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Europe's Power Grid Challenge

A Make-or-Break for Accelerating Electrification

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Key Takeaways

- The EU needs to plan, build and deploy historical amounts of electricity grid equipment to integrate 100 GW of renewables each year, connect 200 GW of storage, and ramp up electrification from 23% to 32% by 2030.
- This is a massive manufacturing challenge. Long-term visibility is paramount: as prices rise and Chinese competitors are ready to step up, electrical equipment manufacturers and grid operators need to cooperate, align calendars and plan long-term.
- More than deploying assets, grid operators need to operate their system flexibly, plan for warfare and prepare for climate change.
- EU and national policy should support operators and suppliers in aligning calendars, ramping up investments and prioritizing European-made equipment.

Introduction

In April 2023, *The Economist* published an article[1] pointing to the vast amounts of electricity infrastructure needed to reach energy transition goals. The article acts as a witness to Europe's newfound interest in the grid's challenge, which later materialized with policy proposals in the Grids Action Plan and Grids Package.

Integrating 100 gigawatt (GW) of cumulated solar photovoltaic (PV) and wind capacity each year and increasing the electrification rate from 23% to at least 32% by 2030 requires historical investments at every level. According to the European Commission (EC), the European Union (EU) needs to invest €1.2 trillion in electricity grids by 2040.[2]

At a time of international warfare, shocks on oil & gas markets and heightened climate change impacts, the EC is choosing to double down on the energy transition. This legislative proposal mostly addresses the need for improved EU coordination in grid planning and accelerated permitting. However, crucial parts of the challenge remain, notably ramping up grid supply chains.

The grid buildout is limited by heavy constraints on the electrical equipment supply chains, which feature limited transparency and flexibility in ramping capacity up and down.

This forces system operators and other market participants to think of ways to optimize those investments, such as by signing long-term framework agreements and operating the system in a flexible way.

The infrastructure also needs to be built and operated in ways to make it resilient: adapted to climate change, acceptable for communities and prepared for military threats.

The EU's entire energy transition can succeed or fail based on the continent's ability to secure materials, build up supply chain capacities, plan, build and connect historical amounts of electricity grids in the next few years. This requires historical levels of coordination among operators, regulators and industry, who have no choice but to get this right, together.

The scale of the grid challenge

As the EU set ambitious targets for renewables expansion and electrification of end-uses came the need to build the grid to connect them and to modernize its operations.

1. "Hug Pylons, Not Trees: The Case for an Environmentalism that Builds", *The Economist*, April 5, 2023, available at: www.economist.com.
2. Proposal for a Regulation of the European Parliament and of the Council on guidelines for trans-European energy infrastructure, amending Regulations (EU) 2019/942, (EU) 2019/943 and (EU) 2024/1789 and repealing Regulation (EU) 2022/869.

According to EC estimations, yearly grid investments in the EU need to increase from the current €70 billion to between €81-124 billion.[3]

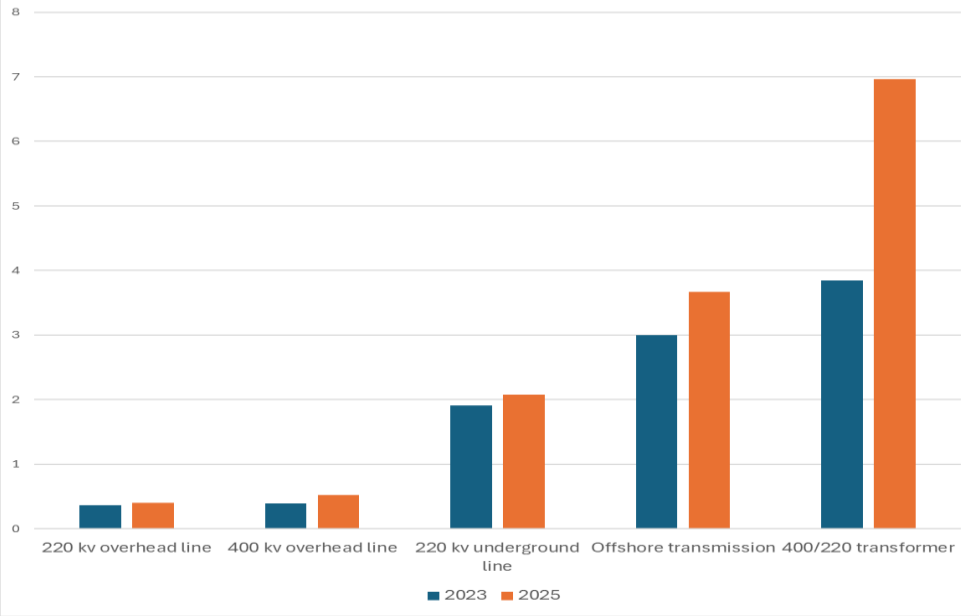
The European Grids Package cites the need for €472 billion investments in transmission grids by 2040, more than 70% of which needs to be domestic (as opposed to cross-border projects). These investments would lead the EU to increase the length of transmission lines by up to 50% by 2040. An additional €730 billion in investments needs to go into distribution grids alone by 2040.

