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Is It More Than “Stakeholder-Washing”? Reflections on Stakeholder Engagement in the SENTINEL Energy Modelling Project and Recommendations for Future Transdisciplinary Research

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Executive Summary

Stakeholder engagement has become increasingly important in energy research and is now even required by many funding agencies. Recent energy modelling projects also claim to involve stakeholders in the research process, although this is usually a process of one-way communication. This raises the question of the extent to which stakeholder involvement can have an impact on the modelling work, or whether it is often a case of mere ‘stakeholder-washing’ to meet funding requirements. In this discussion paper, I reflect on the experiences of stakeholder engagement in the EU Horizon 2020 project Sustainable Energy Transition Laboratory (SENTINEL), discuss the impacts of stakeholder participation on the energy modelling and unfold key challenges of involving stakeholders in energy modelling. I discuss that it worked well to engage stakeholders in defining user needs and discussing modelling results, while only a few stakeholders could be continuously involved through the project period. I also show that although the project successfully identified research questions and needs, the ability of models to answer questions was limited, and making models understandable to users remains a key challenge. Stakeholder engagement in SENTINEL was more than ‘stakeholder-washing’: it led to the identification of user needs and research questions, impacted scenario design, modelling improvements and the development of new modelling tools, and enabled critical reflection on modelling approaches and results. Finally, I make nine recommendations for future stakeholder engagement in energy (modelling) research that can enable mutual learning and enhance the legitimacy, relevance and impact of modelling. The further development of multi-stakeholder communities of practice around innovative energy modelling approaches can facilitate the transition to climate neutrality.

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1. Introduction

In order to solve the great challenges of sustainability and the difficult problems of our time, scientific and non-scientific understandings and a broad spectrum of knowledge are needed (Lawrence et al., 2022). Stakeholder engagement in research has become increasingly relevant as a new form of knowledge production and decision-making (Lang et al., 2012; Lawrence et al., 2022). Stakeholder engagement can be broadly defined as the process of involving interest groups in the research process who are either affected by the research or have a particular interest in the outcomes. Stakeholders can include a wide range of actors, from community members to representatives from businesses and non-governmental organisations to policymakers from local to international levels. In fact, stakeholder involvement is now mandatory for most research projects (European Commission, 2022). But what is its impact on the research process?

This Discussion Paper reflects on the stakeholder engagement in the Horizon 2020 project Sustainable Energy Transition Laboratory (SENTINEL) and discusses its impacts on the energy modelling work and challenges related to the involvement of stakeholders in energy modelling. Was this a case of ‘stakeholder-washing’ or did it have a real impact on energy modelling?

1.1 Levels of stakeholder engagement

There are different degrees of how stakeholders can be engaged. The “ladder of participation” ranges from information, consultation, cooperation, and collaboration to empowerment (Schneider and Buser, 2018). Where projects are placed on this ladder determines the frequency and intensity of participation. Project dissemination is at the bottom of the ladder, as it aims to inform stakeholders about project objectives and outcomes, typically mainly at the beginning and end of the project period. At the top of the ladder, on the other hand, is co-creative or transdisciplinary research, which involves stakeholders throughout the research process. It is applied to integrate the best available knowledge (Lang et al., 2012), to build ownership of problems and solutions and consensus about best ways forward (Waisman et al., 2019), to develop socially relevant and actionable solutions to complex, real-world problems (Fazey et al., 2018), or to achieve greater policy impact (Süsser et al., 2021a).

1.2 Stakeholder engagement in energy modelling

Energy system models can be understood as “laboratories” that enable “thought experiments” which allow stakeholders to explore energy transition options and understand the trade-offs between them (Pickering et al., 2022). Energy models are increasingly used for policymaking (Süsser et al., 2021a) and two-thirds of models have some impact on policy (Chang et al., 2020). In fact, modellers want their modelling work to have a policy impact, and they also want their models to be used appropriately (Silvast et al., 2020). There is a growing awareness in the modelling community that user needs must be considered to ensure their usefulness in practice.

Co-creative or participatory approaches in energy modelling and planning are rare (McGookin et al., 2021). Even if modellers want to engage with stakeholders, this engagement is often limited to an exchange at the beginning or/and the end of the modelling process (Süsser et al., 2021c). It is still common practice for models to be used unidirectionally, informing only a specific target group about

modelling outcomes. This leads to modellers often using their models to answer the questions they themselves are interested in (Braunreiter et al., 2021), or that they believe are relevant to the stakeholders.

However, there are many ways to involve stakeholders in the modelling process to tailor models and model runs to the specific needs of particular cases and contexts (Figure 1). I define six stages of co-creation:

- **Research design:** Stakeholders can be involved in co-defining the problem, modelling needs and research questions. This also allows for the inclusion of different context-specific challenges or worldviews that different stakeholders might have. At the same time, this step helps to clarify what can and cannot be modelled.
- **Model assumptions:** Stakeholders can participate in discussing and defining the qualitative storylines and the quantitative assumptions and input data. They can help quantify the values of parameters, provide data for input, prioritise or exclude features of the energy system, etc.
- **Model development:** Stakeholders might be also involved in model development and scenario building. This requires a more technical understanding of models, but it is possible that stakeholders may possess relevant expertise or even experience of modelling.
- **Model results:** Stakeholders can participate in the discussion and joint assessment of the modelling results and their meaning. This includes the necessary clarification of what the model results do and do not mean. Feedback can provide valuable insights into the relevance of modelling results and lead to a redesign of model assumptions or structures.
- **Outreach:** Stakeholders can also support the design of communication materials and the communication of the research outcomes, as well as the publication of open-access models, data and results.
- **Reflection:** The final phase can involve joint reflection between modellers and stakeholders on stakeholder involvement in the modelling process. This phase makes it possible to improve the involvement of stakeholders in modelling projects.

