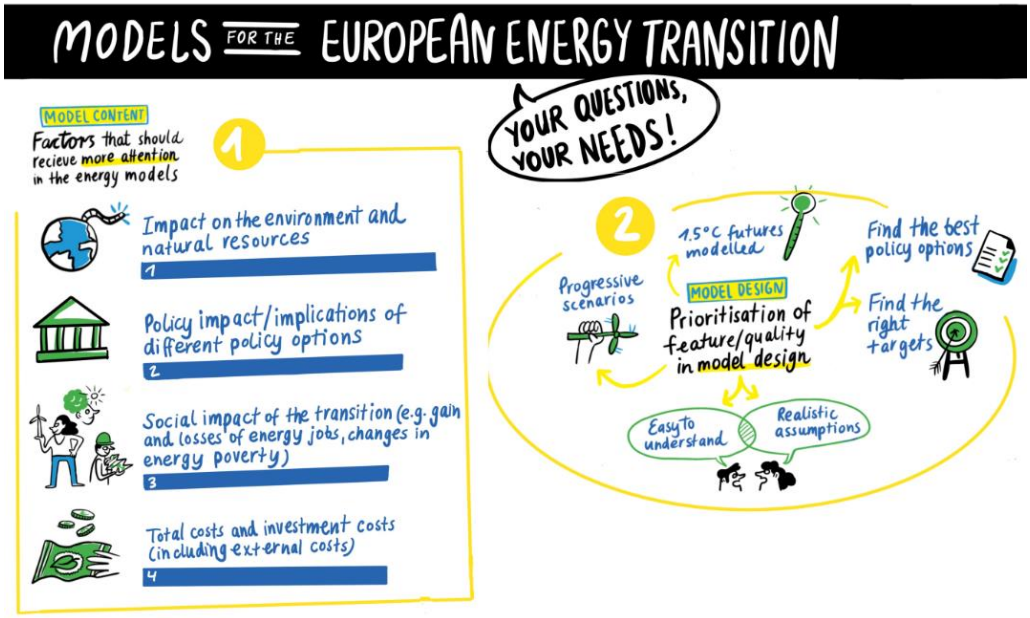
SENTINEL

SUSTAINABLE ENERGY TRANSITIONS

Models for the European Energy Transition: Your Questions, Your Needs!

Workshop Synthesis Report

November 2020



By Diana Süsser, Hannes Gaschnig, Andrzej Ceglarz, Vassilis Stavrakas, George Giannakidis, Alexandros Flamos, Antina Sander & Johan Lilliestam

IASS POTSDAM

Renewables Grid Initiative

TEES lab University of Piraeus Research Center

The SENTINEL project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837089.

Background

The energy transition requires a deep transformation of our today's energy systems. However, such change cannot take place without a meaningful engagement of all stakeholders that are affected by this transformation: policy- and decision-makers, energy companies and grid operators, civil society, academia, and others interested and affected actors.

Energy models can serve as useful tools to inform energy policy- and decision-making. The EC-funded H2020 project Sustainable Energy Transitions Laboratory (SENTINEL) aims to develop a new energy system modelling framework, which is based on user needs and openly available to different users of models and model results.

Work Package 1 of the project is specifically dedicated to the identification and prioritisation of user needs for energy models. For this, the SENTINEL team conducted a literature review, interviews, a European online-survey and a user need stakeholder workshop (**Figure 1**).

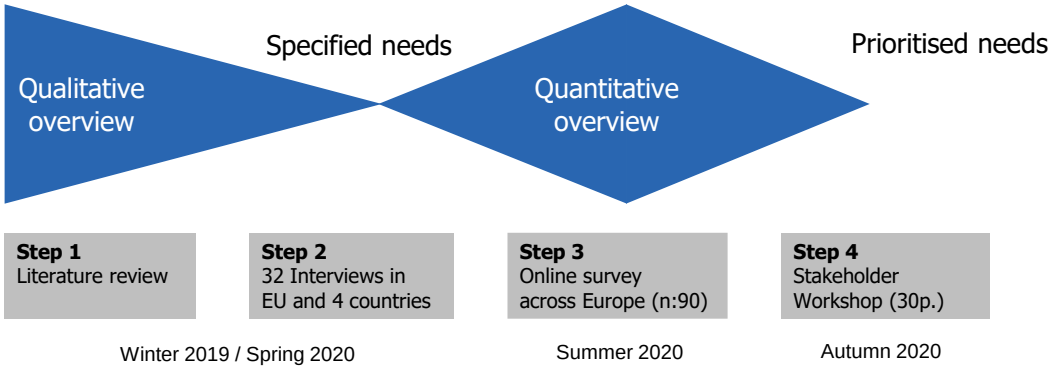


Figure 1: Social-scientific methods in Work Package 1 of the SENTINEL project

This synthesis report presents the results of the workshop "Models for the European Energy Transition: Your Questions, Your Needs!", held on the 1st of October 2020. The insights of the workshop will contribute to the development of new and improvements of existing energy system models of SENTINEL. Additionally, the findings will support the development of the SENTINEL platform that will allow a wide range of decision-makers to address their critical energy system design challenges better.

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Content

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1 Workshop objectives and proceedings

On the 1st of October 2020, around 30 energy decision-makers from politics, business, energy industry, and civil society as well as energy modellers came together to discuss the expectations of energy modelling for the European energy transition (**Figure 2**). This workshop had the objective to provide different stakeholders the unique opportunity to share perspectives on what future energy modelling should look like, and to prioritise most important user needs. The participants of the workshop jointly addressed the following questions:

- What requirements do decision-makers have for energy models?
- What challenges of the transition should models be able to tackle?
- What questions should these models be able to answer?

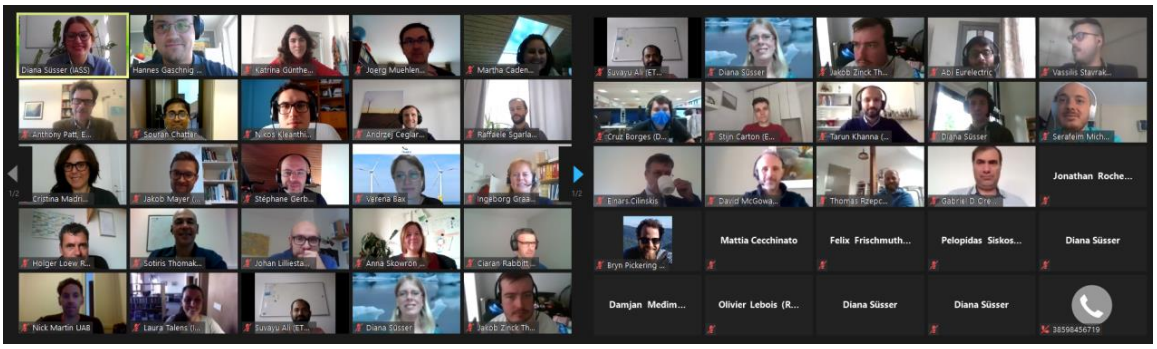

Figure 2: Participants of the workshop

Figure 3 illustrates the agenda of the day. The workshop was divided into four main parts: **(1)** Opening plenary session, **(2)** Parallel breakout sessions – round I, **(3)** Parallel breakout sessions – round II, and **(4)** Closing plenary session. Each of the parallel breakout sessions consisted of five thematic breakout rooms, which touched upon different aspects of the energy transition: **Session 1**: Social and policy aspects in energy models, **Session 2**: Including environmental aspects in energy system models, **Session 3**: Modelling energy demand and supply, **Session 4**: Modelling the economic impacts of the energy transition, and **Session 5**: Designing the model platform of SENTINEL.