The challenge is not of the same scale everywhere. France, Germany and the Netherlands together represent 53% of the EU's total investments projected by 2040 in electricity grids. Germany alone plans to invest €204 billion in distribution by 2035.

Ramping up the supply chain

Market operators describe it as a disruptive increase in demand for grid equipment. With an increasing need to connect renewable electricity sources, offshore wind, and overall host more electricity flows in an increasingly electrified system, the supply chain sees especially high levels of constraints for high-voltage direct current (HVDC) lines, offshore transmission lines, underground cables, switchgears and high-voltage transformers. This is placing inflationary pressures on the entire European supply chain, which needs to adapt rapidly. Estimated prices for those assets have increased since 2023.

Figure 1. Price evolution for key electrical equipment (EUR M/km for cables; EUR M/asset for transformers)



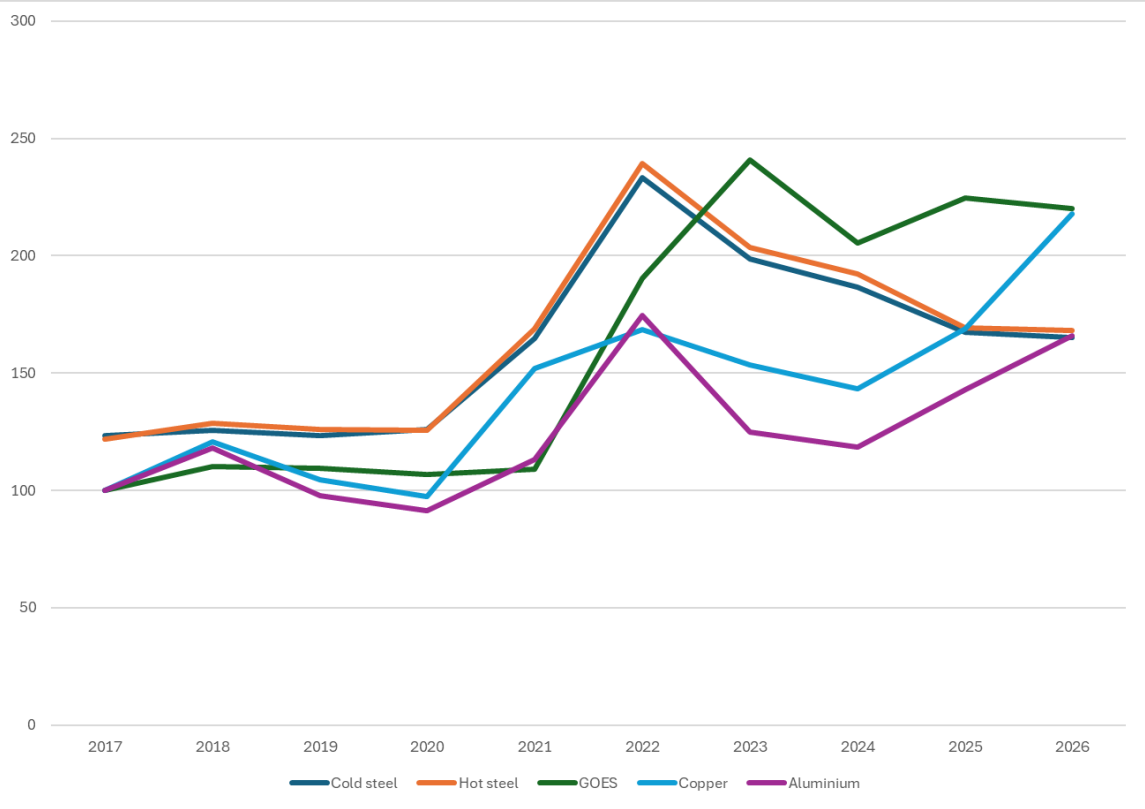
Source: Ifri based on ACER 2026 Unit Investment Cost (UIC) indicators report.