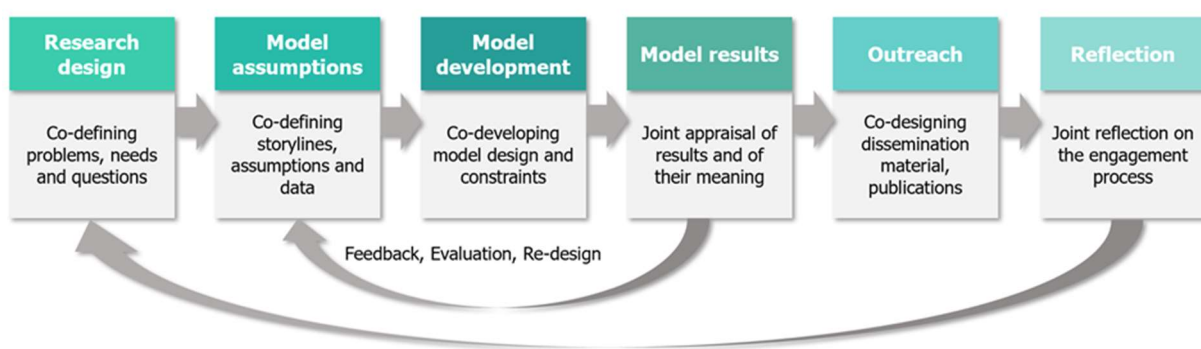


Figure 1: Possibilities for stakeholder engagement along the modelling process.

It is important to note that in reality the process is iterative and not as linear as shown in the figure. Several feedback loops can occur and real-life developments (events such as the COVID-19 and energy crises) make the process dynamic. Along the six stages, different qualitative and quantitative methods can be used to facilitate the exchange. Methods include one-to-one discussions, such as interviews and surveys, or more interactive group formats, such as workshops and focus group discussions.

The involvement of stakeholders along the six steps can enrich the modelling process: it enables a two-way, interactive exchange of knowledge and a joint exploration of the solution space for future energy systems. It also facilitates a shared understanding of the "messy reality" of the energy transition on the ground (McGookin et al., 2022). Moreover, this is a practical way to ensure that modelling outputs are useful to decision-makers and better aligned with local needs and developments. The latter is also important in terms of the time commitment required from stakeholders involved in participatory modelling exercises: continuous engagement can help overcome the challenge of unsteady stakeholder participation due to lack of interest, capacity or unclear outcomes (Lang et al., 2012).

A key challenge that remains is how researchers can ensure that the “right people” participate in the stakeholder engagement. Literally, every citizen is a stakeholder, as (s)he is affected by the energy transition or potentially interested in the outcomes (Lombardi et al., 2020). But in reality, often only a small community of high-level stakeholders, such as policy- or decision-makers, participate in modelling processes (Sgouridis et al., 2022). Thus, modelling projects fail to include inputs from a broader range of stakeholders and do not account for needs by populations and for real-world transition challenges. This can cause users to distrust models and undermine the relevance of modelling outcomes (Braunreiter et al., 2021; Sgouridis et al., 2022).

2. Stakeholder engagement in the SENTINEL project

The SENTINEL project ran from June 2019 to November 2022, including a six-month extension due to the COVID-19 pandemic. The aim of the project was to develop an energy modelling platform that would enable energy modellers and decision-makers to find information about the SENTINEL open energy modelling suite and its application in three different case studies. The SENTINEL case studies covered the European Union as a whole, a regional case study of the Nordic countries, and Greece as a national case study (Error! Reference source not found.).



Figure 2: SENTINEL case studies: a. National level case study (Greece), b. Regional level case study (Nordic region), and c. Continental level case study (European Union, Iceland, Norway, Switzerland, and United Kingdom). Source: (Stavrakas et al., 2021a).

Stakeholder engagement was to be at the heart of the project: It was planned to involve stakeholders at different stages of the research process to support the development of scenarios, model improvements and the platform. The project was divided into nine work packages (WPs). Stakeholders were involved in WP1 User needs and WP7 Case studies, as illustrated in Figure 3.

