

Perspectives

Grid capex in the age of renewables and AI

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Executive summary

- **The grid is the bottleneck.** With the ongoing electrification of the economy, electricity networks are becoming a constraint on the energy transition and, in some cases, slowing down the development of the digital economy. An aging electricity grid not designed for modern-day digital demands is being stretched by AI-driven electricity loads and long lead times for grid connection approval, resulting in curtailment of renewable output due to capacity constraints.
- **An investment supercycle in the offing.** Global total grid spending is forecast to reach \$US5.9 trillion over the 2026–2035 period. In developed markets, aging power assets and compounding electricity demand are creating a multi-decade investment cycle. In emerging markets, millions of kilometres of new lines must be built from scratch.
- **The opportunity spans the value chain.** Transmission faces the most acute capacity shortfall. Distribution networks need both physical and digital upgrades. And the specialist service providers that deliver the work are becoming a critical enabler of the entire programme.

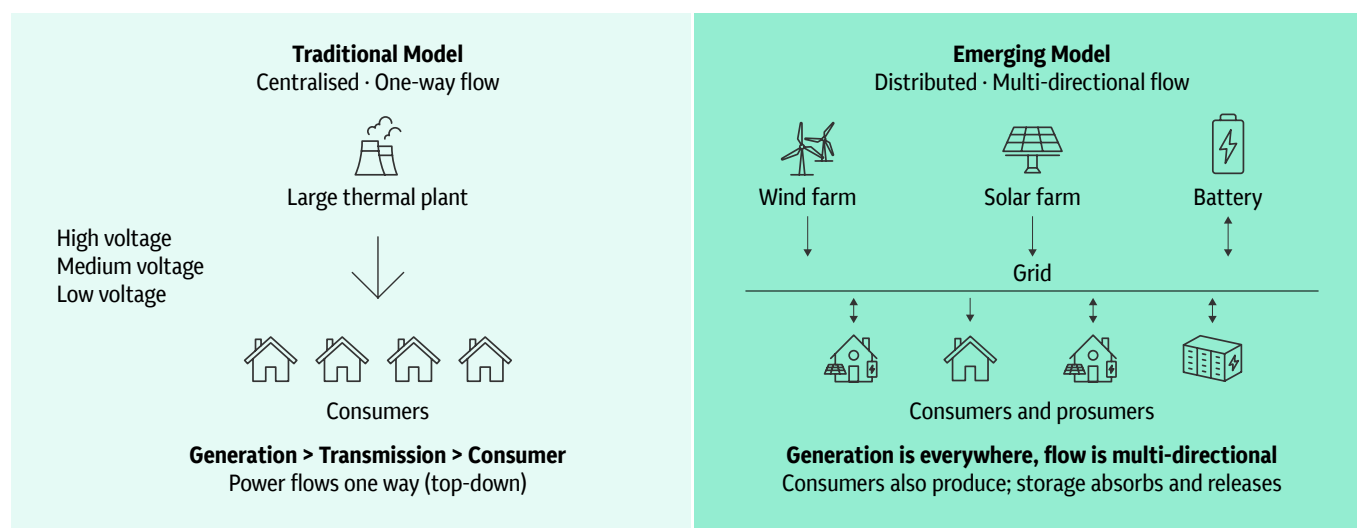
The global electricity grid is entering its most consequential investment cycle in a generation. Across geographies and market structures, the same challenge is emerging: grids need to become more robust, more flexible, and significantly larger. The drivers vary, from renewable integration in Europe to AI-led demand growth in the United States, but they point to the same imperative. The grid, long treated as stable background infrastructure, has become a bottleneck on the energy transition, the digital economy, and industrial growth. Remedying it will demand capital across the entire value chain: in transmission to connect remote generation, for flexibility services to manage intermittency, and on smarter distribution networks for decentralised, bidirectional power flows.

