Navigating the evolving stage of the PV industry: Strategies for achieving transformation and upgrading goals amid deepening reform

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Amid the ongoing structural adjustment and optimization in the global energy sector, the development of renewable sources and energy security has become a shared objective among nations. As an important part of renewable sources, photovoltaic (PV) technology plays a pivotal role in the structural adjustment and optimization of China's energy sector. In 2023, China's PV output value reached RMB1.75 trillion and the installed capacity of PV power generation has ranked first in the world for eight consecutive years. Given the intensifying competition and geopolitical uncertainties, how can Chinese PV companies make a difference?

In 2023, global installed PV capacity reached a record high of 268GW. China, the EU and the US emerged as major drivers of growth in global PV demand. China's PV industry features a highly integrated industrial chain, significant scalability and advanced technological capabilities. Meanwhile, the EU and the US saw a relative slowdown in local of PV market growth due to multiple factors.

Examining the evolution of China's PV industry, Chinese enterprises have been rapidly transforming from being global foundries to taking a leading role on the world stage. They are pursuing win-win cooperation, although this shift inevitably brings various issues and challenges.

To stand out in a changing world marked by intense competition, Chinese PV companies must enhance their core competitiveness. Key elements for success include digital savviness, world-class operational excellence and robust supply chain management, all of which are essential for establishing a strong global presence.

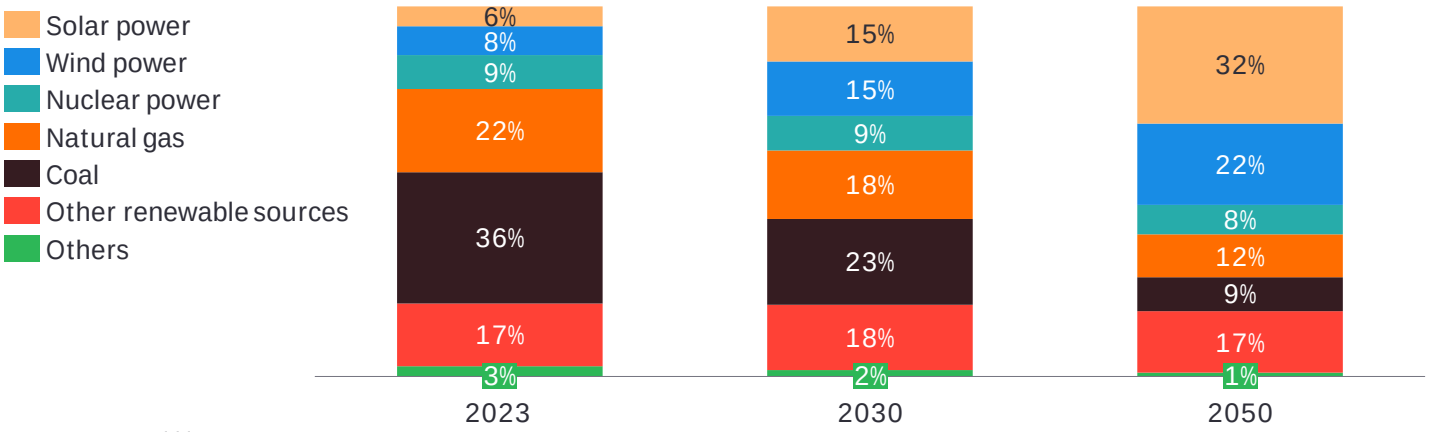
1. A snapshot of global PV markets

A leap forward for the energy revolution and increased policy support across the globe.

Since the 2000s, solar power has garnered escalating interest and witnessed widespread adoption globally. This surge can primarily be attributed to two key factors – the rising demand for clean energy driven by global carbon neutrality goals and the energy revolution, along with a substantial increase in affordability driven by the declining levelized cost of electricity (LOCE) associated with PV power.

