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ELECTRIFYING EUROPE: ENERGY TRANSITION PROJECTS CHANGING THE FACE OF EUROPEAN ENERGY

INTRODUCTION

The need to move electricity generation from fossil fuels to renewables is well understood and widely acknowledged. It is a transition that has seen wind farms and solar panels being inextricably linked to sustainability and new ways of powering society. What is less obvious is that this transition cannot take place without massive and transformative investments in grid infrastructure.

In the United States, for example, 25 investor-owned utilities are planning to spend $36.4 billion on grid modernisation, a 37% compound annual growth rate in investment since 2012. [1] In Europe, meanwhile, the distribution system operator trade body Eurelectric estimates European and UK grid operators will need to invest 400 billion euros ($439 billion) to support the energy transition.[2]

This does not include developments such as grid connections to offshore wind farms, which industry body WindEurope says will be key to exporting renewable energy generated in the North Sea, Baltic region and elsewhere.[3] Nor does it include the development of hydrogen-carrying pipelines and infrastructure to provide dispatchable generation in lieu of natural gas.

This paper, published in advance of Reuters Events' Energy Transition Europe 2023 event in London, on November 13 and 14, looks at how the quest for stable renewable energy generation will change European grids and provide new opportunities for innovation and investment.

CONNECTING EUROPE'S GRID

The role of grid connections in enabling the energy transition was highlighted at the start of the 2000s in research by Gregor Czisch, now head of Transnational Renewables Consulting in Germany. Czisch's research showed how it could be possible to power the whole of Europe with low-cost onshore wind supplemented by limited dispatchable renewable energy from technologies such as hydro and biomass.

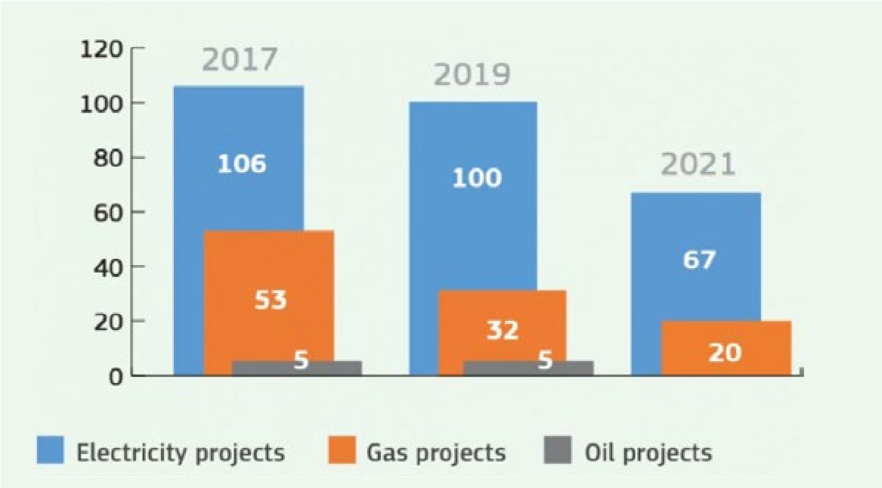
To do this, however, Europe's grids would need to be extensive enough to even out regional differences in wind-based generation, for example stretching from Norway to Kazakhstan and Southern Morocco to the Yamal Peninsula in Russia.[4] Since then, other studies have confirmed the importance of long-distance grid connections in renewable energy integration[5] and calls for a Europe-wide 'supergrid' have been made by industry groups such as Brussels-based Friends of Sustainable Grids.

While the idea of a European supergrid has yet to bear fruit, grid upgrades have featured prominently among Europe's projects of common interest in recent years. The selection process for these projects gives preference to schemes in priority corridors, as identified in Europe's Trans-European Networks for Energy policy.[6]

These corridors include north-south and Baltic region interconnectors, offshore grid links and hydrogen electrolysis interconnections. The policy also supports smart grid deployment, low-carbon gas grids and a cross-border carbon dioxide network.[7] Although the total number of projects of common interest has fallen over time, reflecting increasing modernisation of Europe's infrastructure, the proportion relating to the electricity system has risen, going from 65% in 2017 to 77% in 2021.[8]

EVOLUTION OF EUROPEAN PROJECTS OF COMMON INTEREST BETWEEN 2017 AND 2021.

