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Aligning US-EU Energy Grid Strategies: From Risk to Resilience

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Ministry of Foreign Affairs and International Cooperation

ABSTRACT

The strategic importance of critical energy infrastructure has come into sharp focus amid rising geopolitical tensions, extreme weather events, supply chain disruptions and hybrid threats. The April 2025 blackout across the Iberian Peninsula underscored that key infrastructure relies on a well-functioning power grid. In both the United States and Europe, aging grids – designed for centralised, one-way electricity flow – struggle to accommodate the two-way, variable inputs required by renewable energy sources. As electricity demand surges due to electrification and data centre growth, grids face investment gaps, mounting congestion, supply chain concerns and regulatory challenges. Meanwhile, China's rapid rise as a global grid innovator and supplier introduces new risks to transatlantic technology stacks, including cybersecurity threats and supply chain dependencies. A coordinated US-EU approach to grid and transmission technology offers a strategic path to de-risking. Such cooperation could enhance resilience, foster competitiveness, reduce reliance on rivals and drive innovation and job creation.

keywords

Energy infrastructure | Electrical grids | Supply chains | USA | European Union | China | Transatlantic relations

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Aligning US-EU Energy Grid Strategies: From Risk to Resilience

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Introduction

The strategic importance of critical energy infrastructure has come into sharp focus in recent years. Geopolitical tensions, extreme weather events, supply chain disruptions and hybrid threats underscore that a reliable and resilient energy system is vital to national and economic security. The power blackout across the Iberian Peninsula on 28 April 2025 serves as a powerful reminder that key infrastructure – from transportation and manufacturing to banking systems and public health – relies on a well-functioning power grid.

Yet on both sides of the Atlantic, grid infrastructure is aging and under strain. In the United States, more than 70 per cent of transmission lines are over 25 years old,[1] while in the European Union, around 40 per cent of distribution lines are over 40 years old.[2] These systems were largely built for a centralised, one-way flow of electricity – not the two-way, variable inputs required by renewable energy sources such as wind and solar. Both grid systems suffer from investment gaps, mounting congestion, supply chain concerns and regulatory and planning challenges. As the share of renewables grows, maintaining grid stability – balancing supply and

[1] US Department of Energy, *What Does It Take to Modernize the U.S. Electric Grid?*, 19 October 2023, https://www.energy.gov/node/4834193.

[2] European Court of Auditors, *Making the EU Electricity Grid Fit for Net-Zero Emissions*, April 2025, https://www.eca.europa.eu/en/publications/RV-2025-01.

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demand, regulating frequency and managing real-time fluctuations – requires major upgrades, including advanced technologies and energy storage solutions.

Electricity demand is rising due to the rapid proliferation of data centres supporting artificial intelligence (AI), cloud computing and cryptocurrencies, as well as the electrification of vehicles and resurgence of domestic manufacturing.[3] Yet this leap in next-generation technologies is being built atop an aging grid infrastructure – one that was never designed to handle the scale, speed or complexity of today's energy demands. An outdated or vulnerable grid undermines the ability of advanced economies to scale digital infrastructure, support industry and power next-generation technologies. De-risking the grid and ensuring its reliability amid this transition is therefore not just a technical challenge, but a strategic imperative for economic competitiveness and innovation.

Modernisation and reinforcement require significant investment, and countries such as the People's Republic of China (PRC) are investing heavily in transmission grid infrastructure, both domestically and internationally.[4] China's steep rise as a global grid innovator raises questions about the future security of US and European grid technology stacks. Advanced hardware and software systems are often sourced globally, exposing vulnerabilities to supply chain disruptions.

The digitalisation of energy infrastructure also opens new channels for interference, including security vulnerabilities, cyberattacks and espionage. As the United States and Europe invest in new infrastructure to meet rising demand, producing and sourcing next generation technologies with trusted partners will become important both for domestic and allied security. Leveraging economic instruments such as strategic procurement and targeted industrial policy can help protect transatlantic critical infrastructure, as well as foster local innovation, job creation and new market opportunities.

Growing strategic vulnerabilities across the transatlantic energy system require increased attention from policymakers. By aligning their efforts, the United States and Europe can build a more robust and innovative energy future. In this piece, we explore the current landscape and identify four critical parts of the energy grid technology stack. We highlight policies that have been deployed to advance transatlantic development of these technologies, as well as new areas of opportunity. Finally, we propose a series of concrete actions that can underpin a coordinated transatlantic strategy.

[3] US Energy Information Administration (EIA), *After More than a Decade of Little Change, U.S. Electricity Consumption Is Rising Again*, 13 May 2025, https://www.eia.gov/todayinenergy/detail.php?id=65264.

[4] "China Accelerates Grid Spending to Absorb Deluge of Solar Power", in *Bloomberg*, 20 March 2025, https://www.bloomberg.com/news/articles/2025-03-20/china-accelerates-grid-spending-to-absorb-deluge-of-solar-power.

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1. The electrical grid

The electrical grids of the United States and Europe are intricate infrastructures of power plants, high-voltage transmission networks and distribution systems designed to deliver electricity across large geographic areas. Electricity systems can be divided into three main stages: generation, where electricity is produced; transmission, where it is transported over long distances via high-voltage lines; and distribution, where it is delivered to homes and businesses. Across all stages, the grid depends on advanced technologies – including transformers and control mechanisms – to maintain safety, stability and efficiency throughout the network.

Both the US and European grid systems face a common set of structural and operational challenges that are further complicated by the integration of large-scale renewable energy. Much of the US and European grid systems were built in the mid-to-late 20th century.[5] Obstacles to modernisation include fragmented governance frameworks across multiple jurisdictions, a lack of coordinated investment and inconsistent financial incentives due to mixed public-private ownership models.

