D1.1

Stakeholder Requirements Analysis

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EXECUTIVE SUMMARY

The WHY Project follows the ambitious approach to improve the representation of household electricity demand in Energy System Models by applying a Causal Model to simulate the behaviour of residential consumers which will lead to the consumption of electricity. It is crucial for the development of the models and tools, which are required to reach that goal, is the involvement of stakeholders and the analysis of their requirements. Obtaining the stakeholder requirements is necessary both from a technical perspective (regarding the technical specifications of the WHY Toolkit like temporal and spatial resolutions, etc.) and non-technical perspective (regarding topics like the presentation of results or the general requirements for the toolkit). This process is divided into four phases: (1) Identification of the stakeholders, (2) clustering of the stakeholders, (3) involvement of the stakeholders and (4) results and conclusion phase.

The first phase consists of the identification of the stakeholders who should provide the requirements for the WHY Toolkit. A preliminary research of potential stakeholders has been conducted during the proposal phase of the WHY Project which provided the foundation for the stakeholder identification process during the project. All project partners screened their networks for stakeholders who would potentially benefit from the use of the WHY Toolkit or the use of Energy System Models in general. By involving all partners in the process a variety of different types of stakeholder could potentially be identified, ranging from stakeholders with a technical background to stakeholders with a policy background. Furthermore potential stakeholders for later consultation on project results or methods were also identified during that phase of the project. The stakeholder identification phase resulted in a **total of 85 stakeholders** from 13 EU-member countries and multiple different sectors and with different fields of expertise relevant to the WHY Project. Of these 85 stakeholders **63 stakeholders** were identified as relevant for the requirements analysis. The other 22 stakeholders were of relevance for later stakeholder engagement actions, but it was due to their specific background not expected for them to provide additional input to the requirements. Due to the wide range of different stakeholders it was necessary to cluster these stakeholders according to their background and specific skill set. For that purpose three different clusters were defined:

- **Modelling experts with an academia background and policy consultants:**
  Members of the academic community with focus on modelling or policy consultancy. A total of 14 stakeholders were assigned to this cluster.
- **Energy System Model users**:
  Members of the energy industry, with some experience in Energy System Modelling and a solid understanding of energy systems as well as in energy policies and regulations. A total of 16 stakeholders were assigned to this cluster.
- **Result users**:
  Policy and decision makers who will very likely have limited knowledge in Energy System Models but substantial knowledge in energy related policies and regulations. A total of 33 stakeholders were assigned to this cluster.

The clustering of the stakeholders initiated the second phase of the stakeholder involvement process, the development of the methods to obtain the requirements from the stakeholders. Since the knowledge and expertise of the cluster was very heterogeneous, the WHY Consortium concluded that methods applied to obtain the

requirements needed to be tailored to the specific cluster. For that purpose three different approaches were chosen:

- **Focus Groups:** For the academia cluster the method of creating focus groups and holding workshops was selected. During the preparation of the Focus Groups a lack in participation of stakeholders and limited time lead to a change in the method. The stakeholders had to provide their inputs via a survey and discuss the results during an online workshop. Since the inputs provided by the different stakeholders of the academia cluster were very homogenous, the workshop was canceled as discussions were not necessary. The results from the detailed survey were still used in the evaluation of the requirements.
- **Surveys:** The stakeholders assigned to the cluster of Energy System Model users were asked to participate in a survey. The questions of the survey required a fundamental understanding of modelling and Energy System Models in general but it was assumed that the members of this cluster would have the required expertise to provide the answers without the need for feedback from the WHY Consortium.
- **Interviews:** For the cluster of result users the method of participation in interviews was deemed to be the best option. Interviews provided the big advantage of interaction with the stakeholders and to obtain more detailed answers.

Regardless of the initial assignment of the stakeholder involvement action, the stakeholders were always offered the possibility of participating in another type of involvement action, an option that was very willingly used, as will be described later on.

After defining the best approach to integrate the stakeholders into the WHY Project, the stakeholder involvement phase started, which lasted for 6 weeks. During that time a total number of **27 stakeholders** from 11 different EU-member states participated in the stakeholder involvement actions. Of these 27 stakeholders **19 stakeholders were male** (70%) and **8 stakeholders were female** (30%).

As mentioned before, the stakeholders were offered the possibility to participate in the type of stakeholder involvement action of their choosing, regardless of our initial assignment. This led to a very dominant shift in the distribution of participation. **Only 3 stakeholders participated in the focus groups (or rather the very detailed survey), 5 in the survey and a total of 19 in the interviews.** While this was unexpected it did lead to positive results, as the answers from the interviews provided the most tangible results. Also the interviews provided the best opportunities to get to know the stakeholders and networks for potential exchanges of ideas during the course of the project. **One of the main findings of the Deliverable D1.1 aside from the actual requirements is that Interviews should be the preferred type of actions to obtain requirements and build new networks**.

After finishing the stakeholder involvement process, the inputs of the stakeholders were analysed. The most relevant results for the definition of the stakeholder requirements were obtained from the interviews, the results of the survey provided no new insights as they were in line with the results of the interviews. The results of the focus groups also provided no new insights.

To create a better understanding of the different stakeholders, **5 different personas** following the Persona Method (Pérez-Montoro and Codina, 2017) were created:

- **Elena**: A modeller that designs and develops energy system models and supports decision making by public authorities and private businesses.
- **Max**: An industry expert who works for a company in the energy industry (DSO, TSO, energy supplier, etc.).
- **Polad**: A policy advisor who provides energy policy advice and could be an employee of a consulting agency or work directly as part of a team for policy makers.
- **Markel**: An official representative or policy maker who could be working for the European Commission and is responsible for drafting and negotiating new legislations or regulations.
- **Alex and Andrea:** A working couple who while tackling everyday life also feel the need to provide a sustainable future for their kids.

Following the Volere Requirements Specification Template (Robertson James and Robertson Suzanne, 2012) a set of Toolkit Use Cases (TUCs) was developed. Each TUC describes a specific situation in which the WHY Toolkit would be used by the personas created and described above.

- **TUC 1**: Assessment of an intervention[1]
  - **TUC 1.1**: Assessment of a policy intervention
  - **TUC 1.2**: Assessment of a new business model / technology
  - **TUC 1.3**: Run a full energy system model simulation for teaching purposes
- **TUC 2:** Assessment of a counterfactual scenario
- **TUC 3:** Generate more precise load forecasts
- **TUC 4:** Improve the understanding of one's energy consumption, possibly leading to more informed decision making and the optimization of the energy use
- **TUC 5:** Optimise policy interventions to fulfil a policy objective

The definition of the requirements also follows the Volere method. Requirements are separated into functional requirements (defining what the toolkit should or should not do) and non-functional requirements (defining how the toolkit should do it). The input from the stakeholders resulted in a total number of **22 functional** and **7 non-functional** requirements, which are described in detail in this deliverable. Furthermore a large number of requirements were defined during the proposal phase. While those are not necessarily stakeholder requirements, they must not be neglected, as they could stand in contradiction to stakeholder requirements or be supported by them. **37 functional** and **20 non-functional requirements** were identified that way. A ranking of these requirements and a definition of which ones will be considered will be made later in the project and was not subject to this deliverable.

[1] This use case is slightly different depending on the persona carrying it so sub-use cases were defined for it.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Long text
CSV	Comma Separated Value
DSM	Demand Side Management
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
ESM	Energy System Model
EU	European Union
EV	Electric Vehicles
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
LPG	Load Profile Generator
ME	Modelling experts and policy consultants
MU	Model users
NAPE	National Plan on Energy Efficiency (Germany)
P2G	Power to Gas
P2H	Power to Heat
P2X	Power to X (to refer to an different energy carrier)
RU	Result users
TUC	Toolkit Use Case

1 Introduction

One key goal of the WHY project is the development of the WHY Toolkit, a software which will allow users to employ the Causal Model as well as technical models developed during the project. The software will enable users to:

- make better forecasts[2] for electricity consumption in households,
- analyse, evaluate, and validate policy decisions or other interventions such as changes in regulation, policy measures, funding, etc.,
- examine how today's world would look like if certain energy policy decisions had or had not been taken. By simulating how people might have reacted to certain policy decisions, the WHY model will be able to analyse the effects of these decisions on the system's development.

While the advantages of using such a tool are obvious, the tool itself will need to satisfy the requirements of future users. The issue at hand is that the bandwidth of possible users is broad; it ranges from Modelling experts, who have the knowledge to adapt the underlying models to fit their requirements, to policy makers, who will most likely only use the results of the models without using the tool itself.

Creating a tool that satisfies many different potential users is a challenging task. The solution to this problem requires analysing the requirements of these different user groups. Deliverable D1.1 describes the process and the results of the first stakeholder involvement action of the WHY project, the goal of which was to identify potential users of the WHY Toolkit and their requirements for such a tool.

The deliverable contains the following chapters:

1. **Methodology of Stakeholder Involvement**
   This chapter addresses the general approach of identifying and including stakeholders (potential users of the WHY Toolkit) into the project, and describes the methods used for acquiring their requirements for the WHY Toolkit and its components.
2. **Timeline of the Stakeholder Involvement Actions**
   This chapter briefly describes the timeline of the stakeholder involvement actions, and shows when the different actions took place.
3. **Results of the Stakeholder Involvement Actions**
   This section of Deliverable 1.1 provides a summary of the results obtained from the different types of stakeholder involvement actions. The results are summarised for better understanding, but at this point they are not yet filtered for consideration or not in the remainder of the WHY project.
4. **Requirements for the WHY project**
   Based on the inputs of the different stakeholders during the stakeholder involvement actions, the functional and non-functional requirements for the WHY toolkit are identified by applying the Volere Requirements Specification Template methodology. This chapter includes a full list of the requirements obtained. The

[2] On individual household-level and through upscaling also on larger scales (local, regional, etc.)

identification of the requirements relevant for the WHY project will be described in a later deliverable.

Finally, this deliverable lays the foundation for future work in the WHY project. In particular, the results presented (complemented with the result of the state of the art on research for models, legislation and initiatives, described in Deliverable D1.2) will provide the basis for how the WHY toolkit will be developed. In fact, a prioritisation of the requirements related to the WHY use cases described in Chapter 4 will be done in Deliverable D1.3, resulting in the final list of requirements for the WHY Toolkit. These requirements will be later implemented in Work Packages WP2 to WP5.

2 Methodology of stakeholder involvement

Stakeholder involvement is gaining in importance for the development of new solutions, action plans or similar endeavours (Baur et al., 2002). This is especially true for research and development as well as software development projects (Skyes Sophia, 2017). As stated by multiple sources in the field of consulting (Taysom Sophie, 2020) and (Wedgwood Joe, 2019), there are a multitude of benefits to involving stakeholders in the development of new products, amongst them:

- a better understanding of needs and requirements,
- building trust,
- providing the opportunity to learn.

These are the most valuable for the WHY project and the acceptance of the WHY Toolkit. In this context, the first step of the stakeholder involvement process was obtaining the requirements of potential users of the WHY Toolkit and their results.

The process of involving stakeholders was divided into two phases. In the first phase, the questions “Who are our stakeholders (potential users)?” and “What kind of stakeholder are they?” had to be answered. Stakeholders thus had to be identified and clustered according to their knowledge and potential use of the WHY Toolkit. During this first phase, a methodology for addressing each of the stakeholder groups (clusters) was developed and used to obtain their requirements.

The following sub-chapters describe the stakeholders included into the stakeholder involvement process, the different clusters that they were assigned to, and the type of stakeholder involvement action used for each cluster.

2.1 Stakeholder Groups

The WHY Toolkit addresses a wide and diverse range of potential users, from expert modelers to stakeholders who will only use the results, while not being able to work with the WHY Toolkit itself. It was to be expected that requirements would differ largely depending on the type of potential user (stakeholder). To account for these differences and ensure that the right person was asked the right question, the stakeholders were divided into three different groups with varying characteristics, as seen in Table 1. During the stakeholder involvement process, these groups were described by representative personae following the Persona Methodology (Nyström and Sjögren, 2012).

Table 1 Clusters for the WHY stakeholder involvement process

Characteristic	Modelling experts with an academia background and policy consultants [ME]	ESM users [MU]	Result users [RU]
Experience in creating simulation models	High	Moderate	None
Experience in creating scenarios for simulations	High	Moderate - High	None-Moderate

Experience in working with models	Yes	Yes	No
Technical understanding of energy related issues	Yes	Yes	Maybe
Understanding of (energy related) policy making	To some extent (academia) Yes (policy advisers)	Yes	Substantial Knowledge
Field of work	Researchers, Modelers, Consultants with Expertise in Modelling, Members of Think Tanks	Technical Experts, Employees in the Energy Industry	Policy Makers at different levels (National, municipal, etc.)

As can be seen in Table 1, the stakeholder groups or clusters differ in their respective expertise and fields of work. Since it is the goal of the project to satisfy many different requirements to ensure that the WHY Toolkit will be used in a multitude of different ways and by different stakeholders, the stakeholder involvement actions had to be tailored to the knowledge, language and expectations of the different groups.

The first step of the stakeholder involvement process was identifying relevant stakeholders. The consortium screened their respective networks for potential users of the WHY Toolkit. This screening process was set up to satisfy three criteria:

1. Accessibility of the stakeholder
2. Knowledge and background of the stakeholders and
3. heterogeneity of the entire stakeholder pool.

This had already been done during the proposal phase of the WHY project, and had generated a preliminary list of stakeholders. The process was repeated during the first months of the WHY project, see Chapter 3.

In total, 86 different stakeholders were identified during this first stakeholder involvement phase. Of these 85 stakeholders, 63 were invited to contribute to the definition of requirements for the WHY Toolkit, and were further assigned to the clusters mentioned in Table 1. The reason for those 22 stakeholders, who were not selected for this stakeholder involvement process, to be neglected was, that we did not expect additional inputs from them and they would later on in the project be included in other stakeholder involvement actions. An analysis of the stakeholders' gender distribution in the different clusters is presented in Table 2. In addition, Table 2 shows the number of countries represented in each of the clusters. The full list of stakeholders invited to participate in the stakeholder actions can be found in Annex 1.

Table 2: Analysis of stakeholders

Cluster	Stakeholders contacted	Stakeholders participated	Female participants	Male participants
ME	14	8	13%	87%
MU	16	5	20%	80%
RU	33	14	43%	57%

Total	**63**	**27**	**30%**	**70%**

In total, 27 stakeholders (42%) of the invited stakeholders participated in the stakeholder involvement process. A quarter (30%) of the participating stakeholders were women. Unfortunately, and despite the consortium's sustained efforts, the target of at least 40% women participating in the stakeholder consultation process was not reached. Given the complexity of the topic and the current challenges regarding stakeholder involvement in times of COVID-19, the participation was more than satisfactory. For the purpose of stakeholder interaction, a Key Performance Indicator (KPI) was defined during the proposal phase:

- $KPI_{1.1}$ "Number of experts involved in co-creation activities":
  An **outstanding performance** was achieved (more than 15 experts took part). As indicated in Table 2, a total of 27 experts from different fields cooperated during this co-creation phase of the project, and delivered substantial inputs.

Stakeholders from 13 different countries were contacted. The pool of participating stakeholders represented 11 different countries, as can be seen in Table 3.

Table 3: Country-specific analysis of stakeholders

Country	# of contacts	# of participants	Male	Female
AT	9	7	6	1
BR	1	1	1	0
IT	2	1	0	1
NL	5	1	1	0
BE	1	1	1	0
ES	17	5	2	3
FR	2	1	1	0
DE	18	7	5	2
SE	1	1	1	0
IE	1	0	0	0
HU	1	1	0	1
DK	2	0	0	0
PL	2	1	1	0

Many of the stakeholders invited to the stakeholder participation actions were from countries represented in the consortium. This minimally evens out when looking at the numbers and countries of the stakeholders who actually participated in the stakeholder actions. Nevertheless, it was expected that there would be a larger number of stakeholders from member states corresponding to the consortium partners. The consortium aimed for a wide distribution of countries during the stakeholder process as it

is expected some country specific requirements might exist that would have been missed otherwise. The results did not show any indication that this was actually a problem.

As already mentioned, the stakeholders in the different clusters have different levels of knowledge concerning Energy System Models (ESMs) or Modelling in general, and they come from various fields of work. Thus, different methods of stakeholder interaction had to be developed and used to fit the characteristics of the corresponding cluster.

It needs to be stated at this point, that the initially appointed methods for the different members of each stakeholder group were changed according to the preference of the stakeholders, see Table 4. While not all stakeholders wanted to participate in either a survey or a focus group, there was a large willingness to participate in interviews, which in the end turned out to have positive results on the information gained.

2.2 Modelling experts with an academical background experts and policy consultants: Focus Group

For the cluster of Modelling experts with an academical background and policy consultants (ME), the approach of creating focus groups was chosen. Initially, the consortium considered the possibility of organizing a teleconference with all members of the focus group to discuss the same questions as in the survey. Given the instrument selected, only a small number of Modelling experts with an academical background was required to have a fruitful discussion. Nevertheless, it was quickly clear that, even with so few participants, it would be impossible to find a suitable date to carry out the group dynamic. To overcome this problem, a new dynamic, loosely following a Delphi Method, was proposed. The dynamic consisted of the following tasks:

1. **Video**: Watch a video[3] that contextualizes the project and its main features
2. **Survey**: Fill out an online survey with a prioritization of certain aspects
3. **Discussion rounds**: Discuss the results of the survey in rounds trying to reach a consensus
4. **End results**: Reach consensus

The video was viewed five times, and only three out of seven people completed the second step. In addition, they mostly agreed on the answers, so no discussion was necessary. Given such low participation rates, the instrument was not able to lead to a meaningful discussion, thus no valid conclusion could be drawn from it.

2.3 Model Users: Survey

For the members of the second cluster (MU), which consisted of stakeholders with an (energy-related) industrial background and a general knowledge in the use of ESMs and superficial knowledge of Modelling or scenario development, a different approach for involvement was chosen. This group can provide technical insights on the requirements of

[3] https://www.youtube.com/watch?v=TheG0cAGvxc

the models, and they are, due to working in the (energy) industry, also knowledgeable in the use of model results beyond the scope of research and policy making.

In order to obtain information and requirements from this stakeholder group, the members of the group were asked to participate in a survey. The survey method was chosen because it was expected that this type of stakeholders would have sufficient knowledge not to need additional explanations about the questions asked.

The survey was divided into different parts:

- **General presentation of the project:** First of all, the stakeholder participating in the survey received general information about the contents and goals of the WHY project, in line with the guidelines issued in Deliverable D8.3. In addition, the stakeholder was once again informed about the relevance of his/her participation and what was expected of him/her. Finally the stakeholder was informed about his/her rights and the rules for data protection.
- **Consent Form:** As is the case for all other stakeholder involvement processes (see Deliverable D8.3), the survey also featured a consent form, where the participant had to fill out a set of questions targeting their understanding of the issue and their consent to the use of their data and inputs.
- **General Information:** The first contextual set of questions focused on general information and the background of the participant. This information would be later used to better understand the nature of the answers provided. Furthermore, stakeholders were asked about their general expectations of the scope and features of the WHY Toolkit.
- **Requirements for input and output data:** The next set of questions concentrated on the inputs and outputs of the WHY Toolkit. The purpose of this segment was to identify the type and quality of data that could be provided by the tool from the actual user's point of view, and to identify what results and/or outputs they would require to make the tool useful for their day-to-day business.
- **Questions on the use of the WHY Toolkit:** Within this section the focus was on the general usability of the WHY Toolkit. Special emphasis was put on what type of product the WHY Toolkit should be, and how it should be programmed to incentivize its use by the stakeholder in terms of usability, integrability and general operation conditions as well as the features of the toolkit.
- **Questions on supporting documentation and learning materials:** The last segment of the survey was about understanding what type of documentation and learning materials the stakeholder would need in order to better understand and easily use the WHY Toolkit.

The survey was conducted using Google Forms and the stakeholders were invited via the integrated function of the Google Forms Tool. Prior to this, they were contacted by the consortium members of the WHY project and informed about the upcoming invitation to participate in the survey. The full survey can be found in Annex 2 of this deliverable.

2.4 Result Users: Interview

The last group (RU) of stakeholders includes members who will likely use the results of the WHY Toolkit and might be assisted by a consulting company who will use the WHY Toolkit to create policy-driven scenarios and generate results. In some cases the group of RU might have its own team responsible for these tasks, but that was not identified as the general case.

It was assumed that members of this stakeholder group would have little or no knowledge about ESMs or models in general (with the exception of their own teams), as indicated in Table 1. Therefore, interviews were chosen as the method of stakeholder involvement, since they allow for discussions and explanations of different topics. Interviews are useful not only because the interviewer can explain the questions to the stakeholder, but also because the user can provide further information on the project, the WHY Toolkit or the relevance of certain questions. Lastly, the greatest advantage of interviews for this particular group of stakeholders is that a lack of understanding or knowledge of a topic can be compensated by additional information provided by the interviewer at the time of the interview.

Each of the stakeholders involved in interviews was contacted by a consortium member prior to the interview, and was given general information on the project. Similar to the stakeholders participating in surveys, the interview partners were asked to fill out a consent form prior to the interview to ensure that they are willing to participate.

Compared to the surveys and the focus group, the interviews were overarching in nature. They aimed at collecting general information on the pilot use cases[4] of the WHY Toolkit and their results. However, the interviews did also address the topic of inputs and outputs expected from the Toolkit, as well as expectations on the spatial and temporal resolution. The full list of questions asked during the interviews is provided below:

- How much do models and their results influence your work?
- What role should the WHY Toolkit play (e.g. support a policy decision)?
- What should the scope of the tool be (in terms of scenarios, policy interventions, etc.)?
- What are the current and future challenges or aspects of the energy transition, which should be integrated in future energy models?
- What results should the tool deliver for it to be useful to you?
- How do you want the results to be presented (graphs, tables, interactive displays, etc.)?
- Which spatial and temporal resolution should the results of the tool have (e.g. 15 minute (high-res) versus annual (low-res) and building level (high-res) versus country level (low-res))?
- Would you be interested in directly using such a software tool?

[4] For clarification: During the proposal phase of the WHY project the **pilot use cases** where defined. These are related to the pilot sites relevant to the project and the application of the WHY Toolkit at these pilot sites. Later in this Deliverable **Toolkit Use Cases (TUCs)** according to the Volere methodology will be introduced, which describe the general conditions under which the WHY Toolkit will be used. The two types of use cases should not be confused.

- What would motivate you to use the tool more (e.g. technical specifications, computing time, user interface design, complexity, etc.)?
- Do you want to have a standalone version of the tool for you to run? (A standalone version would be a software product which runs on its own as compared to modules, which will be provided as code and that can be integrated in simulation models.)
- Would you be willing to provide input data (such as load profiles, energy related data, policy suggestions, etc.)?

