Energy Macro Report

Renewables and Power Outlook 2026

Demand surges, supply strains

Power Macro Solution
September 2026

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Record investment, binding constraints

The power sector is entering a phase shaped by two main forces. Renewables continue to lead capacity additions, with 89% of the new gigawatts added in 2025. Renewables are set to make up 36% of global generation already by the end of 2026, rising to over 50% by 2033 as costs decline and the high growth rates of the past decade ease. At the same time, power demand is set to almost double between 2025 and 2050, to 56,000 TWh. AI data centers are driving a concentrated demand surge, particularly in the US and China, and have triggered a revival in gas demand growth that is straining the global gas turbine supply chain. A central factor for the power sector ahead will be the pace of execution: capital is abundant and ambitions are high – but how quickly can physical infrastructure be built to meet demand?

Demand growth is accelerating with electrification, and regional patterns are diverging. Asia leads long-term generation growth, with renewables set to exceed half of China's power mix by the early 2030s. In the US, the system is organizing along functional lines, with renewables meeting energy demand and gas retaining a central role for reliability. Data centers are at the heart of this shift, driving US power growth and introducing a continuous, geographically concentrated load that behaves unlike any demand source the grid was designed to serve.

Supply chains have become crucial for project delivery. Gas turbine order books are full three years out, with the major OEMs carrying backlogs that commit capacity to 2028 and beyond. Transformer manufacturers added 86 GVA of capacity in 2025, and annual additions are set to rise toward 160 GVA through 2028, with the US driving nearly 40% of that expansion. China retains a structural cost and scale advantage for solar modules, battery cells and wind components, while manufacturing capacity gradually diversifies into new markets.

Flexibility is becoming an important factor. Battery storage costs have halved in five years, and energy arbitrage has become the primary revenue driver for operators in mature markets such as Australia. The role of gas is being challenged by geopolitical issues and is increasingly shifting to a flexibility-centered instrument as renewable penetration rises. Meanwhile, pumped hydro storage capacity is positioned to more than triple by 2040, and co-location of storage with generation is already proving an effective way of protecting project returns as capture prices decline.

Data centers are the clearest expression of the execution challenge. Rystad Energy's asset-level data shows the sector making up 4% of global electricity demand by 2035, with capex of $770 billion in 2025 already exceeding upstream oil and gas investment. The pipeline runs well ahead of what the system can absorb: on a project-by-project basis, over half of the announced data center power pipeline is unlikely to materialize by 2035, held back by grid connection queues, equipment lead times and permitting. Developers are turning to behind-the-meter gas, fuel cells and on-site generation to bridge the gap.

For many segments, the pattern is similar: the pipeline of announced projects is the largest on record, and the constraint has moved to the physical and practical: transformers, turbines, grid connections, permitting and skilled labor. Rystad Energy's bottom-up asset database measures the gap between announced ambition and deliverable capacity, and that distinction is what will separate the projects that reach operation from those that stay on the drawing board. For developers, utilities and investors, the advantage now lies in securing scarce inputs early and planning around realistic delivery timelines.

Source: Rystad Energy research and analysis

Chapter 1: Market update

Renewable energy capacity additions dominate 2026, but growth has slowed in some regions

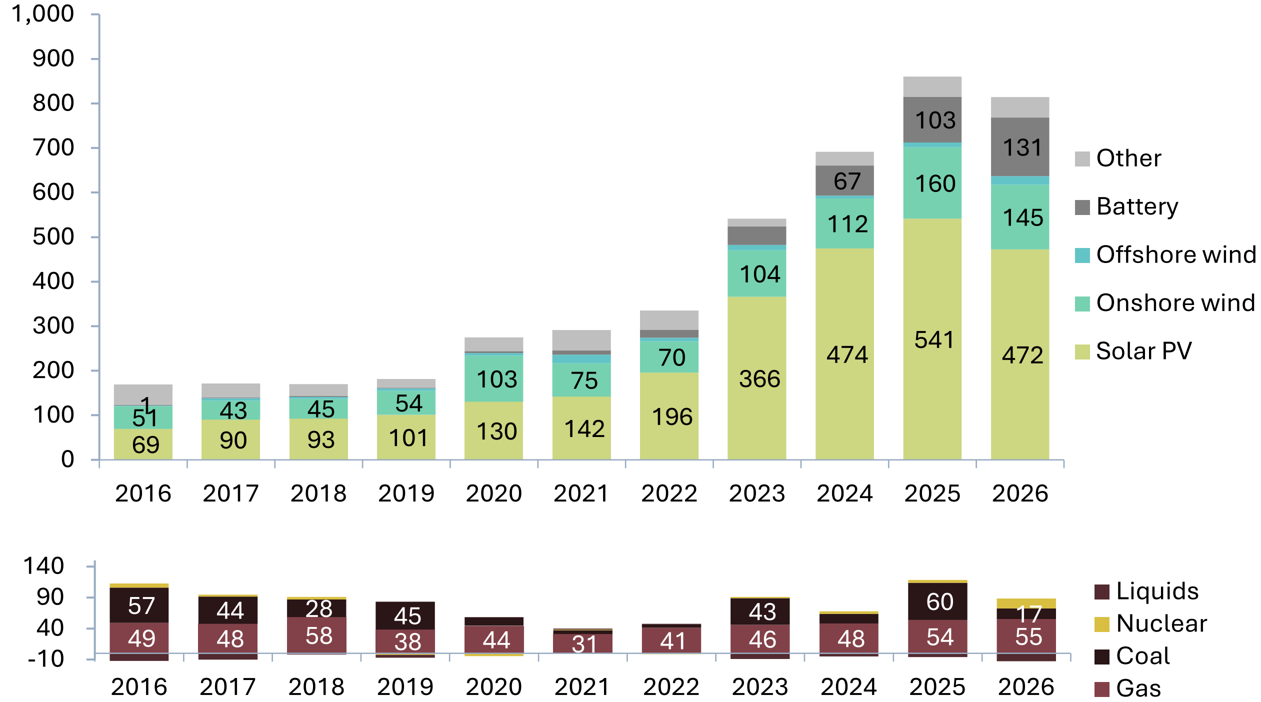
Global power generation capacity has been rising fast over the past decade as more supply is needed to meet surging demand. In the past six years, growth in renewable energy capacity has accelerated as technology costs keep falling, helped by ambitious plans by many regions to reduce their dependency on fossil fuels. As a result, yearly installations of renewable energy have outpaced those of conventional technologies for more than 10 years.

Renewables made up over 89% of added capacity last year and will account for more than 91% in 2026, mainly from solar PV and wind. Solar, wind and battery storage are together set to bring 815 gigawatts (GW) in additions this year. That is less than last year's 860 GW of installations, a slowdown which is mainly due to China, where a record-breaking installation boom is cooling off as subsidy reforms and grid-integration constraints temper the pace of new projects. Because China has accounted for such a large share of global additions, even a modest slowdown there is enough to bend the worldwide trajectory downward, partially offset by continued momentum in Europe, India, the US and elsewhere.

Solar PV capacity continues to be the main driver of growth with around 472 GW of new capacity forecast to come online this year, followed by onshore wind with 145 GW. Battery capacity has entered a trajectory of exponential growth with more than 131 GW expected to be added in 2026, making it the third-largest source of growth. Despite the slowdown in China, the country's additions of renewable energy sources will make up more than half of all global installations.

Conventional power generation sources have expanded at a more modest pace over the past decade but continue to provide net additions. Growth has been led mostly by gas power, as many countries continue to bet on this energy source as a flexible and cleaner alternative to coal. At the same time, countries with plentiful coal resources such as China, India and Indonesia are still expanding their coal generation fleets to help meet increasing demand. After a period of slower growth, nuclear energy is expected to add 16 GW this year, mostly in Asian countries.

Global power generation net capacity additions by source renewables (top) and conventional (bottom)*
Gigawatts



*Gigawatts AC net additions. Other includes bio, geothermal, hydro, marine, pumped storage, and solar thermal
Source: Rystad Energy research and analysis; Rystad Energy Power Macro Solution

Renewables set to make up 36% of global power generation by end of 2026

Total global generation is expected to climb to 33,054 terawatt-hours (TWh) this year, as demand has risen on average 3% per year since 2010. Coal and gas are still the two largest sources of generation and will contribute around 10,400 TWh and 7,200 TWh this year, respectively, or 53% put together.

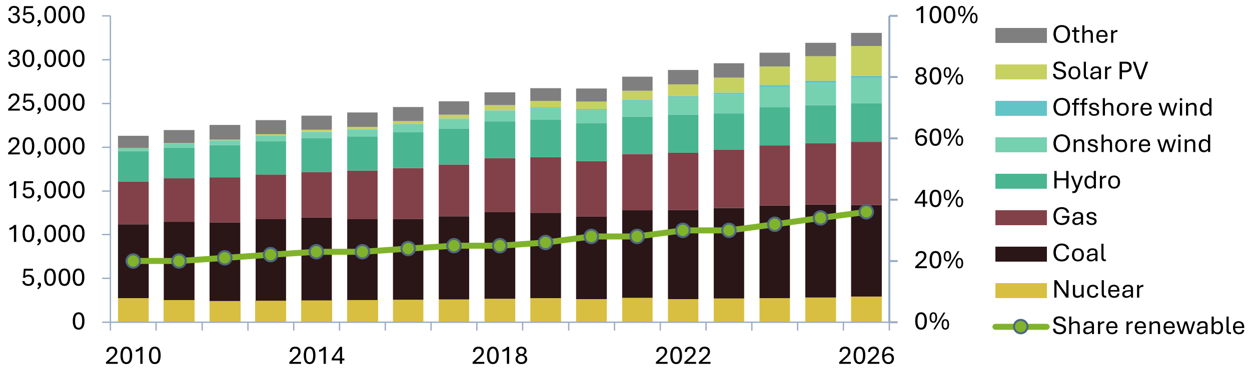
The share of renewable energy continues to grow fast and is forecast to contribute 36% of global supply this year. Of these sources, hydro is the largest with around 4,400 TWh, followed by solar at around 3,400 TWh and onshore wind at 2,900 TWh. Nuclear power generation has been stable over the past decades and is forecast to supply 2,900 TWh this year. Lower nuclear generation in Japan and some European countries is offset by new plants coming online in China, other Asian countries and the Middle East.

Power demand has grown much faster in Asia than in the rest of the world. As a result, generation from both conventional and renewable sources has surged in this region over the past decade. Despite exponential renewable energy additions in China, the country still relies on fossil fuels to meet more than half of its energy needs. New renewable energy supply in Asia has supported new demand rather than directly displacing the use of fossil fuels.

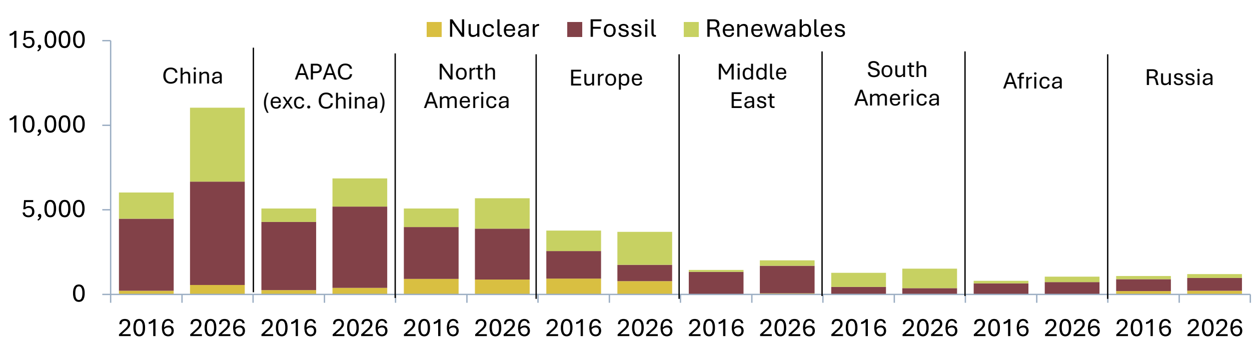
Demand growth in North America and Europe has been more modest, or even negative in some European countries. In these regions, the growth in renewable generation has mostly helped displace fossil fuels in the power mix. In Europe, renewable sources are expected to provide around 52% of power supply this year, compared to 27% from fossil fuels.

The Middle East and Africa rely heavily on gas power, and South America is dominated by hydro. All three regions have begun a rapid expansion of solar and wind capacity.

Global power generation and share of renewable energy*
Terawatt-hours



Power generation by continent and energy source type
Terawatt-hours



*Renewable includes solar PV, onshore and offshore wind, hydro, bio, geothermal, solar thermal, marine
Source: Rystad Energy research and analysis; Rystad Energy Power Macro Solution

RystadEnergy

European prices remain above other major markets, lifted by high gas and carbon costs

Electricity prices vary significantly across major liberalized markets. Average European prices have traded well above other large regions such as China, India and the US, making it challenging for Europe to compete in the global market.

