Energy Policy 110 (2017) 509–517

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Tracking sectoral progress in the deep decarbonisation of energy systems in Europe

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ARTICLE INFO

Keywords:
Energy system decarbonisation
EU climate policy
Policy monitoring

ABSTRACT

Decarbonisation of energy systems requires deep structural change. The purpose of this research was to analyse the rates of change taking place in the energy systems of the European Union (EU), in the light of the EU's climate change mitigation objectives. Trends on indicators such as energy intensity and carbon intensity of energy were compared with decadal benchmarks derived from deep decarbonisation scenarios for the electricity, residential, transport, and industry sectors. The methodology applied provides a useful and informative approach to tracking decarbonisation of energy systems. The results show that the EU has made significant progress in decarbonising its energy systems. On a number of indicators assessed the results show that a significant acceleration from historical levels is required in order to reach the rates of change seen on the future benchmarks for deep decarbonisation. The methodology applied provides an example of how the research community and international organisations could complement the transparency mechanism developed by the Paris Agreement on climate change, to improve understanding of progress toward low-carbon energy systems.

1. Introduction

The European Union (EU) has introduced ambitious objectives to decarbonise its economy, namely a reduction of GHG emissions by 80–95% by 2050 (European Council, 2009) and a mid-term target of an at least −40% reduction of GHG emissions by 2030, both compared to 1990 levels. This latter target has been submitted as the EU's joint “nationally-determined contribution” under the Paris Agreement (European Union, 2015). Numerous studies show that reaching such deep long-term emissions reductions requires profound structural change to energy systems (Bataille et al., 2016a; European Commission, 2011a, 2011b; IEA and IRENA, 2017; Spencer et al., 2015).

There has been increasing efforts to ensure an adequate tracking of progress towards long-term decarbonisation. Such tracking efforts are complicated by the inertia of the energy system; the multiple and interdependent pathways and options for decarbonisation; and the range of drivers, endogenous and exogenous to policy, of decarbonisation. In order to address this challenge, the European Commission has proposed a system of indicators and Member State reporting to track progress towards the EU's 2030 decarbonisation goals (European Commission, 2015).

This paper contributes to this debate in a number of ways. It reviews the available literature tracking the EU's progress towards deep decarbonisation by 2050 (Section 2). It develops a methodology to track energy system decarbonisation in the EU (Section 3). It applies this methodology to the EU, for the power, residential, industry and transport sectors (Section 4). Finally, overarching policy and research implications of the findings are discussed in the conclusion (Section 5).

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http://dx.doi.org/10.1016/j.enpol.2017.08.053
Received 22 February 2017; Received in revised form 31 July 2017; Accepted 24 August 2017

2. Literature review

There is a growing literature exploring roadmaps to decarbonisation in the EU. At the EU level, perhaps the most well-known among these is the European Commission's "Roadmap to a competitive low-carbon economy in 2050" (European Commission, 2011a), and the Energy Roadmap (European Commission, 2011b). At the EU level, the Commission has recently published "The Clean Energy For All Europeans" package (European Commission, 2016b) which includes fully updated model-based energy scenarios involving deep emission reductions and legislative action to foster energy transition to 2030.

Capros et al. (2014a, 2014b) provide a detailed comparison of large-scale energy system models used in the analysis of EU decarbonisation pathways, while a companion paper studies multiple scenarios across these models for the deep decarbonisation of the energy system by 2050 (Capros et al., 2014b). This paper finds that deep decarbonisation scenarios across different models display some key commonalities, and that in the short-term the failure to deploy the necessary enabling conditions for longer-term transformation can jeopodize the feasibility of long-term energy system decarbonisation (Capros et al., 2014b, pp. 244). This supports the argument developed in Section 3 below that studying short-term energy system change can provide insights into progress towards long-term decarbonisation objectives.

At the national level, recent work has also focused on developing long-term low-carbon pathway scenarios. For instance, the Deep Decarbonisation Pathways Project presented a number of 2 °C compatible pathways to 2050 for France, Germany, Italy and the UK (Bataille et al., 2016a). Several EU member state governments have also recently developed national climate or energy plans extending out to 2050, including the UK (HMG, 2011), France (MEDDEM, 2015), Germany (BMUB, 2016), Italy (MiSE, 2013), Denmark (Kebmin, 2011), Finland (TEM, 2014), the Netherlands (Ministry of ELandI, 2011; Ministry of IenM, 2011), Sweden (Naturvardsverket, 2012), and Portugal (Portuguese Environment Agency, 2012). Knopf et al. (2013) and Foerster et al. (2013) analysed long-term decarbonisation scenarios for a number of EU counties (France, Germany, Italy, Sweden, and UK), and find that while different supply-side technology mixes are deployed, outcomes on indicators such as carbon intensity of energy consumption and energy intensity were similar.

