From baseload to flexibility: How is coal's role in China changing

China is shifting its coal fleet from baseload generation to flexibility support, with full retrofitting expected by 2027; continued market reforms and the growth of clean flexibility are essential to a renewable-dominant grid.

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Contents

About 2

Key highlights 2

Executive summary 3

Chapter 1: Coal flexibility in China: context, drivers, and policy evolution 7

1.1 The driver: Coal as a pragmatic transitional tool to China's mounting short-term flexibility needs 8

1.2 Government policy is locking in coal's new role 11

1.3 Mechanisms in support of the transition 14

1.4 Technical pathways of flexibility retrofit in China 17

Chapter 2: China's coal fleet is becoming more flexible, but much of its potential remains untapped 19

2.1 Progress on retrofitting the existing coal fleet 20

2.2 Changing patterns in the use of coal power 22

2.3 Coal utilisation pattern fluctuates more seasonally in recent years 24

2.4 Economic constraints related to coal power's role shift 27

Chapter 3: Unleashing coal's flexible potential while easing the transition to cleaner solutions 29

3.1 Beyond coal: clean flexibility must take the lead 30

3.2 Further power market reform as the key to unlock flexibility 33

3.3 Conclusion: from coal-led flexibility to a clean, market-driven system 38

Supporting materials 40

Methodology 40

Acknowledgement 43

About

As wind and solar installed capacity expands rapidly, the need for power system flexibility is becoming increasingly urgent. To meet this demand, China is strategically repositioning its coal fleet from being a baseload generator to a source of system flexibility.

This report dives into the policy mechanisms supporting this shift, as well as its technical and economic realities. The analysis highlights that China's coal fleet is on track to be fully retrofitted for flexibility by 2027, and the utilisation pattern of coal power is changing. Meanwhile, the findings underscore the urgent need to scale up clean flexibility solutions to accommodate renewable energy growth, improve system efficiency and avoid locking in emissions beyond 2030.

Key highlights

100%

China is on track to retrofit its entire existing coal fleet for flexibility in the next two years.

2 x

Monthly variance of current coal capacity utilisation is twice that of 2016, when the utilisation was at a historical low point.

2027

As coal retrofits potential plateaus by 2027, battery energy storage must scale up.

China has largely retrofitted its coal fleet, but systemic challenges constrain full flexibility

As China enters the 15th Five-Year Plan (FYP), the final planning cycle before its 2030 carbon peaking target, its energy transition is in a decisive phase. Rapid wind and solar expansion is shifting the power system's structure, gradually pushing coal from its traditional baseload role towards being a system flexibility provider. This shift is driven by both system flexibility needs and deliberate policy design. In response, China's vast coal fleet is becoming as flexible as possible following rapid retrofitting during the 14th FYP period.

Over the past decade, the Chinese government has been repositioning coal's role through strategies, mandates and financial incentives.

This analysis finds that China is on track to make its entire coal fleet flexible by 2027. However, completing retrofits also implies that the physical flexibility reserve of existing coal capacity will be fully realised within the next two years. Meanwhile, upfront capital investment, costs associated with flexible operations and lower electricity sales resulting from reduced utilisation continue to bring in pressure on coal power plants.

Clean technologies, particularly battery energy storage, provide significantly better technical performance in flexibility. If the deployment of clean flexibility fails to match the pace of renewable expansion, the system risks relying on additional coal capacity to fill the gap, increasing the risk of reduced efficiency and locking in emissions beyond 2030. China has installed nearly half of the world's battery energy storage and has demonstrated strong recent growth, showing great potential in meeting its flexibility needs with non-fossil sources.

Ongoing efforts to reform the power market and improve system operations are moving in a positive direction. Effective design and implementation will be critical to unlocking any remaining flexibility potential and maintaining system stability as renewable energy accelerates.

01 **Coal's role in China is strategically changing**

Over the past decade, China's coal policy has gone through a progressive shift: coal is increasingly defined by system flexibility and security rather than being a baseload provider, as wind and solar become dominant pillars and gas power remains a smaller role in the electricity mix.

02 **China's coal fleet will be fully flexible by 2027**

Steady progress in retrofitting over the past five years has exceeded the original 2025 target, with 360 GW of coal power completed as of the third quarter of 2024. This positions the country to meet its 2027 goal of maximising flexibility across the existing fleet.

03 The utilisation pattern of retrofitted coal plants is changing

China's average coal utilisation rate has declined by more than 20% over the past two decades. Following a brief post-pandemic increase, in recent years, coal utilisation has resumed its decline. Its current utilisation rate varies more seasonally than it did during its 2016 low period, signalling an early sign of structural shift.

04 As coal retrofits peak, clean flexibility must scale up

As most of China's existing coal fleet completes retrofitting by 2027, the potential for further flexibility upgrades will be largely exhausted. Sustaining renewable integration while reducing reliance on underutilised new coal capacity will require a rapid scale-up of clean flexibility sources, particularly battery energy storage.

05 Power market and operation reforms are key to unleashing flexibility

To integrate untapped flexibility capacity, the government must continue to reform power market design, dispatch practices and system operations. The upcoming 15th Five-Year Plan (FYP) period will be crucial for establishing the country's unified national power market.

As China enters the 15th Five-Year Plan period, it enters the final planning cycle before its 2030 carbon peaking target. Shifting coal towards a flexibility role can fill in the gap in system support needed as renewables expand, while gradually reducing its strategic importance in the bigger picture. However, this approach only works if clean flexibility scales up in parallel. The 15th Five-Year Plan period will be critical in avoiding further addition of coal capacity and locking in extra emissions.

Biqing Yang
Energy Analyst, Asia, Ember

China's coal fleet is transitioning from a baseload workhorse to a provider of residual flexibility and system stability. But this shift is only part of a much bigger structural change underway in the power system. As power markets become more flexible and battery storage and other clean flexibility solutions scale up, the system will rely less and less on coal to do the balancing. Over time, these changes will offload coal from its flexibility role as well, opening the door for its gradual retreat and a cleaner, more flexible power system.

Dr Muyi Yang
Senior Energy Analyst, Asia, Ember

Coal flexibility in China: context, drivers, and policy evolution

Compared with China's rapid expansion in renewable energy manufacturing and deployment, its transition away from coal is proceeding at a slower pace. Coal has fueled China's economic growth, embedded in its socioeconomic system, with layered dynamics at national and regional levels. This report seeks to picture one important dimension of this landscape: coal's evolving function.

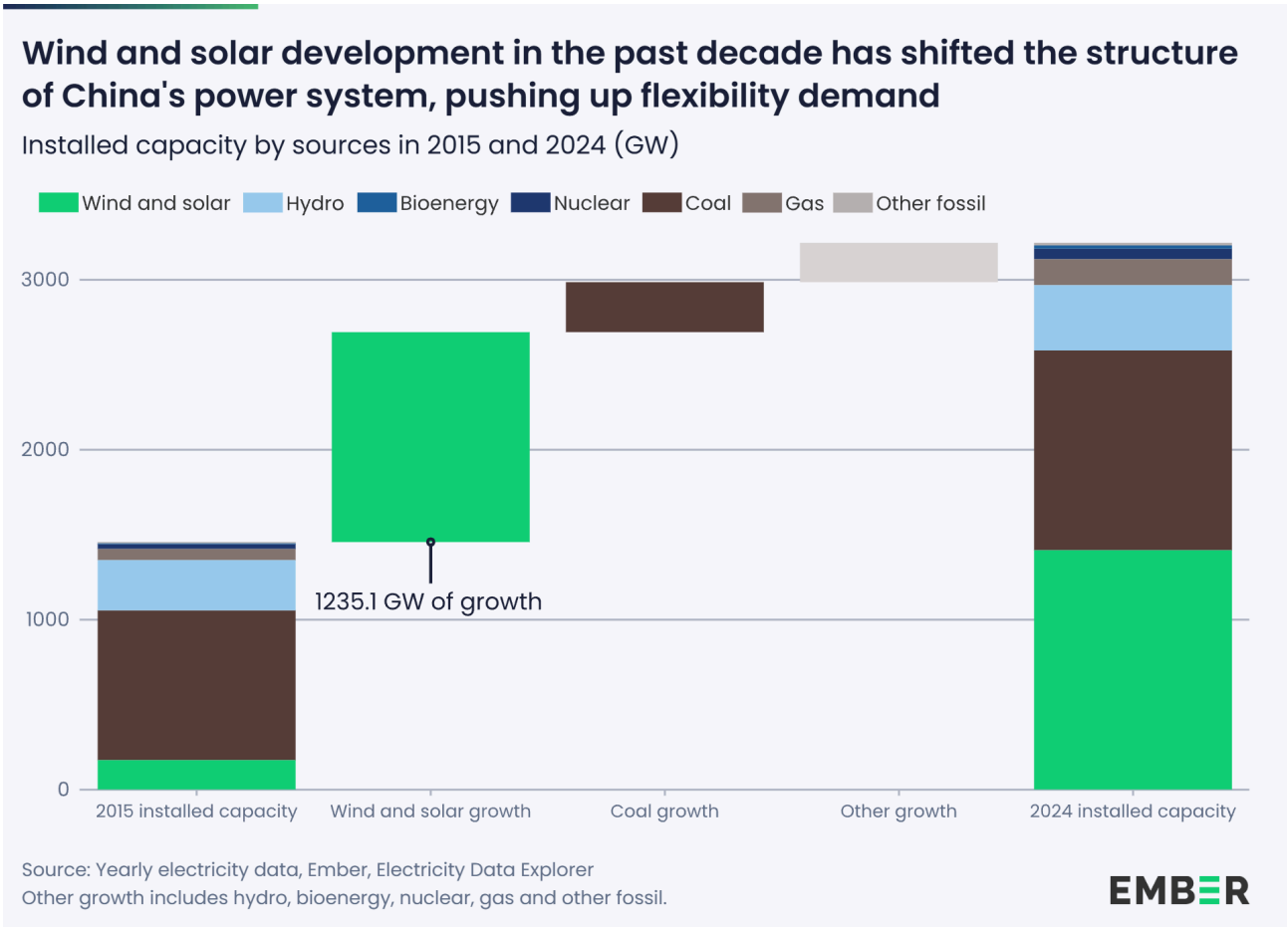
China's coal policy has been evolving through the 13th and 14th Five-Year Plan (FYP) periods (2016-2025), reflected in government strategies, targets, and policy language. Clean energy growth and the "dual carbon" commitment have changed coal's strategic position in China. It is no longer primarily framed as the dominant baseload power. Coal's role is increasingly defined by system flexibility as wind and solar become central pillars of the electricity mix.

