



China Energy Transition Review 2025

China's surge in renewables and whole-economy electrification is rapidly reshaping energy choices for the rest of the world, creating the conditions for a decline in global fossil fuel use.

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About

This report analyses China's progress towards a clean energy future, explores the reasons why it is accelerating and deepening, and sets out some implications for the rest of the world. It draws on data from Chinese government sources, international organisations such as the International Energy Agency and Ember itself, together with insights from structured expert interviews.

The analysis highlights important trends in sectors such as renewable generation and electrification of sectors such as industry, buildings and transport, and analyses the underlying drivers. It then examines how trade with China, China's energy diplomacy and business support are driving clean energy progress particularly in emerging economies.

This report is Ember's first comprehensive review of China's clean energy progress and its implications for the rest of the world, undertaken because of China's centrality to the global transition.

Highlights

84%

Clean generation growth led by solar and wind met 84% of China's electricity demand growth in 2024. In H1 2025 it exceeded demand growth, cutting fossil fuel use by 2%.

-1.7%

From 2015 to 2023, fossil fuel use in final energy across buildings, industry and transport in China fell by 1.7%. Use of electricity grew by 65%.

+69%

Battery storage investment in China rose 69% from H1 2024 to H1 2025, while grid investment rose 22%. China accounts for 31% of global clean energy investment.

75%

Chinese companies lodge around 75% of global clean energy patent applications. In 2000, the figure was just 5%.

25%

Cheap Chinese tech has enabled 25% of emerging markets to leapfrog the US in end-use electrification. 63% have leapfrogged it on solar generation share.

65%

Projected Chinese solar manufacturing capacity in 2030 (1,255 GW) is 65% higher than global solar rollout in 2030 in the IEA's Net Zero Roadmap (761 GW)

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Foreword

The world stands at a pivotal moment. Climate change, energy security, and economic development are no longer separate challenges. Increasingly, they are interwoven – and so too must be our response.

For too long, emerging economies have faced what seemed like a stark trade-off between growth and sustainability. As this report highlights, China's green ascent challenges that assumption.

Through scale, innovation and long-term planning, China is demonstrating that decarbonisation can go hand in hand with industrial upgrading, job creation and improved quality of life. These lessons carry significance not only for China, but for the broader region – especially Southeast Asia, where energy demand is rising and development needs remain pressing.

Of course, China's experience is not a one-size-fits-all blueprint. Each country must chart its own course, shaped by its unique resources, needs and priorities. Still, China provides a valuable reference point – showing what is possible when long-term vision is matched with pragmatic, coordinated action.

For Southeast Asia and other emerging markets, the task ahead is to translate that possibility into tailored strategies. The choices we make today will shape the direction of our economies and the well-being of generations to come. To build a better future, one of the most promising paths lies in seizing the opportunities of the energy transition – and doing so together.



His Excellency Dr Suwit Khunkitti

Chair, Advisory Committee of the International Society for Energy Transition Studies (ISETS)

Former Deputy Prime Minister of Thailand

Faster, broader, deeper: China's energy transition is transforming global energy realities

China's clean energy transition is fundamentally reshaping the economics of energy across the world. Accelerating deployment of renewables, grids and storage in China, combined with electrification of transport, buildings and industry, are rapidly bringing China itself towards a peak in energy-related fossil fuel use, while also reducing costs and accelerating uptake of clean electro-technologies in other countries. These twin trends are creating the conditions for energy-related fossil fuel use globally to peak and decline.

China's adoption of renewable energy continues to accelerate. In 2024, wind and solar electricity generation rose by 25% compared with the previous year. In the first half of 2025 it was 27% higher than in H1 2024 – enough, alongside other trends, to cut fossil fuel generation by 2% compared with H1 2024. In the 12 months to June 2025, wind and solar (2,073 TWh) generated more electricity than all other clean sources (nuclear, hydro and bioenergy) combined (1,936 TWh). Just four years ago, wind and solar generated half as much electricity as other clean sources combined.

The renewables transformation is underpinned by world-leading investment in clean energy, energy storage and transmission grids. China is the biggest investor in clean energy worldwide, spending \$625 billion USD in 2024 – 31% of the global total of \$2,033bn. The volume of installed battery storage tripled in the three years to 2024. Grid investment rose to an all-time high in 2024 of 608 billion RMB (\$85bn USD), up by 25% from 486 billion RMB (\$68bn) in 2019.

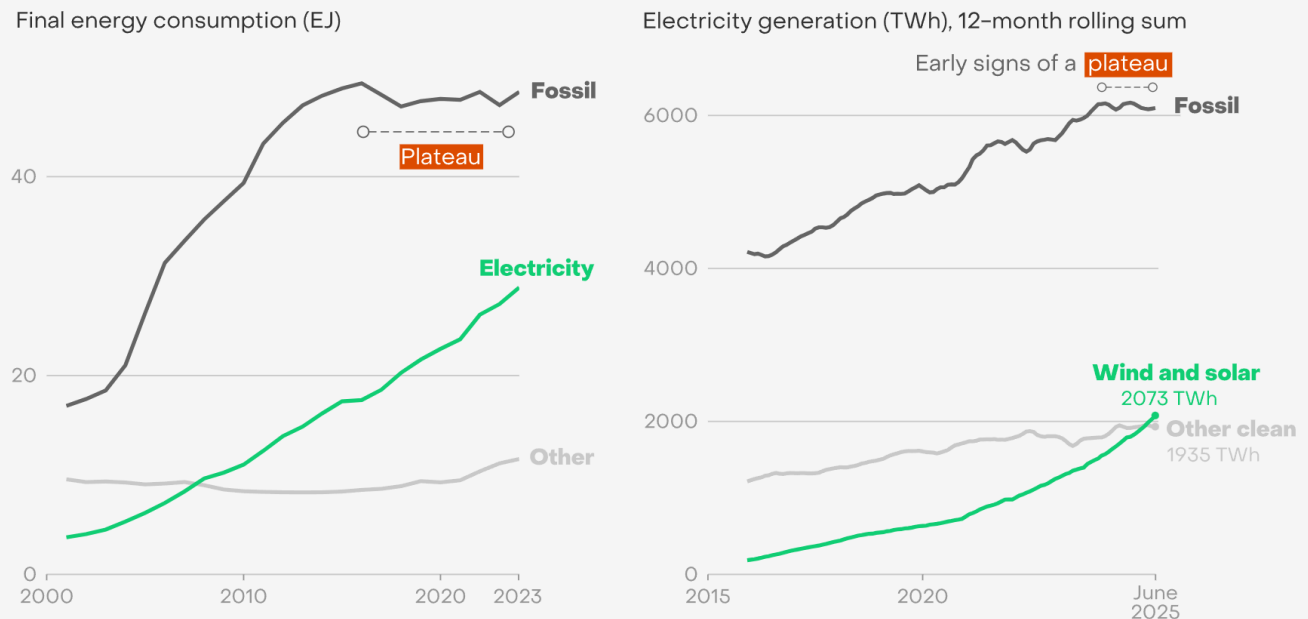
Beyond electricity, the transition is reshaping end-use sectors. Electricity is comfortably the biggest energy source in buildings, and in 2023 overtook coal to become the biggest energy source for industry. Oil-derived fuels still dominate in transport, but China's rapidly-expanding electric vehicle fleet is progressively gaining ground. The share of electricity in final energy demand across the wider economy continues to grow, reaching 32% in 2023, out-pacing many mature economies.

China has embarked on this transition for a variety of reasons. Interviews with experts conducted for this report reveal that within China there is a realisation that the old development paradigm centred on fossil fuels has run its course, and is not fit for 21st century realities. The government's aim to establish an 'ecological civilisation,' which simultaneously delivers on economic, social and environmental goals, is the response, embedded in the Constitution since 2018.

The clean energy transition is constraining China's dependence on imported fossil fuels, reducing energy costs, stimulating growth and jobs and creating export markets. In 2024, investment and production in clean energy contributed 13.6 trillion RMB (\$1.9 trillion) to the national economy – a sum equivalent to about one-tenth of China's GDP, or the total GDP of Australia – and the sector is growing three times faster than the Chinese economy overall. The depth of buy-in within business is reflected in research, development and innovation: Chinese companies now account for about 75% of global patent applications in clean energy technology, up from just 5% in 2000.

These investments in the clean energy future are driving dramatic cost reductions across the world in key technologies such as wind turbines, solar panels, storage batteries and electric vehicles. The benefits are increasingly being felt in emerging markets, many of which are overtaking OECD countries in wind and solar generation share and in electrification.

China's rapid electrification and rising solar and wind power will soon drive down its fossil fuel use



Source: IEA World Energy Balances, Monthly electricity data, Ember
 Final energy consumption: 'Other' includes biofuels, heat, geothermal and solar thermal. Final energy consumption from fossil refers to the on-site burning of fossil fuels or other energy sources for heating, transportation, or other purposes. Non-energy use of fossil fuels is excluded in the figure.
 Electricity generation: 'Other clean' includes bioenergy, nuclear and hydro.



Key takeaways

01 Wind, solar and battery storage deployment in China continues its exponential rise

China's wind and solar generation capacity more than doubled in the three years to 2024, from 635 GW to 1,408 GW. In early 2025, the capacity of wind and solar combined overtook that of coal. Battery deployment tripled in three years, with China adding more in 2024 than the US and EU combined. In the first half of 2025, wind and solar deployment was more than double compared with H1 2024.

02 **Clean generation, headed by wind and solar, is cutting into fossil fuels' market share**

China generated 18% of its electricity from solar and wind in 2024, twice as much as in 2020 (9%). In the first half of 2025, wind generation was higher by 16% than in H1 2024, and solar generation higher by 43%. In 2024, growth in clean generation (wind, solar, other renewables and nuclear) accounted for 84% of electricity demand growth; in H1 2025, it outstripped demand growth, resulting in a 2% fall in fossil generation compared with H1 2024.

03 **Wind and solar now generate more than a quarter of electricity in seven Chinese provinces**

Fourteen provinces exceed the OECD average share of 19% for wind and solar generation. If they were countries, four provinces would rank among the top ten solar generators worldwide.

04 **China is rapidly electrifying heating, industry and transport**

Having grown by an average 4.7% per year in the decade to 2015, final energy-related fossil fuel consumption outside the power sector (in buildings, industry and transport) has since fallen by an average of 0.2% per year. In 2023 the share of electricity in final energy consumption in China reached 32%, and is increasing by about 1 percentage point per year. Electricity is by far the largest source of energy in buildings, supplying 39% of final energy demand, and in 2023 overtook coal to become the largest source of energy in industry (31% of final energy demand). By contrast the EU and US electrification rate has remained stagnant at 24% since 2010.

05 **The advent of cheap wind and solar power is changing energy economics, for mature and emerging economies alike**

91% of newly-commissioned wind and solar facilities globally are cheaper than the cheapest available form of fossil fuel generation. With Chinese factories producing about 60% of the world's wind turbines and 80% of solar panels, it is predominantly Chinese policy and investments that have driven the global price reductions.

06 **China's fossil fuel consumption is poised to peak and begin falling, triggering a global decline**

With wind and solar generation growing exponentially and challenging fossil generation, and with the wider economy electrifying fast, China's energy-related fossil fuel demand is likely soon to begin falling. China accounted for two-thirds of global fossil fuel demand increase during the decade from 2012 to 2022. Falling demand in China, combined with accelerating uptake of clean electro-technologies worldwide, looks set to create the conditions for global fossil fuel demand to decline.

China's investment in the electro-technology revolution is creating choices for every other country, unlocking a clean, more affordable and secure energy future and opening the door to a new diplomacy, moving beyond the geopolitics of oil and gas. Most profoundly, China is showing that a highly electrified energy system centred on wind and solar generation is entirely compatible with a modern, growing, highly industrialised economy.

The scale, pace and depth of China's transition raises questions about the future of fossil fuel production globally. China has been the main 'swing state' for global fossil fuel demand for a decade. Its energy-related fossil fuel consumption is likely to begin falling soon due to the twin trends of clean generation and end-use electrification, and made-in-China electro-technologies are displacing fossil energy across the world. The implications for governments basing their economic growth plans on exporting coal, oil and gas are plain to see.

China's energy sector is undergoing a profound transformation, pushing the country towards a plateau in fossil fuel use. One of the key drivers is the rise of its clean energy industry. Clean power is increasingly accessible, affordable, and attractive for investment. This momentum is creating new economic opportunities. Further market reforms and responsive policies remain essential to sustain clean energy expansion and keep China on track towards carbon neutrality.



Biqing Yang
Energy Analyst, Ember

China has opened the door to a new energy future by building electro-technologies at vast scale, slashing costs and raising the ceiling of possibility. The consequences reach far beyond its borders, enabling the emerging market energy leapfrog and swinging global fossil fuel demand from unrelenting growth to the brink of structural decline.



Sam Butler-Sloss
Research Manager, Ember

China's transition is no longer just additive, stacking renewables on top of fossil fuels. With clean energy surging and electrification spreading across the economy, fossil fuel use in power generation and end-use sectors is nearing a plateau. What once seemed like mere additions now looks like the take-off point for real transformation. The message to the world is clear: a genuine transition is possible, but it takes careful planning, sound policy, and, most importantly, sustained commitment.



Muyi Yang
Senior Analyst, Ember

Forging ahead: China's electricity transition in action

China's clean energy transition is accelerating and deepening, despite geopolitical tensions and mounting domestic economic pressures. It is not just about expanding renewable generation, but about switching energy demand from fossil fuels to electricity, and reimagining how energy is produced, supplied and used across the entire economy.

If there is one area where China's global leadership is widely recognised, it is in the speed and scale of its renewable energy deployment. In 2024 alone, China invested \$625 billion USD in clean energy – [comfortably exceeding](#) Europe (\$426 billion), North America (\$409 billion) and the rest of Asia-Pacific combined (\$291 billion).

Years of record spending are now delivering a rapid buildout of renewables alongside world-leading expansion of storage and grid infrastructure, as well as market reforms that unlock flexibility. On the demand side, electrification is spreading across end-use sectors – and together, these shifts are already weighing on fossil-fuel demand.

This chapter traces how China's transition has evolved beyond clean capacity growth and basic electrification into a system-wide transformation – reimagining how electricity is supplied and used across the entire economy. It also demonstrates how this deepening transition is pushing fossil fuel use towards its peak – and how China's sustained policy commitment points to even greater ambition ahead.

China's system-wide clean energy transformation

	Metric	2019	2024	CAGR 2019-2024 (%)	Change in 2024 (%)	Year-on-year change (%) – H1 2025 vs H1 2024
Generation mix	Clean	2,363 TWh 32%	3,850 TWh 38%	10.3% ▲	15.6% ▲	14.7% ▲
	Wind and solar	629 TWh 8.4%	1,836 TWh 18%	23.9% ▲	24.9% ▲	27.4% ▲
	Fossil	5,140 TWh 69%	6,237 TWh 62%	3.9% ▲	1.8% ▲	-2% ▼
	Coal	4,855TWh 65%	5,828TWh 58%	3.7% ▲	1.3% ▲	-2% ▼
		2019	2024	CAGR 2019-2024 (%)	Change in 2024 (%)	Year-on-year change (%) – H1 2025 vs H1 2024
System building	Grid investment	485.6bn RMB	608.3bn RMB	4.6% ▲	15.3% ▲	14.6% ▲
	Battery storage	1.4 GW	76.0 GW	123.0% ▲	126.0% ▲	69.4% ▲
	Pumped hydro	30 GW	59 GW	14.5% ▲	15.8% ▲	4.8% ▲
	Volume of market traded electricity (% of total electricity supplied)	2,834 TWh 39%	6,180 TWh 63%	16.9% ▲	9.0% ▲	5.0%* ▲
		2019	2023	CAGR 2019-2023 (%)	Change in 2023 (%)	
Electrification	Electricity as a share of total final energy consumption	28.4%	32.4%			
	- Transport	3.1%	4.7%			
	- Buildings	31%	39%			
	- Industry	33%	35%			
	Final fossil fuel energy consumption	47.8 EJ	48.5 EJ	0.4% ▲	2.8% ▲	
	- Transport	14.4 EJ	14.9 EJ	0.8% ▲	5.5% ▲	
	- Buildings	6.5 EJ	6.3 EJ	-0.6% ▼	0.9% ▲	
	- Industry	25.1 EJ	25.6 EJ	0.5% ▲	2% ▲	

Source: NEA, IEA, Ember - 2023 figures are used when 2024 data is not available. Final energy consumption data excludes consumption for non-energy use.

