Transition towards a renewable European electricity system

Scientific and social impacts of the research results

In accordance with Article 22 of the "Regulations for obtaining the doctoral degree at Maastricht University" adopted by decision of the Board of Deans and entered into force on 1st October 2020, this section provides a reflection on the scientific and social impacts of the research results presented within the doctoral dissertation.

For the past three decades, political action to tackle the climate change has significantly lagged behind the evidence-based impetus from the scientific community. Even despite the ubiquity in the media of the ambition of the 2015 Paris Agreement to ensure global warming remains within the 2 – and closer to the 1.5 – degrees Celsius limit by 2100, compared to pre-industrial levels, political action in this direction has been fragmented, globally. Six years later, only six countries enshrined their emission-reduction targets into law, and the EU and five countries have proposed legislation in this direction (see Energy and Climate Intelligence Unit (2020)).[1] In March 2020, the European Commission presented the proposal of the European Climate Law – which sets the EU's ambition to become the world's first net-zero GHG emissions continent by 2050 (European Commission (2020)).

Approximately a third of global GHG emissions are produced by the electricity and heat sector (World Resources Institute (2020)).[2] Therefore, in order to achieve their climate targets, countries need to decrease their reliance on conventional, fossil-fueled power plants and invest in cleaner alternatives at a much larger scale than until now. However, these cleaner alternatives – especially solar and wind energy technologies – differ from conventional technologies in several important aspects, two of which are: they can only generate power under specific weather conditions and they operate at virtually

[1] Bhutan and Surinam have already become net-zero GHG emitters (Energy and Climate Intelligence Unit (2020)).

[2] Sectors are considered together.

zero fuel cost. Scaling up these technologies at the level required by a net-zero GHG emissions ambition will bring about significant changes in the operation of existing electricity system and the functioning of electricity markets. Also, the EU-wide geographical dimension of this ambition requires an integrated approach that goes beyond the traditional national-level energy system. This integrated approach to supra-national power systems would not only enable a less-costly transition towards a low-carbon European power system, but it is also critical in supporting the stability and flexibility of the power system, in general. Indeed, the data used for the research presented in this dissertation point to a systematic, extended period of time during late winter, when potential wind power decreases substantially, in the wider Central European region. What is particularly worth considering is that this is the period with highest power demand, due to the increased demand for heating. This demand is expected to increase considerably in the next few decades, in the context of an on-going transition towards the electrification of the heating sector. At the same time, during the identical time period of mid-late winter, both the Scandinavian and Mediterranean regions experience their highest wind power potential. An advanced cross-European power grid is therefore critical to the resilience of Central European countries, in the face of established weather patterns that result in low power production, during extended periods of high power demand. This fact is becoming increasingly recognized at the political level, as well. In fact, the goal of an Energy Union – whereby electricity would flow among member states without technical or regulatory constraints – was officially launched in 2015. As an intermediate step towards further integration, the European Commission aims to increase the interconnector capacity – that supports cross-border electricity trade – to 15% of installed capacity for electricity production, by 2030, up from 10%, in 2020 (European Commission (2019*c*)).

The research presented in this dissertation identifies and investigates the main challenges faced by the transition towards a low-carbon electricity system in the EU. More specifically, the research presented in Chapter 2 looks at how different European countries can cooperate in order to achieve lower-cost clean power systems. Due to the wide variation in weather patterns across the EU, an integrated approach to the design of a low-carbon European electricity system – as opposed to individual, national-level approaches – would result in significant cost savings. In Chapter Two, I develop a model that provides estimates for these cost savings, for a selection of EU countries.

A second important challenge raised by the large-scale deployment of wind and solar power technologies concerns the current operation of electricity markets. Due to its zero fuel cost, power generated by solar and wind plants puts a downward pressure on electricity prices. This makes it difficult for conventional power plants to remain competitive, even though they are necessary in ensuring the stability of the power grid. Therefore, an understanding of the type of challenges that a high share of these variable

renewable energy sources would bring about for the current design of the electricity market is essential, in order to guarantee the smooth operation of the power grid. In Chapter Three and Four, I investigate the effects of power from solar and wind energy technologies on the electricity price and its variance, as well as on the convergence of electricity prices between different European countries.

The social impact of the research presented in this dissertation is therefore directly related to the global ambitions to lower the GHG emissions associated with the electricity sector.

The scientific impact of these research results adds to an increasing empirical literature that studies the effects of intermittent renewable energy on different aspects of the power system and on the electricity market. The research presented here uses recent electricity data at a high temporal resolution and for wide geographical coverage of the EU.

Ultimately, the research discussed in this dissertation aims to contribute to the understanding of the particular set of challenges that the EU faces in its transition away from a fossil-fuels intensive power system and towards a low-carbon one.