IMF Staff Background Note on EU Energy Market Integration[1]

January 16, 2025

This note was produced at the request of the Polish Presidency of the Council of the EU and presented by Alfred Kammer, Director of the IMF European Department, to the EU's Economic and Financial Committee on January 13, 2025. The note lays out the current fragmentation of EU energy markets and its costs, the benefits of greater energy market integration, and some of the existing impediments to integration. But it is not intended to be a comprehensive analysis of the EU energy system, with most of the focus is on the integration of the electricity grid and market, as the energy system will be increasingly electrified and there is a clear need for greater EU level coordination and action here. The note concludes with some policy recommendations to help achieve the EU's energy and climate objectives.

The case for further energy market integration

Greater integration of European energy markets would benefit the EU through three closely interrelated channels—lower energy prices, enhanced energy security, and decarbonization.

- **Lower energy costs:** Starting in the 2000s the shale revolution in the US opened up a large and persistent energy price gap between Europe and the US. The 2022 crisis widened this gap (while also bringing energy security concerns to the fore). Given that the EU lacks low-cost and abundant domestic energy supplies, narrowing the gap requires a move away from a fossil-fuel-based energy mix towards low-marginal cost energy technologies, including as part of the EU's green transition efforts. This in turn requires rapid and widespread electrification. A coordinated and integrated approach at the EU level would be by far the most cost-efficient way to achieve this. Integration helps lower energy prices due to the possibility to optimize generation choices and share the benefits through electricity trade (as different parts of the EU have different renewables potential), as well as avoid over-investment and reduce energy storage needs (as different parts of the EU have different peak use/generation times).

- **Enhanced energy security:** An integrated energy market boosts energy security. As is the case with other aspects of the single market, integration is the best protection against country-specific or regional shocks. The 2022 gas shock highlighted the resilience the EU gained by sharing gas, and the vulnerabilities that arise when infrastructure is insufficiently integrated across different EU countries. Shortfalls due to technical interruptions, weather phenomena or other factors in parts of the EU can be absorbed by other parts when integration is sufficiently advanced. If instead there are persistent bottlenecks, regional and local price spikes would be the consequence, as seen most recently when electricity prices shot up in some South-Eastern European economies in the summer of 2024. Greater energy interdependence among EU member states would also deliver gains in security by reducing energy dependence on third countries and making sure energy security benefits are evenly shared.

- **Delivering on decarbonization:** The more integrated European energy markets are, the faster, and more cost-efficiently the EU will be able to meet its decarbonization goals by exploiting the renewables potential across its member countries. This will also enhance energy security at the same time.

[1] The views expressed in this note are those of the IMF staff and do not necessarily represent the views of the IMF Executive Board or management.

A brief overview of energy prices

The shale revolution in the US had already opened a lasting energy price gap between the EU and US before Russia's invasion of Ukraine. While there was essentially no transatlantic gas price gap in 2005, EU industrial use natural gas prices subsequently averaged around 2.5 times US prices over 2006-2019, while electricity prices were about twice the US level (Figure 1), contributing to competitiveness shifts already before Russia's invasion of Ukraine. While higher taxes on energy in Europe also played a role, they accounted for a relatively small share of this growing price gap for most EU countries (less than 20 percent on average for the EU as a whole for non-household consumers).

The 2022 crisis led to a further persistent rise in the pre-existing energy price gap for both natural gas and electricity, as natural gas generation is frequently the marginal price-setter. Prices initially spiked to as much as ten times the pre-shock average. They have since receded but stabilized well above pre-pandemic levels (Figure 2). Overall energy prices in the EU relative to the US have roughly doubled compared with the three years before the pandemic. The ratio of electricity prices has increased from around 2 to 3, while for natural gas the ratio has risen from 2 to 4.5 in 2024.

In addition to persistently higher average energy prices, the 2022 crisis also revealed the fragmentation in European energy markets. With natural gas suddenly having to flow west to east (imported LNG) rather than east to west (Russian pipeline gas), the European natural gas infrastructure nearly reached a breaking point in the summer of 2022 with wholesale natural gas (and electricity) prices both spiking and diverging sharply across Europe. The fact that cross-border energy trade was allowed to continue at the height of the crisis, and the broad solidarity shown by member countries, were key to avoiding the worst costs.[2]

While the divergence in wholesale natural gas prices across Europe has since dissipated, this is not the case for electricity prices. On average over 2023-24 the median wholesale electricity price across EU countries has doubled relative to the pre-pandemic level and electricity price dispersion within the EU has tripled (Figure 2). Electricity price volatility over time and across electricity hubs remains more than three times its pre-pandemic average (Figure 3.a). In this respect, electricity market integration is key to avoid price volatility both across countries and over time. If there were no cross-border trade at all today, volatility could be more than five times the observed level (Figure 3.b).