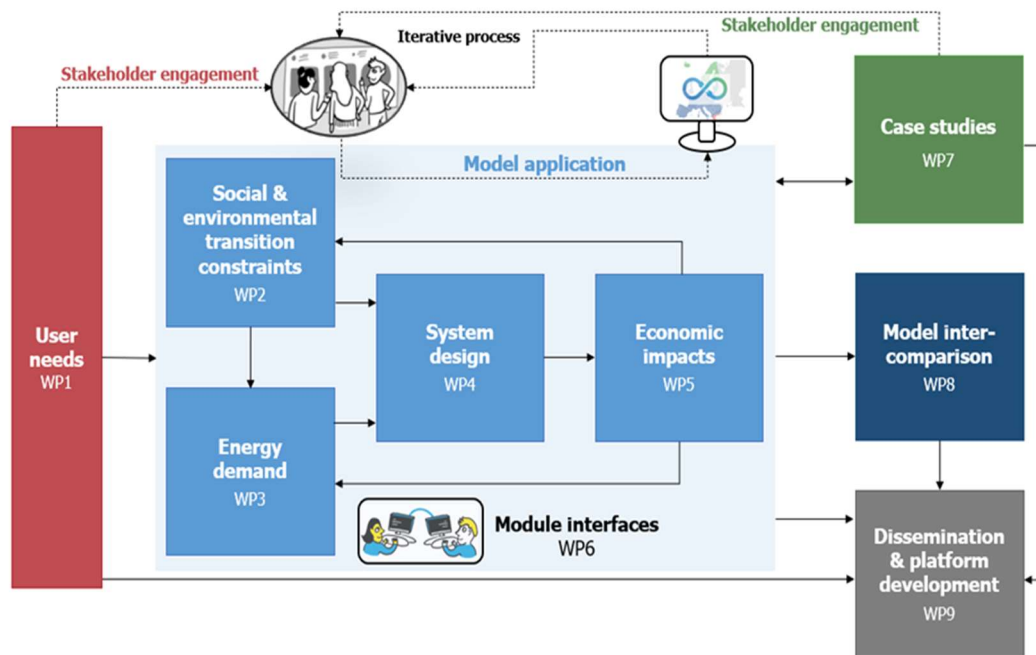


Figure 3: Structure of the SENTINEL projects and the stakeholder engagement.

2.1 Stakeholder groups

We distinguished in the project between model users – stakeholders who are modellers in other organisations and could potentially also use the SENTINEL modelling tools – and the users of results – stakeholders who do not model themselves but use the results from the modelling. Furthermore, we differentiated between four main stakeholder groups (Figure 4).

- the scientific community (scientists that are not part of SENTINEL, think tanks, model researchers in consulting companies, etc.)
- policymakers in governments, in governmental organisations and parliaments, at national and European level
- the energy industry (including manufacturers of components, project developers, municipal utilities, and energy network operators (such as transmissions service operators, distribution system operators and entities related to their work))
- civil society (consumer advice organisations, NGOs, etc.)

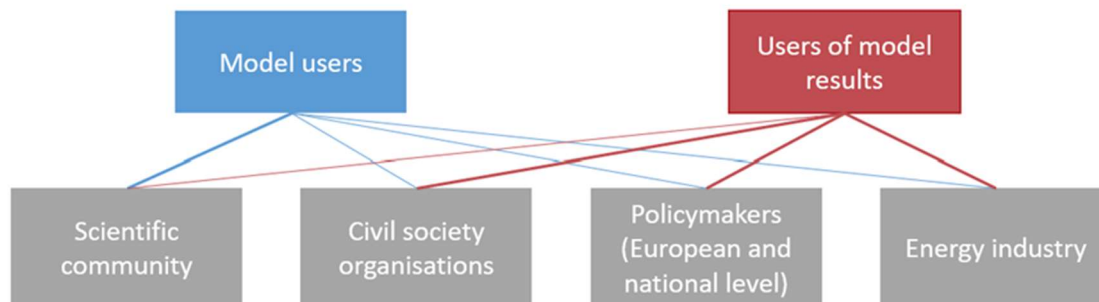


Figure 4: Stakeholder groups in the SENTINEL project.

To identify relevant stakeholders, we conducted a simple stakeholder mapping. An initial list of stakeholders was drafted using institutional contacts and contacts developed during previous EC-funded projects, literature and online research and further recommendations (including stakeholders interviewed in the context of WP1). The selection criteria were based on stakeholders’ general knowledge and experience in the field and the scope of each case study. It was important for us to involve stakeholders who embodied diverse views on the critical issues of the different case studies. Thus, we sent personalised invitations to selected representatives of the respective climate and energy communities.

In addition, to successfully involve external stakeholders into the whole project, we developed a stakeholder engagement plan for all project partners and managed the stakeholder work for all WPs, first under IASS-leadership (now RIFS) (WP1) and then UPRC-leadership (WP7). The Renewables Grid Initiative (RGI) was very closely involved in the stakeholder engagement over the whole project period.

2.2 Aims of and methods for the stakeholder engagement

The objective of the stakeholder engagement under WP1 was to analyse when, why and how models were used in specific policy processes in different places in Europe and how models were influenced by policy. In addition, we aimed to identify key needs for the development and improvement of energy modelling tools. WP7 had the objective to identify context-specific needs for energy modelling and research questions to be answered, as well as to evaluate modelling approaches and results to ensure they met the needs of users. We tailored the different engagement activities to the expected outcomes.

A lot of the stakeholder engagement activities were planned for 2020. We planned to hold several workshops and conduct an online survey and interviews, some in-person. Due to the containment measures taken by countries across Europe in response to the COVID 19 pandemic, most of our activities had to be conducted online (see Table 1). A second wave of stakeholder engagement took place in 2022, where in-person meetings were possible again.

While the pandemic upended our initial plans for stakeholder engagement, we used this opportunity to try new engagement methods, including live voting, annotation, online white boards and visual recording.

Table 1: Stakeholder engagement activities: planned vs. implemented.

Green: remained as planned; Yellow: moved online; Pink: format changed; Blue: additional.

Stakeholder engagement activities	
Planned	Implemented
Interviews, in-person and online	32 online interviews under WP 1
1 online survey	1 online survey
User needs workshop: in-person, June 2020	Online interactive workshops with 30 participants, 1 st of October 2020
Case study workshop in Greece: in-person	6 in-person and online focus groups with 16 key stakeholders November 2019-February 2020; 13 online interviews under WP 7 national case study
Case study workshop in the Nordic countries: in-person	Online interactive workshop, with 29 participants, 4 th of November 2020
Case study workshop in the EU: in-person	Online interactive workshop, with 40 participants, 9 th of December 2020
Stakeholder workshop, in-person, 2022	Stakeholder workshop, in-person, June 2022
Stakeholder interaction to evaluate modelling results	3 “Deep dive”-focus groups with experts, online, June-September 2022
	Final event, online, ~60 participants, November 2022

2.3 Experiences from the stakeholder engagement in SENTINEL

In the following, I present the stakeholder engagement activities and assess what worked well and what worked less well. It is important to mention that the SENTINEL modellers actively participated in the different involvement activities, provided ideas for survey questions, facilitated sessions or presented results.