Source: European Commission[9]



Beyond these major initiatives, European grid operators are also undertaking significant investments of their own. In March 2023, for example, the transmission system operator (TSO) TenneT announced 11 projects to connect a total 22 gigawatts (GW) of offshore wind capacity to shore.[10]

Mainland Europe is also strengthening grid connections with the British Isles, home to Europe's largest offshore wind fleet, with transmission consortium NeuConnect selecting Siemens Energy for a 1.4 GW interconnector project in April 2022.[11]

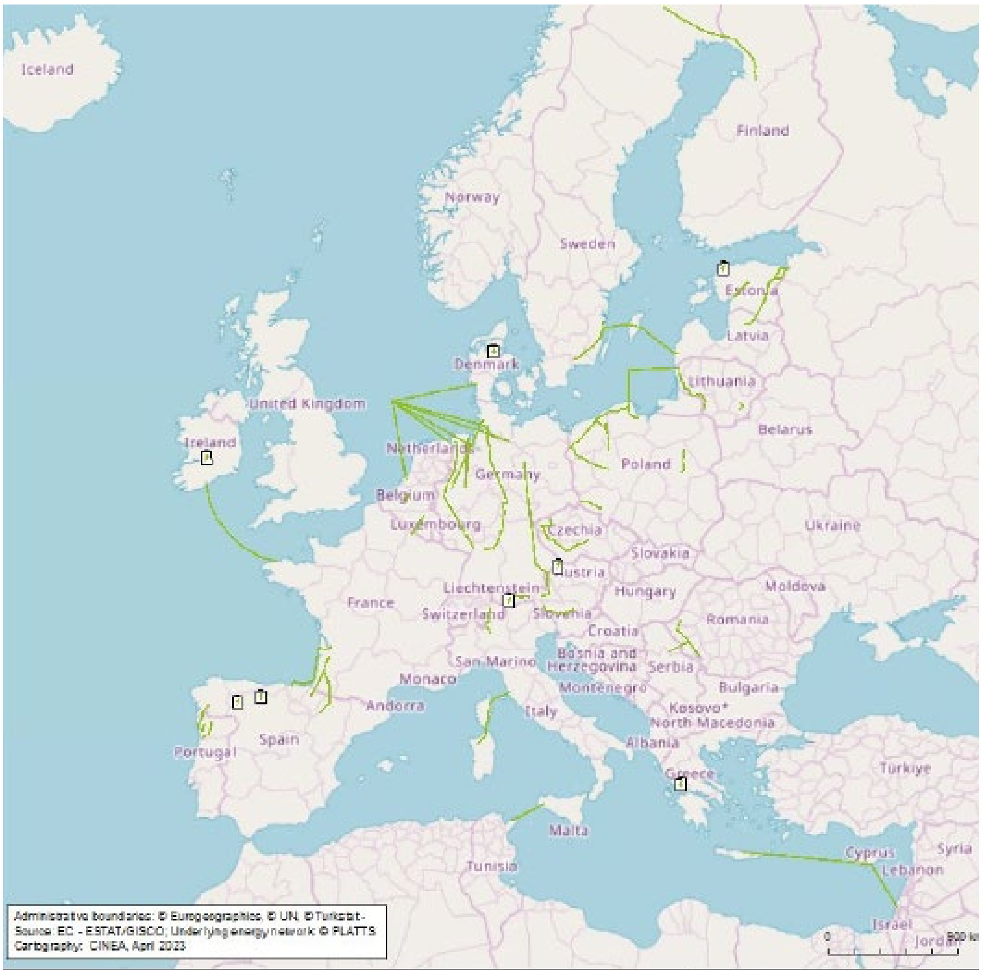
SHAPING THE ENERGY ECOSYSTEM

The result of these investments is expected to be a more flexible and intelligent grid infrastructure that can handle a range of novel energy concepts, such as storage, demand response and aggregation—as well as addressing regional supply and demand imbalances. Although the bulk of grid energy will come from wind and solar, gas turbines are expected to remain in service for the provision of dispatchable generation when needed. But to reduce emissions these turbines are likely to run on low-carbon hydrogen rather than natural gas.

This will require investments in hydrogen infrastructure. Analyst firm Rystad Energy says Europe is at the forefront of moves to produce and distribute green hydrogen made via electrolysis powered by renewable energy.[12] As part of its REPowerEU plan to replace Russian fossil fuels, the European Union aims to produce 10 million tonnes of green hydrogen by 2030, and import a similar amount.[13]

EUROPEAN MAP OF ENERGY STORAGE AND ELECTRICITY TRANSMISSION PROJECTS OF COMMON INTEREST.