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From capacity to system – the supply-side transition deepens

China’s transition is entering a new phase – one where building a “new electricity system” has become a strategic priority, moving beyond the earlier focus on simply adding clean capacity. While the [11th](#) (2006–2010) and [12th](#) (2011–2015) Energy Five-Year Plans prioritised the rapid expansion of renewable capacity, the [13th](#) Plan (2016–2020) marked a pivotal shift towards system integration. This evolution culminated in the [14th Five-Year Plan](#) (2021–2025), which elevated power system reconfiguration to a national strategic agenda – committing to building a “new electricity system” capable of supporting high levels of renewable energy uptake.

Generation from wind and solar rose by 25% in 2024 to supply 18% of China’s total electricity – twice as much as in 2020 (9%) and up from just 4% in 2015. Several provinces generated over a quarter of their electricity from wind and solar in 2024 – Gansu (36%), Hebei (32%), Heilongjiang (30%), Inner Mongolia (25%), Jilin (33%), Ningxia (25%) and Qinghai (46%) – surpassing the European Union’s 29% share of wind and solar generation in some cases, while 14 provinces exceed the OECD average of 19%.

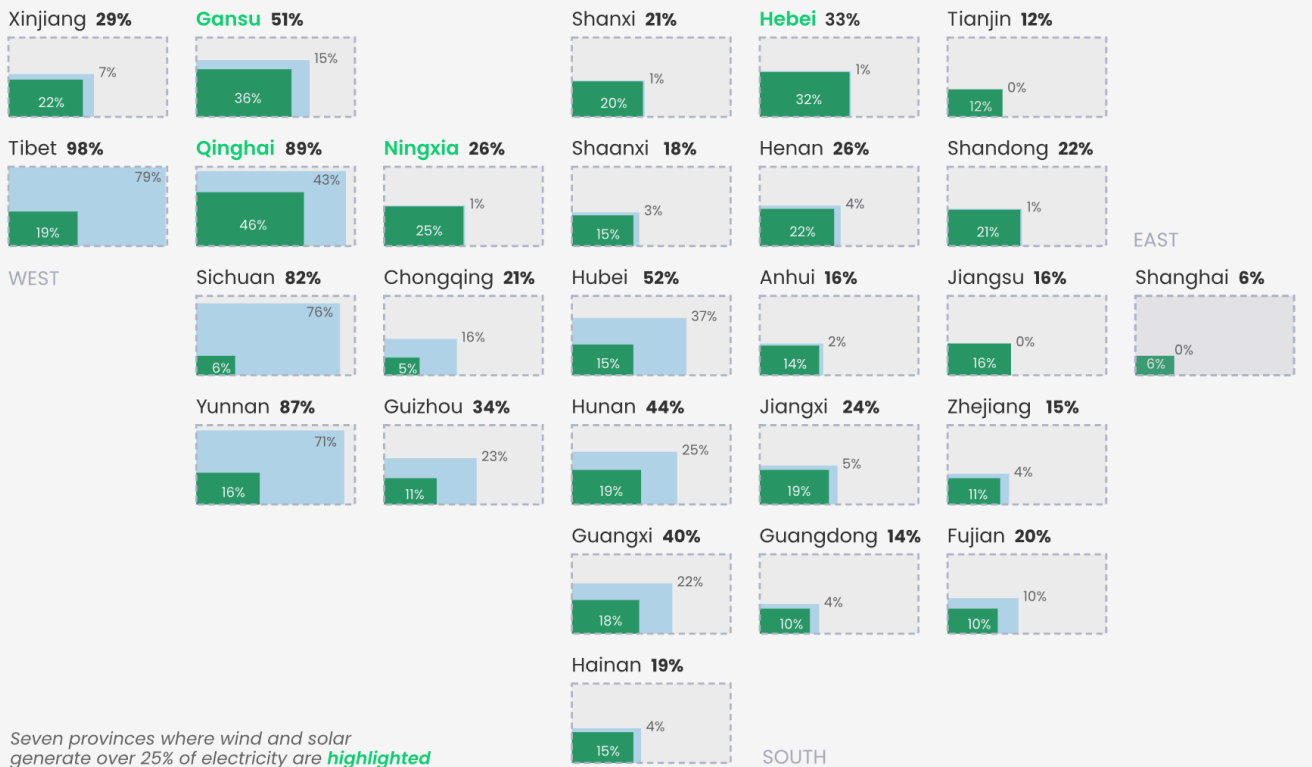
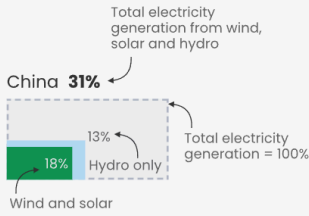
This progress can be attributed to a combination of factors: abundant wind and solar resources; greater land availability, especially in the less populated western regions; and, in several cases, access to long-distance transmission infrastructure that enables the export of surplus renewable power to eastern city clusters and manufacturing hubs. Wind and solar capacity [has grown exponentially](#) for over a decade, and more than doubled in the three years to 2024, from 635 GW to 1,408 GW.

As renewable shares rise, the need for a more flexible power system – able to accommodate rapidly growing variable output and match supply with demand across the country – has become [urgent](#). This is underscored by the challenge of managing longer-term variability in renewable generation, particularly in hydro-rich provinces such as Sichuan, Qinghai and Yunnan. While hydropower is relatively stable over short timeframes, it is prone to seasonal swings – a challenge worsened by [hotter, drier summers](#) in recent years. This has reduced the average capacity factor of China’s hydro dams – the amount of generation per unit of capacity – and also constrained generation during specific periods.

Wind and solar account for over a quarter of electricity generated in seven provinces in China

How to read this chart

Share of electricity generation, 2024 (%)



Seven provinces where wind and solar generate over 25% of electricity are highlighted

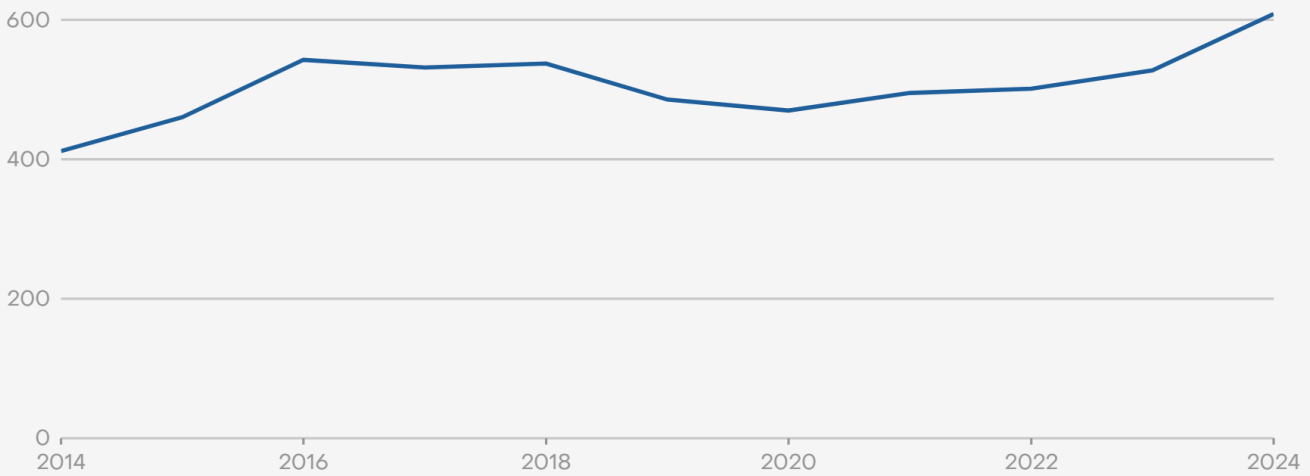
Source: Estimate based on CEC Electric Power Industry Statistics 2024 and Ember calculations; see methodology for details. Owing to limitations in data availability, the figure presents only selected provinces, autonomous regions, and municipalities.



Grid investment is accelerating alongside China’s record-setting renewable boom. In 2024, total investment exceeded [600 billion RMB](#) (\$85 billion USD), up from [485 billion RMB](#) (about \$70 billion) in 2019.

Grid investment in China has rebounded in recent years

Annual network investment (billion RMB)



Source: National Energy Administration's national power industry statistics

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In recent years, China's grid strategy has shifted from large-scale capacity expansion towards strengthening local networks, enhancing cross-regional coordination and improving system flexibility. This reflects the fact that much of the foundational work under the [West-to-East Power Transmission](#) (西电东送) initiative, particularly the three main transmission corridors linking the energy-rich west to coastal industrial heartlands, is now largely complete.

However, with [record-setting wind and solar additions](#) in 2024, integration pressures have returned. National curtailment rates have begun trending upwards, reaching levels not observed for several years. In resource-rich provinces such as Gansu, where over 30% of electricity is now generated from variable wind and solar, grid integration has become challenging – especially given the limited local demand and the need for long-distance transmission lines to eastern demand centres.

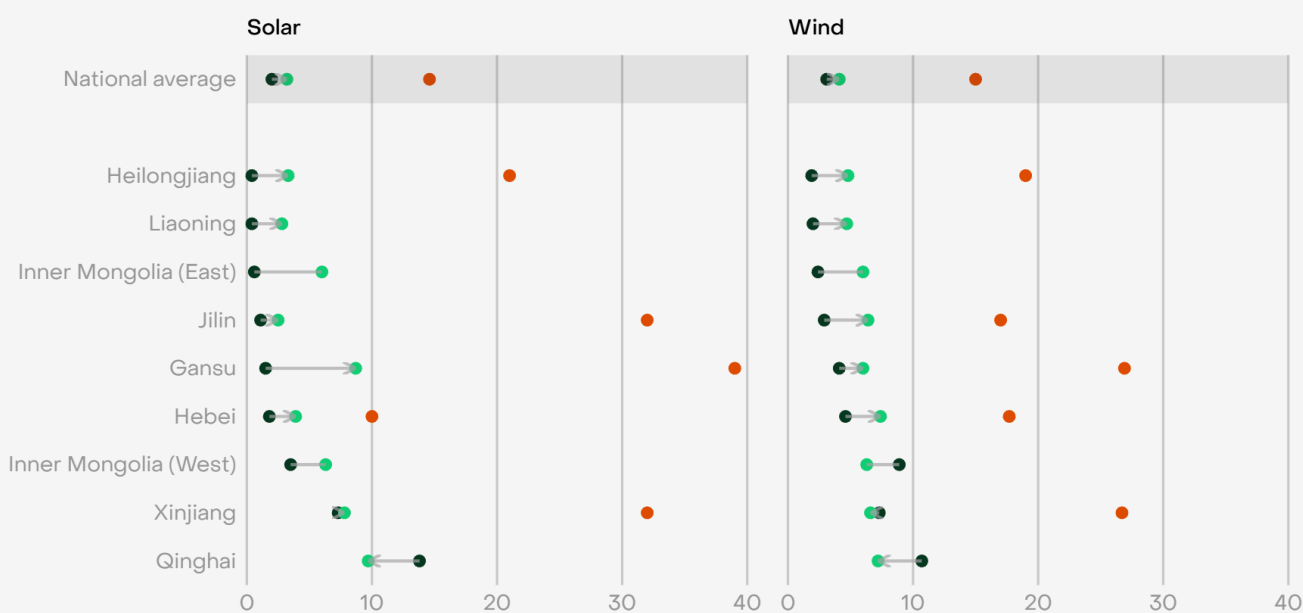
While far from the [severe curtailment](#) experienced around 2015 – when renewable expansion outpaced grid and market readiness in the north – the recent uptick has prompted a renewed policy response. In 2024, the National Energy Administration (NEA) announced plans in 2024 to [fast-track 37 major transmission lines](#) and start another 33 within the year.

Large-scale hydro projects, including [mega dams](#) on the Yarlung Tsangpo, are also set to drive grid investment – both to connect them with demand centres and to strengthen local networks.

Despite record wind and solar growth, China's curtailment remains near 2021 lows and far below 2015 peaks

Wind and solar curtailment rates (%)

● 2015 ● 2021 ● 2024



Source: Notice of the National Energy Administration on Matters Related to the Development and Construction of Wind and Solar Power; Chinese Renewable Energy Industries Association (CREIA)

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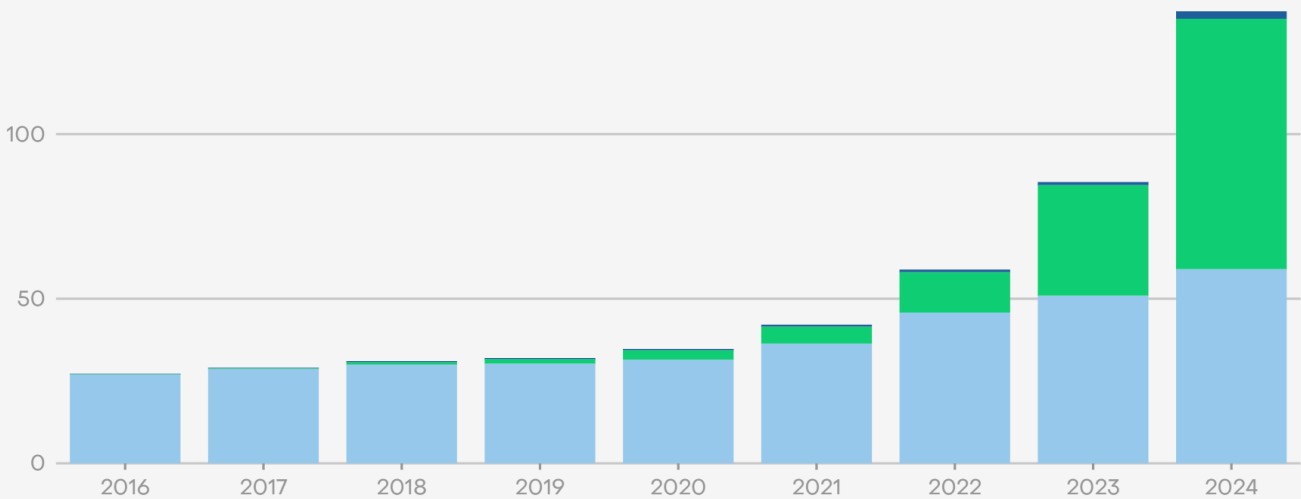
China is rapidly scaling up its energy storage capacity – outpacing the rest of the world.

Since 2021, China’s total capacity has more than tripled, reaching over 135 GW by the end of 2024. While pumped hydro has grown steadily, the most dramatic growth has come from “new-type” storage technologies, particularly lithium-ion batteries. In 2024 alone, China commissioned a record [37 GW/91 GWh of battery storage](#) – more than the combined additions of the [United States](#) (12 GW/37 GWh) and [Europe](#) (12 GW/21 GWh, about two-thirds behind the meter).