3 Timeline of Stakeholder Involvement Actions

The timeline for stakeholder involvement was very ambitious, as the consortium wanted to obtain the information and the stakeholders' requirements early in the project to ensure that any further development of models or the WHY Toolkit reflects these requirements. Figure 2 shows the timeline of the actions.

Action \ Calendar Week	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45	W46	W47	W48	W49
Start of the WHY Project														
WHY Kick-Off Meeting														
Stakeholder Identification														
Preparation of Documents														
Surveys														
Interviews														
Focus Groups														
Evaluation of Results														

Figure 2: Timeline of the stakeholder involvement actions

As can be seen from Figure 2, the identification of stakeholders started a week before the actual kick-off meeting of the WHY project. At the kick-off meeting, initial information on stakeholders to be asked to participate in the stakeholder involvement actions was available, so the preparation of the survey and interview documents began. It was necessary to invest substantial efforts in the preparation of the surveys, interviews and the focus group. The relevance of answers from such a diverse group of stakeholders, with so many different characteristics, required a significant time investment. Multiple iterations among the members of the consortium resulted in final versions of the documents (interview guide and survey, as well as content for the focus group), which were then circulated among the stakeholders.

Following that, a five-week period was scheduled for the interviews and surveys to ensure a high return rate. For the focus group, stakeholders were provided with a two-week period to provide the information requested. Finally, a two-week period was scheduled for the evaluation of the results of the stakeholder interaction. This evaluation led to the results described in the next chapter.

4 Results of the Stakeholder Involvement Action

This chapter provides the results of the analysis of the inputs obtained through the stakeholder involvement actions. The results of each type of stakeholder involvement action are presented in a separate sub-chapter, regardless of whether the inputs are further considered in the project. The resulting requirements are shown in the next chapter.

For the purpose of having a better understanding of the stakeholders, their background and motivation, the initial classification (see Table 1) was reevaluated and a more precise description of the stakeholder types was formulated. For that purpose, personas were created; the persona method (Pérez-Montoro and Codina, 2017) aims at describing classes of stakeholders in a narrative way by indicating who a representative member of that stakeholder group could be, what their background and drivers are, etc.

For the further analysis of requirements, the following personas were created[5]:

- **Modeler** (Elena)**:**
  She designs and develops energy system models to support decision making by public authorities and private businesses. She gathers the required data for the energy system, load flows, and technologies, and integrates them into the models she develops for various purposes. Elena also provides policy recommendations and strategic advice through comprehensive impact assessments based on multiple alternative scenarios conducted with her modelling tools.

  Elena has an engineering background and is proficient when it comes to the functioning of the energy system, energy technologies, and energy economics. Her knowledge also extends to current and future European policy instruments in the energy sector, and their effects on the energy system. She is also well aware of energy system links to broader socio-economic issues, including behavioural aspects, energy poverty, funding schemes and employment. In addition to her very good overview of the energy sector, she specializes in the electricity sector, in particular in the representation of prosumers and decentralised rooftop PV systems and their connection to the entire energy system.

  Elena currently uses a generic ESM, which she would like to considerably improve, in particular the connection of the electricity system to the building sector. She has experience in creating multiple scenarios that explore the impacts of alternative policy measures, in preparing and presenting the model-based results in a clear and concise way, and in analysing the results by drawing appropriate conclusions and providing inputs for policy recommendations. She is also interested in improving the visualisation of her model-based results through user-friendly and interactive figures and infographics.

- **Industry** (Max)**:**
  Max works for an industry company in the energy sector (DSO, TSO, ESCO, energy

[5] Please keep in mind that the personas described here are fictional and, while the names may evoke the gender of the persona, any gender could be applied to each of the personas described. The gender assignment occurred at random and does not respond to any predefined role.

supplier, etc). Max has either a business management or a technical/economic background and is well versed in the functioning of the energy system, especially within his segment. He is familiar with European and national energy policy, but lacks in-depth policy knowledge.

Max's role in the company strongly depends on the type of company he is working for, but he could be, for instance, an expert on grid operation and planning, an energy trader or a developer of new business models for customers. The energy sector provides multiple possibilities for Max to work in.

If Max were an energy trader, he would use consumption forecasting tools or rely on his extensive experience to buy energy at the lowest possible price and sell it at the highest possible price, in order to reduce balancing group deviations. He would be responsible for monitoring electricity price developments and evaluating relevant information in order to spread risk.

As an employee of a grid operator, Max would also rely on forecasts, not to optimise energy trading, but as the one in charge of the optimal operational planning or strategic planning of grid operation or extension. His goals here would be to reduce the costs of grid operation and maintenance and reduce the required amount of investment for grid refurbishment or extension.

If we consider that Max could also be responsible for the development of new business models, he would be more than happy to know in advance how customers would react to his models and how successful they would be.
Regardless of his Job, Max would benefit greatly from the WHY Toolkit, which he would be capable of using, thanks to his technical expertise and knowledge of operating other simpler models.

- **Policy Advisor** (Polad)**:**
Polad provides energy policy advice, either directly, as part of the team of a policy maker, a consultant or an employee of a governing body or regulatory authority, or indirectly, as part of an industry association, NGO or think tank. He is the person in charge of monitoring legislation, gathering information and data, analysing and presenting it. His work lays the foundation for decisions and energy policies.

  Polad has a very good knowledge of the energy system and of current developments (broad overview). In addition, he is up to date with most energy sector policies (either existing or in discussion) at various levels, as well as with other relevant measures, such as financing schemes, public-private partnerships, information campaigns etc. His job requires him to understand the dependencies within the energy system and the effects certain policy changes have on the overall functioning of the system. Polad might have a detailed understanding of some topics, but he is more of a generalist on energy policies.

  Depending on his academic background, Polad is able to use ESMs and might have some knowledge in creating simulation models himself, albeit not at the level required to depict the complexity of current and future energy systems and generate added value to existing ESMs. He is capable of creating scenarios for simulation runs, from defining the general direction of the scenario to

obtaining/creating the data necessary to run them. However, he is most skilled at analysing results, drawing conclusions (policy recommendations), presenting and explaining them.

- **Official Representative / Policy Maker** (Markel)**:**
  Markel is either a high-ranking official working for the European Commission or a Member of the European Parliament. Together with her team, she is responsible for drafting and negotiating European legislation related to energy efficiency, energy markets, renewable energy targets, electrification, etc. She is a person of considerable influence in her organisation.

  Discussing legislative proposals with various stakeholders, such as lobby groups, is part of her job. She is furthermore responsible for informing her superiors and colleagues of the results of these discussions and the various interests of stakeholders, so that these can be taken into account when taking the final policy decisions. For assessing the claims of various stakeholders, as well as the impact of the proposed legislation, she needs evaluation tools, such as models.

  Markel knows the energy sector well, and is regularly updated on new technologies and advances in the field. She is also briefed on policies worldwide and the expected results. She is not an expert in configuring simulations herself, but, depending on her background and previous professional experience, she understands quite well how a model works and the abilities of the models used by her team. Her real interest lies in the results of such simulations and how these can be translated into viable policies. She is the one that commissions the assessments, and likes to have concise and clear results, well displayed, such as through diagrams, to easily explain the results. However, she also needs more details on certain issues, in order to better understand the topic at hand.

- **Citizen** (Alex and Andrea)**:**
  Alex and Andrea are a working couple. They live with their two kids in a roomy flat on the outskirts of a medium-sized town in Europe. On most working days, after preparing breakfast and lunch boxes for the kids, all of them leave the house to school and work and do not return home until late in the afternoon. In the evenings, they take turns preparing dinner, depending on whether it is gym night or badminton practice. Laundry and other chores are usually done on the weekend. Despite having a decent and stable family income, Alex is keenly aware of the family's finances. Alex shops around for cheaper insurance and utility bills. The internet is helpful for that. Alex does not follow the news very closely: Alex has no patience for politicians and their shenanigans, and all the bad news is just depressing. Alex has enough worries with family and work. Alex cannot be bothered with the problems of the world on top of all that. Human-induced climate change, biodiversity loss, growing inequality... not that Alex denies them, but there is not much Alex can do about it. It just seems so abstract and Alex cannot be bothered with it. Alex is more concerned with the children getting safely to school, obtaining good grades and hoping they will stay off drugs and alcohol.

  Andrea, on the other hand, is more relaxed about these things: Andrea just tries to be a good parent and make time for the kids whenever possible - maybe not as

much as Andrea would like, but more than they tolerate. Knowing that the family income is healthy, Andrea is more worried with what kind of world the kids will have to live in when they grow up. Andrea wants to be a good parent now, and would also like the kids to perceive this. Not just now, but also when they are grown up and look back on it. Andrea wants to be able to look them straight in the eye and say that Andrea did what Andrea could do: both the small and the big things. Climate change is a big issue; Andrea reads a lot on it and is willing to make personal efforts and sacrifice comfort to mitigate the family's contribution to it. Andrea just wishes that Alex would get on board with this: if it costs more money or is too inconvenient, Alex will resist the change. Now, if only Andrea could get the kids to take Andrea's side...

As mentioned in Section 2 not all stakeholders could or wanted to participate in the type of action planned for by the WHY project. Many stakeholders originally planned to partake in survey or the focus group decided to partake in interviews instead, leading to the following participation in the stakeholder involvement actions.

Table 4: Resulting participation of the different stakeholders in the stakeholder involvement actions

Stakeholder involvement Action	Participants
Focus Group	3
Survey	5
Interview	19

Since this change in the assignment of different stakeholders to their stakeholder involvement actions rendered the classification of stakeholders originally defined in Section 2 useless, all results will refer to the Personas instead of the original stakeholder classification.

Furthermore, a set of Toolkit Use Cases (TUCs) was developed, describing a specific situation in which the WHY Toolkit would be used by the personas created and described above. The description of the TUCs follows the Volere Requirements Specification Template (Robertson James and Robertson Suzanne, 2012). A full description of the TUCs can be found in Annex 4.

- **TUC 1**: Assessment of an intervention[6]
  - **TUC 1.1**: Assessment of a policy intervention
  - **TUC 1.2**: Assessment of a new business model / technology
  - **TUC 1.3**: Run a full energy system model simulation for teaching purposes
- **TUC 2**: Assessment of a counterfactual scenario
- **TUC 3**: Generate more precise load forecasts
- **TUC 4**: Improve the understanding of one's energy consumption, possibly leading to more informed decision making and the optimization of the energy use
- **TUC 5**: Optimise policy interventions to fulfil a policy objective

[6] This use case is slightly different depending on the persona carrying it so sub-use cases were defined for it.

4.1 Results of the Surveys

Five stakeholders answered the survey. Each one represents a sector, except academics, which provided two answers. Even if it seems that the participation in the survey was low (21%), it is near the mean value for online surveys (29%)[7]. The results can be summarized as follows:

- The text used to explain the survey was clear, as all participants claimed to understand the capabilities of the WHY toolkit.
- The focus of the WHY toolkit should be on Modelling policy strategies, user behaviour interventions and societal trends, not on the integration with other ESMs or revolutionary technologies.
- According to the stakeholders, the key features are Modelling the effects of interventions and counterfactual estimations of policy interventions (rather than pure forecasts or the integration with other ESMs).
- The answers did not mention any challenges to the energy transition that had not already been considered in the project. The same happened for the inputs and outputs of the toolkit. All answers were already considered.
- The preferred output format is a .CSV file that contains the load profile of an individual household with hourly resolution.
- The simulation process should be less than a day.
- The coupling of the heating and transport sectors was identified as a priority.
- Almost all participants would like to use the tool directly (even pay for its use) for research, policy assessment or long-term energy system planning. Nevertheless, the WHY toolkit would only be used occasionally, and only if the results are reliable and can be integrated with their own models or tools.
- The most useful learning materials would be how-to tutorials (with data and source code of toy examples[8]) and user manuals containing the API description.

The total number of answered surveys does not allow for a general conclusion of the results. Nevertheless the results present a good indication of which requirements exist.

4.2 Results of the Interviews

Most stakeholders took part in the interviews. For the full range of answers provided please refer to Annex 3. This chapter summarises the most relevant and common results, structured by the Personas defined in Section 6 and the questions asked during the interviews. There was no representative of the Citizen persona among the interviewees. This is a result of classifying the stakeholders as personas a posteriori.

How much do models and their results influence your work?

- **Summary Policy Advisors:**
  There were different answers here, ranging from no use of models at all, through the use of model results for policy arguments, to the substantial use of models.

[7] https://surveyanyplace.com/average-survey-response-rate/
[8] https://en.wikipedia.org/wiki/Toy_model

Among members of this group, there is a higher tendency towards the individual use of models.

- **Summary Industry Stakeholders:**
  Within this group there is a strong focus on demand forecasting models. Aside from that, some stakeholders show a need for models, but it depends on the situation.

- **Summary Modelers:**
  Within this group there is a high influence of models on their work.

- **Summary Official Representatives / Policy Makers:**
  No influence at all.

What role should the tool play (e.g. support a policy decision)?

- **Summary Policy Advisors:**
  This question yielded a wide range of answers, as expected. One frequent answer was the role of the WHY Toolkit in supporting policy decisions. Another frequent answer was the support for analysing customers' reactions when it comes to new technologies. In addition, stakeholders mentioned better forecasts, support for planning building codes, understanding consumption better, planning future markets (although this could be categorized under reactions to new technologies), exploring different approaches for one particular topic like incentives for new technologies (although that case could be used in multiple situations), and ex-post analyses like for example of new policies (although that case could also be used in multiple situations).

- **Summary Industry Stakeholders:**
  Stakeholders provided very different answers, which came as no surprise, as the group of "industry personas" is quite broad. Answers worth mentioning are that the tool should be used for the evaluation of new business models, for the evaluation of the redesign of tariff systems, for better forecasts, and for providing end users with information on how to optimise their behaviour.

- **Summary Modelers:**
  There was a very clear tendency towards support of policy decisions. Additionally, the stakeholders in this group mentioned that the tool should provide options that focus more on behavioural issues, for instance change in user behaviour, than on technical topics, like for instance increase in efficiency of certain devices.

- **Summary Official Representatives / Policy Makers:**
  The stakeholders were not interested in directly using the WHY Toolkit; one stakeholder mentioned they might be interested in using it, if it was easy to use and fast.

What should the scope of the tool be (in terms of scenarios, policy interventions, etc.)?

- **Summary Policy Advisors:**
  The answers to this question were again very diverse and did not address the question in-depth. One answer that stood out was the relevance of the Energy Efficiency Directive (EED) and of the Energy Performance of Buildings Directive (EPBD). Interestingly enough, one stakeholder mentioned that the EED is of no relevance to the residential sector. Stakeholders also mentioned the National Action Plans on Energy Efficiency. Additional relevant answers: capturing paradigm changes, considering country specific parameters, understanding the drivers behind decisions and from a banking perspective (such as fostering citizens' participation in green bonds and other green financial instruments).

- **Summary Industry Stakeholders:**
  The stakeholders provided very heterogeneous answers. Notable answers were that the scope of the tool should be a holistic analysis rather than focus on single aspects, and that the tool should consider the institutional level (energy system level) as well as all agents of the market system.

- **Summary Modelers:**
  A wide range of answers were provided to this question, with no clear tendency among stakeholders. Among the more relevant answers were the issue of applying the tool for other countries through available country data, the consideration of deep decarbonisation options (both technical and behavioural), a more detailed representation of policy instruments and policy portfolios, and linking the scope of the WHY Toolkit to the five use cases mentioned in the proposal.

- **Summary Official Representatives / Policy Makers:**
  The tool should cover renovation, rooftop PV, and funding programs. Furthermore it should elaborate on the rebound effects caused by consumption increases if people use renewable energy.

What are the current and future challenges or aspects of the energy transition, which should be integrated in future energy models?

- **Summary Policy Advisors:**
  Again very different answers, but some aspects were mentioned by more than one stakeholder. One of the key issues the tool should address is the topic of sector coupling. It should also address the effects of digitalisation. The following trends were mentioned at least twice and should therefore be considered: general behavioural and demographic changes, consideration of income inequalities, electric mobility, demand response and automation, increase of RES-generation, and the development of other markets and the financeability of new technologies.

- **Summary Industry Stakeholders:**
  Stakeholders provided very heterogeneous answers. Two trends were mentioned more than once: more active consumers (energy communities, prosumers, etc.) and the consideration of energy storage systems. Further topics of interest would be sector coupling (including EV) and digitalisation.

- **Summary Modelers:**
  There were quite a few different challenges that were mentioned at this point. The ones that were deemed relevant by more than one stakeholder are the consideration of demand side management (DSM) and flexibility, sector coupling, overall behavioural changes, and the occurrence of potential rebound effects.

- **Summary Official Representatives / Policy Makers:**
  The stakeholders said that energy consumption for heating and cooling and energy imports should be looked into.

What results should the tool deliver for it to be useful to you?

- **Summary Policy Advisors:**
  The analysis of the answers to this question was particularly interesting. The answers were focused less on what the actual results of the tool should be and more on the framework conditions (assumptions, used data, etc.) under which the results should be obtained.
  When asked again for the type of results that would be useful, three stakeholders named energy efficiency indicators, such as energy consumption, as the main result to be provided by the WHY Toolkit, albeit providing slightly different details.

  As for the framework conditions under which the results should be obtained, there were three main findings:

  - The tool needs to offer full transparency with regard to the assumptions used.
  - The tool needs to consistently display the concatenation of human reactions/actions that lead to the results.
  - The usability of the tool seemed to be more relevant than the results for some of the stakeholders.

- **Summary Industry Stakeholders:**
  We received very different answers from the stakeholders pertaining to this group. Among the relevant findings were: the WHY Toolkit should also provide economic results (for instance cost savings, etc.) and not only energy related results. Furthermore, the main factors (assumptions, data, etc.) which led to the results and that the results contain data relevant for the analysed user group.

- **Summary Modelers:**
  Within this group, there was just one answer calling for key demand figures (peak load, annual consumption, load profile, etc.) and parameters as desired outputs of the tool. The other answers concerned the quality of the results and the scientific excellence and robustness of tools/models. Here, the stakeholders agreed that the tool and its underlying database should be open source and as transparent as possible.

- **Summary Official Representatives / Policy Makers:**
  The WHY Toolkit should be able to provide energy saving advice for consumers. In addition, results should be broken down by neighbourhoods and include the demography of the population within the neighbourhood (types of houses, distribution of inhabitants, etc.).

How do you want the results to be presented (graphs, tables, interactive displays, etc.)?

- **Summary Policy Advisors:**
  There are two main tendencies when it comes to the display of the results: graphic results (even interactive ones) and full data sets, for instance tables or raw data. There was no clear preference for one or the other, although some stakeholders noted that they prefer a graphic presentation of the results for communication and dissemination purposes. Overall, both presentation formats (e.g. raw data and interactive displays) are highly relevant for the potential groups of users of the WHY Toolkit.

- **Summary Industry Stakeholders:**
  There was a slight tendency towards more detailed results, although dashboard solutions were also mentioned.

- **Summary Modelers:**
  The stakeholders within this group would definitely like to have raw data and access to the models and the source code. However, they would also be interested in a graphic or interactive display of results.

- **Summary Official Representatives / Policy Makers:**
  There is a clear preference for an interactive and graphic representation of the results. One stakeholder noted they would also want to have tables with more detailed information.

Which spatial and temporal resolution should the results of the tool have (e.g. 15 minute (high-res) versus annual (low-res) and building level (high-res) versus country level (low-res))?

- **Summary Policy Advisors:**
  For both spatial and temporal resolution, very different answers were provided. The focus was on a higher temporal resolution and a rather low spatial resolution (NUTS 2 or 3). However, stakeholders agreed that it strongly depends on the use case.

- **Summary Industry Stakeholders:**
  Answers tend to support the statement that resolution depends on the use case. For strategic planning, an annual/monthly resolution should suffice, whereas for operational planning the temporal resolution should be rather high (15-30 minutes or higher). In terms of spatial resolution, all options are interesting, but stakeholders allocated different priorities to different resolution options.

- **Summary Modelers:**
  There is a strong tendency to link both temporal and spatial resolution to the use case analysed, ranging from 15 minutes for local analysis to annual data for the European and the global level.

- **Summary Official Representatives / Policy Makers:**
  Stakeholders provided very different answers: while one stakeholder highlighted the necessity to link resolution to the use cases, and to the recipient of the results,

the others suggested a weekly temporal resolution and a spatial resolution ranging from national level down to building level.

Would you be interested in directly using such a software tool?

- **Summary Policy Advisors:**
  We received both yes and no answers, with a stronger focus on yes, given certain conditions (price, transparency, etc.). One point that was raised concerns existing IT protocols in companies and how the WHY Toolkit should meet certain conditions in order to be employed by companies.

- **Summary Industry Stakeholders:**
  Stakeholders mostly agreed on their interest to use the tool directly. The purposes for which they would employ the WHY Toolkit differ.

- **Summary Modelers:**
  A very clear yes.

- **Summary Official Representatives / Policy Makers:**
  No clear result could be obtained.

What would motivate you to use the results/tool more (e.g. technical specifications, computing time, user interface design, complexity, etc.)?

- **Summary Policy Advisors:**
  Stakeholders mentioned a variety of factors that would positively influence them to use the WHY Toolkit. “Transparency” was the factor identified most often, i.e. the models and the tool being as transparent as possible and the codes being open source. In addition, a good design and interface as well as good documentation would contribute to the use of the tool.

- **Summary Industry Stakeholders:**
  The answers varied a lot; two tendencies emerged: ease of use and options for the use of the tool, and quality and reliability.

- **Summary Modelers:**
  The key influencing factor for this group is the scientific excellence and robustness of the tool and its results. Furthermore, the usability and transparency of the tool were mentioned.

- **Summary Official Representatives / Policy Makers:**
  One of the stakeholders saw no added value in using the tool, the other one would use the tool if the calculation speed is high and the tool easy to use.

Do you want to have a standalone version of the tool for you to run? (A standalone version would be a software product which runs on its own as compared to modules which will be provided as code and that can be integrated in simulation models.)

- **Summary Policy Advisors:**
  For this question, there is a clear tendency towards the fact that the tool should have interfaces and plug-ins to existing models. A standalone version is preferred for educational or academic purposes.

- **Summary Industry Stakeholders:**
  There is a tendency towards a standalone version, especially due to data protection issues.

- **Summary Modelers:**
  Here the answers differed significantly from each other. One stakeholder wanted to have partial modules (preferably in Python), another would prefer an online version, a third one preferred the standalone version.