3. European Commission-Directorate-General for Energy, Artelys, LBST, Trinomics, Andrea Finessa. *et al.*, "Investment Needs of European Energy Infrastructure to Enable a Decarbonized Economy", *Final report*, Publications Office of the European Union, January 2025, available at: https://op.europa.eu.

More than increased prices, the supply chain has faced physical difficulties adapting to the new needs. Major manufacturers of cables and large power transformers have full order books until the end of the decade. It takes them 3-4 years to build new manufacturing capacity, meaning that we can envisage limited flexibility in the market for evolving demand. According to the International Energy Agency (IEA), lead times for both products have doubled in the past five years, reaching 4 years for transformers.[4]

Those supply chain constraints are further heightened by their exposure to volatile and increasing commodity prices for the main materials needed to manufacture these products: copper (mainly for underground and subsea lines), aluminum (used mostly for overhead lines), steel (for many products, including pylons), and grain-oriented electrical steel (GOES—representing 20% of transformer costs). Prices for those materials have been further affected by the war in Iran and the blocking of the Strait of Hormuz. Given current trends, equipment cost estimates published by ACER and system-wide cost estimates cited by the EC are at risk of underestimation. Such increases will inevitably be borne by equipment manufacturers, operators and users.

Figure 2. Evolution of grid-related materials prices 2017-2026



Source: Ifri based on data from T&D Europe and Trading Economics. 100 = 2017 prices (2009 for cold & hot steel).

4. "Building the Future Transmission Grid: Strategies to Navigate Supply Chain Challenges", IEA, February 2025, available at: www.iea.org.

Grid operators and equipment manufacturers both need evermore visibility from each other to build up capacity. On the one hand, manufacturers call for more long-term planning from grid operators to ramp-up with limited risk.[5] On the other hand, competition in the grid equipment sector prevents manufacturers from publicly disclosing their capacity with operators, as products are tailored for each contract. System operators are thus often stuck with a single supplier, have little visibility over their partner's manufacturing capacity and can face increasing prices and lead times.

In the meantime, the EU already showcases trade deficits in transformers (€ -3.11 billion) and cables (€ -9.29 billion).[6] The EU imported €11.8 billion worth of transformers from China in 2025, over half of its transformer imports. This highlights the strategic nature of this type of equipment in the world, and the already fierce competition in European supply chains to cover the expected expansion. Accelerated industrial policy and supply chain cooperation will be crucial if the EU wishes to ramp up its manufacturing capacity in strategic links of the supply chain and retain a competitive sector.

Aligning long-term calendars will be paramount

The supply chain is one part of the delicate equilibrium required to build large infrastructure projects. Issues with planning, permitting, construction, operation or hiring can also lead to further serious delays and cost overruns in the supply chain, in turn affecting all other aspects of grid projects.

The need to accelerate planning & permitting

Planning and permitting are the most time-sensitive parts of grid project implementation. It is estimated that transmission projects in the EU take an average of 5-6 years to obtain building permits. According to IEA estimates, while it takes 5-13 years to build ultra-high voltage lines in the EU, it takes between 2 and 3.5 years to do the same in China, and 3-6 years in India.[7]

In Germany, according to data from the regulator, 6,165 projects are in the planning approval or notification procedure phase. A further 368 projects are in federal planning or regional planning procedure phase, and 1,043 have not yet entered the approval process.[8]

Building up electricity grids requires permits from regional authorities, including environmental impact assessments. Although not necessarily in national laws, building overhead lines and substations also requires approval processes with local communities ahead of time to minimize conflicts during the project construction.

5. "Accelerating Grid Infrastructure for Europe's Energy Transition", T&D Europe, October 2025, available at: https://tdeurope.eu.
6. Eurostat, 2026.
7. "Electricity Grids and Secure Energy Transitions: Enhancing the Foundations of Resilient, Sustainable and Affordable Power Systems", IEA, October 2023, available at: www.iea.org.
8. Bundesnetzagentur data about grid planning, available at: www.bundesnetzagentur.de.

According to the sector, permitting is slow due to a lack of digitized procedures and systematic processes, and insufficient capacity within regional authorities to handle the increasing volume of files. Infrastructure construction is also often treated in opposition to nature-protection imperatives, even though such projects would advance the energy transition, as highlighted in the previously cited *Economist* article.