The upcoming 15th FYP, the planning cycle that ends with China's carbon peaking target year of 2030, is poised to extend this trajectory, embedding coal as a supporting asset in an increasingly renewable-led system. The government's official recommendations for the 15th FYP highlight the promotion of existing coal fleet retrofits and the scale-up of clean flexibility options.

1.1 The driver: Coal as a pragmatic transitional tool to China's mounting short-term flexibility needs

China's electricity demand continues rising rapidly. In 2025, total electricity consumption reached a record high of 10,368.2 TWh, nearly doubling the level a decade earlier (5,550.0 TWh in 2015).

China's rapid expansion of wind and solar is reshaping its power system and pushing coal power generation towards a structural plateau. In 2024, China's wind and solar installed capacity surpassed that of coal. Looking into the 15th Five-Year Plan (FYP) period (2026-2030), renewables are expected to make up over 50% of the total installed power capacity by 2030.



However, the scale and speed of this growth intensifies system challenges. The variability and non-dispatchability of wind and solar are placing increasing pressure on power system stability.

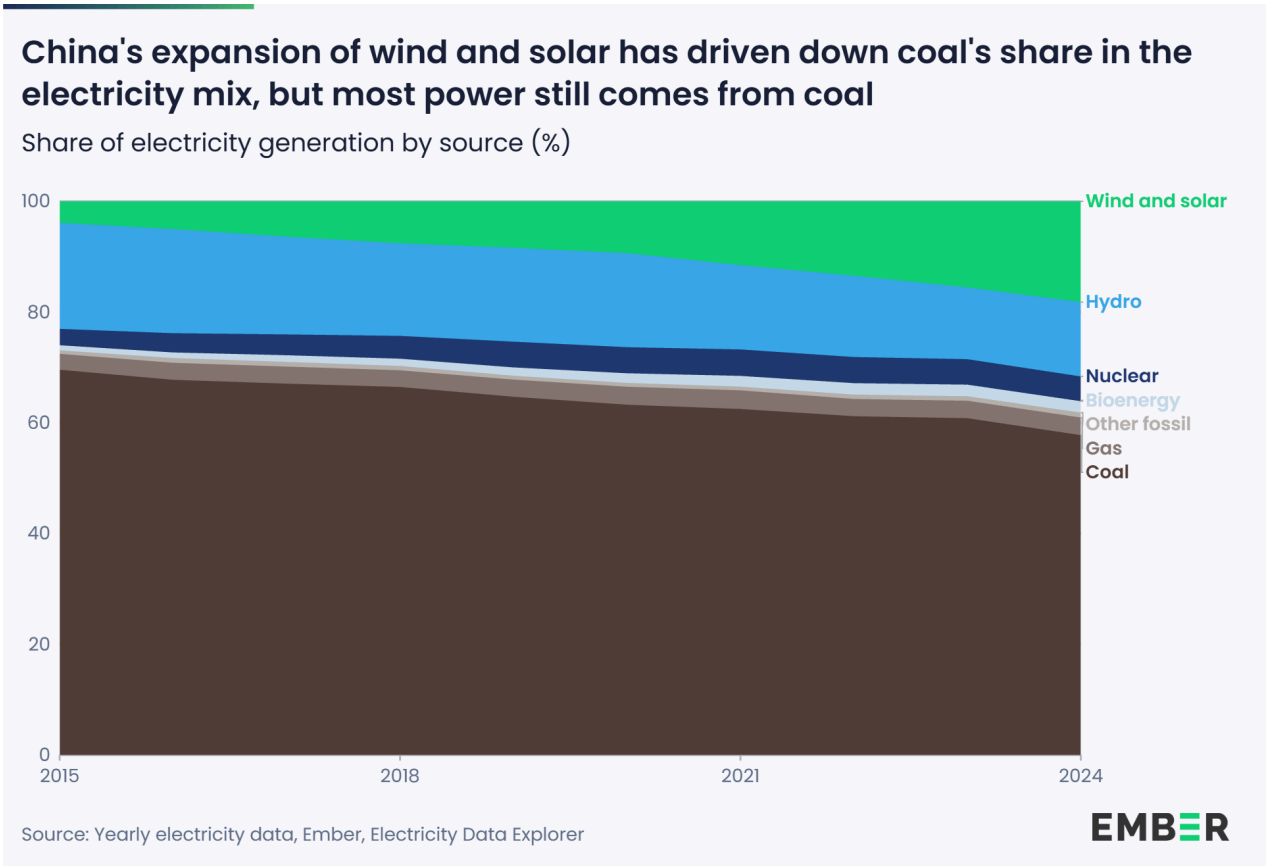
The International Energy Agency (IEA) estimates that China's short-term flexibility needs will be around three times higher in 2030 than in 2022.

Extreme weather events driven by the impact of climate change will further increase this need. In particular, rising summer cooling demand is leading to larger intraday load fluctuations.

Coal power remains China's largest source of electricity, and is likely to retain a significant role in the medium term.

Notably, China's thermal fleet is substantially coal-dominant, with **limited gas capacity**. Unlike many major economies where gas power plants provide flexible balancing, gas only represents a minor share in China due to high import dependency and high marginal costs.

While **battery energy storage** is expanding rapidly, the sheer scale of existing coal capacity makes coal-based balancing and flexibility the most immediate and practical option.



Currently, coal power provides around 70% of China's load regulation capacity, no other resource can yet deliver comparable levels at scale. As a result, China is increasingly leveraging its existing coal fleet to deliver system support.

Meanwhile, shifting coal's role towards flexibility support and away from the responsibility of baseload generation, also provides a transitional and partial solution for longer-term reduction of coal use.

Many countries, both developed and emerging economies, have implemented or actively pursued retrofits to improve coal power flexibility, including for example, Germany, the US, Denmark and India.

1.2 Government policy is locking in coal's new role

China's energy transition follows an approach that prioritises system stability and managed progression. The idea emphasises ensuring that sufficient clean and flexible capacity is in place before reducing the reliance on conventional energy sources. This reflects a broader set of objectives, including safeguarding energy adequacy and protecting local economies.

Over the past decade, China has gradually established a medium-term direction for coal power, repositioning it as a supporting and regulatory source. The shift has been reinforced through detailed policies on coal power flexibility retrofits, and supportive measures linked to ongoing power market reforms.

At the strategic level, China's carbon peaking and carbon neutrality goals, announced in 2020, boosted the expansion of clean technology industries and reframed the long-term role of fossil fuels.

These goals are embedded within the government's top level "1+N" framework, under which both its overarching guidance and the supporting plans, including the *Action Plan for Carbon Peaking Before 2030*, explicitly mentioned positioning coal power as a regulatory and security resource.

This repositioning has been translated into concrete measures since 2016. Coal flexibility retrofits first appeared in the 13th FYP (2016-2020) for energy development and were further specified in the 13th FYP for power, which endorsed a target of retrofitting 86 GW of coal power for flexibility by 2020. In parallel, China's National Energy Administration (NEA) has also been piloting thermal power plant flexibility retrofit technologies.

Policy momentum strengthened during the last five years under the 14th FYP (2021-2025), as rising renewable penetration made system flexibility an increasingly urgent priority.

A major milestone came in November 2021, when China's National Development and Reform Commission (NDRC) and the NEA issued a dedicated policy outlining the **"three integrated retrofits" approach** for coal power – improving energy efficiency, enabling heating application, and enhancing flexibility – and setting implementation targets.

