Introduction to EMP-E 2019 special issue “Modelling the implementation of ‘A Clean Planet for All’ strategy”

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Climate change, and the mitigation of greenhouse gases contributing to it, has become a priority concern for governments around the world (e.g. Refs. [1–4]). The European Union (EU) has been at the forefront of moving the economy and the energy system to a direction more consistent with the recommendations emerging from the scientific community [5] and the international agreements that the EU is a party to Ref. [6]. The EU’s long term strategic vision “A Clean Planet for All” [7] aims for Europe to lead global climate action. It sets the direction for European climate and energy policies to achieve the Paris Agreement and contribute to the UN Sustainable Development Goals. The strategy establishes that the EU should achieve net-zero greenhouse gas emissions by 2050 while enhancing competitiveness, inclusion, fairness and prosperity for all citizens and regions. This translates to an energy transition characterised by the expansion of renewable energies and energy efficiency improvements in all sectors while maintaining the security of supply at competitive prices. These broad and ambitious energy and climate plans set at the EU level required national implementation and consequently EU countries presented their 10-year integrated national energy and climate plans (NECPs) for the period 2021–2030 [1,2]. These were submitted to the EU Commission at the end of 2019 and detailed national long- and short-term plans to achieve the EU carbon targets.

Understanding the impacts of various policy and mitigation options, trade-offs between them and the system-wide effects they may cause is non-trivial and difficult to achieve without formal tools. As a consequence, modelling tools have established a vital role in informing decision-makers and the academic community about such dynamics (e.g. Refs. [5,8,9]), and their role may well become increasingly critical due to the urgency and level of ambition with which climate policies are currently strengthened [1,2].

The Energy Modelling Platform for Europe (EMP-E) aims to be a reference forum for researchers, developers and practitioners of the European energy system. The annual meeting promotes the cross-pollination between models, and the discussion from different technical and political perspectives aims to further increase the quality, transparency and usefulness of the modelling tools. A key feature is the involvement of the European Commission’s Directorate Generals Research & Innovation, Joint Research Centre and Energy, which provide valuable input to the energy modellers and researchers.

The EMP-E 2019: *Modelling the implementation of A Clean Planet For All Strategy* was organised by nine H2020 Energy modelling projects: MEDEAS, MAGIC, MAGNITUDE, plan4res, PLANET, REEEM, Reflex, SET-Nav and Spine, all funded by the European Commission’s Research and Innovation Programme. This edition was coordinated by MEDEAS and presented a balanced mix of high-level panel discussions, interactive focus groups and various poster sessions to enable a peer-reviewed digest of models and policy insight for an informed discussion of the current European energy system challenges. The agenda of the event centered on four main topics: (1) pathways and scenarios towards the Paris agreement; (2) decarbonisation of cities: modelling energy transition, sector coupling and cross-sectoral challenges; (3) investments as a key factor to RES implementation in the EU and; (4) the effects of externalisation on decarbonisation pathways. EMP-E 2019 focus groups, in turn, engaged in discussions over topics, such as transparency and openness of the models, analysis of the energy nexus and biofuels, sensitivity analysis and handling of uncertainty, and the integration of agency and social dynamics in energy models.

Several peer community discussions on energy models and policies took place during the event. From these discussions emerged common positions about current energy transition challenges, but also uncertainties and knowledge gaps that became central issues of the debate. Also here and throughout the conference the issues of transparency, uncertainty and open science gained much of the attention, as these areas are key to improving the accountability of energy models and, with it, their quality and public’s trust in them.

In this special issue, we present research from 8 teams, covering together a wide range of topics from method and uncertainty orientated papers [10,11] to ones focusing on specific sectors [12,13], fuels [14], geographical subsystems [15] or broader dynamics of the energy-environment-economics system [16,17].

In their paper [10] extended an open-source, dispatch and expansion planning modelling framework “urbs” to consider uncertain inputs for intermittent renewable energy sources. The stochastic dual dynamic programming approach was demonstrated for the German system and the results suggested that the stochastic formulation more closely corresponds to the real world economic dispatch. [11]; in turn, carried out a Monte-Carlo based sensitivity analysis to assess which model parameters are most significant for the uncertainties in the outcomes. Their results suggest that the uncertainty ranges widen over time and that assumptions related to households’ energy efficiency and transport energy use have the strongest impact on the outcomes.

In [12], the authors highlighted how a massive introduction of individual vehicles to replace traditional oil-fueled ones would not deliver GHG reductions consistent with climate stabilization and could result in the scarcity of key minerals as lithium and magnesium. Furthermore, sooner or later, there could be an economic contraction due to the oil shortage. Besides, high electrification of light vehicles is not possible without a massive recycling program due to the scarcity of some key

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minerals. Hence, only a radical shift towards light vehicles and a reduction of the energy from the transport sector can achieve the combined objectives of energy savings and GHG emissions reductions globally.

[13] also focused their analysis on the transport sector and used a stochastic optimisation approach to analyse how uncertainties related to battery costs, biomass availability, and climate targets could affect technology diffusion in the sector. The results suggest that electric vehicles (EV) are a no-regret option for reducing emissions, although earlier clarity about the uncertainties would lead to more extensive EV deployment in the long term. Uncertainties about the mitigation required influence the results more than the other uncertainties considered. In [14], the authors presented a conceptual framework to handle the "contrasting scientific evidence" in previous biofuel analysis. The feasibility, viability and desirability of biofuels is considered, together with the impact of imports on energy security. This conceptual framework allows tailoring the definition of both the purpose of the analysis and the resulting performance characterisation to the case study under analysis.

The current trend sees a continuous increase of the urbanised population, making the integrated modelling of urban area subsystems fundamental for understanding how a decarbonisation goal can be reached. In [15], authors presented a city-level energy modelling and assessment methodology, integrating top-down and bottom-up modelling approaches. Among the three different scenarios presented, the one focused on transport electrification leads to the best energy savings and emissions reductions. However, challenges still exist for verifying these models due to the data scarcity and the uncertainties.

[16] focused their analysis on comparing the energy metabolic patterns of China and the EU between 2000 and 2016. The analysis characterises the stagnation of the EU and the massive industrialization and urbanization of China, showing how the entanglement of different factors and dimensions across scales – such as demography and various growth trajectories – explain the observed energy metabolic patterns. The research identifies a wide gap in workload between China and the EU, with the higher loads in China, together with a low dependency ratio, increasing its cost competitiveness.

Finally, [16] considered six climate projections in an energy systems model to assess how climate change may affect electricity generation and demand in the future. While they do not find significant impact across the climate projections for the EU level, they find substantial member state-level impacts for, especially wind and solar deployments and electricity trade. Uncertainty in terms of how the climate will develop is also reflected in the ranges for what the impacts for specific countries and technologies could be.

These eight papers together document a fraction of the research presented and discussed at the EMP-E 2019 workshop. Together, however, they provide a broad perspective on the field more generally, from more methods-orientated problem formulations to those using the tools to provide insights for specific questions. The models very much remain at the core of forward-looking energy system analysis, and platforms like EMP-E will continue to be central in disseminating their outputs and information about them to a broader audience while simultaneously creating a community in which the modellers can exchange information.

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