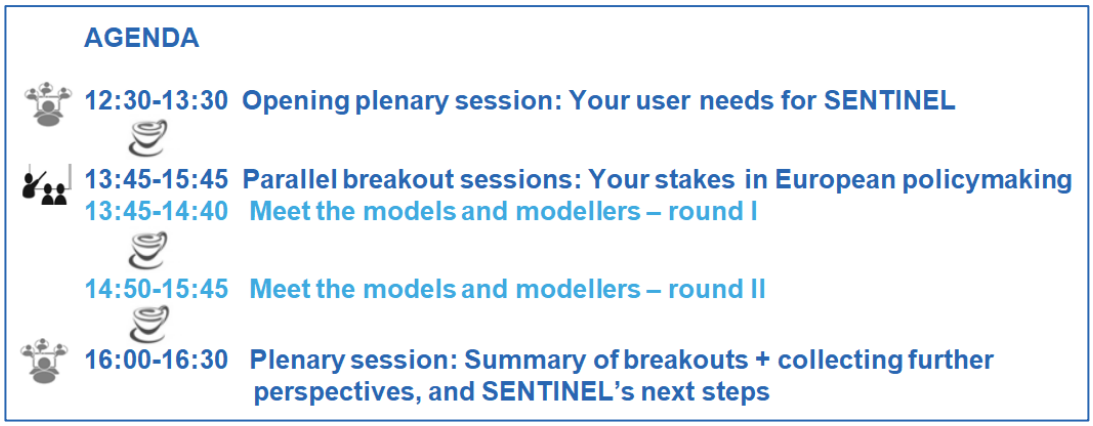

Figure 3: Workshop-Agenda

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2 Opening Plenary Session

Welcome and objectives

Prof. Dr. Anthony Patt introduced the participants to the event by outlining the objectives of the workshop, as well as the scope and main goals of the SENTINEL project (see **Figure 4**).

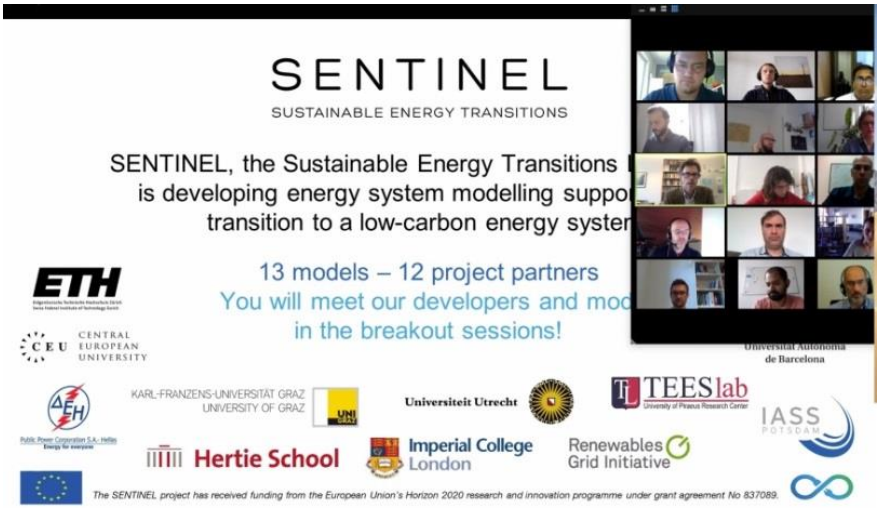

Figure 4: The SENTINEL project

Prof. Patt emphasised the important link between policymakers and energy modellers, by addressing different questions of sustainable mobility by policymakers and the public, relevant for energy modellers: "Will our electricity be reliable when everyone is driving an electric car? If everyone drives an electric car, will it destroy the environment?". Prof. Patt reflected upon the need for energy system models that provide information relevant for understanding the operation of a system that is fundamentally different from our own, in ways that are transparent. Understanding user needs contributes to solve the modelling challenge and helps to identify where priorities are lying.

Prioritisation of user needs & presentation of first results

The research team of the SENTINEL's Work Package 1 has completed a comprehensive literature review, interviews with stakeholders in 5 different jurisdictions in Europe, and an online survey to identify and prioritise user needs. As a thematic introduction to the workshop, Dr. Diana Süsser presented the key findings of this research and guided the participants through the workshops´ prioritisation of key user needs, using the polling tool '*Mentimeter'*.

With the first round of live polling, the session chair asked the participants about their prioritisation of factors that should receive more attention in energy models. The top four ranked aspects by the participants were: (1) impact on the environment and natural resources, (2) policy impact/implication of different policy options, (3) total costs and investment costs, and finally (4) social impacts of the transition (see **Figure 5**).

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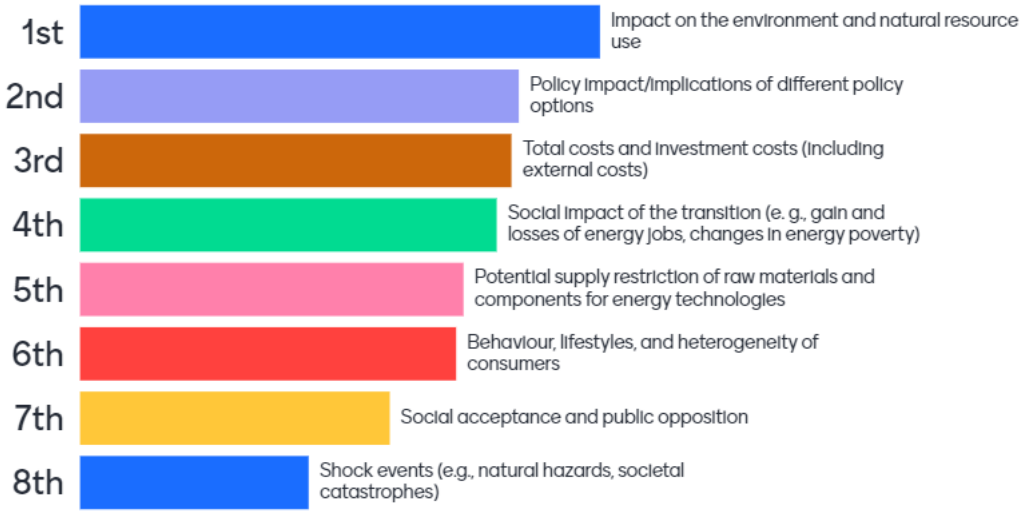

Figure 5: Ranking to the question: Which of the following factors do you think should receive more attention in energy models? (N=28, live poll)

In the second live voting, the session chair asked the participants about the importance of different model features and qualities. Voting results highlighted a clear consensus on the ability of models to analyse progressive scenarios and scenarios with high environmental ambitions (1.5°C futures; see **Figure 6**). However, there was no clear answer on whether models must be rather easy to understand or have realistic assumptions, as well as if they should support finding the best policy options or rather the right targets.