Supercharged by lithium-ion: China's energy storage capacity has tripled in just three years

Cumulative installed capacity (GW)

■ Pumped hydro ■ Lithium ion ■ Other



Source: China Energy Storage Association

Other includes lead acid batteries, flow batteries, super capacitors, compressed air storage, flywheel energy storage and sodium sulphur batteries

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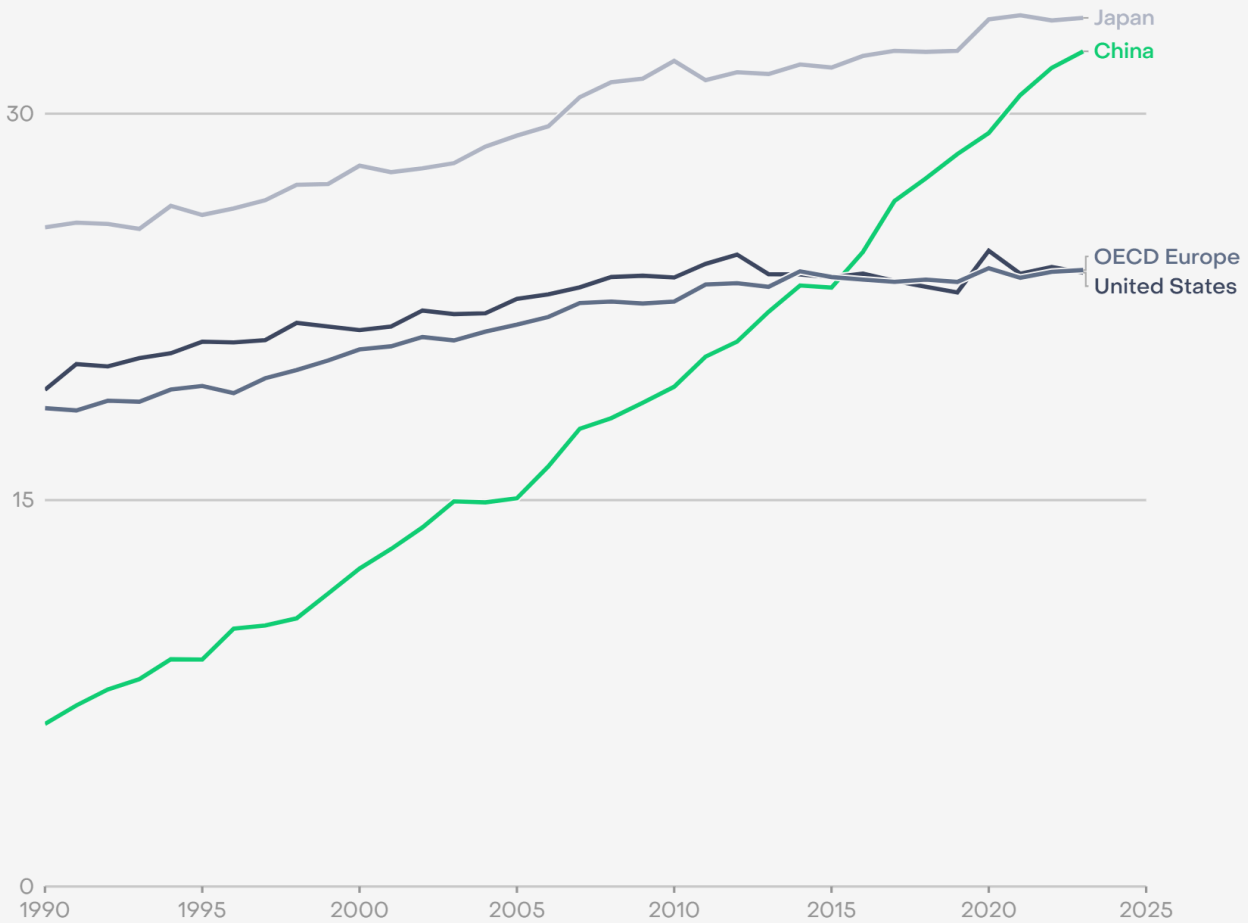
This surge brought China's new-type energy storage capacity to over 30 GW in 2023 – achieving its [2025 target](#) two years early. By the end of 2024, total capacity exceeded 78 GW, with batteries overtaking pumped hydro as the largest source of storage. At the end of H1 2025, battery capacity had [climbed](#) to 95 GW – up 69% year-on-year.

Broadening demand – electrification's expanding frontier

China's transition is advancing on the demand side, with electricity claiming a growing share of final energy use and displacing fossil fuel use. From 2015 to 2023, electricity's share of final energy consumption grew by 1 percentage point per year to stand at 32% in 2023 – well above the US (24%) and OECD Europe (24%). Together with clean generation, rapid electrification is key to rewiring the economy for deep, long-term decarbonisation.

China charges into the electrification era

Share of electricity in final energy consumption (%)



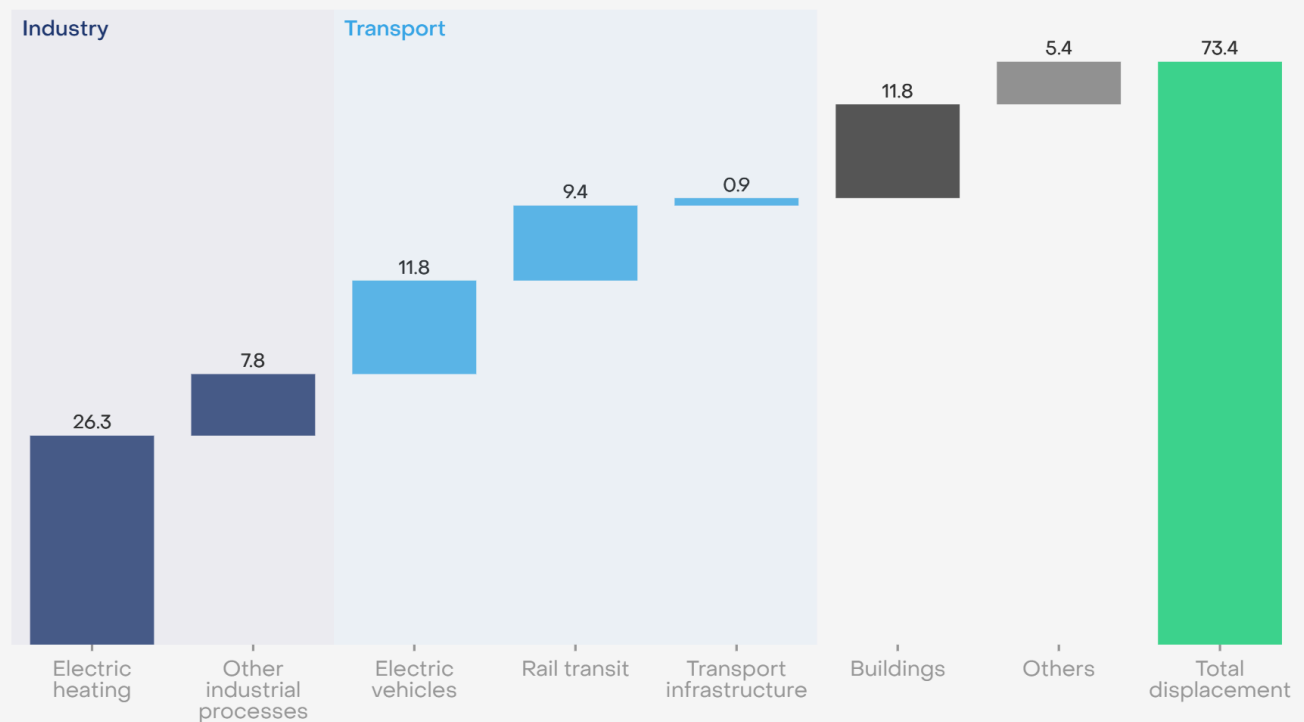
Source: IEA World Energy Balances
Excludes consumption for non-energy use

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Industrial sparks, electric wheels and heating power lead China's electrification. In 2023, [end-use electrification](#) added 73 TWh of new electricity demand, directly replacing fossil-fuel consumption, according to the China Electricity Council (CEC). Industry led the way, replacing coal and other fossil fuels with electric kilns and boilers, adding 34 TWh. Transport followed, with rapid EV adoption and expanded subway and rail systems substituting 22 TWh for oil products. In buildings, roughly 12 TWh of electricity replaced fossil fuels, primarily by substituting loose coal heating in northern China with low-carbon technologies such as heat pumps and geothermal systems.

Industry and transport drove 85% of electrification-led fossil fuel displacement in China in 2023

Electricity used to displace fossil fuels (TWh)



Source: Developed based on China Electricity Council's China Power Sector Annual Development Report (2024). Notes: Electricity substitution in buildings includes the replacement of fossil fuels for heating, cooking, hot water, and other end uses.

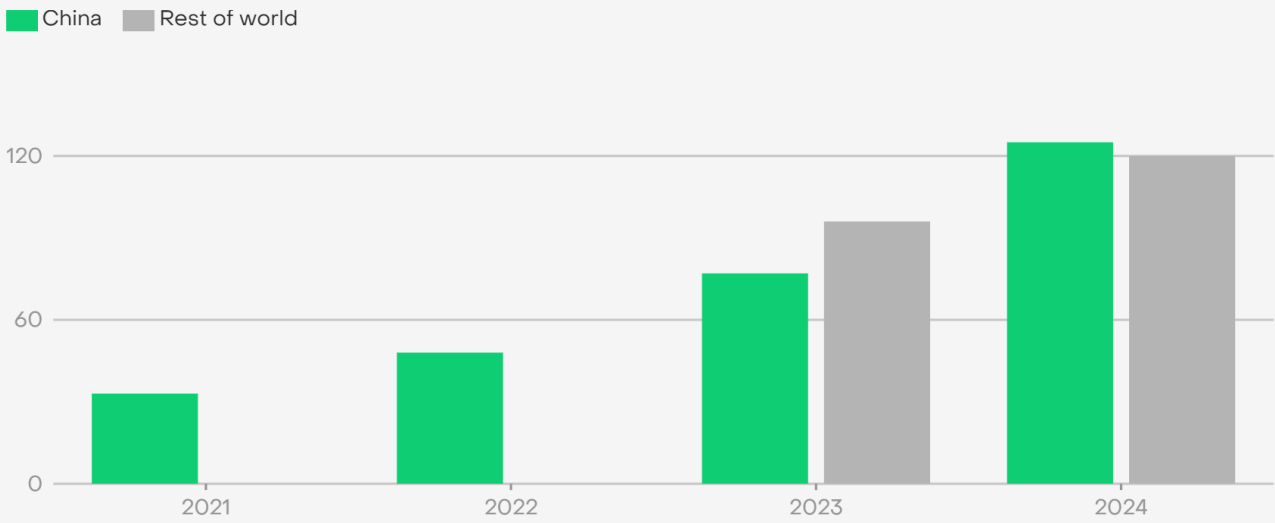
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As the most accessible electrification opportunities have been tapped, China is shifting towards emerging levers for tackling more complex end uses. [Electricity substitution in 2023](#) was well below the 2019 level (over 200 TWh), mainly because much of the low-hanging fruit had already been captured, such as phasing out loose coal in residential heating and electrifying basic industrial applications, especially low- to medium-temperature heating in textiles, food and light manufacturing.

Now, attention is turning to harder-to-abate sectors such as steel, cement and chemicals. Here, green hydrogen is gaining momentum. In 2024, the global renewable-based hydrogen sector added over [70,000 tonnes/year](#) of production capacity, up 42% from the previous year. China accounted for more than 60% of this growth, lifting its renewable-based hydrogen production capacity to just over [125,000 tonnes/year](#) – up from virtually zero just a few years ago.

China is now home to half the world's green hydrogen capacity

Green hydrogen production capacity (thousand tonnes/year)



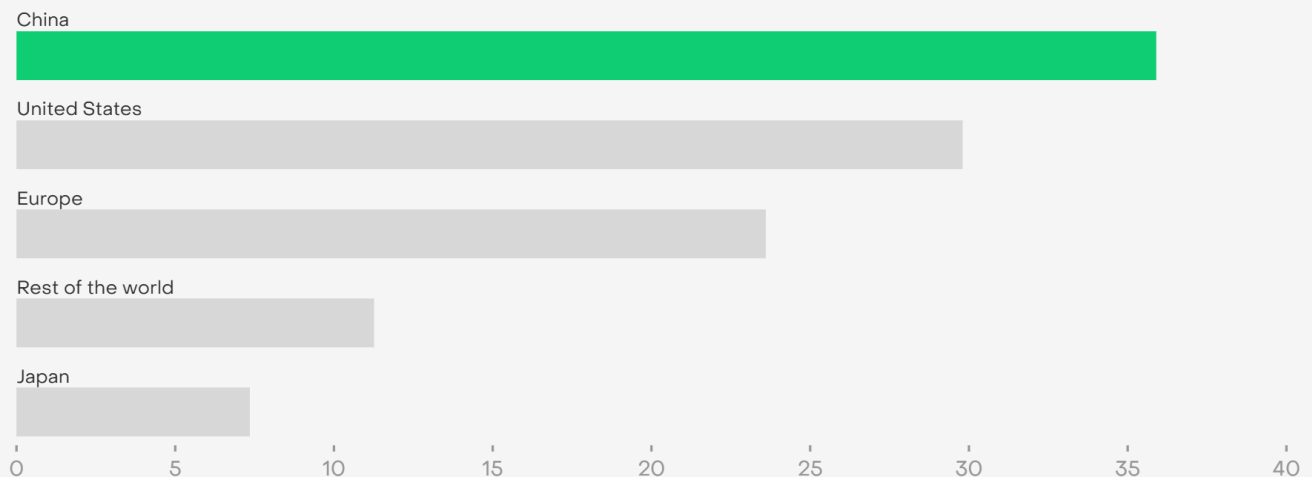
Source: Estimated by the authors based on information obtained from China Hydrogen Development Report (2025). · Notes: Data on renewable hydrogen production capacity for the rest of the world in 2021 and 2022 are not available.

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Heat pumps have emerged as a key solution due to their high energy efficiency. These systems typically consume [three-to-five times less energy](#) than conventional electric or fossil-fuel heating. China has quickly become the world's largest heat pump market, accounting for roughly one-quarter of global sales between 2021 and 2023. This momentum continued in 2024, with Chinese sales over 20% higher than the United States – the second-largest market – and more than 50% above Europe.