Due to increasingly critical energy needs, both the United States and EU are embarking on efforts to expand capacity and individually strengthen their grids. On 8 April 2025, US President Donald Trump issued an executive order aimed at improving the reliability and security of the US grid, with proposals to align infrastructure with growing power generation.[6] Meanwhile, the European Commission has prioritised an update to its grid legislation as part of its broader push for competitiveness and clean energy.[7] The Russian Federation's ongoing geopolitical pressure has only added urgency, accelerating Europe's drive to modernise its grid and better connect countries to the Continental Europe Synchronous Area (CESA).

These efforts unfold within complex regulatory environments. In the United States, grid policy is shaped by a patchwork of federal, state and regional authorities. The Federal Energy Regulatory Commission (FERC) oversees interstate transmission and wholesale electricity markets, while state public utility commissions (PUCs) regulate retail electricity rates and provide state-level oversight. Regional transmission organisations (RTOs) and independent system operators (ISOs) further complicate governance, each with distinct rules and planning processes.

[5] US Department of Energy, *What Does It Take to Modernize the U.S. Electric Grid?*, cit.; and European Court of Auditors, *Making the EU Electricity Grid Fit for Net-Zero Emissions*, cit.

[6] White House, *Strengthening the Reliability and Security of the United States Electric Grid*, 8 April 2025, https://www.whitehouse.gov/presidential-actions/2025/04/strengthening-the-reliability-and-security-of-the-united-states-electric-grid.

[7] European Commission DG for Energy, *Commission Collects Views in Preparation of the European Grids Package*, 13 May 2025, https://energy.ec.europa.eu/node/6600_en.

American grid development is often reactive and fragmented, hindered by jurisdictional divides and inconsistent federal authority.[8] Permitting delays are a major bottleneck. Projects can take over a decade due to complex inter-jurisdictional reviews, limited federal siting authority and local opposition.[9]

In the EU, energy policy – a shared competence between the EU and its member states – is similarly multi-layered. The European Commission sets strategic priorities, but national governments retain autonomy over how these policies are implemented domestically. National regulatory authorities (NRAs) in each member state are responsible for implementing EU energy law and ensuring market compliance at the national level. The Agency for the Cooperation of Energy Regulators (ACER) plays a coordinating role, supporting NRAs and promoting cross-border market integration and infrastructure planning. For example, ACER advises on the implementation of the 2023 EU Action Plan for Grids, which aims to accelerate grid modernisation and enhance interconnectivity.

Long-term grid planning is governed by the Trans-European Networks for Energy (TEN-E) Regulation, a policy framework aimed at strengthening cross-border energy infrastructure. Planning is guided by a ten-year, non-binding network development plan (TYNDP) created by ENTSO-E, the European association of electricity transmission system operators (TSOs). The process faces criticism for being slow, outdated, and lacking a robust needs-based and cost-benefit methodology, with proposed investments falling short of actual requirements.[10] As in the United States, grid expansion is delayed by lengthy permitting – often taking over five years – due to complex cross-border procedures, limited administrative capacity and local opposition.[11]

As a result, there is a growing queue of renewable generation and storage projects awaiting grid interconnection. A 2023 study by Lawrence Berkeley National Laboratory found that nearly 2,600 gigawatts (GW) of proposed generation and storage capacity were actively seeking grid interconnection in the United States.[12] In Europe, a report from Beyond Fossil Fuels, Ember, E3G and the Institute for Energy Economics and Financial Analysis found that 1,700 GW of renewable energy and hybrid projects were waiting for grid connections across 16 countries in 2024-2025.[13]

[8] Sonal Patel, "Out of Sync: The Infrastructure Misalignment Undermining the U.S. Grid", in *POWER Magazine*, 11 June 2025, https://www.powermag.com/?p=235272.

[9] Ibid.

[10] Saša Butorac, "EU Electricity Grids", in *EPRS Briefings*, May 2025, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2025)772854.

[11] Ibid.

[12] Berkeley Lab, *Grid Connection Backlog Grows by 30% in 2023, Dominated by Requests for Solar, Wind, and Energy Storage*, 10 April 2024, https://emp.lbl.gov/news/grid-connection-backlog-grows-30-2023-dominated-requests-solar-wind-and-energy-storage.

[13] Beyond Fossil Fuels (BFF) et al., *How Europe's Grid Operators Are Preparing for the Energy Transition. A Snapshot of Electricity Transmission System Operator Practices and Plans*, May 2025,

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The United States is also going through other policy shifts that impact domestic developments and international cooperation. Recent national security trade investigations, conducted under Section 232 of the Trade Expansion Act of 1962, have placed 50 per cent tariffs on steel and aluminium, the primary components of next generation transmission lines. An ongoing Section 232 investigation into semiconductors and derivative products could further disrupt the supply of critical components for grid infrastructure. Simultaneously, funding for research and development, including programmes backed by the Inflation Reduction Act (IRA), is being scaled back or eliminated. Over the past two decades, US energy policy has swung with the political tide, especially on decarbonisation – creating uncertainty around the long-term direction and durability of regulatory actions.

With the United States and Europe focused on different goals, transatlantic collaboration on energy policy appears increasingly fragmented. However, growing energy demands and rising competition from Chinese state-owned manufacturers present shared challenges and opportunities that both sides will need to address together to effectively de-risk their energy infrastructure.

2. Rising electricity needs

(Geo)political tensions notwithstanding, electrification and energy-intensive digital technologies will create additional demands on legacy grids.[14] In 2024, there were over 8,500 data centres globally, with about 33 per cent of these located in the United States, 16 per cent in Europe and close to 10 per cent in China.[15] Demand for AI will double data centres' electricity consumption from 2024 to 2026.[16] New strategic manufacturing plans, particularly for semiconductor and battery production, will also be critical drivers of electricity.[17]

In the coming years, US and European electricity demand is projected to increase significantly also due to the electrification of various sectors, including transportation and residential heating and cooling.[18] According to the US Energy Information Administration (EIA), total electricity demand in the United States is expected to grow by approximately 2 per cent annually, bolstered by factors such as the adoption of electric vehicles (EVs) and the increasing installation of heat

https://beyondfossilfuels.org/?p=91684.