Suedlink, the emblematic German 700 km North-South transmission line led by TransnetBW and TenneT, is seen as a highly strategic project aiming to connect the wind-rich North with the industry-rich South, and relax the costly grid congestions in the country.[9] However, planning and permitting have taken over 10 years, and construction has yet to start in all parts. Consultation with local communities has forced promoters to build more lines underground than previously envisaged. Such challenges lead to delays, which derail supply chain visibility and increase costs for promoters, the state, and ultimately consumers.

This further highlights the need to accelerate permitting processes, but also the strategic nature of planning and of aligning calendars across sectors and value chains.

Operating the grid in a new reality

While the EU installed 8.3 GW of solar PV during the year 2018, this number grew to 65.1 GW of annual additions in 2025.[10] Large additions of variable electricity generation to the grid need to be followed with a wider transformation to make the best use of existing assets, or the system suffers the triple C: congestion on the grid, curtailment of electricity generation and cannibalization on the market.

The EC estimates that up to 1.7 TW renewable energy projects currently wait in queues to be connected to the grid (if connected, it would multiply the EU's wind and solar capacity by 2.6). Austria, Bulgaria and Romania report zero capacity for new generation load on the transmission line. In Finland, 400 GW of renewables are estimated to be waiting in grid connection queues, which is just under the EU's entire solar capacity.[11]

Once connected, renewables may create congestion on the electricity grid when producing more than needed to meet demand. In those instances, grid operators must curtail generation assets. This has a cost, which varies significantly across Member States. In 2023, it cost Germany €3.1 billion, while the UK spent £1.3 billion, and France only €38 million.[12] Aurora estimates that grid congestion management costs will increase by 26% in 4 years.[13]

9. Suedlink information about project construction, available at: https://suedlink.com.
10. "EU Solar Market Outlook 2025-2030", SolarPower Europe, December 2025, available at: www.solarpowereurope.org.
11. E. Cremona *et al.* "Crossed Wires: Grid Capacity Could Block EU Energy Security", EMBER, April 2026, available at: https://managenergy.ec.europa.eu.
12. F. Roques et al., « Comparaison internationale des plans d'investissements dans les réseaux de transport d'électricité », Compass Lexecon, February 2025, available at : https://assets.rte-france.com.
13. "The State of European Power Grids: A Meta-Analysis", Aurora, December 2025, available at: https://auroraer.com.

Finally, this has implications for the business case of renewables (especially solar PV), since the generation of electricity (especially around midday) that cannot be absorbed leads to negative prices on the wholesale market. That is the cannibalization effect. According to Bloomberg, Germany recorded more than 570 negative price hours in 2025, a 25% increase from 2024. In Spain, there were over 500 negative price hours, doubling from the previous year.[14] Those are revenues that developers lose on the wholesale market. It also leads to higher costs for the state in the case of Contracts-for-Difference (CfDs) and deters industrials from signing Power Purchase Agreements (PPAs).

The job of grid operators has changed tremendously

It completely changes the way system operators need to plan and operate their assets. More than physical assets, operators need to build flexibility into their system and optimize current capacity.

Grid resilience: building grids that last

Operators need to plan wisely to ensure that assets stand the test of time in terms of public acceptance, in the face of worsening extreme weather events, and as new hybrid threats emerge.

Energy has always been strategic, but new threats need to be considered. As an example, Russia attacked Ukraine in 2022 as the country was testing its island mode to prepare for its connection to the European grid. Attacks have increasingly come from precise drone strikes and missiles, targeting substations with the aim of isolating entire distribution regions, rather than neutralizing individual generation assets.[15] The Berlin electricity grid was shut down in January after a sabotage, and millions of cyber-attacks have been detected in the European electricity system since the start of the Russian war in Ukraine.

The job of grid operators has changed tremendously in the last few years. Planning, hiring, operations and budgets need to systematically reflect this.

The EU's response should be further complemented

The EU Action Plan for Grids

Published on November 28, 2023, the EU Action Plan for Grids lays out 14 actions that EC, regulators and operators commit to achieving, with timelines. One key aspect

14. E. Farhat, "Europe Saw Record Surge in Negative Power Prices in 2025", *Bloomberg*, January 2026, available at: www.bloomberg.com.
15. "Battle-Tested Power Systems: Resilience and Preparedness for Europe's Electricity Sector", Eurelectric, February 2026, available at: www.eurelectric.org.

envisaged is the need to plan better: anticipating long-term and giving more transparency for entire supply chains, all the way to local distribution plans.[16]

Action 13 of the Plan aims to address the main supply chain challenge highlighted above related to the need for visibility. The European Network of Transmission System Operators for Electricity (ENTSO-E) and the EU distribution system Operators (DSO) Entity commit to collaborating with equipment suppliers to develop common methodologies, improving visibility and facilitating investments.

