Policy Brief

Decarbonising Electricity

Delivering net-zero electricity by 2040 in a just transition

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Key Messages

- A net-zero EU in 2050 requires net-zero electricity emissions by 2040.
- Achieving net-zero electricity emissions by 2040 in the EU is possible and affordable.
- Net-zero electricity emissions by 2040 requires existing instruments to be tightened and extended in order to set out a clear long-term pathway to this goal.
- There are technical challenges to the operation of zero-carbon electricity systems, which need to be addressed early, to ensure a smooth and secure transition.
- Investments in innovation and skills, attending to all stages in the innovation chain, remain crucial to supporting the transition and capturing its economic benefits.
- The political challenges are as important as the technical challenges, with attention to just transitions at the regional scale essential to meet net-zero targets.

Background and Context

The electricity sector will play a central role in achieving the European Green Deal target of a net-zero EU by 2050. The range of available low carbon electricity generation technologies and abundant resources, including wind and solar, mean that electricity will be a leading sector in decarbonisation, provided it can attract sufficient finance (see Finance Policy Brief).

Electricity is also important for the decarbonisation of other sectors. Buildings, transport and industry will increasingly switch to technologies that use electricity in order to achieve decarbonisation. The success of these sectors switching to electricity in order to decarbonise, depends of course on electricity itself being decarbonised first.

A net-zero EU in 2050 requires net-zero electricity emissions by 2040

There are two important implications from this. First, that demand for electricity will grow substantially. Low-carbon scenarios suggest that the share of total energy provided by electricity in the EU could double between 2020 and 2050, as more and more demands in different sectors switch to electricity[1]. Second, that decarbonisation of electricity must be ahead of other sectors. INNOPATHS modelling suggests that the EU Green Deal requires EU electricity emissions to reach net zero by 2040 (Figure 1).

Figure 1

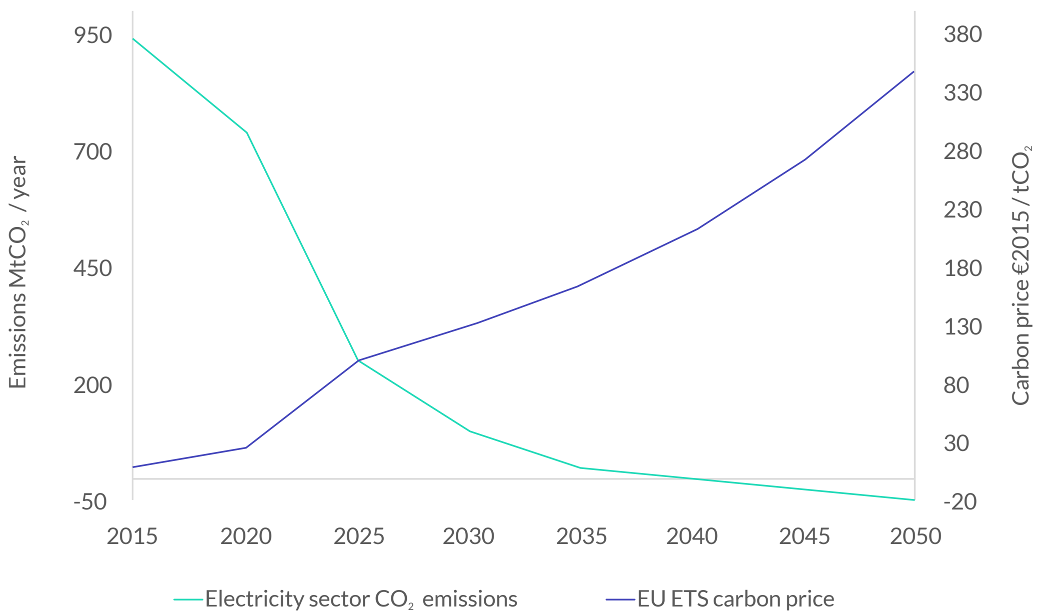


Figure 1: INNOPATHS modelling of a scenario that is consistent with the EU Green Deal – it requires electricity emissions to be net zero by 2040