Drivers of the grid investment cycle

The supply side: renewables and the rewiring of supply

Renewable generation capacity is scaling rapidly, but the grid infrastructure needed to deliver that power reliably is not keeping pace. Globally, 814 gigawatts (GW) of new solar and wind capacity was added in 2025, up 17% on the prior year, and enough to surpass four terawatts (TW) of total installed capacity for the first time.¹ What is needed is not just more grid but also a fundamentally different kind of grid. The old model delivered power in one direction, from large, centralised plants to often passive consumers. The emerging model must handle distributed, variable generation feeding in from all directions, from utility-scale wind farms to rooftop solar, while maintaining the stability and reliability that consumers and industry depend on (Figure 1).

Figure 1:
From one-way to many-way: how power flow is changing

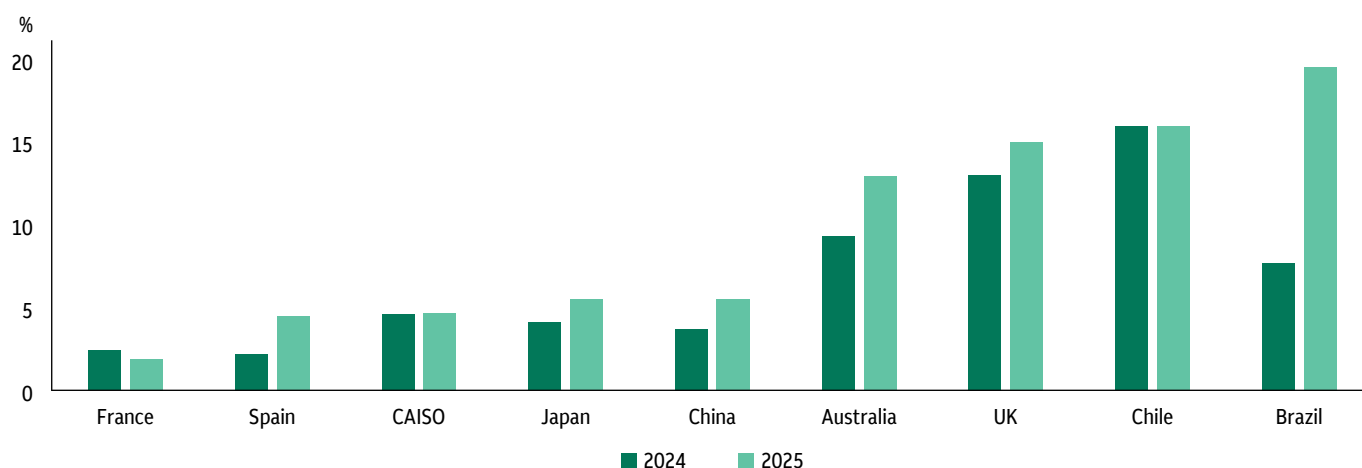


Source: Macquarie Asset Management analysis.

The gap between these two models is already visible. In many jurisdictions, grid infrastructure has simply not kept pace with the generation buildout. The result is growing generation curtailment: clean energy being produced but wasted because the grid cannot absorb it or does not have the necessary infrastructure to transport it. In some markets, curtailment rates for wind and solar have risen sharply (Figure 2).