While the EU deserves credit for developing several regional electricity trading markets and interconnectors, the system remains fragmented. The still limited extent of network integration results in market fragmentation (Figures 4 and 5). This is particularly evident when unexpected shocks stress parts of the system. For example, electricity prices in some South-Eastern European (SEE) countries increased sharply in the summer of 2024 as Ukraine had to import more electricity to meet its domestic demand due to the impact of Russian attacks on its own generation capacity. This created a significant price wedge between SEE and Western Europe given still limited interconnections between the two

[2] France, for example, became an important electricity importer, while historically it is an electricity exporter. And LNG flows east through Belgium at maximum capacity were important to supply Germany with natural gas. The risk of the most exposed countries facing outright gas shortages and rationing was nevertheless real had all Russian pipeline flows been interrupted in the summer of 2022 – not because of a lack of gas at the EU level, but because infrastructure bottlenecks would have made it impossible to transport enough LNG to exposed countries in CESEE (Di Bella et al. 2024). Europe is now on a good path to fix the remaining gaps in its natural gas infrastructure.

regions.[3] Reducing fragmentation requires further market integration, greater use of existing interconnectors and increasing the capacity of the grid, especially across borders.

The macro impact of the energy shock and the impact of the EU-US energy price gap

The period since 2022 has highlighted the adverse impact of energy price shocks for the European economy. The ECB (2023) estimates that the 2022 price spike decreased industrial production by about 2 percent in 2022 in the euro area in the first year. The skyrocketing energy prices also affected export market shares, in particular in energy-intensive industries and producers upstream in the value chain (see ECB 2024). And through the adverse terms-of-trade effect, consumption and investment fell, with that impact mitigated by fiscally costly support measures for households and firms.

In the longer-run, sustained high energy prices adversely impact energy-intensive industries. Energy prices are a notable cost factor in certain sectors (e.g., close to 10 percent for chemicals). In the context of the US shale boom and the emergence of a natural gas price gap with Europe, Arezki et al. (2017) show that a price gap of 10 USD per cubic foot of natural gas opened by the mid-2010s, and that for every USD in price gap chemical manufacturing output (and exports) increased by 1.6 percent in impacted US regions. Kirat (2021) also documents a renaissance of the most energy-intensive industries in the US following the shale boom.

At an economy-wide level, the longer-term adverse effects of energy prices are material but more muted. While highly energy-intensive industries in the US benefited from the shale boom, the effects on broader manufacturing are generally found to have been weak (Kirat 2021; Spencer et al. 2014). In the European context, the 2022 crisis severely impacted energy-intensive industrial production which still remains on a downward trend, but broader manufacturing held up better (Figure 5).[4] This is due to the limited weight of energy in an economy's overall input costs, substitution possibilities, and energy-price-driven improvements in energy efficiency. First, by exploiting various margins (including international trade), firms are able to substitute away from inputs affected by a supply shock, and have done so following the 2022 energy crisis (Moll et al. 2023). Di Bella et al. (2024) estimate that a full shutoff of Russian pipeline gas in the summer of 2022 could have reduced EU GDP by 0.4 to 2.7 percent, but integrated energy markets were crucial to achieving economic effects towards the lower end of this range. Second, firms are able to invest in energy efficiency-improving techniques, allowing them to adjust their production technology.[5] Forthcoming IMF work (Lan et al.) suggests that, after accounting for such endogenous improvements in energy efficiency, the impact of the energy crisis on potential output in the

[3] The average wholesale electricity price in Bulgaria, Greece, Hungary and Romania, increased by 130 percent between April and July 2024 compared to a 35 percent increase for the rest of the EU.

[4] Berk and Yetkiner (2014) and Huntington and Little (2022) attempt to estimate the longer-term relationship between energy prices and GDP per capita (or GDP growth, respectively) in a panel of advanced economies and find statistically significant adverse effects of energy prices. On the other hand, recent OECD work using firm-level data (André et al. 2023) argues that higher energy prices first lower capacity utilization and productivity across the board. But in the medium term, the losses stabilize for energy-intensive industries and can even revert for non-energy intensive sectors if the price increase is modest.

[5] As energy is hard to substitute in the short run, and if firms face a budget constraint, investing in energy efficiency entails a tradeoff with investing in capital-labor productivity improvements. The former becomes more profitable when energy prices rise.

euro area was eventually around 1 percentage point. While less than initially feared by many, this is still sizable, amounting to an output loss of nearly €200 billion a year by 2027.[6]

Some estimates of gains from closer energy integration

The direct benefits of an integrated energy market are sizable. Studies have estimated cost savings of around €40 billion per year from greater integration.[7] Other studies (Zachmann et al. 2024; Roth and Schill 2023) conclude that greater integration even within subsets of countries could reduce the needed dispatchable generation capacity to meet peak demand by nearly 20 percent and storage capacity by 30 percent, compared to a baseline scenario in which integration remains unchanged. Broader IMF analysis finds that a market integration scenario under which cross-border electricity trade rises by 50 percent could raise annual EU GDP in 2030 by around 0.1 percent (Dolphin et al. 2024).

