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What the World Can Learn from China's Energy Transition

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BCG Institute is Boston Consulting Group's real-world think tank. We research the future of thinking about the future. Built on BCG's decades-long intellectual legacy and a global network of academics, scientists, and institutional partners, we bring together expertise across disciplines to advance ideas before they become conventional wisdom. Tracking the forces reshaping business, technology, economics, and geopolitics, we turn emerging patterns into clarity, helping leaders around the world turn early insight into measurable outcomes.

China's progress in the global energy transition has attracted intense interest from policymakers and business leaders.

No other country has expanded renewable generation as quickly, invested as heavily in energy transition supply chains, or played as significant a role in reducing the global cost of low-carbon energy technologies. Given the pace of China's energy transition, there is much that other countries can learn from its experience.

Yet assessments of China's energy transition are often polarized, emphasizing either its extraordinary achievements or its shortcomings. This polarization isn't surprising given the data:

- Over the past two decades, China has reduced its emissions intensity by 50%, yet the country's rapid economic growth means it now accounts for approximately 30% of global emissions.
- China installed more than 1,300 GW of renewable power capacity over the past five years, but thermal coal still accounts for more than half of its energy supply.

Understanding these apparent contradictions is essential for identifying which aspects of the country's energy transition offer lessons for other countries and which are shaped by China's unique circumstances.

By taking an empirical view across sustainability, energy security, affordability, and broader economic outcomes, we identify where China's approach has been successful, where difficult tradeoffs emerge, and which elements can be adopted by other countries. Our analysis identified the five most important drivers of the transition: intense market competition, strong innovation and commercialization, accelerated project delivery, strategic fiscal support, and long-term policy predictability.

Importantly, many of these levers are available to governments everywhere. While market economies must employ different institutions and processes, they possess many of the same policy levers. The challenge for governments is to create durable policy frameworks that provide strategic direction beyond electoral cycles while using public policy and financing to reduce the cost of a once-in-a-generation investment in energy infrastructure.

China's Energy Transition Dashboard

To assess the transition, we evaluated China's performance across sustainability, energy security, affordability, and broader economic outcomes.

Sustainability

Between 2004 and 2024—a period of extraordinarily rapid economic expansion—China reduced its emission intensity by 50%. However, total greenhouse gas emissions have continued to increase and now account for roughly 30% of global emissions. (See Exhibit 1.) Part of this reflects the relocation of manufacturing from developed economies into China, with emissions effectively embedded in products consumed elsewhere. Nevertheless, the composition of China's domestic energy mix remains a factor.

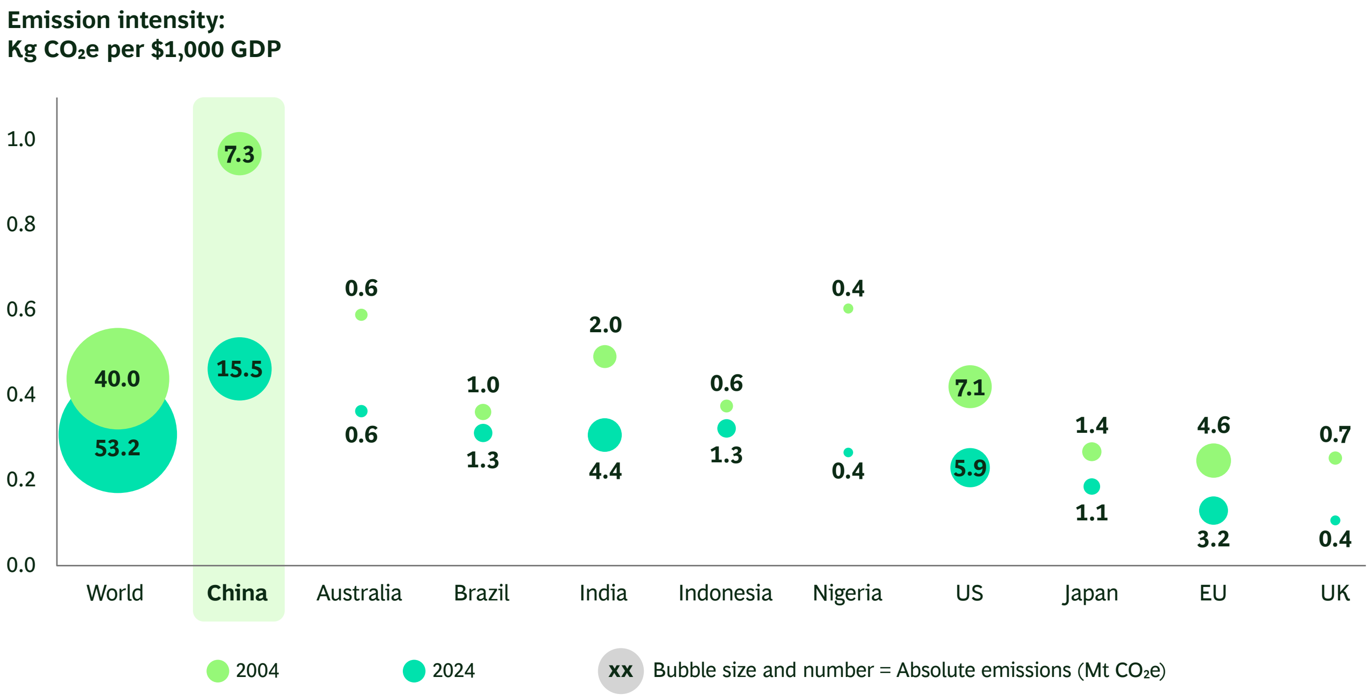
Wind and solar generation have been deployed in China at scale, with 1,300 GW installed in the last five years. In 2025 alone, China installed 430 GW of wind and solar capacity—more than the total installed wind and solar capacity of any other country.