1. Ember, "World adds a record-breaking 814 GW of solar and wind in 2025", March 2026.

Figure 2:
A record amount of wind and solar power was curtailed in 2025



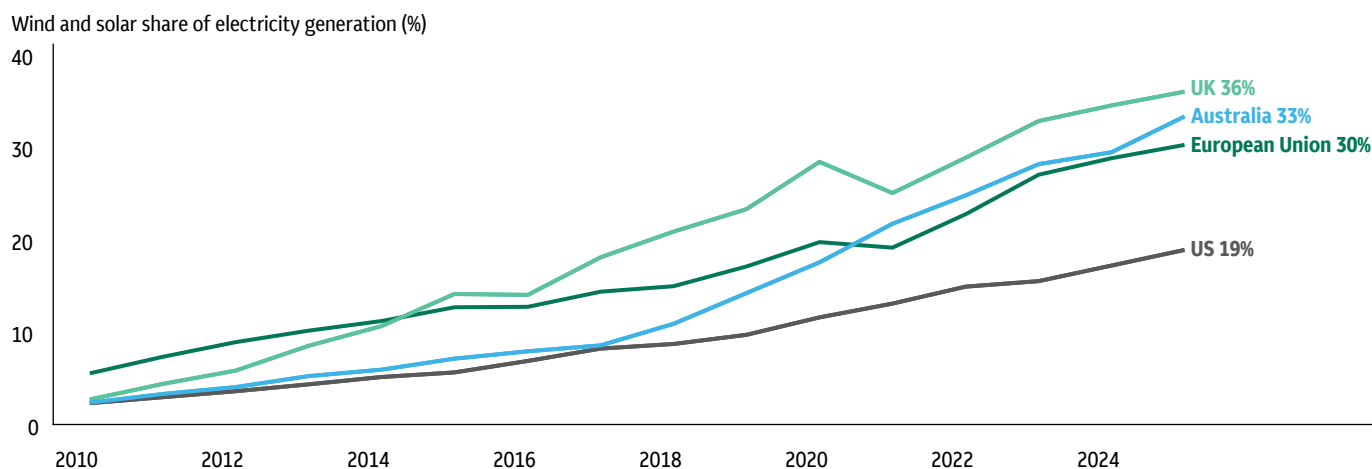
Source: BloombergNEF (BNEF), “Wind and Solar Curtailment Reach New Records”, April 2026. California Independent System Operator (CAISO) operates California's wholesale power grid.

This problem is often compounded by the geographic mismatches that occur when generation is sited far from demand centres. Offshore wind sits off coastlines distant from industrial areas that need them most, as in Italy and Germany. Solar potential is highest in arid regions, not in the cities or built-up areas that consume the power.² Bridging these gaps requires transmission infrastructure that, in many cases, does not yet exist or is severely under-developed or maintained.³

The challenge goes beyond capacity and is created by the switch to different types of technology. The grid is losing a built-in source of frequency stability as wind and solar rapidly displace conventional power plants across markets from the UK to the US (Figure 3). The heavy spinning turbines these plants use — and the physical inertia this rotational mass provides — acts as a physical buffer, resisting sudden changes in frequency when supply and demand fall out of balance. Every synchronous generator that goes offline takes some of that buffer with it. The April 2025 Iberian blackout, which left tens of millions without power for up to 18 hours, underscored the consequences when grid infrastructure and operational practices fail to keep pace with a rapidly changing generation mix.⁴

Solutions are emerging from grid-forming inverters to synthetic inertia, but they raise the technical and commercial complexity for grid management.⁵

Figure 3:
The displacement of synchronous generation is a global phenomenon



Source: Ember, “Yearly electricity data”, accessed 24 April 2026.