Thanks to this action, manufacturers have agreed to disclose some supply chain information in the near future. In addition, stakeholders have developed a harmonized high-level HVDC specifications template for procurement. Such standardization is strategic as it makes it easier for the entire chain to evaluate capacities and needs. Both industry and the EC are evaluating the possibility of extending this scheme to additional products, potentially in distribution.

On the other side, DSOs have started work on a publicly accessible distribution network planning platform, which would be a breakthrough for the sector.

Grids manufacturing package

As part of the Clean Industrial Deal, the EC committed to launching the Grids Manufacturing Package with the European Investment Bank (EIB). The aim is to earmark €1.5 billion for providing counter-guarantees for grid manufacturing projects.[17] According to our information, the first contract is being negotiated with a promoter.

The EU Grids Package

On December 10, 2025, the EC published its new proposal aiming at accelerating the EU's response: the European Grids Package. It amends the permitting and Trans-European Network for Electricity (TEN-E) legislation and provides guidance for operators.

It is key that the EU makes the best use of the grid it has

The amendment to the Permitting Directive was especially needed to accelerate permitting for grid lines and grid-friendly projects (such as repowered wind and hybrid PV+ battery storage). Once transposed and implemented by Member States, this will be key to accelerating timelines and simplifying planning.

The TEN-E amendment proposal mandates the EC to draft a central scenario for EU grid planning every four years, based on data delivered by TSOs. Although the proposal goes in the right direction of longer-term planning, it will be key that the final text lists precise mandates and competences to create a clear process between national and European actors, which empowers actors and aligns timelines.

16. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Grids, available at: https://eur-lex.europa.eu.
17. Pan-EU Power Grid Package Lending Envelope (LE), EIB, available at: www.eib.org.

The guidance, although non-legislative, sends key messages to Member States. It describes the need for action to unclog grid connection queues by prioritizing projects that are ready, and potentially projects that are grid-friendly—those that would add flexibility and/or new demand loads to the grid, thus allowing more projects to be connected. System operators need to implement such principles into precise grid queue management methodologies.

Although this package addresses key bottlenecks, it does not directly support the investment and supply chain challenges.

Solutions found around Europe

Aligning long-term calendars

Each action that improves long-term visibility on either side of the supply chain and facilitates collective action is a solution to the challenge.

The French renewables acceleration law, for example, mandates RTE to plan long-term to 2040. The TSO estimates that this allows it to save €2.5 billion. It plans for a baseline €100 billion investment to reinforce the grid, aligns with national generation and electrification targets, and prioritizes renewables hubs.[18]

Framework agreements also help with visibility. They are still in the majority signed with a single supplier, but they are getting longer, reaching close to 3 years on average. According to the EC consultation on public procurement,[19] framework agreements represented 37% of total procurement value in 2017-2024, up from 17% in 2006-2010.

RTE has entered into such agreements with supply chain partners for standardized equipment in large volumes, allowing manufacturing capacity to ramp up along with its schedule. In Germany, where four TSOs operate, coordination is key. TenneT and TransnetBW carried out joint procurement for the Suedlink line via a common call for tender and joint negotiations. This trend is best exemplified in the UK, as the Great Grid Partnership brings together 7 partners around an investment worth £14.5 billion.[20] This allows them to run competitive procurement, give better visibility to an entire supply chain and standardize the process for more optimization.

These lessons have been incorporated recently with the publication in April 2026 of the Dutch grid investment plan.[21] The planning horizon has been extended from 2035 to

18. "Schéma de développement du réseau 2025 – Synthèse" , RTE, March 2025, available at: https://assets.rte-france.com.
19. Public consultation on the revision of EU public procurement rules, European Commission, November 2025, available at: https://ec.europa.eu.
20. The Great Grid Partnership, National Grid, available at: www.nationalgrid.com.
21. "Investeringsplan 2026: Net op land", TenneT, April 2026, available at: www.tennet.eu.

2040. TenneT is moving towards better prioritization of hubs and standardization with the purchase of prefabricated solutions for substations.

The Public Procurement Act, expected for July 2026, could further encourage long-term framework agreements. Aligning calendars is also a governance question for the EU, which could be dealt with in the Grids Package and the upcoming Governance Regulation for the post-2030 energy framework.