Under this framework, the government set a goal to retrofit **200 GW** of existing coal power capacity for flexibility between 2021 and 2025. The policy requires new and retrofitted condensing units to be able to operate at a minimum load (ML) of 35% of the rated capacity, while combined heat and power (CHP) units are expected to reach 40% ML for at least 6 hours per day during heating seasons.

China's 14th FYP for the energy sector carried these goals forward, raising the retrofit target to **"above 200 GW"** and calling for expanding the share of flexible regulatory power sources to 24% by 2025.

More recently, in February 2024, China's NDRC and NEA released a guiding policy to enhance the country's load regulation capacity and smart dispatch. The policy also raised the ambition for flexibility retrofit of existing coal power units, calling for the entire coal fleet to upgrade **"as much as possible" by 2027**.

Key policies shaping coal's shift to flexibility during the 14th Five-Year Plan (2021-2025) period

Time	Agency	Policy description
August 2021	NDRC, NEA	Issued a policy encouraging renewable power generators to develop peak-shaving capacity, with thermal power retrofits recognised as a source of peak-shaving capacity.
August 2021	NDRC, NEA	Published a strategy for "three integrated retrofits" -- improving energy efficiency, enabling heating applications and enhancing flexibility -- and set a target of 200 GW of flexibility retrofits for existing coal-fired capacity.
March 2022	NDRC, NEA	China's 14th Five-Year Plan (FYP) for the energy sector reaffirmed these goals, increased the retrofit target to "above 200 GW", and called for flexible regulating power sources to reach 24% of total capacity by 2025.
August 2022	NEA, NDRC, SAMR	Updated national standards on coal power energy efficiency and the technical capability of coal units to provide flexibility services to the power system.
November 2023	NDRC, NEA	(Effective from January 2024) Introduced a capacity pricing mechanism to redefine the role of coal power in the electricity system and support its function as a system-supporting resource.
February 2024	NDRC, NEA	Released guidance to strengthen national peak-shaving capacity and smart dispatch. The policy raised ambition for retrofitting existing coal-fired units, calling for the coal fleet to be upgraded "as much as possible" by 2027.
July 2024	NDRC, NEA	Published an action plan for low-carbon retrofitting of coal power (2024-2027), focusing on reducing carbon intensity of the units.
July 2024	NEA	Issued guidance emphasising safety requirements for coal power flexibility retrofit projects.
July 2024	NDRC, NEA, NDA	Released an action plan for the development of a "new power system", highlighting coal power's role in maintaining security of supply and supporting renewable energy integration.
January 2025	NDRC, NEA	Published an implementation plan to enhance power system regulation capacity, requiring provinces to set regulating capacity targets for 2024-2027, and strengthening resource planning and allocation.
April 2025	NDRC, NEA	Issued an implementation plan for the "next generation" of coal power, lowering minimum load requirements to 25-40% for existing units and below 20% for pilot new units.

Source: National Development and Reform Commission (NDRC), National Energy Administration (NEA), State Administration for Market Regulation (SAMR), National Data Administration (NDA)

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National targets have been translated into provincial implementations. For example, Inner Mongolia plans to retrofit 30 GW of coal power capacity for flexibility by 2025, Hubei requires all 53 of its coal units over 300 MW to complete

flexibility upgrades by 2025, Henan has proposed to retrofit its entire existing coal fleet by 2025.

Together, these policies indicate that coal's transition toward a flexibility support role is becoming structurally embedded in China's energy transition strategy.

1.3 Mechanisms in support of the transition

Building on government strategies, a set of supporting mechanisms has been in place to enable more flexible coal operation. During the 14th FYP period (2021-2025), a number of developments have provided stronger economic signals and more tangible financial support for this shift.

1.3.1 Coal capacity pricing mechanism

As a part of its ongoing power market reforms, China has been exploring the establishment of a market-based capacity remuneration. A coal power capacity pricing mechanism was introduced at the beginning of 2024 as an initial step.

The capacity pricing mechanism is widely used in power systems that are more advanced to safeguard electricity supply security. Under such mechanisms, power generators receive payments for maintaining available capacity, while demand response providers are compensated for their ability to reduce electricity consumption when needed. These payments help cover the capital, operational, and maintenance costs associated with maintaining reliable capacity and operating more flexibly.

Under the 2024 policy, the mechanism provides guaranteed payments to coal power producers, reflecting the expectation that coal plants will increasingly operate as back up resources while safeguarding their financial viability.

China uses relatively fixed capacity payments to keep coal power plants financially viable as they shift into backup roles

Annual coal capacity remuneration per kW of installed capacity, relative to the national average fixed costs for maintaining availaible capacity (330 CNY, $47.5 USD), in two provincial categories

	2024-2025	From 2026
Most provinces	30%	≥50%
Advanced provinces*	50%	≥70%

Source: National Development and Reform Commission (NDRC), National Energy Administration (NEA)
*Advanced coal flexibility provinces: Chongqing, Guangxi, Henan, Hunan, Sichuan, Qinghai, Yunan provinces

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The policy marks the first formal separation of the **energy value** and the **system value** of coal power, by remunerating coal power plants not only for the electricity they generate but also for the capacity they make available. At the same time, a fixed and uniform payment is more straightforward to implement and allows for a more predictable impact on end-user electricity prices.

The current design requires power units to declare their maximum available capacity and imposes penalties if units are not able to deliver the declared amount when needed. Local energy regulatory authorities subsequently develop more detailed requirements.

However, because payments are not linked to flexibility metrics, the mechanism creates limited incentives for plants to lower minimum output or operate more flexibly. This design risks slowing coal retirements, incentivising new capacity buildout, and delaying the broader system transition.

In addition, the two-tier provincial framework does not reflect regional differences in demand and supply profiles and system conditions.

In January 2026, the NDRC and NEA launched an important upgrade to the capacity pricing mechanism. The latest policy opens up capacity remuneration

to a **wider range of resources** (including coal, natural gas, pumped hydro, and battery energy storage), and promotes **market-based price formation**, requiring provinces to link capacity remuneration with electricity and ancillary service markets, after their spot markets enter continuous operations.

1.3.2 Fiscal and financial support for flexibility retrofits

Alongside capacity pricing, the Chinese government has advanced fiscal and financial support for coal power flexibility retrofitting.

In 2024 and 2025, this support has been channelled through the "Two New" policy, which provides financial support for large equipment upgrades and consumer goods trade-ins.

Under this framework, the NDRC and the NEA released an implementation plan for large equipment upgrades in the energy sector in 2024. Within the plan, the upgrade of thermal power – including flexibility retrofitting – is listed as the top priority, aiming to mobilise capital and create a more enabling environment for technological upgrading.

Coal flexibility retrofit is also included within the scope of infrastructure real estate investment trust (REITs), a tool that the Chinese government has been promoting to mobilise capital towards infrastructure development.

In the latest version of the eligible sector list, released in December 2025, coal plants meeting the following criteria can apply for REITs: those with a minimum load of under 30% of rated capacity in condensing mode, those co-firing with low-carbon fuels, or those with carbon capture, utilisation and storage (CCUS).

1.4 Technical pathways of flexibility retrofit in China

1.4.1 The principles of coal flexibility retrofit

As discussed previously, China's energy policies increasingly require coal units to operate at higher ramping depth and operate closer to their minimum load (ML).

Coal power plants are not inherently well suited to delivering the rapid regulation and fast ramping capabilities required in power systems with high shares of variable renewable energy (VRE). Compared with gas power units, for example, coal plants are much less flexible due to their higher thermal inertia, which limits their ability to change output at the high rates performed in gas turbines.

Flexibility retrofits therefore focus on improving three core capabilities:

- **larger load regulation capacity:** maintaining stable operation at lower minimum loads to accommodate higher shares of VRE,
- **faster load following:** adjusting output smoothly as demand or VRE generation fluctuates,
- **shorter start-up and shutdown times:** the ability to come online or offline quickly in response to system needs.

Achieving these objectives requires comprehensive modifications across boiler, turbine, and control systems to enhance responsiveness, maintain efficiency and ensure operational safety under variable load conditions.

1.4.2 The technical requirements of coal flexibility retrofit in China

Before retrofitting, flexibility in China's existing coal fleet varies by unit age and different configuration.

On average, China's coal power units that require flexibility retrofit have the capacity of operating with a ML of around 50-60% before retrofitting for

condensing units, and 75-85% for combined heat and power (CHP) units. Units more than 30 years old had ML of around 70% at condensing work conditions.

In terms of policy requirements for retrofitting, the most recent action plan on coal power, issued in 2025, requires coal power units in service to be able to operate with a ML of 25-40% of their rated capacity, depending on unit type, coal quality, and heating configuration.

CHP units represent more than 40% of China's thermal power capacity in 2022 and nearly 80% in northern provinces. They are central to district heating in regions with extensive district heating networks. As heat demand continues to rise in China with rapid urbanisation, CHP units will continue to play an important role in the country's heat supply.

However, compared with pure condensing units, CHP units must simultaneously meet heat and electricity demand, which constrains operational flexibility. Under China's current "heat-led" operating model, in which high heating output corresponds to high electricity output, the capacity for down regulation is limited.