In 2023, the global power structure was dominated by conventional energy sources such as oil, coal and natural gas, collectively constituting up to 61% of the total energy mix. In contrast, renewable energy sources accounted for approximately 39%, with solar power contributing a mere 6%. The current trajectory suggests a significant shift in the power landscape. According to the projections by the International Energy Agency (IEA), by 2030, conventional energy sources will face increasing challenges to their dominance. By 2050, renewable energy is forecasted to emerge as the cornerstone of global power generation, accounting for 79%, of with solar power set to constitute a substantial 32% of this share.

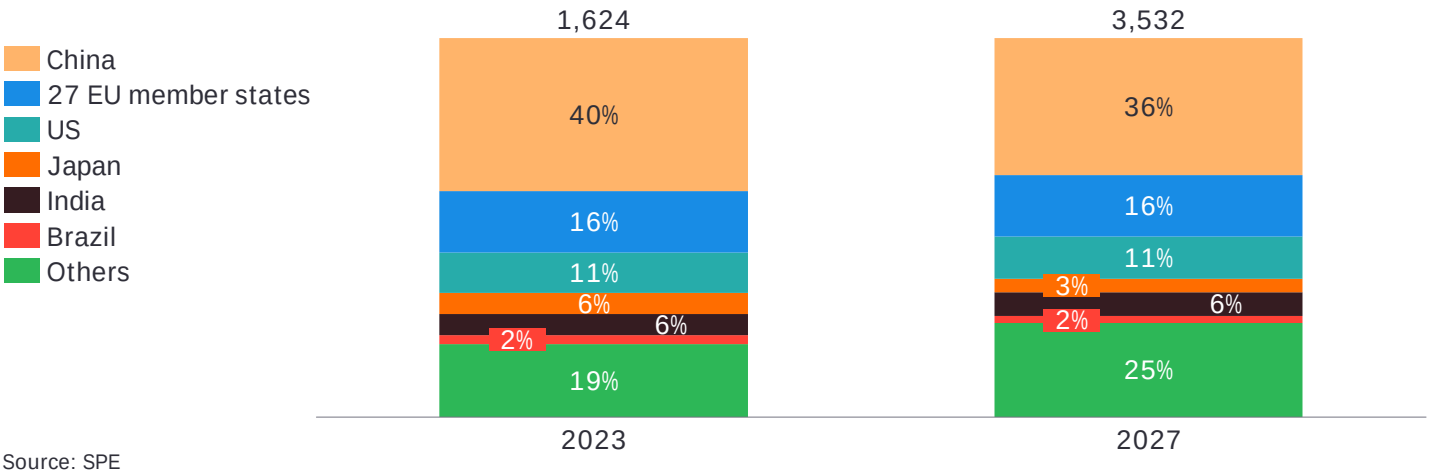
Global power structure and prospect



Source: Our World in Data, IEA

According to the European Photovoltaic Association (SPE), the global installed PV capacity reached 1,624GW in 2023 and is forecasted to leap to 3,532GW by 2027 under the medium scenario, boasting a robust compound annual growth rate of 21%. In terms of country and regional standings in 2023, China ranked first in the world with a cumulative installed PV capacity of 656GW, representing 40% of the world's total. The EU and the US followed with installed capacities of 263GW and 173GW, respectively. As forecasted by the SPE, the global PV installation landscape is poised to maintain its trajectory through 2027. Noteworthy trends include the rapid growth in installed PV capacity witnessed by China, the US and Brazil in recent years, surpassing the global average of 27%. Brazil, in particular, grew at an astonishing rate of 74% in installed PV capacity, attributed to its expansion from a relatively low initial base.