Integration provides further indirect economic benefits to the EU. While it is unlikely that the EU will close the energy price gap with the US fully, combining renewable-based power supply (while still producing or purchasing the marginal energy source at the lowest possible cost—often projected to be natural gas for at least several years) with market integration could go a long way. And the transition to a predominately renewables and low carbon energy system along with a more fully integrated EU energy market would significantly lower energy costs while electricity trade will support resilience to shocks.

Lower energy costs and greater stability of the integrated system are also likely to foster investor confidence in the EU and make investments in innovative technologies more attractive (for example, see the 2023 EIB firm survey). This should stimulate corporate investment not only in energy-intensive industries, but also, and perhaps most critically for the future, in key innovative sectors such as AI, quantum computing, or digital service industries. All of these technologies are underpinned by data centers with significant electricity demand that makes the availability of low-cost electricity a key consideration of investment decisions. Lowering energy costs is, of course, only one part of what the EU should do to ensure it is attractive for investments in new technologies and to reap the potential productivity gains they offer. Deeper integration of the single market more broadly along with regulatory and other reforms will also be important.

The more Europe moves towards electrification and renewable-based power, the greater the gains from integration will be. A more integrated energy market will deliver larger benefits, in terms of the average level and volatility of energy prices across the EU, as renewable energy sources gain further weight in power generation (see Figure 7 for differences in renewables potential across the EU) and electrification of end uses (e.g., electrical vehicles and heating) and industrial production (e.g., green hydrogen) continue to make progress.[8]

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[6] Countries with a higher energy share and lower estimated substitution elasticities such as Germany and Italy face somewhat higher losses relative to other countries.

[7] One study estimates that annual cost savings from greater electricity system integration could amount to more than €40 billion by 2030 (Booz & Co. 2013). Another study found hypothetical gains of €34 billion (in 2021) from a fully integrated electricity markets compared to a scenario where EU countries are producing electricity in isolation (ACER 2022). The European Parliamentary Research Service (2021) estimated annual gains from further energy market integration of €53 billion by 2030. Brown et al. (2018) find that an optimally integrated energy market and sector-coupling reduces costs by up to 37 percent relative to a non-integration scenario.

[8] IMF staff estimates suggest a more cost-effective investment mix to meet emission reduction goals could also generate considerable savings in terms of aggregate investment costs at the EU level (IMF 2024).

What has impeded energy market integration?

Energy policy remains a national prerogative. Despite energy being at the heart of the European integration effort from the very beginning (the European Coal and Steel Community), energy policy remains an intrinsically national prerogative with limited formal powers at the level of the European Commission. The EU treaties leave the choice of the aggregate energy mix in the hands of national governments, for example. The EU-level green transition goals and the response to the 2022 energy crisis have increased cooperation. Solidarity agreements for natural gas were signed by many member countries, for example, and member countries agreed to a voluntary 15 percent demand reduction target. But the overall institutional setup has not changed significantly. And with national authorities ultimately responsible for national energy security, there is a risk of uncoordinated and more expensive approaches.

Different starting positions lead to differing incentives. The fact that member countries differ in their energy intensity, potential for renewable power generation, and financing costs, underpins the gains from market integration but at the same time can make it politically difficult to reap them. This is due to different incentives of economic actors. In exporting countries, while electricity producers have every incentive to boost electricity interconnections, end users (and hence governments) in these exporting countries might fear higher electricity costs as the result of exports. For importing countries, electricity users have an interest in boosting interconnections, but this could undercut domestic generators, which may then lobby the government against greater integration. Of course, most countries would likely be occasional importers and occasional exporters. The political reality of the above considerations is nevertheless highlighted by the fact that infrastructure is not always the main constraint to increased electricity trade in the EU – in fact, member states could already reap benefits by raising the utilization of existing interconnector capacity but purposefully choose not to (Baker et al. 2018).

A fragmented institutional set up leads to failures to internalize network externalities. National regulators prioritize minimizing costs today for their rate payers, and national governments tend to make investment decisions (grid expansion, green transition) with an eye to meeting national targets. In particular, many of the network externalities are not fully internalized.[9] National regulators often do not take into account the impact of their individual decisions on the EU system as a whole, resulting in under-investment in market integration. While it might entail short-term costs in some cases, an integrated energy approach would deliver a long-term gain not only at the EU level but also in individual member countries through greater resilience to shocks, more secure supplies, and ultimately lower prices (see IMF analysis in Dolphin et al. 2024).

The war in Ukraine made the need for energy market integration much more salient than it used to be. With a fossil fuel-based energy mix, electricity interconnections are less critical than with a primarily renewables-based energy system (given ease of transport and storage, intermittency of renewables, etc.). In addition, a long history of Russian pipeline gas imports had made severe supply disruptions appear unlikely.[10] This has changed dramatically since Russian gas flows were curtailed and prices spiked. The EU deserves credit for responding on many fronts, including the RePowerEU package to help countries to transition away from Russian gas and accelerate the rollout of renewables, as well as launching a reform of the electricity market and other measures. But more remains to be done.