At the same time, the use of thermal coal continues to expand in absolute terms, with approximately 180 GW added over the past five years. (See Exhibit 2.) Although coal's share of China's energy system is expected to decline over time as renewables continue to expand, it will remain a significant component of the country's energy system for the foreseeable future.

EXHIBIT 1

China Has Reduced Its Emissions Intensity by Half, But Still Accounts for 30% of the World's Absolute Emissions

Greenhouse absolute emissions and emission intensity, ranked by 2024 intensity from high to low

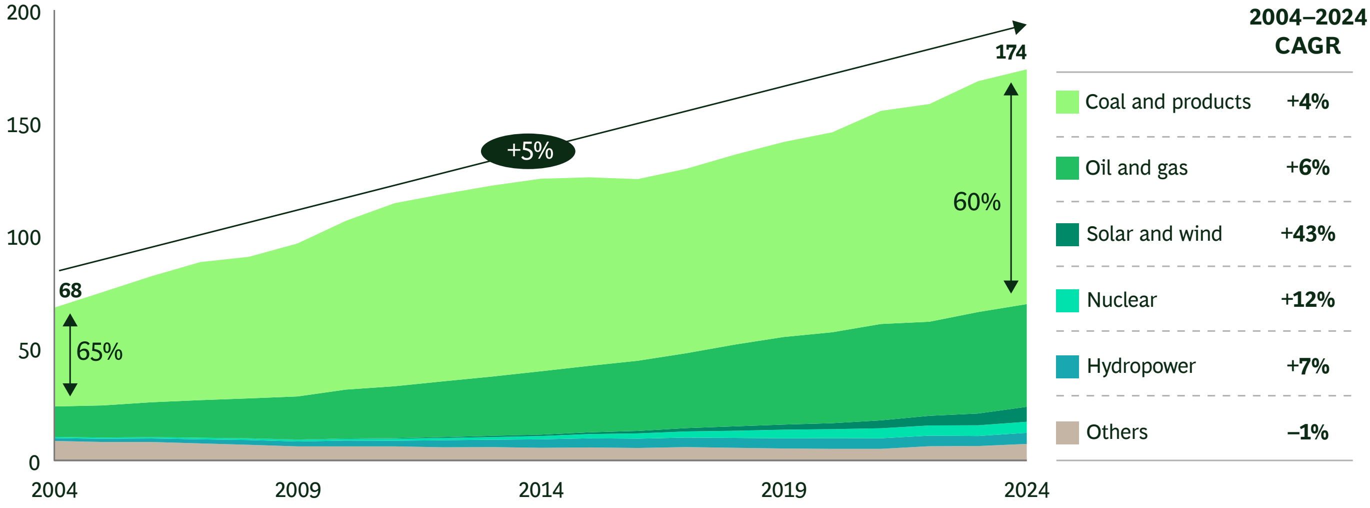


Sources: European Union; International Energy Agency; BCG analysis.
Note: CO_2e = carbon dioxide equivalent.

EXHIBIT 2

Coal Accounts for 60% of China's Energy Supply

China's total energy supply (exajoules), 2004–2024



Sources: International Energy Agency; BCG analysis.

Energy Security

Although China possesses substantial domestic coal reserves—estimated at around 220 billion metric tons in 2023—it remains dependent on imported oil and natural gas. China has sought to improve energy security by diversifying its crude oil imports; yet in 2025, more than half of imports originated from just four countries.

To reduce dependence on imported fossil fuels, China's electrification rate has doubled since 2004, reaching approximately 29% in 2024, and is expected to surpass leading developed economies in the near future.

At the same time, China's dependence on energy imports has increased from approximately 6% of primary energy supply in 2004 to around 24% in 2024. Some increase is inevitable for an economy that has expanded as rapidly as China's, but even after accounting for economic growth, this increase in import dependence has exceeded that of many other industrial economies.

