Using retrospective UK power system modelling to inform the scenario choice for the future

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Quantitative, long-term energy scenarios form the core of strategic decision-making and research on energy and climate change. Due to the growing awareness about the energy system dynamics and its uncertainties, there is a tendency to build larger and more detailed energy system models, engage in detailed modelling of uncertainty and generate large numbers of energy scenarios. While such approaches provide valuable insights into energy system dynamics and the key uncertainties, they primarily target the research audience with extensive modelling expertise. For communication with the legitimised decision-makers and decision support, it is necessary to choose smaller sets of scenarios [1]. A growing body of literature argues for formal techniques to facilitate the choice of scenarios, for example, choosing the most consistent scenarios [2, 3], most diverse scenarios [4], maximally-different scenarios [5, 6], or scenarios of the most influential uncertainties [1]. While the scenario choice needs to be tailored to the specific guiding question and context at hand, the overarching question is what types of scenarios shall be included in the small set of scenarios and why?

In order to gain new insights into the choice of energy scenarios, this IQ SCENE presentation takes a retrospective approach by constructing and assessing the UK power system scenarios from 1990 to 2010. This approach consists of two steps: (i) retrospective modelling and (ii) retrospective qualitative judgements on scenario choice. In terms of modelling, the D-EXPANSE model (Dynamic version of EXploration of PAtterns in Near-optimal energy ScEnarios) is set up with retrospective data. D-EXPANSE model [5, 6] has the structure of the traditional bottom-up, technology rich, cost optimization energy system model with perfect foresight. In addition, it has three state-of-the-art features. First, it systematically explores the near-optimal pathways [7, 8]. Second, it generates large numbers of near-optimal pathways in order to draw patterns [9, 10]. Third, D-EXPANSE includes an algorithm for selecting a smaller number of maximally-different scenarios [5, 6]. For the retrospective modelling, the D-EXPANSE model is based on the historical data of electricity demand, technology and fuel costs. In this way, the impacts of parametric uncertainty on modelling results are minimised as much as possible. In terms of qualitative judgements on scenario choice, the past scenario choices are collected from the historical UK energy scenario exercises from 1978 to 2000. Then, the D-EXPANSE model is run, using these qualitative judgments, and the modelling outputs are compared with the actual UK power system transition from 1990 to 2020.

The results of this retrospective analysis provide food for thought on the development and choice of energy scenarios for the future. First, even when parametric uncertainty is minimised, the D-EXPANSE model in its cost-optimisation

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mode, that is at the core of all conventional bottom-up energy system models, does not approximate well the actual power system transition 1990-2010. The deviation of 17% in total system costs from the cost-optimal solution is observed. Thus, future energy scenario exercises shall look at the near-optimal scenarios too, in addition to the cost-optimal ones. Second, when the past qualitative judgements are used to inform the scenario choice, the resulting scenarios do not cover a broad enough range to encapsulate the actual power system transition 1990-2010. The actual transition deviated from the modelled one not only because of "unknown unknowns," but also due to the "unexpected knowns." These "unexpected knowns" can be covered in the future scenario exercises by considering a set of maximally-different energy scenarios that differ in their technology elements as widely as possible.

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