[9] For example, when the wind is not blowing in Poland, it may not be enough for Poland to have good interconnectors to Germany if Germany doesn't have sufficient interconnectors to France which might have surplus energy.

[10] Calls for greater electricity market integration are not new though (see, for example, Zachmann 2013).

What needs to be done?

Lowering prices, enhancing energy security, and decarbonizing the European economy will require an energy transformation centered around the electricity system. EU members will need to overcome barriers to integration and develop a coordinated strategy for efficiently transforming the EU's energy system (generation, storage, transmission) into a fully integrated, single energy market. The optimal approach will take a Europe-wide perspective but be tailored across countries and regions. We have five policy recommendations:

First, develop a unified EU "blueprint" for the energy system transformation.

The EU should develop a comprehensive, data-driven energy transformation strategy centered on the electricity system. This strategy should:

- *Close information gaps.* Invest in data, modeling, and analytical tools to identify the most cost-effective and critical investments in generation, storage, transmission and complementary infrastructure.

- *Design an overarching blueprint.* Using the improved data and estimates on critical investments, design a forward-looking roadmap for the next few decades that prioritizes efficiency, cost-effectiveness, energy security, and decarbonization while internalizing the various externalities and national incentives that have hampered integration thus far.

This blueprint could serve as a foundation for coordinating EU and national policies, aligning resources and actions to maximize the collective impact. It will also help identify where EU-level action is most needed, including to address the externalities and incentive problems discussed above.

Second, strengthen institutional and financing frameworks.

The EU must address structural deficiencies in markets and institutional barriers to integration with bold, systemic reforms.

- *Establish an EU entity to ensure the development of the grid:* The existing institutional and market structures are unlikely to deliver the network capacity the EU needs (Cremona 2023). Solving this may require a new EU entity to coordinate or even implement the necessary investments, such as an EU grid interconnector operator.

- *Design harmonized instruments:* Ensure new instruments, such as capacity mechanisms, are based on a common framework to prevent fragmented approaches that could undermine the single market.[11]

- *Reform EU budget allocations:* Reform existing funding instruments to prioritize facilitating the energy transformation and an efficient use of resources, as well as support for complementary reforms.

Third, pool resources to accelerate innovation and mitigate risks to the single market.

Beyond addressing coordination failures, collaborative action and pooling resources at the EU level can maximize economies of scale, mitigate risks to the single market, and accelerate breakthroughs in clean energy technologies.

[11] See ACER (2024) for a further discussion of potential new instruments and options to support needed investments.

- *Boost EU level resources for R&D in energy and clean technologies:* Scale up research into developing next generation technologies, such as grid-scale storage technologies to cover intermediate duration periods of low renewable power generation. Moreover, pooling resources to develop new technologies to tackle decarbonization in hard to abate sectors, such as agriculture, will help to ensure the green transition is politically and socially sustainable.

- *Coordinate funding to support the scale up of new clean technologies:* Providing such resources at the EU level on a meritocratic basis will help to mitigate risks to the single market posed by state aid.[12]

Fourth, streamline permitting processes and optimize demand management. To accelerate the deployment of renewables and grids, the EU must tackle longstanding bottlenecks.

- *Simplify and digitize permitting processes:* Standardize and expedite permitting timelines, including across member states, to fast-track renewables and grid infrastructure. Despite some progress, delays due to permitting processes are a major impediment to the rapid deployment of both renewables and grids, with the overall permit-granting process taking several years in some member countries.[13]

- *Enhance demand management:* Improving demand management and responsiveness to electricity prices could also reduce volatility and lower average prices.[14]

Fifth, pursue coordinated action across all levels of governance of the energy market.

Achieving a fully integrated, single energy market requires better collaboration across all levels—EU, national, regional and local. By aligning policies, reducing inefficiencies, and fostering innovation, Europe can achieve a clean, affordable, and secure energy future.

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[12] See Kammer et al. (2024) for further discussion of the potential costs (benefits) of uncoordinated (coordinated) industrial policy in Europe.

[13] See, for example, European Commission (2022).

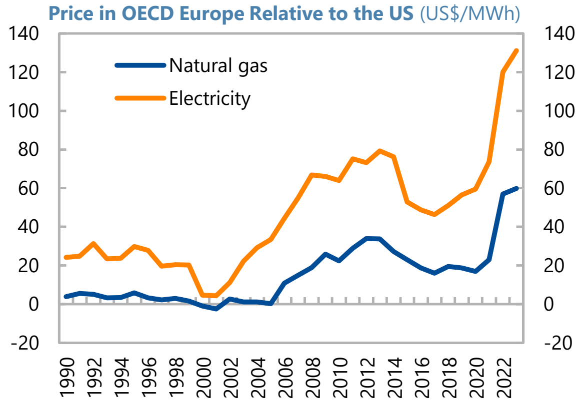
[14] See Heussaff (2024) for a useful discussion of options to lower European energy prices.