[14] International Energy Agency (IEA), *Electricity 2025. Analysis and Forecast to 2027*, February 2025, https://www.iea.org/reports/electricity-2025.

[15] Cloudscene website: Cloudscene Leaderboard, https://cloudscene.com/rankings/leaderboard.

[16] IEA, *Electricity 2024. Analysis and Forecast to 2026*, January 2024, https://www.iea.org/reports/electricity-2024.

[17] Cy McGeady, Hatley Post and Jane Nakano, "Energy Considerations at the Dawn of Strategic Manufacturing", in *CSIS Commentaries*, 19 April 2024, https://www.csis.org/node/110269.

[18] IEA, *Electricity 2025*, cit.

pumps for more efficient home heating.[19] The International Energy Agency (IEA) indicated that EU electricity consumption grew by 1.4 per cent in 2024 as various sectors adapt to new energy conditions, effectively marking a turnaround after two consecutive years of decline.[20]

While the United States is largely energy independent – drawing on a mix of fossil fuels, renewables and nuclear power – Europe faces a more delicate balancing act. It must contend with rising electricity demand while bolstering resilience against price volatility and energy security risks, particularly as it accelerates efforts to diversify away from Russian gas in a shifting geopolitical landscape.

Renewable energy sources, particularly wind and solar, are increasingly positioned to meet a substantial share of rising electricity demand on both sides of the Atlantic. Renewable energy is price competitive, affordable and faster and easier to deploy than traditional infrastructure such as nuclear power plants or long-distance pipelines.[21] In the EU, this transition is being driven by a binding target to source at least 42.5 per cent of final energy consumption from renewables by 2030, with an aspirational goal of 45 per cent.[22] Meeting this target will require investments in renewable generation and grid modernisation. Similarly, in the United States, solar and wind now account for the majority of new capacity additions.[23] According to the EIA, wind power capacity in the United States more than tripled between 2010 and 2022.[24] Solar power grew even faster, increasing 46 times over the same period.[25] In the EU, wind and solar power generation increased more than fivefold between 2009 and 2023, rising from 139 TWh to 721 TWh.[26] During the same period, their share of the EU's electricity mix grew from 5 per cent to 27 per cent.[27]

As both regions increasingly adopt clean energy technologies, grids must evolve to accommodate a growing share of variable energy sources. This requires the expansion and modernisation of grid infrastructure, as well as the scaling-up of storage capacities.

[19] EIA, *EIA Extends Five Key Energy Forecasts through December 2026*, 15 January 2025, https://www.eia.gov/todayinenergy/detail.php?id=64264.

[20] IEA, *Electricity 2025*, cit.

[21] International Renewable Energy Agency (IRENA), *Renewable Power Generation Costs in 2023*, September 2024, https://www.irena.org/Publications/2024/Sep/Renewable-Power-Generation-Costs-in-2023.

[22] European Commission DG for Energy website: *Renewable Energy Targets*, https://energy.ec.europa.eu/node/5600_en.

[23] Federal Energy Regulatory Commission (FERC), *Energy Infrastructure Update for March 2025*, 12 May 2025, https://cms.ferc.gov/media/39324.

[24] EIA, *International Energy Outlook 2023 with Projections to 2050*, 11 October 2023, https://www.eia.gov/outlooks/ieo/pdf/IEO2023_Release_Presentation.pdf.

[25] Ibid.

[26] Ember, *European Electricity Review 2024*, 7 February 2024, https://ember-energy.org/?p=3621.

[27] Ibid.

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3. Assessing critical infrastructure

The grid challenges outlined above cannot be solved with yesterday's technology. As the United States and Europe pursue parallel efforts to modernise their electrical grids – integrating renewable energy, expanding storage capacity and deploying smart technologies – they are increasingly turning to next-generation solutions to boost capacity, enhance resilience and enable more dynamic, decentralised electricity systems.

The adoption of new grid technologies brings with it a new set of security challenges for this critical infrastructure. While diversification to renewables and the digitalisation of grid systems are essential for long-term energy security, they also create dependencies in global supply chains and expose countries to technologies produced in nations that are strategic competitors or non-aligned.

Cybersecurity risks for critical infrastructure remain a top concern for intelligence agencies. In 2024, the "Five Eyes" intelligence agencies issued a joint warning to governments and businesses about the continued efforts of hostile state actors to infiltrate critical infrastructure.[28] The alert specifically highlighted the activities of Volt Typhoon, a Chinese state-sponsored hacking group. By pre-positioning themselves on US and European systems, hostile actors may disrupt or degrade critical infrastructure operations during periods of crisis or conflict. Utilities are essential service providers to the broader economy and are an attractive target. Cybersecurity has long been an industry priority, but the growing interdependence of cross-border power systems – coupled with the rising sophistication of cyberattacks – has significantly complicated both governance and crisis response.[29]

Beyond external cyberattacks, the growing presence of Chinese state-linked firms in key segments of the grid supply chain and infrastructure raises strategic concerns on both sides of the Atlantic. China has been investing heavily in its transmission grid infrastructure to keep up with its boom in renewables.[30] In 2025 alone, State Grid Corporation of China (SGCC) announced that it would invest over 88.7 billion US dollars (650 billion yuan) into its power network (up from 600 billion yuan in 2024).[31] By comparison, in 2024, the US government invested 7 billion US dollars in

[28] US Cybersecurity and Infrastructure Security Agency (CISA), *PRC State-Sponsored Actors Compromise and Maintain Persistent Access to U.S. Critical Infrastructure*, 7 February 2024, https://www.cisa.gov/news-events/cybersecurity-advisories/aa24-038a.