European prices averaged $93.69 per MWh from May 2025 to April 2026 – considerably higher than China's $53.41 per MWh and the US average of $45.20 per MWh. European prices also have greater seasonality, rising in winter when demand is higher and dropping during the summer when demand falls and solar generation makes up a higher share of the power mix.

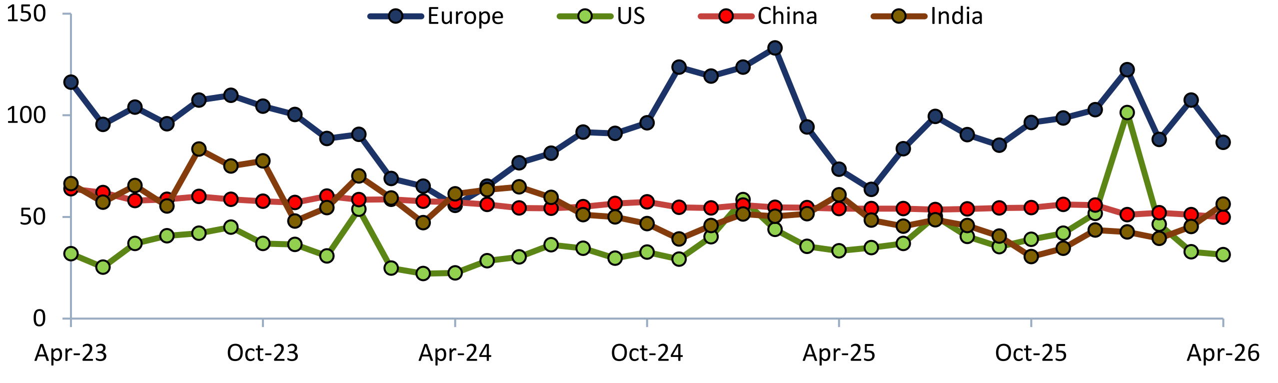
Prices in Europe are highly correlated to the generation cost for gas power as this source tends to be the marginal source of supply, especially during peak hours. Continental prices are therefore lifted by high LNG prices and the cost of carbon.

The generation cost of gas power jumped in March as the global LNG balance was disrupted due to the conflict in the Middle East. China and India also depend on LNG imports for their gas power generation, though gas power represents a much lower share of their generation mix. With the recent increase in LNG prices, both countries have increased coal power generation to reduce their exposure to the high LNG prices. As both countries also have large domestic coal production and lower or no carbon prices, the cost of coal power generation is much lower than in Europe, helping keep power prices at a lower level.

US power prices are also highly correlated to the price of gas. However, the US has vast domestic gas production that helps keep gas prices at around one-third of the price level in Europe or Asia. This leads to the lower average power prices.

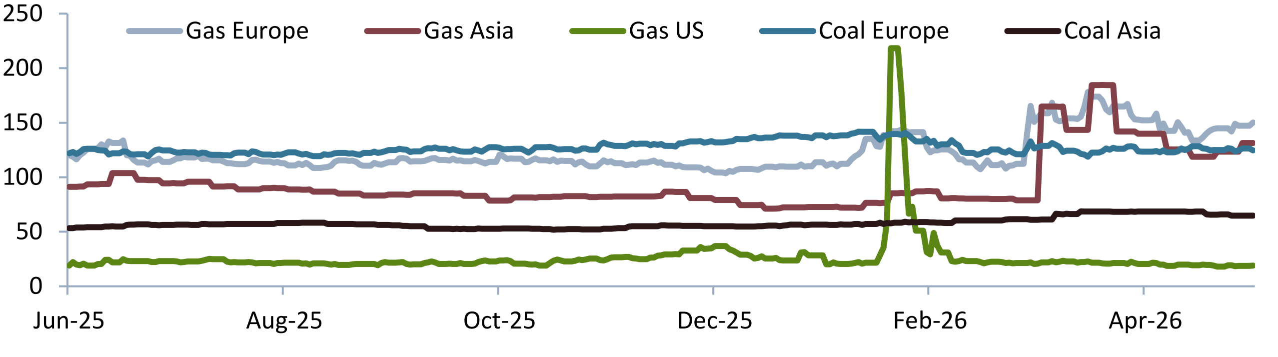
Average electricity prices for selected markets*

USD per MWh



Coal and gas power generation costs

USD per MWh



*European average price includes France, Spain, Italy, the UK and Germany. The US average includes ERCOT, CAISO, MISO, NYISO and PJM. The average for China includes all price regions. Prices for India are day-ahead market prices

Source: Rystad Energy research and analysis; LSEG

Chapter 2: Long-term macro outlook

Renewables dominate future capacity additions as conventional build-out fades

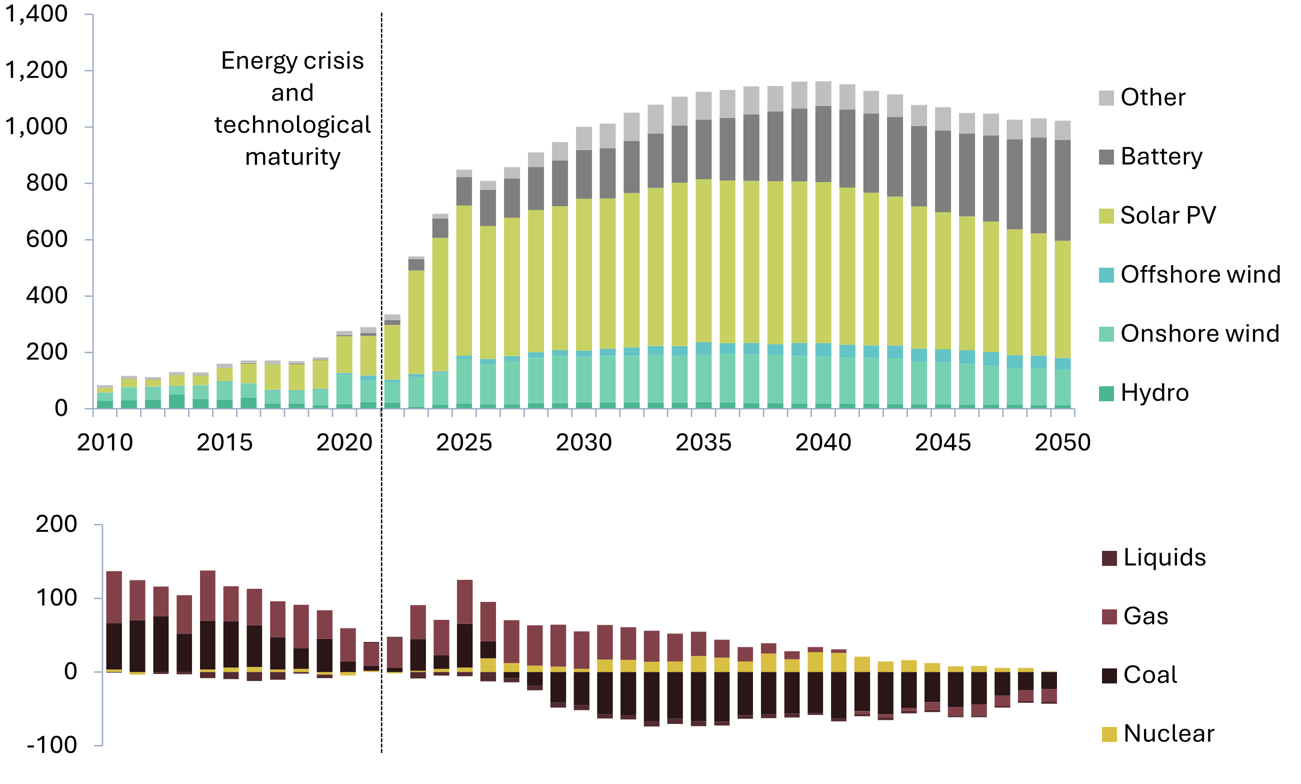
Global power capacity additions have entered a new phase as renewables make up most of the new capacity, which we expect to persist throughout the outlook period. Renewable additions jumped 62% in 2023 alone, and the market is now in a period of a sustained high renewable deployment: last year, some 89% – or 860 GW – of global capacity additions were renewable. This is a result of improving competitiveness of renewable technologies, shorter construction timelines, and supply-chain maturity, particularly for solar PV.

Solar PV is the main driver of capacity growth and will remain the largest source of annual additions until 2050. Onshore and offshore wind also continue to contribute. Batteries will become more visible over time, highlighting the growing need for flexibility and storage as variable renewable generation takes on a larger role in the power system. Together, solar, wind and batteries increasingly define the shape of future capacity expansion.

Conventional capacity additions will become less important over time. Gas is the largest conventional source of new capacity in the near term, supported by its role in system reliability and flexible generation, but additions are shrinking. Coal and liquids also trend downward, with coal moving into net decline as retirements start to outweigh newbuild activity. Nuclear continues to add capacity, but at a smaller scale and with a slower development profile than solar and wind. Even so, dispatchable generation remains important over the long term, particularly for managing seasonal variability and supporting reliability.

The main message is that future power-sector growth is overwhelmingly renewable-led. Conventional technologies still have a role in some markets, but the majority have shifted toward scalable, low-carbon capacity. This also increases the need for grid investment, storage and flexibility solutions to support a more weather-dependent power system.

Global power generation capacity additions by source renewables (top) and conventional (bottom)
Gigawatts



Source: Rystad Energy Power Macro Solution

Asia drives long-term power generation growth as regional mixes diverge

The regional outlook shows that long-term power generation growth is concentrated in Asia. Mainland China is the largest power generation market throughout the outlook, while Asia-Pacific excluding China sees strong growth from a lower base. Rising electricity demand, industrial expansion, urbanization and electrification continue to boost generation needs across the region, making Asia the main driver of global power-sector growth.

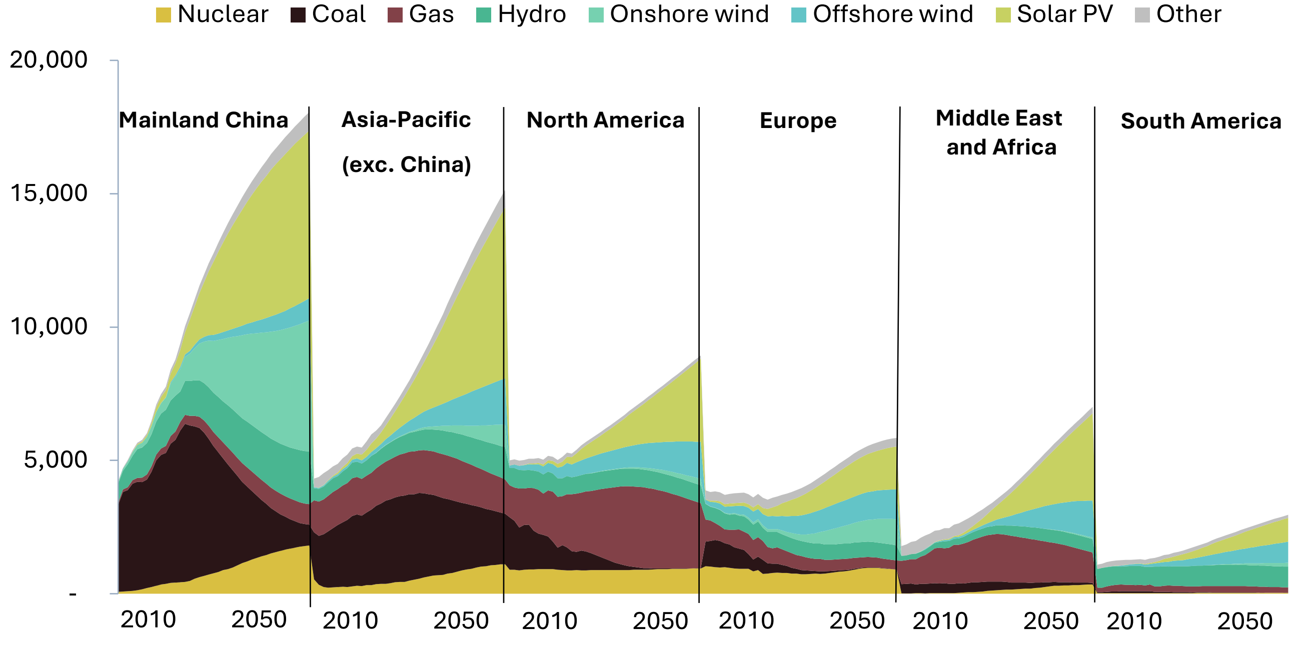
The power mix becomes increasingly renewable-led, but the transition differs significantly by region. Solar PV expands across all major markets and will be one of the most important sources of generation growth. Wind also grows, though its role varies depending on resource quality, permitting, grid access and policy support. Hydro is important in regions with strong existing resources, particularly South America, while nuclear plays a more visible role in markets including East Asia, North America and parts of Europe.