Experiences from Work Package 1

In WP1, we studied the use of models in policymaking and examined the user needs for energy models, by engaging with over 150 European stakeholders. In 2020, we conducted 32 interviews, an online survey, and an online stakeholder workshop.

The interviews were all conducted online with the stakeholder groups noted in Section 2.1. We faced difficulties in reaching some stakeholder groups, specifically policymakers, who were busy dealing with the COVID-19 pandemic at the time. In consequence, we expanded the interview period, and were ultimately satisfied with the number of interviews and the quality of results generated¹.

The survey was conducted online. People were spending a lot of time online in this period and we received a positive response rate to our survey call². Nevertheless, it was, again, much harder to have

¹ The results have been published in Süsser et al., 2021a, 2020.

² The results have been published in Gaschnig et al., 2020b and Süsser et al., 2021b.

policymakers participate in the survey. We received most responses from researchers.

The stakeholder workshop also took place online. We had to redesign the original research concept, as the workshop was originally planned as an in-person event. The preparation of the online workshop was time intensive, as we required interactive tools to arrive at the same outcomes as planned: the prioritisation of user needs. We conducted a live voting of most important needs, using Mentimeter as our online voting tool (see Figure 6). We also used Zoom’s annotation function to vote for participants’ preferences (see Figure 7). Both worked very well and enabled active participation. Nevertheless, it was more difficult to ensure that everyone remained engaged and to respond to individuals. In addition, we used breakout rooms to have deeper discussions on specific user needs regarding environmental, social and political, energy demand and supply, economic impacts and the design of the modelling platform. The breakout discussions enabled a close exchange with the stakeholders and led us to better understand why certain needs are relevant to them. Visual recordings of the results were created and provided appealing summaries (Figure 8). The overall workshop attendance was satisfying, and we confirmed aspects and identified new issues that models should address.

The results have informed the improvement and new development of the SENTINEL models, as well as the modelling platform.

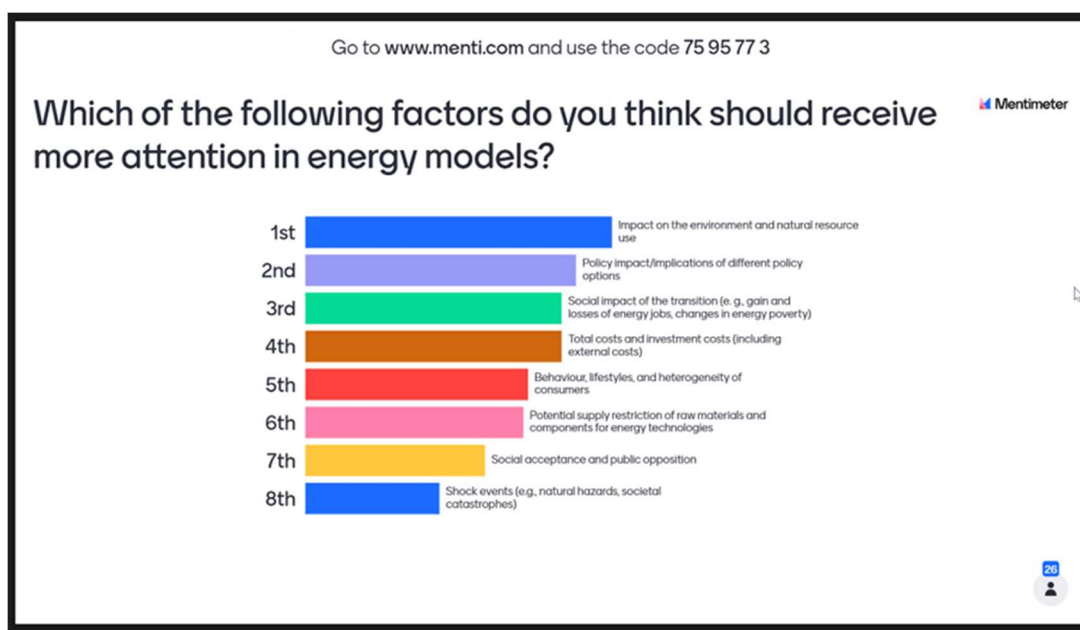


Figure 5: Live polling with Mentimeter to prioritise user needs.

