Climate Recon 2050:
Dialogues on Pathways and Policy

Transparency of modelling

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Introduction: Importance of open energy system modelling

Energy system models play an important role in the process of deriving climate strategies and policies. They are required for verifying and comparing long-term scenarios for climate-compatible transformations of the energy systems. Due to the high policy-relevance, transparency of the whole process is essential.

In recent years, openness in energy system modelling has gained interest and importance. This can be seen in scientific publications (Cao et al. 2016, Pfenninger et al. 2017, Wiese et al. 2018, Pfenninger et al. 2018), in a growing community (open energy modelling initiative), a growing number of open models and grid and data (Openmod Initiative 2018) and importance of the open aspect in research funding (e.g. Horizon2020 calls for open energy data and models).

The main reasons for openness and transparency of energy system modelling and data are that it

- enables transparency and credibility
- enables reproducibility of results
- reduces duplication of effort and thus frees time to develop new ideas
- allows for broad collaboration

The main challenges of 21st century energy system modelling are summarized in Table 1. These can be summarized in the five groups: complexity, uncertainty, interdisciplinary modelling, scientific standards and utilisation. Wiese et al. (2018) figured out that the properties “open source character” and “collaborative code development” as well as certain structural properties like a modular structure (see Table 2) are decisive for tackling these. An open-source approach is a fundamental condition for complying with scientific standards. Transparency, repeatability and reproducibility which are fundamental for scientific credibility as well as a basis for scientific progress, can only be fulfilled if all data and code is provided openly. Openness of a framework is also advantageous for its utilisation, meaning (re-)usability and applicability. Models that have been developed in collaboration of different programmers additionally increase the contribution to transparency and applicability also for other potential users and recipients of results, since already in a collaborative model development process, documentation, clarity and consistency of terminology are fundamental for the collaboration. Furthermore, the danger of biased code is reduced since different developers contribute different viewpoints, that have to be agreed on before being formulated into model code and assumptions. Thus these assumptions are less hidden and more conscious decisions are taken on assumptions that can also be easier communicated.

Summarizing, black boxes of energy system models are not acceptable in research and policy advice anymore since only open source models comply with scientific standards.

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Table 1: Energy System Modelling Framework properties and respective characteristics that are decisive for tackling the energy system modelling challenges, according to Wiese et al. 2018

Challenge	Aspects
Complexity	Increasing sector coupling; high technical, temporal and regional resolution required; extensive input data pre-processing; extensive result data processing
Uncertainty	Epistemic, aleatory, linguistic, decision, planning
Interdisciplinary modelling	Inclusion of the human dimension; energy-water-food nexus; common transdisciplinary understanding
Scientific standards	Transparency, repeatability, reproducibility, scrutiny, scientific progress
Utilisation	Usability, applicability, re-usability, result communication

Table 2: Categorised energy system modelling challenges, according to Wiese et al. 2018

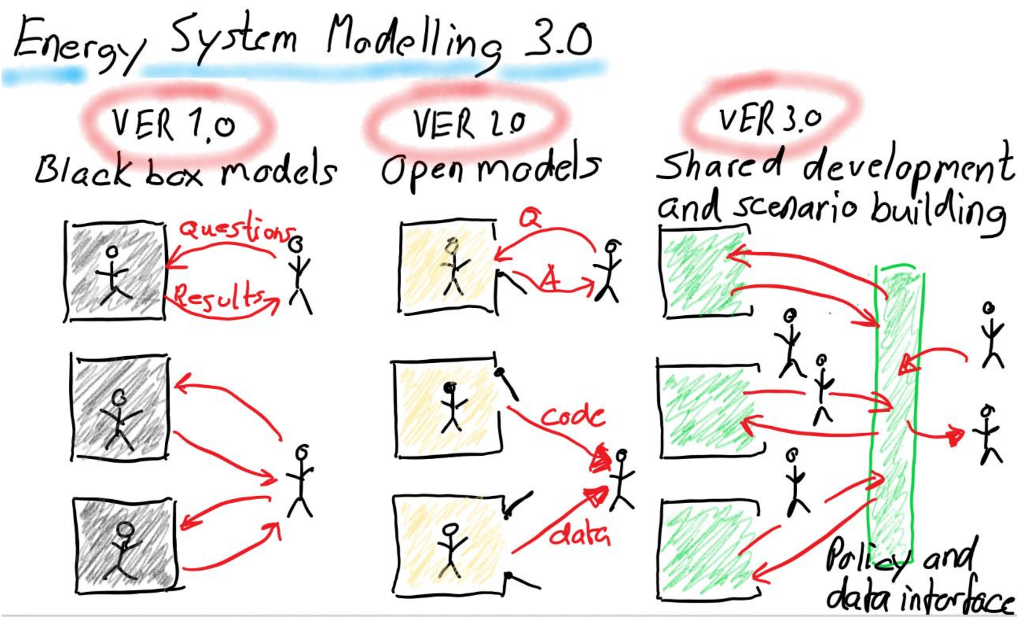
Property	Characteristics
Free and open-source software philosophy	Open-source, documentation, version control, openness of data, code review
Collaborative development	Consisteny of terminology, developer perspective spectrum, intersidciplinarity, testing procedures
Structural properties	Modularity of framework structure, object-oriented implementation, generic concept of energy system representation, data model