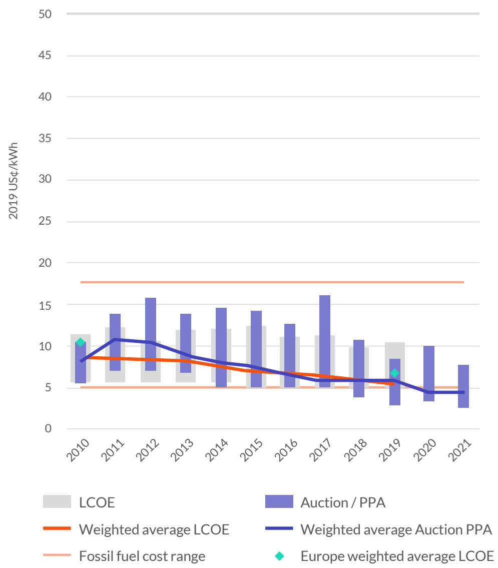
1 From EU scenarios that reduce total CO_2 emissions by at least 95% by 2050, the median value for the share of final energy provided by electricity increases from 21% in 2020 to 43% in 2050. Scenarios as presented in the DEEDS database, available at https://data.ene.iiasa.ac.at/deeds-explorer/#/workspaces

Achieving net-zero electricity emissions by 2040 in the EU is possible and affordable.

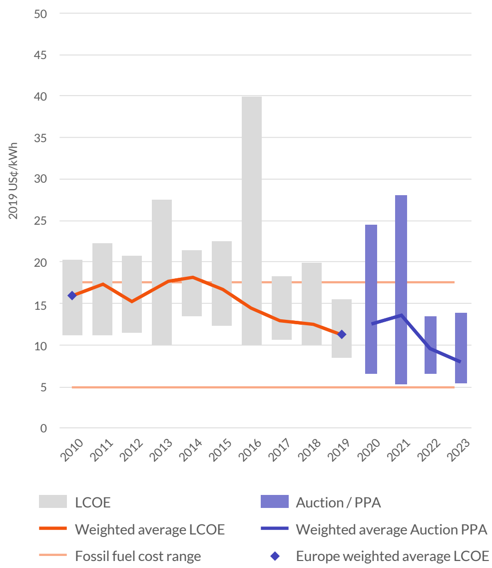
Dramatic cost reductions in low-carbon electricity technologies have been achieved over the past decade, due in large part to the impacts of market support policies. Electricity produced by wind and solar PV is in many cases now cheaper than the same amount of electricity produced by a gas or coal plant (Figure 2). The INNOPATHS modelling shows that decarbonizing the power sector would increase electricity prices initially by almost 2 €ct/kWh in 2025, but afterwards prices would go down again, eventually returning to the levels seen over the last decade. Total power system costs would only increase by 5%.

Figure 2

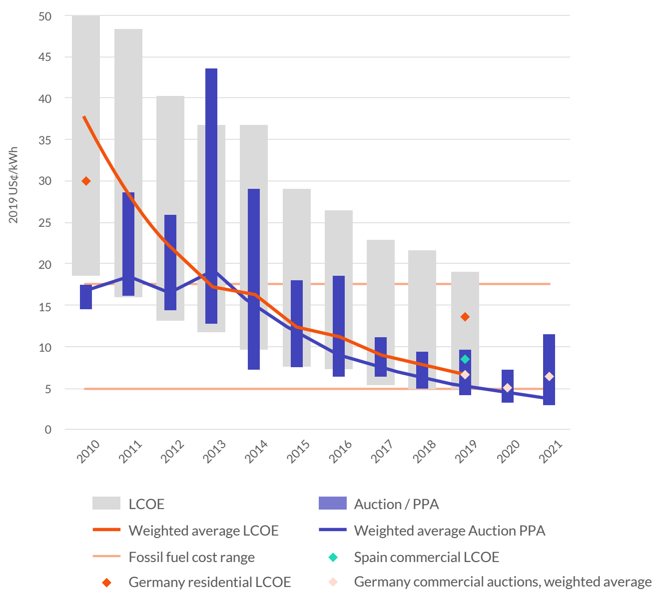
Onshore wind



Offshore wind



Solar PV



However, there are still important challenges that must be faced to deliver a net-zero electricity system, on the way to delivering a net-zero Europe.

Figure 2: Costs of onshore wind, offshore wind and solar PV have fallen globally, and in Europe, since 2010. This figure compares levelised cost of energy (LCOE) estimates, and data from auctions and power purchase agreements (PPAs), for onshore wind, offshore wind and solar PV, with cost ranges of fossil fuel generation. Globally weighted averages are given, as well as some Europe specific data. Data from Bundesnetzagentur[2] and IRENA[3].