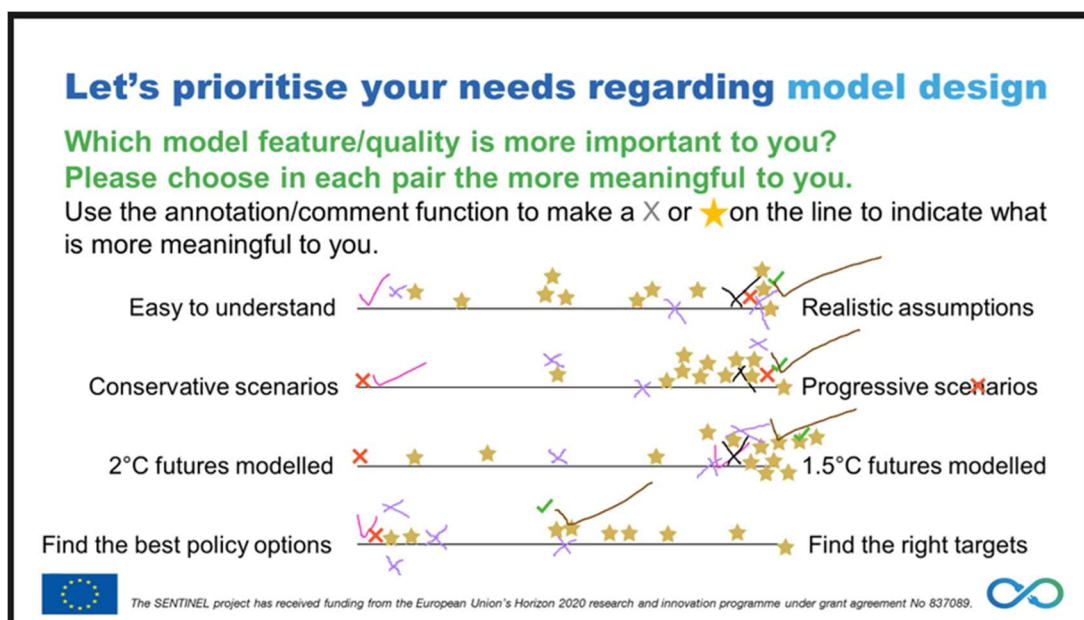


Figure 6: Use of Zoom's annotation function to prioritise preferences.

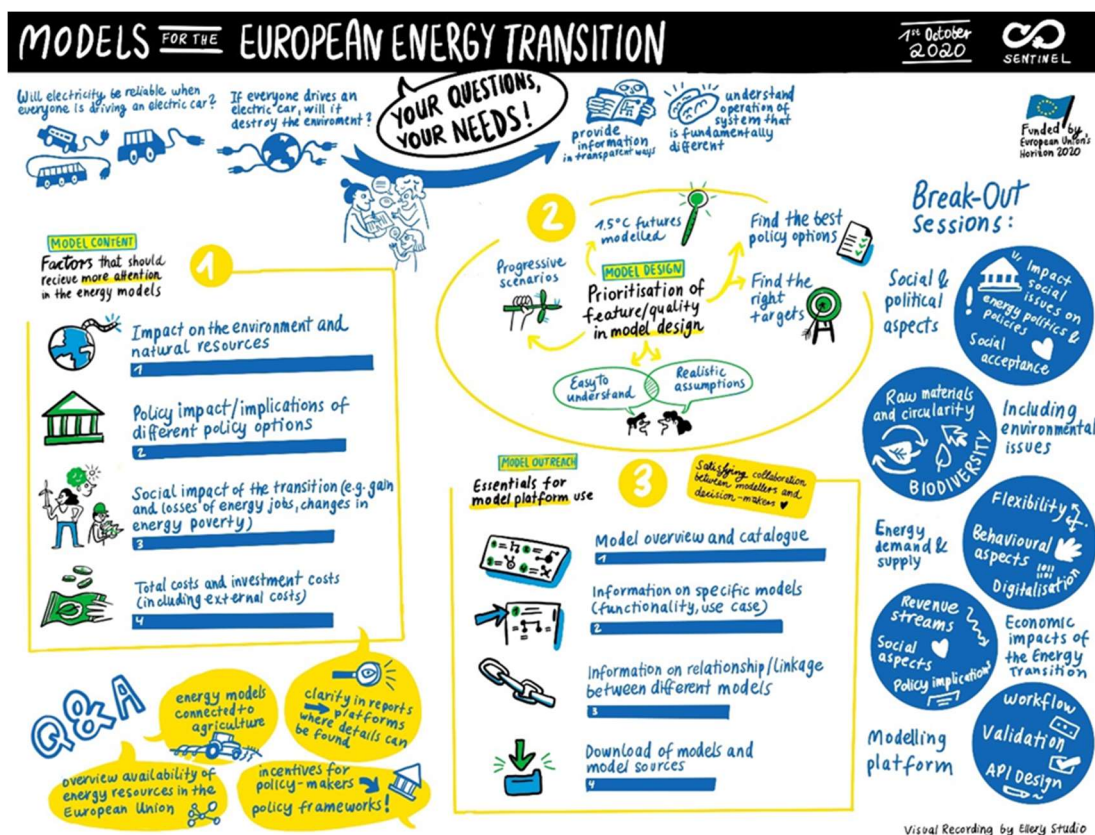


Figure 7: Visual recording of the plenary session of the user needs workshop.

Experiences from Work Package 7

WP7 aimed to apply the models to the case study contexts’ and to evaluate the approaches and results with stakeholders. As part of the WP7 case study, we conducted several smaller focus groups, physical meetings and interviews with stakeholders in Greece and held one workshop for the Nordic countries and one for the EU online in 2020.

For the Greek case study, we had developed an in-person workshop concept, which could not be realised due to the outbreak of the COVID-19 pandemic. The alternative methods were chosen in agreement with the stakeholders and allowed to engage relevant actors successfully.

The stakeholder workshops for the Nordic and European case study consisted of long sessions in breakout rooms using various interactive tools such as voting instruments or mind maps. The online tools worked well, as they allowed for the active involvement of participants. The engagement led to the successful identification of context-specific needs for energy modelling in the different contexts and 250 research questions to be answered by the modelling teams. Nevertheless, it can be noted that overall participation in the workshops declined in comparison to the workshop held in mid-2020. This might have been caused by growing fatigue among participants in online events (virtual event fatigue).

