy guidelines or actions. Summarizing and further elaborating these points, we propose recommendations. These recommendations consist into activities that could make the EDMT development effective to answer energy challenges. These recommendations are divided into activities with stakeholders, activities to create procedures, development and communication activities.

Activities with stakeholders:

- To continue collecting lists of stakeholders, using the snowball sampling, for filling a wider potential network of stakeholders. This network is relevant to collect other user stories and needs and promote an effective uptake of the EDMT.

- To create an active community, where users overcome difficulties and develop new mods to improve the EDMT e.g., through a blog or similar initiatives.

Activities to create processes or procedures:

- To be clear on the license for accessing data and promote where possible the open access, dealing both with legal and market issues. Indeed, the open access of data is not easy to follow and new solutions should be prepared for overcoming legal and market barriers.

- To define a common procedure for creating datasets to be uploaded in the EDMT, in order to simplify the data acquisition. Creating an API, EDMT would support the harmonization of datasets.

- To promote the collection of data at middle-long term period, for producing datasets able to elaborate time trends.

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- To promote the data quality, preparing a list of dataset details sufficient for several data uses. Among these details, information and guidelines about data segregation – in terms of time, sectors, and other aspects –, data granularity, and data normalization should appear.
- To be transparent, within the EDMT and the linked trainings, on the mechanisms behind the calculations and representations and on the composition and structure of datasets (e.g., data units).
- To simplify, as much as possible, the procedure to download, analyze, and obtain representations with the EDMT.

Development activities:

- To prepare a section within the EDMT dedicated to datasets with granularity at building level.
- To divide datasets into sections, according to categories. For example:
    - Energy consumption data per sector (e.g., industrial, residential) and per types of buildings.
    - Energy production data, divided into renewable energy and fossil fuel sources, per type of plants, and type of energy transport.
    - Meteorological data per year and per type of meteorological phenomena.
    - Off-grid production and related data.
    - Socio-economic data relevant for the energy sector.
- To include the list of datasets prioritized in Table 4 and Section 3.2 within the EDMT.

Communication activities:

- To propose graphs and other kind of representations based on graphical and communication expertise. The data should be clear and understandable by all stakeholders.
- To include a section with guidelines on how to transform data and data results into action guidelines. It would be interesting to have a section in which the results and changes, due to some actions, are simulated and shown.

All these aspects should reinforce the existing datasets, promote the creation of new relevant datasets, and create processes for having findable, accessible, interoperable, reusable, and accurate datasets. However, these aspects are only some of the aspects that could be derived from this report. Reading at the entire report, the developers of EDMT could define other relevant ideas.

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CONCLUSIONS

This report identifies and analyses the user stories and needs to suggest the **key aspects to be considered by the EDMT developers.** The identification and analysis are based on a **mixed methods approach** of **social sciences and humanities.** This approach – consisting of a stakeholder analysis and qualitative analysis of user stories and needs – is important to reach exhaustive perspectives and viewpoints on how to develop the EDMT, and **for ensuring its effective use and uptake.**

In the first chapter, a list of stakeholders to be interviewed is selected, promoting a wide presence of perspectives based on geographical distribution, gender inclusiveness, and interdisciplinary expertise. The selected stakeholders were interviewed for collecting their user stories and needs. The most relevant stories address common problems with data handling and previous experiences with comparable software, while the needs are divided into data-related needs, which include a list of relevant groups of data and need to be transparent on which are the features of the data included in the datasets, and into software-related needs, emphasizing the possibility to create a community for users, overcoming the challenges and improving the EDMT.

This report defines relevant energy datasets to be included and linked one another within the EDMT. The datasets should guarantee high levels for data access and quality, while the representations of data and data results should be clear and understandable to all the stakeholder groups. The transformation of data and data results into action guidelines is still a challenge in the energy sector and the EDMT could also be the opportunity to address this aspect.

This report and its methods can be of interest to all projects and actors which deal with the creation of an innovation or an innovative tool in the energy sector.

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ANNEXES

Annex 1. Initial EnerMaps Datasets.