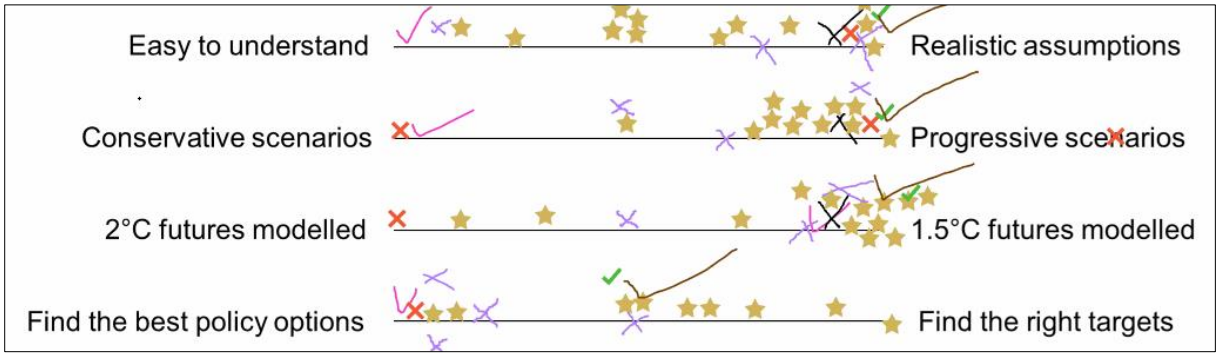

Figure 6: Prioritisation to the question: Which model feature/quality is more important to you? (live annotation with stars, crosses, and tick-marks optionally, N=n/a)

The last live polling was dedicated to the modelling platform. The session chair asked the participants what is essential for them to use the modelling platform. Stakeholders expressed high demand for model overviews and catalogues (general model documentation), specific information on models (application in specific case studies), as well as information on linkages between models, and the ability to download models and sources (see **Figure 7**).

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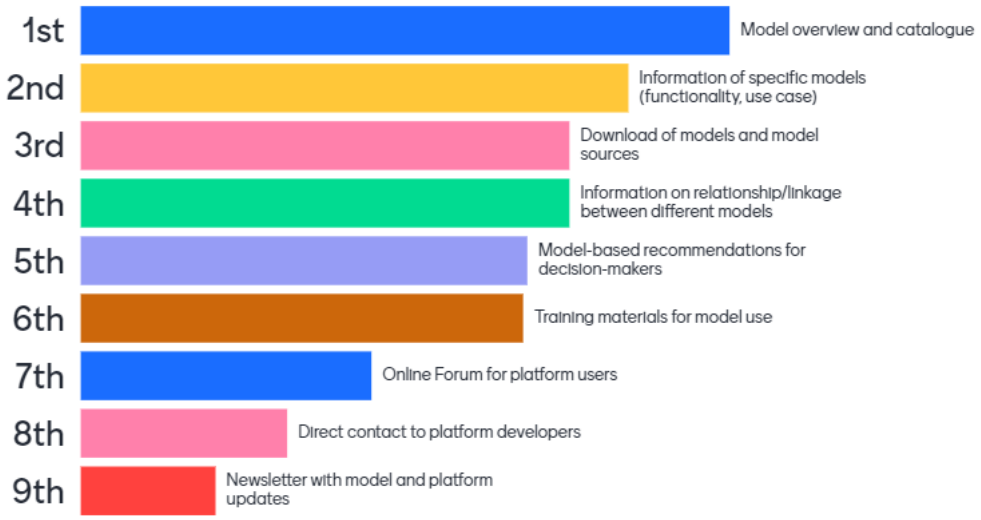

Figure 7: Ranking to the question: SENTINEL will build a model platform that documents different models. What is essential for you to use it? (N=22, live poll)

A discussion followed the prioritisation of user needs. One issue brought up concerned the ability of models to take various regulatory framework conditions into account to model different incentives and mechanisms. One participant emphasised the differentiation between policies and regulations and how both affect each other. Furthermore, one person raised the importance of modelling results being also presented at modelling platforms so that stakeholders are able to dive into more details and build up their future work. This would lead to an increased understanding of models and transparency of modelling results. Last, one participant expressed the need for energy models that include agricultural aspects and land use developments.

3 Parallel Breakout Sessions

Session 1: Social and policy aspects in energy models

Session 1 was hosted by Prof. Dr. Johan Lilliestam and Dr. Diana Süsser from IASS and was dedicated to the integration of social and policy aspects in energy models. First, the session hosts asked the stakeholders what non-technical aspects are currently missing in models. In this context, different aspects related to citizens/consumer behaviour, social choices and impacts, environmental impacts, as well as policy and policy frameworks were mentioned (see **Figure 8**). As a next step, different needs for the integration of these aspects had been discussed. These included the need: **(i)** to understand the science and to compare it with ongoing policy processes, **(ii)** to understand the social implications of different energy scenarios, **(iii)** to understand how behavioural changes can be triggered by policy changes, and **(iv)** to measure distributional impacts, for example local (co-)benefits, but also actual and perceived costs on less wealthy parts of the society.

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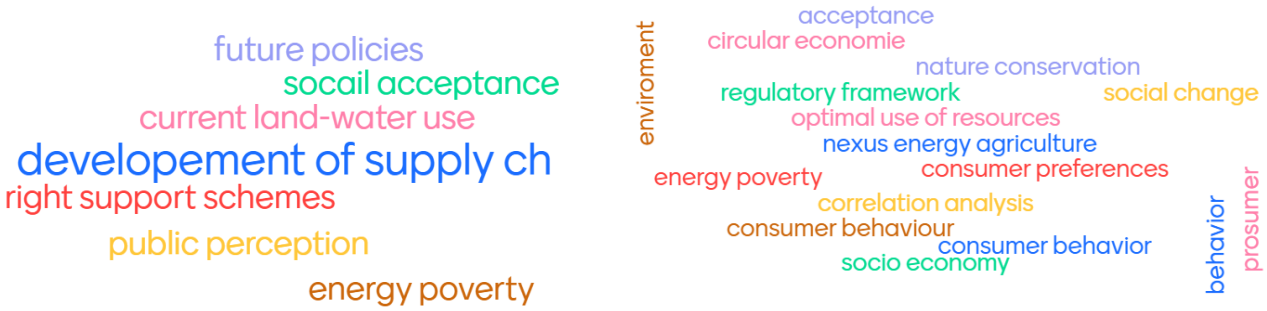

Figure 8: Answers to the question: What non-technical aspects are, from your perspective, missing in the models or model results that you use? (N=9, live wordclouds, 2 rounds)[1]

Next, the session hosts conducted a live poll to address the question what social aspects are most important to be integrated in energy models. Participants of this session pointed out to an improved integration of the impacts of social issues on energy politics (e.g., forced by social movements), the social acceptance of energy technologies and infrastructure, as well as consumer behaviour in energy models (see **Figure 9**).

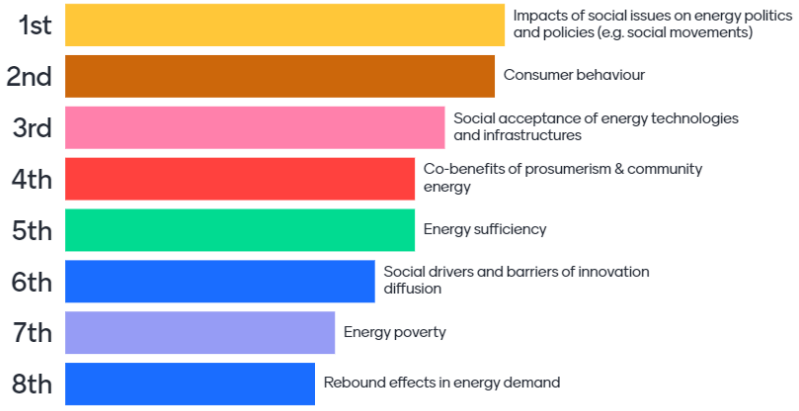

Figure 9: Ranking to the question: What's most important to be (more) integrated? (N=7, live poll, first round)

Finally, the session leads presented the social modelling toolbox QTDIAN, currently under development. The key discussion points and findings are summarised in **Figure 10**.