In 2022, we also conducted an in-person stakeholder workshop in Greece to discuss the SENTINEL modelling results. Presentations by the modelling teams were followed by an interactive climate-neutral world café. The presentations of key modelling results initiated great discussions between the modellers and participants in the Q&A session (Figure 9) and the lunch break. Although the presentations provided a good overview, the session was quite long and some stakeholders left during the lunch or before the begin of the interactive session. Clearly, the workshop should have been designed differently to encourage participation throughout the day. Nevertheless, the climate-neutral world café sessions worked very well. They enabled interactive exchange between the participants and led to the identification of new critical issues and challenges towards a decarbonised energy system in Greece, as well as the identifications of ideas for the design of the modelling platform. It supported the final work in SENTINEL and outlined needs for future research projects.

Furthermore, we conducted so-called “deep dives” with small groups of experts interested in using specific modelling tools or results to discuss modelling approaches and results. These online focus group sessions proved to be very useful as the input from the modellers was limited and much more time was available for discussions with participants. The participants were evenly split into two smaller breakout groups to enable an interactive discussion. This resulted in valuable feedback on the modelling approaches and the identification of next steps to be taken. Among the participants were new stakeholders but also those who have been involved in previous engagement activities.

Last, we held a final SENTINEL event online. Some modelling teams presented key modelling results for the European Union, which was followed by a long panel debate with the modellers. Participants were able to ask questions and this sparked a lively exchange between the modellers and the audience. However, not all attendees actively participated in the workshop by taking part in the live voting or asking questions. Surprisingly, for most of the participants this was their first SENTINEL event. This points to difficulties in securing the continuous involvement of stakeholders throughout the project, potentially due to lower stakeholder involvement in 2021.

Table 2 summarises the key experiences with stakeholder engagement formats. In sum, we successfully involved stakeholders in the project in 2020 and 2022, despite the challenges posed by the COVID-19 pandemic. We moved most activities online and used various interactive formats and tools to understand stakeholder needs, receive research questions and discuss modelling approaches and results. The results from the stakeholder engagement directly fed into the modelling work, which will be further outlined in the next section.

Table 2: Experiences with stakeholder engagement formats.

Engagement activity	What worked well	What did not work well
Online interviews	Extension of the interview period to accommodate the availability of stakeholders and receive necessary insights on model use and needs	
Online survey	Good response rate from different stakeholder groups on user needs for energy modelling	Limited participation of policy-makers in the survey
Online interactive workshops	Annotation functions and live polling for prioritisation of needs; Breakout sessions for deep discussions	Limited participation of policy-makers in the workshop; Lower participation later in 2020
Stakeholder workshop, in-person	Climate-neutral world café enabled interactive exchange	Presentation of modelling results took too much room and led stakeholders to leave before the afternoon session
“Deep dive” focus groups with experts	Interactive breakout sessions for feedback and deeper discussions on modelling approaches and results	
Final event, online	Short presentations of modelling results; Long discussion in form of a panel debate with modellers	

3. Impact of stakeholder engagement on energy modelling

Figure 5 summarises the different methods used to involve stakeholders in the SENTINEL project and how the results fed into the modelling process. The results from the stakeholder engagement directly impacted the modelling work, enabling modellers to answer users’ research questions and to build new modelling tools based on user needs. This section discusses the key impacts of the stakeholder engagement on energy modelling and the challenges we faced.

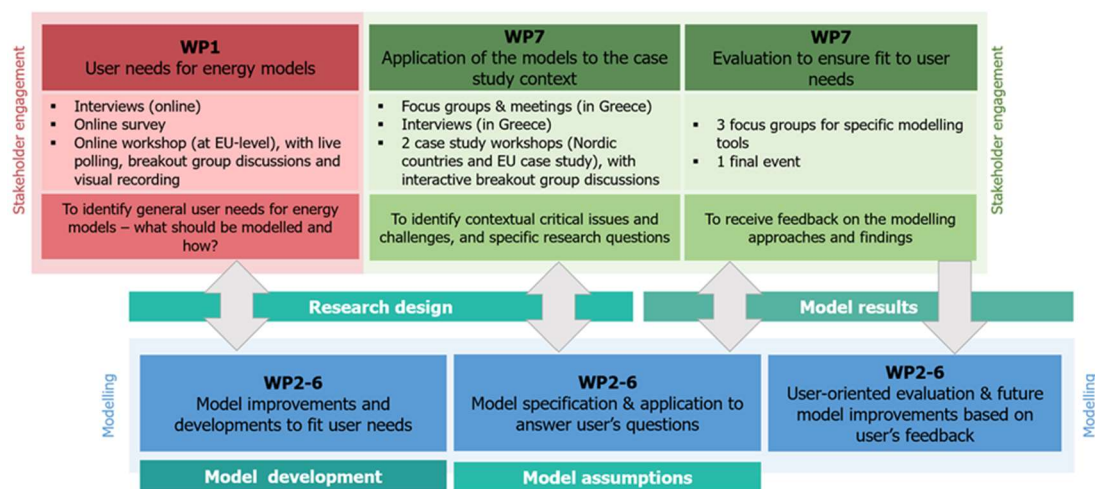


Figure 8: Aims of the stakeholder engagement and methods applied.

3.1 Impact of stakeholder engagement on modelling work

How has stakeholder involvement influenced our modelling work? Stakeholder engagement in SENTINEL had concrete impacts on the research process and modelling work. In the following, I will elaborate on five important impacts.

Stakeholder involvement improved modellers’ awareness of user needs and interests. Although today most modelling projects involve stakeholders to varying degrees, this does not mean that modellers value the insights gained. On the contrary, the findings may only be used as confirmation for planned research projects. In SENTINEL, stakeholder involvement allowed modellers to engage with the different users of models and modelling outputs and to use their needs to justify changes to modelling designs, objectives and assumptions. For example, colleagues in the field of demand modelling indicated that they gained a better understanding of the need to include social aspects in modelling and they subsequently updated the modelling data based on real observations in the EU. Raising awareness

among modellers is essential as it enables critical reflection on tools and encourages modellers to look beyond conventional practice when considering how models can be further developed or how collaboration with researchers who are not modellers can add value.