China's generation mix changes substantially over time, reaching 18,000 TWh within 2050, with solar and wind expanding strongly while coal becomes less dominant in relative terms. The rest of Asia-Pacific also sees rapid generation growth, but with a more mixed power system for longer. This reflects the challenge of meeting rising electricity demand while also shifting the generation mix toward lower-carbon sources, which is particularly felt in high-growth markets.

Mature markets such as Europe and North America follow a different path. Generation growth is more moderate, and the transition is more focused on changing the composition of the existing power mix. Coal declines in importance, while renewables expand and gas continues to support flexibility in some markets. Europe shows a strong shift toward wind and solar, while North America retains a broader mix across gas, renewables and nuclear.

The Middle East, Africa and South America show distinct regional patterns. The Middle East and Africa region is growing from a smaller base, with solar becoming increasingly important alongside gas. South America is more hydro-led than other regions, but solar and wind gradually add diversity.

Global power generation by sector and region
Terawatt-hours



Source: Rystad Energy Power Macro Solution

Global electricity demand nearly doubles to 56,000 TWh by 2050, led by Asia

From around 29,000 TWh today, global electricity demand is set to nearly double to over 56,000 TWh by 2050. Asia drives this expansion, with mainland China and the rest of Asia-Pacific accounting for most of the additional load. In 2025, Asia alone made up more than half of the world's electricity demand.

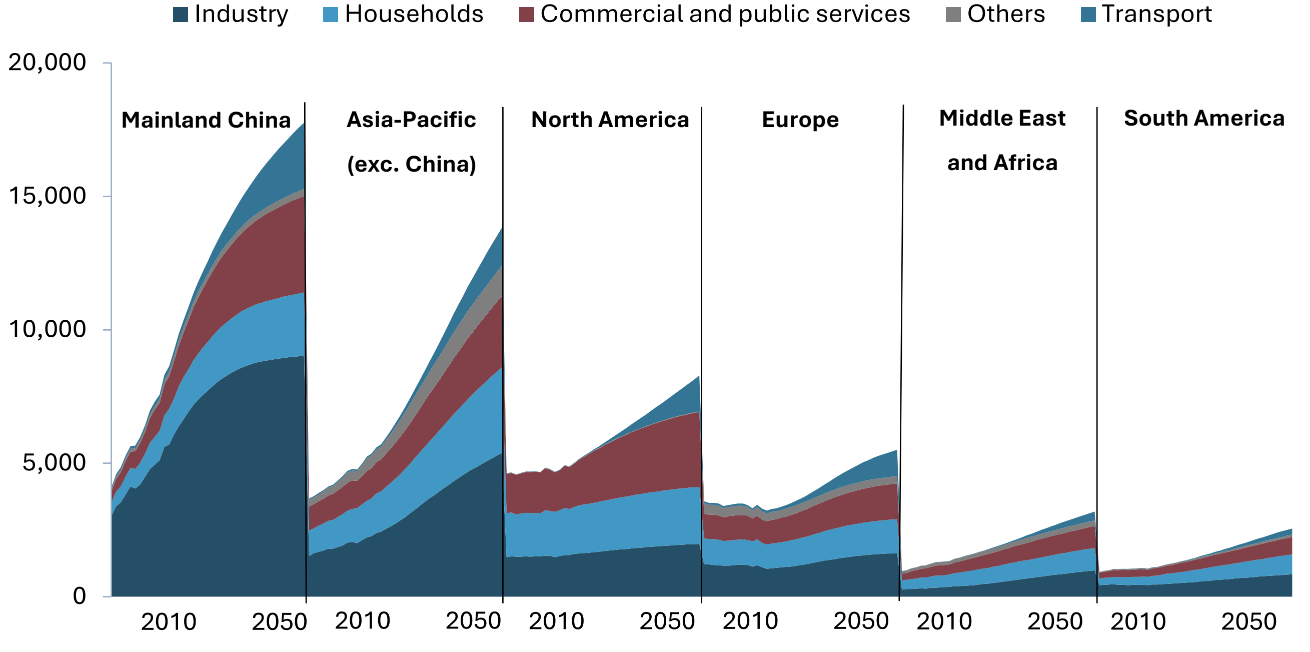
Mainland China is the single largest driver. Total demand climbed from 4,100 TWh in 2010 to over 10,300 TWh in 2025, and is projected to rise toward 17,800 TWh by 2050. Growth is broad-based across sectors with commercial services expanding the fastest, from 410 TWh to 1,670 TWh in the past 15 years. Residential demand tripled to 1,580 TWh and industrial demand more than doubled to 6,600 TWh between 2010 and 2025. Asia-Pacific excluding China follows a similarly broad-based trajectory, with demand set to nearly quadruple from 3,700 TWh in 2010 to around 13,800 TWh by 2050.

North America and Europe post steadier gains as both are more mature, consumption-led economies. North America's total demand stood at 5,200 TWh in 2025 and is expected to rise to 8,300 TWh by 2050, with households and commercial services jointly accounting for roughly two-thirds of the load. In Europe, at around 3,300 TWh in 2025, industrial efficiency gains have reduced electricity consumption in that sector since 2010, while total demand recovers toward 5,500 TWh by 2050 as transport electrification accelerates.

Transport is the steepest relative growth sector in all regions. From a combined base of around 220 TWh in 2010, transport electricity demand is projected to reach around 6,800 TWh by 2050 as EV uptake accelerates in all markets. This is led by China, where transport surpasses household electricity demand at around 2,500 TWh in 2050. By the middle of the century, transport ranks among the top three consuming sectors in most major economies.

The Middle East and Africa, together with South America, are among the fastest-growing demand markets, reflecting broad electrification headroom. The Middle East and Africa combined are expected to grow from 960 TWh in 2010 to 3,200 TWh by 2050, while South America, demand climbs to around 2,600 TWh, with residential electrification a key driver in both regions.

Global power demand by sector and region
Terawatt-hours



Source: Rystad Energy Power Macro Solution

Renewables lead on cost, but dispatchable capacity retains strategic value

Renewables are increasingly setting the benchmark for newbuild power generation economics. Solar PV and onshore wind sit close to or below indicative power-price bands in several markets, supported by continued cost reductions, shorter construction timelines and limited exposure to fuel-price volatility. This reinforces a renewable-led outlook for capacity additions, particularly where grid access, permitting and financing conditions remain favorable.

Cost competitiveness still differs materially by region. In Europe, solar and onshore wind are in the wholesale reference band, but realized revenues are increasingly undermined by falling capture prices and transmission constraints. In North America, cheap domestic gas keeps CCGT plants competitive and lowers the benchmark for new supply, although renewables remain attractive in strong-resource areas and under long-term offtake structures. In Asia, the cost range is wider, reflecting the difference between low-cost markets such as China and India and more import-dependent or constrained markets.

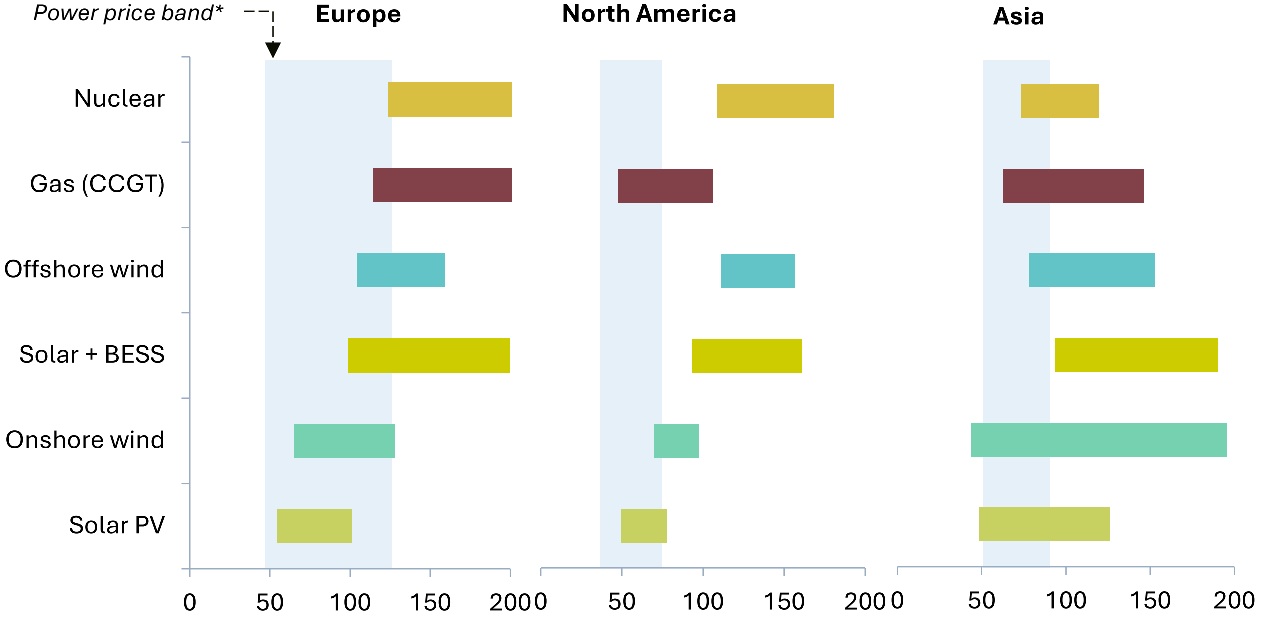
Storage and hybrid solutions become more valuable as renewable penetration increases. Solar-plus-battery projects are more expensive than standalone solar, but they can capture higher-value hours and provide balancing, capacity and flexibility services. Their economics should therefore not be compared only with average wholesale prices.

Conventional and firm low-carbon technologies retain a role, but increasingly as reliability and strategic assets rather than low-cost bulk energy sources. Gas is most competitive in North America, while in Europe and parts of Asia it is more exposed to fuel and carbon costs. Nuclear remains challenging on a merchant basis, but can be supported by long-term contracts, regulated returns or energy-security objectives.

The key message is that future power-sector growth is renewable-led, while dispatchable generation, storage and firm low-carbon capacity are valued for flexibility, adequacy and system reliability in a more weather-dependent power system.

The cost of renewable generation continues to improve as renewable technologies mature. Beyond technological maturity, the widespread increase in capacity additions support economies of scale with the associated gains to supply chains. As such, the LCOE is expected to keep falling, albeit at a slowing pace.

Levelized cost of electricity per region in 2026
USD per MWh real 2025, post-tax

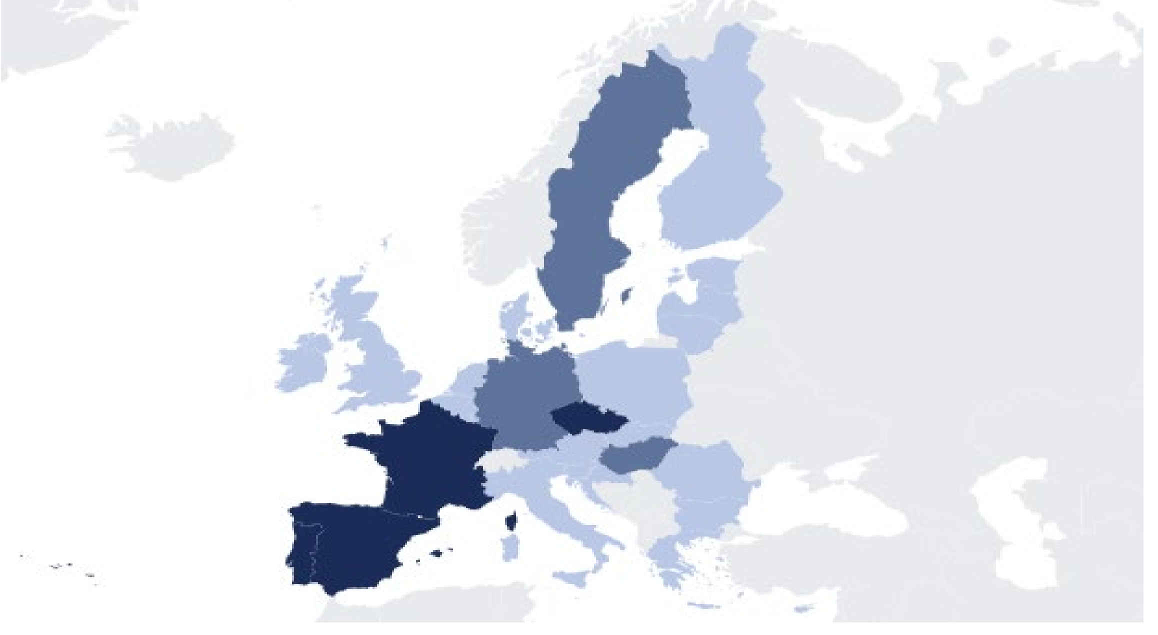


Note: All charts use Base case assumptions, 7.5% discount rate, Post-tax Real LCOE in USD/MWh, with Solar + BESS based on 4-hour battery storage duration
*Indicative wholesale price bands. Actual project revenues depend on capture prices, market design and contracted offtake.
Source: Rystad Energy research and analysis; Rystad Energy Power Macro Solution

Energy security first: EU power-sector policy updates show response to US-Iran conflict

European power-sector response by category

Strong policy response | Some / targeted policy response | Minimal policy response



The 2026 US/Israel-Iran war has triggered power-sector responses focused on energy security in several European countries. The crisis has reinforced three core priorities: power-generation readiness, faster electrification and stronger system resilience.