Cumulative installed PV capacity, by country and region (GW, %)



Source: SPE

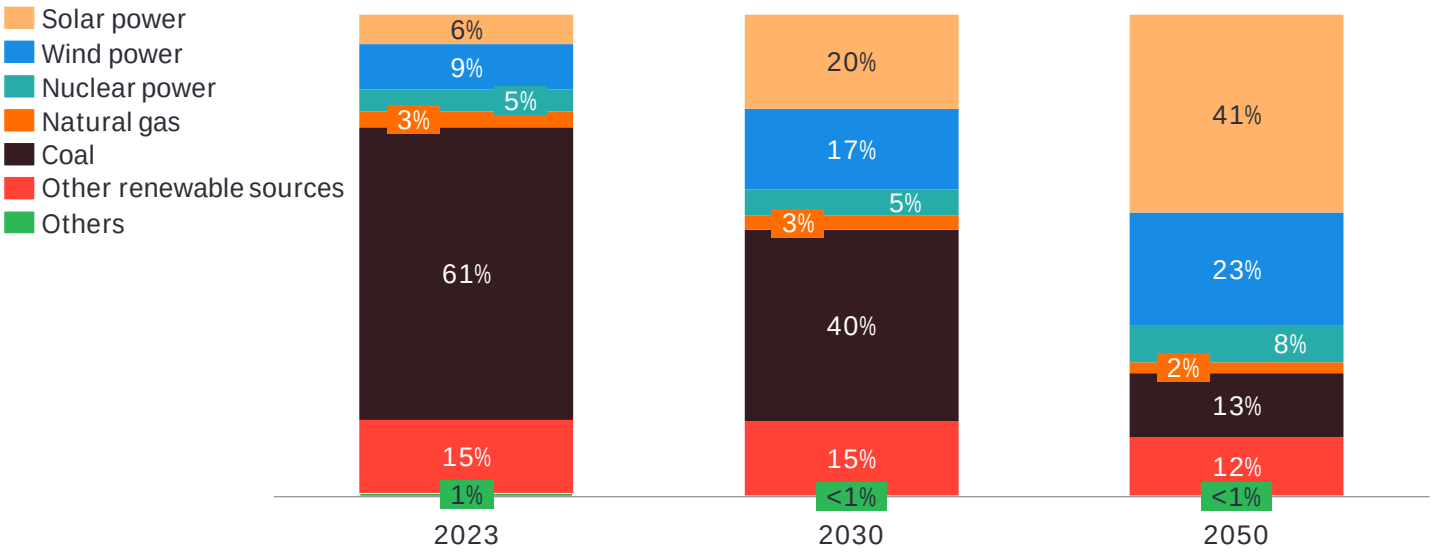
China

In 2023, conventional sources generated 65% of China's electricity, while renewable energy accounted for 35%, with PV contributing only 6%. According to the IEA, by 2050, 76% of power generation is expected to come from renewable sources, with PV projected to contribute 41%. At that point, PV power will play a crucial role in establishing a new power system based on renewable energy in China.

China excels in PV technology and is supported by an integrated manufacturing system and extensive industry-specific experience. Contributing over 80% to the global production capacity and output in various segments of the PV industrial chain, China enjoys tremendous advantage in the PV sector.

Today, policy focus is shifting from directly providing subsidies to promoting high-quality development in the PV industry by addressing industry-wide challenges. These policies aim to enhance the adoption of green electricity and facilitate the deep integration of PV with other sectors to tackle power consumption issue. They also support the power reform efforts to enhance PV power trading and explore new profit models, including transitioning from distributed PV businesses to electricity trading and load aggregation services, in response to the challenges posed by unclear profit models. Additionally, the policies provide guidance for PV development plans, encouraging the construction of offshore PV power stations in coastal areas and large wind and PV bases in desert regions to address the regulated land use concerns.