Stakeholder engagement influenced the research design. The early involvement of stakeholders in the research process was important because it allowed us to identify modelling needs and research questions that are important to users. Furthermore, it enabled us to identify specific gaps in current modelling approaches and differences between what modellers think is needed and where users of model outputs think models should lead (Süsser et al., 2021c). Based on the gaps and needs, we updated input data and designed new modelling tools.

Stakeholder involvement influenced the model specification and application. We defined storyline and scenario assumptions based on real-world policy developments in the case study regions. The different modelling teams run the three SENTINEL scenarios. Additionally, in focus groups and workshops with stakeholders, we collected a total of 185 research questions that are relevant to stakeholders in our three case studies (Stavrakas et al., 2021b). The modelling teams used their modelling tools to answer several of these questions – in some cases even more than one model that answered one question in an integrated way (Serafeim et al., 2022). This approach of developing scenarios and modelling concrete questions from users was essential as it ensured that the modelling results were relevant to the users.

Stakeholder engagement has influenced some new model developments and improvements. SENTINEL modellers have made concrete model developments based on the needs identified in the survey and workshops. For example, the socio-political modelling toolbox QTDIAN was developed based on user needs for better representation of social aspects in models (Süsser et al., 2022). In addition, the ENBIOS module was developed to enable environmental assessment of transition pathways as requested by stakeholders (Martin et al., 2023). In doing so, we have made an important contribution to making models more realistic and thus more useful tools. Both modelling tools were linked to other energy models to support the further development of existing data sources, underlying modelling logics and approaches. In this way, stakeholder engagement enabled a change in modelling practices within SENTINEL and beyond.

Stakeholder engagement allowed us to obtain feedback on modelling approaches and results. The modellers were able to share their applied approaches with relevant stakeholders through deep dives and an online workshop and ask for the relevance of the derived results for the work of decision-makers. For example, one Deep Dive focused on the socio-economic impacts of a just, net-zero energy transition in Europe. This was an important "reality check" to see if users trusted the approach and if the results were useful to them. The findings and feedback from this Deep Dive were used to evaluate and further improve the SENTINEL energy system models that address the social and economic aspects of the energy transition.

3.2 Discussion of challenges of stakeholder engagement

As shown in Section 3.1, stakeholder engagement provided useful contributions to understanding modelling needs and developing *better* models that meet the needs of users. Nevertheless, the involvement of stakeholders in modelling is not an easy task. A key challenge is that energy models are complex tools that often lack transparency. Even if they are 'open', this does not mean that users know what they can do and understand how to use the models and interpret the results. This section outlines and discusses several challenges related to stakeholder engagement in the SENTINEL project and in modelling more generally.

Unforeseen events can disrupt planned stakeholder engagement activities. The COVID-19 pandemic started in 2020 – the year we had planned most of our stakeholder engagement activities. We delayed some activities in the hope that the pandemic would end quickly, but eventually moved most of our activities online, as was common practice in research at the time (Süsser et al., 2021b). Although the pandemic led to some changes, we were able to involve a diverse group of stakeholders and achieved outcomes that brought value to the project (see also Section 3.1). Nevertheless, we faced challenges in finding participants for our events, especially in later phases of the pandemic, as people grew weary of online formats. Due to pandemic-related delays, we finished WP1 later than expected. As a consequence, the results were provided to the modelling teams later than anticipated, which had already begun to improve their models based on their best estimation of user needs.

Energy models are not able to answer all questions of stakeholders. Stakeholder engagement revealed various user needs, especially also in relation to social, political and environmental concerns around the energy transition. Our models were not able to answer all of these questions. This was the case because, firstly, most energy models are technical-economic models and simply neglect aspects that cannot be modelled. The development of the new ENBIOS and QTDIAN models allowed us to extend the existing model portfolio, but their application is far from being standard. Secondly, some of the questions raised were of a social-scientific nature, such as *What technologies will people accept? What are appropriate business models?* Other methods are needed to answer these questions, such as surveys or business model analysis. Some of the questions could be covered by the QTDIAN modelling toolbox, but others we simply left out. This raises the broader question of what it means for decision-making to use models that do not appear to consider important drivers or barriers to the current transition, such as social acceptance or future resource needs. It also emphasises the need for more interdisciplinary research that complements modelling by the social and political sciences. The inability of models to answer stakeholders' research questions also leads to the following question.

Which should come first: the research question or the model? Most of the models were established at the beginning of the project and only two modelling tools were to be newly developed during the project period. This led to the aforementioned challenge that the models could only answer a limited number of research questions. I argue that in order to better answer stakeholders' questions, the research question should come first and only then the model selection process to ensure that the most appropriate modelling tools available are applied or even new modelling tools are developed based on users' needs. In reality, this can be a challenge as developing models from scratch takes a lot of time. Nevertheless, modelling teams should think better about how to use stakeholder input to improve modelling approaches and structures. In addition, smaller modelling tools might be more flexible and better suited to respond to new needs and research questions. This was also the intention of the SENTINEL project, to create a platform of models that can collectively respond to specific research needs.

Modellers are open to considering user needs – but within limits. Many modellers are willing to discuss model assumptions and research questions and to incorporate new constraints in models. However, this may not be enough to answer research questions of key interest to users. This could potentially require changes to the structure of models – which is much more time-consuming and has not taken place within SENTINEL. Timing can also be a challenge: Identifying user needs takes time, and by the time the results are available, the modelling work may have already begun.