Optimizing investments

In the face of the challenge, it is key that the EU makes the best use of the grid it has, now and in the future.

This starts with anticipatory investments. In June 2025, the EC published recommendations for Member States to activate investments in electricity grids before congestion becomes unbearable. We are observing first practices that resemble anticipatory investments in France, Denmark and Finland, where system operators anticipate regional capacity and identify no-regret investments.

One key challenge is locating generation, flexibility and demand where they are most needed. This can only happen if developers know where congestion happens most and where there is still some space to connect to the grid. 20 Member States publish grid capacity hosting maps; however, neither Germany nor Italy does.

It is key that the EU makes the best use of the grid it has, now and in the future

As described above, grid connection queue handling can be improved. Germany, the UK and the Netherlands have added milestones to be achieved by project developers for advancing the grid connection queues, aiming to eliminate ghost projects. Poland, Portugal and Bulgaria have made it easier to receive grid connection when hybridizing already existing renewable energy projects with battery storage.

Finally, grid-enhancing technologies (GETs) can strengthen grid efficiency. Running digital twins can, for example, allow TSOs to simulate future behaviors of the grid and predict the need for replacement, flexibility or else.

Building resilient grids

More system operators systematically plan for climate change adaptation. RTE is making its infrastructure resilient for a climate scenario of +4°C and prepares for a potential cost of €9 billion from extreme weather events. National Grid is ready for temperatures of up to 50°C, and is developing its 'resilient by design' standards for procurement. This is becoming a trend across Europe. It will be highly strategic and a reasonable fiscal measure to systematically prepare for weather events, especially as tools exist for evaluating their risk of happening and potential damage.

Finally, the Ukrainian example has shown the need to better standardise assets, protect them physically from precise drone attacks, stockpile strategic equipment and prepare for rapid intervention. Grid planning exercises, the future Public Procurement Act, as well as the revision of the European energy security framework need to help find the right balance in planning for resilience within acceptable costs.

Conclusions & recommendations

Given the scale of the challenge, all actors, private and public, need to agree on the task at hand, coordinate actions, learn from others' practices and scale fast. One principle remains central in this thinking: aligning long-term calendars among manufacturers, grid operators and regulators will be paramount in the coming years to succeed with the scale required, at reasonable cost, and with resilience. Here are some key recommendations:

- **Plan long-term:** the EU's Ten-Year Network Development Plan (TYNDP) can be carried out every 4 years instead of 2. National transmission and distribution operators should plan for 2040, with a view to 2050 goals.
- **Clarify the EU central scenario:** the Grids Package could give clearer mandates to all actors involved and support capacity-building for the EC in delivering an EU central scenario based on bottom-up input.
- **Align calendars:** climate targets, National Energy and Climate Plans (NECPs), clean energy and electrification targets, network development plans (transmission and distribution) and zoning should all be done in parallel with the same long-term timelines and in dialogue with supply chain partners.
- **De-risk the supply chain:** incentivize long-term framework and joint procurement agreements, de-risk contracts through EU and national public guarantees, and extend their 8-year limit through the Public Procurement Act.
- **Push all GETs and flexibility first:** the Grids Package can further support operators in planning for all GETs and flexibility tools first, before building physical assets.
- **Accelerate standardization:** incentivize further efforts by the supply chain for standardizing products at all voltage levels for all key equipment.
- **Enhance transparency:** strengthen supply chain dialogue, iterative efforts in capacity hosting maps, distribution planning platforms and sharing of manufacturing data.
- **Integrate the energy union:** the fast adoption of common methodologies—cross-border cost allocation (CBCA), demand-response network code, cybersecurity network code—will accelerate exchanges and interconnections.
- **Apply resilience-by-design:** planning for and supporting additional costs stemming from preparing for climate, cyber and physical risks, via the energy security framework and funding from the Cohesion Policy and resilience and

security budgets.

- **Design "made-in-Europe" criteria in public procurement:** for grid equipment on determined volumes, as more data becomes available on demand, capacity and specifications.

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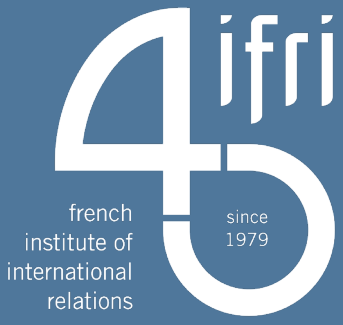

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