France acted decisively, treating energy security as a national-strategy issue and committing to doubling public electrification support to €10 billion annually by 2030. The country also reinforced its nuclear strategy, including plans for six new EPR2 reactors and further work on next-generation nuclear options, while continuing renewables support. France also moved to end gas use in new residential buildings from 1 January 2027. Policymakers framed the country's largely domestic, nuclear-heavy electricity system as a strategic advantage, especially after the low nuclear availability during the 2022 energy crisis.

Spain also responded, with a decree to accelerate electrification and renewables, ease grid bottlenecks, promote energy storage and flexibility, and designate pumped-hydro storage as public utility.

Other European Union states have adjusted their energy-security approaches. Czechia's nuclear agenda has gained momentum as part of its coal phase-out strategy, with reporting linking the push to war-related LNG disruption risks. Portugal has advanced an aligned Iberian focus on renewables integration, grid flexibility and storage. Germany is focusing on gas-supply security and backup capacity, while Sweden has signaled readiness for fuel-saving measures or rationing if the conflict and supply disruption persists.

At the EU level, the collective response was captured in AccelerateEU, launched on 22 April. The five-pillar strategy aims to cut fossil-fuel imports and exposure to price shocks by speeding up electrification, strengthening grids and interconnections and boosting investment. Supporting measures include €330 million for small modular reactors, faster grid initiatives, an emergency permitting tool for power projects and a flexible 80% gas-storage fill target to ease near-term market pressure. The EU Commission has also proposed extending the National Escape Clause for energy-resilience spending.

Source: Rystad Energy research and analysis; Rystad Energy UCube

US-Iran war pushes Asian economies toward immediate adequacy and energy security measures

Asian power-sector response by category

Strong policy response | Some / targeted policy response | Minimal policy response

Asia's economies have responded to the US/Israel-Iran war with a three-part energy-related response: coal for immediate reliability, nuclear for firm domestic capacity, and renewables-plus-electrification for longer-term resilience.

The clearest immediate response was a shift back toward coal-fired generation. Japan temporarily eased restrictions on older coal plants, allowing less-efficient units to run more fully for up to a year. South Korea removed operating limits on parts of its coal fleet so plants could generate at higher levels. In Southeast Asia, Thailand restarted decommissioned coal units and maximized output from its largest plant, while the Philippines increased coal-fired generation and reduced LNG-fired output. Vietnam's state utility EVN also secured additional coal supply to support reliability during peak-demand periods.

Mainland China's thermal generation continued to rise, India relied on higher coal burn to meet record demand, Pakistan shifted more generation toward locally mined coal as imported-gas power weakened, and Indonesia prioritized domestic coal supply for its own plants.

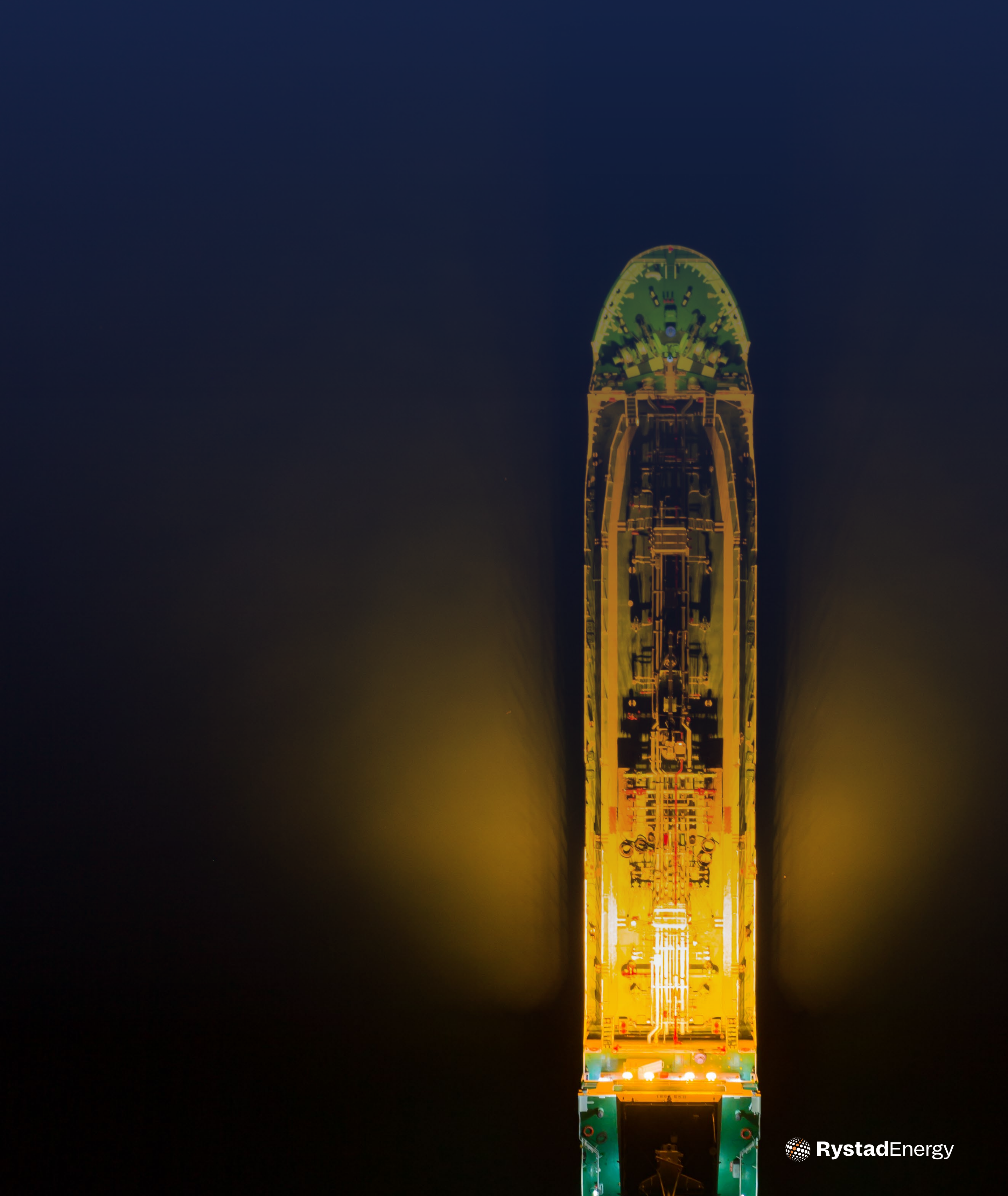
Restarting coal capacity for emergency reliability poses a risk that these plants may become harder to retire even after the crisis. Additionally, long-term policies might require keeping some thermal plants online to prevent future reliability events.

The second impact is a revival of nuclear power. South Korea accelerated reactor restarts to cut LNG dependence, Taiwan (China) supported restarting two closed nuclear units and Vietnam finalized a deal with Russia for the Ninh Thuan 1 plant. Japan continued efforts to restart more reactors, Bangladesh progressed with Rooppur, and China's major nuclear build-out stayed a key buffer against fuel import shocks. These are structural, long-term decisions.

The third element is renewables and electrification as energy security. South Korea is pairing its coal and nuclear response with faster renewable-energy and storage support. India continues expanding clean-power generation even as coal stays central to meeting peak demand. Vietnam pushes rooftop solar adoption, Pakistan relies more heavily on rapid solar growth in rooftop sector to reduce import exposure, and Indonesia promotes a large solar-plus-storage ambition as part of its wider self-sufficiency agenda.

Source: Rystad Energy research and analysis; Rystad Energy UCube

Chapter 3: Supply chain



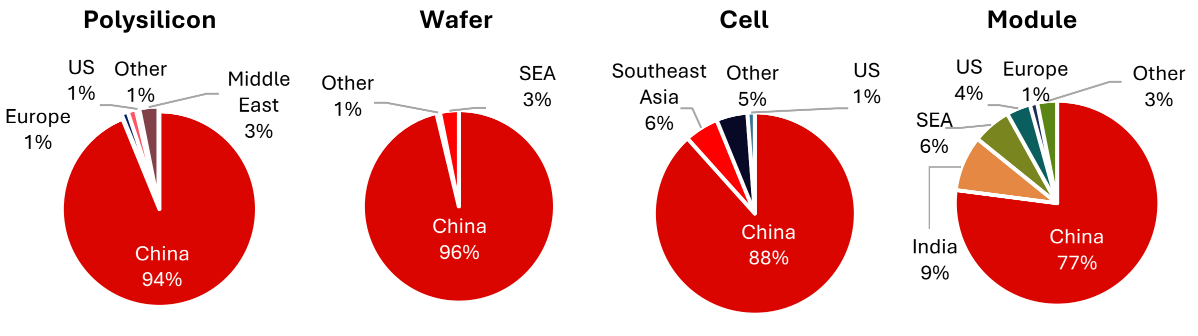
China dominates solar supply chain; module capacity gradually expands in other countries

China holds an overwhelming grip on the solar manufacturing supply chain across every production stage, though non-Chinese capacity is gradually broadening. As of 2026, China accounts for 94% of global polysilicon capacity, 96% of wafer production, 88% of cell manufacturing and 77% of module output, making the upstream stages of the value chain highly dependent on Chinese facilities.

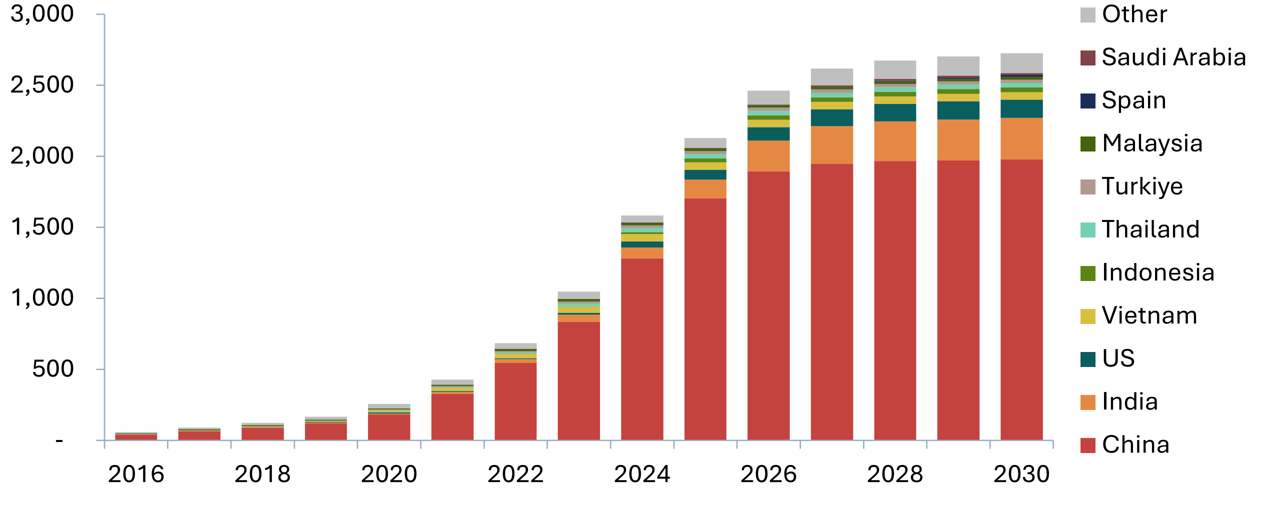
The module segment shows the most diversification, with India (9%), Southeast Asia (6%), the US (4%), Europe (1%) and other regions collectively accounting for roughly one-quarter of global capacity. This reflects deliberate policy-driven efforts to build domestic manufacturing capability. The bottom chart illustrates the expansion that is underway. Global solar module production capacity stood below 500 GW_{DC} as recently as 2022 but is expected to surpass 2,500 GW_{DC} by 2030, representing roughly a fivefold increase in under a decade. China is behind most of this growth, though countries including Vietnam, India, the US, Indonesia, Thailand, and Malaysia are each adding incremental capacity.