Figure 1: Energy prices

The shale boom in the US opened an energy price gap for industrial users between Europe and the US, this gap widened further after the Russian invasion of Ukraine…

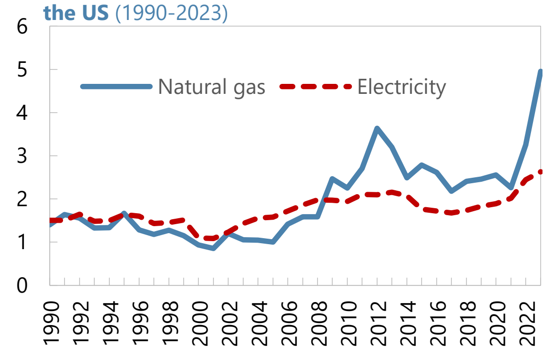
…with Europe paying nearly five times as much as the US for natural gas and more than double for electricity in 2023.

Difference in Industrial-Use Electricity and Natural Gas Price in OECD Europe Relative to the US (US$/MWh)



Sources: IEA; and IMF staff calculations.

Ratio of industrial-use electricity and natural gas prices in OECD Europe versus the US (1990-2023)

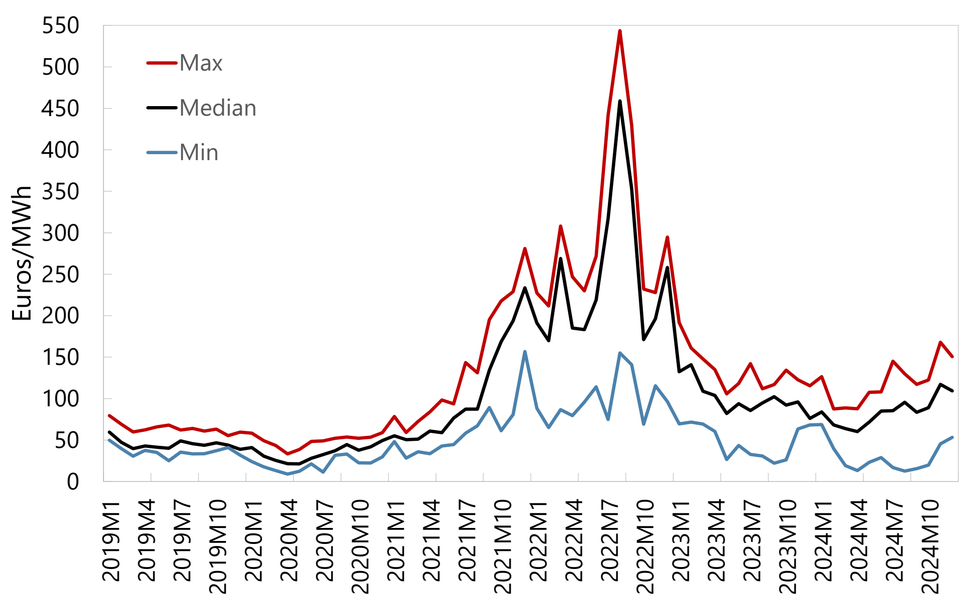


Source: IEA and IMF staff calculations

Figure 2: Wholesale electricity prices

Both the level and dispersion of wholesale electricity prices across EU countries shot up in 2021-22. While they have declined from their peaks, on average over 2023-24 the median price is double the pre-pandemic level and the average dispersion (difference between maximum and minimum) has tripled.

Median Wholesale Electricity Price and Dispersion across EU Countries
(Monthly average wholesale electricity price in euros/megawatt-hour, 2024M12)

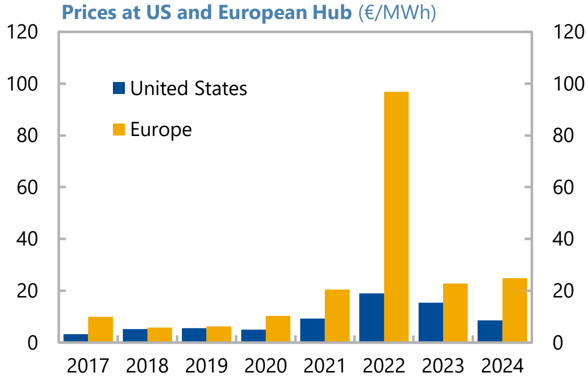


Source: ENTSOE and IMF staff calculations.

Figure 3: Electricity price dispersion and volatility

Electricity price volatility and dispersion across European hubs remains much higher than pre-pandemic and much greater than between US hubs.