During the heating season, CHP units often retain a load regulation capacity of only around 10% of rated capacity. Decoupling heat and electricity generation is therefore essential to unlocking the flexibility of CHP units.

Technological pathways

China's coal power flexibility retrofits follow several core technical pathways: denitrification (DeNOx) system, low-pressure turbine, control logic, boiler combustion, and integrated retrofit packages. Together, these account for around 87% of all flexibility retrofit efforts.

For CHP units, enhancing flexibility requires heat-electricity decoupling. Technologies, such as thermal storage systems, low-pressure cylinder shedding, and electric boilers, can mitigate the operational constraint of the current "heat-led" operating model. These measures enable CHP units to maintain heat delivery while providing greater flexibility in their power output.

China's coal fleet is becoming more flexible, but much of its potential remains untapped

Available evidence suggests that current implementation of coal power retrofitting is broadly aligned with the government's objectives. The 2025 national target for coal power flexibility retrofit was achieved three years in advance, and the country is on track to meet its remaining 2027 goals.

Early signals at both national and provincial levels indicate that coal utilisation is beginning to decline. However, these trends remain uneven and require careful interpretation, given wide variations in local system conditions, policy implementation and retrofit progress across regions.

Crucially, while the technical flexibility of China's coal fleet has expanded rapidly, its full potential is not yet reflected in system operations. Market design, dispatch practices and institutional arrangements continue to shape how and to what extent coal flexibility is activated in practice.

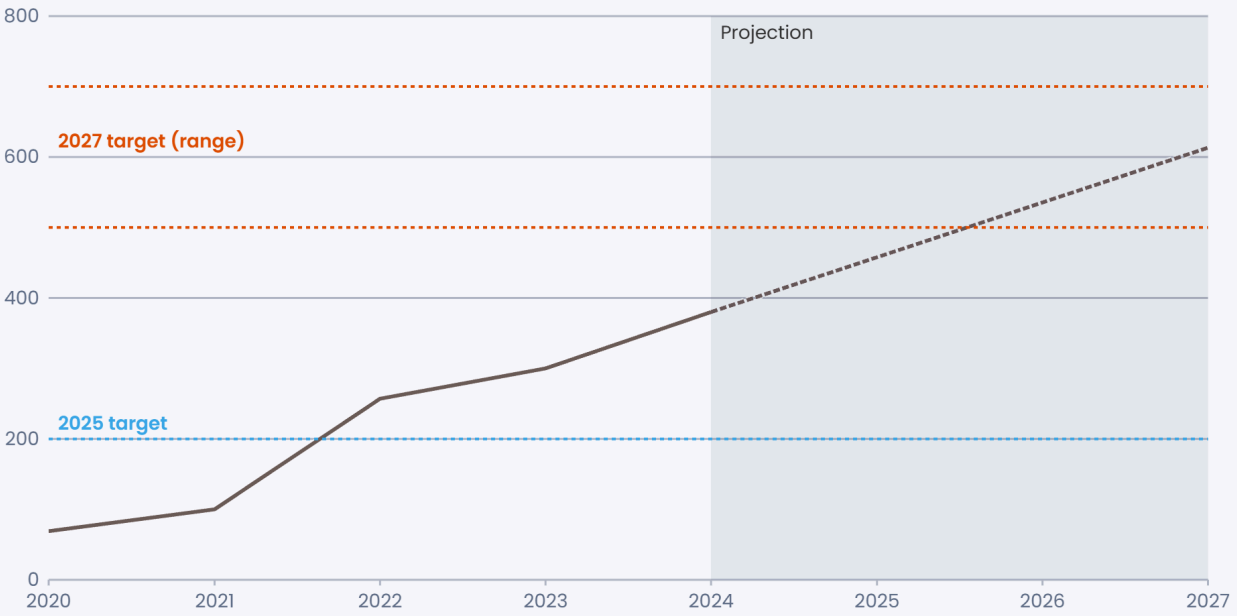
2.1 Progress on retrofitting the existing coal fleet

China has made steady progress in upgrading its coal fleet during the 14th Five-Year Plan period (FYP, 2021-2025). According to the China Electricity Council (CEC), 360 GW of existing coal power capacity was retrofitted for flexibility by the third quarter of 2024. Combined with newly built plants over the last decade, China's total flexible coal power capacity exceeded 600 GW by the end of 2024.

The progress has not only exceeded the original 2025 target, but also positions the country to meet its 2027 goal of maximising fleet flexibility. The China Electric Power Planning and Engineering Institute (EPPEI) estimates this will require retrofitting 500-700 GW of coal power units by 2027. Given the acceleration observed during the 14th FYP period, reaching this range appears technically achievable.

China is on track to meet its 2027 coal power retrofit target, after achieving the 2025 target three years in advance

Exisiting coal-fired power plant retrofit progress in China (GW)



Source: National Energy Administration (NEA), China Electricity Council (CEC), China Electric Power Planning and Engineering Institute (EPPEI), Li, Z., et al. (2024), Ember calculations

While flexibility retrofits were introduced during the 13th FYP (2016-2020), progress before 2020 was modest compared with the rapid expansion during the 14th FYP period (2021-2025). This shift reflects the growing need for system flexibility over the past five years, as renewables penetration accelerated after 2020.

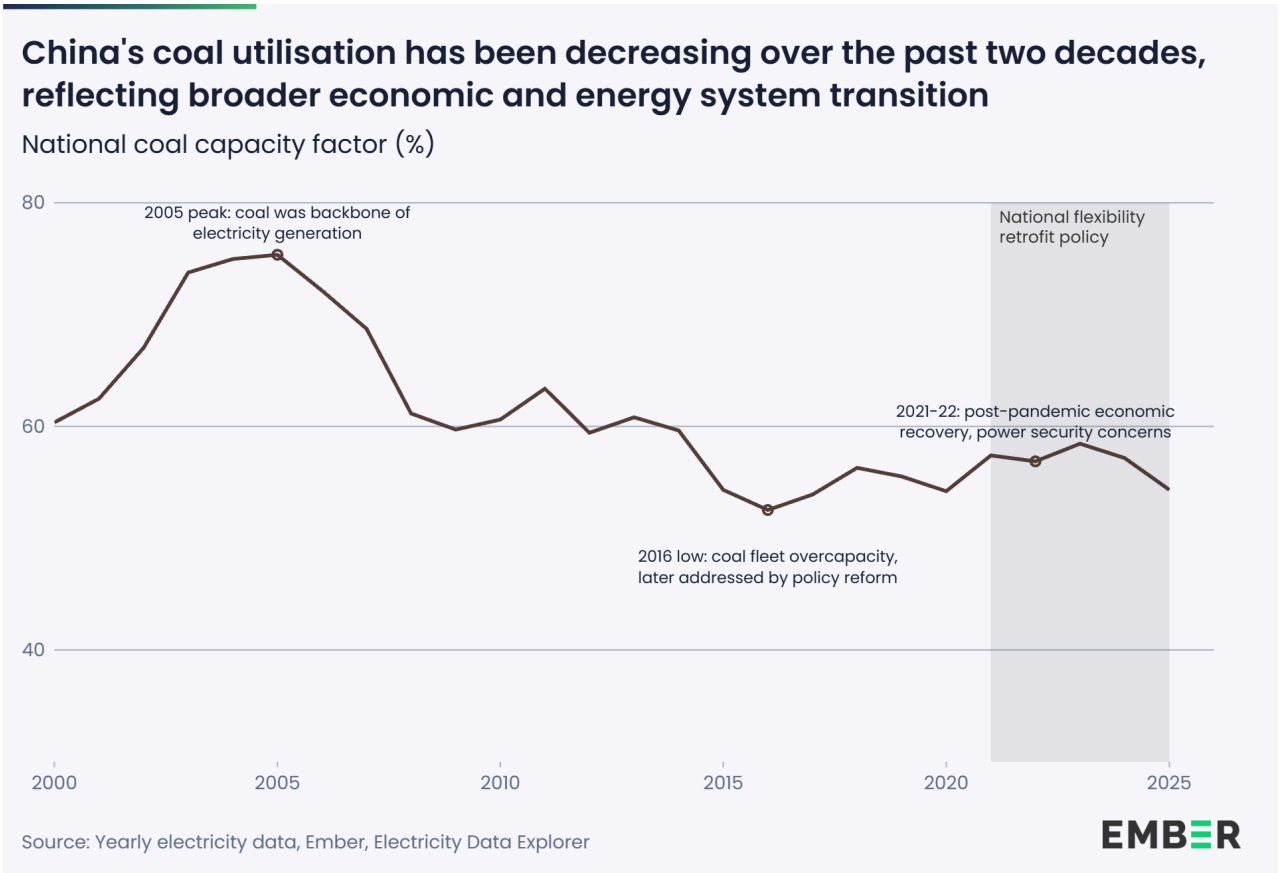
During the 13th FYP, wind and solar curtailment was largely addressed through a combination of grid expansion, enhanced cross-provincial power trading, and the introduction of the Renewable Portfolio Standard (RPS).

Since 2021, however, the scale of renewable expansion significantly accelerated, increasing the urgency of having more flexibility in the system.