Despite this diversification trend, non-Chinese supply remains heavily concentrated in a small number of emerging manufacturing hubs, and their combined share is unlikely to meaningfully challenge Chinese dominance across the full supply chain this decade. Supply chain resilience will be a key strategic concern for policymakers and developers outside China through 2030.

Manufacturing capacity by region, 2026



Solar module production capacity by country
Gigawatts DC



Source: Rystad Energy research and analysis; Rystad Energy Solar Solution

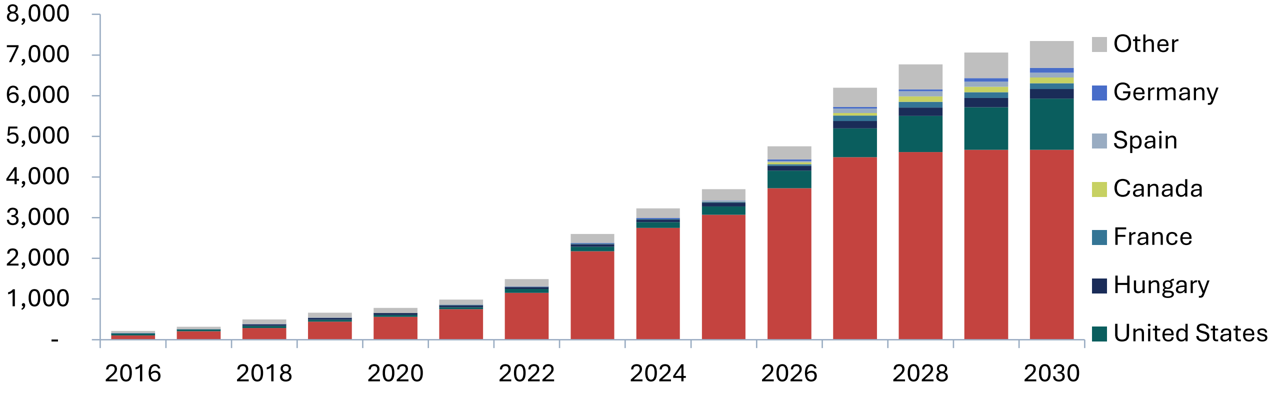
Battery cell manufacturing capacity expands to meet exponential growth in demand

Battery cell manufacturing capacity is expanding to climb from under 500 GWh in 2016 to 7,000 GWh by 2030. China dominates this build-out, accounting for most of the global capacity expansion with companies like CATL, CALB and BYD leading the way. Non-Chinese manufacturing is growing with the US, Hungary, France, Canada, Spain, and Germany all adding capacity, but their combined share remains a modest fraction of the total. As with solar, the structural picture is one of Chinese industrial scale setting the pace while European and North American economies attempt incremental diversification.

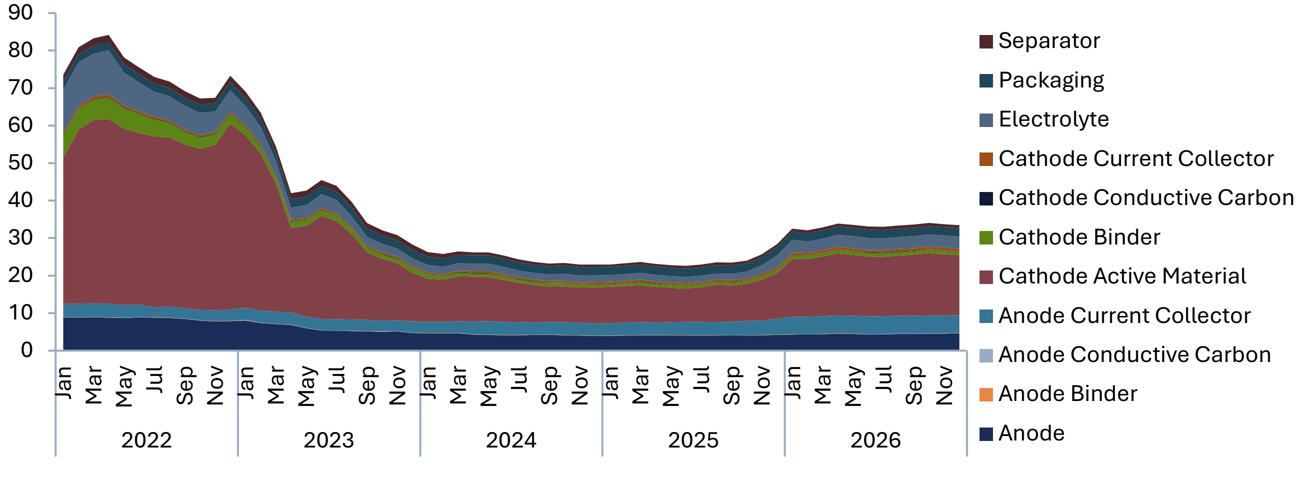
Lithium iron phosphate (LFP) battery cell production costs have dropped sharply since 2022. Total costs peaked at around $85 per kWh in early 2022 before falling steeply to below $30 per kWh by late 2024, a drop of roughly two-thirds in under three years. The cathode active material (the largest single cost component) drove much of this decline, reflecting falling lithium carbonate and iron phosphate input prices following the commodity spike of 2022. Other components have also fallen, though they represent smaller shares of the total cost.

LFP cell production costs have risen in 2026, with cathode materials being the main driver. Even so, LFP cell costs are dramatically lower than their 2022 peak, fundamentally improving the economics of battery storage paired with solar and wind generation.

Battery cell manufacturing capacity
Gigawatt-hours



Lithium iron phosphate battery cell productions costs
USD per kWh



Source: Rystad Energy research and analysis; Rystad Energy Energy Storage Solution and Battery Materials Solution

Chinese wind OEMs retain economic advantage compared to other manufacturers

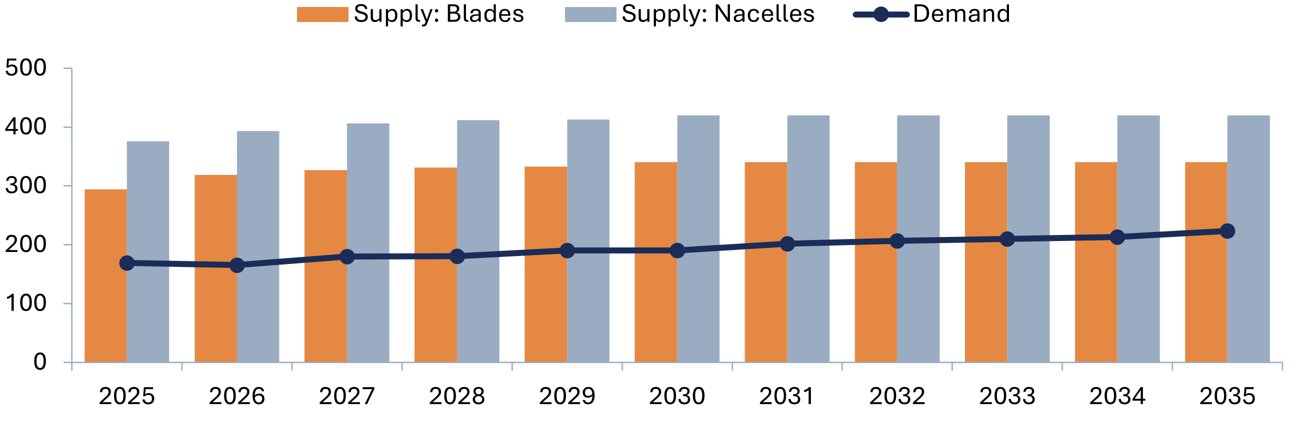
Manufacturing capacity of wind turbines expanded substantially during the past two decades to meet increasing demand. Growth has now stalled, with manufacturing capacity of nacelles expected to rise marginally over the next 10 years from a current level of 375 GW to 400– 420 GW per year in 2035. Blade manufacturing capacity is also expected to be stable at around 320 GW per year in the same time period.

Countries around are the world are expected to continue expanding their wind power generation capacity. Rystad Energy forecasts that yearly wind installations will grow from 166 GW this year to 223 GW by 2035. Despite this growth, existing manufacturing capacity is sufficient to meet demand, as illustrated in the chart.

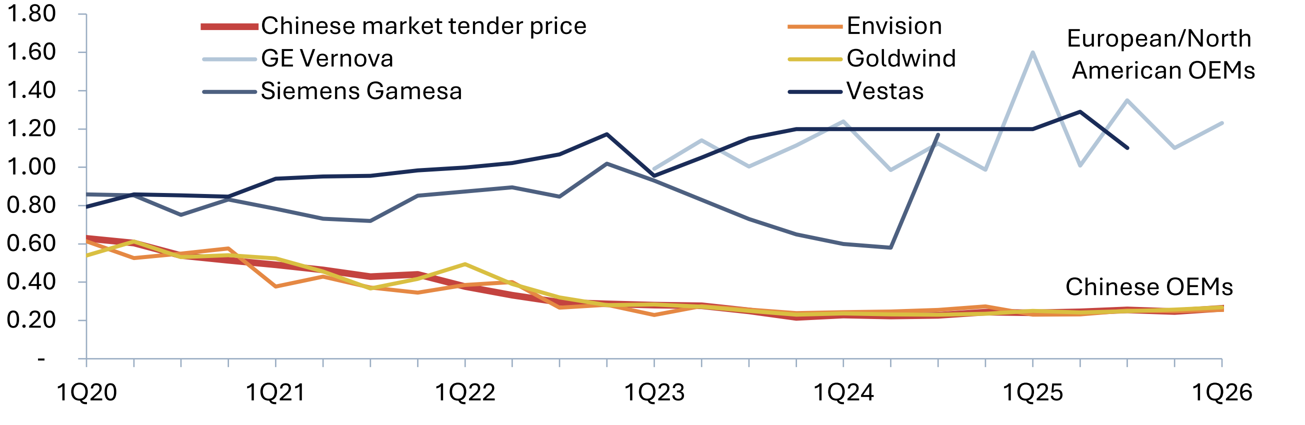
A lot of the manufacturing capacity growth seen over the past decade has been in mainland China, allowing Chinese original equipment manufacturers (OEMs) to benefit from economies of scale and to continue to improve technologically.

This has been reflected in the development of wind turbine prices in the country: The Chinese market tender price has more than halved from $0.63 million per megawatt at the start of 2020 to $0.26 million per megawatt this year. China benefits from lower labor and material costs as well as the supply chain scale. By contrast, average selling prices for European and North American OEMs are currently closer to $1 million per megawatt.