Source: European Commission.[14]

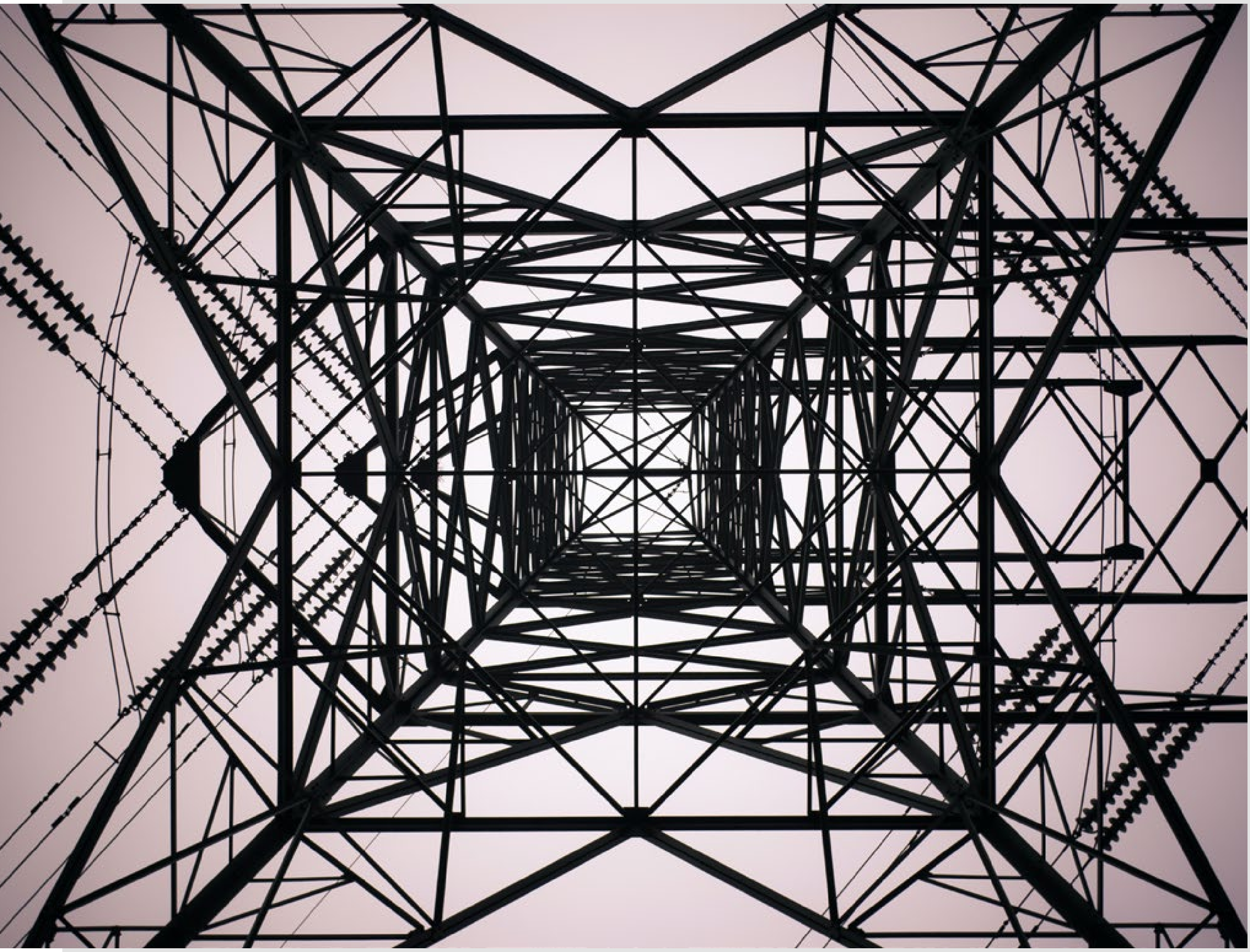


Alongside investments in transmission, distribution and hydrogen infrastructure, the energy transition is encouraging innovation across a vast ecosystem of startups and spinoffs. These are looking to exploit not only the growth in renewables but also trends such as energy storage, energy-related blockchains, demand-side management, vehicle-to-grid applications and power to X, where renewable electricity is used to create low-carbon fuels.