China is powering efficiency by leading the global rollout of heat pumps

Heat pump sales in 2024 (GW)

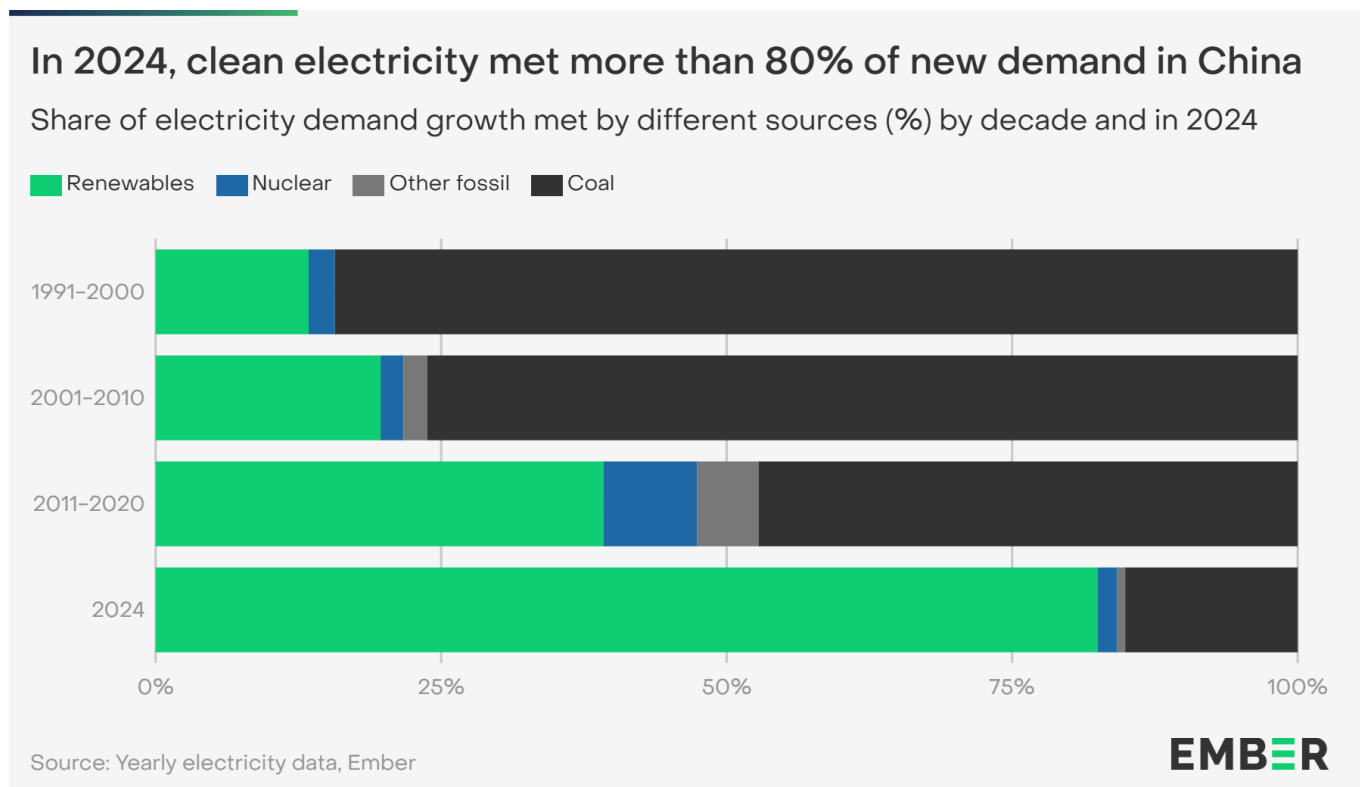


Source: Estimated by the authors based on information obtained from IEA's Future of Heat Pumps in China report and IEA's Global Energy Review report (2025)

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Beyond addition – fossil fuel peaking is in sight

China’s accelerating shift to renewables is driving structural change in the power sector, with coal generation now nearing its peak. In 2024, clean electricity sources – led by wind and solar – met [84% of China’s new power demand](#), up sharply from just 16% during 1991–2000, 22% during 2001–2010, and 47% during 2011–2020.

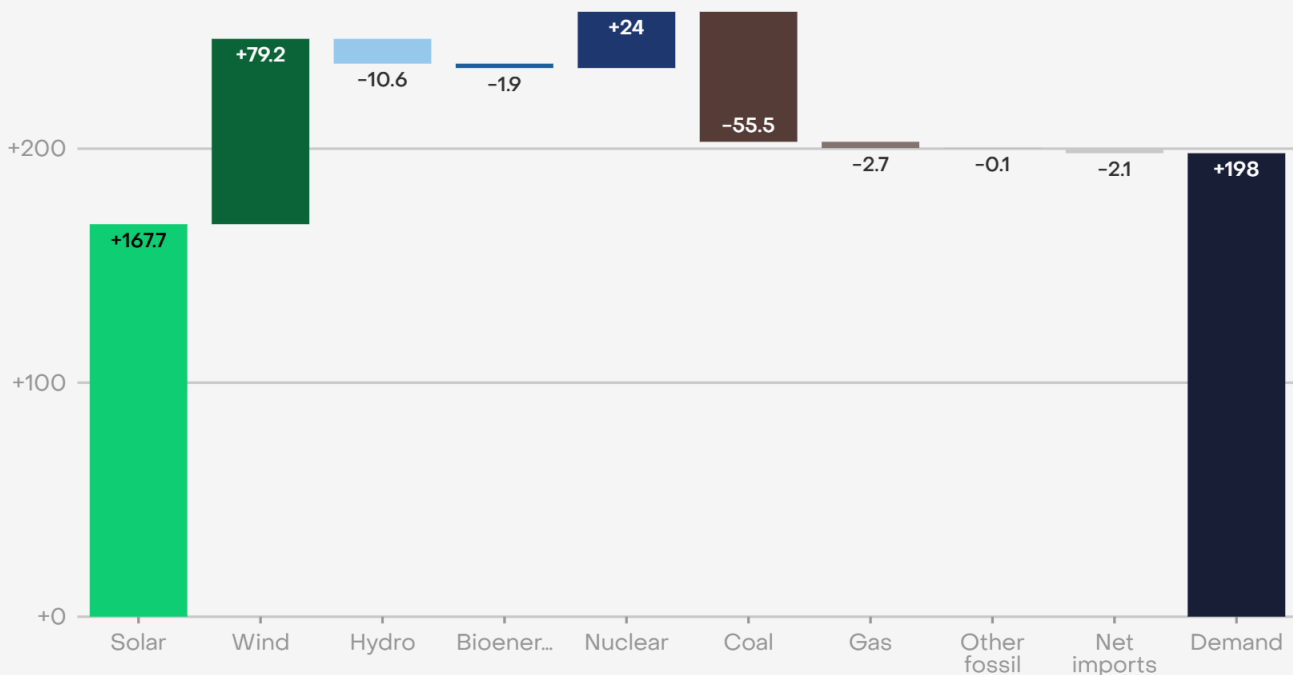


If current trends continue – and, as the next chapter shows, they are highly likely to – the era of “more renewable, more coal” is ending. This challenges the view advanced in some quarters that China’s progress is merely [“energy addition”](#) – stacking renewables atop a still-growing coal base.

Some analyses suggest that the [turning point could arrive this year](#): early 2025 data supports this. Wind and solar generation combined was 27% higher in H1 2025 than H1 2024, with wind up 16% and solar 43%. This contributed to a [2% decline in thermal generation](#) from H1 2024 to H1 2025. While uncertainties remain over economic restructuring and exports, coal power could peak in coming years, depending on economic growth, hydro availability and export demand – likely followed by a short, uneven plateau before structural decline.

China's strong solar and wind growth outpaced rising demand in H1 2025 – cutting fossil generation

Year-to-date change, H1 2025 (TWh)



2024 Demand: 10,073 TWh
Source: Monthly electricity data, Ember

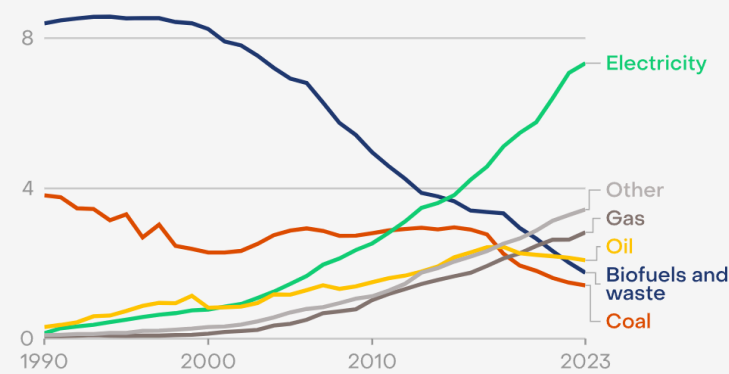
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On the demand-side, electrification is pushing fossil fuel use towards a peak across key sectors. In buildings, coal has largely been displaced by electricity, primarily through the widespread adoption of electric heaters. In industry, electricity overtook coal in 2023 to become the largest final energy source. In both sectors, fossil gas use has grown modestly – particularly in northern China’s centralised heating networks and at industrial sites – but volatile gas prices, [distribution challenges](#) and [concerns over import dependence](#) are likely to limit its further expansion. In transport, petroleum remains the dominant fuel, yet early signs of plateauing – and even decline – are emerging as electric vehicle deployments accelerate.

Electrification is driving a peak in direct fossil fuel consumption in China across a range of sectors

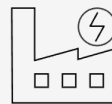
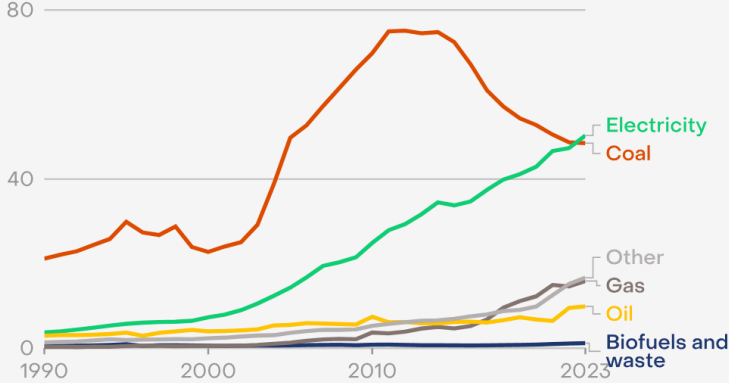
Final consumption by sector (excluding feedstocks for non-energy use), 1990–2023 (EJ)

Buildings



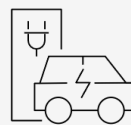
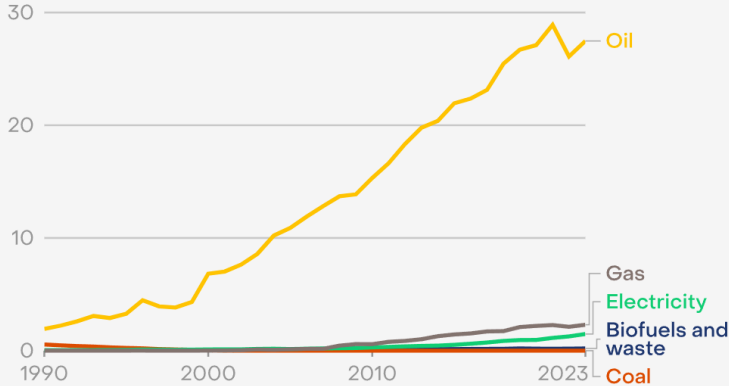
Electricity has played an increasingly important role in final energy consumption in buildings – overtaking coal in 2012 and bio molecules just three years later, in 2015.

Industry



Electricity has overtaken coal as the main source of final energy in the industrial sector – a significant milestone, as industry is the largest energy-consuming sector.

Transport



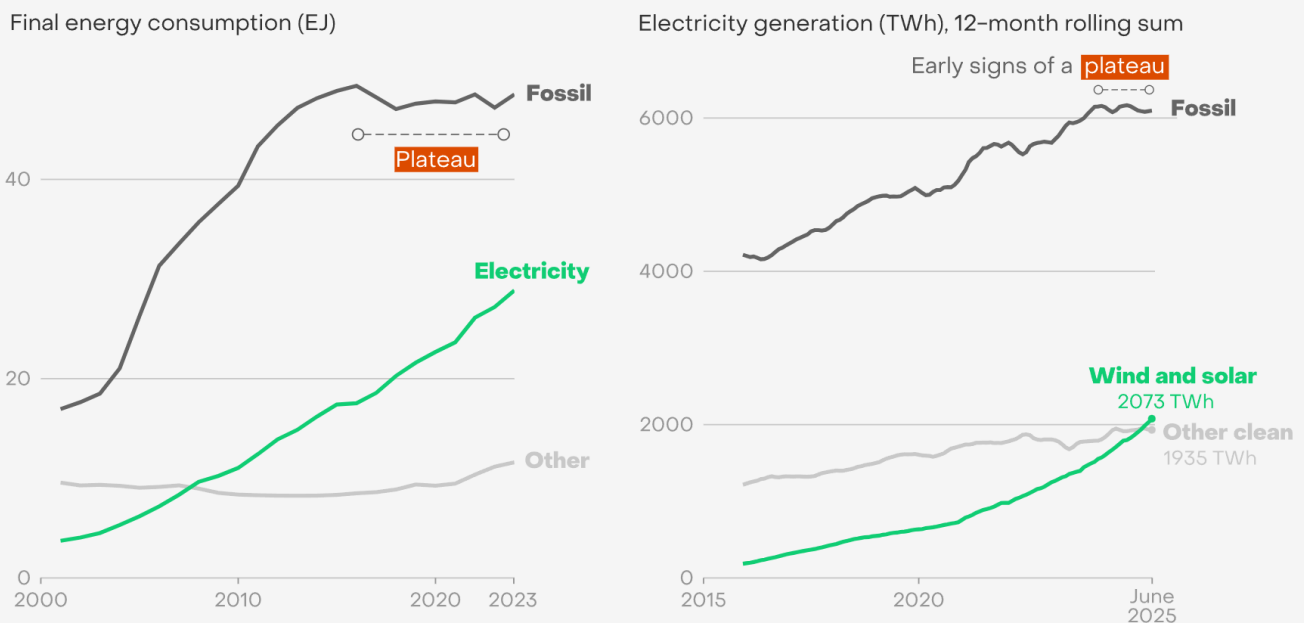
In the transport sector, while petroleum products still dominate, there is a clear and accelerating trend toward electrification, driven largely by the rapid adoption of electric vehicles.

Source: IEA World Energy Balances · Note: Figures presented in the chart exclude fossil fuel feedstocks used for non-energy purposes; other includes heat, geothermal, and solar thermal.

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Together, these shifts are driving a plateau in direct fossil fuel use across the Chinese economy, reversing the steep growth trend of 4.7% per year seen in the decade to 2015. Final fossil fuel consumption (excluding non-energy use) touched a high of 49 exajoules (EJ) in 2015 and subsequently declined by 1.7% (0.2% per year) to 2023. Meanwhile electricity use has risen steadily, reaching nearly 29 EJ in 2023 – underscoring electricity’s rising centrality in China’s evolving energy system.

China's rapid electrification and rising solar and wind power will soon drive down its fossil fuel use



Source: IEA World Energy Balances, Monthly electricity data, Ember
 Final energy consumption: 'Other' includes biofuels, heat, geothermal and solar thermal. Final energy consumption from fossil refers to the on-site burning of fossil fuels or other energy sources for heating, transportation, or other purposes. Non-energy use of fossil fuels is excluded in the figure.
 Electricity generation: 'Other clean' includes bioenergy, nuclear and hydro.



Momentum continues – progress beyond 2024

With fossil fuel peaking on the horizon, the key question is whether China can sustain this momentum. Early 2025 data suggests yes.

In the first half of 2025, wind and solar additions were more than double those in the same period of 2024. For comparison, the 213 GW of new solar exceeded total US solar capacity at

the end of 2024 (176 GW), while the 52 GW of new wind was nearly equal to all wind capacity in Latin America and the Caribbean (55 GW). This surge pushed China's combined installed capacity to [surpass coal](#) for the first time, while – as noted above – [fossil generation fell](#).

Although declines in fossil generation have occurred in other six-month periods over the past decade, H1 2025 stands out: it did not coincide with [unusually high hydro generation](#), nor was it driven by an economic shock like the global financial crisis or Covid-19 lockdowns. With [industrial production up](#) 6.4% and broader economic activity stable, [electricity demand rose](#) 3.7% – yet fossil generation declined, consistent with, though not definitive proof of, a structural shift.

Demonstrating the central role of wind and solar power in pushing out fossil generation, combined generation from wind and solar (2,073 TWh) overtook generation from hydro, nuclear, and bioenergy combined (1,936 TWh) in the 12 months to June 2025. Just four years previously, over the 12 months to June 2021, wind and solar generated only half as much electricity (867 TWh) as these other clean sources combined (1,764 TWh).