Affordability

Retail electricity prices in China have remained stable or declined over the past decade, even as the country has undertaken substantial investment in grid infrastructure. Industrial electricity prices have fallen by approximately 24% in local currency terms over this period, whereas many other industrial economies have experienced significant increases.

Economic Outcomes

Chinese exports of energy transition technologies have expanded dramatically, reaching approximately $147 billion after growing at a compound annual rate of around 18% over the past decade. Major export markets include both the European Union and ASEAN economies.

This progress reflects the interaction of multiple reinforcing factors that have evolved over more than two decades. Some are foundational, including the country's manufacturing base, skilled workforce, and abundant wind and solar resources. Others are deliberate policy choices that have shaped investment incentives and industrial development.

Five Factors Have Catalyzed China's Energy Transition

Our analysis identified five key drivers of China's energy transition. (See Exhibit 3.) Together, they have created an ecosystem that supports rapid deployment, continuous cost reduction, and industrial competitiveness.

EXHIBIT 3

Five Levers Underpin China's Energy Transition—And Most Are Transferable

Levers China has deployed

Intense competition
Local governments competed for capital, giving rise to hundreds of technology firms. Costs fell and exports surged.

Innovation and commercialization
China evolved from fast-follower to inventor, and quickly translated R&D into products.

Accelerated project delivery
Projects reach the grid 2x to 5x faster through parallel permitting and simultaneous investment in generation and the grid.

Savvy fiscal support
Manufacturing subsidies preceded deployment support. Lowered the cost curve and scaled deployment.

Long-term policy predictability
Two decades of consistent direction via Five-Year Plans. Gave investors confidence in a long-payback sector.

Priorities for other countries

Scale, wherever possible
Pursue targeted industrial scaling opportunities, explore geographical expansion, and create larger and more integrated domestic markets.

Translate innovation into manufacturing
Invest in foundational research and convert research into commercial opportunities.

Rethink the government's role
Treat the transition as a long-term national infrastructure program, strengthen long-term policy clarity, and use public finances strategically to improve affordability.

Source: BCG analysis.

Factor 1: Intense Competition

China deliberately engineered strong competition in selected parts of the value chain to support emerging industries by creating dense manufacturing ecosystems that accelerated innovation, commercialization, and cost reduction. In Shenzhen, for example, BYD and other energy transition technology companies are co-located with leading university research institutions, including Peking University's Green Energy Research and Development Center.

In China, local governments play an important role in competing to secure central government funding for industrial development. Over the past decade, this dynamic has encouraged the rapid emergence of new companies developing energy transition technologies. In many regions, numerous firms have entered similar markets simultaneously, creating an exceptionally competitive commercial environment. This competition has driven continuous improvements in productivity, accelerated cost reductions, and strengthened export competitiveness.

With ample fiscal support and local governments unwilling to give up their newly established manufacturing bases, unprofitable firms continue to be subsidized, driving prices down even further. In some cases, this means loss-making companies that might otherwise have exited the market continue to receive assistance.

While this situation can create significant challenges for local economies when companies eventually fail, the benefits for the broader energy transition are considerable. Capacity grows rapidly, costs fall dramatically, and companies look to expand into overseas markets.

Factor 2: Innovation and Commercialization

In the early stages of industrial development, China focused largely on manufacturing technologies developed elsewhere. Increasingly, however, the country has become a leading source of innovation itself.

China awards more than 3.6 million science, technology, engineering, and mathematics (STEM) degrees annually, which is more than the United States, India, and Japan combined. On a per capita basis, China's 2,500 STEM graduates per million people is broadly comparable with leading economies.

This deep pool of scientific and engineering talent has been accompanied by a rapid expansion of China's research and innovation capabilities. Academic publications relating to energy transition technologies produced by Chinese universities have grown substantially over the past two decades, and China has demonstrated an increasing ability to convert this research into commercial outcomes. (See Exhibit 4.)

Between 2000 and 2024, China accounted for approximately 57% of cumulative global energy transition patent filings. Chinese firms are now producing globally recognized technological innovations, exemplified by JinkoSolar setting successive world records for solar cell conversion efficiency.

What's more, China's innovation model places particular emphasis on commercial application. Close links between research institutions, manufacturers, and industrial clusters have enabled new technologies to move rapidly from laboratories into large-scale production.