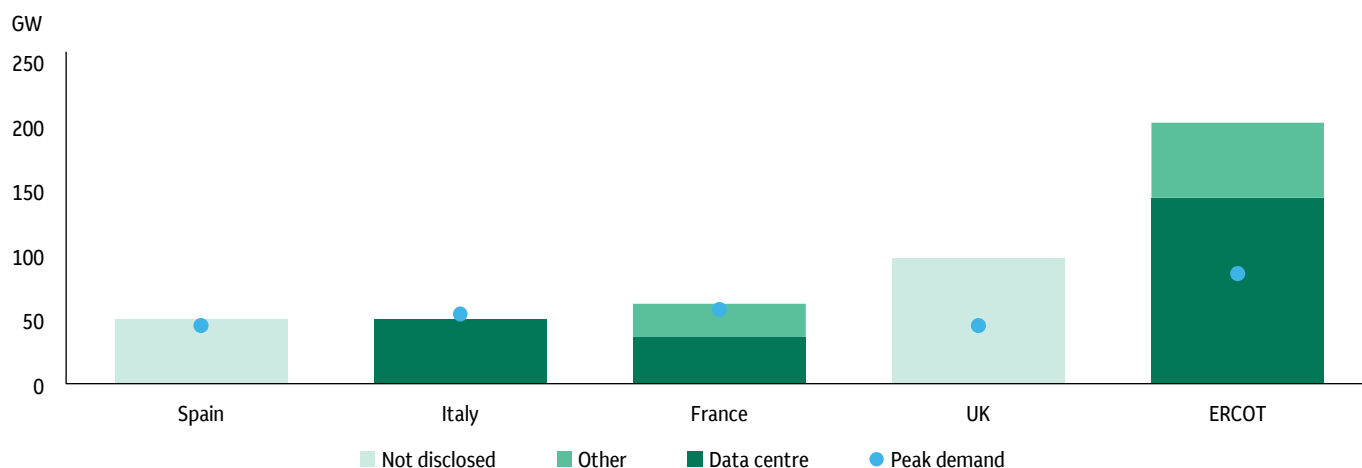
- BNEF, “Grid Investment Outlook 2025”, December 2025.
- Eurelectric, EY and Imperial College London, “Grids for Speed”, May 2024.
- ENTSO-E, “28 April 2025 Blackout: Expert Panel Final Report”, March 2026.
- Baringa, “When the grid stops spinning: the inertia challenge in renewable energy”, September 2025.

The demand side: AI and the return of load growth

On the demand side, the picture is shifting just as fast. Electrification of transport and heating, industrial reshoring, and the rapid buildout of AI infrastructure are all placing new demands on grids simultaneously. Of these, AI stands out for the speed and concentration of its impact. In the United States, electricity demand is inflecting upward after roughly fifteen years of stagnation. In Asia, where demand has been growing rapidly, data centres are compounding the strain on grids that have struggled to keep pace. From 2025 through 2030, global data centre capacity additions are forecasted to be between 69 GW and 141 GW, reflecting an 85% to 174% growth relative to global capacity in 2024.⁶

The physical footprint of AI infrastructure is scaling rapidly. Average data centre sizes have grown from 25 megawatts (MW) in 2020 to nearly 80 MW for those entering service in 2025,⁷ driven by the computing intensity of large language models and other AI workloads. Connecting these larger facilities often requires new transmission infrastructure well beyond the immediate point of connection, and the queue to secure that connection is growing fast. In Texas' ERCOT⁸ alone, 144 GW of data centre capacity is awaiting grid interconnection, against a system peak demand of just 86 GW (Figure 4). The scale of demand pressure is clear, even accounting for the high dropout rates typical of such queues. The resulting capacity constraints in established hubs are pushing development toward regions where land and grid headroom remain more available — in Europe, for instance, toward the Nordics and the southern part of the continent.⁹

Figure 4:
Demand connection queues at transmission level in selected markets



Source: BNEF, "Grid Investment Outlook 2025", December 2025.

Current grid investment plans may not fully reflect the scale and nature of AI-driven demand. As facility sizes continue to expand, the transmission investment required per data centre is materially higher than backward-looking assumptions suggest. The load profile also adds complexity: as Figure 5 illustrates, facility-level power draw varies significantly with utilisation and workload mix. In this example, at 80% average utilisation, a single facility can see intraday swings of 20–40%, creating balancing challenges that compound as data centres account for a larger share of total system load.¹⁰ These variability patterns sit outside what conventional dispatch and reserve planning frameworks were designed to accommodate.¹¹ Hyperscale operators' commitments to match new capacity with clean power procurement further compound the challenge, tying AI load growth directly to renewables buildout and grid integration. Together, these factors point to meaningful upside risk to grid capex forecasts on both the infrastructure and flexibility sides.