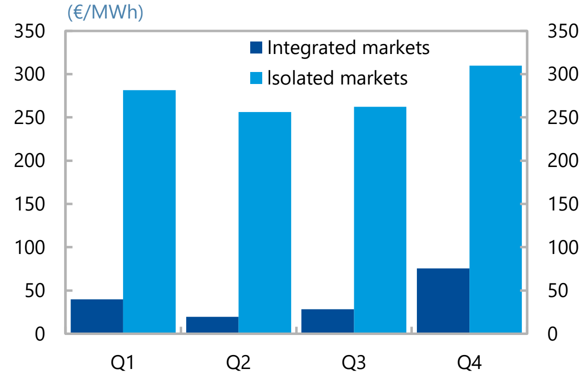
Standard Deviation of Average Annual Electricity Prices at US and European Hub (€/MWh)



Sources: Bloomberg Financial L.P.; and IMF staff calculations.
Note: Latest data for 2024 is through end-November.

Without the existing extent of EU grid integration, estimates suggest electricity price volatility would be more than five times as high as it already is.

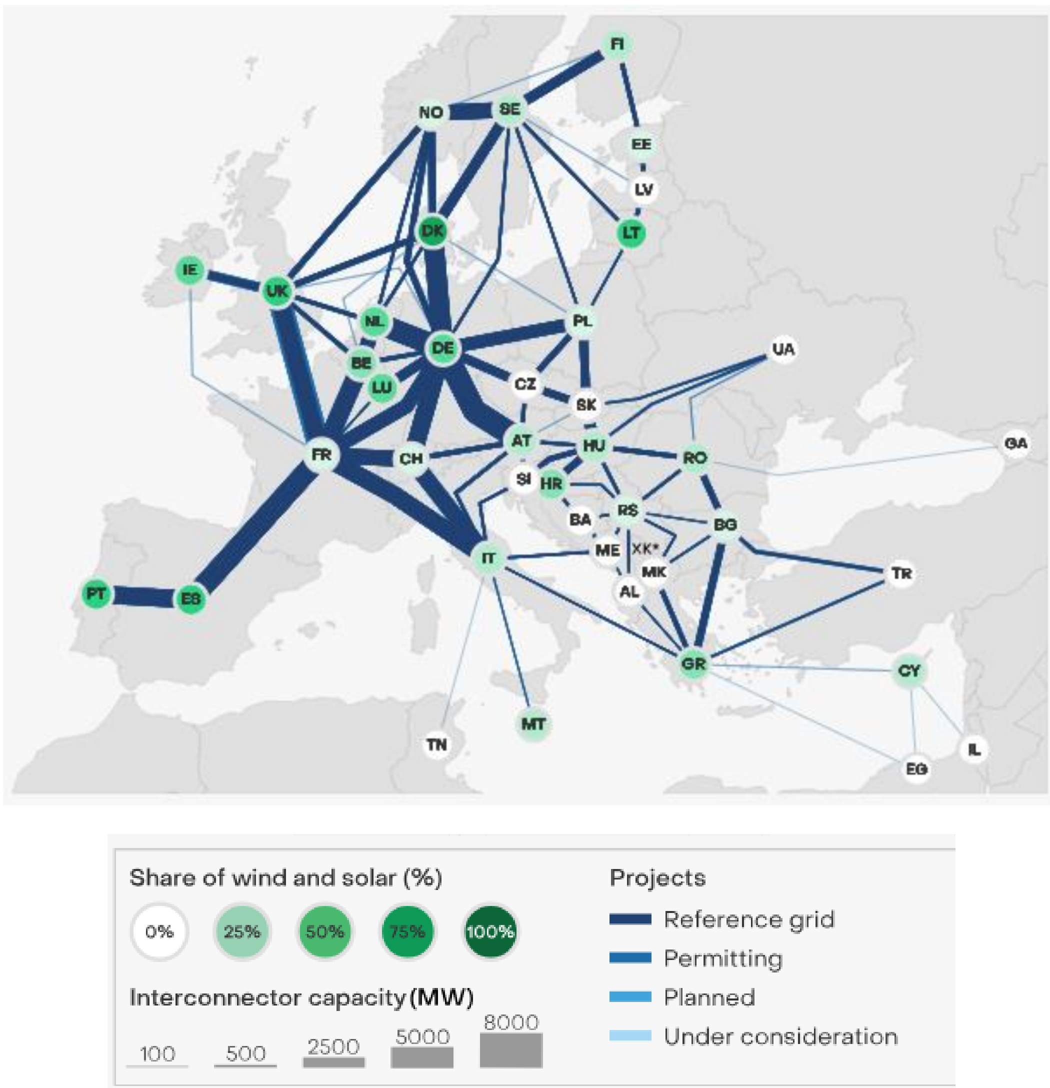
Price Volatility in the EU
(€/MWh)



Source: Zachmann et al. (Bruegel, 2024) based on ACER (2022).
Note: Simulation based on patterns in 2021.

Figure 4: Interconnection capacity in Europe

While significant interconnection capacity has been built across Europe, important gaps in the system remain, and substantial new capacity will be required as the EU energy system electrifies and decarbonizes.