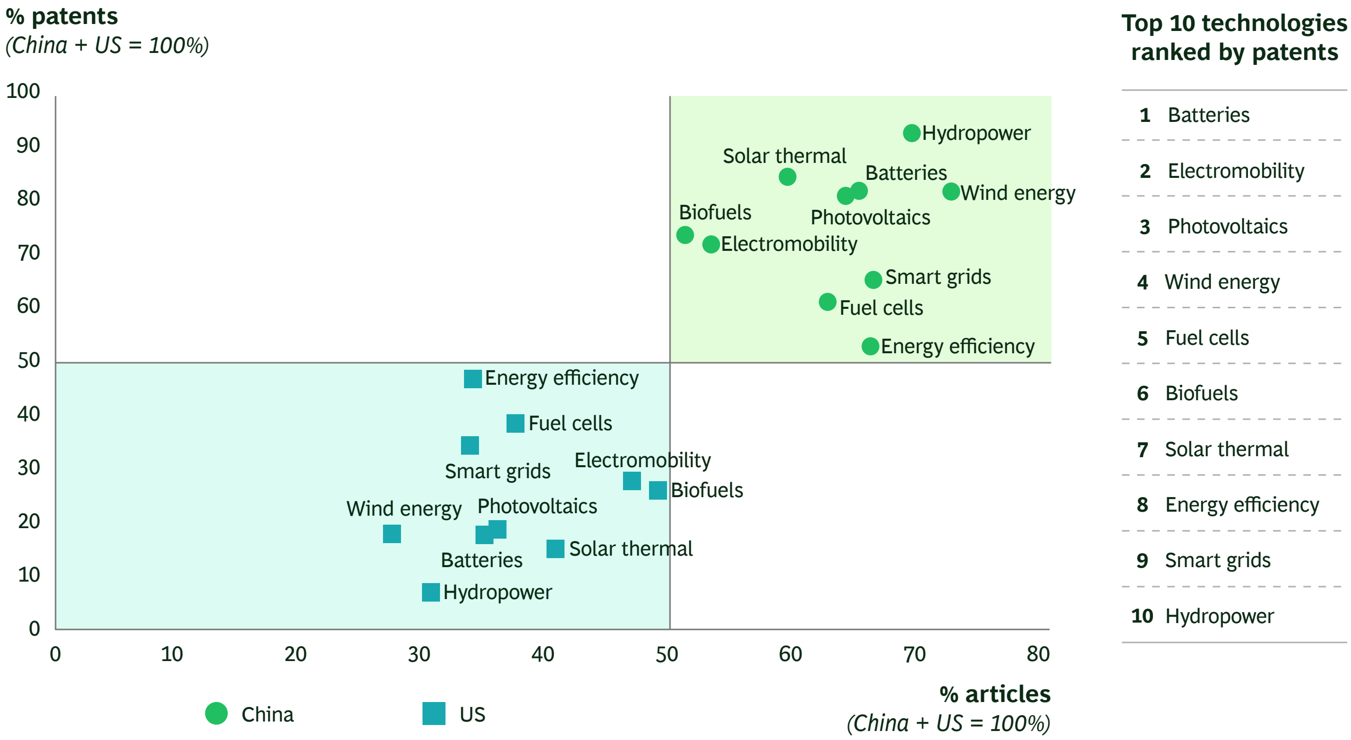
Factor 3: Accelerated Project Delivery

China's permitting and grid connection systems have been designed with rapid deployment as a central objective. The period between final investment decision and grid connection for major renewable energy projects in China is typically two to five times faster than comparable projects in the United States and Europe. Rather than relying on sequential reviews by multiple government agencies, permitting processes are often coordinated in parallel, with standardized interconnection studies reducing administrative delays and uncertainty. In some cases, permitting decisions have reportedly been completed within 18 days. Faster permitting also has a clear business case. Longer development cycles for European renewable projects can reduce investor internal rates of return by an estimated 4 to 5 percentage points relative to comparable projects in China.

Project delivery has also benefited from extensive upfront investment in transmission and distribution infrastructure. Vertical integration across elements of the electricity system has further shortened project timelines by simplifying coordination between generation, transmission, and grid connection. (See Exhibit 5.)

EXHIBIT 4

China Leads in Scientific Publications and Patents Across the Top 10 Energy Transition Technologies