While the wind and solar capacity boom in H1 2025 was partly driven by companies rushing to install before a June reduction in policy support – and grid bottlenecks and integration pressures have increased – signs point to sustained momentum in the transition.

In the first half of 2025, [investment in key national energy projects](#) – including offshore wind and grid upgrades – rose by 22% year-on-year, and [new-type energy storage](#) jumped 69%. The pipeline of large-scale [wind and solar now exceeds 1 TW](#) – over twice the EU's combined installed capacity. Beyond capacity expansion, market reforms are also advancing: China is on track to launch a [unified national power market](#) by the end of 2025, with [efforts to normalise cross-regional trading](#), ensure full renewable participation and strengthen regulatory oversight.

This raises a deeper question: What explains China's ability to maintain such a strong and sustained commitment to the transition? The answer defies simple explanation. While economic benefits like investment and job creation clearly play a role, they do not fully account for the depth of this commitment. More fundamental strategic considerations are at work – and these are the focus of the next chapter.

Chapter 2

China's perspective: From clean energy to powering future prosperity



Interviews with China experts conducted for this report show that for China, the clean electricity transition involves more than decarbonisation – it is a strategic pivot to reimagine development. As the fossil-fuelled growth model – once central to China's economic rise – reaches its limits, the country is pioneering a pragmatic, phased path to "green growth," where environmental and economic goals reinforce each other. This dynamic is creating self-sustaining momentum, towards China's broader ambition to build an "ecological civilisation" – aligning long-term prosperity with sustainability.

Within China, the rationale for China's clean energy transition extends far beyond climate concerns or the falling costs of electro-technologies. Official documents and expert conversations reference the growing belief that the fossil fuel economy has run its course, and that it can and should be replaced by a new, better system centred on manufactured goods that generate and run on renewable electricity. Government plans for the energy transition treat it as a progressive transformation, unfolding over decades, that addresses socioeconomic and environmental goals simultaneously. The multiple benefits already being realised make a slowdown highly unlikely.

For this chapter, we interviewed leading experts on China’s energy transition, both within and outside China. Their insights have shaped our analysis, appearing both in selected quotes and throughout the text.

Contributors include:

- Dr. Philip Andrews-Speed: Senior Research Fellow, Oxford Institute for Energy Studies, UK
- Prof. Pan Jiahua: Director, Institute of Eco-civilization Studies, Beijing University of Technology, China
- Caroline Wang: China Lead, Climate Energy Finance, Australia
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- Prof. Yang Lei: Deputy Dean, Institute of Energy, Peking University, China
- Prof. Yuan Jiahai: Professor of Management Science, North China Electric Power University, China
- Prof. Zhang Yongsheng: Director General, Research Institute for Eco-civilization, Chinese Academy of Social Sciences (CASS), China

Strategic reorientation – the ‘why’ of China’s energy transition

The fossil fuel-based model that powered China’s “economic miracle” is no longer sustainable, socioeconomically or environmentally. From 1978 to the early 2010s, [China’s GDP grew](#) by about 10% annually, lifting hundreds of millions out of poverty and turning China into the manufacturing capital of the world, in tandem with [a six-fold rise in coal consumption](#) and a [five-fold increase](#) in both coal production and oil use.

Today, this model faces mounting constraints on growth, wellbeing, and competitiveness. Energy security is a key concern: [oil import dependence](#) has exceeded 70% since the mid-2010s, and [about 40% of gas is imported](#), exposing China to supply and price risks. China has sought to mitigate these risks by [diversifying import sources](#) while promoting domestic coal production. This strategy is rooted in the prevailing view of coal as the bedrock of energy security – captured in the often-cited phrase [“rich in coal, short of oil, and low in gas.”](#) (富煤贫油少气)

Yet, even coal, once considered an important buffer, is now facing growing constraints. By the end of 2021, China's proved [coal reserves](#) were estimated at 208 billion tonnes, while [annual consumption](#) hit 4.9 billion tonnes in 2024. So even assuming full extractability, current reserves might only last another 30 to 40 years at current rates of use.

Environmental costs are also mounting. Despite decades of efforts to improve energy efficiency and control pollution, degradation continues: air and water pollution, hazardous [smog](#), and carbon emissions – which [doubled in just under two decades](#) to reach one-third of the global total.

Over the past four decades, China achieved what many describe as an economic miracle, primarily driven by a traditional model of industrialisation and urbanisation. Yet if this model delivered such remarkable growth, why is China now so committed to transforming it? The answer is clear: while the old approach brought prosperity, it came at an unsustainable cost – excessive energy consumption, heavy emissions and mounting ecological pressures. That's why the shift to a low-carbon economy is no longer optional; it's essential.

And we have to remember – the energy sector isn't just one economic sector among many. It's the foundation of the entire industrial economy. Fossil fuels have powered everything from manufacturing to transportation. Transitioning to clean energy, then, isn't merely about reducing emissions; it actually creates the momentum to reshape China's entire development model and industrial ecosystem.



Prof. Zhang Yongsheng

Director General, Research Institute for Eco-civilization,
Chinese Academy of Social Sciences (CASS)

Strategic shift: towards an “ecological civilisation.” Recognising that the fossil-fuelled growth paradigm has reached its limits, China’s top leadership increasingly views the energy transition as an opportunity to redefine development.

For decades, climate action in China, as in many countries, was framed as a trade-off between environmental gains and economic sacrifice, encapsulated in the argument that [“the right to emit is equal to the right to develop.”](#) Underlying this lies an ethical paradox: how can developing economies reconcile their legitimate aspirations for prosperity with the reality of finite planetary boundaries?

The clean energy transition offers a solution. It ensures domestic energy security, provides affordable power, enables industrial upgrading and facilitates supply chain expansion. In short, it is a better way to develop, reducing the environmental pressures of the fossil fuel age while creating new opportunities for sustainable growth.

China has woven its transition ambitions into its long-term vision of an [“ecological civilisation.”](#) (生态文明) First proposed in 2007 and embedded in the constitution in 2018, this vision emphasises [“harmony between humanity and nature”](#) and upholds the belief that [“lucid waters and lush mountains are invaluable assets.”](#) At its core, it champions [green development](#), with environmental goals and green electrification serving as [“systemic”](#) levers – addressing environmental challenges while unlocking new avenues for economic growth and global competitiveness.

For China, pushing this transition does two big things. First, it locks in China’s role as the global manufacturing hub for the clean energy age. Second, it fixes a major vulnerability – reliance on imported fossil fuels. And China is serious about this shift. When it sets a direction and commits, it rarely turns back.



Prof. Christoph Nedopil Wang
Director, Griffith Asia Institute, Griffith University

Achieving this vision requires more than incremental adjustments; it demands, as articulated in the government's [White Paper on China's energy transition](#), "a broad and profound systemic transformation of the entire economic and social fabric."

China's approach has evolved from fostering clean energy technologies into a whole-economy strategy. Central to this is the ["1+N" framework](#) launched in 2021, an overarching guiding document for achieving the dual carbon goals – peaking emissions before 2030 and reaching carbon neutrality before 2060 – plus detailed action plans for sectors and regions. China systematically embedded its climate and transition goals into planning, regulation and investment across all levels of the economy, mobilising the entire economic ecosystem – from state-owned enterprises to private-sector innovators and investors – to capture value from the clean energy transition.

Pragmatic implementation – the 'how'

China has adopted a pragmatic "build before break" (先立后破) approach, prioritising the clean electricity build-out before phasing out fossil capacity.

This strategy recognises that a clean energy future requires a reimagining of how electricity is produced, transmitted and consumed – while balancing multiple, sometimes competing, priorities like supply reliability, affordability and the economic transition in coal-dependent regions. To this end, China has taken a progressive approach. Legacy coal plants are being repurposed from baseload to flexible backup, stabilising the grid as renewables, storage and demand response scale, while giving coal-based regional economies time to adapt.

Reflecting this shift, the National Energy Administration (NEA) stated at the 2022 Two Sessions that new coal power projects solely for electricity generation [would not be approved in principle](#), though "supportive units" of limited scale may still be built to ensure reliability. The 2022 Government Work Report called for repurposing coal power for grid flexibility and heating, facilitating renewable integration and displacing polluting loose coal. In 2024, this direction was reaffirmed with a mandate for all eligible coal units to [undergo flexibility retrofits](#) by 2027. However, recent coal permitting has still been [sizable](#), but utilisation rates and dispatch rules will determine emissions trajectories.

Some argue that China’s clean energy growth is merely “additive,” piling new renewables on top of coal, oil and gas use. But, as shown in Chapter 1, surging clean energy is driving China toward structural fossil demand decline – reducing the relevance of the “addition” argument.

China’s transition follows a “build before break” approach – ensuring that new clean systems are in place and reliable before phasing down the old. Like a child learning to walk, stumbles are inevitable; they are signs of progress, not failure. But if not well managed, these early missteps – such as supply disruptions or price spikes – could trigger public backlash and slow momentum. That’s why China is keeping parts of the legacy fossil system, especially coal, in a stabilising role. Rather than driving the system, coal is increasingly acting like training wheels – providing balance and backup while the clean electricity system gains strength and confidence.



Prof. Yuan Jiahai
Professor of Management Science,
North China Electric Power University

Pragmatic and sustained efforts have helped make clean innovations market-ready.

China, like other countries, follows a deliberate sequence: introducing and supporting emerging technologies, scaling them up and eventually mainstreaming them. A distinguishing feature is the interplay between deployment and manufacturing, supported by phased and coordinated policies advancing both in parallel. Sequencing helps, but rapid target-driven growth can still produce boom-bust cycles; though market signals and exit pathways can mitigate these risks.

Beyond subsidies and regulatory incentives, China draws on a broad policy toolkit: signalling priorities through Five-Year Plans and sectoral strategies, funding early-stage research, supporting pilot projects and fostering integrated industrial clusters. Together, these measures create an industrial ecosystem where companies collaborate and compete across the value chain.

China's clean energy rise has been driven as much by market-building as by technology. For example, with solar generation now firmly established, a major [pricing reform](#) came into force on 1 June 2025 which moved renewables away from fixed feed-in tariffs to market-based pricing. For EVs, [purchase subsidies were reduced](#) by 30% annually from 2020 and fully phased out by the end of 2022.

The “build before break” approach draws on lessons from China's own reform experience, such as the dual-track pricing system in the 1980s, which introduced market elements without immediately upending the planned economy. This incremental reform enabled new systems to gain strength and legitimacy while ensuring stability.

Today, a similar logic applies: the growth of clean energy, EVs, and new power systems builds confidence, lowers resistance, and gradually reshapes the legacy structures – turning reform into an opportunity rather than disruption.

“Crossing the river by feeling the stones” remains effective. The zero-carbon industrial park initiative, proposed by the central government late last year, is one such practice, representing a breakthrough in business models and mechanisms. In the face of unprecedented challenges, it remains wise to cross the river by “feeling the stones of others”: continuous learning from international pioneers is one of the key means for China to continue its energy liberalisation reforms.



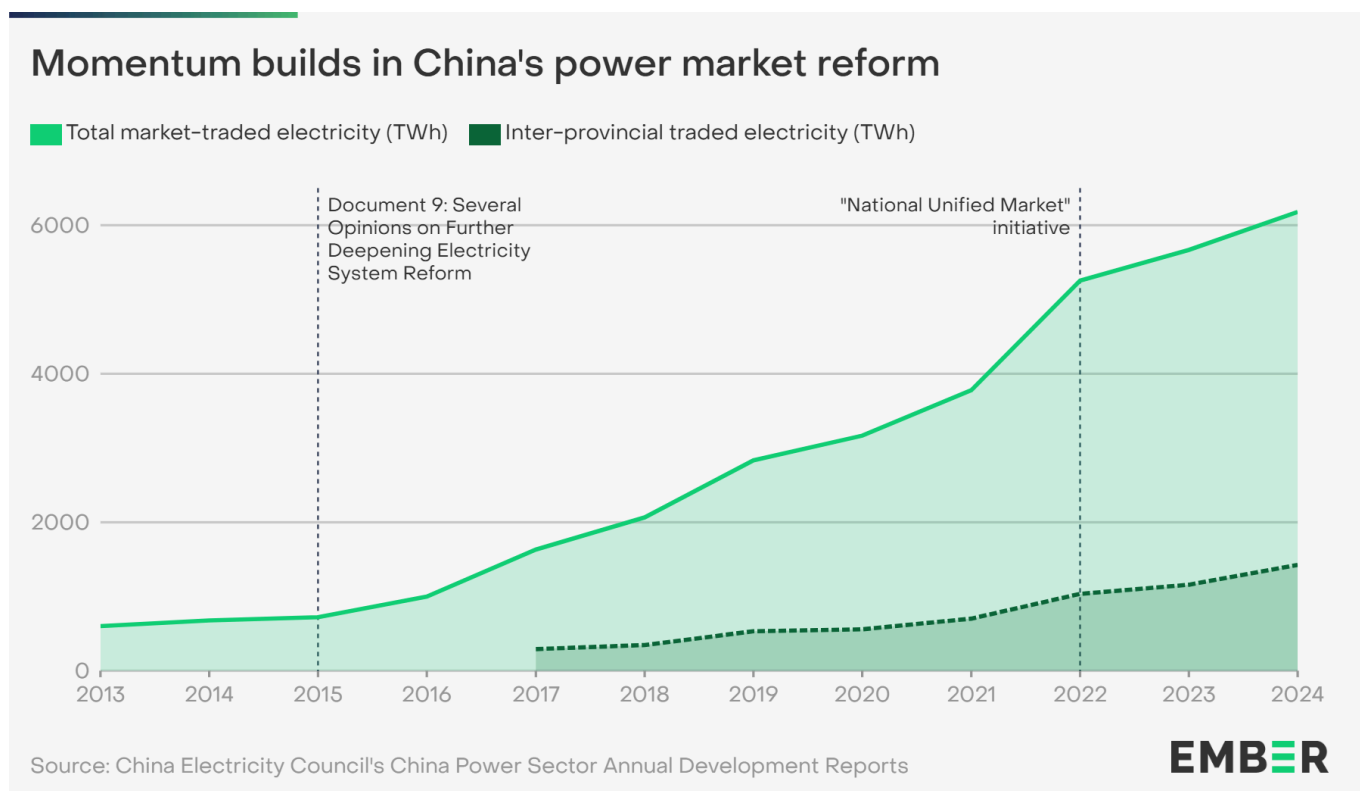
Prof. Yang Lei

Deputy Dean, Institute of Energy, Peking University

Electricity trading provides an illustration of China's iterative, long-term policy making.

As China transitions toward a generation mix based on variable wind and solar power, expanding market-based electricity trading allows supply and demand to be balanced more efficiently – both in real time and across regions.

By 2024, more than 6,100 TWh of electricity – equivalent to 63% of total electricity consumption – [was traded through market mechanisms](#). This marks an eightfold increase from 2015 and nearly a doubling of volume since 2020. Inter-provincial trading has grown particularly fast, reaching 23% of market-traded electricity in 2024. Nearly all provinces have launched pilot spot markets, and as of August 2025, spot markets in several pioneer provinces – including Shanxi, Shandong, Guangdong, Gansu, Western Inner Mongolia and Zhejiang – plus inter-provincial markets have achieved full commercial operation. Coverage is expanding but not yet nationwide; inter-provincial alignment remains a work in progress.



Spot trading is vital for integrating variable renewables, providing dynamic, real-time pricing and dispatch to manage fluctuations. Spot trading, alongside cross-regional exchange, is expected to expand rapidly in the coming years, driven by sustained policy action.