Progress has varied **across provinces**. Guangxi has retrofitted 84% of its coal power units as of September 2025, placing the southern province among the fastest in China. Among major coal-producing regions, Inner Mongolia had retrofitted 51.43 GW of its coal capacity by 2025, almost 70% of the units that require upgrading. Shanxi reports that it has retrofitted more than half of its fleet for flexibility. Xinjiang had completed 36.83 GW by the end of 2024.

Together, these developments indicate strong implementation momentum, while also highlighting remaining retrofit potential through 2027.

2.2 Changing patterns in the use of coal power



Over the past two decades, China's utilisation of its coal fleet has generally declined, reflecting structural shifts in its economic and energy systems.

National coal capacity factor (CF) peaked at around 75% in 2005, when coal power units operated as the backbone of the electricity system and underpinned rapid economic growth.

Utilisation then declined steadily, reaching a low point in 2016, largely due to coal over capacity. Policy reforms introduced in the same year to address this overbuild led to a partial recovery, with coal CF rising to 56.3% by 2018.

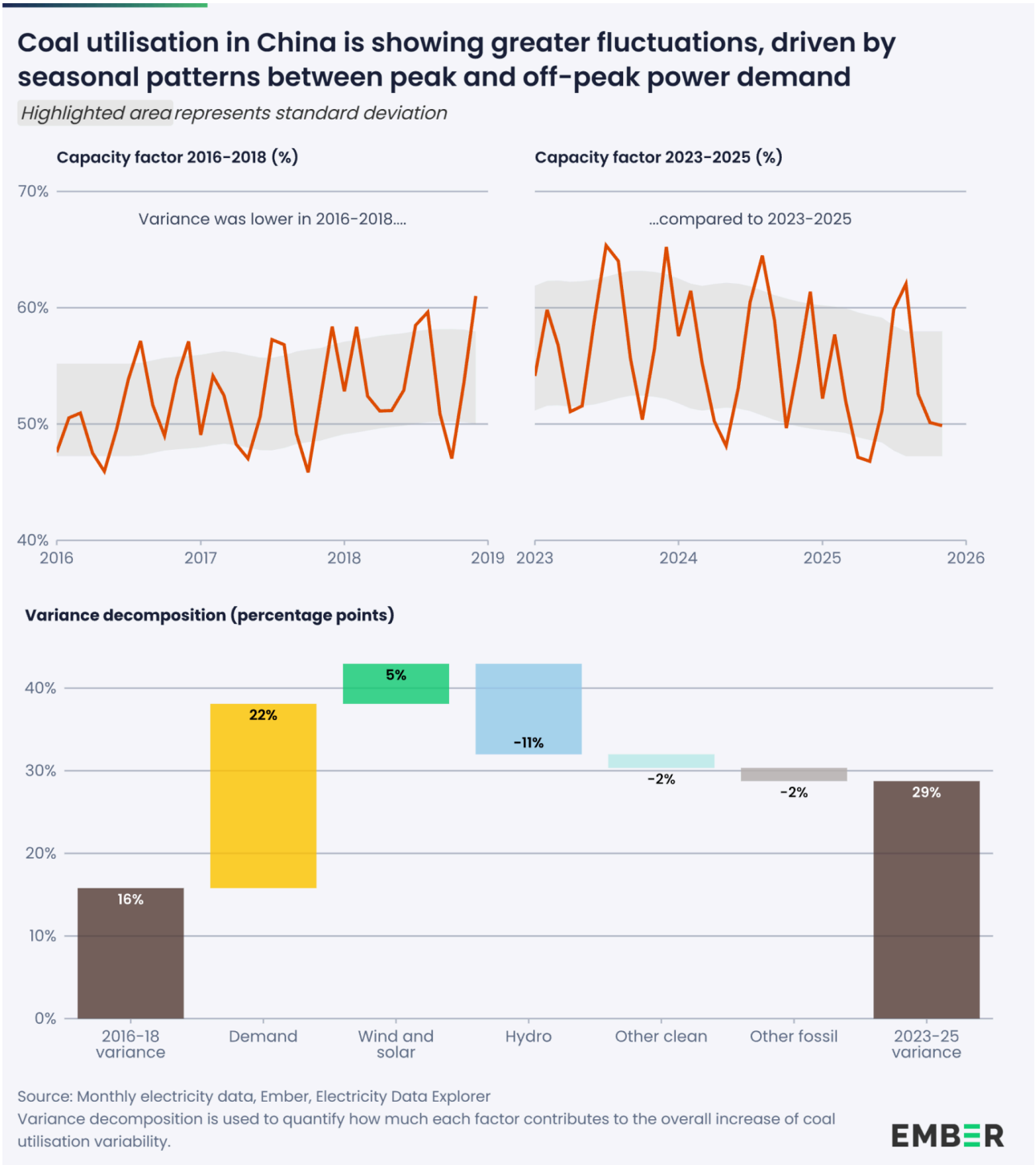
Coal utilisation increased again in 2021 as electricity demand rebounded during the post-pandemic economic recovery, and remained elevated in 2022 with the

government's emphasis on energy security following power shortages and extreme weather events.

More recently, coal utilisation has resumed its decline. Rapid growth in wind and solar has pushed their combined installed capacity beyond that of coal, while policy encourages coal power to operate more as a flexibility support.

Looking ahead, coal utilisation is expected to continue declining through the 15th FYP period (2026-2030) and beyond, as renewables deployment continues to accelerate.

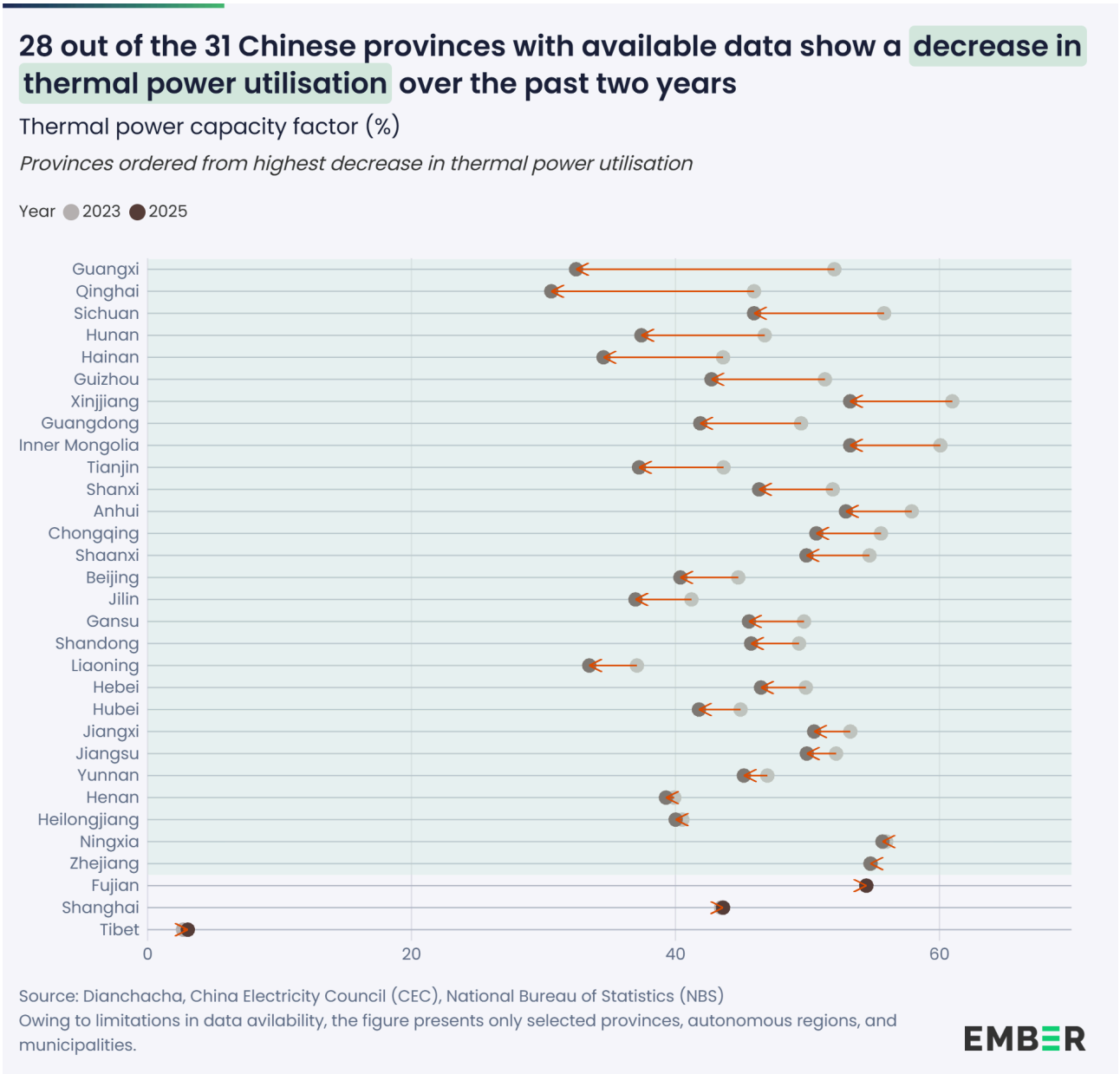
2.3 Coal utilisation pattern fluctuates more seasonally in recent years



Compared with the previous low coal utilisation point (2016-2018), the current period (2023-2025) shows greater month-to-month variation in coal utilisation rate. This suggests that coal is now used less consistently across the year than during the last low-utilisation period, which was largely driven by overcapacity in the fleet.