“Dry spell” in 2021: Not much stakeholder engagement took place. In 2020, we started to engage stakeholders early in the project to design the research based on user needs. However, in 2021, the modelling teams were busy with developing and advancing their models. During this “dry spell” we published many scientific articles and participated in conferences. We also organised the European Platform for Energy Modelling conference, in which many SENTINEL modellers actively

participated. Although some modelling activities and project results were communicated through such events, I think we failed to address our stakeholders sufficiently. Most conferences do not sufficiently speak to the non-scientific community, with whom we communicated less in 2021 than in 2020 and 2022. In 2022, we, nevertheless, were able to communicate much more clearly how the inputs and needs from stakeholders have influenced the modelling work.






We engaged modellers and non-modellers in the project – but who really understands the models? Models have become more and more complex. But we also found that models have become *better* in the sense that they are improving in the direction that users want³. This also includes the transparency and openness of models and modelling assumptions. Nevertheless, we found quite a disagreement when it comes to the trade-off between complexity versus simplicity of models. Models become more complex if they address transition aspects such as sector coupling or spatially high resolution. On the other hand, models are more easily understood if they are simpler. Smaller models may allow for better participation if they are not only ‘open’ but also explained to decision-makers. Communicating models and their results in such a way that they are understood by different target groups is a challenge that we have only partially overcome.





We involved modellers and non-modellers in the project – but who is the platform for? We had difficulties in defining the target group of the SENTINEL platform, which also led to confusion about what the platform should actually do and what its unique selling point could be. This could also be related to the fact that too few resources were dedicated to the development of the platform and further outreach activities, and a lack of expertise within the project team.

³ The results have been published in Süsser et al., 2021b.

4. Recommendations for the successful involvement of stakeholders in energy modelling and beyond

Drawing on the lessons learned in stakeholder engagement in the SENTINEL project (Section 2) and reflections on the impacts and challenges of engaging stakeholders in modelling (Section 3), I have derived nine recommendations for successfully engage stakeholders (in energy modelling).

	Be clear about your target audience and tailor your communication. Think carefully about which stakeholders should be involved in the modelling process, why, how and when. When you know who will use the results of your project, you can tailor the communication.
	Be clear about the expected outcomes of stakeholder engagement to determine appropriate methods. Different stakeholder engagement objectives require different methods. Online engagement may be suitable for the most part, especially in the case of one-to-one interactions; some levels of engagement may require face-to-face events.
	Involve stakeholders continuously. Involve stakeholders throughout the research process and as often as possible where appropriate. In project phases where a lot of work takes place "in the background", maintain engagement through newsletters and other forms of communication. Be sure to communicate to stakeholders how the results of their engagement have been used.
	Be agile in the engagement process. Unforeseen events may require changes in methods and formats or modifications to the project schedule.
	Prepare twice for online events. Online engagement offers many opportunities but requires even more preparation beforehand. It is more difficult to be flexible and responsive to the audience online. Interactive tools such as mind maps and live polls make online engagement more participatory.

	Open the "black boxes" and explain model assumptions. Making models open and transparent is a first step, but making them understandable requires an exchange between modellers and users.
	Take an interdisciplinary approach to overcome the limitations of individual methods. Models are unlikely to be able to address all research questions and needs of stakeholders. Therefore, greater collaboration with social and environmental scientists may be useful to overcome the limitations of techno-economic modelling and consider the multiple dimensions of the energy transition.
	Be sensitive when planning the timing of work packages. When planning a project, be clear about which outcomes of stakeholder engagement will be used by modellers and researchers in the project, when and how, to ensure that they will have an impact on the research.
	Have the right expertise and sufficient human and financial resources for stakeholder engagement. Stakeholder engagement is an essential part of project communication and dissemination. Ensure that you have extensive expertise and resources for both stakeholder engagement and related communication activities. The latter will enable you to build a strong social media presence early on so that stakeholders can be informed of project updates, but also to generate interest in the project outcomes.

5. Conclusion

As the SENTINEL project has shown, stakeholder engagement can go beyond 'stakeholder-washing' and have a meaningful impact on modelling work: It can lead to the identification of user needs and research questions, impact on scenario design, modelling improvements and the development of new modelling tools, and enable critical reflection on modelling approaches and results. Stakeholder engagement in SENTINEL enabled mutual learning: modellers understood what was important to the different stakeholders and reflected critically and improved their own modelling work. Stakeholders got a better understanding of the modelling tools and how they can be used to answer what kind of questions. Nevertheless, there was also "room for improvement", especially in terms of continuity of stakeholder involvement, modellers' time or willingness to change model structures based on user needs, and user-oriented communication of models and modelling results. Here, I have provided nine recommendations for (modelling) research projects, which I hope will be a useful guide for future transdisciplinary research projects. After all, involving stakeholders in energy modelling offers the opportunity to learn from each other, to increase the legitimacy of the models, to make the models more relevant for users and thus to increase the impact of the models for policymaking. Thus, the development of communities of practice of modellers and various stakeholders around innovative energy modelling approaches can facilitate the transition to climate neutrality.

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7. About the author

Dr. Diana Süs was a Research Associate in the Energy Transitions and Public Policy research team at IASS, now RIFS, from 2019-2021. She conducted research in the EU project Sustainable Energy Transition Laboratory (SENTINEL) and led the work within Work Package 1 "User Needs". Her research focused on the interactions between energy policymaking and energy modelling, user needs for energy modelling and how to better represent social and political aspects in energy models. She was also co-responsible for engaging stakeholders in the project to ensure the policy relevance of energy modelling.

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