By the end of 2025, China aims to complete the [initial framework of the unified national electricity market](#). By 2029, the plan is to fully establish the unified market, ensuring consistent market mechanisms and fair regulatory oversight nationwide. This will mark the culmination of a 15-year process, stimulated by myriad policy steps on a coordinated nationwide basis, enabling Chinese consumers and businesses to gain full benefit from the growth of wind and solar generation.

Spot markets gain ground with full operation in six of China's provinces

Progression stages for the implementation of electricity spot markets (as of mid-August 2025)

Province	Simulation	Short-term settlement trial	Long-term settlement trial	Continuous settlement trial	Formal operation
Gansu	█	█	█	█	█
Guangdong	█	█	█	█	█
Hubei	█	█	█	█	█
Inner Mongolia (West)	█	█	█	█	█
Shandong	█	█	█	█	█
Shanxi	█	█	█	█	█
Zhejiang	█	█	█	█	█
Anhui	█	█	█	█	
Hebei (South)	█	█	█	█	
Liaoning	█	█	█	█	
Shaanxi	█	█	█	█	
Chongqing	█	█	█		
Fujian	█	█	█		
Guangxi	█	█	█		
Guizhou	█	█	█		
Hainan	█	█	█		
Heilongjiang	█	█	█		
Hunan	█	█	█		
Jiangsu	█	█	█		
Ningxia	█	█	█		
Sichuan	█	█	█		
Yunnan	█	█	█		
Henan	█	█			
Inner Mongolia (East)	█	█			
Jiangxi	█	█			
Jilin	█	█			
Qinghai	█	█			
Shanghai	█	█			
Xinjiang	█	█			

Source: 2024 Annual Electricity Market Report, supplemented with updates gathered by the authors ·
 Note: Spot markets allow electricity to be traded close to real-time, helping balance short-term variations in supply and demand more efficiently.

The future – the “growing-by-greening” dynamic

China’s pursuit of a new development model powered by clean energy is becoming a key engine of economic progress. Rapid and still-accelerating deployment of products such as solar panels, wind turbines, batteries and EVs has turned these clean energy [electro-technologies](#) into a [new driver of GDP growth](#).

While growth in traditional industries has slowed, new technology sectors are surging ahead. In 2024, the “new” economy – including high-tech, clean electro-technologies, and other innovation-driven sectors – contributed more than [18% of China’s GDP](#), up from [17%](#) in 2020. This surge has been particularly driven by the rapid rise of the clean energy sector. Led by the “[new three](#)” – solar panels, batteries and EVs – this sector expanded [three times](#) faster than the overall economy in 2024, contributing [13.6 trillion RMB](#) (\$1.9 trillion USD) to the country’s economic output – an amount comparable to the annual GDP of Australia. Moreover, growth in clean energy technologies like EVs is generating broader economic synergies by boosting demand for related sectors such as IT services and digital infrastructure.

Sectors like EVs have allowed China to fast-track development and build competitive supply chains at scale. Many Chinese companies quickly recognised the policy direction and acted decisively. What we’re seeing is a dynamic ecosystem where policy clarity, entrepreneurial drive, and industrial capability come together to deliver results.



Dr. Philip Andrews-Speed
Senior Research Fellow,
Oxford Institute for Energy Studies

Outside China, the accelerating clean energy transition is creating unprecedented global demand for equipment and supply chains – much of which is met by Chinese firms. The scale of the global transition is so large that some observers refer to a [“new industrial revolution.”](#) Between 2020 and 2024, annual global investment in the transition – spanning renewable energy, grid infrastructure, electrified heating, and EVs – more than doubled, from about \$930 billion to over [\\$2 trillion](#). Supply chain investment grew even faster, quintupling from \$32 billion in 2020 to [\\$140 billion](#) in 2024.

This global surge reinforces the economic rationale for China's pivot from traditional growth sectors to [“New Quality Productive Forces,”](#) (新质生产力) with innovation-driven sectors such as advanced manufacturing and clean energy at the core.

This has created a powerful feedback loop, a [“growing-by-greening”](#) dynamic – a self-reinforcing cycle that propels China's energy transition forward with increasing velocity. It is like steering a vast ship – it takes time to change course, but once the course is set, the momentum becomes self-sustaining and difficult to reverse – and the rationale for reversing becomes increasingly absent.

Building on the early success of the “new three,” China is now pursuing a broader goal of constructing a comprehensive clean energy system. This is creating demand for innovative solutions to manage long-duration variability in renewable output, electrify harder-to-abate sectors, and address residual emissions.

The deployment of such technologies not only supports a deeper electricity transition but also opens new frontiers for high-value industries, complementing those already established. This dynamic is helping embed the clean energy transformation into China's broader economic restructuring and reinforce the shift towards high-quality, innovation-led growth.

Things like solar, batteries, and electric cars don't have the super high technical and investment barriers that big fossil fuel or hydro projects do. That makes it easier for lots of players, including private companies, to get involved and push the transition forward.

Besides, clean energy has become a real engine for the economy. It's creating lots of jobs and driving growth, so it makes sense to keep expanding it. And on top of that, the transition ties in with other important goals, like poverty reduction.

China's energy transition is pretty much unstoppable now, and going back just makes no sense.



Prof. Pan Jiahua

Director, Institute of Eco-civilization Studies,
Beijing University of Technology

Early progress has turned the transition into a shared national project. The early gains are already reshaping the landscape: millions of green jobs created, tangible [environmental improvements](#) (including a [41% fall](#) in fine particulate air pollution 2013–2022), and consumer-friendly innovations like smart EVs. These changes have fostered strong public backing for the energy transition. A survey jointly conducted by UNDP China and the Nanjing Institute of Environmental Sciences found that clean energy, including solar and wind, is the [most popular climate solution](#), supported by over 90% of respondents. While this support may vary across regions due to China's vast social and economic diversity, it nonetheless reflects a general and widespread tendency towards public endorsement of clean energy development.

Recent deployment figures vindicate this optimism. In 2024 China added almost exactly 1 GW of solar and wind capacity per day (358 GW across the year) – a pace equivalent to building a typical nuclear reactor every single day. Crucially, this wasn't due to a handful of megaprojects but millions of decentralised choices across rooftops, villages and small businesses, in addition to utility-scale developments.

Private firms are leading the most dynamic segments of the transition, particularly in EVs, batteries and renewables. These sectors are not led by legacy energy giants but by private firms, often emerging from IT and consumer tech enterprises.

What's really driving China's transition now isn't just big state projects – it's the mix of private innovation, tech partnerships, and everyday choices. Battery makers, solar pioneers, and EV leaders are working hand-in-hand with tech companies to deliver smarter, faster, and more efficient solutions for users. Families are putting panels on their rooftops, while businesses are investing in clean tech R&D, and even adopting carbon footprint tracking software. When industry, technology, and citizens all move in the same direction, you get a society-driven transition – it's a movement everyone's



Caroline Wang
China Lead, Climate Energy Finance

When businesses see profits in sustainability, workers find quality jobs, and families experience cleaner air and smarter technologies, decarbonisation shifts from obligation to opportunity and becomes a shared national project.

At the April 2025 Leaders Meeting on Climate and the Just Transition – jointly convened by the UN Secretary-General and Brazil’s President – China [reaffirmed](#) its direction:

“The world may change, (but) China will not slow down its climate actions.”

This was more than a rhetorical gesture. It signals continued policy and financial backing for the next phase of the transition – a signal already driving tangible next steps across industries and markets.

How China's transition is reshaping the global energy landscape

The scale and pace of China's clean energy transition, in both renewable generation and end-use electrification, has major implications for other countries. These include providing an example of how a huge and still-growing industrial economy can be transformed to run on clean energy, and producing a growing supply of ever-cheaper clean energy goods for the global market.

Given the sheer scale of China's energy system, its transition is bound to have global spillover effects, redefining the context in which every other country must chart its path to future prosperity. This chapter explores three key implications. First, China expands the possible through vast manufacturing scale, innovation and rapid deployment. Second, it has converted the emerging market energy leapfrog from concept into reality. Third, by scaling electro-technologies at unprecedented speed, China is creating the conditions to bring forward the global peak, plateau and decline of fossil fuel demand.

Expands the possible, by making electro-technologies cheap and big

China expands what's possible around the world in three key ways: manufacturing electro-technologies at enormous scale, driving down costs and expanding the technological frontier. No country has built manufactured technologies – of all kinds – at the scale China

does today. Over the past 15 years, China has applied its manufacturing prowess to the core energy technologies of solar, wind, batteries, EVs and heat pumps. Together, these are technologies able to [replace over three quarters](#) of today's global fossil fuel demand.

China's electro-technology manufacturing capacity is now large, efficient and sophisticated enough to deliver the bulk of the goods needed for the global energy transition at prices affordable in most markets.

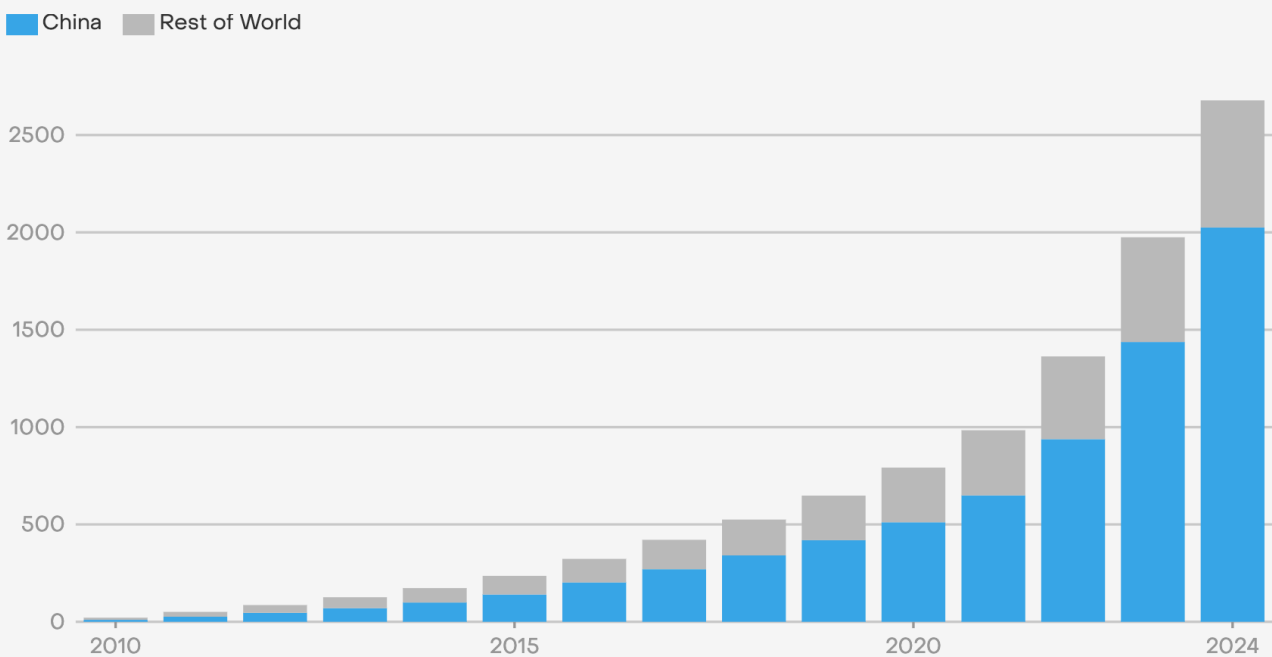
Since 2010, the costs of solar PV, wind and batteries have fallen by between 60% and 90%, increasingly matching or beating fossil-fired competition. In 2024, [91% of new wind and solar projects commissioned](#) were cheaper than the cheapest available fossil fuel alternative. The latest solar and battery prices make the combination competitive with fossil fuels [in most sunny regions](#). In [Viet Nam and India](#), the upfront costs of building a solar farm and a coal-fired power station are now comparable on a per-MWh basis, while only the coal-fired power station incurs ongoing fuel costs.

In electric vehicles, the long-standing rule of thumb has been that [battery packs at \\$100/kWh](#) achieve sticker price parity with Internal Combustion Engine (ICE) vehicles. By July 2025, Chinese battery pack prices had plummeted to around [\\$60/kWh](#). For consumers this means cheaper cars: each \$10 per kWh decline in pack prices shaves about \$500 off average-sized car production costs. In 2024, two-thirds of [electric cars sold in China](#) were cheaper than their ICE equivalents.

The core dynamics behind these global cost declines are learning-by-doing and increasing economies of scale, effects formally captured by [Wright's Law](#), which states that costs fall as a function of cumulative production. From 2010 onwards, Chinese factories have accounted for about three-quarters of global solar module production. Once expensive, these technologies are now cost-competitive – and this is largely driven by China's rapid increase in production volume.

China has driven three-quarters of solar PV manufacturing since 2010

Cumulative production of solar modules (GW)



Source: MIIT, IEA, Jäger-Waldau, Fraunhofer, Ember analysis

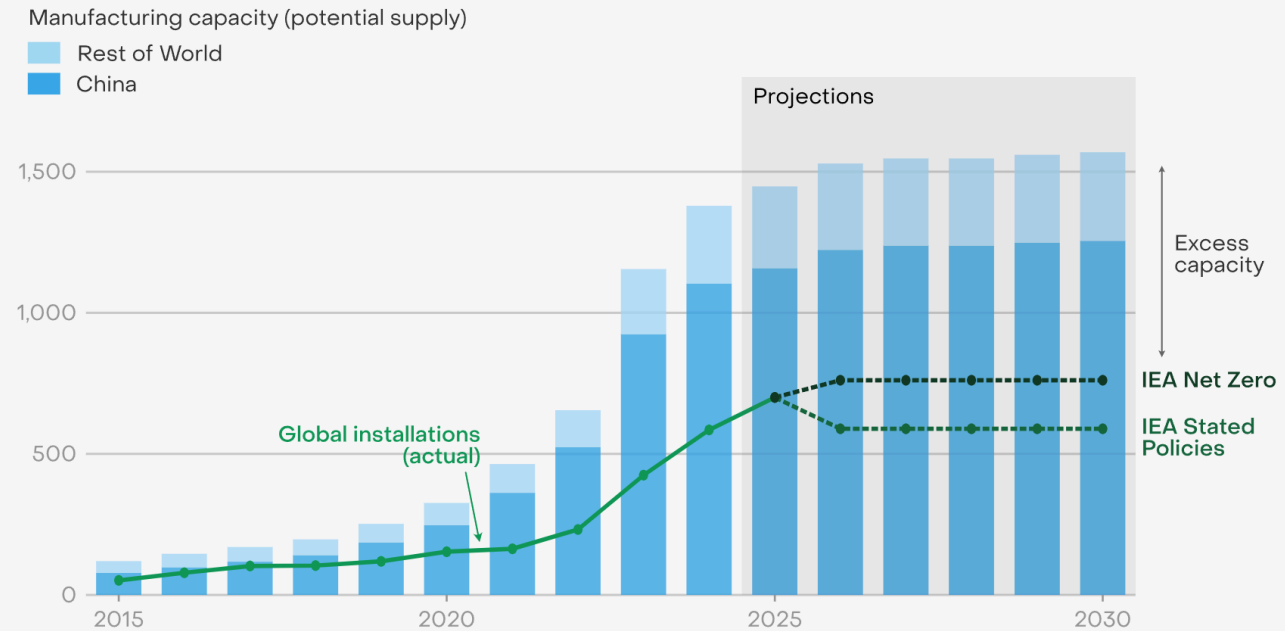
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The scale of manufacturing in China means that it has grown to dominate electro-technology supply chains. In 2024, China produced four in five [solar](#) modules and [battery](#) cells globally, more than two-thirds of [electric vehicles](#), and refined on average [seven out of ten](#) of the critical minerals that underpin them. That same year, Chinese companies also produced [over half](#) of the world's heat pumps, with a significant share destined for the export market.

