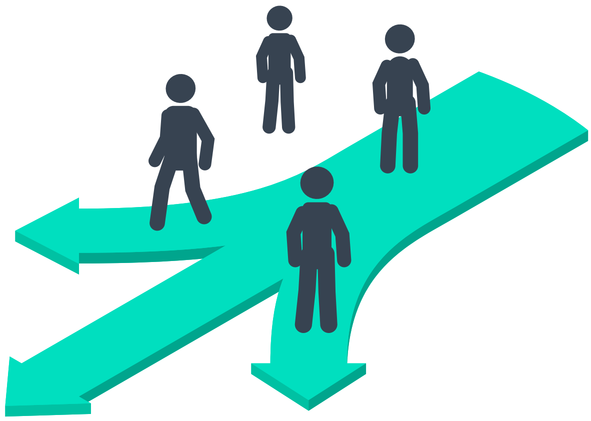
SSH CENTRE

Modelling and Social Sciences & Humanities: Integration of social insights into technical models



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ABSTRACT

Models of climate, energy and mobility systems can support understanding and policy development in these areas, but current models either focus on the physical or social systems, with little integration between the two. An integration of SSH and STEM dynamics via modelling is necessary to advance understanding in these complex systems and develop integrated policy solutions. This can be achieved by promoting interdisciplinary collaborations and by using participatory methods to engage with the actors currently excluded from the policy process.

SUMMARY

- Modelling in climate, energy and mobility systems can support better understanding of interconnected challenges and the development of integrated policy solutions.
- Current models don't integrate technical (STEM) and social (SSH) dynamics well – STEM and SSH modelling communities are (somewhat) divided. An integration of SSH and STEM dynamics via modelling is needed.
- Not accounting for SSH dynamics in models can result in imprecise predictions and ill-thought transition policies.
- Participatory (SSH) methods such as citizen assemblies can facilitate interdisciplinary STEM and SSH collaborations, which in turn can support the development of integrated models.
- Interdisciplinary STEM and SSH collaborations to develop models can bring challenges but give life to more comprehensive models and policies.

KEY DEFINITIONS

Model – "a simplification – smaller, less detailed, less complex, or all of these together – of some other structure or system" [1, p.2]

Complex system – A series of entities or parts, all interconnected with one another. This interconnectedness generates 'emergent' dynamics that would not be capture if each component was examined in isolation

Computer simulation (or modelling) – uses the computing power of pcs to create models of real-life dynamics, to study their behaviour in a virtual environment [2]

Introduction

The development of computer and simulation models has long been part of European strategies to achieve long-term sustainability in in a number of sectors, including the energy sector (e.g. [3,4]). This is reflected in the number of projects funded to develop new models or integrating existing ones (e.g. MEDEAS H2020[1]; SMARTEES[2]) and is supported

1 https://medeas.eu/
2 https://local-social-innovation.eu/

by 'smart' systems (e.g. smart energy meters) and 'big data', which generate a wealth of data critical for simulations [5,6].

One of the key purposes of modelling or Computer Simulation (CS)3 in climate, energy and mobility is to support understanding, decision- and policy-making. Models provide insights on the different systems involved (e.g. amount of critical minerals required by the energy transition) and by simulating how they are connected and how specific dynamics evolve through time, models provide forecasts of the future state of a system (e.g. IPCC reports). These alternative future scenarios can be used to develop integrated policies to support the sustainability transition in these sectors. However, current models tend to focus either on the physical and technical (i.e. STEM) or the human and behavioural components (i.e. SSH), with insufficient integration between the two, therefore leading to partial solutions [WJ].

This literature brief reviews current practices, emerging understandings and future directions for SSH and modelling, highlighting the continued existence of a divide between SSH and STEM modelling communities and a necessary integration between SSH and STEM via CS to support the sustainability transition. This research-based brief argues[4] that the gap can be bridged by supporting interdisciplinary teams that span these communities. In doing so this would support innovative projects that push the boundaries of different disciplines, bringing them closer and therefore giving life to more comprehensive, integrated models of climate, energy and mobility systems.

Current understandings

Significant findings

The **aim of modelling is to develop simplified representations of complex systems** to [1]:

- Help understand the interconnectedness of systems;
- Identify the source of specific challenges;
- Make predictions of the future state of the system;
- Support policy design by understanding potential cascading effects of policies implemented.

In the context of climate, energy and mobility systems, modelling can help answer questions such as 'what is the potential sea-level rise in a +1.5° world?' or 'what is the most efficient carbon policy to reduce carbon emission in the energy system?' or 'what incentives could lead a market to switch to a fully electric car fleet?'. The answers to these questions clearly involve interactions between physical and human systems.