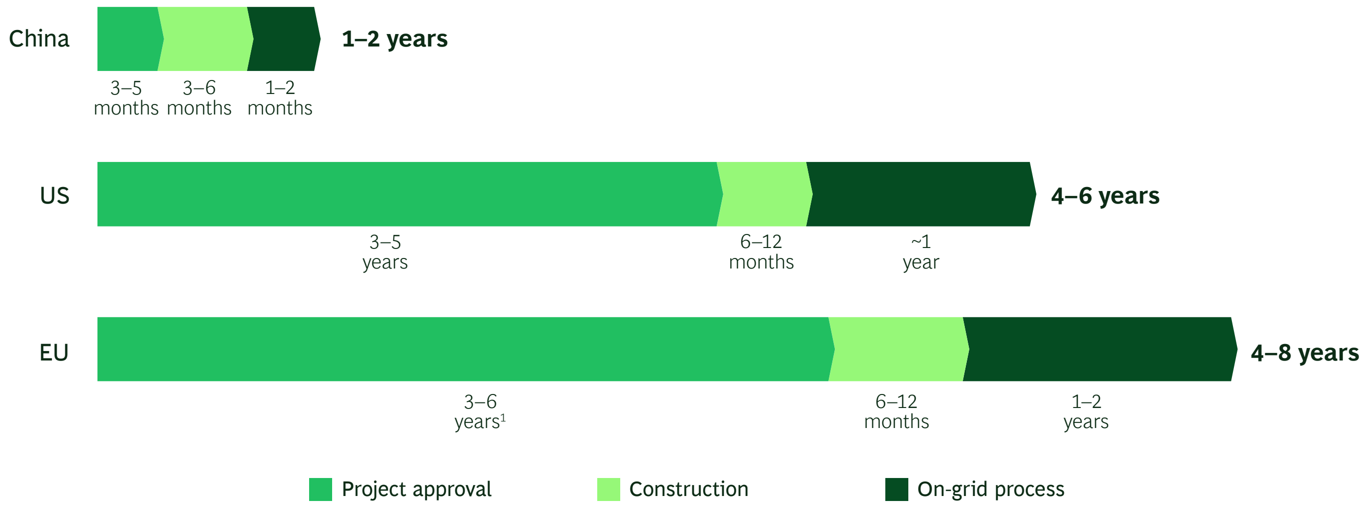


Sources: IRENA; Scopus; BCG analysis.
Note: Data is cumulative from 2000–2024. Patent data from International Renewable Energy Agency (IRENA). Article publication data based on Scopus database, including all publication articles, excluding reviews, with relevant keywords of certain technologies in title, abstract, or keywords.

EXHIBIT 5

China Completes Projects Before Comparable US or EU Projects Complete Permitting

Project development time from initiation to on-grid, utility-scale solar and onshore-wind, 2024



Sources: BCG project experience (China); Lawrence Berkeley National Laboratory and resources for the future (US); Solar Power Europe and International Energy Agency (EU); BCG analysis.
[1]The EU's Renewable Energy Directive (RED III) target is 2 to 3 years, but actual permitting times can still exceed 6 years in some cases.

Factor 4: Savvy Fiscal Support

While many governments have relied on fiscal incentives to stimulate demand, China invested early and heavily across the supply side of the energy transition. This reflected their view that energy infrastructure is a vital national asset that can strengthen competitiveness and stimulate economic development for decades.

While it's true that China's state-owned energy companies have been able to invest in projects with relatively modest financial returns, and state-owned banks have offered financing on highly favorable terms, these institutional characteristics alone do not fully explain China's success.

Between 2008 and 2010, manufacturers of the first 50 megawatt-level wind turbines received subsidies of RMB 600 per kilowatt. Between 2011 and 2020, approximately RMB 100 billion in central government funding was directed towards China's domestic electric vehicle industry. As manufacturing capability strengthened, China established a leading global position across numerous components of the energy transition value chain.

Over time, investment increasingly shifted towards transmission and distribution infrastructure—the grid investments required to support growing demand and integration of renewable power. Only after strengthening both manufacturing capacity and supporting infrastructure did China significantly expand deployment incentives, such as feed-in tariffs. (See Exhibit 6.)

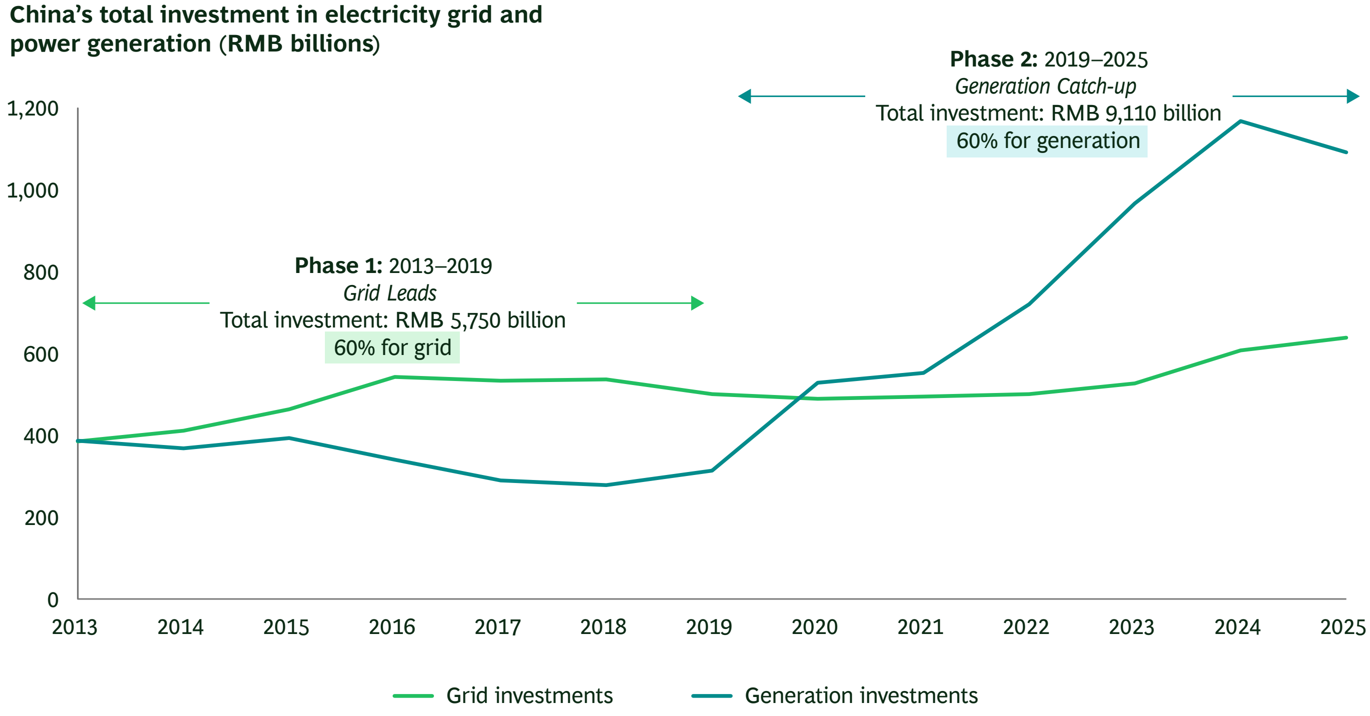
Looking ahead, the country has announced plans to invest approximately RMB 5 trillion in grid infrastructure between 2026 and 2030 through a combination of public and private investment, representing roughly an 85% increase compared with the previous five-year period.