But scale matters more than share. The International Energy Agency's [Net Zero Roadmap](#), one of the most widely-used pathways to limiting global warming to 1.5C, requires 761 GW of solar capacity to be added globally per year in 2030. Already today, Chinese factories alone can theoretically supply that, and [China's projected solar manufacturing capacity](#) in 2030 (1,255 GW per year) is 65% higher than the IEA Roadmap deployment figure. Batteries tell a similar story: in 2024, [Chinese battery manufacturing capacity](#) was about 2,500 GWh, over double last year's global demand. By 2030, China is [gearing up](#) for 6,300 GWh per year of battery manufacturing capacity.

China's projected solar manufacturing capacity outpaces even global net zero scenarios, promising lower prices and faster adoption

Solar PV modules, GW



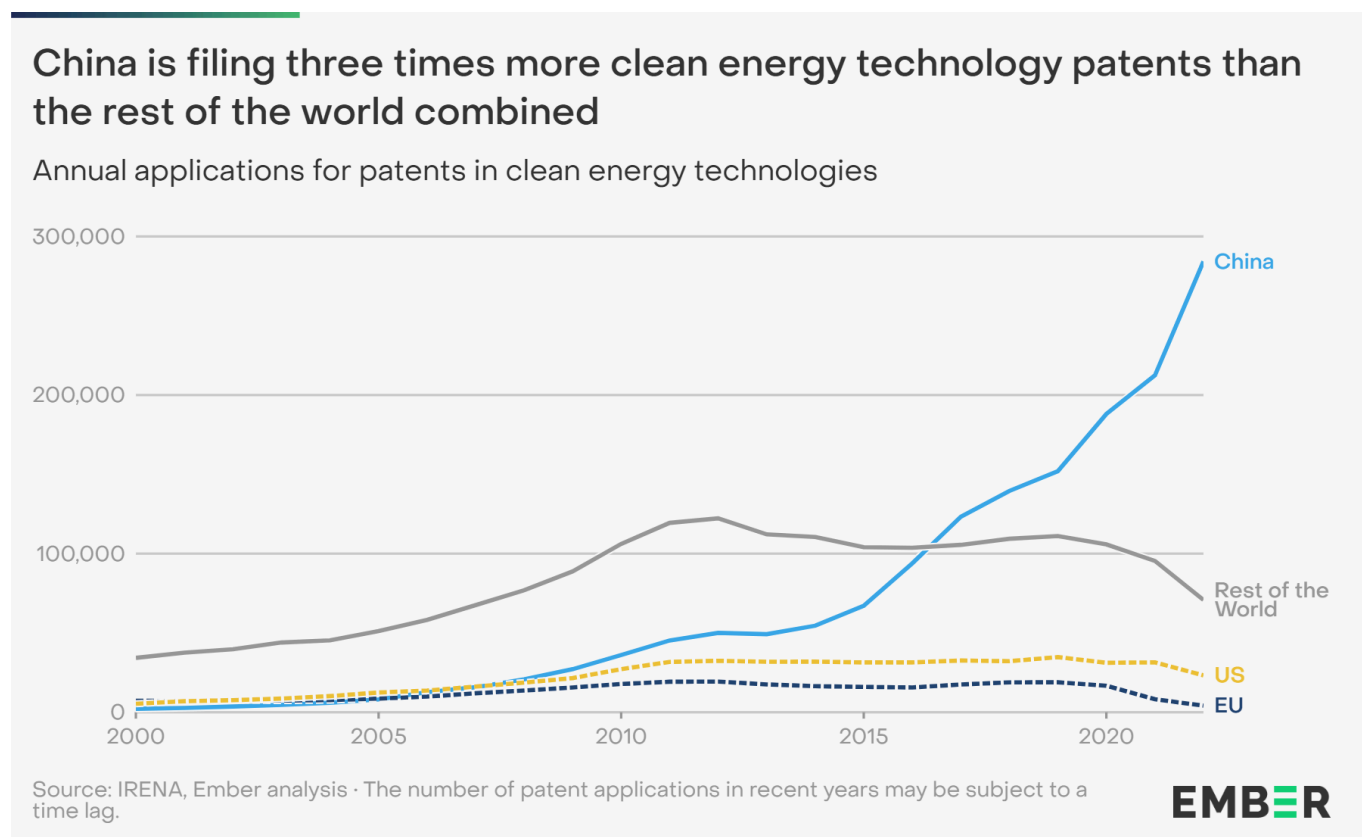
Source: IEA, Infolink, Ember analysis. 2025 estimated solar additions from BNEF. · Manufacturing capacity projections are based on Infolink.

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The result is a buyer's market: as hardware prices keep plunging, the consumer case for clean power and electric transport just keeps strengthening. The rapid scale-up has also created cyclical overcapacity, compressing margins for manufacturers and increasing consolidation risk. But, from a purely technology perspective, Chinese industrialists have made climate scenarios look attainable.

Importantly, analysts and policymakers worldwide who rely on cost figures even a couple of years old risk designing highly suboptimal technology pathways. [Studies show](#) that the costs of renewables are often overestimated in academic research. As academic conclusions frequently inform government modelling, there is a risk that governments may also overestimate energy transition costs by relying on outdated figures for technologies such as wind and solar power, battery storage, EVs and heat pumps.

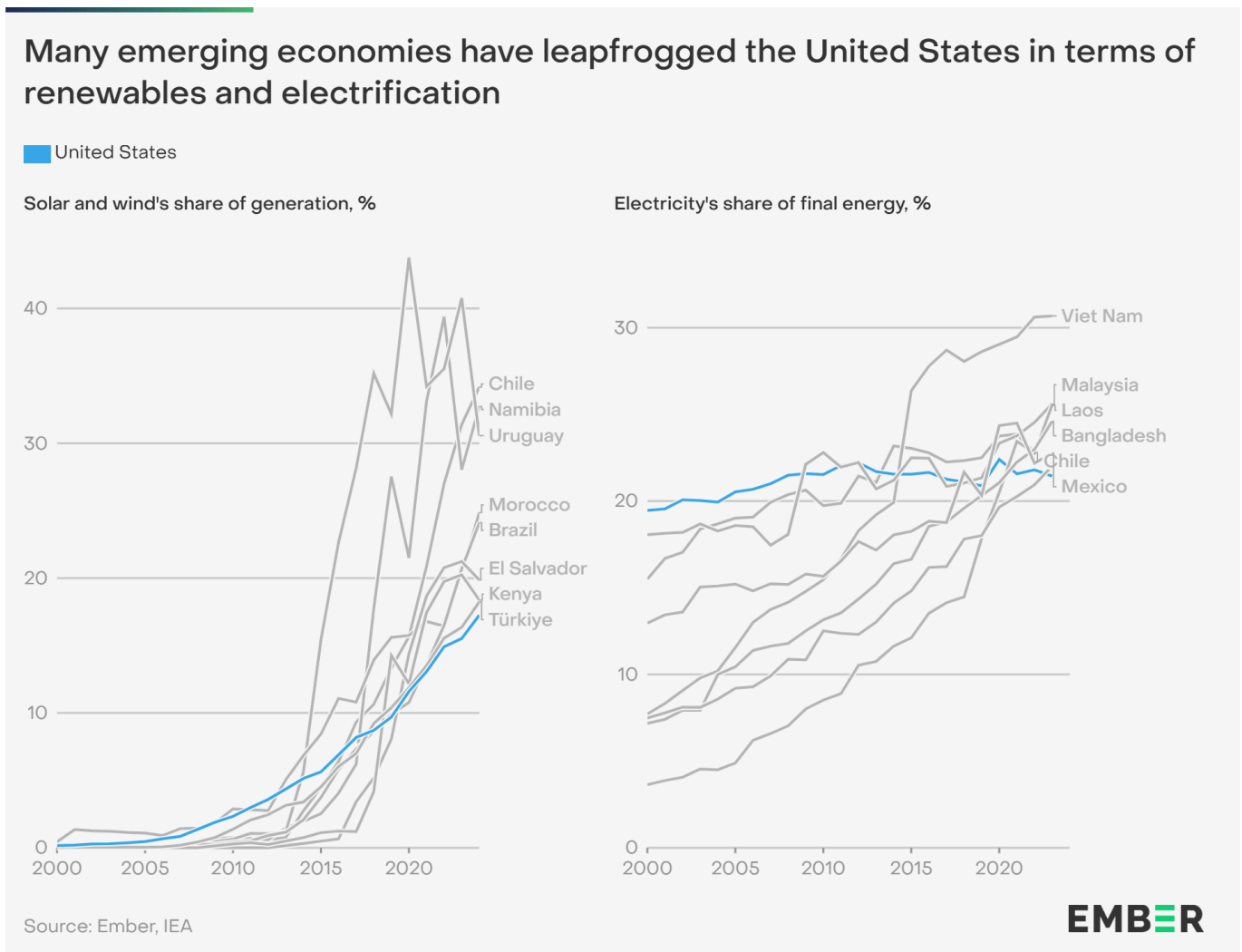
If 'made in China' captured the country's role in the 2010s, 'invented in China' increasingly captures its role today. China has become the energy transition's science laboratory as well as its factory. [China's share of patent applications](#) globally in clean energy technologies has risen from around 5% in 2000 to around 75% in 2022 – including 90% in solar and wind, 85% in energy storage, and more than 70% in batteries and electromobility, based on [IRENA's patent database](#).



Equally striking is China's corporate Research and Development (R&D) spending in the energy sector, which has [sailed past](#) the US and Europe. In 2023, Chinese corporations invested ten times more in [R&D in the electricity sector](#) than their US counterparts. In concrete terms, this innovation acceleration has led to family-sized [electric vehicles](#) that charge in ten minutes for 400 km of range; [batteries](#) light enough to power heavy trucks and short-haul aircraft; offshore wind turbines as tall as the [Eiffel Tower](#) rated at 22 MW each; ultra-high voltage lines carrying 12 GW of desert solar power [3,300 km](#) to coastal cities; and solar panels achieving [24% efficiency](#). In each case, it is a Chinese firm that is raising the ceiling of the possible; and the impact of raising the ceiling is global.

Enables the emerging market leapfrog

China is turning the 'emerging market energy leapfrog' from concept to reality. Its scale in the manufacture and export of affordable clean technologies, along deployment know-how, has contributed to faster adoption in many emerging markets. For comparison, in 2023, about one-quarter of emerging markets in Africa, Asia and Latin America had higher economy-wide electrification than the United States, and roughly 63% had a higher solar share in power generation. (See Methodology for definition of 'emerging markets'.)



Countries exceeding the United States in solar and wind generation shares span Africa, Asia and Latin America, including Brazil, Chile, El Salvador, Kenya, Morocco and Namibia. While emerging markets' overall share of solar and wind generation remains below that of mature economies, it is [growing faster](#).

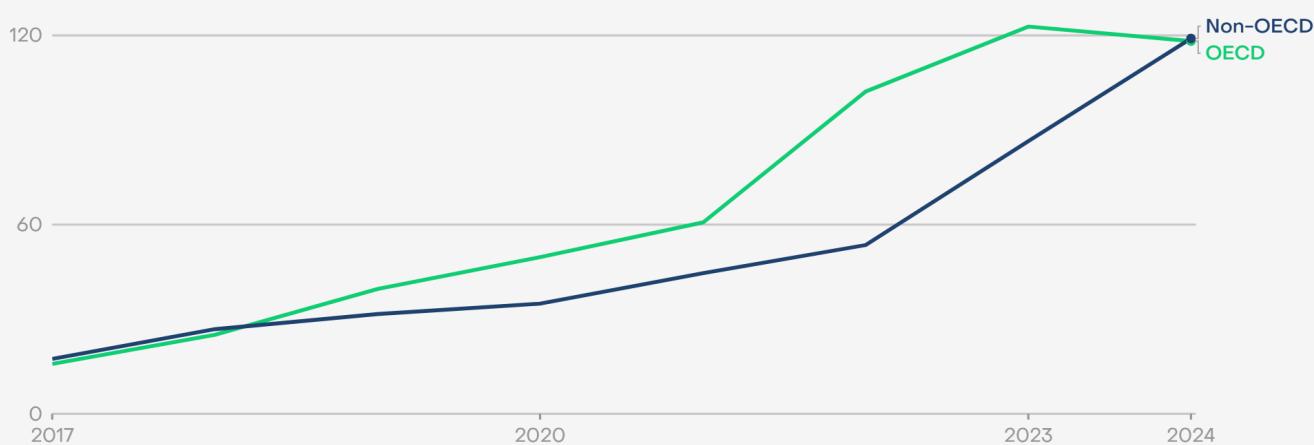
The shift has perhaps been accelerated by measures that some governments have taken in an attempt to shield their own clean tech manufacturing sector from what they regard as China's uncompetitive practices. These include [US bans and tariffs](#) on imports of solar panels and components from China, extending recently to [third countries](#). If sustained and broadened, such measures could fragment supply chains and slow deployment timelines in some markets. On the other hand, they may increase availability for others as restrictions on imports by one country can create more of a buyer's market for others.

Meanwhile, electrification leaders range from Mexico and Chile to Egypt, Bangladesh, and Viet Nam, with rapid progress particularly evident in Asia, where Chinese technologies are more accessible. Just as electricity networks once spread outward from pioneers like New York and Berlin, electricity-first industrialisation is now radiating from eastern China to Southeast Asia. Countries where electricity's share of final energy is rising quickly include Viet Nam, Laos, Malaysia and Bangladesh.

China's [solar exports tripled in five years](#), reaching 242 GW in 2024, with around half going to emerging markets. In many countries, this is already adding materially to their capacity to generate electricity. Since 2018, Chinese solar exports to Namibia, Senegal, Cambodia, Afghanistan and Pakistan have all been larger than their entire centralised capacity as of 2023. Imports to Kenya, Yemen, Sri Lanka and Tanzania have been more than half the size of their centralised electricity systems. Brazil has imported about 90 GW of solar capacity from China (in an electricity system with a total generation capacity of 274 GW, as of July 2025). In other words, new energy is achieving in years what took old energy decades.

