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[Dachzeile]

Energy models as "laboratories" for exploring smart and sustainable energy systems

What role do businesses and households play in smart and climate-neutral energy systems? Why does this pose challenges for energy modelling? Diana Süsser (IASS) and Andrzej Ceglarz ([Renewables Grid Initiative](#)) shed light on this in their article.

The Paris climate goals, the European Green Deal and the Energy Union Strategy call for a climate-neutral economy and society by mid-century. For this to happen, our energy system must be profoundly transformed: from electricity and heat to transport and industry. That is why it is particularly important that different actors – such as companies and households – actively participate in the energy transition.

The energy transition is structurally changing our energy system: energy production is becoming more decentralised, moving closer to the residential areas and industrial plants that consume the electricity. Digital solutions, such as smart electricity meters, will be deployed. Our energy system will be coupled and largely based on renewable energies. In addition, the energy system will become more democratic: actors such as households and businesses will be more actively involved in energy production as prosumers (producers and consumers). These developments require a new type of interconnection between electrical transmission and distribution networks, which in turn must be based on smart solutions.

Models as laboratories to explore our energy future

Today, politicians and entrepreneurs must make decisions about the design of our future energy system, even if they are associated with many uncertainties. Scientists can support decision-making by using computer-based energy models.

Energy models can function as virtual "laboratories" in which different future scenarios for our energy system can be explored. Within the project Laboratory for a Sustainable Energy Transition (SENTINEL), we improve energy models based on user needs and make them openly available. Together with various stakeholders from politics, business, and civil society, we develop questions that the models should be able to answer, define challenges of the energy transition in specific case studies, and develop and discuss different transformation pathways.

Energy models are becoming increasingly complex and can deliver results with better temporal and spatial resolution. However, one weak point is the inadequate inclusion of different actors, such as households and industry. Their behaviour and attitudes towards sustainable measures are often neglected, but they play a crucial role in the success of the energy transition. We use the following two examples to show why companies and households are so important for a smart and sustainable energy supply.

Smart interconnection of renewable electricity producers and consumers

Decentralised energy production enables companies and households to participate as democratically equal participants in the smart market of the future. Smarter and interconnected electricity markets enable companies and households to become electricity producers and consumers at the same time and/or to sell their energy to the market. They will therefore take on increasingly important roles in the energy system in the future. In addition to other factors, such as the increased share of renewables, the entry of these new market participants brings with it the need for storage and so-called smart or intelligent grids that can dynamically compensate for fluctuations in production. Such participatory and decentralised energy production has many advantages, including the financial participation of local actors, shorter transport distances, and reduced energy transmission losses.

Demand-side flexibility for stable grids

On the way to a decarbonised energy system, demand-side flexibility will play an important role in supplying electricity to buildings and industry as well as in the stability of the grid. Smart appliances, such as heaters or washing machines, can already be programmed today to run when renewable energy is available and cheapest. But companies will also produce more flexibly in the future than they do today. Demand flexibility thus makes an important contribution to grid stability. Research projects, such as FlexCoop, are developing new instruments for demand-side flexibility as well as new business models, also for energy cooperatives.

These two examples illustrate that companies and households have an important role to play in the energy system of the future and can actively shape the energy transition. However, successfully incorporating such needs and concerns into energy models requires the development of inclusive and participatory approaches that enable the exchange of ideas and perspectives from many actors. Accordingly, it is important to ensure that complex knowledge related to energy modelling is prepared in such a way that it can be discussed with people from beyond the science and energy communities.

A practical example: developing an energy scenario for Europe

A good example is provided by the PAC project, which has developed an energy scenario for Europe that is compatible with the Paris Agreement. The development of the scenario was led by civil society actors. While the Renewables Grid Initiative was responsible for coordination, CAN Europe and the European Environmental Bureau oversaw the implementation. On the one hand, the scenario is intended to be a concrete proposal for European energy infrastructure planning that ensures the development towards an energy system based on renewable energy. On the other hand, the PAC project serves as a platform for exchange between numerous stakeholders representing different energy realities.

Within the PAC project, several workshops were held to facilitate face-to-face exchange between modellers from all stakeholder groups. The meetings were mainly aimed at understanding from a technical point of view how the energy system should be designed and represented in energy models. The end-result of this process was a scenario that offered policymakers an alternative proposal to the current scenarios of the grid operators and advocated for the rapid development of a renewable energy-based system.

Specifically, and with reference to the examples discussed above, one of the workshops emphasised the importance of taking more account of the distribution grid in transmission grid planning – i.e. a stronger focus on the local level – with a view to smarter interconnection. This could be done, for example, through a regular and precise exchange of information between distribution system operators and transmission system operators or through a governmental structure for cooperation in scenario development. With regard to the topic of flexibility, the exchange enabled a discussion on concrete topics: e.g. how important it is to model time scales for flexibility needs as well as to generalise the behaviour of distribution grids in different European countries in models.

These developments show that further research is needed to better understand various challenges and needs of societal actors, including those of the energy prosumers of the future, and to better reflect them in energy models.

This post first appeared on the sustainable.digital blog on 15.4.2021.

On 29.04.2021, Diana Süsser will give an impulse on energy modelling for exploring smart and sustainable energy systems at the Smart Grid event. You can register and find more information about the event [here](#).