Decomposition of the drivers of this change shows that increased variability is primarily linked to stronger seasonality in electricity demand, with significantly higher summer peaks in recent years. Wind and solar generation further contribute to short-term fluctuations, although their seasonal complementarity mitigates the effect. The main offsetting factor is hydropower's summer peaking pattern, which matches demand well.

It is important to note that the decline in coal utilisation remains relatively modest and recent, indicating that there is still significant scope to further activate flexibility within the existing coal fleet. This potential is explored in more detail in Chapter 3.



At the provincial level, thermal power utilisation trends vary, reflecting differences in retrofit progress and local conditions, including energy resources, policy frameworks and socio-economic structures. These variations provide useful insights into the effectiveness of policy approaches in changing coal utilisation.

Provinces that have advanced more rapidly on retrofitting have seen faster declines in coal utilisation. Guangxi, for example, where more than 80% of the

coal fleet has been retrofitted for flexibility, has seen a marked reduction in utilisation, with coal CF falling by 19.6% between 2023 and 2025.

2.4 Economic constraints related to coal power's role shift

2.4.1 Cost structure of flexibility retrofits

The cost of retrofitting coal units for flexibility depends on factors such as unit age, capacity, automation levels, technical design and operational expertise. According to the China Electricity Council (CEC), retrofit typically costs between 500 CNY ($71.8 USD) and 1500 CNY ($215.2 USD) per kW.

Beyond upfront capital expenditure, flexible operation introduces additional costs. These include higher operation and maintenance expenses, accelerated depreciation resulting from more frequent low-load operation, increased wear and tear, and more frequent component replacement. Reduced operating hours further lower revenues by lowering electricity sales.

Operating at lower load levels also reduces fuel efficiency. Coal consumption per unit of electricity generated increases as load falls – by around 10% at a 40% load, 20% at a 30% load, and by nearly 60% at a 20% load. When coal power plants operate primarily as flexible load-regulation resources, operators must absorb these efficiency losses in their cost.

Low-load operation also introduces higher safety risks and greater uncertainty over plant lifetimes, further shaping operational decisions.

2.4.2 Revenue models and policy support

To strengthen the business case for the use of coal as flexibility support, the government has introduced supporting policies, including the coal capacity pricing mechanism, alongside dedicated funding programmes to mobilise capital for retrofit projects.

Under China's current framework, coal power revenues from electricity sales derive from three main components:

- Electricity payments: payment based on electricity generated and sold.
- Capacity payments: compensation for maintaining available capacity to ensure system adequacy, regardless of utilisation.
- Ancillary services payments: additional income for services such as load regulation, frequency regulation and reserve provision.

As China advances towards its long-term carbon neutrality goal, companies are encouraged to explore new revenue models. In practice, many companies, particularly large state-owned enterprises (SOEs), have begun diversifying into renewable energy and other energy storage projects.

The government has further promoted joint ventures between coal power and renewable energy companies. This approach has been particularly encouraged in regions such as Inner Mongolia, where both coal resources and renewable potential are abundant, aiming to sustain the long-term business model of local coal power companies.

Unleashing coal's flexible potential while easing the transition to cleaner solutions

China's determination to reposition coal as a flexibility provider has accelerated retrofit activities across its fleet, putting the country on track to meet its 2027 goals. As China enters the 15th Five-Year Plan (FYP, 2026-2030), two structural challenges are coming into focus.

First, the scope for further retrofitting is inherently limited. By 2027, retrofit potential is expected to be largely exhausted. Sustaining flexibility gains without expanding coal capacity will therefore depend on the rapid uptake of clean flexibility solutions, particularly battery energy storage.

Second, despite the expansion of flexibility capacity, much of its potential remains underutilised. These constraints are less linked with physical capacity than with power market design, dispatch practices and system operations.

China aims to establish a unified national power market by 2030, with core structures and key mechanisms in place by 2025. Market-based trading has expanded rapidly, 64.0% of electricity consumption was traded on the market in

2025, up from just 16.9% in 2016. The 15th FYP represents a critical window to align market rules and regulations with the evolving power system.

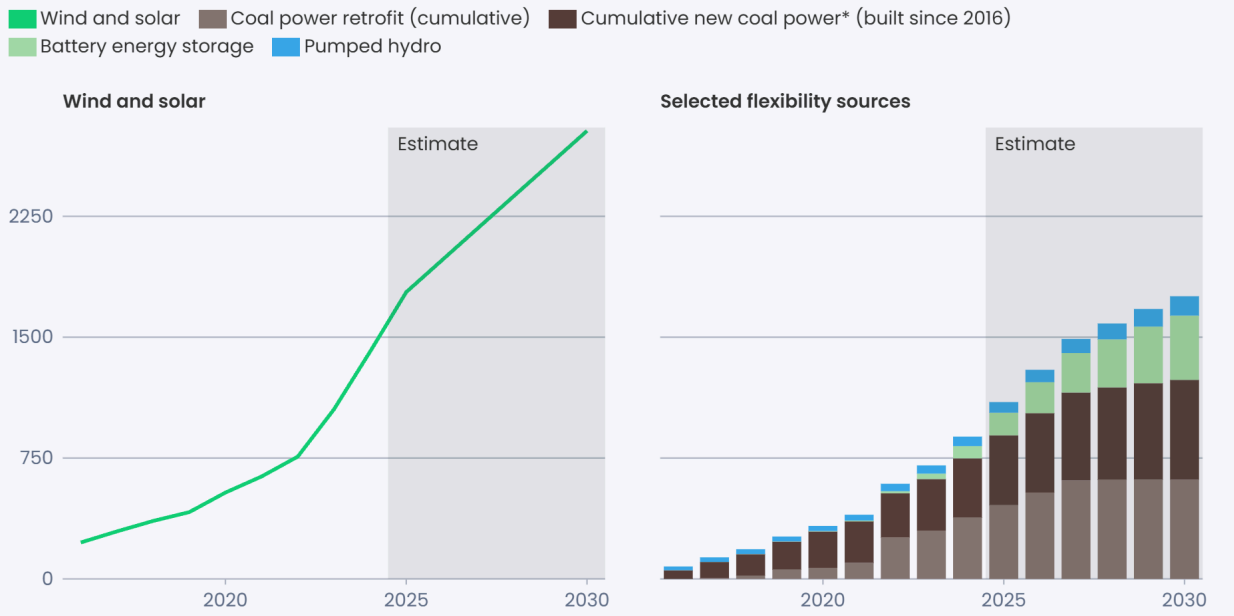
Looking ahead, the International Energy Agency (IEA) estimates that nearly 60% of China's flexibility needs in 2030 could be met by non-fossil resources. Managing this shift to clean flexibility will be essential to deliver meaningful emission reductions while maintaining a secure, renewables-led power system.

3.1 Beyond coal: clean flexibility must take the lead

To date, China's existing coal fleet has served as a reserve to meet rising flexibility needs. However, the remaining retrofit margin is narrowing under current timelines. As a result, clean flexibility, newly coal capacity and pumped hydro combined are set to make up a growing share of China's flexibility. Meanwhile, the demand for flexibility will continue to rise. Wind and solar capacity is set to expand rapidly well beyond 2027. China targets 3600 GW of wind and solar by 2035, actual deployment is likely to exceed this goal.