2 Bundesnetzagentur 2021, Beendete Ausschreibungen

3 IRENA (2020) Renewable power generation costs in 2020. Available at: https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019

Net-zero EU electricity emissions by 2040 requires existing instruments to be tightened and extended in order to set out a clear long-term pathway to this goal.

Substantial progress has been made in decarbonising electricity. Data from IEA[4] and the EC[5,6], shows that renewables increased from providing 22% of the EU's electricity in 2010 to 36% in 2019, in which year the combined output from all low carbon sources accounted for 60% of total electricity.

However, there remains a considerable distance to travel. The pace of investment in zero-carbon generation needs to be increased, and fossil fuel generation needs to be retired. Investors require clear long-term signals. In order to achieve this, a clear pathway needs to be established that sets out the journey not only to 2030, but all the way to 2040, at which point the system should be operating with net-zero emissions.

Existing frameworks can be used to implement this pathway. The EU Emissions Trading System (ETS) sets limits on CO_2 from electricity generation and other sectors, and is currently calibrated to the EU's 2030 emission reduction targets and commitments under the Paris Agreement. The ETS should be extended and tightened in order to match the ambition of EU's net-zero 2050 target, and to set a pathway for net-zero electricity emissions by 2040. This means implementing an average annual reduction in the scheme's emissions cap of around 4% from the early 2020s onwards.

INNOPATHS modelling suggests that such a tightening of the EU-ETS cap would almost triple CO_2 prices to around 130€/tCO_2 in 2030 (Figure 1), leading to an almost complete coal power phaseout and a 60% reduction in gas-fired generation by 2030. Compensating for the phase-out of coal and gas, INNOPATHS modelling also shows wind and solar capacity additions increasing dramatically, to roughly 80GW/year for wind and solar combined on average in the period 2021-2030.

National Energy and Climate Plans will also help to establish the long-term net-zero pathway for the electricity sector. Plans should not only focus on the period to 2030, but also set out a strategy for the crucial decade of 2030-2040. Although for some Member States (MSs) it may be appropriate to target faster emissions reduction, overall the Plans must be consistent with an EU-wide goal of net-zero electricity emissions by 2040. The Plans are an important mechanism by which the benefits of cross-EU coordination might be identified, while respecting the principle of subsidiarity. Thus, the Plans should set out MS-level strategies and policies that reflect individual MS characteristics, but also identify EU-wide coordination or support that would be required to ease the transition within their national contexts, considering the kind of technical as well as political obstacles that will be discussed in the following points.

4 IEA Data and Statistics. Available at: iea.org/data-and-statistics

5 EC (2021) Nuclear energy statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Nuclear_energy_statistics#Nuclear_heat_and_gross_electricity_production

6 EC (2021) Renewable energy statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics#:~:text=In%202019%2C%20renewable%20energy%20represented,the%202020%20target%20of%2020%20%25.&text=The%20share%20of%20energy%20from,27%-20reached%208.9%20%25%20in%202019.

There are technical challenges to the operation of zero-carbon electricity systems, which need to be addressed early, to ensure a smooth and secure transition.

Zero-carbon electricity systems, dominated by variable renewable generators, will pose technical challenges relative to the current paradigms of electricity system operation. For example, the variable output of renewables can create challenges for balancing the amount of electricity being generated with the demand on the system at the same moment. The different locations of renewables compared to where conventional generators have been located, may place stresses on existing electricity grids. The reduction in the 'inertia' provided to the system by conventional generators may create challenges in maintaining the stability of the system.

There are technical solutions to each of these challenges. The balancing of supply with demand can be assisted through electrical storage – both grid-scale and distributed – and through demand-side response. Investments in distribution and transmission grids can improve the accommodation of renewables on the system. Inertia can be provided through means other than conventional thermal generators, or fast frequency response can reduce the need for inertia.

Several system operators are already commissioning these kinds of technologies and services, inviting bids to win contracts for the services. It has also been proposed that continuing market reforms – in particular increasing the granularity of electricity prices both in space and in time, leading towards a "locational marginal pricing" (LMP) approach – could help to provide the incentives for both supply and demand-side actors to take actions conducive to supporting a zero-carbon system.