Supply and demand of blades and nacelles
Gigawatts

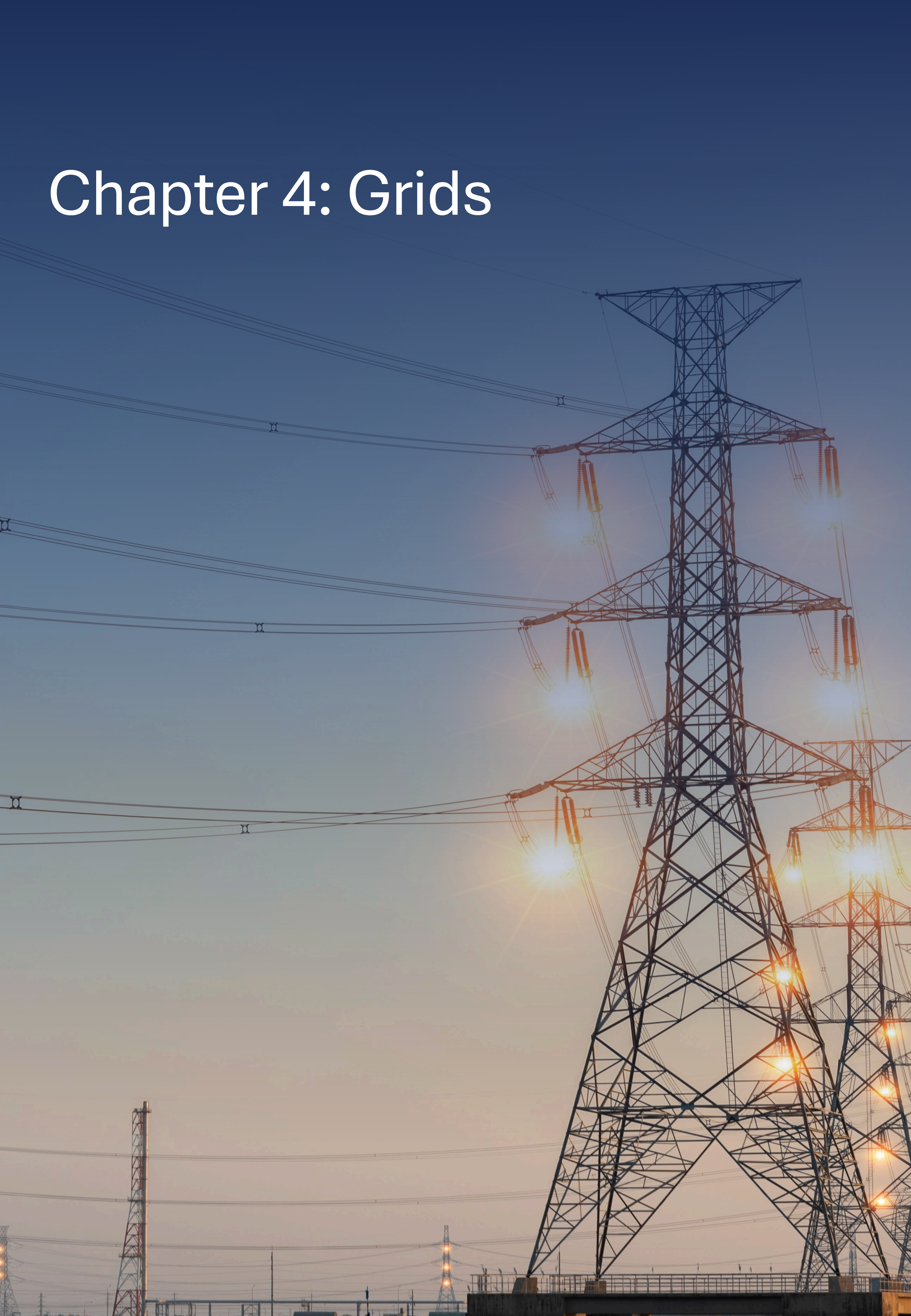


Average selling price of wind turbines from selected OEMs
Million USD per MW



Source: Rystad Energy research and analysis; Rystad Energy Wind Solution

Chapter 4: Grids



Revised grid investment plans point to accelerated new line additions

Grid investment has entered a rapid growth phase, with both new line additions and capital spending accelerating sharply. Project announcements suggest that the pace will increase further, with transmission expected to grow even faster than distribution in the near term.

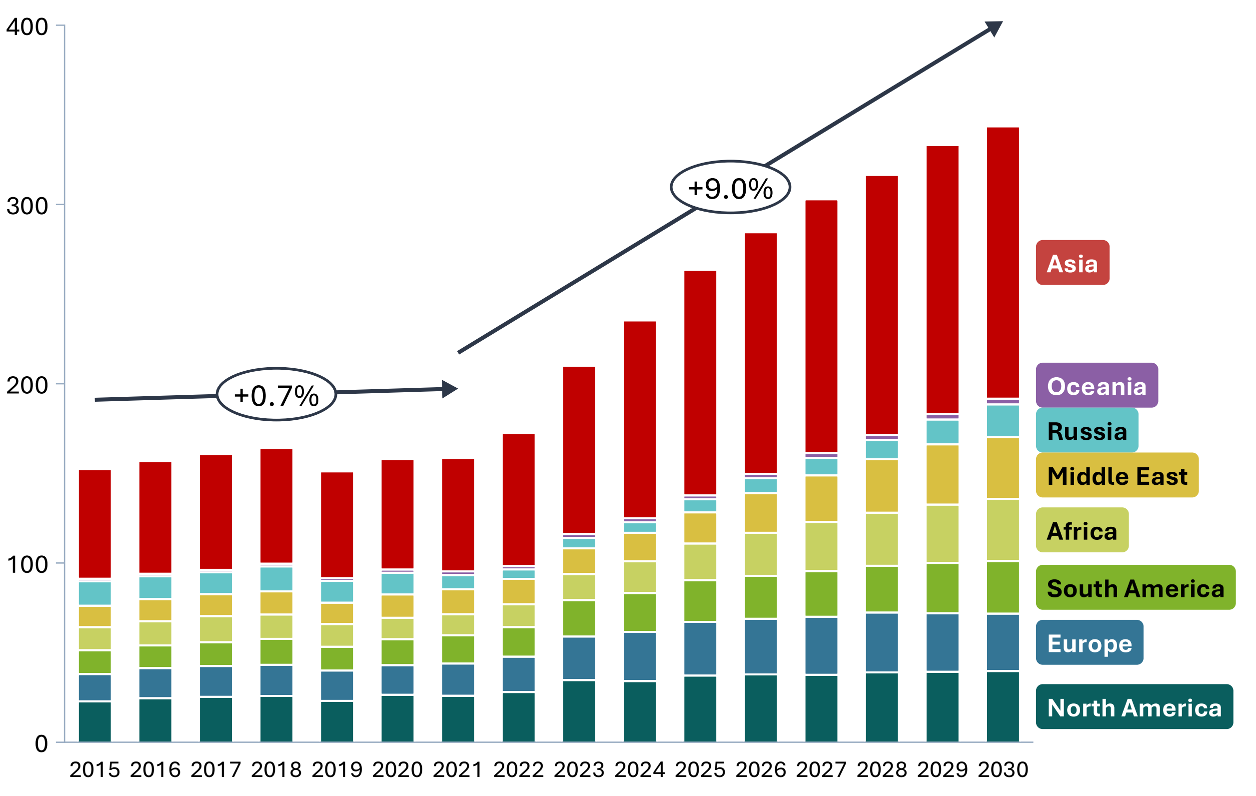
On the capacity side, annual high-voltage (HV) and extra-high-voltage (EHV) line additions rose only around 1% per year before 2020. Growth has since accelerated to around 9% per year, a pace expected to hold through 2030. Asia leads in new kilometers added, though substantial grid expansion is underway in all regions.

Spending has followed a similar trajectory. Before 2020, annual investment rose about 5% per year, but has since accelerated to around 10%, with that momentum expected to continue through 2030. North America and Asia are the largest spenders, followed by Europe. In the US, independent system operators (ISOs) and regional transmission operators (RTOs) have announced multiple $10 billion+ EHV transmission expansion programs over the past year, with many scheduled to begin operation in the early 2030s.

Several factors are behind the US transmission investment. Around 65% of projects address reliability and aging infrastructure, while some 25% relate to generation and load growth stemming from expanding supply and rising intermittency. In markets like ERCOT in Texas, new demand from data centers is an increasingly prominent driver.

Together, these trends point to a structural step-change in grid development, led by renewables integration, electrification and rising demand, with transmission infrastructure now a defining feature of global energy capital allocation.

Annual high-voltage and extra-high-voltage additions by continent
Thousand kilometers



Source: Rystad Energy research and analysis; Rystad Energy Power Solution

Chapter 5: Flexibility and storage

BESS project costs fell 50% in five years and moderate BESS capex declines remain foreseeable

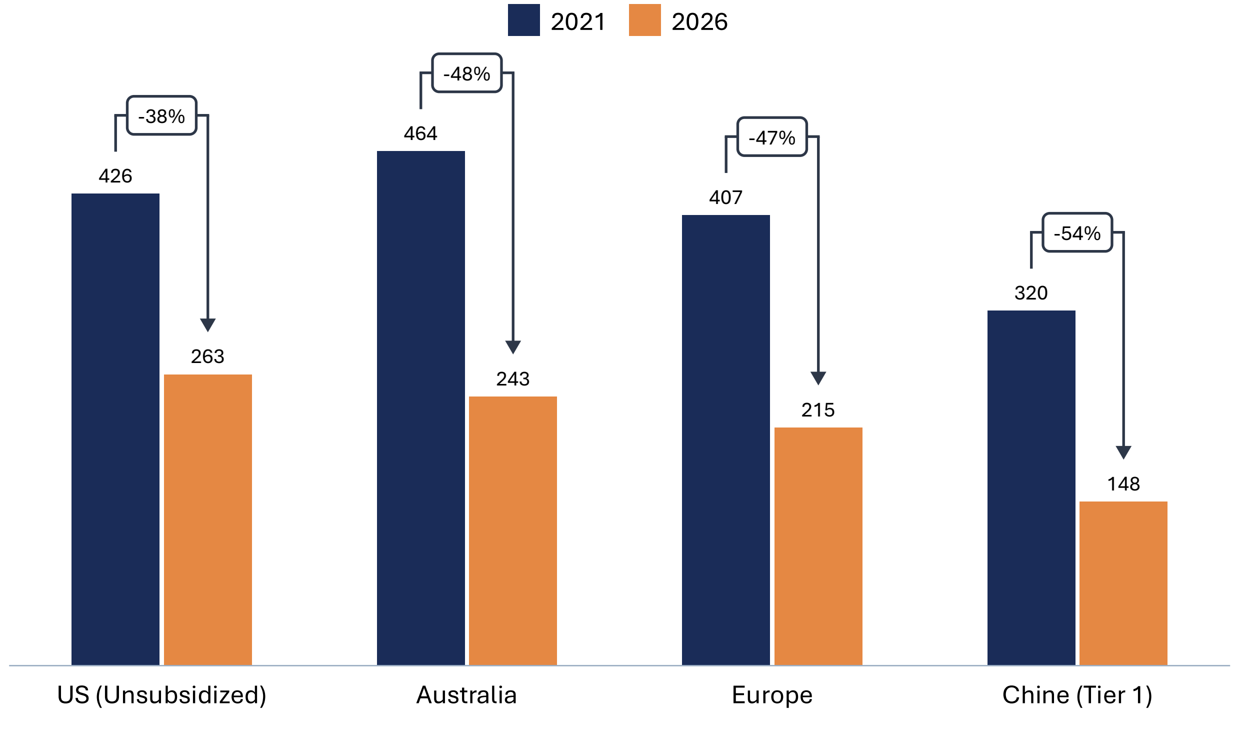
Project costs for battery energy storage systems (BESS) have fallen globally over the past five years, led by China, where costs have more than halved. The US market has seen a smaller 38% reduction, as tariff exposure has limited the pass-through of lower battery cell prices into delivered BESS costs.

The decline in lithium iron phosphate (LFP) battery cell prices has been the main reason for lower BESS project costs. After the lithium price surge in 2022, LFP cell material costs fell around 56% to $35 per kilowatt-hour (kWh). Lower cell costs have also supported price reductions for direct current (DC) block containers. In China's spot market, a 5 MWh DC block container is currently priced at around $65 per kWh. The gradual phaseout of China's tax rebates could raise DC block costs by up to 13% in export markets, although strong competition among Chinese manufacturers may keep overseas prices close to domestic levels in the short term.

Further reductions in total BESS project costs are likely to come from efficiency gains and higher container energy density. BYD has released a 15 MWh container solution for 2026, compared with CATL's 9 MWh Tener stack in 2025. Higher energy density can reduce project development costs by lowering the number of containers required for a given project size.

The cost benefit will depend on how quickly larger-format cells scale up. Containers with higher energy density are mainly enabled by larger cell designs, including cells above 500 ampere-hours (Ah), which are currently more expensive than 314 Ah cells. As production expands, larger cells could move down the cost curve, allowing higher-capacity containers to approach the price level of today's 5 MWh systems. This could cut total BESS project costs by another 5% to 10% over the next two to three years.

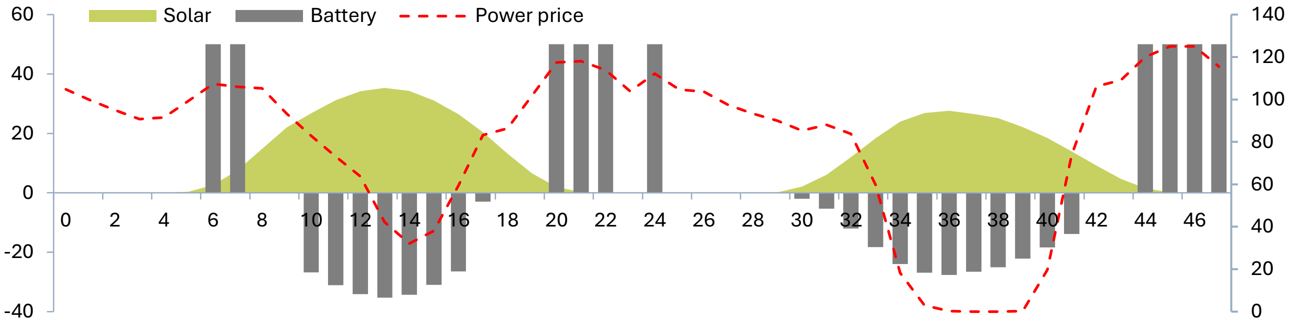
Turnkey capital cost of a hybrid 4-hour utility-scale BESS in each market*
USD per kilowatt-hour (USD/kWh), real 2026**



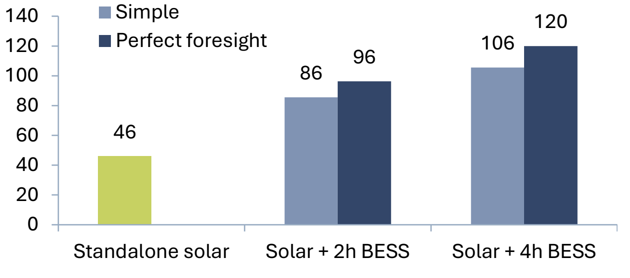
* Battery cells (LFP) are imported from China * overall 20% inflation is included to convert the prices in 2021 to real 2026
Source: Rystad Energy research and analysis; Rystad Energy Energy Storage Solution

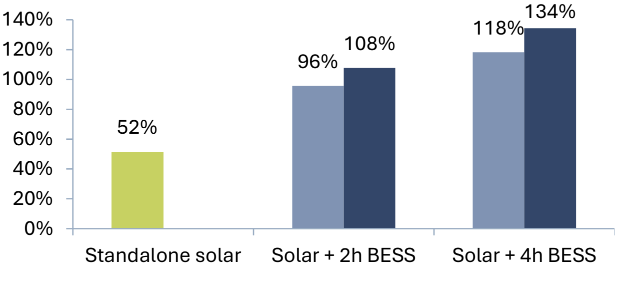
Co-location is already a key lever to ensure profitability amid falling capture prices

Co-located solar PV (50 MW) + BESS (50 MW, 200 MWh) generation*
Megawatts (LHS), wholesale power price (RHS)



Modelled capture prices, Germany 2025
EUR/MWh





Installed capacity of renewables has seen explosive growth in the past few years. Regions including the US, Europe, China and Australia have been among the early adopters and the first to experience the transformational shift in price-setting. Higher volumes of wind and solar lead to cannibalization of capture rates, which in turn challenge the economics of wind and solar. Zooming into an affected market, Germany 2025, shows how the power price correlates with solar generation, resulting in capture rates at roughly 52%. Co-location of battery energy storage systems (BESS) with solar installations, or hybrid projects, provides an elegant solution to these falling capture rates.

