How technological and new societal trends may influence the European sustainable energy transition: analysis of policies, methodologies and impacts

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Abstract

Although a number of European countries have developed low-carbon energy strategies and analysed them in the form of scenarios, only a part of them consider projections to 2050. No country so far developed a complex view on the role of technological, as well as non-technological factors (e.g. social acceptance of technologies, stakeholder participation, lifestyle and consumption patterns), and policies to address both aspects. New societal trends can often be linked to general megatrends, which have potentially large increasing or decreasing impacts on energy demand. Such trends include e.g. transition to a circular and sharing economy, a prosumer society and digitalisation of economic and private life. The main goal of this research is to develop an approach to analyse European long-term strategies for climate neutrality with a focus on the role of technological and new societal trends that affect the sustainable energy transition. The research is based on using qualitative (e.g. literature review, expert procedures, impact assessment, scenario development) and quantitative methods (e.g. text mining, statistical analysis, clustering, network analysis, modelling), as well as a various data sources (e.g. international reports, scientific publications, patents, media, foresight projects, statistical databases). To address how technological and new societal trends – in their interaction – may influence the sustainable energy transition, three perspectives are taken in this thesis: policy, methodology and impacts.

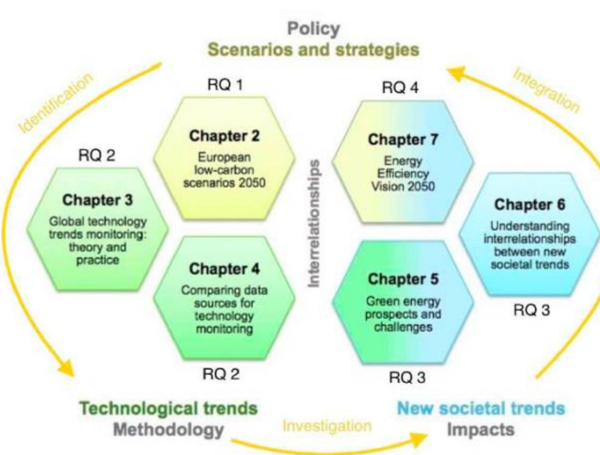
Currently, the development of the energy sector is associated with such global challenges as climate change, growth of energy consumption, depletion of natural resources, negative environmental impacts and energy security. These challenges are widely discussed in various reports at the global and regional level (e.g. European Commission, 2019; IEA/OECD, 2022; IPCC, 2023; National Intelligence Council, 2021; UNEP, 2022; United Nation, 2015; WMO, 2023). To reduce negative effects connected with these challenges and to move towards sustainable energy infrastructures, national governments need to be aware of the ***technological trends***, which have a significant long-term social and economic impact in different areas.

Technological options to mitigate climate change are, however, only part of the equation. Choices in lifestyles have at least similar impacts on climate footprints. Changes in lifestyle may, at first, be considered as privation from a life we could lead otherwise without the pressure from climate change. However, lifestyles may also consciously integrate limits in our environment and emerge as new societal trends. ***New societal trends*** can often be linked to general megatrends, which have potentially large increasing or decreasing impacts on energy demand (Grubler et al., 2018). Such trends include among others: (1) the digitalisation of the economy and of private life; (2) new social and economic models, including the sharing economy and prosumaging; (3) the industrial transformation, including decarbonisation of industrial processes and the circular economy; and (4) changes in the quality of life, including health effects, urbanisation and regionalisation. The trend towards digitalisation may act also as a facilitator for all other trends – for example, the diffusion of mobile phone apps facilitates car sharing (Brugger et al., 2019).

Therefore, the main research question of this study is: *How can technological and new societal trends impact the European long-term sustainable energy transition?*

To address how technological and new societal trends – in their interaction – may influence the sustainable energy transition, three perspectives are taken in this study (Figure 1, see below): **"Policy"** (aspects related to how new societal trends can be integrated into energy strategies and policies), **"Methodology"** (aspects including approaches and methods to identify and analyse technological and new societal trends and their interrelationships) and **"Impacts"** (aspects associated with how the new societal trends may influence future energy demand).

Figure 1. Methodological approach



"Policy" perspective

As was mentioned above, only a part of the European low-carbon energy strategies and scenarios consider long-term projections (2050) and take into account both technological and non-technological aspects (such as social acceptance of technologies), which may play a great role in achievement of the EU climate neutrality targets (Chapter 2). Nevertheless, the role of these trends in the strategies and their contribution to the energy transition is still understudied. Non-technological aspects (such as social acceptance, lifestyle and consumption patterns, etc.) are fragmentally mentioned in the energy scenarios, but are not yet considered in energy strategies on a systemic level. Understanding the interrelationships between the new societal trends and their simultaneous influence on energy demand (i.e. decreasing, increasing or shifting), may give insights into how they are covered by existing and emerging policy instruments (i.e. regulation, economic and financial instruments, as well as soft instruments) and what additional policies need to be developed to accelerate the EU's energy transition (Chapter 6). Analysis of the role of new societal trends in different scenario pathways and quantitative assessment of their impact on energy efficiency gains, can be helpful for more efficient integration of these trends into scenario development (Chapter 7).