In some cases, the appropriate measures may be taken at national or sub-national level by system operators. In other cases, cross-border, cross-EU or cross-European coordination may be required to achieve optimal outcomes. National Energy and Climate Plans should be used to identify how MSs plan to meet the technical challenges of operating a zero-carbon electricity system by 2040, including identifying which aspects are internal MS policies, and which have cross-border implications and thus require harmonization within broader EU strategies. These aspects should inform the ongoing development of the Energy Union. The organizations of the European Electricity Transmission System Operators (ENTSO-E) and the European Distribution System Operators (E.DSO) are key intermediary actors. Their involvement will be crucial in understanding the implications of MS level strategies and the degree to which they can be enhanced by cross-border coordination. Areas for consideration could include increased harmonisation of markets to enable more optimal trading and flow of power between systems; and coordination of strategic grid expansion plans, including meshed offshore networks.

Investments in innovation and skills, attending to all stages in the innovation chain, remain crucial to supporting the transition and capturing its economic benefits.

The support provided by European countries to renewable generation through market deployment policies has greatly exceeded the amount invested in R&D. However, R&D investment tends to yield higher social returns.

There are of course risks to R&D investment, as in a global market there is no guarantee that market share can be held once achieved. Whereas European companies were once leading in the manufacture of solar PV, in 2020 there were no European companies in the top ten PV manufacturers. On the other hand, 2 European companies were still within the top ten for wind turbine manufacturing.

Whilst solar PV and wind are now relatively mature technology classes, there is still space for innovation. In PV novel materials could allow applications such as printable cells and building integrated designs. In the case of wind, floating offshore designs could open up huge new capacities. Innovations will also be needed in various supporting system elements, including electrical energy storage, fast frequency response, and IT systems that enable demand-side response and other characteristics of a smart grid.

Hence there remain many opportunities for future innovation in the electricity sector, which can be addressed both by national research institutes, and by EU programmes such as the EU Innovation Fund. It is crucial that such support attends to all stages in the innovation chain, from early stage research, through pre-commercial demonstration and on to the commercialisation phase, from where the policies and market designs discussed in the previous point should help to pull innovations through to market. Innovation policy should also seek to: identify sectors and technologies in which EU companies may preserve a comparative advantage; seek to support the location of manufacturing industries, from both domestic and international companies; and be open to opportunities for within-EU and international collaboration.

The political challenges are as important as the technical challenges, with attention to just transitions at the regional scale essential to meet net-zero targets.

Policy makers should also pay particular attention to regions which could be strongly affected by the transition out of fossil fuels. In the UK, the coal industry declined with no attention given to transitional arrangements for affected regions, leading to multi-generational unemployment. At present countries such as Poland, Estonia, Czechia, Bulgaria and Germany have high shares of coal in their electricity supplies. As discussed above, INNOPATHS modelling suggests that the effect of tightening the EU ETS cap to make it consistent with net-zero electricity by 2040, will very likely be an almost complete phase-out of unabated coal by 2030. Addressing the employment impacts of this transition is therefore an urgent priority.

There is also a risk that policies to promote zero-carbon technologies could, if not carefully designed, have unintended negative impacts on low-income households. For example, policies that reward distributed energy either directly through feed-in tariffs, or as a result of their avoidance of network charges, could result in a cash-flow from poor to rich households, as the upfront costs of home energy systems make them more likely to be accessed by high-income households.

Member States' National Energy and Climate Plans should be used to identify particular justice challenges associated with a rapid transition to a net-zero electricity system, for particular regions, or for low-income customers generally. The Plans should set out national-level strategies for addressing these issues, but also highlight opportunities for cross-EU support and collaboration. Such issues and requests could be directly linked to the Just Transition Mechanism[7]. Investment in R&D and manufacturing for low carbon industries could be linked to regions most vulnerable to unemployment resulting from the phase-out of fossil fuels, and could also be considered a part of post-Covid green recovery.

7 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/just-transition-mechanism_en

Further Information

For further information, please consult the following publications:

- Hughes, N., Goudouneix, É., Calbay, D. and Küfeoğlu, S. (2019) "Annex 6 - National innovation systems in a global context: comparison of the impacts of innovation in wind power and solar PV in four European countries." In Verdolini, E. (ed.) Deliverable D2.4 Report on the sectoral and national (plus EU) innovation system case studies.

- Pietzcker, R.C., Osorio, S., Rodrigues, R., 2021. Tightening EU ETS targets in line with the European Green Deal: Impacts on the decarbonization of the EU power sector. Applied Energy 293, 116914. https://doi.org/10.1016/j.apenergy.2021.116914

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