Battery energy storage must scale up during the 15th Five Year Plan period (2026-2030), as coal retrofit potential plateaus around 2027

Cumulative installed capacity of wind and solar and selected flexibility sources (GW)



Source: National Development and Reform Commission (NDRC), National Energy Administration (NEA), China Energy Storage Alliance (CNESA), Global Energy Monitor (GEM), Yearly electricity data, Ember, Electricity Data Explorer

*"New coal power" refers to **gross additions**, it excludes plant retirements and therefore does not represent China's projected net coal capacity. See methods for calculation details of 2025-2030 estimates

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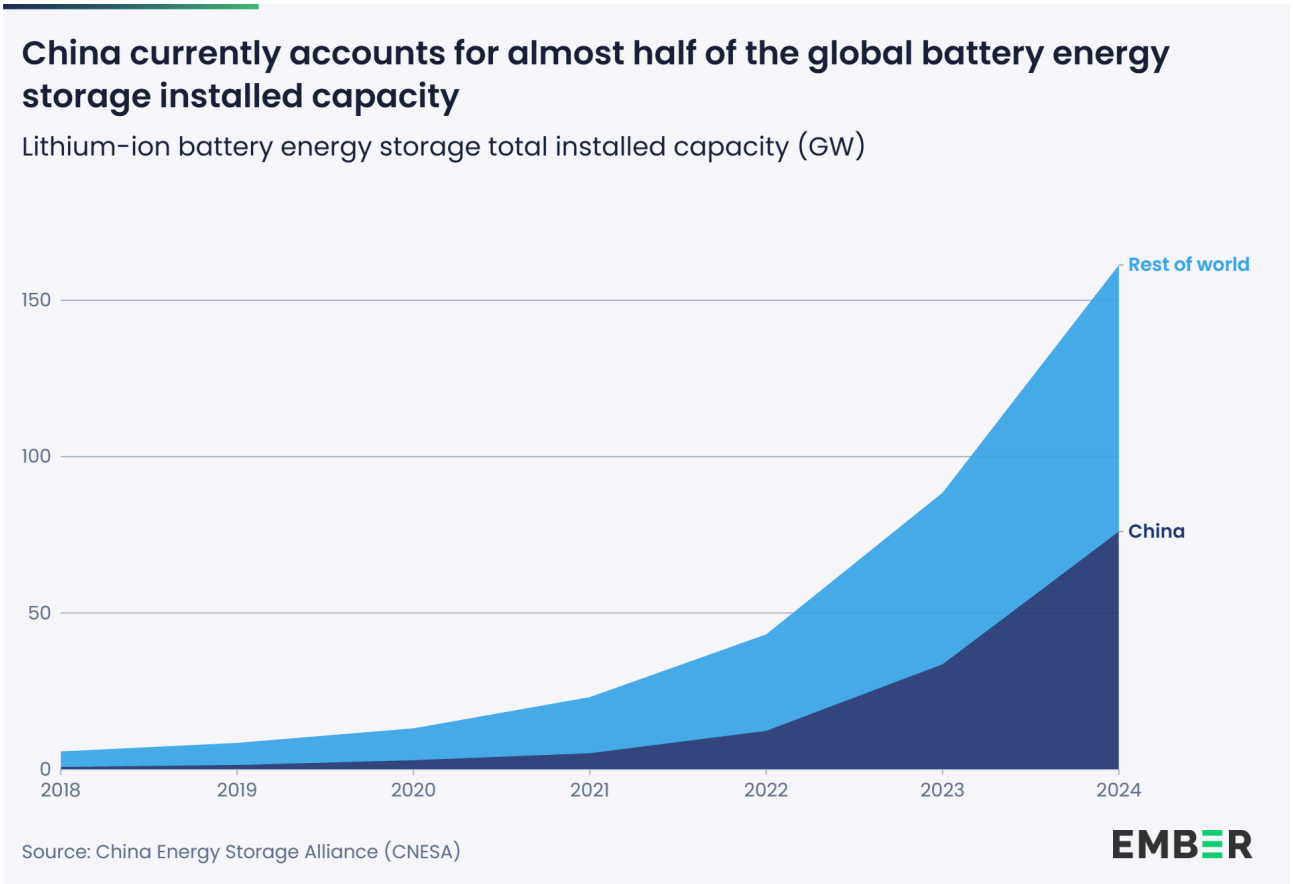
If battery energy storage deployment, along with pumped hydro expansion and other flexibility options, such as demand response and interconnection, fails to keep pace, the system risks falling back on additional coal capacity that may be underutilised. This would increase the risk of locking in emissions beyond 2030 and prolonging the fossil fuel use plateau.

Coal also faces inherent technical limitations. Compared with battery energy storage, coal power cannot reach similarly low minimum load levels or match ramping performance, while carrying higher operational and safety risks.

Policy direction is increasingly aligned with cleaner alternatives. China has already installed almost half of global battery energy storage capacity.



In September 2025, the government released an action plan setting a target of 180 GW of "new energy storage" by 2027, a category that is defined dominantly by battery energy storage.

As of the end of 2025, after the strong growth in December, China had already installed 144.7 GW of new energy storage capacity, putting the country on track to soon surpass its 2027 target ahead of schedule. China Energy Storage Alliance (CNESA) now projects new energy storage capacity (dominated by batteries) to reach 371.2-450.7 GW by 2030.

The beginning of 2026 also sees positive policy momentum for battery energy storage, as the January policy from NDRC and NEA opens up the **capacity pricing mechanism** to the technology, recognising the value of its capacity for the first time, and providing additional incentives for energy storage operators.

3.2 Further power market reform as the key to unlock flexibility

The challenges of expanding coal flexibility and sustaining clean flexibility growth reflect the wider system pressure.

These dynamics are closely linked to structural issues that the government has sought to address through rounds of power market reform since 2015. Electricity pricing still does not consistently reflect underlying supply and demand conditions, and dispatch decisions remain partly administrative. China's reform agenda signals a shift towards a more market-oriented power system.

The year 2025 marks a milestone in this transition, as China aims to establish the foundation for a unified national power market. Reform momentum has accelerated, including the transition of wind and solar projects towards market-based pricing, and a faster timeline for spot market development.

3.2.1 Ancillary service market

China's ancillary service market is evolving from an administratively managed add-on into a core component of the power market structure. Unlike most mature electricity spot markets with stronger price signals, load regulation is remunerated in China as an ancillary service.

Over time, policy has shifted from non-remunerated ancillary service provision to pilot market mechanisms, and more recently, towards formal integration with spot and mid- to long-term (MLT) markets. Reform directions also point to a growing role for emerging actors and clean flexibility technologies in providing ancillary services.

China has been reforming its electricity ancillary service market for the past two decades

Year	Policy
2002	Ancillary services provided without remuneration after the separation of generator and grids.
2006	Administrative payments for ancillary services introduced.
2014	First market-based mechanism (peak shaving market) launched in northeast China.
2015	Current round of power market reform begins.
2017	National policy framework issued calling for more market-oriented mechnism.
2021	Regulatory updates clarified market structures, opened participation to emerging actors such as battery energy storage, demand side response, and virtual power plants, and began reallocating the costs to be shared between generators and electricity users.
2022	Guiding document on building a unified national power market, setting out the integration of mid- to long-term market, spot market and ancillary service market.
2023	Basic rules of the power spot market, highlighted strengthening links with ancillary services.
2024	Pricing mechanism policy, strengthening links with electric power markets, shifting costs further towards end users, and enabling wider participation by emerging providers.
2025	Basic rules for the ancillary service market formalised, establishing national standards.

Source: National Development and Reform Commission (NDRC), National Energy Administration (NEA)

Evidence from more advanced regional markets highlights the impact of this approach. In China's northeast grid region, including Heilongjiang, Jilin, Liaoning and eastern Inner Mongolia, the coal capacity factor has remained below the national average for the past decade, with a sharper decline in recent years.

This trend is notable given the region's high heating demand and large share of combined heat and power (CHP) units, which typically face greater operational constraints. Lower utilisation is closely linked to the region's early introduction of an ancillary service market in 2014, which provides financial incentives for power plants to operate at reduced output.

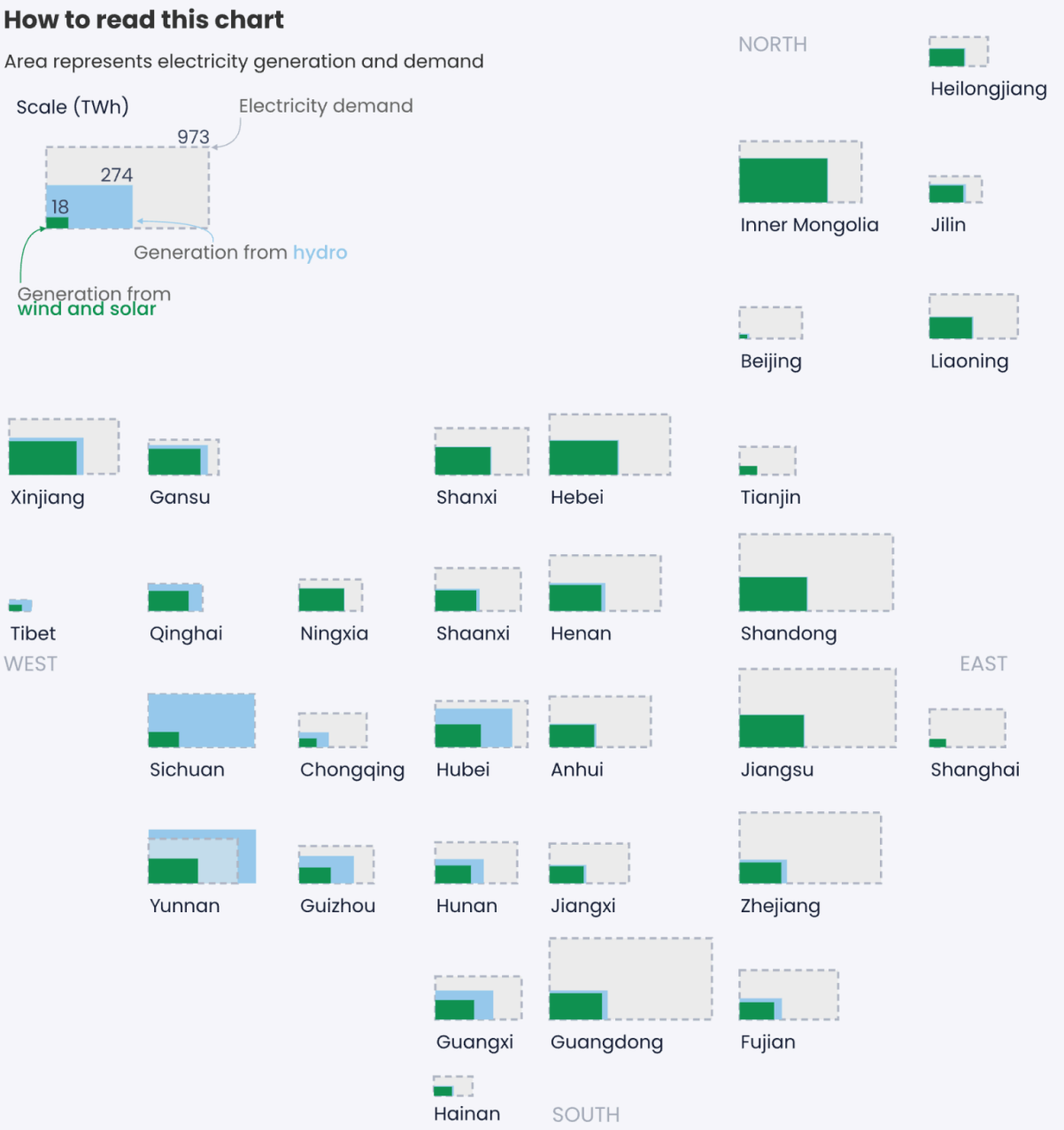
To maximise the role of ancillary service markets in unlocking system flexibility and integrating clean flexibility sources, reform momentum must be sustained through the 15th FYP (2026-2030). Priorities include expanding market-based mechanisms, covering the full range of ancillary services, strengthening links with spot and MLT markets, and improving cost allocation arrangements.