Factor 5: Long-term Policy Predictability

Perhaps the defining characteristic of China's approach has been the consistency of long-term policy direction. For more than two decades, successive Five-Year Plans have identified the energy transition as a national strategic priority. As far back as 2010, China's Twelfth Five-Year Plan established a target to increase the share of non-fossil fuels in primary energy consumption to 11.4%. Its industrial policy focused not only on building domestic manufacturing but also securing key upstream inputs, such as critical minerals and other materials.

EXHIBIT 6

China Invested in the Grid First, Enabling Later Generation Growth Through State-Owned Enterprises



Sources: China Electricity Council; Company financial report; BCG analysis.
Note: Total investment completed, including both public and private investment. The State-owned Assets Supervision and Administration Commission of the State Council (SASAC) is an institution directly under the State Council of China that acts as the state's owner for centrally administered state-owned enterprises.

This policy stability has reduced uncertainty for businesses making investments that require large upfront capital and long payback periods. Investors have been able to commit capital with greater confidence that the broader policy environment would continue to support long-term returns. (See Exhibit 7.)

This does not mean that China's policy environment has been static. Policy adjustments have occurred. For example, central government subsidies through feed-in tariffs for new utility-scale and distributed solar photovoltaic projects and wind projects ended in 2021. Nevertheless, these changes have generally occurred within a broader strategic framework that has remained remarkably consistent over time.

Tradeoffs of the Transition

While the speed of China's energy transition is notable, it has not been achieved without tradeoffs. These experiences provide valuable lessons for policymakers seeking to accelerate their own transitions while avoiding unintended consequences.

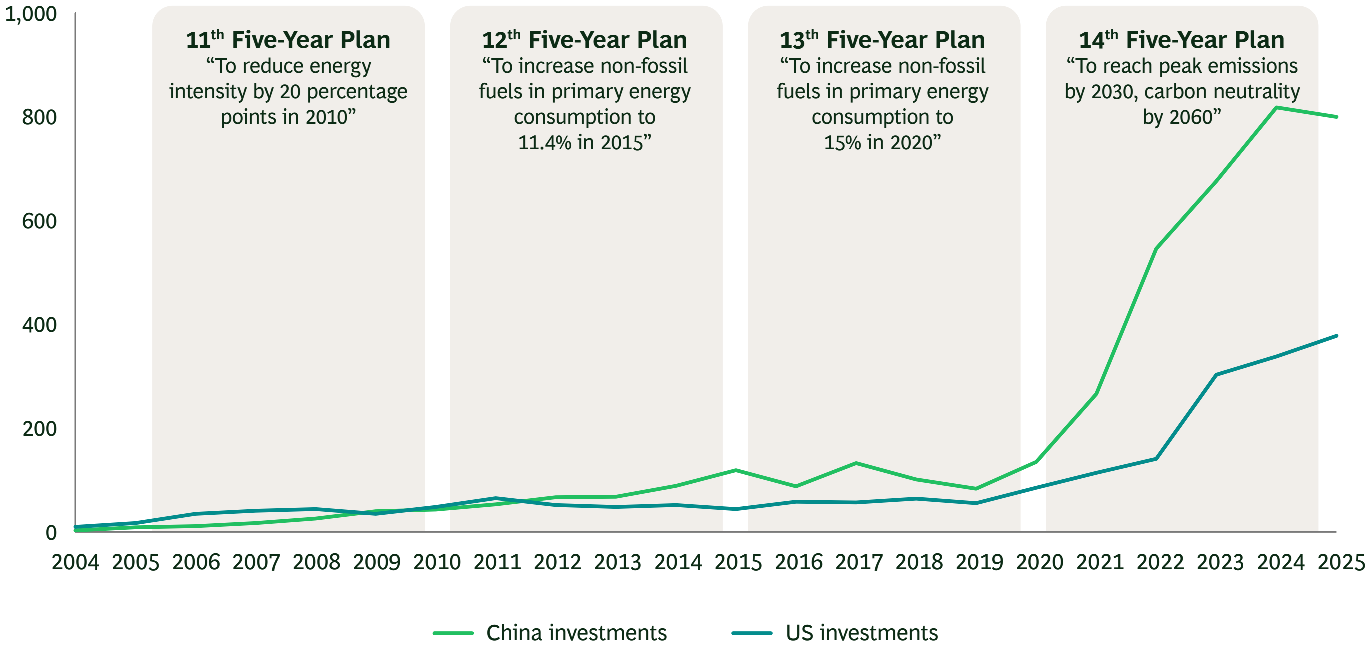
China has largely succeeded in financing the transition without significantly increasing electricity prices for consumers. However, some of these costs have instead been absorbed by public institutions and state-owned grid operators, effectively shifting a portion of the financial burden to the broader public sector through taxation and public finance.