[1] Colour and size have no meaning in the figure.

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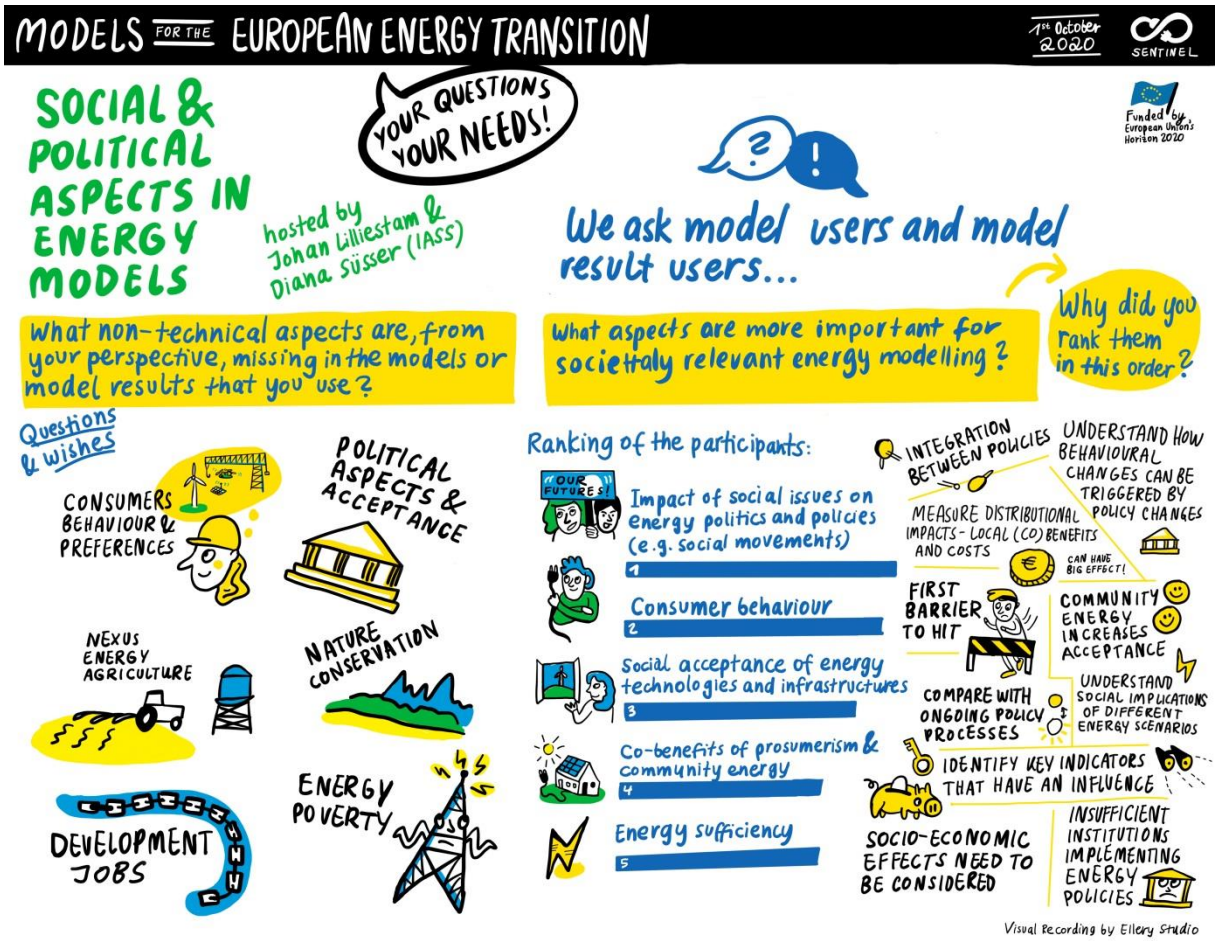

Figure 10: Visual recording of Session 1. Illustration by Ellery Studio.

Session 2: Including environmental aspects in energy system models

Session 2 was hosted by Dr. Cristina Madrid López and Nicholas Martin from the Universitat Autònoma de Barcelona and was dedicated to the integration of environmental aspects into energy models. First, participants were asked to list environmental aspects or impacts that they think are important to include in energy modelling. After using the '*Mentimeter'* word cloud board, we have processed the frequency of responses by own environmental (and social) categories as follows:

1. Nature and biodiversity: 5
2. Full life cycle impacts: 4
3. Electromagnetic & noise pollution: 2
4. GHG and other emissions: 2
5. Raw materials/circularity: 2
6. Human health: 1
7. Water pollution: 1

In order to prioritise these categories, the session hosts next asked participants to repeat the above process using a matrix in the *'MIRO'* application. Participants were asked to write text within 'sticky notes' and then to place these blocks of text onto a matrix that included four

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priority scores – *must*, *should*, *could* and *won't* – according to the 'MoSCoW' method[2] (see **Figure 11**). The blocks could also be grouped by user type – science, policy, industry, and NGO – regardless of the group that they themselves fall into. Importantly to note, stakeholders participating in this session did not post opinions for the '*won't*' score.

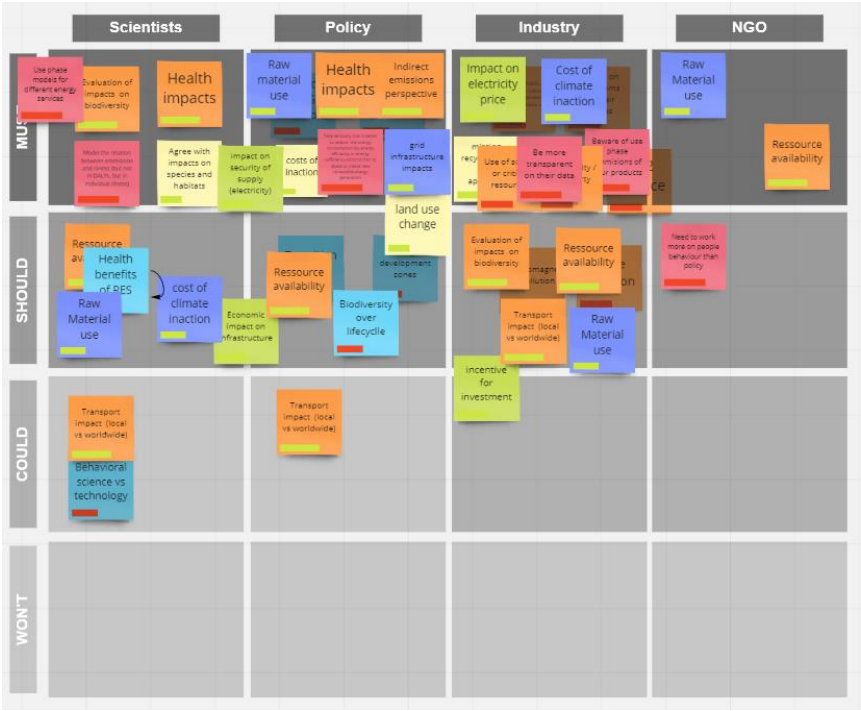

Figure 11: Responses to the question: What environmental aspects are needed? (N=7)

By weighting the 'must', 'should' and 'could' scores with four, three, and two points, respectively, a final score for each category of environmental issues/impacts was derived as follows:

1. Raw materials/circularity: 39
2. Nature and biodiversity: 22
3. Full life cycle impacts: 21
4. GHG and other emissions: 12
5. Human health: 12
6. Electromagnetic & noise pollution: 6
7. Land use: 6
8. Water pollution: 0

Lastly, in order to assess the reasons that these categories were deemed important, and how they will be used, the session moderators undertook an interactive exercise by allowing participants to write their thoughts within a *'MIRO'* mind mapping sheet, while a discussion was undertaken to clarify the points being added. Three key categories could be identified:

- To aid decision-making processes.
- To enable links to other models, policies, and strategies.
- To facilitate citizen empowerment and stakeholder engagement.