[29] Spencer Feingold and Filipe Beato, "Iberian Blackout: Cyberattack Is Not to Blame – But the Threat to Power Grids Is Real. Here's Why", in *World Economic Forum Articles*, 1 May 2025, https://www.weforum.org/stories/2025/05/spain-might-not-cyberattack-blackout-power-outage-electric-grids-vulnerable.

[30] "China Accelerates Grid Spending to Absorb Deluge of Solar Power," in *Bloomberg*, cit.

[31] "China's State Grid Outlays Record $88.7 bln Investment for 2025", in *Reuters*, 15 January 2025, https://www.reuters.com/business/energy/chinas-state-grid-outlays-record-887-bln-investment-2025-2025-01-15.

IRA-linked funds in the grid,[32] while privately held companies spent 34 billion US dollars on grid technologies and transmission.[33] Beijing views a robust grid as key to energy security and economic growth and is rapidly closing technology gaps. As part of this effort, China continues to expand its network of ultra-high voltage (UHV) transmission lines to move electricity efficiently across vast distances and balance regional supply and demand.[34]

China's ambitions do not stop at its borders. The PRC has made strategic Belt and Road investments in energy infrastructure across Asia, Africa, Europe and Latin America.[35] Under the Global Energy Interconnection (GEI) initiative announced by President Xi Jinping in 2015, China envisions a globally interconnected electricity network designed to transmit renewable energy across continents.[36] Opportunities to supply the rest of the world are enormous, with 85 per cent of new energy demand in the coming years expected to come from outside the developed world.[37] Chinese equipment (from transformers to smart meters) is widely used globally, raising supply chain security questions for the United States and EU.

The grid technology stack includes hardware like inverters, transformers and storage systems; software and data networks that support smart grid functionality; and the ownership and control structures that govern infrastructure development. Four critical areas create vulnerabilities within the US and European grid systems: (1) the supply and deployment of inverters and transformers, (2) grid energy storage systems, (3) smart grid technologies and associated data networks and (4) Chinese ownership or investment in electricity infrastructure.

Vulnerabilities exist in two main ways: the devices can be controlled or manipulated remotely by hostile actors, or the devices may be disabled due to parts or supplies that are not readily available.

3.1 The supply and deployment of inverters and transformers

As the United States and Europe accelerate the integration of renewable energy sources, power inverters convert the output of solar panels or battery storage

[32] US Department of Energy, *2024 Wrap-Up: Advancing a More Powerful Grid*, 19 December 2024, https://www.energy.gov/node/4847253.

[33] Edison Electric Institute website: *Industry Data*, https://www.eei.org/en/resources-and-media/industry-data.

[34] Xiaoying You, "'A Bullet Train for Power': China's Ultra-High-Voltage Electricity Grid", in *BBC News*, 15 November 2024, https://www.bbc.com/future/article/20241113-will-chinas-ultra-high-voltage-grid-pay-off-for-renewable-power.

[35] Fiona Quimbre et al., *China's Global Energy Interconnection. Exploring the Security Implications of a Power Grid Developed and Governed by China*, Santa Monica, RAND, December 2023, https://www.rand.org/pubs/research_reports/RRA2490-1.html.

[36] Ibid.

[37] Marco Arcelli, "The Opportunity of Meeting Energy Demand in the Global South", in *World Economic Forum Articles*, 2 May 2024, https://www.weforum.org/stories/2024/05/opportunity-servicing-energy-demand-global-south.

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systems into alternating current (AC) synchronised with the grid. Inverters typically include network connectivity to facilitate remote diagnostics, firmware updates and performance optimisation. This connectivity also introduces significant cybersecurity risk via attacks or control by hostile actors.

Inverters sit at critical nodes in the power system, and their coordinated failure could destabilise grid operations. A substantial share of the global inverter market is dominated by Chinese manufacturers.[38] Concerns have emerged that these devices could contain embedded vulnerabilities that might be exploited to disrupt grid operations. A May 2025 Reuters report reported that US security researchers discovered undocumented communication devices embedded within Chinese-manufactured solar inverters used in grid applications.[39] Experts noted that such hardware could allow actors to override local controls, disable equipment, or alter operational settings.[40]

Beyond inverters, transformers are also essential, long-life components of the transmission grid and difficult to replace quickly in the event of failure or sabotage. China is the world's largest exporter of electrical transformers.[41] In 2019, the United States seized a Chinese-manufactured transformer intended for use in Colorado over cybersecurity concerns.[42] The transformer was sent to Sandia National Laboratories for examination. While the reasons for the seizure and the results of the examination were not public, the incident underscored the strategic sensitivity of these assets and attempts to remotely manipulate their operation.

3.2 Grid energy storage systems

Energy storage technologies store surplus power when demand is low and release it during peak times. Utility-scale energy storage systems (ESS) bank electricity into batteries for later use or convert it into other energy forms. ESS are becoming key to the modernisation of electrical grids, particularly in the context of variable renewable energy sources such as solar and wind power. Unlike conventional fossil fuel-based generation, variable renewable energy sources are inherently intermittent (they do not produce power continuously) and non-dispatchable, leading to temporal mismatches between supply and demand. ESS, particularly

[38] Wood Mackenzie, *Top 10 Solar PV Inverter Vendors Account for 86% of Global Market Share*, 14 August 2023, https://www.woodmac.com/press-releases/top-10-solar-pv-inverter-vendors-account-for-86-of-global-market-share.

[39] Sarah Mcfarlane, "Rogue Communication Devices Found in Chinese Solar Power Inverters", in *Reuters*, 14 May 2025, https://www.reuters.com/sustainability/climate-energy/ghost-machine-rogue-communication-devices-found-chinese-inverters-2025-05-14.