At the industry and individual sector level, long term decarbonisation trajectories or roadmaps have been explored by several authors, both in academic literature and in the grey literature; for instance, in the chemicals sector (Cefic, 2013), the steel sector (Neuhoff et al., 2014a), the cement sector (Neuhoff et al., 2014b), and the power sector (European Climate Foundation, 2013).

To date, however, the potential uses of long term decarbonisation pathways for real-time policy evaluation has only just begun to be explored, both in the literature or in national policy frameworks. A significant contribution in this regard is (Bataille et al., 2016b). This paper focuses on a number of uses of decarbonisation pathways, including as a tool for structuring national policy formulation, building stakeholder consensus, and for revealing enabling conditions to make pathways a reality. Another important contribution comes from (Mathy et al., 2016). The latter article explores ways in which long term decarbonisation trajectories can be used to manage uncertainty and risk in the policy making process, and focuses in particular on the role of "dynamic" indicators.

At the national governmental level, the UK has institutionalised the use of long-term decarbonisation scenarios as a means of evaluating current climate policy (for example (Committee on Climate Change, 2016)). The European Commission publishes every three or so years an assessment of current policy trajectories in the form of the so-called EU Reference Scenario (European Commission, 2016a). Meanwhile, the European Environment Agency's annual "Trends and Projections" report (European Environment Agency, 2015) is an invaluable guide to EU and national progress in reducing emissions. However, it is nevertheless largely a descriptive rather than evaluative document, as its evaluation of progress is not explicitly linked to any normative long-term pathway for individual sectors. To the extent that it is evaluative, policy evaluation tends to focuses on 10–15 year emissions trends based on requirements under the EU's Monitoring Mechanism Regulation and Effort Sharing Decision (European Parliament and Council, 2013).

Thus, while progress is being made, there is still an important gap – both in the academic literature and in policy circles – when it comes to the use of normative long-term decarbonisation scenarios for the purposes of both ex ante and "real time" policy evaluation. This paper is a therefore intended as a contribution toward filling this gap.

3. Methodology

The methodology described in the following paragraphs does not allow for a *deductive* conclusion to be reached regarding whether the EU and its Member States are on track for deep decarbonisation. In any case, the pathways towards the 2050 objective are too varied, uncertain and complex to allow such a clear-cut judgement. The methodology allows for the gathering of a large quantity of structured data on the decarbonisation of the EU energy system and the comparison of these observed changes with long-term decarbonisation scenarios. On this basis, expert judgement can draw an *inductive* conclusion regarding the likely adequacy of current sectoral decarbonisation trends, in the light of the EU's long-term objective of an 80% reduction in GHGs by 2050.

The methodology rests on the understanding that the inertia of socio-economic systems, in particular the energy system, places significant mid-term constraints upon transformation pathways towards ambitious long-term mitigation objectives (Clarke et al., 2014, ff. 462). The achievement of long-term mitigation actions thus depends on short and mid-term actions to unlock "…the potential for deep GHG-emissions reductions several decades from now" (Clarke et al., 2014, pp. 464), through for example energy technology innovation and deployment, avoidance of infrastructure lock-in, or the control of energy demand growth. The extensive literature summarized by the IPCC shows that the study of long-term scenarios can generate insights into the nature, timing, magnitude and uncertainties of the mid-term energy system changes required for plausible long-term transformation pathways (Bruckner et al., 2014). In turn, the analysis of recent historical data against these mid-term indicators can be used to derive insights into the adequacy of current energy system change in the light of long-term objectives, particularly if the historical data analysed includes leading indicators such as investments and technology deployment. For example, the International Energy Agency (IEA) also uses an approach of model-derived mid-term benchmarks on indicators selected according to, inter alia, the Kaya identity, against which current changes in energy systems and technology deployment are compared (IEA, 2017, 2016). Certainly, the approach taken in this paper has limitations, including the uncertainties and diversity inherent in long-term pathways and the potential for structural breaks in energy system pathways; limitations in data availability to track, for example, leading indicators such as investments in energy efficiency; and the complexity of causal relationships between ultimate and proximate drivers of emissions outcomes (Blanco et al., 2014). Care should be taken in interpreting short-term indicators in terms of progress towards long-term objectives, and a broader contextual knowledge of decarbonisation pathways and policies must be applied in interpreting results.

The starting point for the methodology of this study is the sectoral Kaya identity. The Kaya identity allows the identification of the drivers of aggregate emissions changes, and the isolation and analysis of those most targeted by policy (generally speaking, sectoral energy and carbon intensity). In this study, the analysis focused largely on energy and carbon intensity of four sectors, i.e. electricity, transport, residential buildings and industry.

13 EU28 level and Member State level deep decarbonisation scenarios were gathered. Scenarios covered the EU28 in aggregate, and the