Competition between provincial governments to attract investment and preserve local manufacturing has, in some sectors, contributed to duplicate investment, excess capacity, and cutthroat competition that leaves many companies with persistently low profitability. Between 2017 and 2024, as government investment in electric vehicles accelerated, profitability in China's automotive industry fell by approximately one-third, while capacity utilization declined and supplier payment delays increased. China's two largest grid operators generated an average return on equity of just 2% between 2020 and 2024, as opposed to the 4% to 15% typically earned by major US and European utilities. Many companies remain dependent on public support, exposing local governments to debt risks with knock-on impacts to employment.

EXHIBIT 7

The Consistency of China's Five-Year Plans Has Reinforced Investor Confidence in Green Energy

Annual total investment in green energy ($US billions)



Sources: BloombergNEF; BCG analysis.
Note: Includes main energy transition industries, such as solar, wind, storage, hydrogen, CCUS, and EV. Investment types include green tech deployment, investments in the green energy supply chain, equity investments and public market funding in green tech companies, and debt issuance specifically for energy transition purposes.

The rapid pace of deployment has also produced environmental and social impacts. China's permitting system has demonstrated that renewable energy projects can be approved and constructed quickly, but this raises questions about whether sufficient consideration is consistently given to wider environmental and social impacts.

The rapid build-out of wind and solar capacity has led to higher levels of renewable energy curtailment, as grid infrastructure and electricity demand have struggled to keep pace with the growth in generation. China's solar curtailment rate increased from approximately 3% in 2021 to around 7% in 2025, while wind curtailment rose from 2% to 6% over the same period.

Taken together, these side effects provide important context for China's achievements. The country's experience offers lessons not only in what can be achieved through rapid deployment, but also in how policymakers and businesses can anticipate and manage the challenges that accompany it.

Transferring China's Levers to Other Sociopolitical Contexts

China's experience inevitably reflects features of its own political and institutional system. A centrally planned economy, state-owned financial institutions, and provincial governments directly accountable to central government create conditions that cannot simply be replicated elsewhere.

However, many of the most effective elements of China's approach are not unique to its political system. Rather, they reflect policy choices that could be adapted, albeit differently, within market-based economies. Three priorities stand out for governments and policymakers seeking to accelerate their own energy transitions.

As governments around the world navigate difficult tradeoffs, China's experience offers a rich case study on how energy transitions can be accelerated.

Scale, wherever possible

Governments can deliberately create opportunities for industries to achieve scale to reduce costs, strengthen domestic supply chains, and improve global competitiveness. Achieving scale in an energy transition does not require centralized economic planning. Governments can create scale through long-term procurement, predictable regulation, and open access to expanding markets—all well-established tools in market economies.

Pursue targeted industrial scaling opportunities.

Governments can identify areas where they possess durable competitive advantages and support scale through long-term public procurement contracts, supportive codes and standards, and targeted public investments. Achieving scale is likely to be most effective where countries benefit from distinctive capabilities, natural resource endowments, research strengths, or existing industrial ecosystems. For example, countries with favorable geology may be well positioned to develop competitive industries in carbon capture, utilization, and storage or geothermal energy, while others may find greater opportunities in advanced grid technologies or fusion. In sectors where competitive domestic industries are unlikely to emerge, policymakers may instead prioritize rapid deployment and secure access to global supply chains.

Explore geographic scaling opportunities.