- **Summary Official Representatives / Policy Makers:**
  One stakeholder would not want to use the tool at all, while the other would prefer a standalone version due to data protection issues.

Would you be willing to provide input data (such as load profiles, energy related data, policy suggestions etc.)?

- **Summary Policy Advisors:**
  While not all stakeholders are willing to contribute data, there is a general tendency towards providing data for the tool and a willingness to cooperate with the project.

- **Summary Industry Stakeholders:**
  General positive tendency to provide data, but data protection issues have been mentioned.

- **Summary Modelers:**
  Generally yes, but this group does not have load profile data; they would rather contribute policy suggestions and policy instruments.

- **Summary Official Representatives / Policy Makers:**
  There is a general negative attitude towards sharing data. Although one of the stakeholders was indecisive.

5 Requirements for the WHY project

To draw conclusions from the stakeholder involvement it was necessary to identify the main requirements (functional and non-functional) from the answers provided by the stakeholders. The requirements engineering followed the Volere methodology by applying the Volere Requirements Specification Template (Robertson James and Robertson Suzanne, 2012). Furthermore, the requirements defined during the proposal phase were added, following the same approach.

The following indicators are used to describe a requirement:

- **ID:**
  Identification code for the requirement.
- **Name:**
  Relatable name for the requirement.
- **Requirement Type:**
  Requirements can either be functional or non-functional. Non-technical requirements are described in more detail by applying the Volere classification (Robertson James and Robertson Suzanne, 2012).
- **Description:**
  A precise and comprehensible description of the requirement.
- **Rationale:**
  A description of the justification of the requirement and why it is considered in the further course of the project.
- **Fit Criterion (measurable):**
  Description of the possible ways to measure whether or not the requirement was fulfiled.
- **Components:**
  List of components of the WHY Toolkit that are affected by this requirement. These will be discussed in Section 6.
- **Requirements blocked by this one:**
  List of requirements that this requirement blocks and are thus not considered any further.
- **Requirements that block this one:**
  List of requirements that block this requirement, resulting in this requirement not being considered any further.
- **Persona Satisfaction:**
  The satisfaction of stakeholders when the requirement is fulfiled on a scale from -5 (extremely disappointed), through 0 (uninterested), to +5 (extremely pleased).
- **Source:**
  Who or what dictates the fulfilment of this requirement.
- **Priority:**
  Description of the importance of this requirement according to the stakeholder value on a scale from 1 (very low) to 5 (very high).
- **Difficulty:**
  Level of difficulty for requirement implementation (estimation). Scale from 1 (low difficulty) to 5 (extreme difficulty).

A total of 86 requirements were identified during this process, which are separated into functional and non-functional requirements below. In the following chapters only the title and the description of the requirement are indicated. An in-depth description can be found in Annex 5.

For the purpose of full disclosure, requirements resulting from the stakeholder involvement actions will be marked with [SIP], requirements related to the WHY Toolkit coming from the Grant Agreement will be marked with [WT-PP], and requirements related to the WHY project in general coming from the Grant Agreement will be marked with [WP-PP].

5.1 Functional Requirements

This section contains the full list of functional requirements. Functional requirements describe the functions that an application or of one component should be able to perform. So it basically describes what the WHY-Toolkit must do after a data input.

These requirements were either identified during the stakeholder involvement process or were defined during the proposal phase. Over the course of the project, the requirements will be ranked and filtered to focus only on those to be considered for the development of the WHY Toolkit. For the decision process two main factors will be considered:

1. **The practicability of the requirement**: While we value the inputs of our stakeholders, it must be understood that not all of them can technically be met. You cannot have a simulation of the entire energy system of Europe with a high geographical and temporal resolution and expect the simulation to solve within minutes, for example.
2. **Relevance to the WHY Use Cases**: During Task T1.3 the requirements will be mapped to the WHY Use Case where they are most relevant and could be tested. In a similar situation as the previous one, some requirements could be very difficult to test inside one of our use cases or be directly out of the scope of the project (requirements from traffic modelling or industrial sector, for example).

In any case, we will do our best to consider all requirements inside the toolkit developed in the project.

The final list of requirements is:

- **R_S1 - Support for policy making [SIP]:**
  The WHY Toolkit needs to be able to provide support for policy decisions, and show how these policies will affect the behaviour of household consumers, thus providing insight into the effectiveness of the policy.
- **R_S2 - Consumers' reaction to new technologies [SIP]:**
  The WHY Toolkit needs to be able to simulate how consumers will react to new technologies and provide insights on whether these technologies will be used.
- **R_S3 - Consumers' reaction to new business models [SIP]:**
  The WHY Toolkit needs to be able to simulate how consumers will react to new business models and provide insights on whether these business models will be a success or not.

- **R_S4 - More accurate forecasts [SIP]:**
  The WHY Toolkit should be able to provide better forecasts for household electricity consumption (in the very short, short and medium term)[9].
- **R_S5 - Focus on behavioural components [SIP]:**
  The WHY Toolkit should have a strong focus on behavioural aspects, not only on technical ones. Therefore, not only technical modelling should be done. The WHY Toolkit should include behavioural elements and represent lifestyle changes.
- **R_S6 - Consideration of the Energy Efficiency Directive (EED) [SIP]:**
  It needs to be possible to include the contents of the EED as interventions.
- **R_S7 - Consideration of the Energy Performance for Buildings Directive (EPBD) [SIP]:**
  It needs to be possible to include the contents of the EPBD as interventions.
- **R_S8 - Consideration of the National Plan on Energy Efficiency (NAPE) [SIP]:**
  The interventions contained in the WHY Toolkit should consider the framework presented in the NAPE.
- **R_S9 - Paradigm changes [SIP]:**
  The WHY Toolkit should be able to consider technical and social paradigm changes, both from a behavioural and a technical perspective.
- **R_S11 - Sector coupling [SIP]:**
  The WHY Toolkit should be able to consider sector coupling options including power to gas (P2G), power to heat (P2H), or electric vehicles (EV).
- **R_S12 - Digitalisation [SIP]:**
  The WHY Toolkit should be able to calculate the effects of digitalisation on household energy consumption.
- **R_S13 - DSM & flexibility [SIP]:**
  The WHY Toolkit should be able to perform demand side response actions and use flexibilities.
- **R_S14 - Active consumers [SIP]:**
  The WHY Toolkit should be able to consider active consumers, such as prosumers, and consumer collectives such as energy communities.
- **R_S15 - Results: EE indicators [SIP]:**
  The WHY Toolkit should provide energy efficiency indicators as a result of the simulations.
- **R_S16 - Results: Economic effects [SIP]:**
  The WHY Toolkit should provide the economic effects as results of the simulations of interventions.
- **R_S17 - Transparency [SIP]:**
  The WHY Toolkit should provide full transparency (within the limits of privacy and data protection) on how the results were obtained. This includes the methodology applied to gain the results, the data used for the simulations and also the concatenation of the consumers decisions and actions.
- **R_S18 - Cluster by user groups [SIP]:**
  The results of the WHY project should be able to be clustered by user groups for additional insights.

[9] Very Short Term (less than a day), Short Term (less than a week), Medium Term (less than a year), Long Term (more than a year).

- **R_S19 - Form of results (also non-functional requirement) [SIP]:**
  The results of the WHY Toolkit should either be presented as raw data or in the form of (interactive) graphs and diagrams.
- **R_S20 - Spatial resolution [SIP]:**
  The WHY Toolkit should provide spatial resolutions ranging from country size to building size, depending on the pilot use case.
- **R_S21 - Temporal resolution [SIP]:**
  The WHY Toolkit should provide temporal resolutions ranging from less than 15 minutes to an annual resolution, depending on the pilot use case.
- **R_S27 - Support in planning building codes [SIP]:**
  The WHY Toolkit should allow users to calculate the effects of different building codes, and thus provide them with the possibility to evaluate building codes.
- **R_S28 - New or redesigned tariffs [SIP]:**
  The WHY Toolkit should be able to analyse the effects and the acceptance of new or redesigned energy tariffs.
- **R_S29 - Future markets [SIP]:**
  The WHY Toolkit should allow the users to analyse new (future) markets for energy (services) as to their impact including the citizen's acceptance.
- **R_G6 - Define a Sustainability Assessment Model [WT-PP]:**
  The WHY Toolkit should provide additional results to only energy consumption related results. These additional results are subsumed in the Sustainability Assessment Model, including for instance economic and social effects and results.
- **R_G7 - Assess smart meter data to create clusters of energy behaviour [WP-PP]:**
  To better classify and cluster energy behaviour data, substantial amounts of smart meter data need to be gathered and analysed. This will lay the foundation of the Causal Model.
- **R_G9 - Create an instrument to classify a subject into one of the clusters/segments [WP-PP]:**
  Given a load profile and other relevant information of a particular household, a procedure that allows a classification [possible probabilistic] of what cluster of behaviour (as defined in R_G8) this particular household belongs to, has to be developed.
- **R_G11 - Create a full Causal Model [WT-PP]:**
  The WHY Toolkit needs to develop a full Causal Model for the electricity consumption at household level, including those aspects that affect consumer participation in energy efficiency (EE), demand response (DR) and decentralised generation (DG) actions.
- **R_G12 - Create a simplified Causal Model [WT-PP]:**
  The WHY Toolkit will need to contain a simplified Causal Diagram for the electrification of transport and for HVAC systems.
- **R_G13 - Monitor the behaviour of households [WP-PP]:**
  To better understand the energy consumption behaviour, invasive and non-invasive monitoring devices have to be deployed on volunteer houses over the course of the WHY project.
- **R_G14 - Define different methods of retrieving information [WP-PP]:**
  Use instruments from Social Sciences and Humanities (SSH) to retrieve information (surveys, focus groups, roleplay games, validated instruments) during the WHY project.

- **R_G15 - Foster citizen participation [WP-PP]:**
  The WHY project should provide a gamification experience to foster the participation of citizens (badges, information from past energy consumption, etc.).
- **R_G16 - Adjustability of the Causal Diagram [WT-PP]:**
  The Causal Diagram needs to be fully adjustable to data collected by different means to build the Causal Model.
- **R_G17 - Evolution of the Causal Model [WP-PP]:**
  Develop a long-term representation of the evolution of the Causal Model taking into consideration the expert knowledge of the different stakeholders.
- **R_G18 - Models for appliances and services [WT-PP]:**
  The WHY Toolkit needs to contain mathematical models for different appliances and services irrespective of the energy carrier used. This will make it possible to compare the energy consumption of these appliances and services and to choose the ones with the highest relevance.
- **R_G20 - Model the future of appliances and services [WT-PP]:**
  The models contained in the WHY Toolkit need to be able to consider future developments of energy appliances and services. The attributes or parameters of these models will not be constant and S-curve models will be fit to historical data to project future technological developments.
- **R_G21 - Model the replacement of appliances and services [WT-PP]:**
  The models describing the energy appliances and services need to be capable of considering replacement cycles for possible causes (broken, old fashion, energy standards, cash incentives, etc.).
- **R_G24 - Model decentralized generation and storage [WT-PP]:**
  The WHY Toolkit needs to consider models for decentralized generation and storage for individuals and communities (with special emphasis on photovoltaic generation and EVs).
- **R_G25 - Model load control techniques [WT-PP]:**
  The WHY Toolkit needs to be able to model the energy storage and the energy management systems.
- **R_G27 - Use of price signals [WT-PP]:**
  Models of the WHY Toolkit that concern prosumer behaviour at the building level should consider, among others, the possibility of price signals for load shifting behaviour.
- **R_G28 - Model power2gas [WT-PP]:**
  The WHY Toolkit should provide the possibility to consider power2gas appliances (hydrogen, methane, etc.) in the simulations. Feeding hydrogen into a distribution grid and using it for maximizing one's consumption, for example as seasonal energy storage, needs to be considered.
- **R_G29 - Model Cogeneration and Power2X [WT-PP]:**
  The WHY Toolkit needs to allow considering cogeneration and integrating it with the *Component* of the Energy Management System and the *Component* for P2G. Furthermore, other forms of P2X, like power to mobility (Electric Vehicles -EV) and P2H need to be considered.
- **R_G30 - Use a Multi Agent Model [WT-PP]:**
  The WHY Toolkit needs to contain a multi agent system that is capable of upscaling the results of a simulation to the temporal and geographic scale needed for large-scale ESMs.

- **R_G31 - Provide traditional load forecasts [WT-PP]:**
  Development and implementation of a model that properly segments the residential sector and is based on actual behaviour theories. The former segmentation will be achieved by using time series feature extraction, whereas the latter will use structural causal models.
- **R_G32 - Provide load forecasts under interventions [WT-PP]:**
  Development and implementation of a model that properly produces load forecasts of buildings under interventions such as lockdowns, policy incentives, tariff changes, etc.
- **R_G33 - Provide "business as usual" backcasts[10] for counterfactual Modelling [WP-PP]:**
  Set the variables of the causal model artificially to values that fulfil the specifications of the counterfactuals (alternate versions of past events) and estimate the results.
- **R_G34 - Model anomalies in load behaviour [WP-PP]:**
  During the WHY project an analysis needs to be performed, whether it is possible to detect anomalies in the load profiles of households. This means that if a household belongs to a certain cluster of consumers, it should be analysed if there are certain anomalies in its load behaviour as compared to the other members of the cluster.
- **R_G35 - Full ESM integration (PRIMES, TIMES and PROMETHEUS) [WT-PP]:**
  The WHY Toolkit must provide plugins for ESMs to be directly called from within the ESM, which will contribute to the enhanced use of the WHY Toolkit.
- **R_G36 - Develop an interface for configuration [WT-PP]:**
  The plugins developed for the connection of ESMs and the WHY Toolkit need to have full consistency and proper customisation to fulfil the requirements of the ESMs at the level of coverage, granularity, methodological approach, demand resolution, etc.
- **R_G37 - Run simulation tests [WP-PP]:**
  During the WHY project, a set of simulation tests with focus on normal and critical scenarios needs to be developed for the future users of the WHY Toolkit.
- **R_G38 - Do a sensitivity analysis [WP-PP]:**
  It is crucial for the relevance of the WHY Toolkit that results are sensitive to external variables and interventions. For that purpose, a sensitivity analysis of these should be conducted during the project.
- **R_G39 - Co-define a set of scenarios that includes policy interventions, projections of macro drivers and key parameters [WP-PP]:**
  The success of the five use cases depends on their level of detail. To this end, workshops with stakeholders and end users will be organised to define the required details.
- **R_G40 - Consider the following interventions [WT-PP]:**
  The WHYToolkit should be able to consider the following interventions: energy taxation, policies, measures to address barriers and market failures, subsidies for RES and EV, information campaigns, demand response schemes, access to finance, ambitious eco-design, energy performance of buildings and energy labeling, technology standards and Emission Trading System pricing.

[10] https://otexts.com/fpp2/backcasting.html

- **R_G41 - Consider the following impacts [WT-PP]:**
  The WHY Toolkit should be able to provide results of an analysis of interventions and new technologies on: energy consumption and fuel mix, load profile, energy costs and prices, energy services (i.e. heating, mobility), behavioural changes, different forms of energy efficiency investments (i.e. thermal insulation, heat pumps, purchase of energy efficient appliances, etc.), energy affordability for households, energy access, energy and technology poverty, and others.
- **R_G42 - Carry on an ethical impact analysis [WT-PP]:**
  The WHY Toolkit needs to provide the data to carry on an ethical evaluation (increase the inequality, include discrimination, energy poverty etc.) of the impact of different interventions.
- **R_G43 - Develop Educational materials [WP-PP]:**
  To ensure that the WHY Toolkit is used and understood by a large number of users, the creation of educational materials and a summer school course focused on capacity building activities on energy demand Modelling and the WHY Toolkit are necessary.
- **R_G44 - Write technical documentation [WP-PP]:**
  Develop a technical reference manual of the WHY Toolkit and its components during the WHY project.
- **R_G45 - Assess a black-out in a microgrid [WT-PP]:**
  As part of the WHY Toolkit the Causal Model needs to be able to forecast the behaviour of household consumers during a black-out, if they are supplied with electricity in a microgrid setting.
- **R_G46 - Assess changes in energy tariffs [WT-PP]:**
  The WHY Toolkit or rather the Causal Model needs to be able to forecast how customers of an energy retailer would change their consumption behaviour following a change in tariff structure.
- **R_G47 - Estimate the impacts of municipal intervention [WT-PP]:**
  The WHY Toolkit needs to be able to forecast the impact interventions at a municipal level have on the energy consumption of households (buildings).
- **R_G48 - Reassess the 2030 and 2050 decarbonisation scenarios [WP-PP]:**
  The WHY Toolkit should be applied directly during the WHY project to reassess with the improved household load predictions the 2030 and 2050 decarbonisation scenarios, including the recent EU policies for emission reduction and energy efficiency.
- **R_G49 - Investigate the effect of the improved representation of energy demand from the built environment on long-term global energy scenarios [WP-PP]:**
  The WHY Toolkit should be applied to the global use case.

5.2 Non-Functional Requirements

Non-functional requirements, as opposed to the functional requirements, describe attributes such as quality attributes or performance standards of the WHY-Toolkit. So it basically describes how the WHY-Toolkit does the things it does.

The following non-functional requirements were either identified during the stakeholder involvement process or were defined during the proposal phase. Over the course of the

project, the requirements will be ranked and filtered to focus only on those to be considered for the development of the WHY Toolkit.

- **R_S10 - Different countries (Non-functional: scalability or extensibility requirements) [SIP]:**
  The WHY Toolkit should be applicable in different EU countries by using country specific parameters.
- **R_S19 - Form of results (Non-functional: appearance requirements) [SIP]:**
  The results of the WHY Toolkit should either be presented as raw data or in the form of graphs and diagrams depending on the user requirements.
- **R_S22 - Robustness of the results (Non-functional: robustness or fault-tolerance requirements) [SIP]:**
  The results of the WHY Toolkit need to be robust and comprehensible.
- **R_S23 - Standalone software - local installation (Non-functional: productization requirements) [SIP]:**
  The WHY Toolkit should be programmed as a standalone software product which can be installed locally.
- **R_S24 - Modular structure & interfaces (Non-functional: Productization Requirements) [SIP]:**
  The WHY Toolkit should have a modular set-up where users can easily access single modules via interfaces or plug-ins to existing ESM.
- **R_S25 - Ease of use (visual) (Non-functional: Appearance Requirements) [SIP]:**
  The user interface of the WHY Toolkit needs to be comprehensible and self-explanatory to promote the use by different stakeholders.
- **R_S26 - Ease of use (parameters, etc.) (Non-functional: appearance Requirements) [SIP]:**
  The user interface of the WHY Toolkit should provide the user with the possibility to make own simulations with a limited set of input parameters which can easily be edited.
- **R_G1 - Requirements should be compiled from the stakeholders [WP-PP]:**
  The list of requirements would be discussed with the stakeholders. To this end different activities should be carried out to foster their participation.
- **R_G2 - Selection or prioritization of models to be used or developed for each component should be done by the partners [WP-PP]:**
  The stakeholders requirements could include the development of models for different components of the energy value chain. If it is not possible to consider all of them (because they fall out of the scope of the project or due to lack of budget), then the partners should choose which of the models will be prioritized.
- **R_G3 - Types of interventions will be gathered mainly from the stakeholders [WP-PP]:**
  The interventions to be considered in the WHY Toolkit should be discussed as part of the actions carried out to retrieve the requirements from the stakeholders (R_G1)
- **R_G4 - A prioritization of the interventions has to be made (possible, important and critical) [WP-PP]:**
  As in R_G2, if it is not possible to consider all interventions required by the stakeholders (because they fall out of the scope of the project or due to lack of budget) the partners should choose which should be implemented first.

- **R_G5 - Projections of the parameters and external variables of the model have to be collected from official or credible sources [WP-PP]:**
  Data for the external variables of the causal model should be collected using credible sources. The use of official and reliable sources, together with the application of open science policies, ensures the verifiability of the results obtained.
- **R_G8 - Follow an open science policy (publish RAW and processed datasets and scripts to process the data) [WP-PP]:**
  In order to make scientific research more reproducible, accessible, and collaborative, all the processed datasets and programs to process the data will be released with open-source or public domain-equivalent licenses, and using widespread raw formats.
- **R_G10 - Locate enough volunteers for each cluster to achieve a high power and control the Type S and M errors [WP-PP]:**
  Enroll enough volunteers to cover each cluster of energy profiles and allow to control the Type S and M error in the group using reasonable guesses obtained from the assessment of the energy profiles.
- **R_G19 - Only the most relevant (with respect of the energy consumption) appliances and service models on the residential should be made [WT-PP]:**
  Compare various energy consumption appliance and service models and select the ones with the highest relevance.
- **R_G22 - All models will be created using Python Script [WT-PP]:**
  Use Python version 3 or higher as a programming language for the WHY Toolkit.
- **R_G23 - Open source models will be developed [WP-PP]:**
  The source code has to be accessible for anyone who wishes to inspect, modify or enhance it.
- **R_G26 - Use interoperable inputs and outputs [WT-PP]:**
  The WHY Toolkit needs to be able to interact with existing Energy System Models. Therefore it needs to use appropriate data structures to ensure data exchange between applications (e.g. JSON, CSV).
- **R_G50 - Improve the level of granularity of ESM [WT-PP]:**
  Improve the temporal and geographical granularity of the ESM used in the five pilot use cases to be carried out in the project.
- **R_G51 - Reduce the forecasting error at all levels [WT-PP]:**
  Reduce the forecasting error on all geographical and temporal levels used by the ESM in the five pilot use cases to be carried out in the project.
- **R_G52 - Consider at least 12 interventions [WT-PP]:**
  A state of the art will be carried out in Task 2.1. It will cover (among other things) a survey of interventions at the European level that could affect residential load profiles. The project has defined four topics of relevance: energy efficiency, demand response, distributed generation and electrification of services. the most relevant interventions pertaining to each topic will be analysed.
- **R_G53 - Energy profiles should consider at least 50% of the population [WT-PP]:**
  Several clusters of behaviours have to be created (R_G10) and assessed. These clusters should aim to cover at least 50% of the population.
- **R_G54 - Validate the forecast of interventions [WP-PP]**
  Validate (in terms of goodness of fit, MAPE, MSE or statistical significance) the forecast of the interventions set on R_G53.

- **R_G55 - Proxy validate the counterfactual model [WP-PP]:**
  Validate (in terms of goodness of fit, MAPE, MSE or statistical significance) the forecast of the interventions set on any of the Randomized Control Trials carried out in the project.
- **R_G56 - Carry out eight co-creation activities [WP-PP]:**
  At least eight activities that involve stakeholders should be carried out in the project.
- **R_G57 - Produce ten (non-unique) policy recommendations [WP-PP]:**
  Based on the achieved results, at least two policy recommendations for each of the five use cases should be produced.