"Methodology" perspective

To incorporate both types of trends (technological and non-technological) into energy scenarios a systemic methodology including a combination of qualitative (literature review, expert surveys, interviews, etc.) and quantitative methods (bibliometric and patent analysis, clustering, network analysis, etc.) is needed to identify and analyse such trends and their interrelationships. As was noted previously, given the lack of a systemic approach for analysis of non-technological trends, methodological learning can be taken from existing international practices and theoretical approaches used for technology monitoring (Chapter 3), which cover a wide variety of information sources (e.g. scientific publications, patents, media, foresight projects, conferences, international projects, dissertations, presentations). Taking into account the specificity of the subject area and each data source, as well as the accurate formulation of a research goal, can help to select the most relevant information sources to monitor new societal trends (Chapter 4). It is also important to learn from the approaches linking trends monitoring to scenario development activities to understand how policies may support climate technologies that contribute positively to energy transition. This can be helpful to develop the ways for the efficient integration of new societal trends into energy scenarios and models (Chapter 7).

"Impacts" perspective

To effectively integrate the new societal trends into energy scenarios, it can be important to know not only the potential impact of these trends on future energy demand (i.e. decreasing, increasing, shifting), but also their connections with other trends, in order to develop policies that may have synergetic impacts on them. As mentioned above, different types of connections can be investigated through mapping using network analysis, which may help to see a bigger picture of the interrelationships between new societal trends and understand what policy measures can support their development in combinations (dyads). Methodological approaches proposed to analyse technological trends in sustainable energy and their connections with other trends (Chapter 5), can be applied for analysis of interrelationships between new societal trends and assessment of their potential impact on energy demand in three dimensions: impact degree, impact scale and impact direction (Chapter 6). It is essential to evaluate the controversial impact of new societal trends on future energy demand and analyse quantitatively how they might interact with energy efficiency (policies) (Chapter 7). Therefore, a systemic approach is needed to assess the implications of an increase or decrease of energy efficiency and energy demand in all sectors and develop the specific indicators of change based on qualitative (expert) and quantitative (statistical) data.

Recommendations

• A more harmonised approach with national requirements at the EU level

Although the European countries have a joint vision of the energy future to 2050, the energy scenario development in these countries is still rather spontaneous and disjoint. According to the statistical data, the EU member states have different progress in reaching the GHG emissions reduction targets 2050 and a potential to improve their scenario policy settings, which in its turn, may influence the efficiency of national energy policy in the future. The results of this study can be applied to discuss the requirements for all European countries as a part of a more harmonised approach to achieve the EU 2050 targets, opening the possibilities for constant monitoring of the progress on the European level. First, collaboration and joint efforts are needed on the EU level to provide higher consistency and transparency in achieving the EU 2050 targets. Second, the scenario development process on the national level needs to be more interactive, with active involvement of key stakeholders (e.g. government, business, academia, NGOs, the general public). Third, new renewable technologies play an important role in achieving the EU 2050 goals. However, not only technological options, but also non-technological aspects (e.g. social acceptance, lifestyle and consumption patterns, institutional changes) should be explored in more detail, with the specific requirements adapted to the EU context. Fourth, the scenarios should take into account economic aspects (costs and benefits) in order to be feasible and more adaptable to the future changes. Moreover, the strategy developed should be effectively incorporated into the national policy: not only into strategic thinking, but also into short-term decision-making. Finally, constant monitoring is needed on both national and regional level to regularly measure the success of each country and the EU as a whole.

• Integration of different types of trends and their interrelationships into scenario development

Taking into account substantial and potentially disruptive impacts of new societal trends, such as circular and sharing economy, digitalisation of economic and private life, prosumer society etc., it is important to investigate interrelationships between such trends, their controversial impact on the European future energy demand and policy measures that may influence their development in a synergetic way. This can help to better understand how demand-side energy policies in specific areas at the trends intersections could be designed to maximise their contribution to energy transition. The results can be helpful to inform EU policymakers how energy policies have to be designed to reduce energy demand by stirring synergetic new societal trends. First, network analysis allows to see the overall picture of interrelationships between new societal trends and study what policy measures are being taken at their intersection. Second, the areas where policy gaps are identified can be explored more in detail to discover new emerging trends that are not yet covered but already require policy action. Additional investigation of these gaps can help inform the policy makers about the measures that are missing and can be put on the policy agenda. Third, some new societal trends may be connected with a group of factors, which are closely interrelated and may require simultaneous policy actions in several areas. Fourth, the analysis of policies at the intersection of trends allows to determine additional policy measures associated with their development and how the policy agenda should be redesigned to maximise their positive environmental impact. Furthermore, more information about individual trends, and especially their interplay, are required in the future to gain more certainty concerning the quantitative impacts on future energy demand in the European countries and can be helpful to formulate the appropriate policy measures.

• Integration of the results into policy decision-making

Although, in recent decades trend analysis has been used in development of low-carbon energy scenarios in the European countries, there is still the room for further improvement, particularly, in the ways of more efficient integration of the results into policy decision-making. While this research aims at raising awareness of the large effects that the technological and new societal trends might have on energy consumption, it will be crucial to further intensify the endeavour of studying not only the cost-effective potentials, but also to further quantify the impacts, including cross-sectoral effects that societal trends will have on future energy demand. This might ultimately inform policy-makers how European policies have to be designed in order to shape political, commercial and individual decision-making in a way that further decreases energy demand rather than counteracts efficiency gains. Further research is needed to design a process to explicitly link trend analysis into policies and strategies within a systemic framework. Such a framework should include analysis of emerging trends (e.g. technological, societal, as well as economic, political and others), along with their individual attributions and interrelationships, as well as the ways of their integration into energy (efficiency) policies.

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