Based on a poll of 2,835 startups,[15] the most popular focus areas for energy innovation globally are renewables and the internet of energy, a technological term that refers to the upgrading and automating of infrastructures for electricity producers and manufacturers.[16] Notable European startups in the energy space include Energy Vault, a Swiss company developing gravity-based storage, and StoreH Energy Storage Technologies of Italy, which has created a hydrogen-on-demand unit.[17]

A prime driver for innovation investment is a growing consumer and corporate appetite for clean energy. Consumers are increasingly seeking green energy tariffs, buoying the fortunes of specialist providers such as Octopus Energy, which saw revenues doubling in its 2021-2022 financial year.[18]

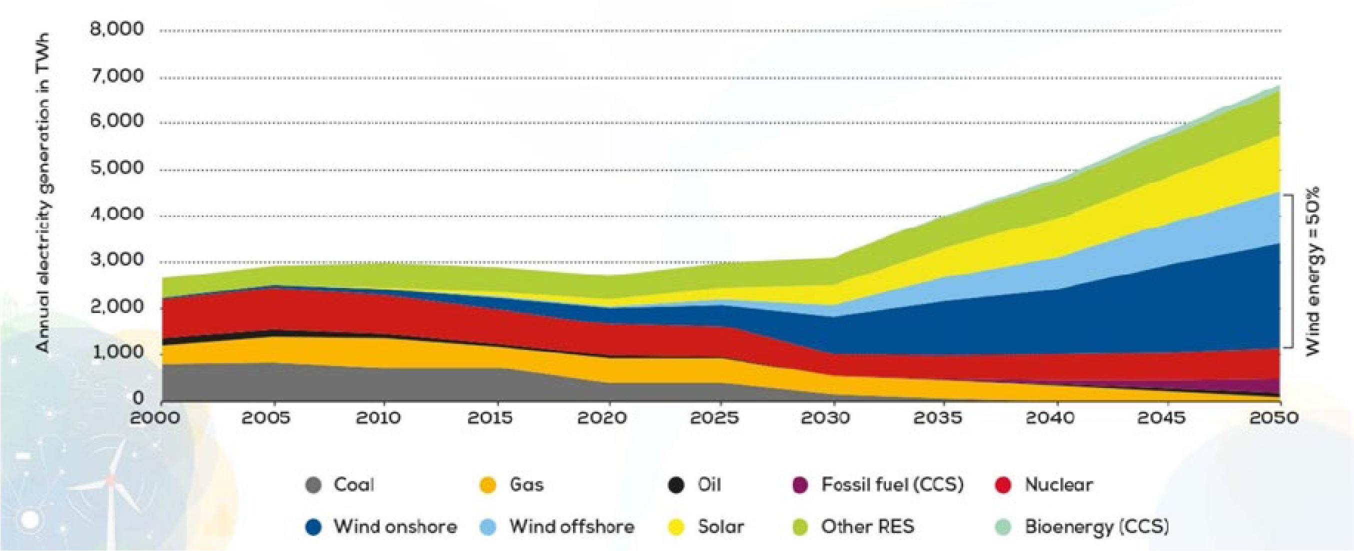
Meanwhile, European companies have gone from buying barely 100 megawatts of clean energy via power purchase agreements in 2013 to 18.5 GW in 2021, according to RE-source, a corporate renewables sourcing platform,[19] although volumes fell in 2022 because of market volatility.[20]



WEANING EUROPE OFF FOSSIL FUELS

EU ELECTRICITY GENERATION MIX UP TO 2050.

Source: European Technology & Innovation Platform on Wind Energy.[21]



Clean energy requires grid modernisation because the most cost-effective sources of low-carbon generation—wind and solar—are not dispatchable. Instead of being turned up or down to match grid demand, intermittent renewable energy must be imported from wherever it is being produced, which may be a considerable distance away from load centres.

Wind and solar are intermittent not only in space but also in time, so there is no way of guaranteeing that peaks in production will match peaks in demand. Because of this, low-carbon grids will need significant amounts of energy storage, typically in the form of pumped hydro and lithium-ion battery capacity.

Standalone energy storage systems could be supplemented with electric vehicle battery capacity as vehicle-to-grid technology takes off. These developments represent a major shift in the way electricity grids are designed and operated. Previously, transmission systems were limited in scope, since fossil fuel generation could be installed relatively close to load centres, and energy flows were largely unidirectional, from power plants to consumers.