China's power structure and prospect

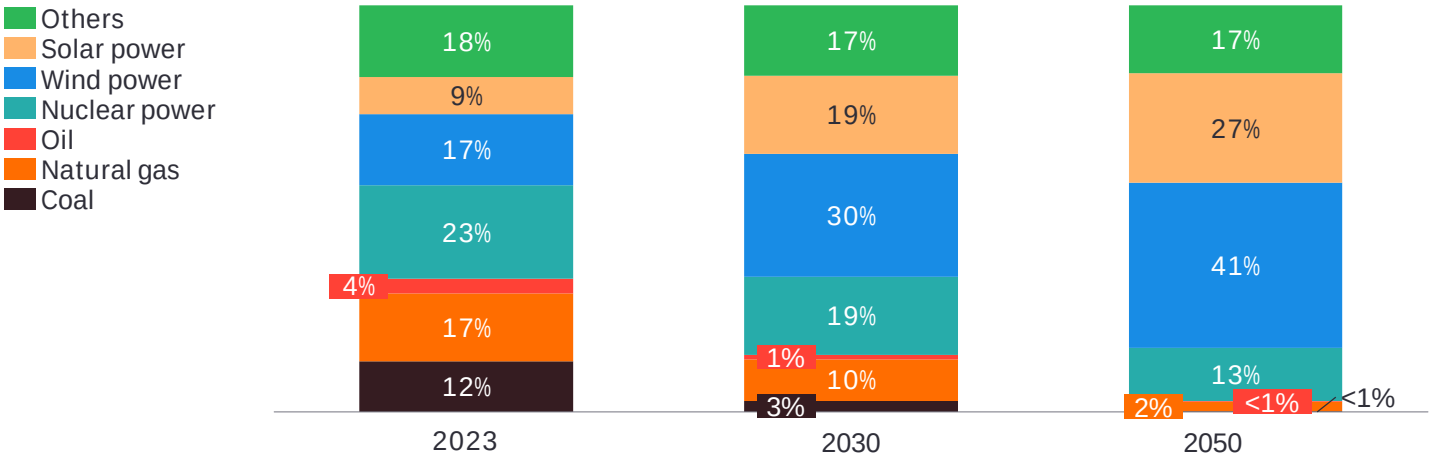


Source: China Electricity Council, Our World in Data, IEA

EU

As a global leader in the fight against climate change and a hub for PV technology, the EU has demonstrated strong performance in the renewable energy sector. In 2023, total installed PV capacity reached 263GW, making it the second largest globally. In terms of electricity supply structure, renewable sources accounted for 67% of power generation, with PV contributing 9%. According to the IEA, by 2030, the share of renewable energy in total power generation is expected to rise to 86%, with PV's contribution increasing to 19% by 2030 and 27% by 2050.