Dataset with Hyperlink	Description	Level	Granularity
PVGIS: Solar Radiation Data	Solar radiation dataset consisting of the average irradiance over a time period, taking into account both day and night-time, measured in W/m2. Optimum angle data sets are measured in degrees from horizontal for a plane facing the equator.	Worldwide	
JRC: Geothermal Power Plant Dataset	Dataset of worldwide geothermal power plants including technological details (e.g. nameplate and running capacity, turbine type)	Worldwide	
JRC: Hydro-power plants database	Dataset of European hydro plants with basic information on all the European hydro-power plants.	EU27 + UK	
JRC: Wind power plants	The Open Power Plants database contains locations of European power plants, including wind power plants.	EU27 + UK	
EEA: Share of gross final consumption of renewable energy sources	Approximated estimates for the share of gross final consumption of all renewable energy sources.	EU27 + UK	NUTS0
Energy consumption in households	Share of final energy consumption in the residential sector by type of end-use	EU27 + UK	NUTS0
Installed electricity capacity by country	Installed electricity capacity by country from the EU energy statistical pocketbook.	EU27 + UK	NUTS0
Eurostat: Population	GEOSTAT 1km^2 population grid containing population estimates per 1km x 1km grid cell.	EU27 + UK	1km x 1km
Eurostat: HDD	Heating degree days (monthly and annual)	EU27 + UK	NUTS2
Eurostat: CDD	Cooling degree days (monthly and annual)	EU27 + UK	NUTS2

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SETIS: Private R&I investment in energy technologies	Integrated Strategic Energy Technology Plan Communication for each Member State on the level of investment in R&I from the private sector (expenditure by businesses and industry).	EU27 + UK	NUTS0
CORDIS EU research projects under Horizon 2020	This dataset contains projects and related organisations funded by the European Union under the Horizon 2020 framework programme for research and innovation from 2014 to 2020.	EU27 + UK	NUTS0
IEA Summary Country RD&D Budgets	Summary country RD&D budgets containing total public energy RD&D expenditure data from the IEA's Energy Technology RD&D Budget Database.	EU27 + UK	NUTS0
CORINE Land Cover	This dataset provides consistent and thematically detailed information on land cover and land cover changes across Europe based on the classification of satellite images. Classifications distinguish various urban, vegetation, and water topologies for simple land use identification.	EU27 + UK	
COPERNICUS: Wind speed	Magnitude of the two-dimensional horizontal air velocity.	EU27 + UK	0.5°x0.5°
EMHIRES: Wind power generation	High resolution RES generation time series data of wind power capacity factors at NUTS 2 level	EU27 + UK plus Cyprus, Iceland, Balkans countries	NUTS2
EMHIRES: Solar power generation	High resolution RES generation time series data of solar power capacity factors at NUTS 2 level	EU27 + UK	NUTS2
Energy Efficiency Indicator	The Global Tracking Framework measures the national energy intensities and the compound annual growth rate for all countries from 1990-2014.	Worldwide	NUTS0
EDGAR CO2 emissions	Timeseries 1970–2018 of CO_2 emissions by country and sector (Buildings, Power Industry, Transport, Other industrial combustion, Other sectors) in Mt CO_2/year.	Worldwide	NUTS0
CORDEX: 2m air temperature	EU-wide data on air temperature at 2m.	EU27 + UK	