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ANNEX A - List of stakeholders contacted

No.	Name	Cluster	Nationality	Gender	Participation
1	Energienetze Steiermark	Model Users	AT	M	Yes
2	Energie Steiermark Technik	Result Users	AT	M	Yes
3	Austrian Energy Agency	Modelling experts and policy consultants	AT	M	Yes
4	e-Control Austria	Model Users	AT	M	Yes
5	TU Graz	Modelling experts and policy consultants	AT	M	No
6	FH-Technikum Wien	Modelling experts and policy consultants	AT	M	Yes
7	FH-Technikum Wien	Modelling experts and policy consultants	AT	M	No
8	Weizer Energie Innovationszentrum	Result Users	AT	F	Yes
9	Agora Energiewende	Not invited	N/A	N/A	N/A
10	TU Wien	Modelling experts and policy consultants	AT	M	Yes
11	COPPE, University of Rio	Modelling experts and policy consultants	BR	M	Yes
12	WISE Europa	Modelling experts and policy consultants	PL	M	No
13	CMCC Research center	Modelling experts and policy consultants	IT	F	Yes
14	Wuppertal Institute	Modelling experts and policy consultants	DE	M	Yes
15	European Commission, DG Energy	Result Users	PT	M	No
16	IIIASA	Modelling experts and policy consultants	NL	M	Yes
17	REScoop.eu	Result Users	BE	M	Yes
18	I-DE	Not invited	N/A	N/A	N/A
19	EVE	Result Users	ES	M	Yes
20	Ministerio Transición Ecológica - Secretaria de Estado de Energía	Not invited	N/A	N/A	N/A
21	Siemens	Model Users	DE	M	No
22	Debagoiena D2030	Not invited	N/A	N/A	N/A
23	Oñargi	Result Users	ES	F	Yes
24	Alginet	Model Users	ES	F	No
25	Som Energia	Model Users	ES	M	No
26	ENARGIA	Result Users	FR	M	Yes
27	Goiener	Model Users	ES	F	Yes
28	Nosa Enerxia	Model Users	ES	M	No
29	Goiener	Not invited	N/A	N/A	N/A
30	Deutsche Unternehmensinitiative Energieeffizienz (DENEFF)	Result Users	DE	M	Yes
31	co2online	Result Users	DE	F	No
32	European Council for an Energy Efficient Economy (eceee)	Result Users	SE	M	Yes
33	Buildings Performance Institute Europe (BPIE)	Result Users	DE	M	Yes
34	European Alliance of Companies for Energy Efficiency in Buildings (EuroACE)	Result Users	IE	M	No
35	50Hertz	Result Users	DE	M	No
36	Climate Action Network (CAN) Europe	Result Users	DE	M	No
37	European Alliance to Save Energy (EUASE)	Result Users	IT	F	No
38	European Heat Pump Association (ehpa)	Not invited	N/A	N/A	N/A

39	Regulatory Assistance Project (RAP)	Result Users	HU	F	Yes
40	European Climate Foundation (ECF)	Result Users	NL	F	No
41	European Federation of Intelligent Energy Efficiency Services (EFIEES)	Result Users	FR	F	No
42	European Association of Energy Service Companies (eu.ESCO)	Result Users	DE	M	No
43	former European Copper Institute (CU)	Not invited	N/A	N/A	N/A
44	Aalborg University	Result Users	DK	M	No
45	Next Kraftwerke	Result Users	DE	M	Yes
46	Asociación de Fabricantes de Bienes de Equipo Eléctricos (AFBEL)	Not invited	N/A	N/A	N/A
47	EURELECTRIC	Not invited	N/A	N/A	N/A
48	European Distribution System Operators (E.DSO)	Result Users	DK	F	No
49	Association of European Manufacturers of automotive, industrial and energy storage batteries (EUROBAT)	Not invited	N/A	N/A	N/A
50	Frauke Thies, Smart Energy Europe (smartEN)	Result Users	DE	F	No
51	The Coalition for Energy Savings	Result Users	DE	M	No
52	TNO	Modelling experts and policy consultants	NL	M	No
53	CBS	Not invited	N/A	N/A	N/A
54	UCC	Modelling experts and policy consultants	NL	M	No
55	Wageningen University	Modelling experts and policy consultants	NL	M	No
56	PSI	Not invited	N/A	N/A	N/A
57	IDAE	Result Users	ES	F	Yes
58	Regenera Levante	Model Users	ES	M	No
59	Gamesa	Model Users	ES	M	No
60	Property Management Association from Euskadi	Not invited	ES	M	N/A
61	Urban Department Basque Country	Result Users	ES	M	Yes
62	Wellness Smart City	Model Users	ES	M	No
63	Ingeteam	Model Users	ES	M	No
64	EKI Foundation	Not invited	ES	M	N/A
65	University of Comillas	Modelling experts and policy consultants	ES	M	Yes
66	N/A	Not invited	N/A	F	N/A
67	N/A	Not invited	N/A	M	N/A
68	N/A	Not invited	N/A	F	N/A
69	Biko consulting	Not invited	N/A	M	N/A
70	N/A	Not invited	N/A	F	N/A
71	N/A	Not invited	N/A	M	N/A
72	N/A	Not invited	N/A	M	N/A
73	BC3	Model Users	ES	M	No
74	Aarhus University	Model Users	ES	F	No
75	University of Comillas	Model Users	ES	F	No
76	CSIC	Not invited	N/A	M	N/A
77	Silesian University of Technology	Model Users	PL	M	Yes
78	University of Deusto	Result Users	ES	M	No

79	City of Worms	Result Users	DE	F	Yes
80	City of Worms	Result Users	DE	M	No
81	City of Eschborn	Result Users	DE	M	No
82	City of Würzburg	Result Users	DE	M	No
83	City of Nürnberg	Model Users	DE	M	Yes
84	City of Karlsruhe	Result Users	DE	F	No
85	Energy Agency of Northrhine-Westphalia	Result Users	DE	M	No

ANNEX B - Stakeholder Involvement Action: Survey

WHY Toolkit Survey

Background

Energy system models (ESMs) have been used by experts to project and describe long-term impacts of interventions on energy systems. While ESMs have yielded useful results in simulating energy supply, there is a lack of accuracy in simulating energy consumption, especially in the residential sector, where a diversity of dwellings and human behaviours produce a broad spectrum of consumption patterns. To address this issue, the EU-funded project "WHY" will quantitatively analyse people's daily decisions regarding energy consumption and their reactions to specific policy-driven interventions and how these translate into electricity consumption behaviour with the help of a causal model. In the context of the project, interventions are external stimuli such as changes in funding schemes, changes in policies, changes in taxes or subsidies, etc.

Having a model which provides users of ESMs with information on how consumers will react creates new possibilities for consumption behaviour analysis. Combining the causal model with technical models for energy services used by consumers (for instance appliances) will provide new insights into the resulting electrical load profiles of households and thus improve energy demand modelling in leading ESMs.

Practical uses

What is the use of the tool outside of the modelling world? The WHY Toolkit, which will combine all the models developed in the project within a software product for the user will allow:

- To make better forecasts of household electricity consumption
- To analyse, evaluate and validate policy decisions or other interventions such as changes in regulation, funding, etc.
- To analyse how today's world would look like if certain energy policy decisions had or had not been made. By simulating how people might have reacted to certain policy decisions, the

WHY model will be able to analyse the effects of these decisions on the system's development.

Stakeholder involvement

What good is a tool if it does not satisfy the requirements of future users? You have been identified as a potential user of the WHY Toolkit and/or its results. We would like to include you in the WHY stakeholder process and ask you to provide us with input to make the WHY Toolkit as useful as possible.

What do we expect from you?

You have been invited to fill out the following online survey which will take approximately 15 minutes. The data you provide will be used anonymously. The survey is prepared in

Google survey, if you cannot/do not want to use Google survey feel free to ask for alternatives and we will provide you with a document containing the questions.

The survey is divided into four sections:

- General information
- Requirements for input and output data
- Questions on the use of the Toolkit
- Questions on documentation and learning materials

By filling out the survey you provide the WHY consortium with the necessary information to tailor the WHY Toolkit to your particular needs. Since you know best what you need from such a tool, we kindly ask you to fill out the survey as precisely as possible. After the survey is closed and the results evaluated, you will be presented with the results.

Rights as Stakeholder

Your participation in this project is voluntary and no costs are derived for you. You have the right to withdraw at any point during the activity, for any reason, and without any prejudice. All your inputs and insights will be transcribed and used only for the sole purpose of research (e.g. dissemination, outreach, etc.). If requested, we can provide a summary of your transcript before it is used in our research. Publication of the results will not disclose personal data as your names will always be hidden and changed by an alias such as: Stakeholder 1, Stakeholder 2, etc. Your information can be deleted upon request at any moment. Data contained in this survey will be kept at least until 5 years after the end of the project for auditing or reporting purposes by request of the funding agencies. After that date, all personal data will be removed. A copy of your answers will be sent to you. The responsible for the recorded inputs, video sessions, contact data and any other personal information are Cruz E. Borges (cruz.borges@deusto.es) and Thomas Nacht (thomas.nacht@4wardenergy.at). You can contact them to solve any question related to this survey.

* Required

1. E-Mail-Adresse * _____

2. By providing your email above, you acknowledge that: *
Please choose the corresponding answers.

- ❏ Your participation in the action is voluntary
- ❏ You are at least 18 years of age
- ❏ You have read the WHY information sheet that provides enough details about the project (purpose, expected duration and procedures of the study)
- ❏ You have been informed about your right to refuse to participate or to leave the activity at any moment without any justification
- ❏ You have been notified of the contact persons, in the case you have questions or doubts during the activity
- ❏ You have been informed that a copy of the consent form will be sent to your email account
- ❏ You have had enough time to decide on your participation in the study

- ❑ You have been informed about the questionnaire that you have been asked to complete
- ❑ You have been informed about the storage procedures of the study data
- ❑ You have been informed about the confidentiality of your personal data
- ❑ You allow experts involved in the study under confidentiality agreements to utilize the information for the purpose of the study and only for this
- ❑ You agree to participate in the study

General Information

3. Which sector does your organisation belong to? *
Please choose the corresponding answers.

- ❑ Academia
- ❑ Policy
- ❑ Industry
- ❑ NGO
- ❑ Other: _____

4. Do you understand the capabilities of the tool (as explained in the introductory text) in relation to the points below? *
Please choose only one of the answers.

- ❑ Yes
- ❑ No

5. What aspect do you consider the tool should focus? *
Please choose only one of the answers.

- ❑ Integration with existing Energy System Models
- ❑ Inclusion of different Energy Policy Strategies / Actions
- ❑ Inclusion of different User Behaviour Interventions
- ❑ Inclusion of New Societal Trends
- ❑ Inclusion of Several Technological Advances

6. Please rate the following features from 1 (not important) to 5 (most important) *
Please choose only one of the answers per line.

	1	2	3	4	5
Forecast household loads					
Analyse the impact of policy decisions on household energy consumption					
Estimate how household energy consumption would look like if certain (relevant) energy policy decisions had or had not been made					
Integrate with Energy System Models like PRIMES or TIAM-ECN					

7. What are the current and future challenges or aspects of the energy transition, which should be integrated in future energy models?

_____

Requirements for input and output data

8. What should be the inputs of the tool? Please include them as keywords separated by semicolons.

_____

9. What should be the outputs of the tool? Please include them as keywords separated by semicolons.

_____

10. What data formats should be used to provide the inputs and outputs of the tool? *
Please choose the corresponding answers.

- ❏ REST web API with JSONs, XMLs or similar
- ❏ Database
- ❏ Regular files (.CSV or .XLSX)
- ❏ Other: _____

11. Which temporal resolution for the inputs and outputs should be used? *
Please choose only one of the answers per line.

	< hour	hour	day	month	year	> year
Input						
Output						

12. Which geographic resolution for the inputs and outputs should be used? *
Please choose only one of the answers per line.

	Building Level	Community Level	City Level	Regional Level	Country Level	International Level
Input						
Output						

13. Prioritize the following sectors coupling to include in the toolkit
Please choose only one of the answers per line.

	Do not consider	Low Priority	If possible	High priority	Essential
Heat (Cogeneration)					
Transport (EV)					
Energy-Water-Food Nexus					
Gas (Power 2 X)					
Waste (Biogas)					

14. What metrics (KPIs) would you use to measure the performance of the tool (especially the forecasting results)? Please include as many keywords as desired, separated by semicolons.

_____

Questions on the use of the Toolkit

15. What would the tool be used for in your company? *
Please choose the corresponding answers.

- ❑ Research-based projections
- ❑ Policy design, definition of policy instruments and/or setting strategic policy
- ❑ objectives
- ❑ Policy assessment or justification
- ❑ Definition of interventions to change citizens' / users' / customers' behaviour
- ❑ Lobbying, political positions, negotiations
- ❑ Long-term planning (industrial or urban development or similar)
- ❑ Operation optimization (industrial, policy or similar)
- ❑ Investment or other industrial decisions
- ❑ Others: _____

16. How much time are you willing to wait for an answer from our model? *
Please choose only one of the answers per line.

	Seconds	Minutes	Less than a day	More than a day	Can only be run on HPC
Simulation time					

17. Would you like to use the tool yourself, or would you rather have someone else do it for you?
Please choose only one of the answers.

- ❑ Use it directly
- ❑ Have someone else use it and provide me with the results

18. How often are you going to use the tool? *
Please choose only one of the answers.

- ❑ Daily
- ❑ Regularly
- ❑ Occasionally

19. What background will the user of the tool have? *
Please choose only one of the answers.

- ❑ Civil servants
- ❑ Policy advisors
- ❑ Energy engineers
- ❑ Researchers in the energy field
- ❑ Activists or policy makers
- ❑ Others: _____

20. Would you be willing to pay for such a tool? *
Please choose only one of the answers.

- ❑ Yes

❑ No

21. If the previous question was answered with yes, please indicate how much you would be willing to pay (Please try to be clear, a whole figure in € would be enough). *

_____

22. How important is it for you to be able to integrate the tool with your own models / tools?*
Please choose only one of the answers per line.

Not at all	1	2	3	4	5	Very important

23. What conditions must be given that increase the chance that you would use the models or the results, respectively, in future policy-making / your work?

_____

Questions on supporting documentation and learning materials

24. To what learning materials do you want to have access? *
Please choose the corresponding answers.

❑ Text book
❑ Complete summer courses
❑ How-to tutorials (with data and source code)
❑ Plenary session videos
❑ Short videos
❑ Exercises with solutions
❑ Cheat sheet
❑ One pagers
❑ Full documentation
❑ Others: _____

25. What technical documentation do you want to be provided? *
Please choose the corresponding answers.

❑ API description
❑ Call-caller diagrams
❑ Sequence diagrams
❑ Interactive API testing facilities
❑ Architecture and modules' descriptions / overviews
❑ Complete model with reduced complexity for demonstration and tutorial purposes
❑ Install or deploy scripts
❑ User manuals
❑ Others: _____

ANNEX C - Answers of the Stakeholder Interviews

How much do models and their results influence your work?

- Industry I:
  - It strongly depends. In the normal line of business (E-Stmk TK is the technical part of the energy supplier business focusing on the implementation of new technologies and approaches) rather not. When it comes to the realisation of projects models play a role.
  - Generally models are developed in house but rather from partners with the requirement that they function, there is hardly any interest in the algorithms themselves.
  - Single projects are evaluated (economically) with different models (not necessarily energy system models)
- Industry II:
  - Presently, as a result of the integration of smart meters in the network, and of ever-improving SCADA systems, we are obtaining highly precise real-time and past data. The reality is that the consumption pattern of our residential clients has been stable in the past years. If we add to this (observation) that we have not seen a significant increase in new consumer access points, nor had a widening of the grid, we consider that the data that we have had at our disposal have been sufficient for planning and operating the distribution grid.
  - Having said this, in an immediate future, the integration of new energy models of decarbonisation (both conventional installations and self-consumption) and the integration of the EV, imply an important change in the household consumption pattern, and as a result, a supply and generation forecasting model can be very useful for distribution companies in the planning and operation of the future network (investment plans, forecasting of facility loads, planning manoeuvres ...).
  - In this context of increased demand, distribution companies must optimize the planning and deployment of the network to mitigate problems and improve investments. In the future, it will be important to be able to control bidirectional power flows (from the network to the consumer and from the consumer to the grid, as a result of self-consumption) instantly, and to control the increase in power demanded taking into account the incursion of the electric vehicle, all with the aim of giving stability to the system. Therefore, the model should include both the demand forecast (including consumption of electric vehicles) and the generation forecast (conventional facilities and self-consumption)
- Industry III:
  - Models predicting consumption are obligatory in our operation because the authorities demand those predictions.
- Industry IV:
  - They only work with generation forecasting systems (live measurement at the plants)
  - They do not need such models for their daily work

- They are not a supplier for household customers, but those would probably not be interested either, because they work with standard load profiles - there is no added value
- If you supply a standard load profile, you don't care how the customer behaves, you just need to know how much electricity the customer consumes, not when and what moves him
- It is rather a question for DSOs, who have to do the daily balancing
- This will only significantly change if we get 15 minutes delivery and billing (we are not there yet today) - smart meters could provide an incentive
- But there is also the question of what financial incentive customers have to adapt their behaviour - electricity exchange prices (e.g. 1ct/kWh) are too low for customers to compensate for loss of comfort
- Industrial customers: When Next Kraftwerke offers flexible tariffs, they divide the consumption into consumption that cannot be influenced and consumption that can be controlled automatically without loss of comfort
- Private households - example: Customer with EV and heat pump – value added is generated by intelligence/digitization, (runs in the background).
- behavioural change can only be achieved by a high financial incentive, which may be interesting for prosumers who use their own electricity, because they can save costs by using their own electricity
- In the future: flexible automated management of EVs and heat pumps with separate meters
- Question from me: Only in Germany? What would happen in case of a blackout (special situation)?
- One has to see what the financial incentives are - in Western Europe electricity costs (as part of the additional household charges) are not relevant, in other countries where electricity is very scarce or very, very expensive, consumers would maybe adapt their behaviour
- Black-out: What happens in a black-out - high consumption and too little power generation - We have many mechanisms (interruptible loads, control energy) with which we can react.
- In our meshed network a black-out is very unlikely, in case of a predicted blackout you would go ahead and say, consumption please at certain times, etc. – for large consumers like electric heating, normal private use (refrigerator, washing machine) makes little difference - it does not help to predict them
- Proposal under discussion: Today, EVs cannot be recharged, or may only be recharged with reduced power - network operators would have the tools to influence user behaviour.
- There are no incentives for flexible charging of electric cars (only combined with own consumption), which is actually good for the system - seasonal differences (in winter it would have other effects on the system), but with a household battery it would work - could be controlled by the network operator or a supplier like them
- People are not interested in operating their own batteries, but that they have comfort
- Supply and demand, if there is too much demand, the price rises

    - Forecasts or models that identify grid problems could help, we would then need solutions to react to them
- Modeller I:
    - His work is actually directly related to the development and use of demand-side models. He currently develops new buildings model (via the H2020 NAVIGATE project), but following different methodologies (modular structure)
- Modeller II:
    - Much, as he extensively uses modelling outcomes to provide policy recommendations at the national and EU level
    - Familiar with LEAP + PRIMES modelling frameworks, but not a modeller
    - His PhD is very close to the WHY project (he should develop a module that quantifies energy sufficiency analysis) – decision: use existing or develop a new one from scratch? Idea for collaboration with WHY.
    - Focus on demand-side modelling
- Modeller III:
    - Comparing his model with other modelling approaches and model results (establishing a "mutually learning" approach)
    - Influencing each other on how we design scenarios and build storylines (e.g. recently models started exploring very ambitious levels on CO2 reduction towards climate neutrality)
- Official Representative / Policy Maker I
    - modelling has zero impact on the daily work
- Official Representative / Policy Maker II
    - modelling has zero impact on the daily work
- Policy Advisor I:
    - Only partially
- Policy Advisor II:
    - Elena Verdolini is an applied economist, focusing on industrial economists. She is also a professor and tries to contribute to policy debate in EU
    - Models shape her research interests and questions- her research work on econometrics is used as an input to the model
    - Models help her teach about climate change, by using graphs for model results and projections (mostly from multi-model exercises)
    - Also models support her to influence the policy debate
- Policy Advisor III:
    - Very much, as they are now developing similar work in Policy Advisor III on improving the representation of the residential sector in Brazil
    - Collect data from 5000 Brazilian municipalities to produce an econometric model, data are on annual basis (yearly consumption of electricity)
    - Understand the impact of climate change on electricity consumption – it is very important to be included in WHY (esp. air cooling). Enrica De Cian is leading this work so it may be important to contact her
- Policy Advisor IV:
    - no reply
- Policy Advisor V:
    - Political measures and political strategies are derived from scenarios and models

- As Policy Advisor V they need arguments - models are very important
- The topic of energy efficiency is not really taken into account, or is constantly linked to the development of energy consumption, regardless of how the topic develops (static view) - i.e. no dynamic demand topics (e.g. consideration of electricity efficiency measures in a specific grid region)
- The models and the assumptions behind them are important for Policy Advisor V
- They use only the results of the models - if they commission studies, they may also use models (e.g. data model from Forschungszentrum Jülich - feed assumptions and the model delivers results)

- Policy Advisor VI:
  - Policy Advisor VI is a small NGO, he is also a private consultant
  - For Policy Advisor VI he is interested in these issues
  - He was involved in two projects coordinated by Fraunhofer ISI – detailed modelling of energy use and household investment behaviour (first project – 15,000 detailed surveys in eight countries, second project – 18,000 detailed surveys in eight countries)
  - As a consultant, he is noticing that power grids are becoming an important topic in Sweden (very electrified country, high electricity consumption/capita, intensive industry), especially the capacity of the distribution grid in the Southern part of Sweden
  - Partly a transmission problem, but also regionally a problem – from an efficiency point of view: We speak about adding more capacity, there is also talk of flexibility, but there is no discussion about the role of energy efficiency – can we permanently lower demand or can we combine energy efficiency investments with something else
  - It is a question of cost per household – energy efficiency is expensive, but we don't look at the savings through avoided new capacity
  - He is currently working on a project proposal for utility laundry rooms in multi-family housing (at regional scale) – the move to the use of heat pumps and tumble-dryers – looking to model the impact of massive-scale installment of this type of washing equipment
  - As many of these dwellings are looking into installing EV charging stations, they would not save money, but they would avoid increasing the cost for upgrading the building
  - This project does not bring you flexibility directly, but it lowers the peaks
  - Part of this would be a behavioural issue – how to explain it to stakeholders (condominium associations)
  - They are also looking into power purchase agreements for the entire building, smart meters
- Policy Advisor VII:
  - As a think tank, they do policy analysis, work with scenarios, develop their own models and use the results of models developed by other organizations
  - They work a lot with model results and also try to improve their own Modelling
  - Own models: development of GHG emissions and energy consumption in the building sector (e.g. 2030 and 2050 targets, also participate in Horizon

2020 projects, e.g. EU Calc - where they developed the model for the building sector)
    - Our model would be interesting for them, it depends on what it really does, who the target group is - tools for decision makers are often a bit simpler, they are interested in detail
- Policy Advisor VIII:
    - They do not use in-house models; they are cooperating with partners who have models
    - Primary use of models is to substantiate claims regarding regulation (impact of regulation ideas in the EU & US)
    - She would like to use models more
- Policy Advisor IX:
    - ESM are used for impact assessment they are the main tools for any legislative proposal or for communication with member states (for instance targets for 2030).
    - PRIMES is used as reference for member states
- Policy Advisor XI:
    - Models are used to perform a socio-ambiental assessment of the investment decisions (including the social profile of the company asking the loan). Each bank of the federation has their own set of KPIs and even made external experts to assess some of the investments.