A hybrid project where the BESS is sized for energy arbitrage reveals that such projects can significantly outperform standalone solar on the market. Depending on the charge and discharge behavior such a system with a 2-hour storage duration was able to achieve capture prices between 96 to108% of the yearly average power price. For a 4-hour system this increases to up to 134%, 82 percentage points higher than a standalone solar farm.

Achieving higher capture prices comes as at a cost of a higher LCOE due to the added capex. In 2026, Rystad Energy estimates a 4-hour hybrid solar project to have an LCOE in the range of €160/MWh. In other words, a €40/MWh gap to the achieved price. This excludes revenue stacking in ancillary markets, however. As costs continue to drop, the addition of flexibility will become a necessary add-on to ensure the long-term profitability of solar farms.

The hybrid system was modelled with two simplified BESS behaviors: 1) simple optimizer charges during the midday window and discharges at after 6 pm until its storage is exhausted, and 2) perfect foresight has exact knowledge of power prices for the next 48 hours. It profit-maximizes over that window. After 24 hours, the resulting state of charge becomes the new starting point, and the model re-optimizes the next 48 hours. These two methods are used to represent a conservative and an optimistic view of capture prices for hybrid projects.

*BESS with perfect foresight charge/discharge behavior
Source: Rystad Energy research and analysis

Chapter 6: Data centers

Data centers are the fastest-growing power sector, consuming 4% of global electricity by 2035

Global electricity demand is set to rise 65% between 2020 and 2035, reaching 40,300 TWh. Data centers are the fastest-growing sector, rising sevenfold from 257 TWh to 1,692 TWh, making up 4% of total 2035 demand.

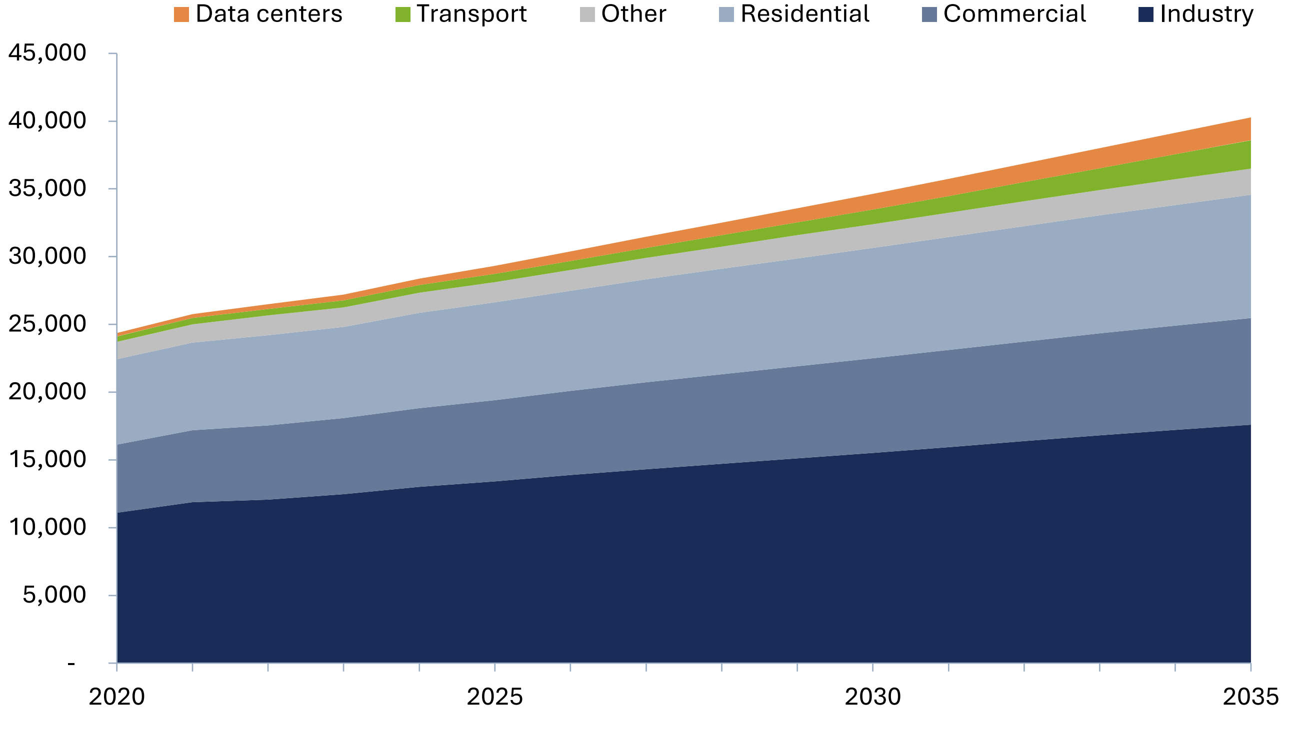
Data centers account for 9% of all new global electricity demand added from 2020 to 2035. The sevenfold growth rate exceeds every other sector, including transport electrification. AI workloads now drive more than half of electricity use at large hyperscale facilities, making this a structurally new demand profile.

The 4% share in 2035 understates the grid challenge this growth will bring. Data center load is geographically concentrated, operates at a capacity factor near100%, and requires firm power at all times. The IEA estimates its high-efficiency scenario would put power demand roughly 20% below the base case by 2035, but AI-driven workload growth keeps the trajectory pointing sharply upward.

Demand growth is concentrated to three regions. North America leads with around 63 GW of installed capacity in 2025, forecast to reach 126 GW by 2030 on a risked basis. Asia-Pacific follows at 52 GW growing to 86 GW, with China accounting for the largest share and the highest AI and HPC workload intensity of any region. Europe's 19 GW base is projected to nearly double to 36 GW, though established FLAP-D hubs face grid saturation and new capacity is migrating to emerging markets including Finland and Spain.

Within the global power demand mix, data centers rank fifth by absolute new demand contribution, behind industry (41% of 2020–2035 additions), residential and commercial (18% each) and transport electrification (11%). The distinction lies in growth rate and concentration: industry grows roughly 60% over this period while data centers grow sevenfold, and their load is anchored in a narrow set of grid zones rather than diffused across millions of end-users.

Global power demand by sector
Terawatt-hours



Source: Rystad Energy research and analysis; Rystad Energy PowerCube

Over half of the data center power pipeline is unlikely to materialize by 2035

After applying project-level risk factors, Rystad Energy's base case puts data center power demand at 1,692 TWh by 2035, against an unrisked asset-level total of 3,518 TWh. Roughly 52% of the announced pipeline is unlikely to materialize into operational capacity, equivalent to a cumulative shortfall of around 12,400 TWh over the 2020 to 2035 period.

Grid infrastructure is the primary gating constraint. Interconnection queues stretch to five to seven years in key markets, with substation transformer lead times now exceeding 160 weeks. Projects stall at the queue stage despite secured land and financing, waiting for grid capacity to be formally allocated and equipment to be delivered.

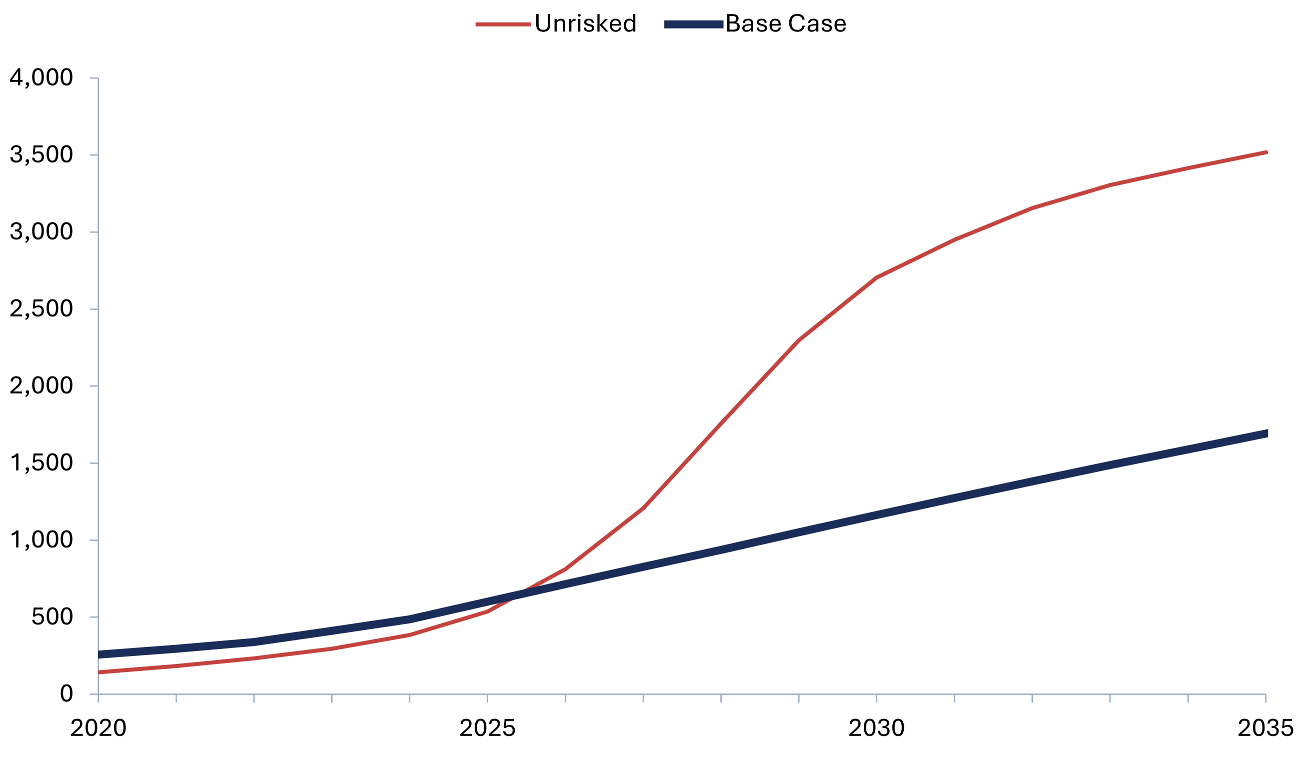
Developer behavior amplifies the attrition. Operators routinely apply across multiple sites, advancing only the most viable. Cancellations rose from six in 2024 to 25 in 2025, with over 20 more in the first quarter of 2026. Goldman Sachs estimates 60% of near-term capacity materializes on time, falling to 50% at two years, confirming that the raw pipeline overstates what will reach the grid.

The two series diverge sharply from 2026 onward, when speculative pipeline projects inflate the unrisked view at an accelerating rate.

By 2035, the unrisked total exceeds the base case by 108%, as early-stage capacity with limited execution certainty comes to dominate the announced inventory.

For utilities and grid operators, this divergence creates a persistent planning challenge: building infrastructure for a load that may be a fraction of what developers announce, across locations that can shift materially before projects reach financial close.