[40] Ibid.

[41] Observatory of Economic Complexity (OEC) website: *Electrical Transformers*, https://oec.world/en/profile/hs/electrical-transformers.

[42] Rebecca Smith, "U.S. Seizure of Chinese-Built Transformer Raises Specter of Closer Scrutiny", in *The Wall Street Journal*, 27 May 2020, https://www.wsj.com/articles/u-s-seizure-of-chinese-built-transformer-raises-specter-of-closer-scrutiny-11590598710.

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battery energy storage systems (BESS), play an important role in addressing these challenges and can help ease transmission congestion, deferring or eliminating the need for costly upgrades to grid infrastructure.

China currently dominates the global supply chain for lithium-ion batteries, which constitute most deployed grid-scale storage systems. According to the IEA, China is responsible for approximately 85 per cent of global lithium-ion battery cell production capacity by monetary value.[43] In 2022, China produced 85 per cent of the world's anodes, 82 per cent of electrolytes, 74 per cent of separators and 70 per cent of cathodes.[44] The PRC processes over 90 per cent of the world's graphite.[45] In 2022, Chinese companies accounted for over two-thirds of the world's processing capacity for cobalt and lithium, two critical materials for battery production.[46]

This concentration of supply chain capacity presents strategic risks, exposing other nations to disruptions arising from geopolitical tensions, trade restrictions, or domestic policy shifts within China. The recent restrictions placed by China on specific raw materials needed to produce automobile batteries brought supply chain vulnerabilities into sharp focus.[47] China's dominance may also lead to market distortions and price volatility, hindering the ability of other countries to deploy storage at scale. It also positions Beijing to shape global standards in ways that may not align with other nations' strategic or environmental priorities.

Compounding these supply chain concerns, the aforementioned May 2025 Reuters report revealed that some Chinese-manufactured battery systems in the United States equally contained undocumented communication modules, raising alarms about the potential for remote manipulation.[48]

3.3 Smart grid technologies and data networks

Smart grids integrate advanced digital communication, automation and control technologies into the conventional grid to enable better energy management. These technologies support the two-way flow of electricity and information between utilities and consumers, facilitate the integration of renewable energy sources and enhance the overall operational intelligence of the grid.

Common smart grid technologies include advanced metering infrastructure (AMI), supervisory control and data acquisition (SCADA) systems, phasor measurement

[43] IEA, *Batteries and Secure Energy Transitions*, April 2024, https://www.iea.org/reports/batteries-and-secure-energy-transitions.

[44] EIA, *China Dominates Global Trade of Battery Minerals*, 21 May 2025, https://www.eia.gov/todayinenergy/detail.php?id=65305.

[45] Ibid.

[46] Ibid.

[47] Ibid.

[48] Sarah Mcfarlane, "Rogue Communication Devices Found in Chinese Solar Power Inverters", cit.

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units (PMUs), demand response management (DRM), advanced distribution management systems (ADMS), distributed energy resources management systems (DERMS) and vehicle-to-grid (V2G) technologies. Both the hardware and software to operate these cutting-edge systems can introduce security vulnerabilities.

The UK's cross-party Coalition on Secure Technology has raised concerns about foreign dependencies in this context, specifically calling on the British government to boost domestic manufacturing of cellular radio modules, which are critical for connecting Internet of Things (IoT) devices. According to the Coalition, three Chinese companies currently control over 50 per cent of the global market for these modules – components that are widely embedded in smart meters, edge devices and other grid-connected equipment.[49] The integration of these components has raised concerns about data transmission and remote control capabilities.

A precedent for such concerns can be found in a recent case uncovered by cybersecurity firm Dragos. According to Dragos' report, the Volt Typhoon group maintained unauthorised access to the operational technology network of Littleton Electric Light and Water Departments in Massachusetts for nearly nine months (from February to November 2024).[50]

At the centre of the threat matrix are communication networks. One prominent concern has been Huawei, the Chinese tech giant known for telecommunications gear, which also sells industrial network equipment and has developed solutions for smart grids. Huawei's involvement in smart grid infrastructure has prompted security concerns due to obligations under Chinese law for firms to cooperate with state intelligence agencies.[51]

As a result, Huawei has been subject to increasing restrictions. The United States has banned Huawei from federal telecommunications networks and barred its involvement in critical infrastructure sectors, including energy.[52] In Europe, several countries have followed suit: the UK excluded Huawei from its 5G networks and has taken steps to remove its technology from smart grid pilot programmes.[53] Germany announced in 2023 that it would phase out Chinese components from

[49] Lucy Fisher, "Chinese Components in 'Smart' Devices Pose Sabotage Threat to UK, MP Warns", in *Financial Times*, 20 February 2025, https://www.ft.com/content/518e6b5d-068a-4375-a625-87d8c5b422a1.

[50] Keenan Bassma, "Notorious Chinese Hacking Company Went Nearly a Year Undetected in Littleton Utility Company", in *Boston 25 News*, 13 March 2025, https://www.boston25news.com/news/local/notorious-chinese-hacking-company-went-nearly-year-undetected-littleton-utility-company/BBEQYUB5AJFZFPMBD343EN2SEY.

[51] "EU Must Be Aware of China's Intelligence Law when Drawing up 5G Rules", in *Reuters*, 19 July 2019, https://www.reuters.com/article/technology/eu-must-be-aware-of-chinas-intelligence-law-when-drawing-up-5g-rules-king-idUSKCN1UE193.

[52] "U.S. Actions Against China's Huawei", in *Reuters*, last accessed 20 June 2025, https://www.reuters.com/graphics/USA-CHINA/HUAWEI-TIMELINE/zgvomxwlgvd.