3.2.2 Inter-provincial market integration

China has been investing heavily in its high-voltage direct current (HVDC) network to transfer power from resource-rich western and northern provinces to eastern coastal demand centres.

While current HVDC technology can operate at utilisation rates as low as 10%, institutional and market arrangements continue to constrain the efficient use of this infrastructure and its supporting flexibility.

The geographical mismatch between renewable resources and demand highlights the need for a unified national market



Source: 电查查 (Dianchacha), National Bureau of Statistics (NBS), China Electricity Council (CEC), National Energy Agency (NEA), National Renewable Energy Consumption Monitoring and Early Warning Center, ERA5, Ember data, Ember modelling
Owing to limitations in data availability, the figure presents only selected provinces, autonomous regions, and municipalities.

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Transmission planning and market design remain partly misaligned, many corridor decisions reflect earlier development models that prioritised local generation and long-term contracts. Since inter-provincial trade is still dominated by these inflexible contracts, imported electricity remains largely inflexible, limiting the scope for dynamic adjustment as local supply and demand shift.

Progress towards a unified national power market offers the opportunity to unlock system-wide flexibility. In 2025, notable steps were taken towards this vision – in July, the NDRC and NEA introduced a policy to enhance trading between the State Grid and China Southern Grid regions; in December 2025, the two ministries issued a new policy on evaluation and regulation to support a fully integrated market.

3.2.3 Power system operation

Dispatch practices continue to constrain flexibility. Economic dispatch - allocating generation based on marginal cost - is not yet fully implemented to ensure the system operates cost-effectively, and coordination with the spot market remains limited.

In addition, the current dispatch mechanism requires excessive reserve and lacks a dynamic mechanism to manage load and renewable forecast. As a result, the system tends to carry reserve surpluses, keeping many coal power units online and limiting renewable integration.

Transmission constraints further restrict efficiency, as certain lines receive dispatch priority. This causes power flows to follow fixed routes rather than responding to market signals, diminishing the ability of the system to optimise across regions.

China is taking decisive steps in this direction. In February 2024, the NDRC and NEA issued a policy highlighting smart dispatch capacity building, and in

December 2024, China released an action plan for 2025 to 2027 to enhance flexibility and optimise power system dispatch. Deeper alignment between market design and dispatch practice will be essential to fully unlock flexibility.

3.3 Conclusion: from coal-led flexibility to a clean, market-driven system

From the 13th (2016-2020) to the 14th FYP period (2021-2025), China's policy has steadily repositioned coal power from a baseload to a provider of system flexibility. Government strategy and mandates have reinforced this role shift, prompting rapid retrofitting across the existing coal fleet and overcoming significant technical challenges in the past decade.

Yet the progress has revealed its limits. Coal's flexible potential remains only partially realised. Market and operational constraints continue to limit the extent to which retrofitted coal can respond dynamically to system needs.

At the same time, the scope for further flexibility gains from existing coal units is narrowing. By 2027, the existing fleet will be mostly retrofitted and coal is technically less capable than emerging clean flexibility options, particularly battery energy storage.

This tension has sharpened policy urgency. The past 13th and 14th FYP periods also represent the decade of the latest round of power market reform in China. In 2025, a series of new policies and regulatory measures accelerated power market reform. Continued reforms in these directions are able to not only unlock the flexible operation of coal units but also integrate a broader range of clean flexibility technologies.

As China approaches the 15th FYP and the critical milestone of 2030, coal use is nearing a structural plateau. Transition in the upcoming five years will require a coordinated effort to reduce reliance on coal as a baseload and accelerate

clean flexibility deployment. Without addressing persistent market and regulatory constraints, the system risks reverting to the easier option of building new coal, jeopardising energy transition targets and delaying emissions reductions.

A power system dominated by renewables will require two parallel efforts: fully utilising the transitional flexibility embedded in the coal fleet and rapid scaling of clean, market-driven flexibility solutions.

Supporting materials

Methodology

China's existing coal fleet retrofit progress is collected from the following sources:

- State Grid Corporation of China: Service report on new energy development (2020)
- National Energy Administration (NEA) press release on 2021 coal flexibility retrofit progress
- China Electric Power Planning and Engineering Institute (EPPEI): China electric power development report 2023
- Li, Z., *et al.* (2024) Study on China's power system flexibility resource development strategy under the "dual carbon" targets. Engineering Sciences, 2024, 26(4): 108-120
- China Electricity Council (CEC): National electric power supply and demand situation analysis and forecast report

China's national coal capacity factor (CF) is calculated by dividing annual coal electricity generation by the maximum possible generation, defined as mid-year coal power installed capacity multiplied by 8,760 hours per year (8,784 hours for leap years).

The change in coal capacity factor variance is decomposed as follows:

1. Monthly coal generation is expressed as the sum of monthly demand minus generation from other sources in that month.
2. Each series is expressed in equivalent coal capacity factor terms by dividing each month by the coal capacity hours in that month (Coal capacity * Days in month * 24). Because the same denominator is used across all series, the identity (coal = Demand - sum(Generation)) is preserved.
3. Each series is normalised to remove the long term growth/decline trends. We achieve this by subtracting the 12x2 centred rolling mean of the series. Because this operation is linear and applied to every series, the identity is again preserved.
4. The variance is calculated for two 36 month periods, 2016-2018 and 2023-2025. The variance of this sum is the sum of all sign-adjusted covariance terms, including each series' own variance. Pair covariances are generally split evenly between series (for example, wind-solar covariance is assigned half to wind and half to solar). The exception is pairs involving demand, where the full pair covariance is assigned to the non-demand component. We make this choice on the basis that demand is more or less out of the control of the system planner, while the planner can actively choose what generation technologies to deploy.
5. To calculate the change over time, 2016-18 values are subtracted from 2023-25 values.

The 2025-2030 estimates for selected flexibility sources is from:

- Wind and solar installed capacity is based on China's nationally determined contribution (NDC) of expanding wind and solar power installed capacity to 3,600 GW by 2035, and the NEA's 2026 outlook.
- Retrofitted existing coal power capacity is based on the 2027 retrofit target in the National Development and Reform Commission (NDRC) and NEA's

guiding opinions on strengthening power grid load regulation, energy storage and smart dispatch capabilities.

- Pumped hydro installed capacity is based on China's mid- to long-term development plan for pumped hydro (2021-2035).
- New coal power (built since 2016) is calculated based on the Ember's Electricity Data Explorer and coal plant retirement data from Global Energy Monitor (GEM).
- Battery energy storage capacity is based on the NDRC and NEA action plan for scaling up new energy storage (2025-2027), China Energy Storage Alliance (CNESA) annual lithium-ion battery energy storage installed capacity data, 2025 lithium-ion installed capacity and 2030 outlook.

Province demand for 2025 is taken from 电查查. Hydro generation for 2025 is taken from NBS. Wind generation is based on NBS, with unreported generation estimated based on historic CEC data. Solar generation is based on NBS, with unreported generation estimated based on historic CEC data, ERA5 weather data, NEA capacity data, National Renewable Energy Consumption Monitoring and Early Warning Center data on utilisation, and Ember monthly estimates of solar generation.

Acknowledgement

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Photo

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