EU power structure and prospect



Source: Statista, IEA

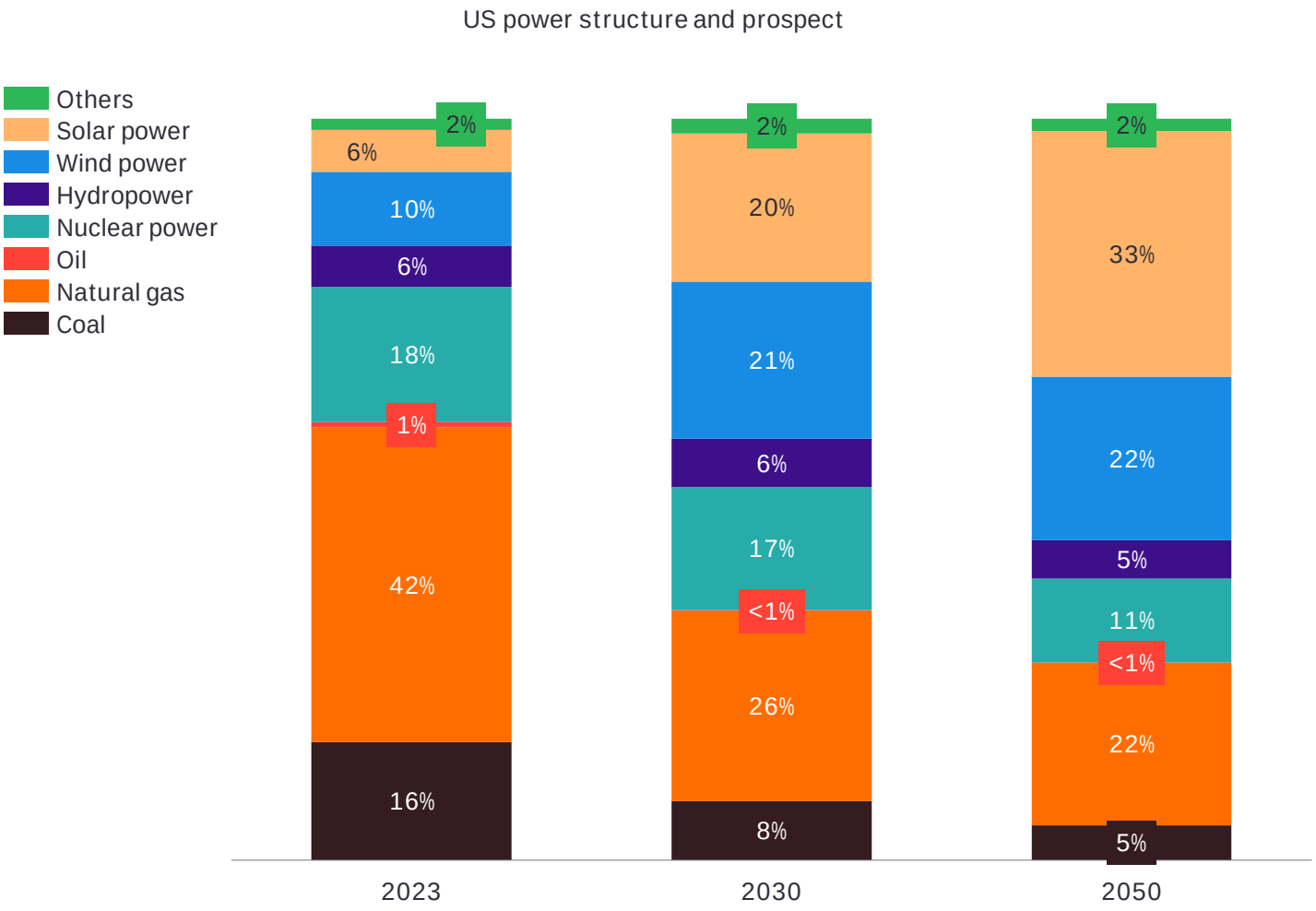
However, stringent environmental regulations, high production costs and inadequate policy support have hindered PV industrial development to a certain extent. For example, in terms of silicon wafers and batteries, the EU accounts for less than 1% of the global market share. Currently, the EU's PV sector is heavily reliant on imports, with more than 90% of solar PV wafers and other PV modules imported from China.

To support the development of local PV businesses, the EU has implemented a range of policies and measures in recent years. Notably, *the REPowerEU: Joint European Action for more affordable, secure and sustainable energy,* outlining a plan to invest an additional 210 billion euros in key clean energy technologies by 2027. Additionally, *the Net Zero Industry Act*, sets a target for at least 40% of clean energy projects to be supplied by local businesses by 2030. It also proposes that EU member states impose restrictions on suppliers from third countries if their products account for over 65% of the EU's market share[1].

[1] Through the tendering process, vendors are likely to experience a downgrade of rating.

US

The US is a major energy power, primarily driven by oil and gas. In 2023, conventional sources contributed 59% to its total power generation, while renewable energy accounted for 41%, with PV power represented only 6%. Achieving carbon-free electricity by 2035[2] remains a significant challenge. Consequently, the development of PV power is essential for adjusting the energy structure in the US and for reinforcing its leadership in energy resources. According to the US Energy Information Administration (EIA), renewable energy is projected to supply 66% of power by 2030 and 73% by 2050, with PV's contribution expected to rise to 20% by 2030 and 33% by 2050.