Although China's domestic market is unusually large, its firms have consistently expanded internationally to reach additional demand. As markets across Brazil, India, Southeast Asia, and other emerging economies increase their investments in low-carbon energy, export opportunities will extend well beyond manufacturing. For example, in 2025, French renewable energy company Voltalia signed new maintenance contracts covering 940 MW of Brazilian wind and solar projects, illustrating how companies can achieve scale by exporting services and operational expertise alongside technology.

Create larger and more integrated domestic markets.

China's scale provides manufacturers with access to a vast, relatively integrated domestic market. Other countries can replicate some of these advantages by reducing regulatory fragmentation and deploying more consistent market access rules across neighboring jurisdictions (for example, across European countries or US states). More consistent permitting processes, technical standards, safety requirements, and energy pricing can expand the effective size of the domestic market, allowing firms to scale more quickly before competing internationally.

Translate innovation into manufacturing

In segments where competition drives innovation, productivity, and cost reduction—particularly manufacturing and the commercial application of new technologies—governments can accelerate commercialization by investing in foundational research, STEM talent, and innovation ecosystems.

Invest in foundational research.

Governments can strengthen funding for energy transition disciplines and attract top STEM talent to drive the next wave of breakthroughs. China has built a strong pipeline of STEM talent, supported by high-quality research and cross-disciplinary collaboration. France pioneered the first solar cell, while scientists from the United States and Japan jointly invented the lithium-ion battery. Continuing to fund world-class research remains essential.

Convert research into commercial products.

Governments should give commercialization the same priority as innovation. China has benefited from locating research institutions alongside manufacturing clusters, which allows for rapid collaboration between universities and manufacturers. Similarly, many of the world's most successful innovation ecosystems, including Silicon Valley and Germany's advanced manufacturing clusters, emerged from competitive private markets supported by public investment in research, infrastructure, and skills. Government support can strengthen links between universities, industry, investors, and manufacturers to help more countries convert scientific breakthroughs into globally competitive industries.

Rethink the government's role

The energy transition requires a once-in-a-generation build-out of long-lived infrastructure—from electricity transmission and distribution to storage and other enabling assets—that can underpin economic growth, industrial competitiveness, and energy security for decades. Like highways, water systems, or public education, much of this infrastructure generates broad societal benefits. Financing it solely through utility bills can underinvest in nationally important assets while increasing political resistance to the transition.

China's approach combines long-term strategic direction from the central government with implementation by provincial and local governments and coordination across ministries. Other governments have likewise demonstrated an ability to pursue durable national priorities by embedding them within stable institutions. The key is to provide long-term policy continuity, coordinate across multiple levels of government, and sustain investment over decades.

Treat the transition as a long-term national infrastructure program.

Governments can align public agencies, industry, and investors around the goals of the energy transition. Specifically, streamlining permitting would accelerate project delivery and strengthen business cases. This does not mean compromising important environmental and social safeguards—which would ultimately be self-defeating—but there is ample scope to make permitting processes more efficient. Initiatives such as Singapore's Urban Redevelopment Authority, the UK's COVID Vaccine Taskforce, and the construction of the US Interstate Highway System demonstrate how governments can successfully coordinate complex, long-term national priorities.

Strengthen long-term policy clarity.

Governments can embed key elements of energy policy within durable institutions that operate with a degree of independence from short-term political cycles. Independent agencies, statutory mandates, and other institutional mechanisms can provide credible long-term direction while allowing governments to adjust implementation over time. Institutions such as the US Social Security Administration, the Federal Reserve, and the European Central Bank demonstrate that governments can successfully entrust strategically important national priorities to enduring governance structures that outlast individual administrations.

Use public finance strategically to improve affordability.

Targeted government support—including concessional loans, state guarantees on project debt, loan guarantees, direct investment, and other financing mechanisms—can reduce the cost of capital while shifting a portion of the costs of long-lived infrastructure from ratepayers to the broader tax base. During periods of rapid infrastructure build-out, particularly in natural monopoly segments such as electricity transmission and distribution, financing through the broader tax base can reduce pressure on consumer prices and help sustain public support for the transition. Precedents already exist across market economies, from the US Department of Energy's Loan Programs Office to France's fully state-owned utility, EDF. The objective is not necessarily greater state ownership, but rather deploying public finance strategically where market incentives alone may prove insufficient.

As governments around the world seek to navigate increasingly difficult tradeoffs between affordability, energy security, competitiveness, and decarbonization, China's experience offers one of the richest empirical case studies available on how energy transitions can be accelerated.

Many of its most effective approaches, including investing strategically, fostering competition, strengthening commercialization, accelerating project delivery, and creating credible long-term policy direction, can be adopted across a wide range of political systems.

In other words, many countries possess the policy tools that have underpinned China's progress, but few have deployed them with the same degree of ambition, coordination, and persistence. What sets the most effective governments apart is their ability to provide durable direction that survives changes in political leadership. That direction must be backed by strategic public financing that lowers the cost of the energy transition. The countries that move fastest will be those that most effectively align policy, capital, and execution behind a common objective and sustained intent.

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