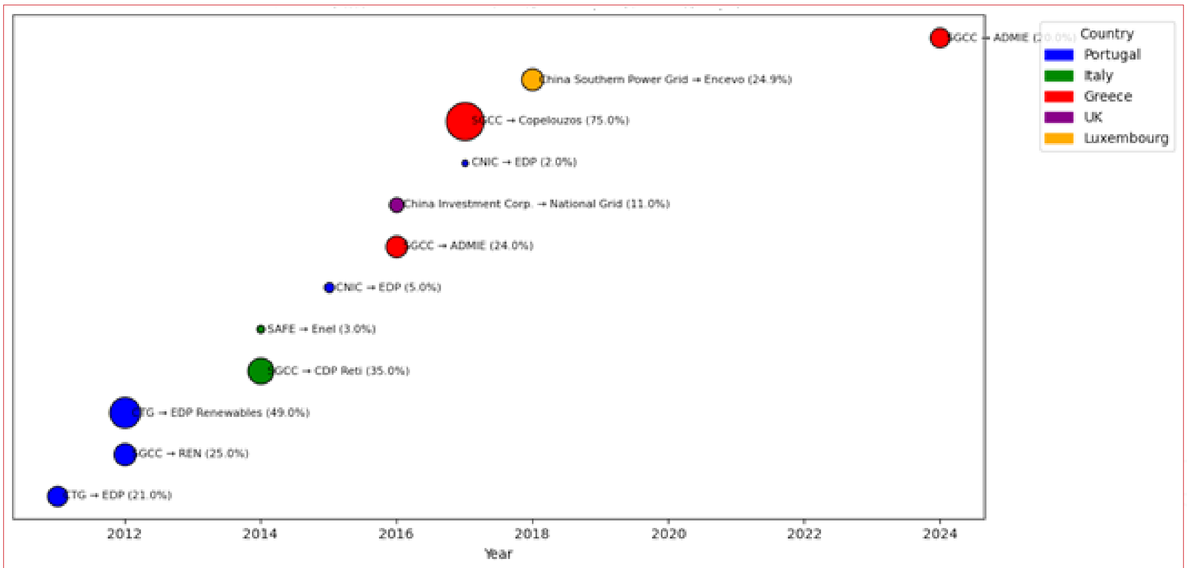
[53] UK Government, *Huawei to Be Removed from UK 5G Networks by 2027*, 14 July 2020, https://www.gov.uk/government/news/huawei-to-be-removed-from-uk-5g-networks-by-2027.

critical energy and telecommunication systems by 2026.[54] Similar scrutiny has emerged in other European countries, where regulators have discouraged the use of Huawei gear in grid communication backbones.[55]

3.4 Chinese direct ownership and investment in electricity infrastructure

According to the American Enterprise Institute's China Global Investment Tracker, Chinese entities invested 1.49 trillion US dollars globally between 2005 and 2024, with 464.86 billion US dollars (31 per cent) directed toward the energy sector.[56] While US regulations limit Chinese ownership of electricity infrastructure, Chinese investment is more prominent in Europe, especially in Southern countries affected by the 2010s economic crises.

Figure 1 | Timeline of Chinese investments in European energy grid sector (2011-24)



SGCC is the most active investor, acquiring major stakes in national grid operators:[57]

- Portugal: 25 per cent of REN (2012–2014);
- Italy: 35 per cent of CDP Reti (2014), which holds shares in Terna and Snam;
- Greece: 24 per cent of ADMIE (2016), increased to 44 per cent in 2024; also acquired 75 per cent of Copelouzos (2017).

[54] "Germany to Phase out Huawei, ZTE Components from Its 5G Core Network", in *Reuters*, 11 July 2024, https://www.reuters.com/business/media-telecom/germany-agrees-phaseout-huawei-zte-components-5g-core-network-2024-07-11.

[55] Cynthia Kroet, "Eleven EU Countries Took 5G Security Measures to Ban Huawei, ZTE", in *Euronews*, 12 August 2024, https://www.euronews.com/next/2024/08/12/eleven-eu-countries-took-5g-security-measures-to-ban-huawei-zte.

[56] American Enterprise Institute website: *China Global Investment Tracker*, https://www.aei.org/?p=830737.

[57] Nicolas Mazzucchi, "China and European Electricity Networks: Strategy and Issues", *FRS Notes*, No. 17/2018 (12 September 2018), https://www.frstrategie.org/en/node/92.

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China Three Gorges Corporation (CTG) holds a 21 per cent stake in Portugal's EDP.[58] China Southern Power Grid entered Europe in 2018 with a 24.9 per cent stake in Luxembourg's Encevo.[59]

Other notable investments include:[60]
- SAFE's 3 per cent stake in Italy's Enel (2014);
- China Investment Corp.'s 11 per cent stake in the UK's grid (2016);
- CNIC's 5 per cent stake in EDP, raised to 7 per cent by 2017.

Several attempted acquisitions were blocked, including in Belgium (Eandis), Spain (REE) and Germany (50Hertz).[61]

These investments give Chinese entities influence over energy governance and access to sensitive grid data and policy forums, particularly through their participation in entities like ENTSO-E.

4. Policy recommendations: Enhancing US-EU cooperation for grid security

As the governments continue their individual work to strengthen their grids, and regardless of their different opinions on decarbonisation and renewables, transmission technologies and grid security should remain a focus of future transatlantic dialogues due to the shared opportunities and challenges. Similarly, this work should also be addressed in the ongoing US-UK Technology Agreement, agreed by leaders on 8 May 2025.

In the past, the US-EU Energy Council served as the primary platform for transatlantic coordination on energy security and infrastructure resilience, with grid modernisation, cybersecurity and the integration of renewables included in discussions over the life of the Council. The Trade and Technology Council (TTC) also included discussions on the importance of energy security, aligning standards and screening mechanisms to reduce dependency on high-risk vendors, including those from China, and coordination on challenges associated with incorporating more clean energy into power grids.[62]

[58] EDP, *EDP and China Three Gorges Establish Strategic Partnership*, 22 December 2011, https://www.edp.com/en/node/146376.