Source: Our World in Data, EIA

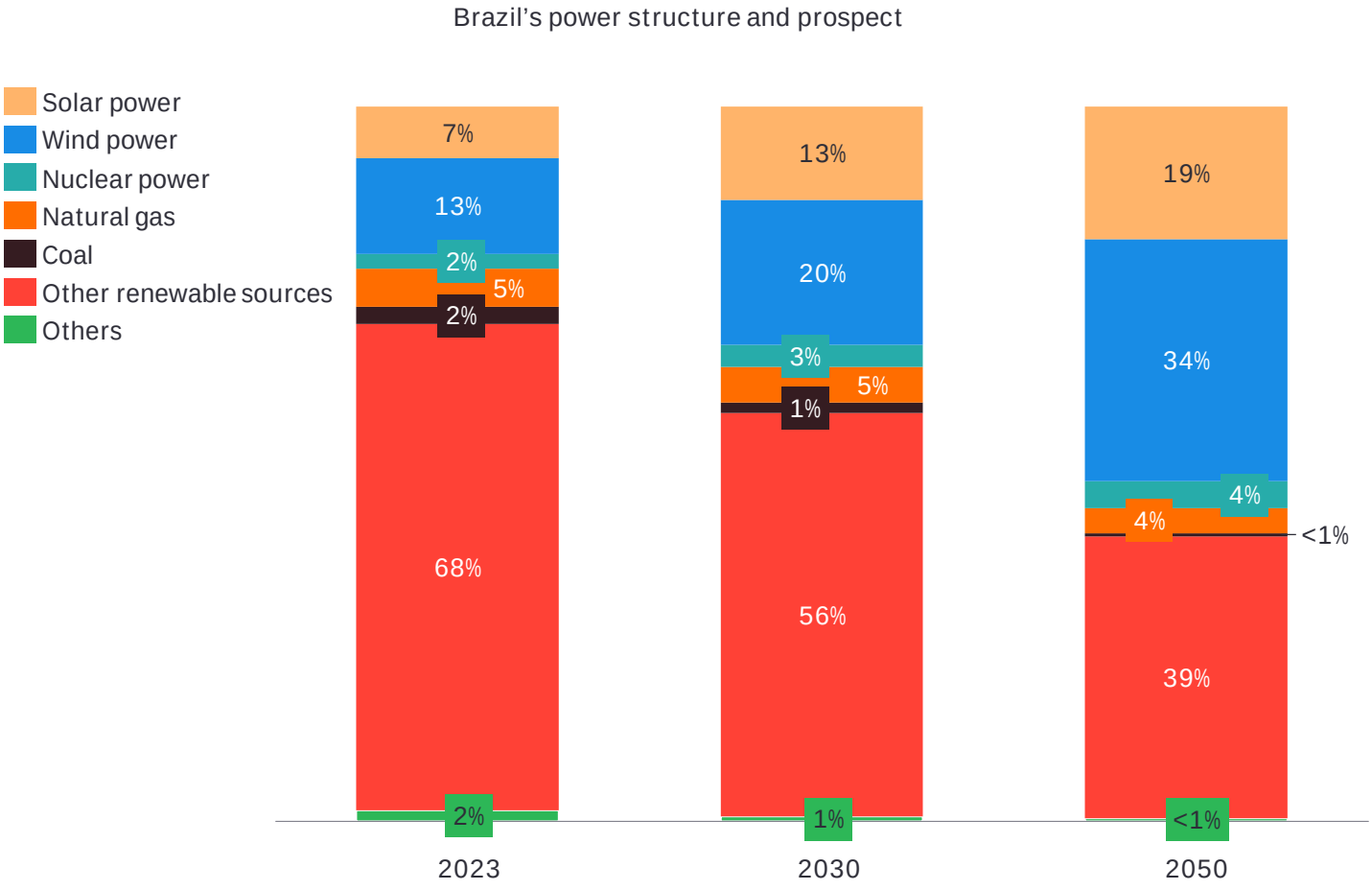
The US market offers significant potential for PV installation; however, local PV companies have struggled to adapt to market demands for PV products. According to the Solar Energy Industry Association (SEIA) and Solar Power World, in 2023, silicon production capacity was only 60,000 tons, with 100% of the capacity remaining idle. Additionally, the US has limited production capacity for silicon wafers and batteries. By the first half of 2024, the production capacity of PV modules reached approximately 26,550. As a result, the US is experiencing a relatively slow growth in its local PV sector.