6. See Macquarie Asset Management, Data centres: Powering the growth of AI and cloud computing (August 2025) for more detail.

7. US Federal Energy Regulatory Commission, "2025 State of the Markets", March 2026.

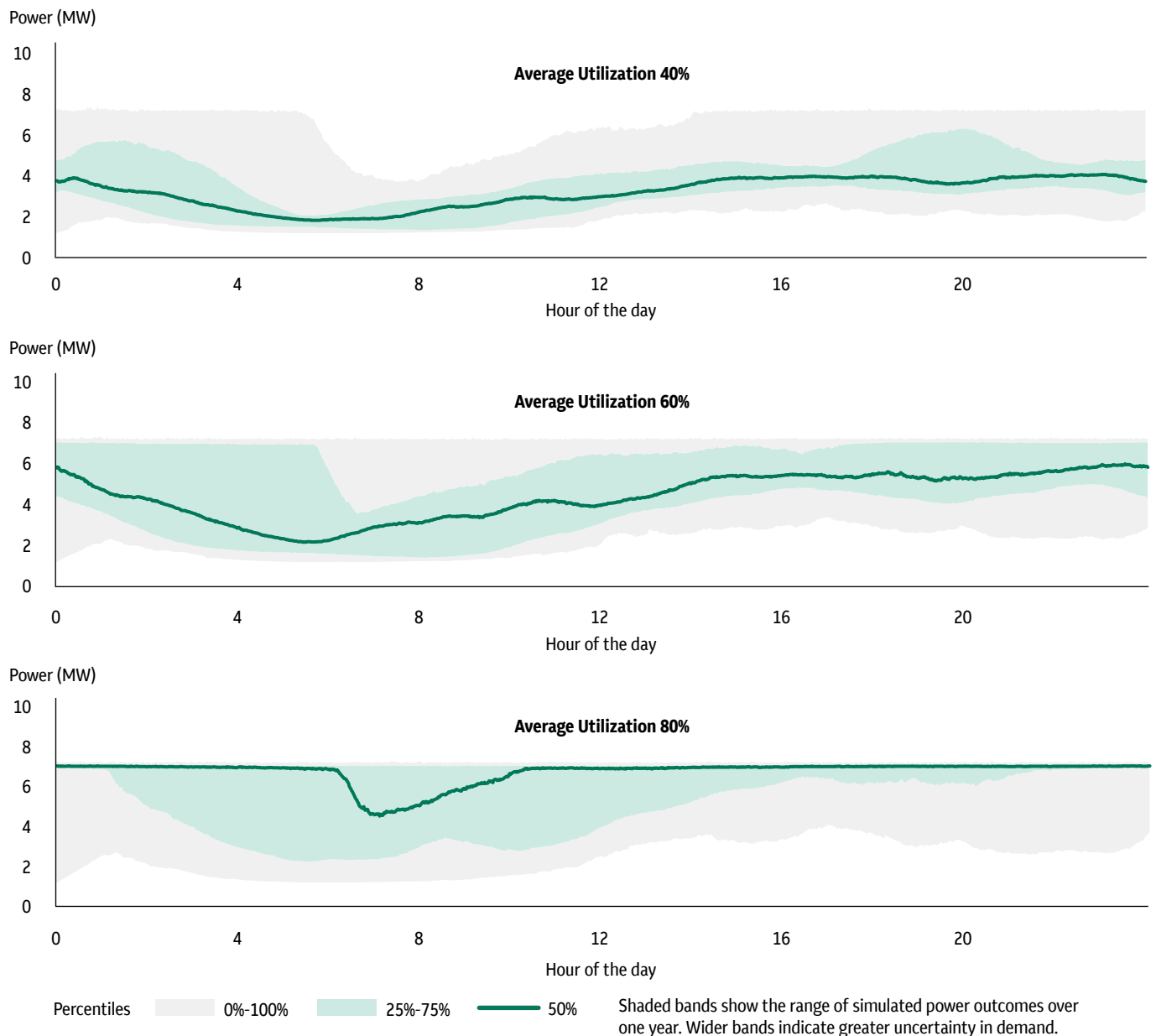
8. Electric Reliability Council of Texas. ERCOT is the operator of Texas's electrical grid.