[59] Nicolas Mazzucchi, "China and European Electricity Networks", cit.

[60] Ibid.

[61] Ibid.

[62] Trade and Technology Council (TTC), *Joint Statement EU-US Trade and Technology Council of 4-5 April 2024 in Leuven, Belgium*, 5 April 2024, https://ec.europa.eu/commission/presscorner/detail/en/statement_24_1828.

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Despite these efforts, more work remains to be done. To address the growing challenge posed by Chinese dominance in power grid and transmission technologies and their supply chains, the United States and the Europe must adopt a coordinated set of policy and procurement strategies. The speed and scale of China's manufacturing capabilities, which has been evident in clean technologies such as solar power, requires transatlantic cooperation. Together, the transatlantic partners can reinforce transatlantic economic security and competitiveness.

Below are a series of policy recommendations:

1) *Prioritise transatlantic grid security and innovation*: The United States and EU and/or the United States and UK should launch a process focused on securing and modernising their electricity grids while maintaining domestic industrial capabilities. This initiative would prioritise:
- Shared cybersecurity collaboration to protect critical infrastructure from foreign interference.
- Joint R&D on advanced grid technologies, including AI-driven grid management, long-duration energy storage and high-voltage direct current (HVDC) systems.
- Shared threat intelligence and resilience planning to address vulnerabilities in transmission networks.

This process could be housed under a re-launched US-EU Energy Council or similar structure that the transatlantic partners establish.

2) *Leverage strategic procurement to exclude high-risk vendors*: Both sides should adopt procurement policies that prioritise trusted vendors and explicitly exclude suppliers linked to authoritarian regimes or those failing to meet transparency and security benchmarks. Key actions include:
- Creating a joint "trusted vendor" list for public procurement in grid infrastructure.
- Mandating security and origin disclosures in all bids for transmission projects.
- Using trade defence and anti-coercion instruments to counter predatory pricing by Chinese state-backed firms.
- Share intelligence concerning Chinese vendors and suspected vulnerabilities and ensure that this information is considered as the US and Europe countries screen inward investment in the electricity transmission sector.

These approaches mirror successful strategies in the telecom sector and would help prevent China from undercutting Western firms through subsidised bids.

3) *Strengthen Transatlantic supply chains for grid components*: To support the transatlantic supply chains, the US and EU should support domestic and allied production of critical grid components such as semiconductors, rare earth magnets and power electronics. This support could include:
- Joint industrial initiative to fund research and development as well as strategic manufacturing hubs in both regions.

- Using trade agreements as incentives for reshoring and nearshoring of key supply chain segments, including agreements that exempt these products from tariffs.
- Coordination to secure raw materials from trusted partners who are also committed to economic and energy security.

Such efforts would enhance supply chain resilience while creating high-value jobs on both sides of the Atlantic.

4) *Align standards and certification for grid technologies*: To reduce dependency on Chinese suppliers and accelerate deployment of trusted alternatives, the United States and Europe should harmonise technical standards and certification processes for grid components. This includes:

- Mutual recognition of testing and safety protocols for transformers, smart meters and control systems.
- Joint development of interoperability standards for digital grid platforms and renewable integration.
- Developing aligned cybersecurity protocols and information-sharing mechanisms for grid infrastructure could improve the ability of both regions to prevent, detect and respond to cyber or hybrid threats.

Such alignment would create a larger, unified market for transatlantic manufacturers, lowering costs and increasing competitiveness against Chinese firms. Joint standards would also provide commercial clarity in third-country markets.

Conclusion

A coordinated US-EU approach to grid and transmission technology represents a strategic pathway within the de-risking framework. Cooperation could not only strengthen grid resilience but could also help foster competitiveness, reduce reliance on rivals, secure supply chains, drive innovation and create jobs. Together, the United States and Europe can chart an effective course out of gridlock.

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Appendix

Table 1 | The US and European grids systems

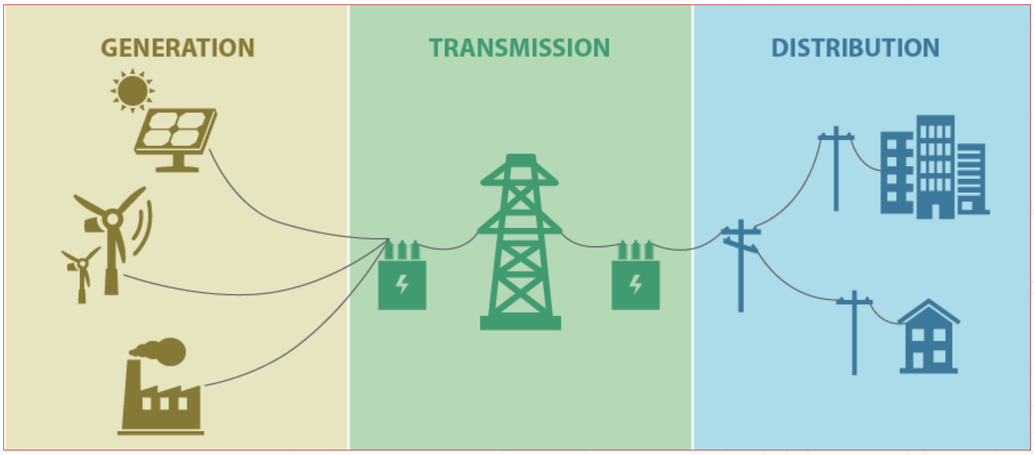
Category	United States	Europe
Grid structure	The US electrical grid is segmented into three major interconnections – the Eastern, Western and Texas (ERCOT) Interconnections – which operate largely independently. These systems rely on AC, allowing for voltage levels to be easily stepped up or down using transformers in substations. A limited number of HVDC transmission lines link the three Interconnections. HVDC lines transmit power over long distances with higher efficiency and lower energy losses than AC systems but represent only a small fraction of total US grid capacity.	Europe is organised into several synchronous areas, the largest being CESA. Ukraine and Moldova synchronised their electricity grids with CESA in 2022.[63] Estonia, Latvia and Lithuania synchronised with CESA in February 2025.[64] Other areas include the Nordic (Sweden, Norway, Finland and eastern Denmark), British and Irish grids, interconnected via HVDC links.
Transmission technology	The United States has ~700,000 circuit miles of transmission lines (typically made from aluminium, steel or a combination of both materials). Lines can be high voltage (HV), extra-high voltage (EHV) and UHV lines. UHV lines are rare but valuable for long-distance, low-loss transmission.	The EU grid spans ~11 million kilometres, with 97 per cent being distribution networks. HVDC links are used for asynchronous energy exchange between synchronous areas.
Ownership models	Grids and transmission lines are owned by a mix of investor-owned utilities (IOUs, serving 72 per cent of electricity customers), publicly owned utilities (POUs, serving 15 per cent) and electric cooperatives (serving 12 per cent). IOUs are for-profit; POUs and co-ops are not-for-profit. Ownership affects investment strategies and risk tolerance.	TSOs are responsible for high-voltage networks and cross-border infrastructure. Distribution system operators (DSOs) oversee medium- and low-voltage networks. National TSOs are typically state-owned or publicly regulated monopolies (e.g., RTE in France, TenneT in the Netherlands and Germany, and Terna in Italy). DSOs may be public, private, or municipal. Liberalised markets exist for generation and retail, with

