ENERGY SYSTEM MODELLING FOR REGIONAL POWER SECTOR'S DEEP DECARBONISATION—MODELLING ASPECTS AND CHALLENGES

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Abstract

Power sector deep decarbonisation challenge the current energy system to integrate a wider range of low-, zero-, and negative-carbon electricity supply technologies. Multiple layers, segments, and networks of the time-dependent and geospatially distributed resources, processes, and consumers represents the complex interactions of electricity supply chain processes. Suitable methods and tools are necessary to derive relevant insights and analysis about the energy system to support the strategic plan energy sector expansion and transition in the region. This paper presents the necessary aspects to consider when modelling regional electricity supply chain system and points out the challenges in the context of deep decarbonisation.

The key aspects and challenges of energy system modelling are derived from literature review. Select energy system modelling frameworks are presented, and the extent to which they consider these aspects and how they tackle challenges are discussed.

The results identifies key aspects of energy system modelling for the assessment of regional electricity supply chain capacity in the context of deep decarbonisation (scope and coverage, system boundaries, level of complexity, spatiotemporal resolutions, model formulation, data, and assessment criteria). Each of the studied modelling frameworks are capable to model generic or specific type of energy production, storage, and distribution network capacities with various level of complexities and scales. There are challenges pertaining to energy system modelling: (1) addressing space and time; (2) balancing model complexity and tractability; (3) integrating social, resource, and environment dimensions; and (4) resolving uncertainty, transparency, and reproducibility. Spatiotemporal resolutions are the major specific challenge considering the complex investment and operational constraints related to resource adequacy, access, suitability, and service reliability. Scale of the model increases when including additional system boundaries, i.e., more detailed conditions of how the complex system interacts. Computational capacity needs to be expanded to include large-scale resource transport and storage on top of generation capacity expansion problem, otherwise simplification of system complexities needs to be addressed. Assessment area expands with including externalities related to energy system development (socio-economy, resource, and environment). The accuracy of the results is also dependent on data quality and can be improved with a more transparent and collaborative process. In discussing these challenges, possible areas for future research are presented and recommendations are made to ensure the continued relevance for energy systems modelling in deriving strategic insights to support policy-making process in the region.

There is still a broad range of opportunities for researchers to contribute to the development of future energy system modelling. Focus on the spatiotemporal uncertainties of renewable resources and the spatial implications of infrastructure deployment are paramount in assessing the costs, potentials, and impacts of expanding the energy supply chain. To summarise, the appropriate or relevance of energy system modelling needs to be reviewed critically for their suitability and trade-offs in tackling region-specific challenges. The approach presented here is one contribution to improve current methods of modelling and analysis of energy system by adding the key aspects for an improved strategic decision support in regional energy planning.