As fossil fuels are replaced by renewables, transmission networks will need to span the entire continent and distribution systems will have to be predominantly bi-directional, accepting energy from distributed sources of generation as well as delivering it to end users. Although this conversion will require significant investment, the development of more diverse, flexible grids also offers opportunities for efficiency gains. Energy storage, for example, can help avert the need for grid upgrades on congested electricity networks.

Thus, if a node experiences demand beyond what the local network can deliver, a nearby battery plant could fill the gap. Another notable development is the ability to use the electricity network to tie together a range of distributed assets, such as rooftop solar, residential storage and controllable loads, in a virtual power plant.

Such plants can use available resources to offset the need for new generation and may be a more cost-effective and socially acceptable way of serving growing grid requirements than building additional infrastructure.[22]

To achieve a decarbonised energy system, "Non wire system efficiency measures are necessary but not enough on their own," says the European Network of Transmission System Operators (ENTSO-E), which represents 39 electricity TSOs from 35 countries, in a video. "Even if we optimised every inch of our current power system, it would still not be able to cope with the large amount of renewables expected in the future. We need more infrastructure to support this energy transition."[23]

ACCOMMODATING RENEWABLE ENERGY SOURCES

To fully match supply and demand in a low-carbon world, Europe's grids will also need to incorporate much higher levels of intelligence than they have at present. The networks will have to predict imbalances based on past usage patterns and meteorological data—and manage controllable loads and energy storage assets accordingly. This added intelligence will need to extend to—and possibly beyond—end-user meters.

Smart meter penetration across Europe was expected to reach 56% by the end of 2022, with 172 million devices installed. Penetration is set to grow to 74% by 2027.[24] "Utilities in the European region are increasingly adopting technologies like artificial intelligence and digital twinning, coupled with increased government support and initiatives, further attracting investments in smart grid projects," observes research firm Mordor Intelligence.[25]

Grid intelligence will also be needed to cope with fluctuations in electrical frequency and voltage. These must be kept within strict limits for the correct functioning of the grid, and in legacy electricity networks the large rotating masses of thermal turbines act as natural pacemakers to ensure stability.

Future grids, dominated by wind and solar, will not have this capacity, and in renewables-heavy markets such as South Australia there have already been concerns about the stability of the electricity system.[26] To overcome these issues, grid operators are interested in procuring capacity that can perform ancillary services such as voltage control and frequency regulation.

Quick-acting lithium-ion batteries have emerged as an important asset in this respect because they can rapidly respond to changes in frequency and voltage with brief nudges of power that can keep the system in line. In April 2022, the analyst firm Wood Mackenzie predicted Europe's grid-scale energy storage capacity could expand 20-fold by 2031, with Britain—which only has limited grid connections to the mainland—leading the charge.

Most battery storage capacity in Britain is used for frequency response and similar services, to the point that there is only limited room for further growth in such applications. "The saturation of fast-response ancillary markets will see UK energy storage project development more tightly linked to renewable energy growth, pushing for longer duration storage assets from mid-decade," observed Wook Mackenzie lead analyst Anna Darmani.[27]

Even with highly interconnected, responsive grids, there will still be times when Europe cannot be powered by wind and solar. European weather patterns typically include up to 100 hours a month of calm, dark weather a month from November to January, during which wind and solar generation is unlikely to cover total demand. In these periods, wind and solar will need to be supplemented with hydropower, pumped hydro storage and, potentially, low-carbon hydrogen. The EU already hosts more than a quarter of global pumped hydro storage capacity and is keen to unlock more.[28]

OUTLOOK AND CONCLUSIONS

The energy transition represents the greatest change ever seen in grid design and operations, with ENTSO-E estimating that a failure to provide the necessary investment could destabilise the electricity network and increase European electricity bills by a total 9 billion euros a year. The body has called for 6 billion euros of investment a year up to 2040, resulting in annual savings of 3 billion euros. "There is an enormous scope for new European opportunities," it says.[29]

The improvements made in coming years could see Europe's grid becoming fit for a renewable future where energy can be sourced indefinitely, without climate impacts. At the same time, there is considerable scope for industrial leadership since all grids around the world will ultimately face the challenges being addressed by European entities.

How to efficiently and cost effectively modernise Europe's grids will be a major agenda item at Reuters Events' Energy Transition Europe 2023 event in London, UK, on November 13 and 14, featuring more than 50 executive speakers and 40-plus business-critical sessions. To find out more, see events.reutersevents.com/energy-transition/energy-transition-europe.

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