[2] MoSCoW method is a prioritisation technique, see International Institute of Business Analysis (IIBA), 2009. A Guide to the Business Analysis Body of Knowledge. 2nd edition, Toronto, Ontario, Canada.

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Figure 12 provides a summary of the session.

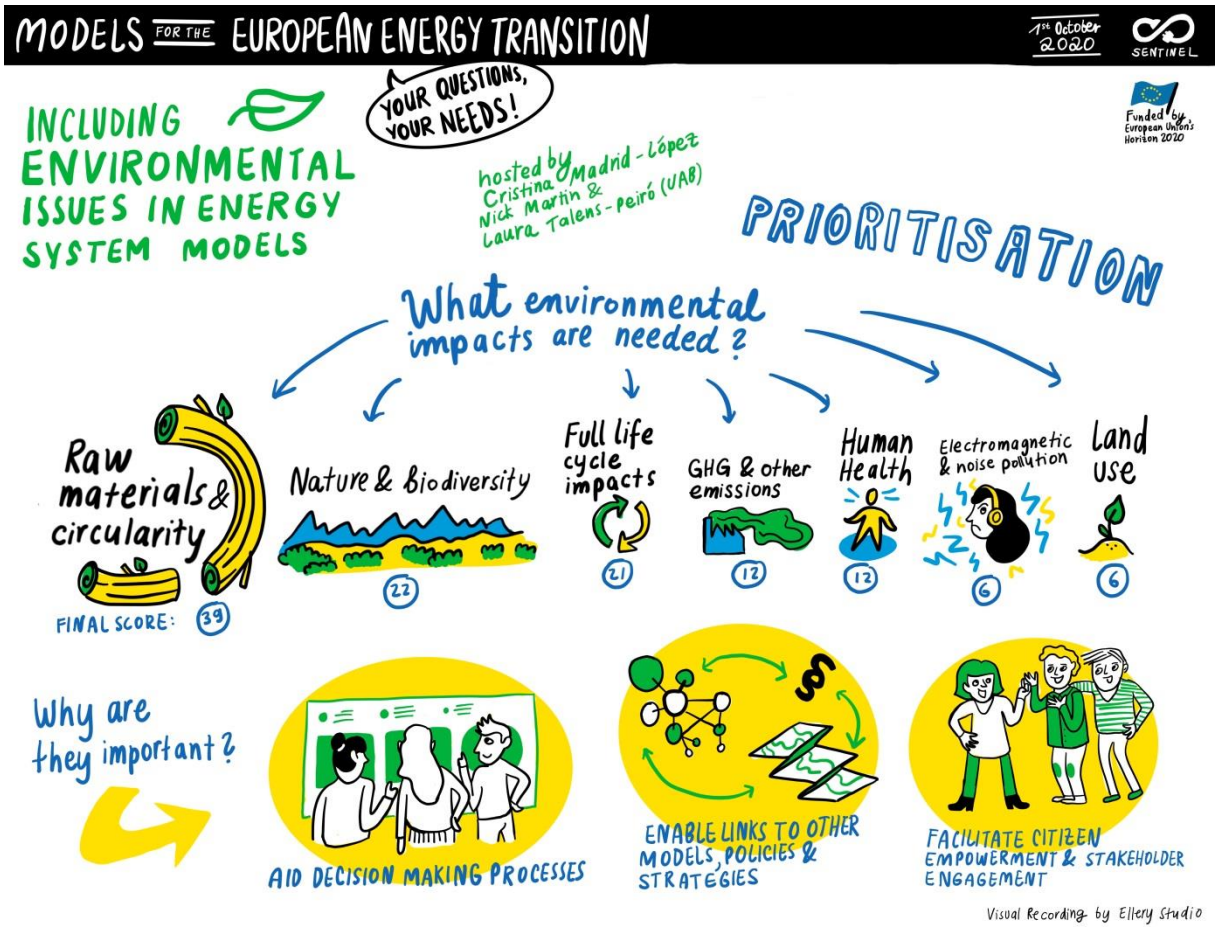

Figure 12: Visual recording of Session 2. Illustration by Ellery Studio.

Session 3: Modelling energy demand and supply

Session 3 was hosted by Dr. Souran Chatterjee and Prof. Dr. Diana Urge-Vorsatz from the Central European University, together with Prof. Dr. Jakob Zinck Thellufsen from the Aalborg University. The session started with a presentation about the importance of modelling energy demand and supply, and the introduction to the four energy demand models (DESTINEE, BEVPO, HEB and DREEM) as well as the three energy supply models within the SENTINEL modelling framework (EnergyPLAN, Calliope, IMAGE).

Both the demand and supply models play a vital role to support policymaking and decision-making. The presentation was followed by a discussion of key questions addressed to the stakeholders: What do you think a demand model should assess and with what time horizon (2030/2050/2100)? What kind of supply modelling is crucial to you?

The discussants found that demand and supply models should be used to model demand and supply of energy for 2030 and 2050 (EC decarbonisation targets). Modelling for 2050 to 2100 involves too much uncertainty, and it has been perceived to be like “modelling the unknown”.

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The discussion, moreover, showed a high demand for modelling behavioural aspects, such as prosumer and consumer profiles, demand-side management, and demand responses. These aspects are important because they could provide flexibility and balancing services to the grid. Furthermore, the participants of this session discussed that renewable energy production, including building-integrated renewable energy generation, varies geographically, and this is an aspect that should be incorporated in the demand and supply models.

The participants also emphasised that, in addition to modelling demand and supply, it is important to understand and acknowledge the vital role of strategic investments to technological innovations, such as hydrogen and battery storage, in order to achieve 100% renewable energy production. This aspect of investments demands for much more emphasis on the coordination between demand and supply modelling. On the other hand, it was highlighted by the participants that, although some of the key effects of energy efficiency measures, such as digitalisation, are already considered in demand models, smart features (e.g., smart appliances) should be also incorporated in energy demand modelling, and that energy efficiency should be modelled in supply models and not only in demand models.

In summary, the session hosts identified four key gaps in demand modelling that should be tackled (see **Figure 13**):

1. Modelling of lock-in effects
2. Integration of renewable and energy-efficient measures
3. Modelling of the ´human factor`
4. Data scarcity in energy demand modelling