[63] ENTSO-E, *Continental Europe Successful Synchronisation with Ukraine and Moldova Power Systems*, 16 March 2022, https://www.entsoe.eu/news/2022/03/16/continental-europe-successful-synchronisation-with-ukraine-and-moldova-power-systems.

[64] ENTSO-E, *ENTSO-E Confirms Successful Synchronization of the Continental European Electricity System with the Systems of the Baltic Countries*, 9 February 2025, https://www.entsoe.eu/news/2025/02/09/entso-e-confirms-successful-synchronization-of-the-continental-european-electricity-system-with-the-systems-of-the-baltic-countries.

		companies such as EDF, Enel, Iberdrola and E.ON.
Regulatory bodies	FERC oversees transmission rates and services, authorises the placement of new interstate transmission lines and reviews utility mergers and acquisitions. State-level PUCs regulate rates. Grid operations are managed by ISOs within a single state and by RTOs across multiple states. These entities balance electricity supply and demand in real time, coordinate regional transmission and distribution networks, and determine fixed rates of return for transmission use.	ENTSO-E coordinates 40 TSOs across 36 countries, including EU member states as well as several non-EU countries such as the UK, Switzerland and Türkiye. NRAs oversee national TSOs and DSOs. At the EU level, ACER coordinates between NRAs and monitors cross-border markets.
Investment mechanisms	Utilities recover costs through ratepayer tariffs approved by PUCs. IOUs raise capital via public markets; POUs use tax-exempt bonds; co-ops rely on federal programmes. Federal support includes the Infrastructure Investment and Jobs Act (IIJA) and IRA.	Grid development is funded through tariffs, national public funding and EU-level instruments like the Connecting Europe Facility for Energy (CEF-E). TSOs issue bonds; smaller DSOs use bank loans.
Market structure	Deregulation in the 1990s ended vertical integration. Most transmission remains under regulated monopolies, though competitive markets exist in some regions.	Electricity generation and retail are liberalised. TSOs and DSOs operate as regulated monopolies, with unbundling required to separate network operations from generation/supply.

Figure 2 | Simplified schematic of electric power sector systems



Source: Ashley J. Lawson, "Introduction to Electricity Transmission", in *CRS In Focus*, No. IF12253 (18 November 2022), https://www.congress.gov/crs-product/IF12253.

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List of acronyms

ACER	Agency for the Cooperation of Energy Regulators
ADMIE	Greece Independent Power Transmission Operator
ADMS	Advanced distribution management system
AI	Artificial intelligence
AMI	Advanced metering infrastructure
BESS	Battery energy storage system
CEF-E	Connecting Europe Facility for Energy
CESA	Continental Europe Synchronous Area
CGT	China Three Gorges Corporation
DERMS	Distributed energy resources management system
DRM	Demand response management
DSO	Distribution system operator
EDP	Energias de Portugal
EHV	Extra-high voltage
EIA	US Energy Information Administration
ENTSO-E	European Network of Transmission System Operators for Electricity
ERCOT	Electric Reliability Council of Texas
ESS	Energy storage system
EU	European Union
EV	Electric vehicle
FERC	Federal Energy Regulatory Commission
GEI	Global Energy Interconnection
GW	Gigawatt
HV	High voltage
HVDC	High-voltage direct current
IEA	International Energy Agency
IIJA	Infrastructure Investment and Jobs Act
IRA	Inflation Reduction Act
ISO	Independent system operator
IUO	Investor-owned utility
NRA	National regulatory authority
PMU	Phasor measurement unit
POU	Publicly owned utility
PRC	People's Republic of China
PUC	Public utility commission
R&D	Research and development
REE	Red Eléctrica de España
REN	Redes Energéticas Nacionais
RTO	Regional transmission organisation
SCADA	Supervisory control and data acquisition
SGCC	State Grid Corporation of China
TEN-E	Trans-European Networks for Energy
TSO	Electricity transmission system operator
TWh	Terawatt hour

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TTC	Trade and Technology Council
TYNDP	10-year network development plan
UHV	Ultra-high voltage
UK	United Kingdom
V2G	Vehicle-to-grid

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