What role should the tool play (e.g. support a policy decision)?

- Industry I:
    - Evaluation of new business-models when it comes to the acceptance of the customers for new models. Sensitivities are normally predefined, when business-models are developed in the company. The actual decision of the customers would thus be of high interest.
    - Also the reaction from changes in the legislation on the customer behaviour could be of relevance for new business model development.
- Industry II:
    - The tool could help in institutional energy policy decision making.
    - a) From the point of view of distribution, we observe the following needs for the efficient integration of renewables:
        - Improve the access and connection process, in order to have a comprehensive and clear regulatory framework that regulates the access and connection process efficiently.
        - Optimize the operation of the system, developing flexibility markets, as well as regulation and norms of networks to facilitate the integration of renewables (balance between generation and consumption).
        - In general, it would be interesting if the model could make contributions in order to adapt the regulatory framework to the new energy models.
    - b) It could also help in the need to redesign a new tariff framework to guarantee the sustainability of the electricity system. (Access or capacity – note added by Chris) tariff adapted to supply and generation forecasts.
    - The tool should help consumers make decisions:

        - a) Contracting the optimal power
        - b) Optimal selection of the (access or capacity – added by Chris) tariff.
        - c) Optimal self-consumption model based on the needs of each consumer, for a better use of the energy produced.
        - d) In short, the possibility of being able to manage the supply points effectively, having the possibility of obtaining, through the model, different results in different scenarios. Possibility of carrying out simulations with the different variables that affect energy consumption and generation.
- Industry III:
    - This type of tool could be a mechanism that we could use whenever we note that the real consumption will be different from the predicted in order to avoid costs related to this difference.
- Industry IV:
    - Different user groups – 15 minutes resolution - it would be interesting to offer users a 15 minutes tariff (product design)
    - Or get information from it - it would be interesting for certain users, but it won't work in the short term, because the incentives in our electricity system are too low - we have to do something about the network charges
    - Interesting is the perspective development, not the status quo, we might encounter situations where we have to act (interesting for policy makers)
    - In general, it helps to develop further information on user behaviour and to present it interactively, even if it is not relevant for actors like them in their daily work
    - Such tools also help with visualization, they help create the policy framework that is missing - much better suited than studies
    - Depending on the policy framework, the tools can also help (there is no point in having a 15 minutes resolution without being able to address it commercially)
- Modeller I:
    - Supporting Energy Policy decisions, policy advice
    - Influence local policy makers, national and EU
- Modeller II:
    - Supporting Energy Policy decisions
    - Open up options that are not only technical, but behavioural issues both on individual responsibility but also community level
- Modeller III:
    - Most important is to support Energy Policy decisions at various levels in order to explore the different specificities of WHY Use cases as e.g. other target groups are relevant for the microgrid case (e.g. grid operators/ energy community) vs the national/ EU case (e.g. policy makers)
- Official Representative / Policy Maker I
    - Sees no possibility for using the WHY Toolkit
- Official Representative / Policy Maker II:
    - Role is not as important but it needs to be easy and fast
- Policy Advisor I:
    - Provide better forecasts for the consumption behaviour of households

- Policy Advisor II:
  - The role of the tool depends on the target audience
  - The tool has high potential impact, especially if more targeted to energy consumers
  - It is useful to national or regional authorities for their planning to tighten the building codes (in new buildings)
- Policy Advisor III:
  - to inform policy decisions at local and national levels
  - but also for power companies to understand electricity demand, as utilities need to have better forecasts for future demand)
- Policy Advisor IV:
  - no reply
- Policy Advisor V:
  - Support of political decisions
  - For many companies it is exciting to know what effects it has on the demand for certain products, e.g. measurement control technology, for energy service providers for the operation of the plants, or when it comes to topics such as Smart Home, Smart Factory – it is failing right now because nobody can really estimate how the demand for controllable power (on the supply and demand side) is, and what this means for services and products
  - Question from me: Do companies come to you as an association or is it only relevant for their operative business?
  - It strongly affects the operative business of individual companies, but is politically mirrored because, for example, in the case of an amendment to the EEG, the remuneration is linked to grid-compatible behaviour, but there are no market signals (in the case of CHP - because of grid-compatibility, the subsidy is reduced, but when within the spectrum of full-use hours these are called up, there are no market signals)
  - EEG revision: Plants from one kW upwards must be equipped with measurement and control technology, but for what purpose?
  - Another aspect: In Texas there is a capacity market where supply and demand are on a level playing field. This does not exist in Germany. Texas: Seasonal peaks or daily peaks are served both by generation and grids and by energy efficiency measures - energy efficiency is a resource in the system and is also addressed by the market.
- Policy Advisor VI:
  - In modelling, the behavioural aspects are extremely important not only for network capacity, but also for modelling energy use
  - One challenge, from an energy policy point of view, is to help people understand that electrification is coming, it is important to keep costs down
  - Communication challenge, what sort of behavioural decisions does one take in multi-family buildings – the investments you do today have a very long life, if tariffs will increase quicker, it will be a challenge
  - An educational problem: How can we make people understand – the solution is not just to build more power lines, the decisions we take today can help us keep the system cheaper and we do not have to oversize it as much

    - Smart metering is important, but not in the way we use it today, it is not a good way to provide feed-back, few consumers are really interested in their energy consumption
    - Example: Study on programmable thermostats – people assumed they would save a lot of money, but they were not, sometimes households were consuming more
    - Part of the problem was that people did not know how to program them, the design was cool for engineers, but not for the households, only for installers
    - There is no standardization for smart meters, they will only work if they are easy to use
    - If electricity is very expensive/prohibitive, maybe consumers will react, but it is easier to teach people to change behaviour, make it a social norm
- Policy Advisor VII:
    - If the target group are policy makers, then we should model the effects of political decisions
    - Such a tool could also prove interesting for the private sector, when it comes to planning or developing future markets (how markets could develop under certain scenarios)
    - The fact that modelling is currently not able to depict energy consumption behaviour correctly is also due to the fact that energy models are based on standard behaviours, but each person behaves differently (personal circumstances, personal level of awareness)
- Policy Advisor VIII:
    - Another use case is to explore ideas – e.g. worked with former colleagues on a carbon border adjustment tax for the power market in Europe versus enlarging the European ETS to South-East Europe – they explored impacts
- Policy Advisor IX:
    - Very important role for communication purposes with the member states!
    - For communication purposes: Description of behavioural patterns
    - Check of effectiveness of measures for policy making
    - Last rung of the causal stair (Counterfactuals) will be very relevant in post-ex evaluation of measures and policies
    - Evaluation of the reaction of energy system changes to macro-economic effects
- Policy Advisor X:
    - The tool should support both the analysis of the effectiveness of current energy planning policies and for the proposal of modifications or design of ad hoc measures, as well as for decision making and generating basic information that feeds other models or tools.
- Policy Advisor XI
    - Implement the impact appetite framework to help the impact evaluation of projects (in contraposition to the risk appetite framework of traditional banks). In particular, evaluation of the aspects that modify the spread to charge or the capital immobilized by the bank

What should the scope of the tool be (in terms of scenarios, policy interventions, etc.)?

- Industry I:
  - Holistic analysations, not so much single aspects.
  - Especially dynamics and transitions in the energy system should be within the scope of the tool (the energy system is evolving more rapidly now)
- Industry II:
  - As we have explained in the previous points, we believe that the scope should be both at the institutional level, and at that of all market agents (producers, retailers, distributors, consumers ...):
  - At the institutional level with a view to adapting the regulatory framework to the new energy models.
  - Producing, retail, and distribution companies: in order to establish new business planning policies to adapt to new consumption and generation models.
  - Consumers: in order to manage supply points effectively.
  - Specifically the scope of the tool should be the planning and operation of the future network, adapted to the new models, and with the aim of providing stability to the network.
- Industry III:
  - The tool could function in a variable perimeter; with interventions of the retailer or the government.
- Industry IV:
  - No discussion on this point
- Modeller I:
  - Temporal linked to geographical scale (e.g. higher temporal resolution in the microgrid case is required)
  - Upscaling ? use similar patterns for countries, from data that we have to other comparable countries
- Modeller II:
  - It should include deep decarbonisation options to reach the climate neutrality for the EU
  - It should include a more detailed representation of policy instruments and portfolios (and their drivers), e.g. economic, fiscal, non-market, infrastructures, regulatory, education campaigns
  - How to properly include non-market policies? agent-based modelling approach: social inter-dependencies to understand technology penetration
  - Modal shifts depending both on economic terms and on social interactions should be endogenously included in the model
  - COVID-19 impacts should be integrated in the tool: Economy and legal frameworks and infrastructure
- Modeller III:
  - Directly related to the five use cases – difficult to develop one tool addressing all target groups and policy questions
  - The tool should be flexible enough to handle both the short-term (e.g. for the microgrid case) and the long-term (for the EU/global studies)
- Official Representative / Policy Maker I:

    - The WHY Toolkit should be easy to use in the daily work
- Official Representative / Policy Maker II
    - The WHY Toolkit should cover renovation, PV on the roof, funding programs. Consumption increases if people use renewable energy
- Policy Advisor I:
    - Housing sector, single family homes
- Policy Advisor II:
    - Should be more directed to the public
    - Explore digitisation of households
    - Talk more about the benefits of climate action for individual consumers (e.g. benefits of reducing energy consumption or becoming prosumer)
- Policy Advisor III:
    - Produce scenarios for different policy interventions
    - Scenarios should capture real-world developments
- Policy Advisor IV:
    - The scenarios must be medium-long term and establish objectives as well as roadmaps to achieve them
- Policy Advisor V
    - In Germany: National Action Plan on Energy Efficiency (NAPE) - KfW programs are also included
    - EU: EED & EPBD, eco-design and labeling
    - In the industrial sector: The BesAR (in the EEG) is in contradiction with energy efficiency measures (peak shaving, peak lifting) - companies would fall out of the BesAR by increasing energy efficiency.
- Policy Advisor VI:
    - You want to understand how the system is developing, so you input things into the model (policy tools, financial tools, incentives) – first take a step back and understand what the realistic tools are (literature review on household behaviour) and concentrate on the most important interventions, the ones that have the largest impact, not the small ones, so that the model does not become too complex and unmanageable
    - We need to understand the drivers, otherwise the models will not be realistic
    - Different inputs in different countries, regions – households have different drivers in different countries (e.g. connecting financial cost of an appliance with energy efficiency – the higher the cost, the better the appliance)
    - Pricing of power at different times might not be the most important driver for people, financial gain might be less important than doing the right thing, doing something for the climate, for the society, for local jobs
    - Example: Baker who is not allowed to expand because of grid capacity – energy efficiency would mean more available capacity and it would make the local economy grow, more important than the couple of cents one saves
    - Especially affluent households cannot be reached through price
    - We need to understand what motivates people to save energy – the same drivers would help us understand how to model power use
    - Power savings might be the consequence of other decisions, less the result of direct interventions to reduce power consumption

    - Electrification versus climate – strong driver: If we want to electrify, we need to make sure we use the power wisely and at the right time.
- Policy Advisor VII:
    - The EPBD itself has so many sub-measures (energy certificates, financing instruments, inspections) - choose a measure, e.g. improving the informative value of energy certificates and analyse what effects it has on people's behaviour
    - Any measure contained in the EPBD could or should be covered by such a tool
    - It has to be about concrete measures in order to be able to show the connection (Note: Renovation wave, published two weeks ago - no case law, but there are detailed measures that one could use as Modelling basis)
- Policy Advisor VIII:
    - Many of these power wholesale models – the demand side is very roughly represented – in the one she used, the demand is exogenous over time, linked to GDP on a statistical basis, other models are sectorally disaggregated
    - An improvement would be to treat energy efficiency or demand response not as an exogenous 'thing', and just reduce the load (I assume that Hungary will have 4% improved energy efficiency), but in an endogenous way – what would be the impact/need on the networks (5% reduction on each peak hour each day in each Hungarian residence)
    - A real 'super tool' is one where the demand is represented in a very refined manner – it is very difficult to do, it is much easier to model the operational choices of a power plant
    - Another aspect: feedback – demand not as a given, we meet it with supply and network capacity, but they are optimized together (goal for a power model)
    - The EED has no impact on the consumer – at the level of the consumer directives are not relevant
    - Important how consumers would react to different tariff designs (network and retail tariffs) – how well do you incentivize users to consume in a way which is good for the power system
- Policy Advisor IX:
    - First off, policy interventions are most important with a strong focus on energy relevant interventions
    - Capturing trends (paradigm) is important (but there is a strong doubt, that is possible Full disclosure on the assumption etc. are most important)
    - There are multiple different scenarios that would be relevant to analyse, but we should rather limit our scope in the use of the tool than have over ambitious objectives.
    - More detailed scope for analysations for a more granular view is more valuable
- Policy Advisor X:
    - We believe that the tool should allow the simulation of different combinations of exogenous and endogenous factors to energy consumption: energy and carbon prices linked to the emission rights markets, socioeconomic situation and trends at the micro and

macroeconomic level, market dynamics, population projections, trends in terms of home equipment or fleet, consumption habits or behaviour patterns, new energy business models with a greater weight of renewable energies and a more active role of consumers, new figures such as active consumers, communities energy, self-consumption, energy sharing, changes in the energy supply induced by the new energy and climate guidelines (closure of thermal power plants, de-dieselization of the car park, circular economy, etc.)
    - Likewise, the tool should allow evaluating the impact of energy efficiency policies and measures, considering aspects such as the rebound effect, among others, so that an adequate signal will be provided to the authorities responsible for the design of policies in order to optimize the design and economic resources allocated to future policies.
- Policy Advisor XI:
    - Foster the pay per performance in energy efficiency actions
    - Foster the deployment of renewables (mostly in rural areas)
    - Finance refurbishing of public buildings
    - Foster the participation of citizens on green bonds and other green instruments

What are the current and future challenges or aspects of the energy transition, which should be integrated in future energy models?

- Industry I:
    - Sector coupling
    - Hydrogen (entire value chain)
    - Energy Communities and Prosumers in general
    - Energy Storage systems in general.

  All these aspects should be found in the models as well.

- Industry II:
    - The policies and objectives developed by the EU for the decarbonisation of the energy model in the long term.
    - High penetrations of renewable generation in the networks (conventional installations and self-consumption)
    - Integration in the network of distributed resources (distributed generation, electric vehicle ...)
    - Electrification of mobility: deployment of the electric vehicle, charging points.
    - Active participation of end customers in the market, consumers also become energy producers. Need to adapt the system to customer needs.
    - Facilitate the achievement of environmental objectives: reduction of emissions.
    - Allow the integration of new services available to consumers. Provide data to consumers.
    - Integration of new technologies for electrical networks. Digitalisation and electrification of energy demand.
    - Integration of storage systems.

    - The need for the development of electricity generation to be accompanied by the development of electricity networks.
    - Importance of Cybersecurity and data security.
    - Data management: need for data processing technology
- Industry III:
    - The variability of the consumption (pattern) to adapt it to renewables generation.
- Industry IV:
    - Home office will not have a major impact on the system - only shifting consumption (from offices to homes) - it balances out
    - The consumption within household also shifts, the consumption profile changes, it varies from day to day
- Modeller I:
    - Integration between demand, renewables and storage
    - Demand Side Management for RES integration
    - Supply side: already covered
    - Transport: EVs, electrification across all sectors
- Modeller II:
    - Technical approaches should be complemented with behavioural options
    - Rigorous tool to cover multiple aspects and policies
    - Include behavioural change and potential rebound effects
    - Policy representation towards the climate neutrality target
    - Compare transparently the carbon budgets and emission trajectories
- Modeller III:
    - Sector integration (Electric vehicles, prosumers)
    - Integrating flexibility options across sectors
    - Deep decarbonisation options
    - Non-technical, behavioural aspects, lifestyle changes
- Official Representative / Policy Maker I
    - Energy transition: modelling of energy consumption for heating and cooling
- Official Representative / Policy Maker II
    - Energy transition: need of importing energy / electricity
- Policy Advisor I:
    - The effects of a change in the current regulation on the consumption
- Policy Advisor II:
    - Ability to model different policy instruments and portfolios (e.g. building codes, Rate and deepness of renovation)
    - Digitalisation in buildings
    - Behavioural change of consumers
    - Inequalities that may increase through decarbonisation
    - The links of decarbonisation with other SDGs (clean air, fairness)
    - Impacts on the labour market on specific sectors (e.g. winners/losers)
- Policy Advisor III:
    - Better represent heterogeneity, as most existing models do not have the required granularity, e.g. geography, social or weather models
    - Problem is the model aggregation- we should move beyond the notion of “representative” agents

    - Improved modelling of sectoral integration between energy demand and supply
- Policy Advisor IV:
    - Reduction in consumption and adaptation of installed capacity based on reduced demand.
- Policy Advisor V
    - Control via energy prices: Electricity is getting cheaper, fossil fuels are becoming more expensive, this is driving the demand for electricity
    - People live more in single households
    - Home Office
    - Digitization (mobile working, streaming, power consumption of data centers - in Germany driven by data protection)
    - Digitalisierung (mobiles Arbeiten, Streaming, Stromverbrauch von Rechenzentren – in Deutschland durch Datenschutz getrieben)
    - Demographic developments
    - Sector coupling - more electrically heated and electromobility
    - Policy framework and energy prices, technological innovations (digitization)
    - Demand management from the energy grid is lagging behind
    - Demand management from changed consumption patterns - things are produced and delivered just in time - break between the energy industry (energy should be used when it is available and cheap) and consumers and industry 4.0 (other requirements)
- Policy Advisor VI:
    - No discussion on this point
- Policy Advisor VII:
    - Difference between prescribed changes in behaviour (e.g. home office) and voluntary changes in behaviour
    - Digitization
    - Electromobility as mass market
    - Consumers are becoming increasingly aware of the need to implement more climate protection, but only a small part of the population will take the decision to manage their energy consumption more consciously (consumers are interested in services, not in energy quantities)
    - Increasing electrification of thermal energy
    - Heat perception is very individual and is very rarely taken into account into Modelling, so the models are not accurate
    - Citizens are not interested in constantly monitoring their energy behaviour, they want energy services - an optimization of the system should happen automatically, if there are economic advantages, they are willing to invest in it - it must be a standard offer
    - Question from me: Conflict between individual consumption and optimization?
    - Automation is only accepted if the consumers can program e.g. buildings with their preferences and if they can override the programming if they want to
    - The moment a person experiences a loss of control, he is not willing to accept automation

    - Automation of buildings is connected to safety-relevant aspects - if topics are combined (e.g. optimization of energy consumption and increased safety at the same time), then acceptance increases
    - Cost savings are a topic that is often overrated, for some people motivation enough, but the sums that can be saved do not justify the investment (from a purely economic perspective)
    - Energy saving investments often have many other benefits that are not priced in, this dilemma must be solved
- Policy Advisor VIII:
    - Electrification (EVs and heat pumps) – the way they will operate and impact networks and generation capacities depends, at the building level, on the energy performance of buildings
    - Sector coupling makes a lot of sense, need for storage (for example hydrogen – which is expensive)
    - We should not heat with storage
- Policy Advisor IX:
    - Challenges:
        - Capturing data is one of the crucial challenges, Uncertainties in the data collection
        - Energy system integration different fuel types in combination or as a replacement for one another analysis on how different parts of the system work together
        - Climate Change as opportunity and challenge for the energy transition
    - Should be integrated:
        - Circular economy
        - Energy Value chain
        - Hydrogen (from generation, transport, consumption etc.)
        - Heating cooling / network is not well developed in the large ESMs
        - Consideration of different income classes
        - Demand side in general
        - Better building models
- Policy Advisor X:
    - If we talk about the energy transition in the long term 2030 and beyond, the following aspects seem key:
    - Security of supply and stability of the electrical system on a 100% renewable horizon.
    - Energy intensity of the economy and evolution towards a decoupling between economic growth and energy demand.
    - Sector coupling or integration of sectors through new energy vectors, storage technologies, new business models.
    - Modifications of behavioural patterns and societal trends, mediated by the digitization of the economy, which affect social and consumption habits, as well as the management of energy demand and efficiency.
    - Uncertainty in the evolution of costs and performance of technologies that are not yet mature.
    - Uncertainties associated with the regulatory and legal framework, stability of the financial situation and aid programs to facilitate the competitiveness

of technologies that still require support to reach maturity and be competitive on the same playing field.

- Policy Advisor XI:
  - How the regulations evolve and what interventions are carried out
  - How the [other more profitable] markets evolve
  - How citizen react to actions that could hurt the reputation of companies
  - The "financeability" of the new technology and new business models

What results should the tool deliver for it to be useful to you?