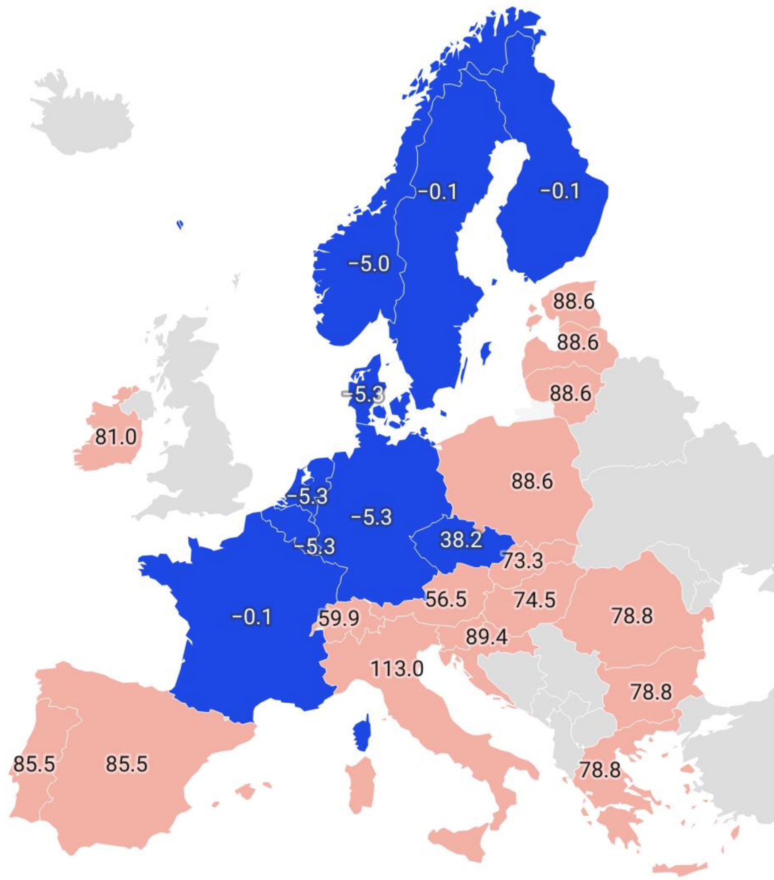


Source: Ember based on ENTSO-E data.

Figure 5: Differences in Day-Ahead Electricity Prices

Lack of market integration can lead to stark price differences across neighboring countries.

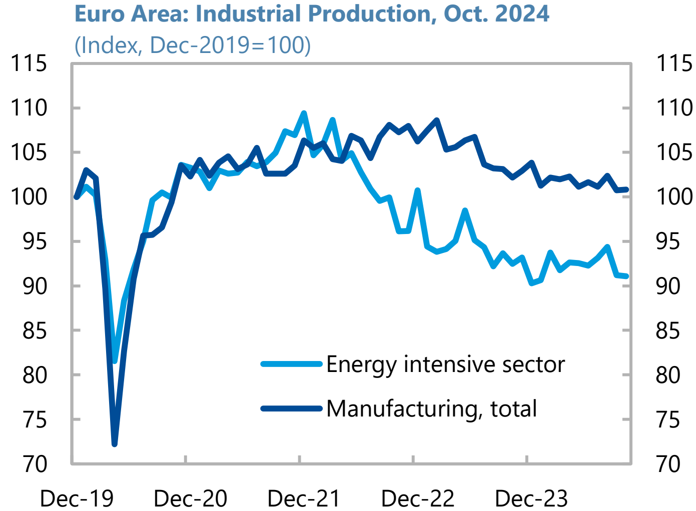
Negative Prices in 2023: When Export Meets Bottlenecks 1/
Day-Ahead Prices in the EU-27/EEA(Norway) and Switzerland
(€/MWh, as of September 20, 2023 at 11:00)



Source: ACER calculations based on ENTSO-E Transparency Platform data.

1/ Countries in blue had negative prices while countries in pink had positive prices. "Bottleneck" should be understood as "market congestion", a "situation in which the economic surplus for a single day-ahead or intraday coupling has been limitedby cross-zonal capacity or allocation constraints" (see Capacity Allocation and Congestion Management).

