# Energy Transition Pathways to a low-carbon Europe in 2050: the degree of cooperation and the level of decentralization

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## Executive summary

1. Motivations underlying the research

The European Union is in an ongoing debate on how to reach the 2050 carbon emission targets to fulfil the commitment of the Paris Agreement. In this regard, the SET-Nav research project (2016-2019) brought together a large European consortium of energy and climate modelers to analyze strategies to decarbonize all energy sectors as well as the end use. It started from the technological focus of the European Union SET-Plan and developed several comprehensive, cross-sectoral scenarios – the SET-Nav pathways. The pathways show that – while several options are still at hand – the next years' decisions on the European energy system are critical in order to achieve a low-carbon energy future.

The objective of the SET-Nav project is to support strategic decision making in Europe's energy sector, enhancing innovation towards a clean, secure and efficient energy system. The motivation of the SET-Nav pathways is to reflect a new level of understanding of interactions and interdependencies between actors, technologies and policy interventions in Europe's energy-economic system. The framing of the SET-Nav pathways storylines considers two key uncertainties: the level of cooperation (i.e. cooperation versus entrenchment) and the level of decentralization (i.e. decentralisation versus path dependency). The modelling assumptions for these pathways were an 85-95% emissions reduction by 2050; 40% as an intermediate reduction target in 2030 and meeting all reduction goals by 2020. The pathways serve two main purposes: first, to determine main drivers and critical uncertainties and second, to highlight outcomes and consequences. The former are modelling parameters, the latter are modelling results. Drivers are policies or intermediate actions, for example. Outcomes consist of costs, the electricity mix or infrastructure developments, among others. Specifically, in this paper, we presents the overall analysis of the SET-Nav pathways for the energy demand sectors (buildings, transport, and industry) and the electricity supply mix in Europe.

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## 2. A short account of the research performed

Four pathways analyse a European energy transition to achieve an 85-95% emissions reduction by 2050. The approach is based on a unique suite of linked models developed in the SET-Nav project. The models combine several perspectives with different sectoral priorities but also by integrating the energy consuming sectors - buildings (heating and cooling), transport, and industry - with the power-producing sector thus reflecting the increasing sector coupling within the future energy system. In addition, the central point of connection among the models is that all interpreted the pathways storylines for their respective sector and hence some common data inputs were harmonized (e.g. fossil fuel prices, technology costs, CO2 budget and price).

The analysis provides a large range of results that quantify the pathway narratives from today until 2050. They include the electricity mix, the modal split in transportation, the heat mix and energy consumption by industry among others. Hence, the research conveys a greater picture of the energy transition, which allows comparing several development paths and their limits and challenges of the politico-technology-energy system.

## 3. Main conclusions and policy implications of the work

Each pathway exploration of decarbonisation options (under different circumstances) provided an understanding of the effect of different policies in reducing greenhouse gases. Such as the prohibition of conventional transport (internal combustion engine), the power system expansion, re-configuration of distribution grids, and others. An interesting insight is that debated technologies such as CCS, nuclear energy and coal can be dispensed for other effective decarbonisation alternatives. Moreover, all the pathways envision a decisive reduction of emissions by 2030 and the successful expansion of renewable energy sources (in particular wind power) as a main driver. Hence, new technologies (batteries, hydrogen or bio-gas) will be crucial for the decarbonization of non-electricity sectors or providing balancing options for variable renewable energy sources in the power sector. In short, main conclusions and policy implications:

- More research and public support will make decentralised heat supply and heat pumps an important part of the demand side
- To decarbonise industry, extending the ETS with a minimum price as well as expanding public RD&I (research, development and innovation) funding are important measures.
- A CO2 tax as the central element of a broader energy tax reform could provide the incentives needed for fuel switching.
- Policies to overcome barriers to energy efficiency are also crucial, as is pushing sales of electric vehicles and inducing a modal shift from cars to public transport, car-sharing, cycling and walking.

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