- Industry I:
  - Any results relating to the economic aspects (including the sensitivities)
  - The main influencing factors need to be shown as well.
- Industry II:
  - Short, medium and long-term forecast of energy and power demand taking into account the integration of the electric vehicle.
  - Short, medium and long-term forecast of power generation taking into account the integration of conventional facilities and self-consumption
  - It would be interesting if this analysis were to be carried out as broken down as possible: by (transformation - note Chris) centres, LV lines, phases, centralization of meters (note by Chris: ”meter clusters”), meter ....
- Industry III:
  - That consumers react to external stimuli.
- Industry IV:
  - The tool should differentiate between user groups (a young family has a different consumption pattern than a single, than a pensioner; a family in the city has a different pattern than someone who lives in a house with a heat pump) - which are the relevant loads, the ones that have a greater impact, and which ones can be neglected
  - There is not much except heat pumps and EVs in the household sector
  - Example: It would make more sense to leave the washing machine running at night, but the landlord forbids it.
  - Electricity prices are not the same every day, and consumers' preferences regarding when they do their laundry are also different
  - Quantity also makes a difference - large loads are interesting
  - Economically irrational consumption also exists
- Modeller I:
  - Should be open source
  - Use the tool not as black box, but use it to parameterize behavioural aspects and operational decisions in Modeller I model
  - Use the tool flexibly (intermediate steps are more interesting)
  - Should be more helpful for modelling teams
  - Provide appropriate documentation
- Modeller II:
  - Should be open source and easy to use
  - Highly transparent documentation on the tool and data
  - Produce Key demand figures and parameters that can be used by other models and research
- Modeller III:

    - Link with NEWTRENDS activities
    - Open source and also easy to be taken up and integrate parts of the WHY Toolkit code to other modelling frameworks: Modularisation
    - Initiate a webinar between the projects to exchange ideas
- Official Representative / Policy Maker I
    - Results of the tool: simple possibilities and hints for consumers to save energy
- Official Representative / Policy Maker II:
    - Results of the tool: renewable energy balanced with zero / breaking down results to the level of neighbourhoods / calculation should include demography of the population
- Policy Advisor I:
    - Detailed description of the consumption of the households down to the devices
- Policy Advisor II:
    - The tool should be very easy to use and should be easy to be integrated in teaching material/presentations to show the buildings transition
    - Very intuitive to be used in a class but also to policy makers
- Policy Advisor III:
    - Open source modelling code and user friendly toolkit to be used as a plug-in in existing models
    - Scientific excellence and robustness of the WHY Toolkit is critical
- Policy Advisor IV:
    - It must respond adequately to human behaviours when establishing energy demand so that we are able to understand what that consumption will be like depending on the social variables of each moment.
- Policy Advisor V
    - As output energy efficiency indicators, e.g. final energy consumption, primary energy consumption, final and primary energy productivity
- Policy Advisor VI:
    - How can we commercialize energy efficiency investments in the absence of a market? It is hard to sell the power savings, the energy savings yes, but not the power savings.
    - If there would be a market, it would be good to have a very detailed representation
    - Important is the possibility for a modeler to verify the transparency of the assumptions
    - California – utility incentives to save energy during certain periods of the day, based on modelling
    - For a policy maker – make them understand how energy efficiency and other investments and power can be linked – it is necessary to illustrate with households
- Policy Advisor VII
    - Results that can be classified by user groups - the more clearly the user groups are defined, the better
    - Policy instrument - Modelling - how do different user groups react to it and what is the energy consumption
- Policy Advisor VIII:

    - Interesting if it can provide information on the changes in "composition" of a household (heat pump, one or two EVs, etc.) through interventions
- Policy Advisor IX:
    - Impact on energy consumption is key. Energy savings are one of the main factors
    - Also the whole behavioural/decision chain should be part of the results including the rebound effects (this is one of the most interesting aspects)
    - Impact on local jobs, energy poverty, Check for other macro tools and check what input they need.
    - Same for environmental effects (like negative effects of circular economy)
    - Apart from the type of results, the transparency of the results and the information on what basis these results were acquired are of utmost importance.
    - Results have to be transparent and comparable.
    - Regardless of the results, there should also be the possibility to keep the tool alive and updateable
- Policy Advisor X:
    - Our main interest is in improving the forecasts of demand for a series of energy services so that it serves as input to the models already available in the MTERD or new tools that are developed. Also in having a variety of these forecasts in different scenarios to be able to carry out sensitivity analyses. To cite some examples of our interest:
    - Effect on the demand for energy services of the implementation of storage systems "behind the meter"
    - Effect on the demand for energy services of the implementation of self-consumption systems in different modalities, and other distributed energy resources such as the electric vehicle
    - Effect on the demand for energy services of the electrification of thermal demand
    - Effect on demand of the appearance of new business models such as demand aggregators, energy communities
    - Effect on demand derived from communication campaigns and other legislative, fiscal, and financial measures.
    - Analysis of the impact of energy efficiency policies and measures in relation to the fulfilment of the planned objectives, and allowing the identification of the most profitable actions in economic terms and results.
- Policy Advisor XI:
    - It should follow the endearing technology principles:
    - Free Software
    - Interpretable and easily modifiable
    - Be able to interact with the developers
    - Modular design

How do you want the results to be presented (graphs, tables, interactive displays, etc.)?

- Industry I:
    - Dashboard solutions!
- Industry II:

    - The proposed formats are correct. It would be interesting to have the data in Excel format for treatment.
- Industry III:
    - A detailed database.
- Industry IV:
    - No discussion on this point (they did it with their own datahub and got positive feedback)
- Modeller I:
    - Access to the tool and the entire database is preferable, so that it he can use it for his own purposes // graphs and interactive tables are not much important
- Modeller II:
    - Database to extract data (as he is a researcher)
    - Graphs and tables, preferably interactive
- Modeller III:
    - As a modeller/researcher, Lukas prefers to have access to the entire dataset, the source code and the documentation of the WHY Toolkit. He thinks that interactive user-friendly displays can be preferable for end-users of the tool.
- Official Representative / Policy Maker I
    - Results: interactive and graphics
- Official Representative / Policy Maker II:
    - Results: interactive and graphics, tables for the details
- Policy Advisor I:
    - Graphic results
- Policy Advisor II:
    - visually catchy to help showing results to a wide audience
    - interactive displays // coloured pictures
    - ability to generate different figures to display
- Policy Advisor III:
    - most interesting to have the entire dataset, the full equations of the model and how the toolkit can be adapted to different specificities
    - Enough information for the tool should be provided in order to allow users to modify and adapt the toolkit
- Policy Advisor IV:
    - Graphs, tables and databases.
- Policy Advisor V
    - Graphs, maps and rankings are interesting
    - Energy mix composition - if energy efficiency were an energy source, where would it be?
- Policy Advisor VI:
    - The requirements depend on the user
    - For investment decisions a very detailed output
    - For policy makers a simple display (input – output), just to illustrate the issue
    - Easy-to-communicate graphics
- Policy Advisor VII:
    - Ideally a mix of everything - you could use it in different publications, different users have different preferences

- Policy Advisor VIII:
  - No discussion on this point
- Policy Advisor IX:
  - Interactive displays are nice for communication with the member states.
  - Generally raw data is required. Tables are more important than nice pictures.
- Policy Advisor X:
  - In general, editable formats such as pivot tables, in datasheets to present data and thus be able to transfer them (copy and paste) and process them (perform other operations) are very suitable and of our preference.
  - A report with graphs, at least to present the operation of the model, simulations according to different hypotheses and input conditions of the model, methodology and some examples of results also seems convenient to help understand the tool.
  - Interactive presentations such as those provided by some Business Intelligence (BI) solutions are very attractive and useful for communicating results, however, from our point of view, although they are welcome, they are not a priority since we have the ability to develop them from raw data in editable formats.
- Policy Advisor XI:
  - RAW data with intermediate results

Which spatial and temporal resolution should the results of the tool have (e.g. 15 minute (high-res) versus annual (low-res) and building level (high-res) versus country level (low-res))?

- Industry I:
  - Temporal resolution: Annual data for strategic decisions. Higher Resolution for more short-term planning.
  - Spatial resolution: County Country (Austria) Central Europe
- Industry II:
  - In order to control bidirectional power flows in order to maintain a stable network, it would be interesting to have the information in 15 minute intervals.
  - For the planning of operations for network improvement, maintenance and repairs, it would be interesting to have the information in intervals of one hour.
  - With regard to the annual planning of investment plans, it would be interesting to have a 3-4 year forecast.
  - As far as spatial resolution is concerned, it would be interesting to have information at all levels, (transformation - note Chris) centres, low voltage lines, phases, meter centralization, and meter.
- Industry III:
  - In our case, at least 30 min intervals.
- Industry IV:
  - It should be as high-res as possible
  - Different user groups – 15 minutes resolution - it would be interesting to offer users a 15 minutes tariff (product design)

    - Or get information from it - it would be interesting for certain users, but it won't work in the short term, because the incentives in our electricity system are too low - we have to do something about the network charges
    - Interesting is the perspective development, not the status quo, we might encounter situations where we have to act (interesting for policy makers)
- Modeller I:
    - Different resolutions for different purposes (e.g. local study 15 min, annual for EU and global level)
- Modeller II:
    - Low resolution: sufficient to have an annual/country view
    - But load duration curves should be more disaggregated to enable the linkage with supply-side modelling which is commonly more granular
- Modeller III:
    - 15-60 min could be relevant for the microgrid case
    - If we want to inform technical aspects/DSOs, 15 min is relevant, but at the national level 1 hour is sufficient
    - The highest spatial disaggregation can be relevant for municipality level, but building blocks/hectare level are more than sufficient at the city level
    - Also mapping income levels at the district/city level (but difficult to find relevant data for all EU MS
- Official Representative / Policy Maker I
    - Time and Geography: Different resolutions are necessary, depending on who is the target person and how the results have to be communicated
- Official Representative / Policy Maker II
    - Time and Geography: time, weekly / geography, down to a single building - data protection issues may arise
- Policy Advisor I:
    - monthly
- Policy Advisor II:
    - As the typical user of the tool is a policy maker or a planning authority, the tool resolution should be close to the actual decision making processes (e.g. national but also regional – NUTS-2 or 3 level in some EU countries)
    - Temporal: monthly resolution is ideal for policy makers, 15-min for grid operators
- Policy Advisor III:
    - Higher spatial and temporal granularity is important, but computing power is required for deep resolution
    - Yearly resolution is most important to IAMs, but daily or hourly resolution is important for WHY Toolkit– more details are more difficult due to computer running time
    - Go down to level of municipalities (not to the level of buildings)
- Policy Advisor IV:
    - Depending on the amount of data, hourly would be sufficient.
- Policy Advisor V
    - Annual aggregation, but also the specific hours at which energy efficiency is particularly valuable
    - Difference between what is interesting for politicians and what is interesting for market participants: For market participants, 15 minutes is

too low-res, they want real time (e.g. companies that offer smart meters need analysis data in real time), for political purposes a rough clustering by days is interesting.
    - Spatial resolution: building level interesting for energy consulting level, country level interesting for rankings
- Policy Advisor VI:
    - No discussion on this point
- Policy Advisor VII:
    - Resolution according to different types of buildings, one week resolution could be very interesting (for their work)
    - Interesting to look at the regional level, the regions are different in each country (counties, etc.)
    - Energy consumption takes place in buildings, certain types of buildings can be found in certain neighbourhoods, because these neighbourhoods often have a certain age - if you could create an overlap, that would be very interesting
- Policy Advisor VIII:
    - Temporal resolution: A good model needs to be at least hourly; ideally 15 minutes – requires high computational capacity
    - Spatial resolution: If we want it to deal with the European power market, it needs to cover Europe in an endogenous way (all the units of power stations in Europe, all the interconnectors should be there) – most models cover countries as nodes – that is not enough, market models should be overlapping with network models, so not only cross-border capacity limitation should impact the prices, but also internal congestions.
    - PRIMES has no network model behind it
    - Typical households (ideal types) should have preloaded data of their daily curves and overall demand
- Policy Advisor IX:
    - Basically, European level is required! But national and local level is relevant for certain purposes, especially when it comes to the specifications of the different nations.
    - Normally with annual data, demand response will be promoted in the future and will require more granular data.
    - Generally, it is difficult to answer at this time.
- Policy Advisor X:
    - 15 minutes is desirable. Minimum hourly resolution. Regarding disaggregation by type of user, it seems convenient to distinguish some basic typologies:
    - Types of household according to the life cycle and economic situation (single person, families with minors, groups, pensioners, unemployed, etc.)
    - Building types (single-family, multi-family homes)
    - Climate zones
    - Income levels / quintiles
    - Availability or not of electric heating and cooling systems
- Policy Advisor XI:
    - No answer

Would you be interested in directly using such a software tool?

- Industry I:
  - Generally tools were not used, all required results were obtained via studies.
  - But if the tool were easy to use, it might be an option to use it themselves.
- Industry II:
  - Yes
- Industry III:
  - Yes.
- Industry IV:
  - He would use the model for political discussions, not for his daily work, because flexible tariffs depend on incentives
  - Today: EVs and heat pumps are the 'low hanging fruits', we can forecast and influence them well, for that you do not need such a tool
  - If it changes, and it is necessary to influence other loads or set other incentives, then perhaps
  - behavioural change depends on the price spread, he is inclined to say that the majority of people would not change their behaviour in a way that would influence the system, because we cannot offer such a big financial incentive (too politically explosive)
- Modeller I:
  - Yes- especially if open source
- Modeller II:
  - Yes, definitely
- Modeller III:
  - Yes, very interesting- especially if open source and good documentation. They can use it as plug-in version to our buildings model
- Official Representative / Policy Maker I:
  - Direct use of the tool: not interested
- Official Representative / Policy Maker II
  - Direct use of the tool: yes, interested
- Policy Advisor I:
  - yes
- Policy Advisor II:
  - Yes, if it is easy to use and free
- Policy Advisor III:
  - Yes, for sure, especially if transparent, well-documented, open source and scientifically robust
- Policy Advisor IV:
  - No.
- Policy Advisor V
  - Yes
- Policy Advisor VI:
  - No discussion on this point
- Policy Advisor VII:
  - He could imagine this being relevant for the work at Policy Advisor VII
- Policy Advisor VIII:

    - She has been using wholesale power market models for Europe in her previous job
- Policy Advisor IX:
    - Personally: Absolutely.
    - From a company perspective: Rather not, as there are substantial restrictions to the software that can be used. If we want the EC to use the software, we need to talk with the IT. But just having the results is probably the safer version.
- Policy Advisor X:
    - Yes, of course
- Policy Advisor XI:
    - Yes

What would motivate you to use the results tool more (e.g. technical specifications, computing time, user interface design, complexity, etc.)?

- Industry I:
    - Self-explanatory
    - User-supportive input of data
    - Inconsistent/Incompatible inputs need to be highlighted and prevented by the tool not the user
    - It must provide a dashboard solution
    - Generally a simplistic tool is preferred
    - Inputs should be limited to parameters
    - If input data is required a full description of the data sets is necessary.
- Industry II:
    - First and foremost: the quality and reliability of the data provided. And secondly: the simplicity of use, speed of execution and flexibility of interaction.
- Industry III:
    - Its technical specs.
- Industry IV:
    - Different choices should be offered, e.g. it should be possible to cluster user groups ('I would like to have all people between 20 and 35' or 'all those living in the city' or 'all those living in the country'), because they have a basically different consumption pattern
    - One could thus offer different tariffs to different actors - but a company should consider this carefully, as these tariffs have political implications
    - If we would move away from standard load profiles, and everything would have to be balanced every 15 minutes, then everyone would need such a tool, but then one gets into a political discussion about user groups and prices
- Modeller I:
    - Robustness (scientifically robust and solid methodology and results)
    - Computing time is not that relevant as parameterisation of their model base on WHY Toolkit is one-off process (not continuous)
- Modeller II:
    - Transparent documentation and data

    - Usability of the tool (user-friendly as a stand-alone tool or through collaboration with project partners)
    - Use it for policy consultation, decision making support, for scenario building + also enhance the tool with new functionalities
- Modeller III:
    - The most important is to ensure that the WHY tool is scientifically robust, produces results that can be explained, has proper documentation and covers aspects not covered by inhouse modelling tools. The computing time is not so relevant for a research institute.
- Official Representative / Policy Maker I:
    - Use the tool more often: doesn't expect an added value for the daily work
- Official Representative / Policy Maker II
    - Use the tool more often: often used if calculation time is small and tool not too complex
- Policy Advisor I:
    - easy usability, fast computation time
- Policy Advisor II:
    - Good documentation (e.g. video explaining how the tool works, or small exercises using the tool and publishing them in YouTube)
- Policy Advisor III:
    - Prefer to develop the tools in Python and R, as these are used by most IAMs worldwide (and in Policy Advisor III)
    - Prefer to run in a few hours at the most (not more)
    - Ideally we should go beyond electricity and capture entire energy demand in the buildings sector
- Policy Advisor IV:
    - (No reply).
- Policy Advisor V:
    - Design of the user interface
    - Example: Odysee Mure – Energy efficiency indicators for country rankings, it also paints maps showing what progress has been made
- Policy Advisor VI:
    - No discussion on this point
- Policy Advisor VII:
    - Absolute transparency about the assumptions behind the model
    - They would use the model as experts, would like many details
    - Would also want to change many input factors, combined with a user-friendly interface
    - If it serves to inform policy makers, and they as experts compile this information, it would be interesting to have many options to change
    - Target group policy maker: they have different requirements, may want to have certain predefined scenarios
    - Ganz genau überlegen, für welche Zielgruppen das Tool gemacht werden soll, und ob man nicht verschiedene Versionen anbieten soll
    - Think very carefully about the target groups for which the tool is designed, and whether we should offer different versions
    - Note: Making the tool available in other languages, not only English - would increase the reach of the tool.

- Policy Advisor VIII:
  - Open coding is important
  - Not picky on interface and other things, it should only be able to answer the questions that it is asked (doing the job)
- Policy Advisor IX:
  - Most important: Full transparency of assumptions and results.
  - For a direct use it needs to fulfil the security requirements
  - It needs full adaptability (for the input structure), which enables the user to play with the parameters and get the sensitivities.
  - Regular updates (Changes in policies and new Eurostat data)
- Policy Advisor X:
  - Quality and reliability of the results, supported by the assumptions of the model and the solidity of the basic information.
  - Technical specifications.
  - Applicability.
  - Versatility and learning capacity of the model based on experience and feeding the model with updated data.
- Policy Advisor XI:
  - No answer

Do you want to have a stand alone version of the tool for you to run? (A standalone version would be a software product which runs on its own as compared to modules which will be provided as code and that can be integrated in simulation models.)

- Industry I:
  - If the tool requires an input of data, it should under no circumstances be web-based, as this would prevent E-Stmk from using it!
  - Generally a stand alone version is preferred.
- Industry II:
  - Both options would be interesting, but we would prefer a standalone version.
- Industry III:
  - No Opinion
- Industry IV:
  - Integration with existing models would be complicated, because all consumption (also outside of private households) would have to be considered, e.g. industry, and across Europe
- Modeller I:
  - Partial modules are more interesting and Python is the preferred programming language for MESSAGE
  - MESSAGE: modular structure // model comparison by replacing part of model decisions with WHY Toolkit
  - Probably WHY Toolkit to provide input for load profiles to MESSAGE- But we should modularize the WHY Toolkit to ensure its high usability
- Modeller II:
  - Probably YES, But it is better if the model can be linked with other tools
- Modeller III:
  - Better to have an online version to check quickly how it works etc.
  - stand-alone tool is preferable for the modellers

    - Model plug-ins to integrate to their models. Python is the preferred language to ensure the easiest way to link
- Official Representative / Policy Maker I:
    - no
- Official Representative / Policy Maker II
    - yes, should work on a local computer, important because of data protection issues
- Policy Advisor I:
    - yes
- Policy Advisor II:
    - She is more interested in the modelling output
    - But plug-ins can be an interesting option for modellers
    - Also great if this stand-alone version can be used by PhD students
- Policy Advisor III:
    - More interested to have a version that is linked with COFFEE/BLUES. Simply download and adapt to their reality
    - The WHY modelling toolkit should not be a black box
    - Soft-link between the models vs full hard-link: preferable to support both modes of operation
    - Proper documentation
- Policy Advisor IV:
    - One that can be integrated into existing models.
- Policy Advisor V:
    - Both are interesting
    - Criticism of PRIMES for lack of transparency, but it would be interesting to see it reflected in these models
- Policy Advisor VI:
    - No discussion on this point
- Policy Advisor VII:
    - If there is a plug-and-play solution that works smoothly, an integration would be good, otherwise a stand-alone version (but as a non-modeler he can't really judge that)
- Policy Advisor VIII:
    - A plug-in for other models than PRIMES would be interesting
    - Linking it to other models should be made easy
- Policy Advisor IX:
    - A web-based solution would be preferable.
- Policy Advisor X:
    - We find it complex to integrate the tool into existing models since there is a high diversity of models programmed in very different environments and some are proprietary solutions that cannot be acted upon at the source code level.
    - Therefore, it seems sufficient to us that the output data are compatible or at least can be transformed to the input parameters of a representative sample of these models or at least the most widely used ones. [NOTE, they use TIMES bases models]

Would you be willing to provide input data (such as load profiles, energy related data, policy suggestions etc.)?