Disentangling the complexity of these systems requires methods and techniques that can capture the interaction between social, technical and ecological dynamics, the decision making of diverse social actors and the non-linearity embedded in some of these interactions [7]. Modelling can support this integrated approach and develop understanding of the interconnections between different systems, but can also be a virtual laboratory to test potential first, second and nth order effects of a policy. **Modelling can therefore support the development of integrated policies that consider both the social dynamics and physical limitations of the systems involved**.

Despite modelling becoming increasingly popular with both STEM and SSH communities, these **modelling communities continue being divided, producing models that focus either on the physical (STEM) or social (SSH) dynamics** [WJ; PMSS]. This is especially problematic when investigating complex topics such as climate, energy and mobility, which are all (interconnected) complex systems where both social and physical dynamics play a large role [8]. Not accounting for either physical or social dynamics can lead to partial understandings and misguided solutions. For instance, climate models that do not include people's choices and behaviours both positively (e.g. fast shift in energy demand) or negatively (e.g. complexity and cost) could lead to wrong future scenarios. Similarly, models that focus on influencing people's transport choices would not see full application unless the technical system was built into the model to show what is technically possible (e.g. how quickly can electric cars be produced). SSH dynamics (i.e. here intended as human behaviours, culture, etc.) influence every step and actor involved in the sustainability transition, particularly on the demand side and around the acceptance of new solutions and how decisions are made. It is widely acknowledged that climate-related challenges are rooted in social behaviour [9].

Integrating SSH and STEM dynamics via modelling is therefore necessary to advance our understanding in these complex systems and develop integrated policy solutions. However, integrated models currently available only include a stylised version of the 'other' system (i.e. STEM stylises behaviours, SSH stylises physical dynamics), which is still a limited approach. This is due to a series of **challenges that hinder a full integration** [WJ; PMSS]: 1) the **balance between simplicity and complexity of integrated models** - embedding SSH understandings (e.g. human behaviours) in technical and physical models increases the complexity of simulations, which may result in a model that is too complex to understand. Significant simplifications need to be made, with the risk of oversimplifying human behaviours [10]. Any model thus comes with serious caveats, which are often not acknowledged (by researchers) and therefore not understood (by decision-makers); 2) how to **translate and implement qualitative SSH data into models** - models tend to require/prefer large amounts of quantitative data and key social dynamics need to be reduced to parameters (e.g. the speed of social change, change of lifestyles, etc), which may result in a misrepresentation of those behaviours and, ultimately, in inaccurate findings; 3) **difficulty in characterising *change*** - to provide future scenarios, models need to specify how behaviours will change to simulate the evolution from today to the future (e.g. 2050), but in SSH research it is challenging to study these hypothetical changes to inform models.

Emerging practices

Interdisciplinary collaborations between and SSH and STEM communities working with models are key to develop models that can better simulate social factors, which are necessary to simulate transition behaviours [7; PMSS]. **These can**

3 Hereafter called 'modelling', as here modelling and CS are used as synonyms.

4 This work is based on a literature review of the fields involved and interviews with two experts.

be facilitated using qualitative, participatory methods such as stories, narratives and storytelling (e.g. see [11]). These are increasingly being used to capture data on social behaviours that can be used to inform climate, energy and mobility models [WJ; PMSS]. **Participatory modelling** [12] is another method that can support the integration between STEM and SSH dynamics via modelling. This involves an iterative process where the model is developed with the actors involved in the system that is being simulated. This process ensures active participation by the actors involved to capture key dynamics and behaviours to include in the model and ultimately their ownership and buy-in in the model and its results.

Some of these methods are implemented in past and current projects that champion best practice in the field. **SMARTEES**[5], for instance, is a modelling project that used participatory methods to engage with a large number of stakeholders to inform model and policy development. The project aimed at improving policy design to support the energy transition by fostering inclusive participation of citizens and local communities in the development of models and found that using participatory methods to involve these actors in model and policy development can lead to acceptance of solutions proposed [WJ]. The team developed a model to evaluate the effects of policy interventions and social innovation related to energy and mobility and implemented a range of participatory methods: co-production to develop scenarios that were used as input in the model, interviews and surveys to capture key behaviours to be represented in the model and engagement activities such as citizen assemblies and neighbourhood open events to ensure members of the public were represented in models' aims and thinking.

Finally, the **BEHAVIOUR**[6] project champions interdisciplinary STEM and SSH collaborations bringing together psychology, social science, technology, economics and energy system analysis to develop Agent-Based Models. The models developed simulate the energy behaviours of private households by introducing human behaviours in the models with the aim of understanding whether individuals can be influenced to support the low carbon transition in Norway [PMSS].