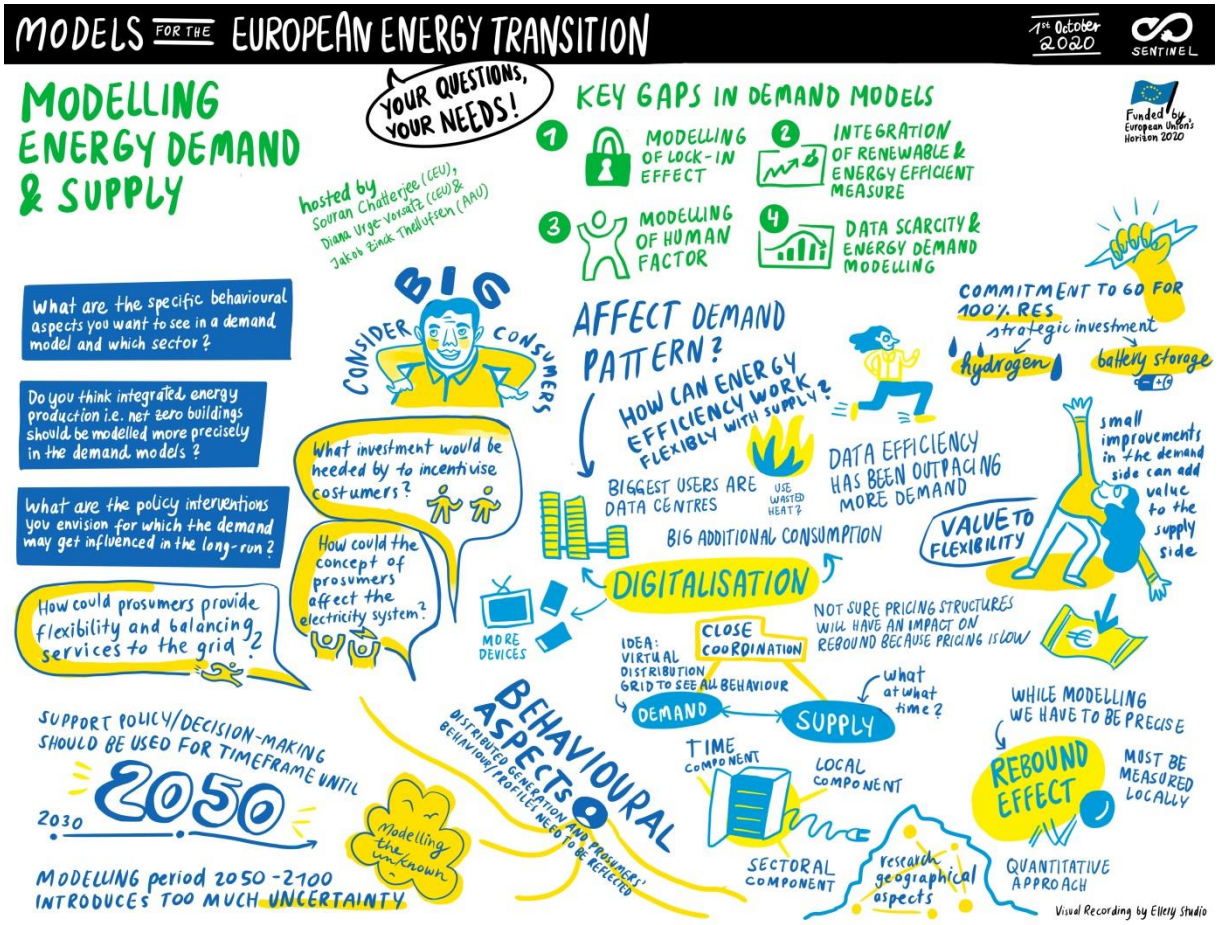

Figure 13: Visual recording of Session 3. Illustration by Ellery Studio.

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Session 4: Modelling the economic impacts of the energy transition

Session 4 was hosted by Mr. Tarun Khanna from the Hertie School and Jakob Mayer from the University of Graz and dealt with the economic impacts of the energy transition. The session started with a presentation about the relevance of modelling and an introduction to the three economic models within the SENTINEL modelling framework: EMMA, BSAM and WEGDYN. The hosts presented the key model improvements planned and discussed the relevance of the models, model improvements, and model linkages with the participants (see **Figure 14**). The session hosts received high ranking for all three aspects, with different weights in the two rounds.

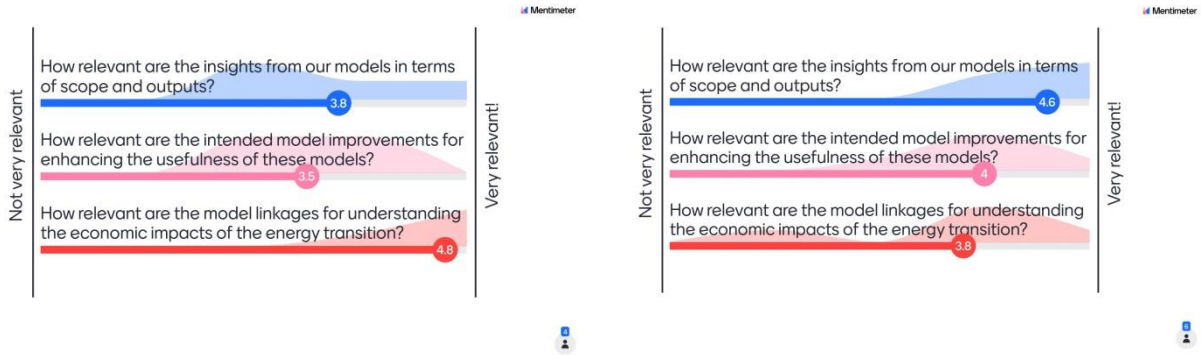

Figure 14: Responses to the questions of the relevance of the models, model improvements, and model linkages (Round 1 with N=4, Round 2 with N=6, live poll)

The live ranking was followed by a discussion. The discussion revealed the significance of temporal and geographical resolution of models to be considered when inter-linking models. The participants emphasised the need for harmonised model inputs and outputs during modelling exercises. Furthermore, the stakeholders demand to model pathways towards a point in time instead of simulating specific points in time because it would make modelling analyses much more dynamic. This allows highlighting concrete steps and milestones along the way necessary to achieve societal targets such as the “well below 2°C” objective of the Paris Agreement.

Additionally, an important point discussed was the topic of uncertainty. Participants expressed the need to communicate model uncertainties in a transparent way. This can be done by comparing the outputs of different models with similar scope and by conducting sensitivity analyses, both in a standalone and in a soft-linked manner, to find the most important factors related to the outputs of the models. Both approaches will be taken within SENTINEL.

Moreover, the moderators identified the need for a better consideration of issues such as energy poverty at the micro level in models, in addition to accounting for achieving emission reduction targets at the macro level. In looking at such trade-offs, the stakeholders consider necessary to analyse ways on how to manage or overcome them. This could be done by using multiple criteria of measuring societal well-being when comparing different energy system designs.

The session also brought up needs linked to session 1 and session 2. Participants stated that models should be able to capture the social aspects (e.g., social acceptance of new technologies, or citizen lifestyles) of the energy transition. Policymakers specifically demanded

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that insights regarding the environment and society should be provided through modelling exercises.

Another key takeaway is that revenue streams of the centrally organised energy system (i.e., few large utility companies) are going to shift from wholesale markets to ancillary service markets because of the increasing share of decentralised variable renewable electricity generation. Towards this direction, demand-side management has been seen by the session participants to provide significant additional value.

Last, stakeholders emphasised that policy implications based on the model results should consider the timing of decommissioning and policies for renewables, to derive business models and strategies for the coming years.

Figure 15 shows a summary of the session's key points of discussion.