China ships as many solar panels to emerging markets as developed countries

Estimated solar panel exports from China, GW



Source: Ember's China's Solar PV Export Explorer

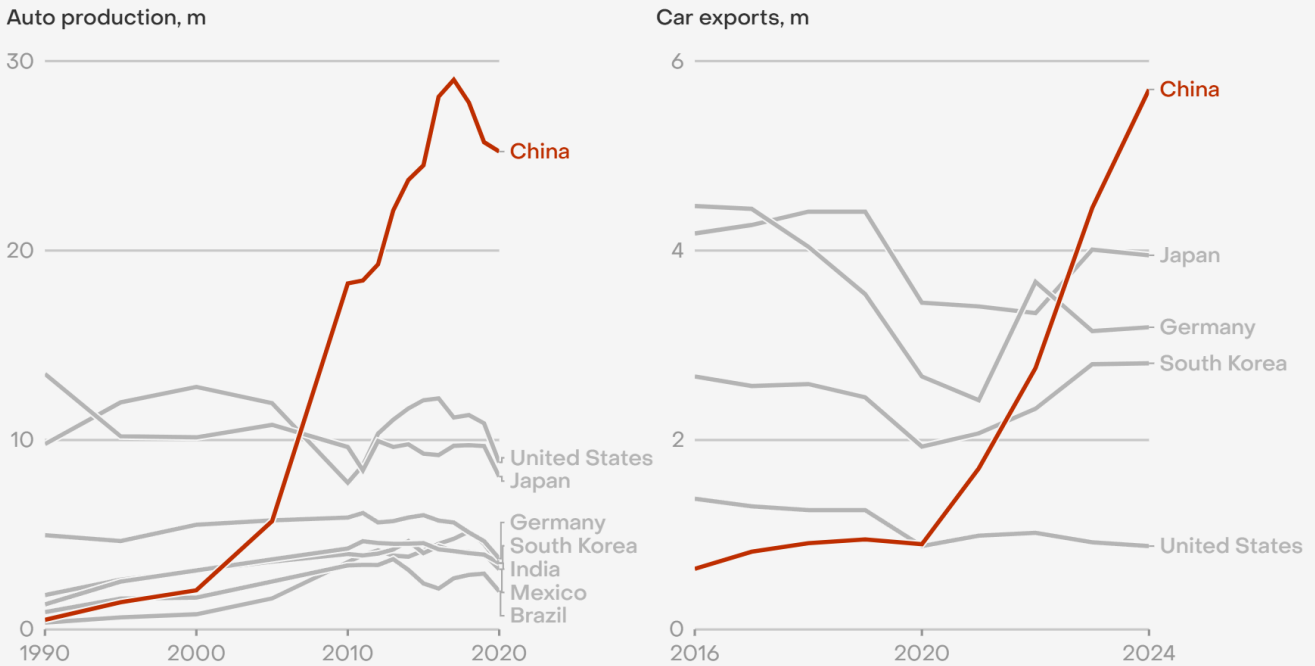
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Rapid module price declines have improved the affordability of solar. Solar module prices fell over 70% between 2022 and mid-2025, down to \$0.08/W for spot purchases in China. In some places, this is materially changing people's prospects of gaining access to modern energy. At these prices, it would take a \$20 module cost for the average person in Sub-Saharan Africa to double their electricity consumption. In illustrative terms, multiply the module cost fivefold to cover inverters, wiring, supplier margins and logistics costs, and the whole kit still comes in, on an upfront basis, below the price of a Tecno Pop 8 smartphone, a top seller in African markets. On a levelised cost of electricity basis, these prices make a small solar PV kit far cheaper than a stand-alone [diesel generator](#). Using solar panels to double the [total electricity consumption](#) of the 1.25 billion population of Sub-Saharan Africa would cost about \$25bn for modules at present spot prices – about the amount the region [spends every year on fuel](#) for stand-alone generators. The scale of China's solar manufacturing is such that [even using just one-seventh of projected 'spare' manufacturing capacity](#) by 2030 could provide basic electricity access to everyone still without power across 88 low-income countries in Africa and other regions of the world.

Realising these gains depends on non-module costs and delivery constraints (soft costs, taxes, logistics, storage for reliability, quality assurance and after-sales service), as well as financing and policy. In many contexts, utility-scale and distributed solar can be deployed faster than new fossil gas capacity, and it reduces exposure to imported fuel price volatility and local air pollution.

Where solar goes, batteries are following. In 2024, China exported \$61 billion USD worth of batteries, with a quarter of this going to emerging markets, where they both help to integrate higher levels of variable solar generation into the electricity system and build domestic automotive industries. One of the most significant trends in the auto trade is that over the past decade, China has evolved from being a net car importer into the world's largest exporter.

China's fast-rising car production has turned it from importer to the world's biggest exporter



Source: OICA, Wikipedia, Alix Partners, NYT · 2024 exports are estimates

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A growing share of these car exports consists of EVs, up from 7% in 2020 to [41%](#) in the first five months of 2025. In 2024, emerging markets [overtook the European Union](#) as China's largest EV destination. Exports to emerging markets [surged](#) from \$0.5 billion in 2020 to \$16.5 billion in 2024.

Price comparisons indicate that Chinese EVs are often priced below local ICE alternatives. In Thailand, the [average market price](#) of a Chinese battery electric vehicle (BEV) in 2024 was around \$30,000 USD, versus a conventional internal combustion engine vehicle (ICEV) at approximately \$34,000. In [Mexico](#) and [Brazil](#), the BYD Dolphin Mini launched at around \$20,000. With the BYD Seagull retailing in China at under \$8,000, export pricing could be lower over time, subject to tariffs, taxes, logistics and local-content rules.

In some cases Chinese companies are also [committing](#) capital and technical expertise to local production. Since 2020, Chinese EV and battery companies have announced around [\\$80 billion](#) to build production facilities in markets such as Indonesia, Thailand and Brazil.

China has also announced diplomatic and financing initiatives to support renewables deployment in Africa, including a [three-year plan](#) launched in 2024 with pledges on solar rollout, project development and funds to localise supply chains. Amid [concerns over African nations' debt levels](#) with respect to China – some linked to earlier energy-sector loans – there are [signs](#) that more sustainable financing approaches are being explored. These include [a gradual shift in some cases](#) toward investment-based models and concessional finance, along with stronger oversight mechanisms.

Some analysts view the combined emphasis on clean energy deployment and manufacturing, which China is pursuing domestically and in some cases supporting in other emerging economies, as a departure from the historic development pathway of “grow first, clean up later”, potentially aligning a country’s economic and environmental goals. The extent to which this materialises will vary by country policy, financing conditions and local capabilities.

China’s transition is reshaping the global fossil fuel demand outlook

China’s energy-related fossil fuel demand appears to be approaching a plateau –with possible decline ahead – and this will be significant for the fossil fuel production industry the world over. In the past decade, China has been the single largest driver of global growth in fossil fuel use, responsible for about two-thirds of the global increase in primary demand; and in the power sector, accounting for almost 80% of the rise in fossil generation.

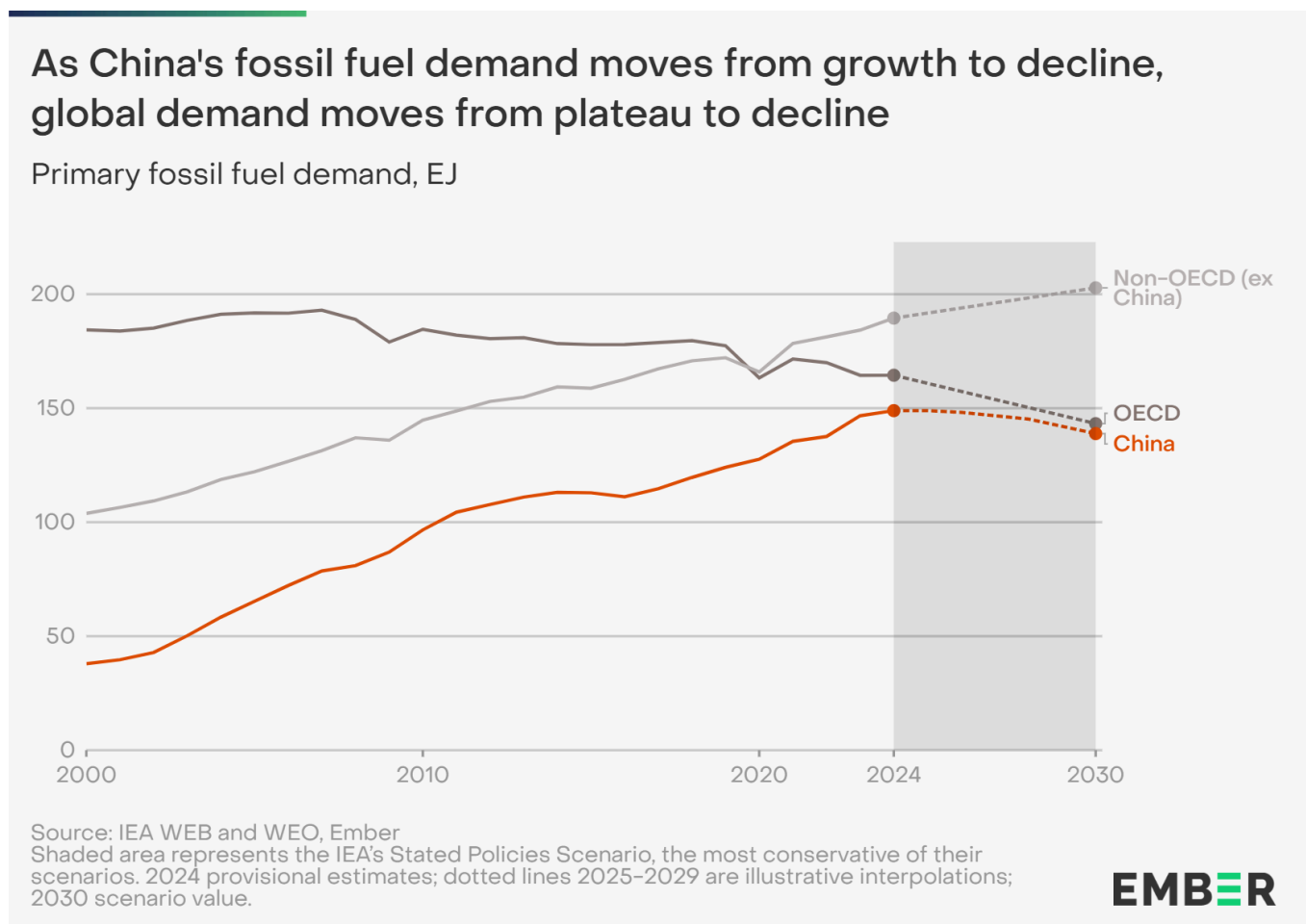
As we outlined in Chapter 1, the accelerating rollout of renewable generation is set to tip China’s power sector fossil fuel use into decline soon. Outside the power sector, in buildings, industry and transport, final energy-related fossil fuel use has broadly plateaued, with decline possible if current trends persist. Whether this materialises depends on economic growth, hydrology, export demand, policy execution and grid integration.

Fossil fuel use across the OECD has fallen since around 2009. If China’s demand also declines, countries representing more than half of global use would be in contraction.

Outside China, uptake of clean electro-technology – made more affordable largely by China’s manufacturing scale – is helping mature and emerging economies alike to accelerate their own transitions. In 2024, clean energy goods exported from China [shaved](#)

[the carbon emissions](#) of importing countries by an estimated 1%, by implication cutting their fossil fuel demand by a similar amount.

If these trends continue, it's likely that the world's fossil fuel demand will be in structural decline by 2030.



Entering an era of falling fossil fuel demand will have profound implications for a number of countries. Governments planning to achieve economic growth by stimulating fossil fuel production face an immediate challenge, especially if investors respond logically to the global trend. While the fossil fuel sector contracts, electro-technology will continue to get cheaper as its use and manufacture expands, and as it achieves social acceptance worldwide.

Falling fossil fuel demand will also change the politics of climate change, keeping the goals of the Paris Agreement within play, and cementing alliances between governments that want to grasp the opportunity which cheap electro-technologies are delivering.

Conclusion

China's energy transition is here to stay

China's clean energy transition appears likely to stay. It is embedded in multiple policy frameworks and into the constitution, contributing materially to investment and output, and recent data point to continued acceleration. Several national targets have been met ahead of schedule, including the 2025 target for 30 GW of 'new-type' energy storage two years ahead of schedule, its 2025 target of a 20% market share for new-energy vehicles three years ahead, and its 2030 target of 1,200 GW of wind and solar capacity six years ahead.

Given the scale of China's economy, changes in its energy system have global effects. Whether they appear to be ripples of threat or of opportunity will depend on the lens through which they are viewed; but their scale should not be mistaken. The most visible trend is the rapid rollout of wind and solar power, but that is just the tip of the iceberg; the berg itself comprises flexibility and grid investment to make the most of cheap renewables, consistently forward-looking policy and market reforms, synergies between manufacture and deployment, and above all the inexorable replacement of fossil fuels in end-use sectors with electricity that is itself increasingly clean.

For every country other than China, and for every business and investor connected with energy, the fundamental question is: 'what is the best path for me, given the new realities?' While some are struggling to plot a course between different concerns – energy costs, industrial policy, import dependence, geopolitical alignment – others are embracing the opportunity that electro-technologies offer, and forging ahead with their own energy revolutions. China's rapid progress may not have provided an answer that is immediately palatable to everyone, but it is undeniably changing the context for the question.

Three groups of countries merit a specific mention. For low-income countries – largely but not exclusively in Africa – affordable Chinese solar panels and batteries represent an opportunity for improving electricity access which simply did not exist a decade ago. But success depends on grid upgrades, market and regulatory reform to attract investment, and stronger governance to manage increasingly decentralised systems.

For countries which have embarked on a clean energy transition but are now in the grip of ‘delayism’, China offers an example of a full-throttle energy transition, commensurate with carbon targets, which is powering a fully industrialised country while increasing both GDP and energy security. Pursuing this path, however, demands navigating difficult trade-offs across financial, industrial and economic policy domains, where competing priorities such as industrial upgrading and social welfare must be carefully balanced against transition goals. The intricacy of these decisions tests countries’ governing capacity and political resolve.

And for petrostates and others committed to expanding fossil fuel extraction, China’s clean energy progress raises questions about the long-term viability of fossil fuel expansion-led development plans. They must decide whether to reinforce their existing fossil sectors or begin diversifying – drawing on their deep technical expertise and institutional experience to take leadership in emerging clean energy industries.

Methodology

Chapter 1

Data is gathered primarily from China’s National Bureau of Statistics (NBS), the National Energy Administration (NEA), the China Electricity Council (CEC), as well as international sources such as the International Energy Agency (IEA) and Ember. Certain datasets are not available for 2024; in these cases, the most recent year available has been used. In some cases more up to date monthly data is available. Ember’s monthly China electricity data is based on NBS and NEA data, with some processing; see our [methodology](#) for details.

Province generation data from the CEC is available up to 2022; data for 2024 is estimated. Hydro, thermal and nuclear generation are taken from NBS. Wind generation is taken from NBS and adjusted to match historical province data from the CEC. Solar generation is estimated based on province-level installed capacity from the NEA, solar insolation and temperature data from ERA5, utility-scale solar farm location data from GEM, population density data from NASA, and province level curtailment data from CWEA. It is adjusted to match historical province data from the CEC. Wind, solar and hydro generation are also adjusted to match national total generation in 2024.

Chapter 2

This chapter adopts a qualitative approach to examine the underlying rationales for China’s clean energy transition, drawing on insights from leading scholars with a deep understanding of the country’s evolving energy landscape. These insights were gathered

through semi-structured interviews conducted in June 2025. To reinforce the analysis, the interview findings are triangulated with a review of relevant literature, policy documents, and recent regulatory developments. Together, this combination of expert perspectives and documentary evidence provides a nuanced understanding of the deeper logics and motivations driving China's clean energy transition.

Chapter 3

The calculation of the share of emerging markets that have leapfrogged the United States includes emerging markets across four key regions: South Asia, Southeast Asia, Africa, and Latin America. This analysis excludes the Middle East and Central Asia, as these regions exhibit higher per capita energy consumption than Europe, which would skew the leapfrogging assessment.

Solar generation and electrification calculations are based on 2023 data, representing the most comprehensive and recent data available. Final energy consumption data is sourced from the International Energy Agency (IEA), while electricity generation data is obtained from Ember. The share of developing countries that have leapfrogged is calculated as a share of developing countries' final energy demand (for electrification) and electricity demand (for solar).

Export data for Chinese batteries and solar equipment were sourced from China's [customs statistics portal](#). Further information on solar export methodology is available at Ember's [China's Solar PV Export Explorer](#). Patent data were drawn from [IRENA's INSPIRE](#) database, which covers clean energy patents and enabling technologies for the energy transition. Note that patent data for recent years may be subject to partial underestimation due to time lags in data collection and processing.

Solar installation and manufacturing capacity analyses utilised historical data from the IEA and forward-looking projections from Infolink. Annual installation requirements under the IEA's Stated Policies Scenario and Net Zero Emissions by 2050 Scenario were calculated assuming linear growth between 2025 estimates and 2030 scenario targets.

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Contributors

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