9. BNEF, "Grid Investment Outlook 2025", December 2025.

10. Vercellino, R. et al., "Measurement of Generative AI Workload Power Profiles for Whole-Facility Data Center Infrastructure Planning", National Laboratory of the Rockies, April 2026.

11. For example, The North American Electric Reliability Corp (NERC) issued a Level 3 alert (the highest level) in May 2026 following instances of data centres unexpectedly dropping load or oscillating demand rapidly, creating grid reliability concerns. See: NERC, "Essential Action to Industry: Computational Load Modeling, Studies, Instrumentation, Commissioning, Operations, Protection, and Control Essential Action to Industry: Computational Load Modeling, Studies, Instrumentation, Commissioning, Operations, Protection, and Control," May 2026.

Figure 5:
AI training loads are volatile: simulated intraday power swings at a 10 MW colocation facility



Source: Vercellino, R. et al., “Measurement of Generative AI Workload Power Profiles for Whole-Facility Data Center Infrastructure Planning”, National Laboratory of the Rockies, April 2026. Utilisation refers to the share of compute nodes actively running workloads at a given time. The three scenarios (40%, 60%, 80%) reflect the range of plausible operating conditions. No facility sustains 100% node occupancy continuously, as workloads arrive and complete at different times and nodes cycle between jobs. Production GPU clusters have been observed to operate at average node occupancy of 65–82% depending on workload type.

Aging grids, missing grids

These pressures are not arriving sequentially — they are compounding. In developed markets, renewable integration and surging data centre demand are landing on transmission and distribution infrastructure that was largely built in the post-war decades and is approaching the end of its operational life. Asset replacement alone would constitute a significant investment need; layered on top of electrification, renewable integration, and AI load growth, it becomes an investment supercycle.

In emerging economies, the challenge is different in character but no less significant. These markets are expected to account for nearly 80% of global electricity demand growth through 2030,¹² driven by industrialisation, urbanisation, and rising cooling needs. Yet, much of the grid infrastructure needed to serve that demand does not exist. The IEA estimates that emerging markets outside China need to add 2.3 million kilometres of new transmission lines by 2040.¹³ The buildout is gaining momentum: in Southeast Asia, the World Bank and Asian Development Bank have pledged over \$US12 billion to support the ASEAN Power Grid initiative, while Latin American markets such as Brazil and Chile are scaling grid investment to integrate fast-growing renewable capacity.¹⁴ Many of these markets also have the opportunity to deploy modern, flexible grid technology from the outset rather than retrofitting it onto aging networks.