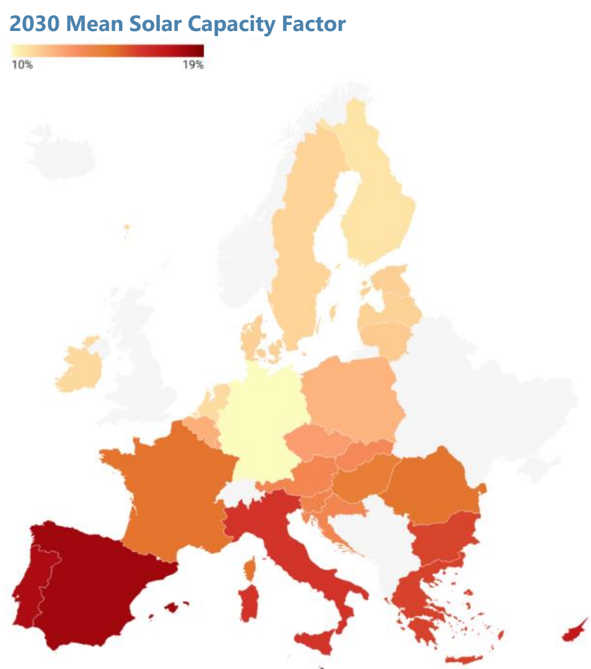
Figure 6: Decoupling between industrial production in energy-intensive sector and overall manufacturing



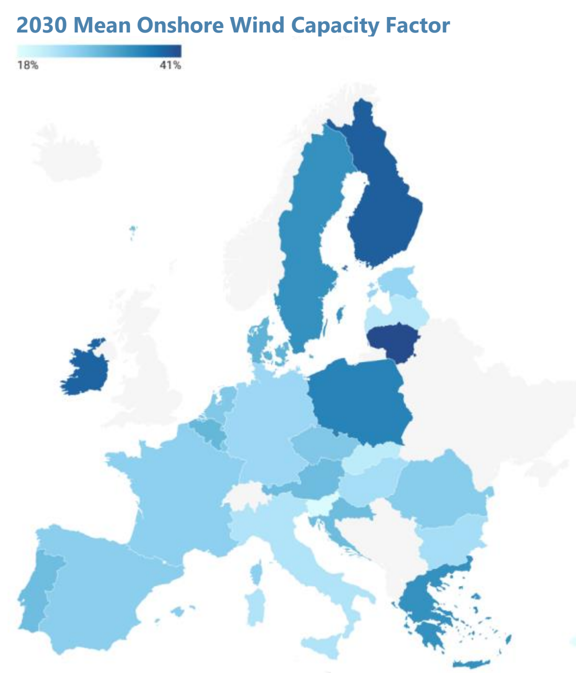
Sources: Eurostat; Haver Analytics; and IMF staff calculations.

Figure 7: Illustrating the importance of integration with renewables-based energy supply

The potential for renewables generation differs widely across Europe, with more solar potential in the south and onshore wind in the north.



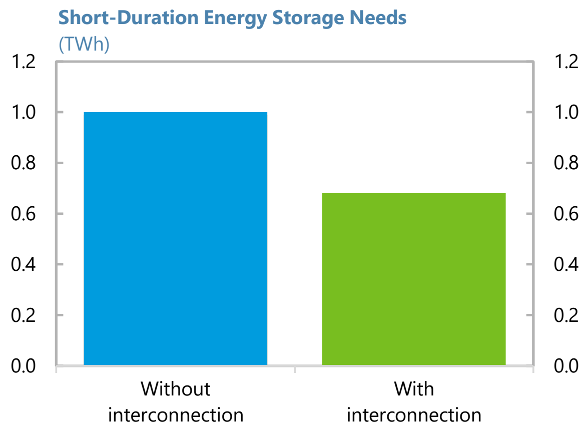
Source: Zachmann et al. (Bruegel, 2024).
Note: "Capacity factor refers to electricity produced at realistic wind or solar conditions, relative to the amount produced if the plants would in each hour have operated at their peak capacity. The figures are based on the assumptions for installed renewable capacities in 2030 reports to ENTSO-E.



Source: Zachmann et al. (Bruegel, 2024).
Note: "Capacity factor refers to electricity produced at realistic wind or solar conditions, relative to the amount produced if the plants would in each hour have operated at their peak capacity. The figures are based on the assumptions for installed renewable capacities in 2030 reports to ENTSO-E.

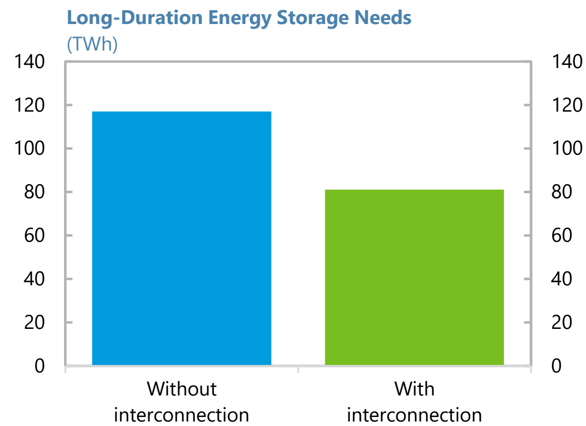
Figure 8: Energy market integration reduces required investments in storage

Energy market integration would reduce both short duration…



Source: Bruegel 2024 based on Roth and Schill 2023.

…and long-duration energy storage needs.



Source: Bruegel 2024 based on Roth and Schill 2023.

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