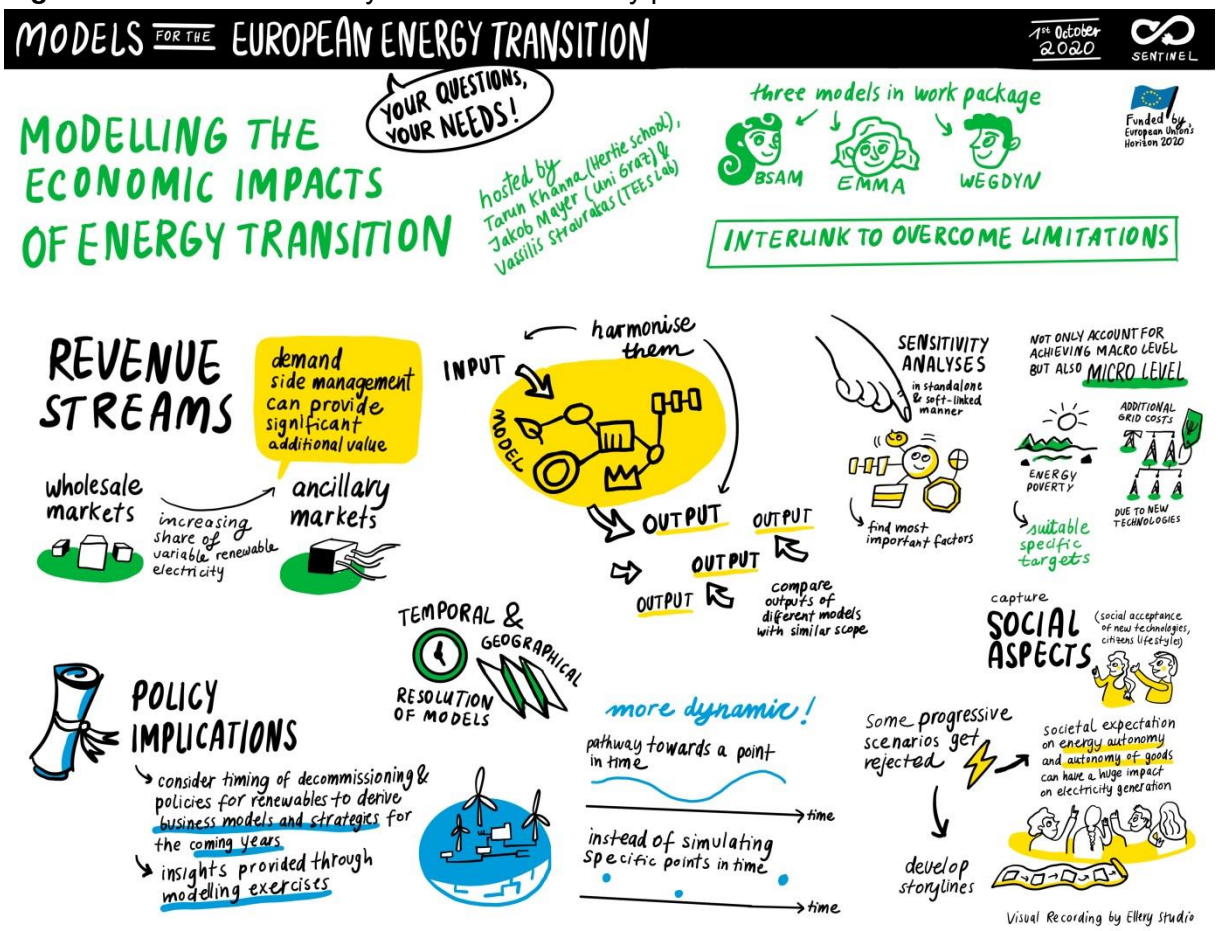

Figure 15: Visual recording of Session 4. Illustration by Ellery Studio.

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Session 5: Designing the model platform of SENTINEL

Session 5 was hosted by Suvayu Ali of ETH Zürich and Andrzej Ceglarz from the Renewables Grid Initiative. It was dedicated to the technical aspects of the development of the SENTINEL energy modelling platform. Modellers from the SPINE and the openENTRANCE project participated in this session and shared their opinions on relevant developments needed and synergies between the projects.

One participant remarked that a primarily text-based data format is difficult to scale to large datasets, and thus, there is a need to extend frictionless data package to existing binary data formats like HDF5 and NetCDF.

The participants of the session compared the workflow managed in the SPINE project and SENTINEL. The SPINE project provides an integrated workflow solution based on the Python library dagster. In comparison, the SENTINEL modelling platform does not propose any solution to manage workflows; it is solely focused on the frictionless data format. This choice is motivated by the desire to accommodate diverse working environments. That said, providing workflows for frequent repetitive tasks like dataset creation has been identified to potentially be useful.

Another point of discussion was data validation. The participants identified a potential overlap with the SPINE project, and there is potential for collaboration on this topic. A common requirement for both projects is validating against foreign keys, meaning that a part of the dataset should be validated by a condition on a different part of the dataset, e.g., when a model has definitions of entities, which then form an allowed set. The next step will encompass checking in another part of the dataset, if an entity is present in the allowed set.

Furthermore, the discussants found that there is a common requirement to reconcile different temporal and spatial resolutions. Often the basis of segmenting data may be incompatible, e.g., a spatial dataset can be segmented by administrative regions or structurally, say, a power company might segment demand data based on their installed capacity. This issue does not have a clear solution, however, the issue of scale is partially addressed by the SPINE modelling toolbox, by defining "moldable regions": it retains data in their most granular units, and aggregates them to create the larger units as needed.

Last, the topic under discussion was the Application Programming Interface (API) design. One possibility that emerged from the discussion was to follow and match the API used by the SPINE project to read/write datasets. This approach will improve the compatibility between the SENTINEL platform and the SPINE project. **Figure 16** summarises the key points of discussion.

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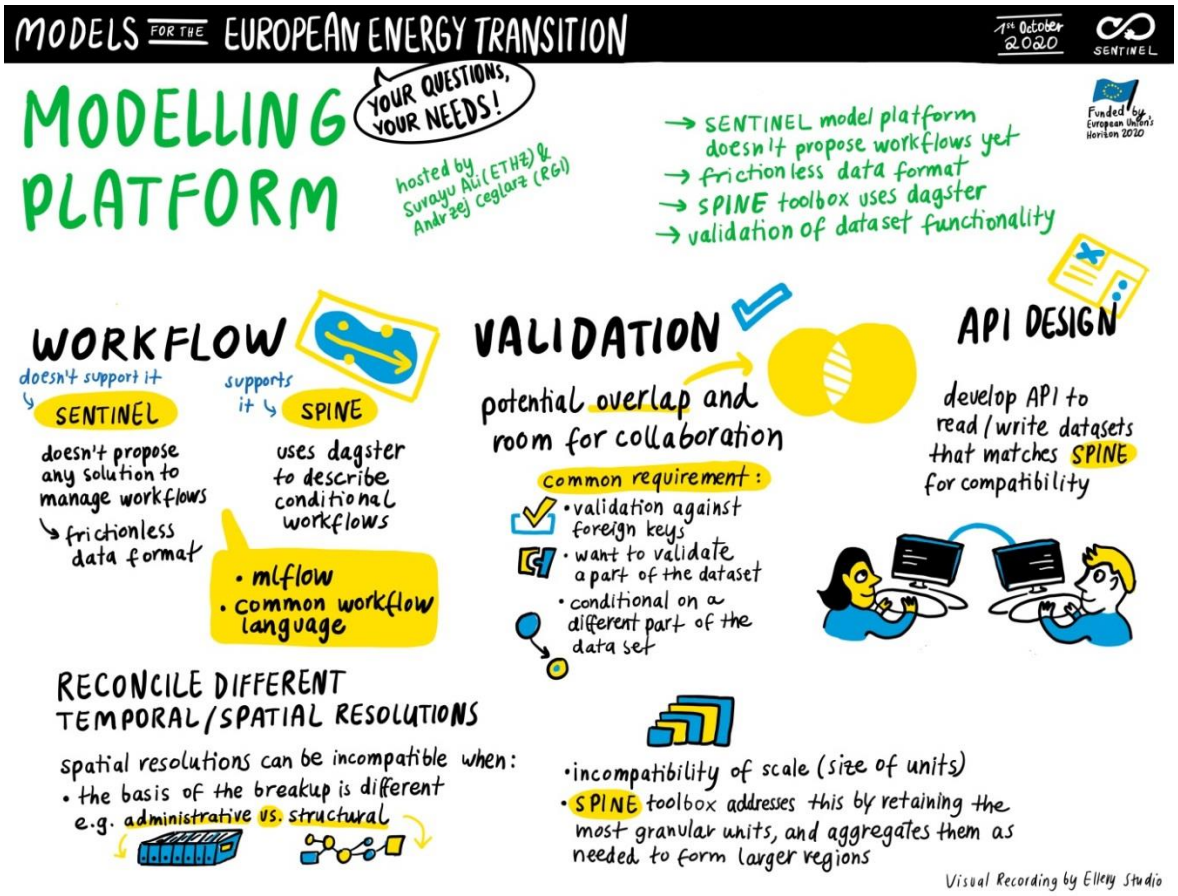