Development and status of open energy modelling in Europe

The open energy modelling initiative lists open energy models (Openmod Inititive 2018). According to Brown et al. (2018), their development can be summarized as three waves of open models starting from 2001 with three models, three more in 2010 and additional 24 in 2017.Also for grid and energy data projects, a major increase can be recognized in recent years.

Looking at the history of energy system modelling, one could summarize a development from black box models (Ver 1.0), just providing the results, to a significant amount of open models (Ver. 2.0). These open models provide data, assumptions and code to a different degree of transparency. The next, slowly starting, but not yet realized development could have a focus on shared development and scenario building with policymakers and the better organization of collaborative model development (Ver. 3.0) also across institutes to reduce the huge number of open models doing almost the same, being developed in parallel (see also Figure 1).

Figure 1: Simplified illustration of the different stages of energy system modelling



What should be open?

There is no clear, static definition of an open energy system model, since it consists of several parts that can have different levels of openness as shown in Figure 2 . The challenges in achieving full transparency in the data are higher than for the model code, since energy system models include huge amounts of input data in a mix of different original sources, that are neither well described, nor correctly licensed. **Error! Reference source not found.** breaks down in more detail the different transparency aspects of the energy system modelling process (dark grey boxes) and additionally mentions the different options for the different modelling aspects. Practical advice on the tools and possibilities available for opening the black box of energy system modelling was published in an article from several members of the open energy modelling initiative (Pfenninger et al. 2018)

Figure 2: Open Energy System Modeling Process (Pfenninger et al. 2018)

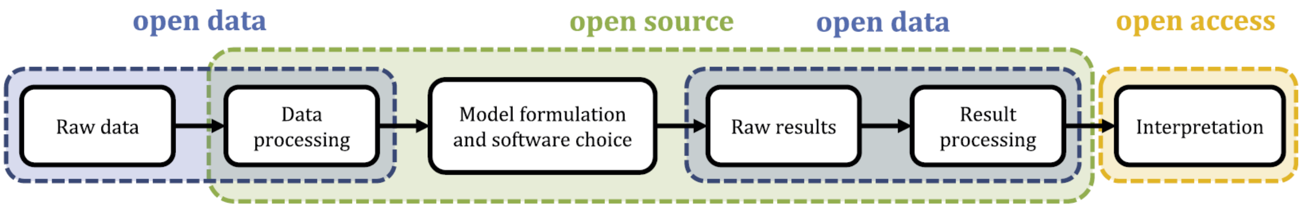
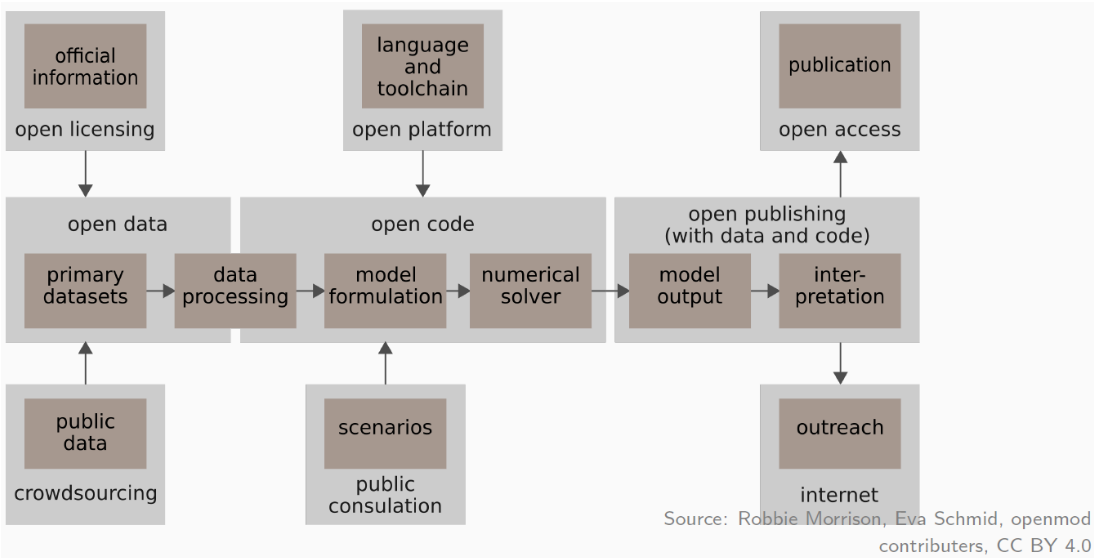