- Industry I:
  - Yes Data already provided
- Industry II:
  - Yes, as long as the Data Protection Regulation is respected.
- Industry III:
  - The data are managed by the distribution operator and are owned by the client, but we could look into the viability of this request.
- Industry IV:
  - Would be interested in further information
- Modeller I:
  - Yes, if he can. Not much on load profiles, but more on policy suggestions and policy instruments
- Modeller II:
  - Yes, he is willing to provide, but he currently has limited access to granular data sets.
  - More interested to provide specific policy suggestions to model, largely focusing on behavioural and social aspects
- Modeller III:
  - more on policy suggestions and policy instruments
  - sharing data and information between WHY-NEWTRENDS (as they will also use some load profile data)
- Official Representative / Policy Maker I:
  - no
- Official Representative / Policy Maker II:
  - can't be decided at the moment
- Policy Advisor I:
  - Yes
- Policy Advisor II:
  - Yes, but currently very limited access (only to consumption and PV production in her household)
- Policy Advisor III:
  - Yes, for sure. Together with Enrica De Cian (mostly data for Brazil)
  - More links of WHY with their global models (COFFEE/TEA) that represent the EU as a region (like in TIAM-ECN)
- Policy Advisor IV:
  - Yes. Energy data.
- Policy Advisor V:
  - No, only members have data
  - Is interested in further cooperation and in testing the WHY Toolkit (possibly by member companies) - needs energy efficiency connection for possible publications or events
- Policy Advisor VI:
  - Very interested in receiving more information and participating in our stakeholder engagement.
- BPIE:

    - Could imagine testing the prototype with own data, especially with policy proposals
    - Is interested in receiving further information and being invited to workshops
- Policy Advisor VIII:
    - They do not have input data, we should contact DSOs or aggregators for that
    - Interested in how the model works, can be contacted for a demonstration
- Policy Advisor IX:
    - Being realistic: It will be not doable to input own data
- Policy Advisor X:
    - Yes. We have:
        - Load profiles of some equipment.
        - Estimates of consumption by uses and energy sources, with some disaggregation in terms of climatic zone and building typology
        - Global consumption data of the residential sector by energy sources
        - Energy efficiency indicators at global and sector level
        - Indicators of energy poverty disaggregated for different variables (climatic zone, building type, income level, economic situation of households)
        - Results of actions financed by aid programs for energy rehabilitation, for improving efficiency in industry, for the acquisition of alternative vehicles, recharging infrastructure, etc.
        - Energy planning policies or measures (for example, in the PNIEC, the ENPE Strategy).
- Policy Advisor XI:
    - Socio-economic distribution of persons seeking financing for EE or DG projects.
    - Impact appetite framework criteria

ANNEX D - Toolkit Use Cases:

ID	TUC_1.1
Use Case Name	Assessment of a policy intervention
Persona (who)	Modeller / Industry / Policy Advisor
Purpose and goal (what)	The modeller wanted to assess a what if scenario of his/her energy system model
Scenario of use (when)	The persona has already a model that lacks a good representation of demand and behavioural aspects
Trigger (why)	A new scenarios has been defined by someone (for example a new energy policy is going to be defined and some policymakers / lobbies / ngos / etc.) and the researcher needs a full assessment of the impacts that it will produce
Preconditions	The data (including parameters) for the scenario have to be already collected and processed
Main flow (how)	1- Define and code an scenario 2- Run the model + Run the Multi Agent System + Use the Plug-in system (including the null plugin) + Run the Full Energy System Model (including the null Energy System Model) 3- Assess the results
Output	An holistic list of KPIs per designated temporal and spatial resolution
Critical success parameters	The simulation runs in less than a day
Priority level	5
Reason for assigning this priority	Is the expected way to use the tool
Relevant Pilot "Use Case"	ALL but MICROGRID
Components involved	ALL
Relevant requirements	

ID	TUC_1.2
Use Case Name	Assessment of a new business model / technology
Persona (who)	Industry
Purpose and goal (what)	The industry wanted to assess the reaction of the citizens towards a new business model around the energy system
Scenario of use (when)	The persona has new business models in development and also has identified potential customers

Trigger (why)	The new business model needs to be evaluated on whether the potential customers will accept it and how the potential customers will react to the novel business model
Preconditions	A comprehensive definition of the business model needs to be available. Like the potential customers, the value chain, marketing etc.
Main flow (how)	1- Define and code an scenario 2- Run the model + Run the Multi Agent System + Use the Plug-in system (including the null plugin) + Run the Full Energy System Model (including the null Energy System Model) 3- Assess the results
Output	Information on the reason why or why not the business model was accepted by the potential customers. Information on the energy and economy related results of the application of the business model
Critical success parameters	the simulations runs fast and produces high-quality and plausible results
Priority level	3
Reason for assigning this priority	It was mentioned by some of the stakeholders, yet it was not in the original scope of the project
Relevant Pilot "Use Case"	ALL
Components involved	Depending on the business model and the proposed group of customers. It could be the entire range of components or it could be a very limited and specific range.
Relevant requirements	

ID	**TUC_1.3**
Use Case Name	Run a full energy system model simulation for teaching purposes
Persona (who)	Modeller
Purpose and goal (what)	The modeller wants to explain to a serie of students how an Energy System Model works so it will use a toy example and carry on all steps from the definition of a scenario, to the construccion of the households load and generation profiles, etc.
Scenario of use (when)	In a tutorial session
Trigger (why)	To teach a serie of person how to use the models developed in the project
Preconditions	The data (including parameters) for the scenario have to be already collected and processed

Main flow (how)	1- Define and code an scenario 2- Run the model + Run the Multi Agent System + Use the Plug-in system (including the null plugin) + Run the Full Energy System Model (including the null Energy System Model) 3- Assess the results
Output	An holistic list of KPIs per designated temporal and spatial resolution
Critical success parameters	The simulation runs in less than a day
Priority level	5
Reason for assigning this priority	It is needed to be used at the summer school and in all teaching materials
Relevant Pilot "Use Case"	--
Components involved	ALL
Relevant requirements	

ID	**TUC_2**
Use Case Name	Assessment of a counterfactual scenario
Persona (who)	Modeller / Policy Advisor
Purpose and goal (what)	The modeller (or policy advisor) wants to analyse a counterfactual scenario for the energy system
Scenario of use (when)	They lack a model with an accurate representation of energy consumption and human behaviour
Trigger (why)	Key model assumptions are changed, e.g. different socio-economic trends due to COVID, so new counterfactual scenarios should be developed
Preconditions	Scenario input parameters have to be already gathered Actual data have to be already collected
Main flow (how)	0 - collect the data of the actual result 1 - Define the scenario (the intervened or business as usual) 2 - Run the model in the scenario + Run the Causal Model + Run the Multi Agent System + Use the Plug-in system (including the null plugin) + Run the Full Energy System Model (including the null Energy System Model) 3 - Use the actual result to adjust the result of the simulation
Output	An informed counterfactual scenario for the energy system
Critical success parameters	the simulations runs fast and produces high-quality and plausible results
Priority level	5

Reason for assigning this priority	Expected way to use the WHY toolkit
Relevant Pilot "Use Case"	ALL
Components involved	ALL
Relevant requirements	

ID	**TUC_3**
Use Case Name	Generate more precise load forecasts
Persona (who)	Industry
Purpose and goal (what)	The industry wanted to improve their load forecasts
Scenario of use (when)	There is a lack of knowledge on how the load forecasts and the behaviour of users under conditions that are not the standard use case
Trigger (why)	New technologies emerge, new regulations or laws are passed, there is a change within the technical system that needs to be evaluated, there is a need for grid extension or refurbishment, new consumer/producers request grid access. Furthermore a system operator wants to apply new approaches to system operation and need precise information on user (energy) behaviour Additionally better forecasts are needed to get better results as an energy trader and be able to buy or sell energy more accurately
Preconditions	Conditions under which forecasts are made, need to be known, substantial knowledge on system operation and system parameters need to be in place
Main flow (how)	1 - Define the scenario (application of the business model) 2 - Run the model 3 - Run the Multi Agent System 4 - Assess the resulting load profiles
Output	Load profiles in the temporal and spatial resolution required by the user of the WHY-Toolkit
Critical success parameters	The simulation has a short computation time and creates load profiles that match the actual profiles (post-ex-analysation)
Priority level	5
Reason for assigning this priority	One of the key results originally planned for the WHY-Toolkit
Relevant Pilot "Use Case"	MICROGRID, GOIENER
Components involved	Depending on the size of the scenario up to the Multi-Agent-System
Relevant requirements	

ID	TUC_4
Use Case Name	Create an improved understanding of the own energy consumption that can lead to more informed decision-making and optimization of the energy use
Persona (who)	Citizen: Alex and Andrea are two sides of the same persona. They have different views, which may sometimes be conflicting.
Purpose and goal (what)	Alex wants to save on household bills (including energy and transport) but without loss of comfort or requiring extra effort. Andrea is intent on reducing the family's ecological footprint. A trade-off that is acceptable for both is necessary to change the status quo. Andrea is trying to push-through minor behavioural changes by invoking the support of his kids.
Scenario of use (when)	Any time a convenient opportunity presents itself. Now is as good as any time, other daily worries permitting.
Trigger (why)	For Alex: whenever a good bargain is presented: by a friend, in a magazine, via the internet. As long as it doesn't require sacrificing convenience too much. For Andrea: whenever the (likely) effects of climate change are presented in the news, Andrea is reminded of the green-house emissions that are caused by their own actions - or their inaction. E.g. indications on the gas and electricity bill, or when booking travel confront Andrea with this.
Preconditions	Clear and actionable information about cost and environmental impact must be easily available. The family needs help with making personal decisions that will satisfy both sides of the persona.
Main flow (how)	1. Be confronted with some information and consequences of a habit or a decision about to be taken. (Grab attention) 2. Be presented relevant alternatives and weigh pros and cons in terms of money and impact. (Offer alternatives) 3. Study the option on offer - compare, contrast, consult, discuss. 4. Make decisions; take action; change habits. 5. Receive a report afterwards about the decision taken or the habit changed - or not, as the case may be. (Give feedback)
Output	Provide clear decision criteria and advice.
Critical success parameters	Information easily accessible, relevant, easy to interpret and to act upon.
Priority level	3
Reason for assigning this priority	I guess that the toolkit will be difficult to use directly by the citizens; they are not our primary objective.
Relevant Pilot "Use Case"	GOIENER The problem is to anticipate the decisions and behavioural changes made on an individual level and translate them to the Goiener purchasing strategy.
Components involved	Depending on the size of the scenario up to the Multi-Agent-System
Relevant requirements	

ID	TUC_5
Use Case Name	Optimise policy interventions to fulfil a policy objective
Persona (who)	Official Representative / Policy Maker / Policy Advisor / Modeller
Purpose and goal (what)	Find the best mix of interventions to fulfil a policy objective
Scenario of use (when)	The persona has already a model that lacks a good representation of demand and behavioural aspects
Trigger (why)	A new policy objective is set and now several policy statements are discussing what is the best strategy to reach it. Instead of defining a set of scenarios, the policy statement wants to find an optimal strategy.
Preconditions	The data (including parameters) for the scenario have to be already collected and processed A universe of accepted interventions is provided
Main flow (how)	1- Define and code an scenario (including the list of potential interventions allowed to be used) 2- Execute an evolutionary algorithm that constructs the best set of interventions. 3- The fitness function of the algorithm will be a run of the toolkit 4- When the optimization algorithm finish, assess the population of solutions
Output	A population of sets of interventions and their potential impact
Critical success parameters	The system runs in less than a day and converge to an optimum or at least give a good representation of the pareto frontier of the problem
Priority level	3
Reason for assigning this priority	It is an interesting use case from the scientific point of view but stakeholders are not interested in it: "Models are especially useful when they are set up to directly answer specific questions that policymakers might have, i.e. to explore the implications of options that they are considering. In contrast, they are less useful when they tell policymakers what course of action, from the modeller's perspective, would be best." From Sentinel D1.1
Relevant Pilot "Use Case"	ALL
Components involved	ALL
Relevant requirements	

ANNEX E - Requirements

ID	R_S1	R_S2	R_S3	R_S4
Name	**Support in Policy Decision Making**	**Consumer's reaction to new technologies**	**Consumer's reaction to new business models**	**More accurate Forecasts**
Type	Functional	Functional	Functional	Functional
Description	The WHY-Toolkit needs to be able to provide support for policy making decisions. And further provide insight on how these policies will affect the behaviour of household consumers, thus providing insight on the effectiveness of the policy.	The WHY-Toolkit needs to be able to simulate how consumers will react to new technologies in the energy System and provide insights on whether these technologies will be used or not.	The WHY-Toolkit needs to be able to simulate how consumers will react to new business models in the energy System and provide insights on whether these business models will be a success or not.	The WHY-Toolkit should be able to provide better forecasts for household consumption (very short, short and medium term)
Rationale	It was mentioned by multiple stakeholders	It was mentioned by multiple stakeholders	It was mentioned by multiple stakeholders	It was mentioned by multiple stakeholders
Fit criterion (measurable)	It will be quite hard to test this during the project duration but once the tool is being used the reaction of the consumers to new policies can be compared with the predictions of the model	It will be quite hard to test this during the project duration but once the tool is being used the reaction of the consumers to new policies can be compared with the predictions of the model	It will be quite hard to test this during the project duration but once the tool is being used the reaction of the consumers to new policies can be compared with the predictions of the model	It will be possible to measure the fulfilment of this requirement by comparing measured load profiles with results from the WHY-Toolkit
Components	All Behavioural Models	All Behavioural Models	All Behavioural Models	All Components
Blocks	-	-	-	-
Is Blocked	-	-	-	-
Satisfaction	5	5	3	3
Source	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders
Priority	5	3	3	5
Difficulty	3	3	5	3

ID	R_S5	R_S6	R_S7	R_S8
Name	**Focus on behavioural aspects**	**Consideration of the Energy Efficiency Directive (EED)**	**Consideration of the Energy Performance for Buildings Directive (EPBD)**	**Consideration of the National Plan on Energy Efficiency (NAPE)**
Type	Functional	Functional	Functional	Functional
Description	The WHY-Toolkit should have a strong focus on behavioural aspects and not only technical ones. Therefore not only technical modelling should be done.	It needs to be possible to include the contents of the EED by corresponding interventions.	It needs to be possible to include the contents of the EPBD as interventions within the WHY-Toolkit.	The interventions contained in the WHY-Toolkit should consider the framework presented in the NAPE.
Rationale	It was mentioned by multiple stakeholders	It was mentioned by some stakeholders	It was mentioned by some stakeholders	It was mentioned by some stakeholders
Fit criterion (measurable)	The fulfilment of this requirement can be checked against when analysing the source code and functionalities of the tool	The fulfilment of this requirement can be checked by going through the interventions considered in the WHY-Project	The fulfilment of this requirement can be checked by going through the interventions considered in the WHY-Project	The fulfilment of this requirement can be checked by going through the interventions considered in the WHY-Project
Components	All Behavioural Models	All Behavioural Models	All Behavioural Models	All Behavioural Models
Blocks	-	-	-	-
Is Blocked	-	-	-	-
Satisfaction	5	3	3	3
Source	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders
Priority	5	4	4	4
Difficulty	2	1	1	1

ID	R_S9	R_S10	R_S11	R_S12
Name	**Paradigm Changes**	**Different Countries**	**Sector coupling**	**Digitalisation**
Type	Functional	Non-Functional: Scalability or Extensibility Requirements	Functional	Functional
Description	The WHY-Toolkit should be able to consider technical and social paradigm changes, both from a behavioural and a technical perspective.	The WHY-Toolkit should be applicable to different countries by using country specific parameters	The WHY-Toolkit should be able to consider sector coupling options (Including P2G, P2H, EV).	The WHY-Toolkit should be able to calculate the effects of digitalisation on the household energy consumption
Rationale	It was mentioned by some stakeholders	It was mentioned by some stakeholders	It was mentioned by the stakeholders and was also mentioned in the proposal	It was mentioned by some stakeholders
Fit criterion (measurable)	This will be very hard to measure, as a paradigm change needs substantial time to happen. So to check whether the results of the WHY-Tool are right, will need a long time	The measurement of the fulfilment of this requirement can be done by analysing the energy related results of the Toolkit with specific results in the country to be investigated	If the technical models for those options are working, the requirement is fulfiled	The fulfilment of this requirement can be checked with the availability of models on digitalisation
Components	All Components	All Components	Energy Storage (Batteries and EV) Controllable Appliances Power2gas	Probably all technical components
Blocks	-	-	-	-
Is Blocked	-	-	-	-
Satisfaction	2	3	5	3
Source	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders
Priority	3	3	5	3
Difficulty	3	4	2	4

ID	R_S13	R_S14	R_S15	R_S16
Name	**DSM & Flexibility**	**Active Consumers**	**Results: EE-Indicators**	**Results: Economic effects**
Type	Functional	Functional	Functional	Functional
Description	The WHY-Toolkit should be able to perform demand side response actions and use flexibilities	The WHY-Toolkit should be able to consider active consumers such as prosumers but also collectives of consumers such as energy communities	The WHY-Toolkit should provide energy efficiency indicators as results of the simulations	The WHY-Toolkit should provide the economic effects as results of the simulations of interventions
Rationale	It was mentioned by the stakeholders and was also mentioned in the proposal	It was mentioned by the stakeholders and was also mentioned in the proposal	It was mentioned by the stakeholders and was also mentioned in the proposal	It was mentioned by the stakeholders
Fit criterion (measurable)	If the technical and behavioural models for those options are working, the requirement is fulfilled	If the technical and behavioural models for those options are working, the requirement is fulfilled	The fulfilment of the requirement can be checked with the available results of the tool	The fulfilment of the requirement can be checked with the available results of the tool
Components	Energy Storage (Batteries and EV) Controllable Appliances Power2gas	All Components	Probably all technical components	Probably all technical components
Blocks	-	-	-	-
Is Blocked	-	-	-	-
Satisfaction	3	4	5	5
Source	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders
Priority	5	4	5	5
Difficulty	3	3	1	2

ID	R_S17	R_S18	R_S19	R_S20
Name	**Transparency**	**Cluster by user groups**	**Form of results**	**Spatial resolution**
Type	Functional	Functional	Functional & Non-Functional: Appearance Requirements	Functional
Description	The WHY-Toolkit should provide full transparency on how the results were obtained and what decision processes on a methodological but also behavioural level	The results of the WHY-Project should be able to be clustered by user group for additional insights	The results of the WHY-Toolkit should either be presented as raw data or in the form of graphs and diagrams	The WHY-Toolkit should provide results in a range of spatial resolutions ranging from country size to building size
Rationale	It was mentioned by the stakeholders and also in the proposal	It was mentioned by the stakeholders	It was mentioned by the stakeholders	It was mentioned by the stakeholders
Fit criterion (measurable)	The fulfilment of the requirement can be checked with the available results of the tool	The fulfilment of the requirement can be checked with the available results of the tool	The fulfilment of the requirement can be checked with the available results of the tool	The fulfilment of the requirement can be checked with the available results of the tool
Components	All Components	All Components	All Components	All Components
Blocks	-	-	-	-
Is Blocked	-	-	-	-
Satisfaction	5	3	5	5
Source	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders
Priority	5	4	5	5
Difficulty	3	1	1	4

ID	R_S21	R_S22	R_S23	R_S24
Name	**Temporal Resolution**	**Robustness of the results**	**Standalone Software - local installation**	**Modular Structure & Interfaces**
Type	Functional	Non-Functional: Robustness or Fault-Tolerance Requirements	Non-Functional: Productization Requirements	Non-Functional: Productization Requirements
Description	The WHY-Toolkit should provide results in a range of temporal resolutions ranging from <15 minutes size to annual resolution	The results of the WHY-Toolkit need to be robust and comprehensible	The WHY-Toolkit should be programmed as a stand-alone software product which is installed locally	The WHY-Toolkit should have a modular set-up where users can easily access single modules via interfaces or plug-ins
Rationale	It was mentioned by the stakeholders	It was mentioned by the stakeholders	It was mentioned by the stakeholders	It was mentioned by the stakeholders
Fit criterion (measurable)	The fulfilment of the requirement can be checked with the available results of the tool	The fulfilment of this requirement can only be checked by comparing the results the tool provides with actual measurements	The fulfilment of this requirement can be checked if the final product is a standalone software	The fulfilment of this requirement can be checked if the final product if the modules are accessible
Components	All Components	All Components	All Components	All Components
Blocks	-	-	-	-
Is Blocked	-	-	-	-
Satisfaction	5	5	4	5
Source	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders
Priority	5	5	3	4
Difficulty	4	3	2	2

ID	R_S25	R_S26	R_S27	R_S28	RS_29
Name	**Ease of use (Visual)**	**Ease of use (Parameters, etc.)**	**Support in planning building codes**	**New or redesigned tariffs**	**Future Markets**
Type	Non-Functional: Appearance Requirements	Non-Functional: Appearance Requirements	Functional	Functional	Functional
Description	The User-Interface of the WHY-Toolkit needs to be comprehensible and self explanatory to promote the use	The User-Interface of the WHY-Toolkit should provide the user with the possibility to make own simulations with a limited set of input parameters which can easily be edited	The WHY-Toolkit should allow users to calculate the effects of different building codes and thus provide them with the possibility to evaluate building codes	The WHY-Toolkit should allow to analyse the effects and acceptance of new tariffs or redesigned tariffs	The WHY-Toolkit should allow the users to analyse new (future) markets for energy(services) regarding their effects and acceptance of use.
Rationale	It was mentioned by the (mainly non-expert) stakeholders	It was mentioned by the (mainly non-expert) stakeholders	It was mentioned by a stakeholder	It was mentioned by a stakeholder	It was mentioned by a stakeholder
Fit criterion (measurable)	The fulfilment of this requirement can be checked by having a test group use the interface and see if it is easy to use and understand	The fulfilment of this requirement can be checked by having a test group use the interface and see if it is easy to use and the requested parameters to be changed are there	The fulfilment of this requirement can be checked if the final product if the modules are accessible	The fulfilment of this requirement can be checked if the final product if the modules are accessible	The fulfilment of this requirement can be checked if the final product if the modules are accessible
Components	All Components	All Components	Building Building Model Components	Behaviour Model Components	Behaviour Model Components Potentially other parts
Blocks	-	-	-	-	-
Is Blocked	-	-	-	-	-
Satisfaction	3	3	2	2	2
Source	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders	Interview Stakeholders
Priority	2	2	1	3	2
Difficulty	3	4	3	4	5

ID	R_G1	R_G2	R_G3	R_G4
Name	**Requirements should be compiled from the stakeholders**	**Models to be used or developed for each component should be prioritized by the partners**	**Types of interventions will be gathered mainly from the stakeholders**	**A prioritization of the interventions has to be made (possible, important and critical)**
Type	Non Functional: Usability and Humanity Requirements	Non Functional: Usability and Humanity Requirements	Non Functional: Usability and Humanity Requirements	Non Functional: Usability and Humanity Requirements
Description	The list of requirements would be discussed with the stakeholders. To this end different activities should be carried out to foster their participation.	The stakeholders requirements could include the development of models for different components of the energy value chain. If it is not possible to consider all of them (due to fall out of the scope of the project or lack of budget) the partners should prioritize them.	The interventions to be considered in the WHY Toolkit should be discussed as part of the actions carried out to retrieve the requirements from the stakeholders (R_G1)	As in R_G2, if it is not possible to consider all interventions required by the stakeholders (due to fall out of the scope of the project or lack of budget) the partners should prioritize what should be implemented.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	The fulfilment of this requirement can be checked if stakeholders were consulted	The fulfilment of this requirement can be checked if a prioritization is made over the models needed to be developed	The fulfilment of this requirement can be checked if stakeholders were consulted	The fulfilment of this requirement can be checked if a prioritization is made over the models needed to be developed
Components	ALL	ALL	ALL	ALL
Blocks	ALL	All conflicting ones	ALL	
Is Blocked	--	R_G1	R_G1	R_G1
Satisfaction	5	-	5	-
Source	T1.1	T1.2	T1.3	T1.3
Priority	5	5	5	5
Difficulty	2	2	2	2