Future SSH priorities

Despite initial efforts to integrate SSH and STEM insights into models, **further work is needed to develop comprehensive, integrated models that capture the nuance of actors in the interconnected climate, energy and mobility systems**. This is going to result in increased understanding of cascading effects in socio-technical-environmental systems, more accurate simulations and, ultimately, in the design of policies that can provide the right incentives to steer behaviours towards sustainability [8]. Future integrated models will be able to test these policies to identify unexpected consequences and prepare for second and nth order (unexpected) effects. However, this is also going to result in a higher complexity of the models and therefore the need for better and more careful communication of the results and their validity [PMSS].

The modelling techniques and methods to integrate SSH and STEM are engaged in a maturation process of their own [WJ], with models being able to simulate increased complexity thanks to increased computing power and the development of participatory approaches that can support wider engagement, which could lead to a longer list of methods to support the integration. The list of actors invited to participate in modelling, policy and future scenarios is also going to expand to include harder-to-reach members of society, businesses, community groups and other organisations and ensure a plurality of opinions, aims and interests is represented. **The increased implementation of participatory methods such as participatory modelling, applied to a larger audience to introduce SSH topics in models around climate, energy and mobility is going to result in higher levels of engagement from all actors involved and a renewed push towards the transition**.

The maturation of modelling, the computing technological advancements and Big Data [13] will allow to run more complex simulations allowing for modelling of more nuanced behaviours. One interesting development in the field is 'plug-and-play' models, i.e. the development of 'modules' (e.g. betting behaviour, energy market, climate change dynamics) that can be reused to enhance existing models or build new ones to avoid duplication of efforts [WJ], which will support the diffusion of more sophisticated behavioural models.

These **developments in modelling and participatory approaches can also lead to new research questions** where models can help understand the role of human behaviours in the solution to key challenges (e.g. 'how can energy use and demand change over time in energy systems?'), or the interconnection between different systems (e.g. 'what are the opportunities in the employment sector driven by the sustainability transition?'), or identify win-win solutions (e.g. 'what are the key components of a policy to promote a just transition and minimise resistance?') [PMSS]. The focus on participation in models could raise new questions on, for instance, understanding the role of local neighbourhoods and generally local democracy in the sustainability transition [WJ]. **Humans have the responsibility to understand how we can limit our impact on the environment, and integrated models can help** [WJ].

Takeaways

Takeaways for the European Commission

- More EC funding should be dedicated to interdisciplinary groups that undertake projects that have a strong and wide participatory component and who involve in the model and policy development actors that are currently left out to lead to more inclusive and (likely) accepted policies;
- EC funding should be directed to developing new shared 'languages' such as modelling which will support interdisciplinary collaborations;
- Funding should prioritise the development of new and extend existing models of socio-technical and ecological systems to bring together SSH and STEM modelling communities;

5 SMARTEES •• LOCAL SOCIAL INNOVATION (local-social-innovation.eu)

6 https://ife.no/en/project/role-of-energy-behaviour-in-the-low-carbon-transition-behaviour/

- Integrated SSH and STEM models on climate, mobility and energy can be used by EC to design proactive future-looking policies that consider potential responses from the actors they are trying to target, to ensure that the measures to promote the transition are likely to be accepted and this should be promoted across all sectors managed by the EC;
- The integration of SSH and STEM via modelling should be included in the EC priorities as it supports just transitions [PMSS];
- Transition is characterised by turbulence and the predictive capacity of models decreases. EC should promote better communication of modelling-based project results explaining validity and limitations [PMSS].

Takeaways for Stakeholder and Businesses

- Businesses should approach interdisciplinary collaborations between SSH, STEM and modelling communities as an investment as it takes time to learn to speak the same language, but climate, energy and mobility models resulting from these collaborations are more comprehensive;
- Not taking SSH dynamics into account in modelling the sustainability transition will lead to underestimating the role of people's behaviours, both positively (e.g. fast shift in energy demand) or negatively (e.g. increased complexity) in the transition and therefore give wrong insights [PMSS];
- It is important to engage with a wide range of actors from different parts of the system (e.g. national energy agencies and governmental institutes) and involve citizens in making change happen by including them in the modelling via participatory methods [WJ].

Takeaways for SSH CENTRE

- The SSH and STEM integration via modelling takes time and requires a long-term vision. People engaging in one should seen it as personal development. SSH CENTRE could support this by making the SSH-STEM collaborations in WP2 longer-term and modelling could be one of the methods used.
- A new type of interdisciplinary education needs to be promoted (e.g. knowledge brokers). This should be included in the principles part of the Open Education and Knowledge Platform being developed as part of WP6.
- The integration between SSH, STEM via modelling has mutual benefits for all fields involved [WJ]. SSH CENTRE can support this with its final recommendations to EC and research more in general.

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