To support the development of local PV businesses, the US introduced a raft of measures to contain China's export of PV products along with anti-dumping and countervailing actions. This includes the effectiveness of the US Section 201 and 301, the enaction of the Inflation Reduction Act, which plans to invest US$369 billion in combating climate change and improving energy security. Additionally, the US has proposed incentives for the entire lifecycle of the PV industry, such as the production tax credit (PTC), investment tax credit (ITC), advanced manufacturing production tax credit and direct manufacturing subsidies.

[2] The "3550" plan is the major framework for the US to achieve carbon neutrality – the US pledges to achieve a carbon neutral power sector through a transition to renewable energy-based carbon-free power generation by 2035 and 100% carbon neutrality by 2050.

Brazil

In Brazil, around 89% of power generation comes from renewable sources. According to the IEA, this proportion is expected to rise to 92% by 2050, with PV power contributing 19%. Driven by preferential tax cuts, net metering policies[3], rising electricity price[4] and declining PV module costs, Brazil has experienced rapid development in its PV sector over the past decade. Installed PV capacity grew from 8MW in 2013 to 39GW in 2023, making Brazil the third largest country in the world for newly added installed PV capacity and the sixth largest by cumulative installed capacity. Located in the tropical climate zone, Brazil enjoys abundant solar resources, positioning it as one of the most promising PV markets in Latin America.



Source: Our World in Data, IEA

To meet local needs, Brazil relies heavily on importing PV modules due to its underdeveloped industrial chain. Currently, 99% of PV modules are imported from China, as Brail lacks production capacity of silicon materials, silicon wafers and batteries in the middle and upper streams, with a PV module production capacity of less than 5GW. Therefore, China's PV technology is expected to play an important role in Brazil's energy transition for the foreseeable future.

Brazilian Vice President Geraldo Alckmin has emphasized the strategic significance of local production of solar power devices, stating that it would enhance energy security and support the transition to a low-carbon economy. To promote the development of local PV industry, Brazil has introduced restrictions on imports. In December 2023, the Executive Management Committee of the Brazilian Chamber of Foreign Trade (GECEX) decided to impose an import tariff on solar panels and reimpose import tariffs on 324 related products to encourage domestic renewable energy development. Additionally, the Brazilian government aims to attract investments of over 300 billion reais (approximately US$60 billion) for building power infrastructure from 2020 to 2030, with more than 50% of the newly added investment focused on PV and wind power.