Figure 16: Visual recording of Session 5. Illustration by Ellery Studio

4 Closing Plenary Session

The closing plenary session started with a summary of the morning plenary by Dr. Diana Süsser, by using the visual recording of “Ellery Studio” (see **Figure 17**). The summary was followed by short presentations of the discussion points and findings of the parallel sessions by the session hosts, to ensure all issues relevant for the participants were reflected. The participants had a chance to add further aspects to the summary via the zoom annotation function and the chat. Raised topics included model structure inter-comparisons, uncertainty aspects, and model integration. The hosts used ZOOM annotation to capture final needs and feedback and ended the workshop with an outlook of the next steps within the SENTINEL project and opportunities to stay connected with the participants in the future.

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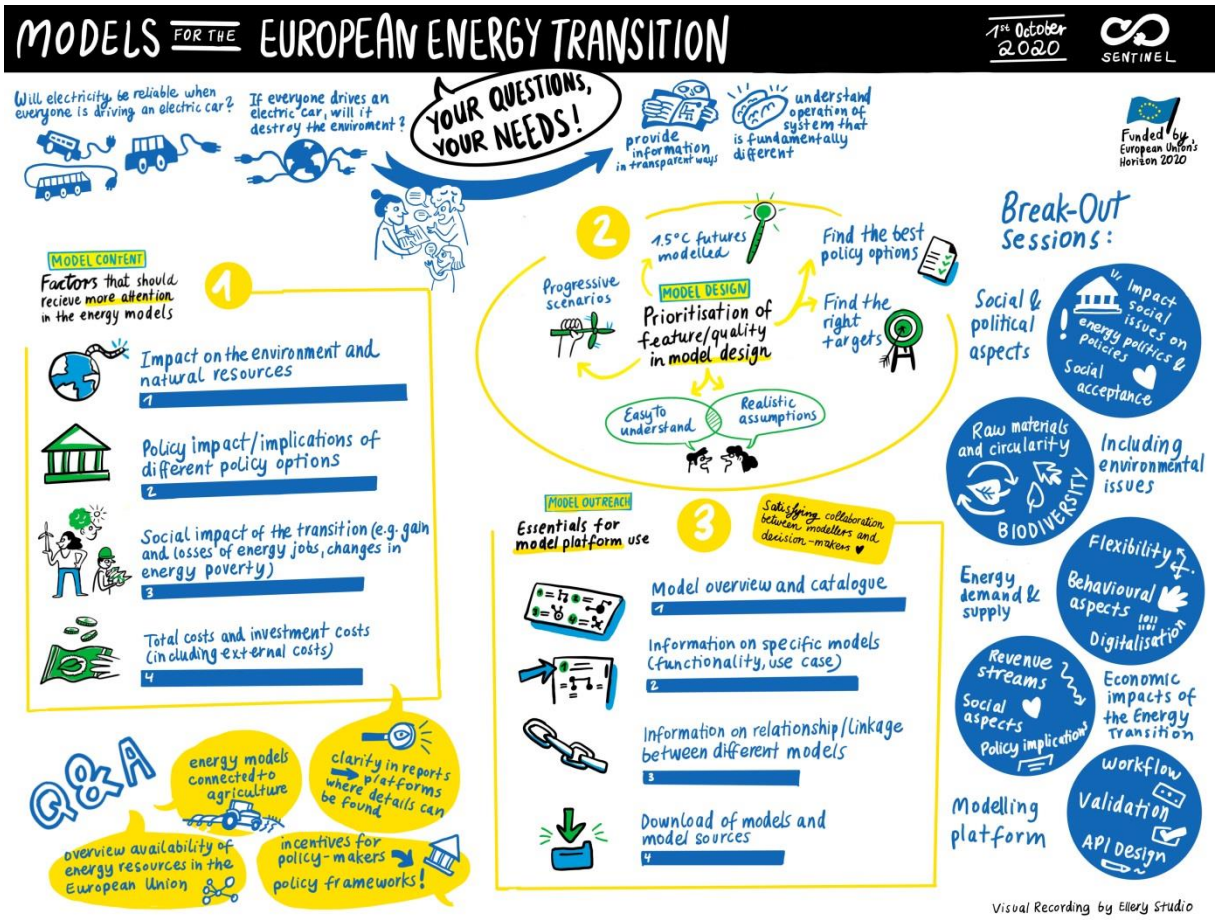

Figure 17: Visual recording of the key user needs identified

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About SENTINEL

The Sustainable Energy Transitions Laboratory (SENTINEL) project is funded by the European Union Horizon 2020 research program. The transition to a low-carbon energy system, as understood by the scientific and policy communities, will involve a major redesign of the energy system, primarily around renewable sources, in accordance with 2030 and 2050 targets that the European Commission has defined. The interdisciplinary consortium of energy modellers develops an open-source platform, which consists of well-suited energy models to support the European Energy Transition. Please find an overview of project partners and modules below. Please find more information about SENTINEL here.

The SENTINEL models and consortium

Module	Model	Focus	Developer
Social and Environmental Transition Constraints	QTDIAN*	Social drivers/constraints of technology diffusion	Institute of Advanced Sustainability Studies (IASS), Germany
	ENVIRO*	Life-cycle analysis of energy technologies	Autonomous University of Barcelona (UAB), Spain
	ATOM	Agent-based technology adoption	University of Piraeus Research Center (UPRC), Greece
Energy Demand	DESTINEE	Electricity demand generator	Imperial College London, UK
	BEVPO	E-mobility diffusion, utilisation, and charging	ETH Zürich, Switzerland
	HEB	Technology-specific building sector demand	Central European University (CEU), Hungary
	DREEM	Energy demand and Demand-side management	University of Piraeus Research Center (UPRC), Greece
System Design	EnergyPLAN	Energy supply: focus on sectoral integration	Aalborg University (AAU), Denmark
	Calliope	Energy supply: focus on geographical integration	ETH Zürich, Switzerland
	IMAGE	Global integrated assessment model	Utrecht University (UU), Netherlands
Economic Impact	EMMA	Top-down electricity market simulation	Hertie School (HSG), Germany
	BSAM	Agent-based capacity bidding simulation	University of Piraeus Research Center (UPRC), Greece
	WEGDYN	Computable general equilibrium impacts	University of Graz (UGR), Austria

* new model to be developed within the project

… with additional support of

Acknowledgments

We would like to thank all participating stakeholders for dedicating their time and providing us with important input during the workshop. We are also grateful to all SENTINEL partners for the commitment in organising this workshop as well as for their support in writing this report.

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List of Participants

Last name, first name	Affiliation, country
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