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sciGRID: European transmission network	Open Source Reference Model of European Transmission Networks for Scientific Analysis containting vertices and links of the transmission network for the EU	EU27 + UK	
Product Trade by year and country	Product Trade by year and country	EU27 + UK	NUTS0
Medarac, H. et al.	The dataset contains projections of fresh water withdrawal and consumption from the European energy sector on NUTS2 level by 2050 following EU Energy Reference Scenario 2016.	EU27 + UK	NUTS2
Photovoltaic power potential	Photovoltaic power potential for Europe	EU27 + UK	
Wind power density	Wind power density by height for Europe	EU27 + UK plus Turkey	
SDH: Large Scale Solar Heating Plants	This dataset contains a list of large scale solar heating plants located in Europe and with a nominal capacity higher than 700 kWth	EU27 + UK	
S2BIOM: Biomass supply	Estimated supply of biomass resources in Europe	EU27 + UK	NUTS0
HotMaps: Building stock analysis	This dataset contains building stock analysis data for EU28. Data is available per country and are organized by residential and service sectors, addressing specific types of buildings and time periods.	EU27 + UK	NUTS0
H2020 SET-Nav*	Strategic Energy Roadmap datasets containing scenario data for energy demand.	EU27 + UK	
H2020 HEART*	Energy consumption of the EU building stock	EU27 + UK	
INTERREG GRETA	Financial and economic data of Near SurFace Geothermal Energy in Central Europe	several EU countries	
INTERREG recharge green*	RES potential in central Europe	several EU countries	

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FP7 SINFONIA*	Space heating, cooling and domestic hot water consumption in buildings	several EU countries	
IEA SHC Task 45: Large Solar Heating and Cooling Systems	A database with detailed descriptions of large solar heating and cooling systems from all over the world	Worldwide	
UK Power Networks	SmartMeter Energy Consumption Data in London Households	London	
TABULA	Building typology data	several EU countries	
EPISCOPE	The EPISCOPE project focused on the energy refurbishment of houses in 20 European countries. Among the collected information, data regarding the construction period (different classes are defined in each country) and the building type (single-family, terraced house, multi-family house and apartment block) may be useful for risk assessment of large geographic areas.	several EU countries	
ODYSSEE: Building stock data	Building stock data including floor area of dwellings, consumption by source, and stock of appliances and dwelling	EU27 + UK	NUTS0
ENTRANZE: Building stock data	Building stock data including floor area of residential and non-residential buildings, heating/AC system data, and energy use by sector	several EU countries	NUTS0
CommONEnergy: Building stock data	Building stock data including building sector data and final energy demand data for non-residential buildings	several EU countries	NUTS0
Zebra2020: Building stock data	Building stock data including data for energy efficiency trends in buildings as well as data for NZEB buildings	several EU countries	NUTS0
National Housing Census: Building stock data	The National Housing Census contains socioeconomic data as well as building stock data including type and size of housing	EU27 + UK	NUTS0
Building Data Genome	Open data set from 507 non-residential buildings that includes hourly whole building electrical meter data for one year.	N/A	N/A

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Heat demand densities	Heat demand densities of the residential and service sector (delivered energy)	several EU countries	
Emissions of large combustion plants	An inventory of emissions from large combustion plants	EU27 + UK	NUTS0
Energy supply and use by agriculture activities	Energy supply and use by NACE Rev. 2 activity (in this case, the agriculture).	EU27 + UK	NUTS0
Electricity prices for household consumers	Electricity prices for household consumers - bi-annual data (from 2007 onwards)	EU27 + UK	NUTS0
Expenditure per household on energy	Mean consumption expenditure per household on electricity, gas, and other fuels.	EU27 + UK	NUTS0
Energy dependence	The indicator shows the extent to which an economy relies upon imports in order to meet its energy needs. It is calculated as net imports divided by the gross available energy.	EU27 + UK	NUTS0
Regional GDP	GDP expressed in PPS (purchasing power standards) eliminates differences in price levels between countries. Calculations on a per inhabitant basis allow for the comparison of economies and regions significantly different in absolute size. GDP per inhabitant in PPS is the key variable for determining the eligibility of NUTS 2 regions in the framework of the European Union's structural policy.	EU27 + UK	NUTS2

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Open source tools to share, compare,
and reuse low-carbon energy data

WHAT IS ENERMAPS?

EnerMaps Open Data Management Tool aims to improve data management and accessibility in the field of energy research for the renewables industry.

EnerMaps tool accelerates and facilitates the energy transition offering a qualitative and user-friendly digital platform to the energy professionnals.

The project is based on the FAIR principle defining that data have to be Findable, Accessible, Interoperable and Reusable.

EnerMaps project coordinates and enriches existing energy databases to promote a trans-disciplinary research and to develop partnerships between researchers and the energy professionals.

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