12. IEA, “Electricity 2026”, February 2026.

13. IEA, “Building the Future Transmission Grid”, January 2025.

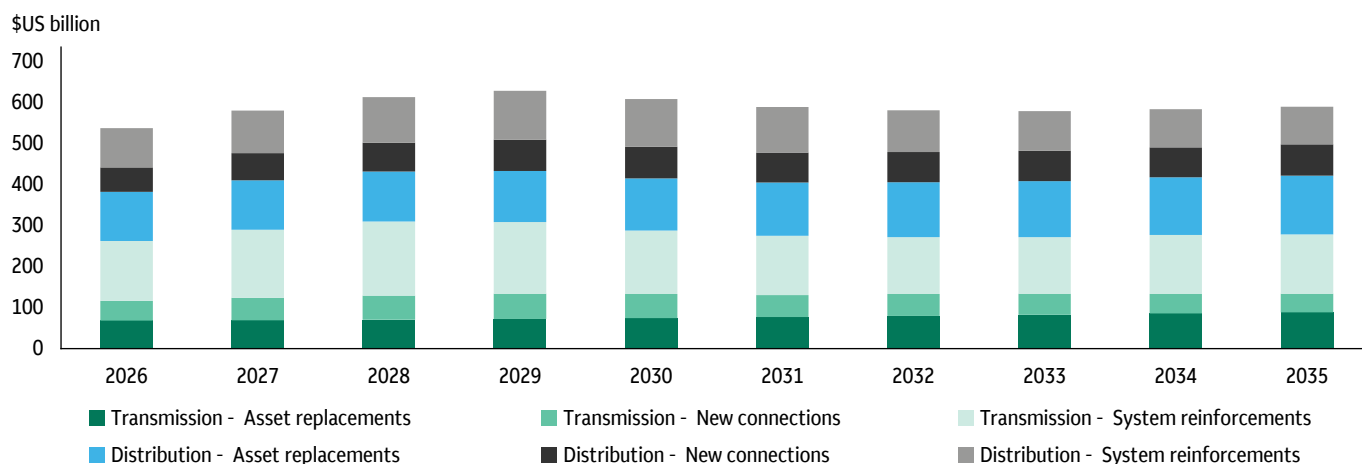
14. IEA, “Breakthrough Agenda Report 2025”, October 2025.

The investment opportunity: where the capital needs to go

The scale of investment required is substantial. Over 2026–2035, global grid spending is expected to reach \$US5.9 trillion, split roughly evenly between distribution and transmission.¹⁵

That spending falls into three categories: system reinforcements (44%), which upgrade the wider network to handle increased loads and new generation; asset replacements (35%), to retire infrastructure that has reached the end of its useful life; and new connections (21%), to link new sources of demand or generation to the grid (Figure 6).

Figure 6:
Global grid investment in transmission and distribution forecast, 2026–2035

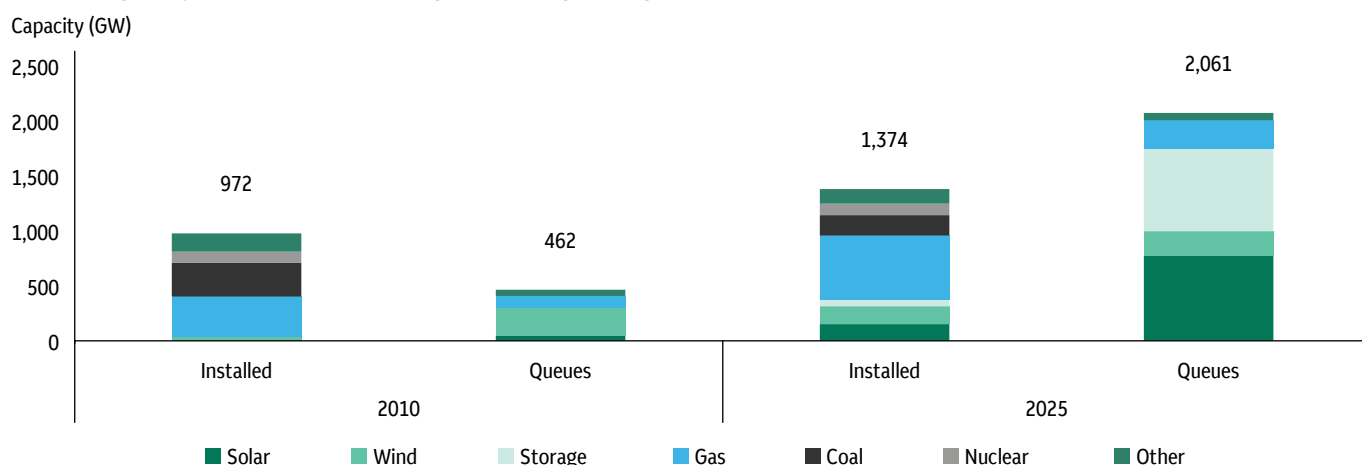


Source: BNEF, “New Energy Outlook 2025: Grids”, August 2025.