ID	R_G5	R_G6	R_G7	R_G8
Name	**Projections of the parameters and external variables of the model have to be collected from official or credible sources**	**Define a Sustainability Assessment Model**	**Assess smart meter data to create clusters of energy behaviour**	**Follows an open science policy (publish RAW and processed datasets and scripts to process the data)**
Type	Non Functional: Performance Requirements	Functional	Functional	Non Functional: Legal
Description	Data for the external variables of the causal model should be collected using credible sources. The use of official and reliable sources, together with the application of open science policies, ensures the verifiability of the results obtained.	The WHY Toolkit should provide additional results to only energy consumption related results. These additional results are subsumed in the Sustainability Assessment Model, including for instance economic and social effects and results.	To better classify and cluster energy behaviour data, substantial amounts of smart meter data need to be gathered and analysed. This will lay the foundation of the Causal Model.	In order to make scientific research more reproducible, accessible, and collaborative, all the processed datasets and programs to process the data will be released with open-source or public domain-equivalent licenses, and using widespread raw formats.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	The fulfilment of this requirement can be checked tracking the sources of all data collected	The fulfilment of this requirement can be checked if a methodology to assess technological, environmental, economic and social impacts is defined and implemented. The type of KPIs of output should include at least one for each type.	The standard deviation of the measurements inside each cluster is minimized	Datasets are uploaded to ZENODO following the DMP and fulfiling the FAIR data principles
Components	ALL	ALL	Causal Model	ALL
Blocks				
Is Blocked				
Satisfaction	5	4	4	5
Source	T1.3	T1.3	T2.1	T2.1
Priority	5	4	5	5
Difficulty	3	3	3	2

ID	R_G9	R_G10	R_G11	R_G12
Name	**Create an instrument to classify a subject into one of the clusters/segments**	**Locate enough volunteers for each cluster to achieve a high power and control the Type S and M errors**	**Create a full Causal Model**	**Create a simplified Causal Model**
Type	Functional	Non Functional: Performance Requirements	Functional	Functional
Description	Given a load profile and other relevant information of a particular household, a procedure that allows a classification of what cluster of behaviors (as defined in R_G8) this particular household belongs to, has to be developed.	Enroll enough volunteers to cover each cluster of energy profiles and allow to control the Type S and M error in the group using reasonable guesses obtained from the assessment of the energy profiles.	The WHY Toolkit needs to develop a full Causal Model for the electricity consumption at household level, including those aspects that affect consumer participation in energy efficiency (EE), demand response (DR) and decentralised generation (DG) actions.	The WHY Toolkit will need to contain a simplified Causal Diagram for the electrification of transport and for HVAC systems.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	The classification error es small	Expected power is 80%, Type S error is below 10% and Type M error is below 25%	Not strong assumption are included in the causal model	Strong assumptions will be made to simplify the causal model created
Components	Causal Model	Causal Model	Causal Model	Causal Model
Blocks				
Is Blocked				
Satisfaction	5	4	5	3
Source	T2.1	T2.1, T2.3	T2.2	T2.2
Priority	5	4	5	3
Difficulty	3	5	5	5

ID	R_G13	R_G14	R_G15	R_G16
Name	**Monitor the behaviour of households**	**Define different methods of retrieving information**	**Foster citizen participation**	**Adjustability of the Causal Diagram**
Type	Functional	Functional	Functional	Functional
Description	To better understand the energy consumption behaviour, invasive and non-invasive monitoring devices have to be deployed on volunteer houses over the course of the WHY project.	Use instruments from Social Sciences and Humanities (SSH) to retrieve information (surveys, focus groups, roleplay games, validated instruments) during the WHY project.	The WHY project should provide a gamification experience to foster the participation of citizens (badges, information from past energy consumption, etc.).	The Causal Diagram needs to be fully adjustable to data collected by different means to build the Causal Model.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	Number of monitorized devices deployed in each household	At least 2 methods are defined	At least a citizen participation mechanism is implemented	The Causal diagram fit the data with enough statistical significance ($\alpha < 0.05$)
Components	Causal Model	Causal Model	Causal Model	Causal Model
Blocks				
Is Blocked				
Satisfaction	3	3	3	4
Source	T2.3	T2.3	T2.3	T2.4
Priority	3	4	4	4
Difficulty	5	3	5	5

ID	R_G17	R_G18	R_G19	R_G20
Name	**Evolution of the Causal Model**	**Models for appliances and services**	**Only the most relevant (with respect of the energy consumption) appliances and service models on the residential should be made**	**Model the future of appliances and services**
Type	Functional	Functional	Non Functional: Performance Requirements	Functional
Description	Develop a long term representation of the evolution of the Causal Model taking into consideration the expert knowledge of the different stakeholders.	The WHY Toolkit needs to contain mathematical models for different appliances and services irrespective of the energy carrier used. This will make it possible to compare the energy consumption of these appliances and services and to choose the ones with the highest relevance.	Compare various energy consumption appliance and service models and select the one with the highest relevance.	The models contained in the WHY Toolkit need to be able to consider future developments of energy appliances and services. The attributes or parameters of these models will not be constant and S-curve models will be fit to historical data to project future technological developments.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	It is assessed if different causal models needs to be written	Component testing, Integration testing, acceptance testing	Component testing, Integration testing, acceptance testing	Component Testing, Integration testing, acceptance testing
Components	Causal Model	Appliance Models, Energy Management System Model	Sustainable assessment module, Energy management system model, Multi agent system, Energy system model	Behavioural Models, Appliance Models, Sustainable Assessment Module, Energy Management System Model, Multi agent system, plug-ins
Blocks				
Is Blocked				
Satisfaction	3	5	4	5
Source	T2.4	T3.1	T3.1	T3.1
Priority	3	5	4	5
Difficulty	5	5	4	4

ID	R_G21	R_G22	R_G23	R_G24
Name	**Model the replacement of appliances and services**	**All models will be created using Python Script**	**Open source models will be developed**	**Model decentralized generation and storage**
Type	Functional	Non Functional: Operational and Environmental Requirement	Non Functional: Legal	Functional
Description	The models describing the energy appliances and services need to be capable of considering replacement cycles for possible causes (broken, old fashion, energy standards, etc.).	Use Python version 3 or higher as a programming language for the WHY Toolkit.	The source code has to be accessible for anyone who wishes to inspect, modify or enhance it.	The WHY Toolkit needs to consider models for decentralized generation and storage for individuals and communities (with special emphasis on photovoltaic generation and EVs).
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	Functional testing, Interface testing, Integration testing, acceptance testing	Non-Functional Testing (It could be a unit test)	Non-Functional Testing (It could be a unit test)	Functional testing, Interface testing, Integration testing, acceptance testing
Components	Behavioural Models, Appliance Models, Sustainable Assessment Module, Energy Management System Model, Multi agent system, plug-ins	Building Model, Behavioural Models, Appliance Models, Energy Management System Model	All components	All components
Blocks				
Is Blocked				
Satisfaction	3	3	5	4
Source	T3.1	T3.1	T3.1	T3.2, T3.3
Priority	3	4	5	4
Difficulty	4	1	1	4

ID	R_G25	R_G26	R_G27	R_G28
Name	**Model load control techniques**	**Use interoperable inputs and outputs**	**Use of price signals**	**Model power2gas**
Type	Functional	Non Functional: Operational and Environmental Requirement	Functional	Functional
Description	The WHY Toolkit needs to be able to model the energy storage and the energy management systems.	The WHY Toolkit needs to be able to interact with existing Energy System Models. Therefore it needs to use appropriate data structures to ensure data exchange between applications (e.g. JSON, CSV).	Models of the WHY Toolkit that concern prosumer behaviour at the building level should consider, among others, the possibility of price signals for load shifting behaviour.	The WHY Toolkit should provide the possibility to consider power2gas appliances (hydrogen, methane, etc.) in the simulations. Feeding hydrogen into a distribution grid and using it for maximizing one's consumption, for example as seasonal energy storage, needs to be considered.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	Functional testing, Interface testing, Integration testing, acceptance testing	Interface testing, Integration testing, acceptance testing	Functional testing, Interface testing, Integration testing, acceptance testing	Functional testing, Interface testing, Integration testing, acceptance testing
Components	All components except both behavioural and appliance models	Upscale, Plug-ins, Energy system model	Building models, Appliance models, Energy Management System Model, Multi Agent System	All components
Blocks				
Is Blocked				
Satisfaction	4	5	5	5
Source	T3.2	T3.2	T3.2, T3.3	T3.3
Priority	5	4	5	4
Difficulty	4	3	4	5

ID	R_G29	R_G30	R_G31	R_G32
Name	**Model Cogeneration and Power2X**	**Use a Multi Agent Model**	**Provide traditional load forecasts**	**Provide load forecasts under interventions**
Type	Functional	Functional	Functional	Functional
Description	The WHY Toolkit needs to allow considering cogeneration and integrating it with the Component of the Energy Management System and the Component for P2G. Furthermore, other forms of P2X, like power to mobility (Electric Vehicles -EV) and P2H need to be considered.	The WHY Toolkit needs to contain a multi agent system that is capable of upscaling the results of a simulation to the temporal and geographic scale needed for large-scale ESMs.	Development and implementation of a model that properly segments the residential sector and is based on actual behavior theories. The former segmentation will be achieved by using time series feature extraction, whereas the latter will use structural causal models.	Development and implementation of a model that properly produces load forecasts of buildings under interventions such as lockdowns, policy incentives, tariff changes, etc.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	Functional testing, Interface testing, Integration testing, acceptance testing	Functional testing, Interface testing, Integration testing, acceptance testing	The solution is able to provide Short, Medium and Long Term forecasts	The solution is able to provide Short, Medium and Long Term forecasts in a scenario setting
Components	Appliance Models, Energy Management System Model, plug-ins, Upscale, Multi Agent System, Energy System Mode	All components	Upscale	Upscale
Blocks				
Is Blocked				
Satisfaction	5	5	5	5
Source	T3.3	T3.4	T4.1	T4.2
Priority	4	5	5	5
Difficulty	4	4	3	5

ID	R_G33	R_G34	R_G35	R_G36
Name	**Provide "business as usual" backcasts for counterfactual Modelling**	**Model anomalies in load behaviour**	**Full ESM integration (PRIMES, TIMES and PROMETHEUS)**	**Develop an interface for configuration**
Type	Functional	Functional	Functional	Functional
Description	Set the variables of the causal model artificially to values that fulfil the specifications of the counterfactuals (alternate versions of past events) and estimate the results.	During the WHY project an analysis needs to be performed, whether it is possible to detect anomalies in the load profiles of households. This means that if a household belongs to a certain cluster of consumers, it should be analysed if there are certain anomalies in its load behaviour as compared to the other members of the cluster.	The WHY Toolkit must provide plugins for ESMs to be directly called from within the ESM, which will contribute to the enhanced use of the WHY Toolkit.	The plugins developed for the connection of ESMs and the WHY Toolkit need to have full consistency and proper customisation to fulfil the requirements of the ESMs at the level of coverage, granularity, methodological approach, demand resolution, etc.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	The solution is able to provide backcasts in a scenario setting	The solution is able to detect artificially induced anomalies in loads profiles	PRIMES, TIMES and PROMETHEUS models can be set up and run	PRIMES, TIMES and PROMETHEUS models can be set up and run
Components	Upscale	Counterfactual module	Plug-ins	Plug-ins
Blocks				
Is Blocked				
Satisfaction	5	5	5	5
Source	T4.3	T4.3	T4.4	T4.4
Priority	5	5	5	5
Difficulty	5	5	3	2

ID	R_G37	R_G38	R_G39	R_G40
Name	**Run simulations tests**	**Do a sensibility analysis**	**Co-define a set of scenarios that includes policy interventions, projections of macro drivers and key parameters**	**Consider the following interventions**
Type	Functional	Functional	Functional	Functional
Description	During the WHY project, a set of simulation tests with focus on normal and critical scenarios needs to be developed for the future users of the WHY Toolkit.	It is crucial for the relevance of the WHY Toolkit that external variables, interventions and results are sensible. For that purpose, a sensibility analysis of these should be conducted during the project.	The success of the five use cases depends on their level of detail. To this end, workshops with stakeholders and end users will be organised to define the required details.	The WHYToolkit should be able to consider the following interventions: energy taxation, policies, measures to address barriers and market failures, subsidies for RES and EV, information campaigns, demand response schemes, access to finance, ambitious eco-design, energy performance of buildings and energy labeling, technology standards and Emission Trading System pricing.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	A set of simulation test are produced	A set of simulation test are produced	Number of actions carried out to co-define scenarios	Number of interventions of the list included in the causal model
Components	ALL	ALL	ALL	Causal Model
Blocks				
Is Blocked				
Satisfaction	5	5	5	5
Source	T5.1	T5.1	T5.1	T5.2
Priority	5	5	5	5
Difficulty	3	3	2	3

ID	R_G41	R_G42	R_G43	R_G44
Name	**Consider the following impacts**	**Carry on an ethical impact analysis**	**Develop Educational materials**	**Write technical documentation**
Type	Functional	Functional	Functional	Functional
Description	The WHY Toolkit should be able to provide results of an analysis of interventions and new technologies on: energy consumption and fuel mix, load profile, energy costs and prices, energy services (i.e. heating, mobility), behavioral changes, different forms of energy efficiency investments (i.e. thermal insulation, heat pumps, purchase of energy efficient appliances, etc.), energy affordability for households, energy access, energy and technology poverty, and others.	The WHY Toolkit needs to provide the data to carry on an ethical evaluation (increase the inequality, include discrimination, etc.) of the impact of different interventions.	To ensure that the WHY Toolkit is used and understood by a large number of users, the creation of educational materials and a summer school course focused on capacity building activities on energy demand Modelling and the WHY Toolkit are necessary.	Develop a technical reference manual of the WHY Toolkit and its components during the WHY project.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	Number of impacts of the list included in the Sustainability Assessment module	Number of ethicals advices made over the pilots use cases	Number of materials created	Number of pages of technical documentation created
Components	Sustainability Assessment Module	Sustainability Assessment Module	--	--
Blocks				
Is Blocked				
Satisfaction	5	5	3	3
Source	T5.3	T5.3	T6.1	T6.2
Priority	5	5	5	5
Difficulty	3	3	2	2

ID	R_G45	R_G46	R_G47	R_G48
Name	**Assess a black-out in a microgrid**	**Assess changes in energy tariffs**	**Estimate the impacts of municipal intervention**	**Reassess the 2030 and 2050 decarbonisation scenarios**
Type	Functional	Functional	Functional	Functional
Description	As part of the WHY Toolkit the Causal Model needs to be able to forecast the behaviour of household consumers during a black-out, if they are supplied with electricity in a microgrid setting.	The WHY Toolkit or rather the Causal Model needs to be able to forecast how customers of an energy retailer would change their consumption behaviour following a change in tariff structure.	The WHY Toolkit needs to be able to forecast the impact interventions at a municipal level have on the energy consumption of households (buildings).	The WHY Toolkit should be applied directly during the WHY project to reassess with the improved household load predictions the 2030 and 2050 decarbonisation scenarios, including the recent EU policies for emission reduction and energy efficiency.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	Results of the Use Case	Results of the Use Case	Results of the Use Case	Results of the Use Case
Components	ALL	ALL	ALL	ALL
Blocks				
Is Blocked				
Satisfaction	5	5	5	5
Source	WP5	WP5	WP5	WP5
Priority	5	5	5	5
Difficulty	4	4	4	4

ID	R_G49	R_G50	R_G51	R_G52
Name	**Investigate the effect of the improved representation of energy demand from the built environment on long-term global energy scenarios**	**Improve the level of granularity of ESM**	**Improve the forecasting error at all levels**	**Consider at least 12 interventions**
Type	Functional	Non Functional: Performance	Non Functional: Performance	Non Functional: Performance
Description	The WHY Toolkit should be applied to the global use case.	Improve the temporal and geographical granularity of the ESM used in the five pilot use cases to be carried out in the project.	Improve the forecasting error on all geographical and temporal levels used by the ESM in the five pilot use cases to be carried out in the project.	A state of the art will be carried out in Task 2.1. It will cover (among other things) a survey of interventions at the European level that could affect residential load profiles. The project has defined four topics of relevance: energy efficiency, demand response, distributed generation and electrification of services. the most relevant interventions pertaining to each topic will be analysed.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	Results of the Use Case	Improved one step of resolution (from month to weeks, from day to hour- ly, from country to region, from city to buildings, etc.)	MAPE <3% national / international level <7% regional / customers aggregation level <10% city / microgrid level <15% building level	12, 3 interventions per category
Components	ALL	Upscale	Upscale	Causal Model
Blocks				
Is Blocked				
Satisfaction	5	5	5	5
Source	WP5	DoA	DoA	DoA
Priority	5	5	5	5
Difficulty	4	3	5	3

ID	R_G53	R_G54	R_G55	R_G56	R_G57
Name	**Energy profiles should consider at least 50% of the population**	**Validate the forecast of interventions**	**Proxy validate the counterfactual model**	**Carry out eight co-creation activities**	**Produce ten policy recommendations**
Type	Non Functional: Performance	Non Functional: Performance	Non Functional: Performance	Non Functional: Usability and Humanity Requirements	Non Functional: Performance
Description	Several clusters of behaviours have to be created (R_G10) and assessed. These clusters should consider at least 50% of the population.	Validate (in terms of goodness of fit, MAPE, MSE or statistical significance) the forecast of the interventions set on R_G53.	Validate (in terms of goodness of fit, MAPE, MSE or statistical significance) the forecast of the interventions set on any of the Randomized Control Trials carried out in the project.	At least eight activities that involve stakeholders should be carried out in the project.	Based on the achieved results, at least two policy recommendations for each of the five use cases should be produced.
Rationale	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA	Set in the DoA
Fit criterion (measurable)	>50% population	<15% MAPE	<15% MAPE (proxy)	8 actions / 3 stakeholders per action	10, 2 per use case
Components	Causal Model	Upscale	Upscale	Causal Model	ESM
Blocks					
Is Blocked					
Satisfaction	5	5	5	5	5
Source	DoA	DoA	DoA	DoA	DoA
Priority	5	5	5	5	5
Difficulty	3	5	5	2	2

ANNEX F - External Review

Template for review of deliverables of the WHY-project

"Climbing the causality ladder to understand and project the energy demand of the residential sector"

Thank you for your collaboration with the WHY project consortium. With your valuable input we can make certain that our deliverables will have a high quality and will be of value to both the consortium and external readers.

This template will help you to write a structured review on the deliverable you were asked to review and provide the WHY consortium with the necessary information to improve the quality of our deliverables.

General information

Deliverable:	D1.1. - Stakeholder Requirements Analysis
Name	Dr. Heike Brugger
Company	Fraunhofer ISI
Function	Coordinator of the Business Unit Energy Policy

Review of the deliverable

In the following chapters we would like you to give us your impressions on the deliverable you have just reviewed.

General feedback

Please provide us with your general feedback on the deliverable (format, structure, general contents, readability, use of graphics, etc.)

Generally, the deliverable has a very good quality. The content is very interesting. It is a bit difficult to understand why the two parts are summarized together in one deliverable and I would say that some reasoning would help the reader. Currently, it is even emphasized that the two parts do not really have anything to do with each other, which is kind of puzzling. The numbering of the (sub) chapters is not correct, please update. Also it would help to have the numbering in the table of contents already.

Feedback: Language

Please provide us with the information if the language used in the Deliverable is understandable or whether there are any notable improvements concerning grammar, writing style, spelling, etc. necessary

The language is well and good to understand. There are no improvements in writing style etc. needed. However, the punctuation should be checked more carefully.

Feedback: Contents

Please provide us with an in depth feedback on the contents of the deliverable. Did you find all the information required to fully understand the Deliverable? Did you find any particular errors in our contents, assumption, etc.? Did we miss important sources that we should add to the Deliverable and increase its value?

As for the first part of the deliverable, it was all clear and interesting to read. I would have liked, in addition to the summary, so see some reflections from your side on what you have learned from the interviews etc, Additional, rather than (only) a full list of requirements, It would have also been nice to but this full list somehow in perspective (e.g. give an outlook how you will proceed with this).

As for the second section, I am missing a bit the overall picture of what the tool should accomplish (which would indeed be a nice bridge to the part above, so I was not sure why you did not exploit this). In addition, a restructuring in terms of the workflow rather than the three categories might help. Personally, I found myself jumping between the flow chart and the various categories trying to

figure out how these parts go together. I guess a little restructuring could go a long way in terms of readability.

Feedback: Display of results etc.

Please provide us with feedback on the way results are presented. Are graphs, diagrams and tables understandable and well positioned. Is the text accompanying the graphs and tables sufficient or would you like more details? Is the quality of the displays sufficient

The only graph included is the architecture of the model, which is well understandable. It might be interesting to highlight (e.g. by framing differently) the parts that are newly to be developed or substantially enhanced in the course of the project.

Feedback: Results in general

Please provide us with feedback on the results that were provided by the Deliverable. Are the results comprehensible and provided in a good and structured manner? Are all the results presented in the deliverable correct and resilient?

see comments above

Feedback: Executive Summary.

Please provide us with feedback on the executive summary. Contains the relevant information of the deliverable? Is it of adequate length? Follow the same structure as the main document?

Generally, I think the executive summary provides a good overview of what happens in the deliverable. I personally found it a bit difficult to follow the step from the method of approaching the stakeholders to the model architecture. From my perspective, it would be helpful to clearly mention the four phases at the beginning of the summary and then describe them one by one (and clearly indicate when a new phase starts). Furthermore, it would be great if you could explain in one / two sentences why you are doing certain things, e.g. why do you develop the architecture here and how does it relate to the stakeholder engagement described before. I know this will come in detail later, but it would help to guide the reader through the different phases. At the same time, I do not think that the list of bullets of the Code-Elements is very helpful / particularly needed at this point. The length is okay, it should not be (much) longer. But a clearer structure would be very helpful.

Also, I am wondering whether one standard section on describing the WHY project should be added at the very beginning, which will then be used in all the deliverables and provide the overall aims / objectives etc. of the project.

Feedback: Necessary Improvements

Please provide us with a summary of the necessary improvements that the Deliverable needs to have a satisfying quality. Please also indicate the sections this relates to.

The deliverable already has a quite satisfying quality. I would not say that there are any things that absolutely need to be done. However, providing a clearer reasoning for how the first and the second part of the deliverable relate together, would be very helpful for the reader. Also, a clearer description of the workflow, the aim and the connection of the code, the APIs and the components, rather than just a listing of the individual elements would highly improve the readability.

Feedback: More elaboration would be nice

Please indicate sections or elements of the Deliverable you found interesting and where you would like additional information which is not provided in the Deliverable in the current state.

see above

Feedback: Notable Results worth disseminating or publishing

Please provide us with a summary of the results and insights provided in the Deliverable which you think are worth disseminating or publishing.

This was a very foundational deliverable and I do not think the content lends itself to an (academic) publication already. That being said, the part on the requirements is super interesting and I am looking forward to how this unfolds in future and would definitely like to see this as a part of a publication. In addition, the other parts are quite good foundations for future publications (e.g. about the architecture).