AT A GLANCE
Requested by the ITRE Committee
Study in Focus

European Parliament

Energy system infrastructures and investments in hydrogen

Including an impact analysis of Ukraine's connection to the EU power grid

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The original full study[1] discusses the present and future of the European electricity and gas infrastructure, exploring production capacity scenarios and their impact on the electricity system (including the role of interconnections, transmission and distribution grids, prosumers, and storage). It also assesses the potential impact of renewable hydrogen development in terms of production and transport. Furthermore, it discusses Ukraine's synchronisation with the EU power grid and its potential impact on the EU energy system.

Background

The EU's energy mix is expected to dramatically change by 2030 and even further by 2050 due to mounting political momentum for energy system decarbonisation that was accelerated by the Covid-19 pandemic and Russia's war of aggression against Ukraine. Decarbonising Europe's energy system rests on three key pillars: first, the mitigation of greenhouse gas emissions from the energy sector; second, reducing external dependency risks; third, the facilitation of this transition borne by citizens must be at a reasonable cost. This transition implies a profound transformation of energy production, import, and transmission infrastructures. It includes the development of renewable energies, the adaptation of the electricity transmission and distribution grid, and the progressive reduction of the current gas network and its adaptation to renewable gases, including hydrogen. Since the 2022 REPowerEU communication, multiple reforms and action plans have been instituted to match these objectives.

Key findings

The European energy system has undergone profound changes over the last three decades, marked by a reduction in energy demand and a shift from coal, oil and nuclear to renewables and natural gas. The EU's energy transition has been in line with the objectives of energy demand reduction and renewable energies penetration set forth for 2020. During the past decade, increased development of the electricity infrastructure facilitated a gradual growth in cross border electricity exchanges while electricity production remained stable. At the same time, developments of the gas transmission network have slowed down and are now focused on the maintenance of existing assets.

This has had multiple impacts on the EU's energy infrastructure. First, there has been a decentralisation of power production. Second, a modest reduction in reliance on energy imports, resulting in part from a large increase in locally produced biomass. Third, there have been impacts on intraday wholesale electricity prices, including increased volatility, especially in countries with high shares of renewables. Nuclear power, though undergoing a decline, has consistently been the largest contributor to the EU's power generation since 1997. A stabilisation of the decline in nuclear is predicted from 2030 in some scenarios, propelled by the emergence and advancement of new nuclear reactors, while others estimate that new capacity additions may prove inadequate to offset the closure of current power plants.

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Achieving Fit for 55 objectives by 2030 and 2050 will require rapid acceleration in the electrification of end-uses and of wind power development. All scenarios analysed in this study, despite being conservative, involve a strong evolution in energy production and demand at four levels. First, it requires increased electrification of end-uses. Second, while growth in solar power aligns with the EU solar energy strategy, there are development challenges for wind power. Third, a large drop in fossil fuel consumption is anticipated that could be paired with an increase in fossil power plant capacities to compensate for the unpredictability of variable renewable energies if low-carbon flexibility assets are not developed. Finally, total plant capacity is expected to significantly grow compared to electricity production. Capacity factors will be overall lower, and production costs per kWh higher.

As the EU's energy system electrifies, optimising the penetration of variable renewable energies through holistic planning of flexibility portfolios becomes pivotal for a successful energy transition. In order to reduce the need for fossil power plants, there will be an increased need for flexibility services directly proportional to variable renewable energy penetration. Grid flexibility will be provided by an extensive portfolio of technologies. Substantial investments in grid infrastructure at all levels are anticipated. Meeting flexibility requirements also calls for additional storage resources, with batteries and longer-duration storage solutions playing complementary roles. Lastly, influencing the demand-side by increasing shares of self-consumed energy and fostering a market for demand response are crucial complementary drivers steering this transition.

The development of low-carbon hydrogen is a strong lever for decarbonisation of the energy system that can benefit from the existing gas infrastructure. Renewable and low-carbon hydrogen produced by electrolysis can help decarbonise the currently gas-intensive production of hydrogen, replace other fossil fuel-intensive end-uses, and, in the long-term, be used as a fuel for existing natural gas power plants, and thus provide long-term energy storage. To achieve a sufficient scale to meet the EU's goals, a cost-efficient solution would be to centralise electrolysis production in large projects (in the EU or in neighbouring countries). To this end, the development of a hydrogen transmission network would be an economic solution avoiding unnecessary development of expensive power lines. This network could benefit from the existing natural gas network. However, the EU's 2030 objectives for renewable hydrogen are extremely ambitious compared to the maturity of announced projects.

The emergency synchronisation of Ukraine and Moldova to the European continental grid serves short- and long-term interests on both sides. In the short-term, it has allowed Ukraine to secure its electricity supply during intensive Russian bombing, and during maintenance of Ukraine's nuclear plants. It has also allowed Ukraine to export significant amounts of electricity to its European neighbours, thus generating valuable profits. In the long-term, Ukraine aims to become an important supplier of electricity to Europe, mainly from its nuclear power plants. Recent agreements also point to strong participation in the future hydrogen economy.

This study provides seven key recommendations based on these key findings:

- Remove economic and regulatory barriers to renewable power development.
- Create and regularly update a bettered assessment of flexibility requirements at the Member State level.
- Remove barriers to self-consumption to optimise grid flexibility.
- Adapt remuneration models for grid operators.
- Plan for the partial decommissioning of the gas distribution and transmission network.
- Use biomethane development to limit the decommissioning of the gas distribution network.
- Capitalise on the gas transmission network for the development of hydrogen, but prioritise local production.

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[1] Possémé, B., Poulin, F., Boillet, C., Gouret, M., Mantulet, G., Abbas, A., 2024, *Energy system infrastructures and investments in hydrogen, including an impact analysis of Ukraine's connection to the EU power grid*, Publication for the committee on Industry, Research and Energy (ITRE), Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2024/754207/IPOL_STU(2024)754207_EN.pdf.

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