The opportunities created span the grid value chain, but three segments stand out.

- Transmission and interconnection:** This is where system reinforcement needs are most acute. New generation clusters and demand centres require long-distance capacity that does not yet exist. In the US, over 2,000 GW of generation and storage capacity sat in interconnection queues at the end of 2025 — 1.5 times the country's entire installed base (Figure 7).¹⁶ This is much larger than 15 years prior. In Europe, cross-border interconnectors represent a specific sub-opportunity: the EU is still lacking 88 GW of cross-border transmission capacity needed to meet its 15% interconnection target by 2030.¹⁷ Across both markets, new generation is being built far faster than the grid needed to carry it.

Figure 7:
Active capacity in interconnection queues, US power plants, 2010 and 2025



Source: Lawrence Berkeley National Laboratory, “Interconnection Queue Dataset & Summarized Data Files, through 2025”, May 2026.

15. BNEF, “New Energy Outlook 2025: Grids”, August 2025.

16. Lawrence Berkeley National Laboratory, “Interconnection Queue Dataset & Summarized Data Files, through 2025”, May 2026.

17. European Commission, “European Grids Package” (COM/2025/1005), December 2025.

- **Distribution networks:** They are where the energy meets the end user. Electric vehicles, heat pumps, rooftop solar, and urban data centres all connect at the distribution level. In Europe, an estimated 70% of new renewable generation and storage will be integrated at this layer by 2050, further stretching networks already contending with the geographic mismatch discussed above. Yet, distribution grids have historically attracted less attention than headline transmission megaprojects. The challenge is compounded by age: approximately 30% of European distribution grids are already over 40 years old,¹⁸ a share expected to exceed 50% by 2030.¹⁹ Beyond physical reinforcement, distribution grids also require digitalisation — smart meters, automated switching, and real-time monitoring — to manage increasingly complex two-way power flows. This is a large and fragmented opportunity set, but one where the investment case is being driven by the same structural forces reshaping the rest of the grid.
- **Grid services:** Delivering on asset replacements, new connections, and system reinforcement requires a broad range of physical capabilities: construction, inspection, power electronics installation, digital monitoring systems, and emergency response. Demand for skilled service providers is growing in lockstep with the capex cycle, and the firms that can deliver this work at scale are becoming a critical enabler of the broader investment programme. The market is fragmented, with meaningful consolidation potential, and benefits from long-term demand visibility underpinned by the multi-decade cycle described above. For a deeper look at this opportunity set, we explore this theme in *Infrastructure adjacencies: Where infrastructure meets private equity* (April 2026).

Battery storage merits mention as a second-order beneficiary. While not grid infrastructure per se, battery storage directly benefits from the same drivers: renewables integration, grid flexibility needs, and rising demand volatility. As grids become more complex and variable, the value of fast-responding, location-flexible storage assets grows in parallel.

Conclusion

Grids are no longer the infrastructure that is “seen and not heard”; they are the bottleneck for both energy transition and AI-driven load growth. The issues related to variable renewables, electrification and data centres, aging assets, and emerging-market expansion are compounding at the same time. Together, the priority is no longer just building more power plants. It is upgrading and expanding the grid: building new transmission lines, upgrading the technological capacity of local networks to “sweat the assets” more efficiently, and developing the services and control systems needed to connect and run an increasingly complex system. For investors, that means a multi-year opportunity set across interconnection and reinforcement, digital distribution, and the specialist providers that deliver the work.

18. European Parliamentary Research Service, “European Grids Package: Lessons Learnt from the Implementation of the TEN-E Framework”, December 2025.

19. Eurelectric, EY and Imperial College London, “Grids for Speed”, May 2024.

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