Figure 3: Steps of the energy modelling process and its transparency possibilities (Morrison 2018)



Open licenses

An important progress in clear rules for open models can be attributed to open licenses. An open license is a set of conditions applied to an original work that grants permission for anyone to make use of that work as long as they follow the conditions of the license. It can be applied to an original creation like e.g. a song, data, a piece of software and thus also energy system models.

Although there are a lot of different licenses, the main decision to be taken is if it should be a permissive or a copyleft license. The copyleft one obliges a user of e.g. a model to share his own further development of this model by publishing under the same license, a focus of the copyleft thus lies on sharing improvements while the permissive license allows almost everything. Permissive licensed works might thus be more widely used, but copyleft licensed work contributes to spreading open source since derivatives of the work need to be published also under a copyleft license. More information on license options in general can be found on e.g. https://choosealicense.com/ and specifically for energy system models: https://wiki.openmod-initiative.org/wiki/Choosing_a_license as well as in Morrison (2018) and Pfenninger et al. (2018).

Full or no transparency?

Full transparency of all stages of modelling is challenging to achieve, however a general guidance could be that the aim for "best practice" should not shy anybody away from realising small steps on the pathway to full transparency and accessibility of data, code and output. It is still valuable to open only parts of the model, data or data processing steps. Every bit of information can be supportive when researchers try to reproduce or reuse the work of others. Researchers should not shy away from sharing code, even if they believe it is not yet comprehensive enough to result in fully replicable science. More information and practical advice on how to open up in energy modelling can be found in Pfenninger et al. (2018).

Remaining challenges and possible measures

A main challenge in increasing not only model transparency but also the accessibility is the growing model complexity, including more and more temporal, spatial, technical and economic detail and extending the scope on the spatial scale as well as on e.g. sector coupling. This complexity makes it increasingly difficult for recipients of the results like policy makers to really scrutinize the model results. Besides reducing complexity that is necessary for the specific questions to be answered, more focus has to be put on result communication, explaining contexts and insights and not only numbers. How Mai et al. (2013, p.9) put it: ”[w]hat modelers consider “results” and what decision makers deem useful information may not overlap”.

The next step of model development should focus on collaborative code development, which forces good documentation and understandability from an early stage already and thus increases accessibility for others. Furthermore, there will be efficiency gains and thus time to work on the interesting questions if the work of building up very similar models in parallel could be decreased. Modular models that are collaboratively developed and maintained by several institutions could be supported by changes in the structure of research funding that enable continuous work on model maintenance and development, organized collaboratively by several institutions. A high leverage effect for increasing openness could be open licenses as a precondition for funding.

Regarding data, challenges are especially high due to the huge amounts of input data in energy system models coming from a mix of sources that are neither well described, nor correctly licensed. Possible measures could be improved data management education for modelers as well as for the original data suppliers (like TSO, ENTSO-E), also spreading the knowledge of open licenses.

The benefits of basing long-term scenarios as a basis for climate strategies on open data and models for the different shareholders have been described and presented here. Although openness is not standard in that respect yet, the progress in increasing transparency in long-term scenarios is ongoing.

References and further reading

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