Data center power demand - base case vs asset pipeline
Terawatt-hours



Source: Rystad Energy research and analysis; Rystad Energy UCube, GMS

The US, China and Europe are the top markets driving data center buildout

Global data center capacity was 141 GW across nearly 7,000 facilities by the end of 2025, more than double the installed base five years earlier. On a risked basis, capacity is forecast to nearly double to 262 GW by 2030. Unrisked capacity could reach as high as 517 GW if all announced projects are delivered.

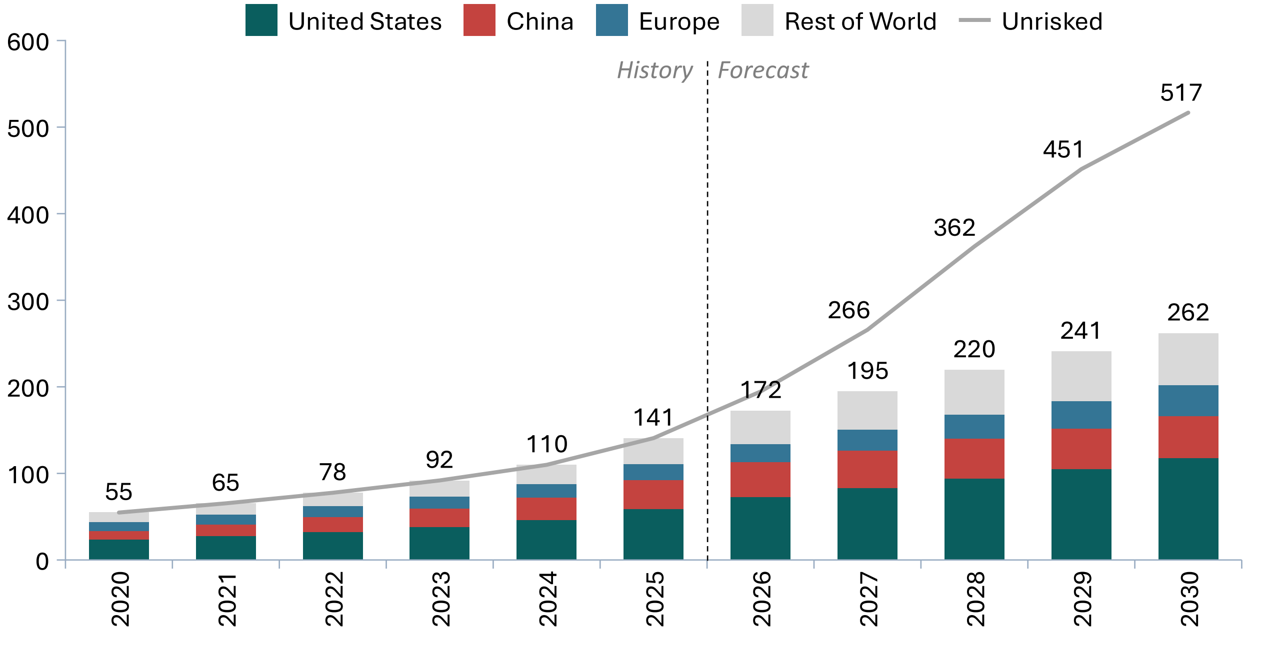
The data center buildout reflects a fundamental shift in how AI is developed and deployed. Training the largest AI models requires significantly more compute than previous generations of software, and that compute must be housed somewhere. The result is an infrastructure expansion without historical precedent.

The US is the largest market with over 40% of global capacity and the largest absolute additions through 2030. Growth is primarily driven by hyperscale campuses built for foundational AI model training. Northern Virginia, home to the world's highest concentration of data center capacity, is the primary hub, but the search for available high-voltage power is pushing operators into new regions across the country.

China is the second-largest market, with capacity expected to nearly double by 2030, underpinned by domestic hyperscalers and continued state investment in digital infrastructure. Europe is forecast to grow at a compound annual growth rate (CAGR) of around 14% through 2030. Established hubs like Frankfurt and London are increasingly constrained by power availability, shifting large-scale development to the Nordic region and Southern Europe, where affordable clean power and land are more accessible.

Beyond these three markets, the “rest of world” group is among the fastest-growing in absolute terms. In Asia-Pacific, expansion is concentrated in mature hubs such as Singapore, while Malaysia, India, and Indonesia are attracting global cloud providers seeking to localize data storage through colocation. The Middle East is emerging as one of the fastest-growing regions, with the UAE and Saudi Arabia deploying sovereign capital to build domestic AI infrastructure, backed by low-cost land and energy. Earlier-stage markets such as Morocco and Australia are also drawing hyperscale investment, where land availability and access to renewable energy are becoming key advantages.

Risked and unrisked cumulative data center facility capacity, split by top markets
Gigawatts



Source: Rystad Energy research and analysis; Rystad Energy Data Center Solution

Data center capex was $770 billion in 2025, surpassing upstream oil and gas

Data center capital expenditure reached $770 billion in 2025, exceeding investments for upstream oil and gas activities in the same year. This is a more than sixfold climb from $112 billion in 2020, with the sharpest jump coming since 2022 as generative AI investment has scaled up.

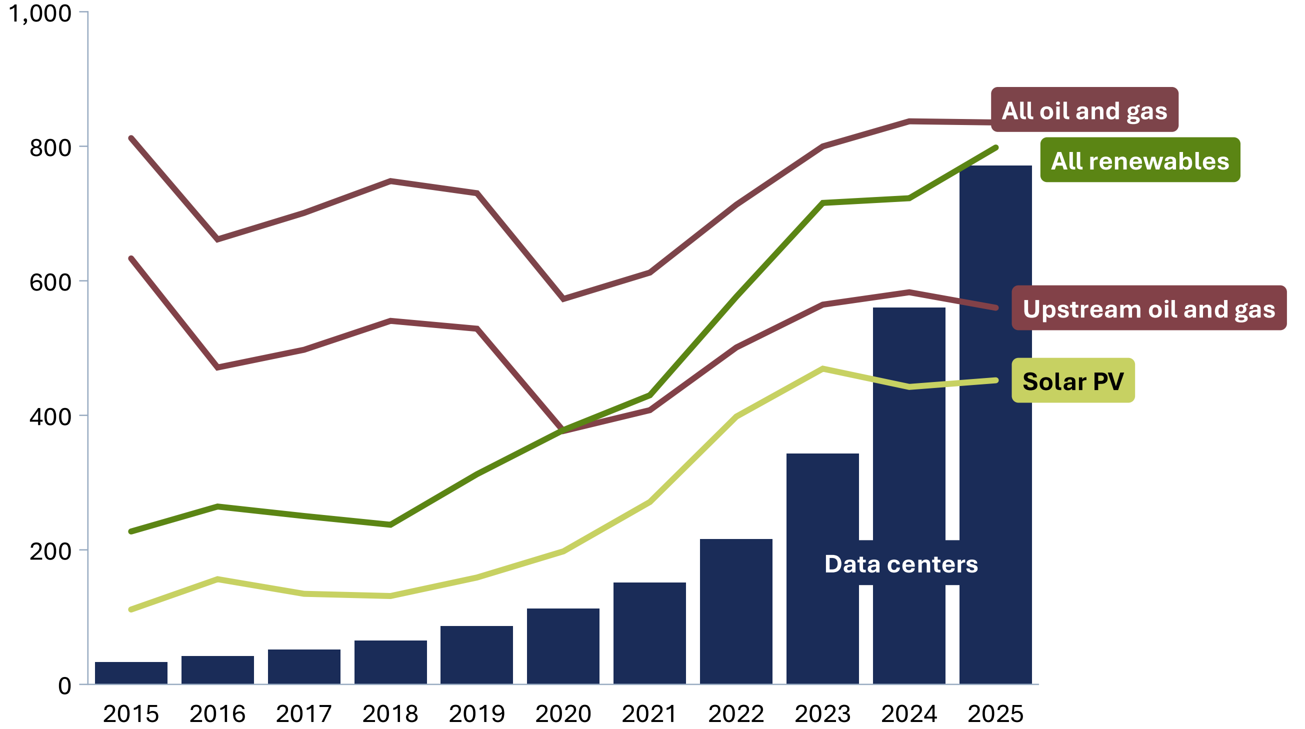
The magnitude of these investments is unprecedented. The combined capex for data center infrastructure is now approaching parity with the full oil and gas sector – upstream, midstream, and downstream – an industry that is made up of thousands of companies across the entire value chain.

Solar PV investments, broadly acknowledged as the most substantial growth story in energy supply over the past 10 years, were eclipsed by data centers already in 2024. This year, Rystad Energy expects investments in data centers to match investments in the renewable generation industry.

In other words: Data center infrastructure is rapidly emerging as one of the largest single categories of capital deployment in the global economy, concentrated among a remarkably small number of companies.

This concentration carries structural implications. The hyperscalers' ability to finance at scale, thanks to strong operating cash flows from legacy revenue streams and access to low-cost debt, gives them advantages in securing land, power, and equipment through long-term contracts that get priority allocations from suppliers. This dynamic reinforces market concentration at both the infrastructure and application layers and underscores the degree to which the physical buildout of AI is becoming a capital-intensive, industrial-scale undertaking, one that increasingly competes with traditional energy and infrastructure sectors for equipment, skilled labor and grid capacity.

Historical investments of data centers and energy sector[1]
Billion USD (nominal)



1) All oil and gas: upstream, midstream and downstream investments in oil and gas;
All renewables: investments in solar PV, solar thermal, offshore wind and onshore wind
Source: Rystad Energy research and analysis; Rystad Energy Data Center Solution, Oil & Gas Solution and Renewable & Power Solution

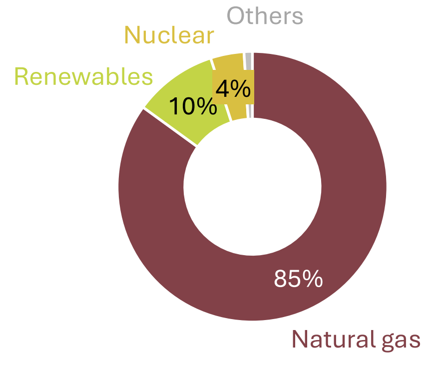
Gas-based turbines, engines and fuel cells emerge as adopted BTM solutions

Behind-the-meter (BTM) power for AI data centers is dominated by distributed gas generation, primarily aeroderivative turbines and reciprocating engines, alongside a smaller but growing set of fuel-cell-based solutions.

These assets are mature in conventional power and industrial settings, but their use as high-duty-cycle prime power for concentrated, variable AI loads is still early, with limited operating history at multi-hundred-megawatt scale. Within this gas-centric landscape, aeroderivative turbines are often used where sites seek larger unit sizes and higher on-site autonomy, while reciprocating engine platforms are typically selected for modular expansion, flexibility and redundancy from multiple units.

Rising demand for distributed gas generation has lengthened equipment lead times, prompting developers to evaluate a broader set of options, including gas-fueled fuel cells in non-attainment regions, even though these alternatives still represent a small share of installed capacity. Renewable and battery configurations are increasingly layered into BTM designs to reduce net emissions and support decarbonization and community goals, but their larger footprints and added permitting steps mean they generally complement, rather than replace, gas as the prime-power backbone. Nuclear-linked concepts remain confined to longer-dated, hyperscale-driven strategies.

Power sourcing strategy of announced BTM projects (risked)
Percent



BTM power considerations for data centers by power generation type

		Distributed gas[1]	Fuel cells	CCGTs	**Mature renewables** Solar, wind	**Maturing renewables** Battery co-location	Nuclear
Reliability	Firm power	Yes	Yes	Yes	No	No	Yes
	Fast ramping	Yes	Yes	No	No	Yes	Somewhat
Feasibility	Quick deployment	Yes	Yes	No	Somewhat	Somewhat	No
	Easily scalable	Yes	Somewhat	Somewhat	Yes	Yes	No
	Space efficient	Yes	Somewhat	Yes	No	No	Somewhat
	Affordable	Yes	Somewhat	Somewhat	Yes	Somewhat	No
Sustainability	Low emissions	No	Yes	No	Yes	Yes	Yes

BTM prime-power technologies (Distributed gas, Fuel cells) — **Hybrid approaches** (CCGTs, Mature renewables, Maturing renewables, Nuclear)

Yes No Somewhat

1) Distributed gas refers to simple cycle turbines and reciprocating engines
Source: Rystad Energy research and analysis; Rystad Energy Data Center Solution

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2. the data is not disclosed or made available to the public, and
3. all processing is limited to defined, case-specific tasks such as internal summaries, comparisons, extraction of relevant information, responses to internal inquiries, or similar support functions.

For the avoidance of doubt, the Client shall not use the Product or any related data to (i) train or improve any Internal AI system in a general or ongoing manner (i.e., beyond the scope of specific, limited tasks described above), (ii) develop or operate automated tools (such as report generators) that replicate or compete with Rystad Energy's Products, or (iii) engage in any other form of unauthorized use of the Product in connection with the Client's Internal AI.

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