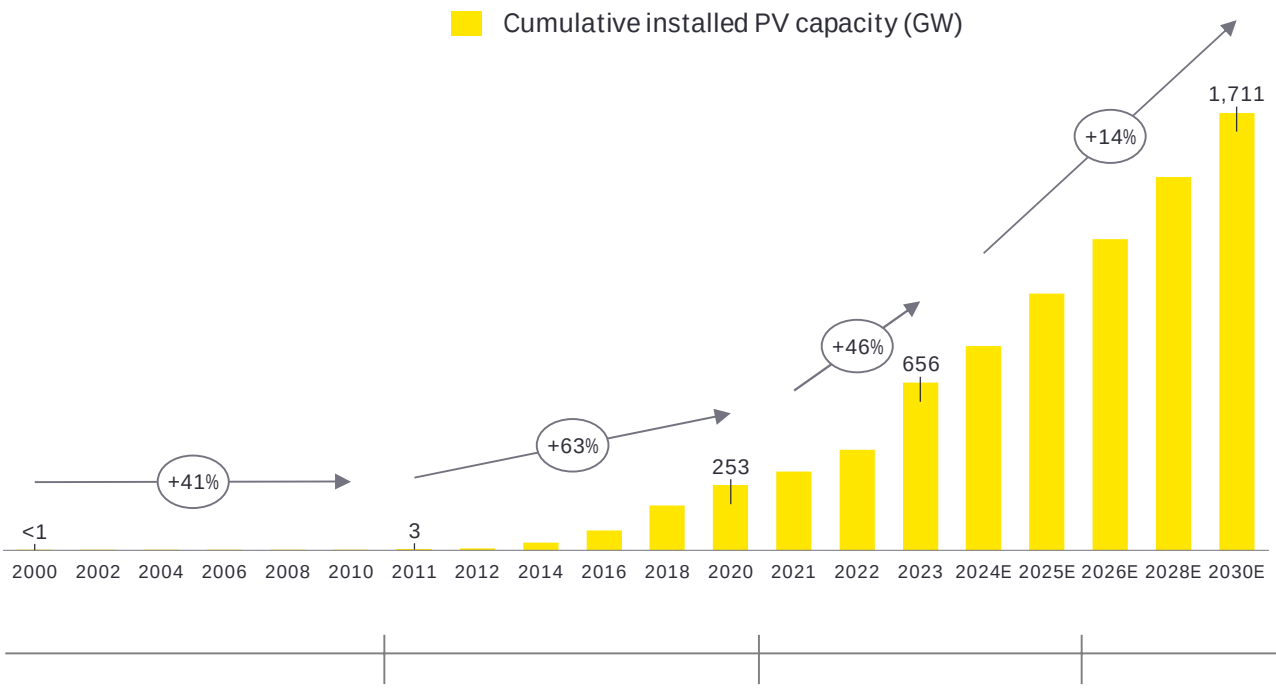
[3] Net metering policy: Distributed PV projects under 5 MW in size enjoy preferential tax cuts and net metering policies in Brazil.

[4] Electricity price hiked due to hydropower crisis.

2. Evolution of China's PV industry

Having experienced challenges and setbacks, China's PV industry is adapting to the changing world.

History, status quo and prospect of China's PV industry



Start-up and market expansion with products of low technology content and added value (2000-2010)	Reimagination and transformation at an accelerated pace (2011-2020)	High-quality development and global expansion (2021-2025)	Technology leadership and win-win cooperation (2026 and beyond)
▸ "Global PV foundry", being the world's largest producer of PV modules in 2007 ▸ Being reactive due to dependence on other economies for raw materials, technology, devices and market	▸ Being reshaped due to the European debt crisis, shrinking market and anti-dumping and counter-vailing investigations ▸ Being revitalized to adapt to the changes thanks to efforts against crisis, policy support and growing demands ▸ China overtaking the European countries and the US to rank the first in the world in terms of both newly added and cumulative installed PV capacity	▸ Innovating and upgrading empowered by new generation of information technology driven by cost reduction and productivity improvement ▸ Investing more overseas as a result of increasing trade conflicts and domestic competition	▸ Racing in technologies as innovation and breakthrough being the key to leadership ▸ Global cooperation on technology, production, management, branding and services toward healthy development and building a shared future with win-win results

Source: IRENA, SPE, CPIA

Start-up and market expansion with products of low technology content and added value (2000-2010)

In the early 20th century, the EU countries strengthened policy support for the development of PV industry, thus stimulating demands for solar power. Meanwhile, developed countries shifted parts of PV industrial chain offshore, including silicon production featuring high energy consumption and high pollution and labor-intensive assembly. During this period, Chinese companies ushered in the era of PV foundry thanks to an abundant supply of cheap local labor. Within a few years, China became the world's largest producer of PV modules. However, behind the prosperity, there was a hidden danger – Chinese PV companies generated revenue by exports due to inadequate domestic demand while products were of low technology content and low added value. Indeed, China's PV industry was trapped into a dilemma due to dependence on other economies for raw materials, technology devices and market.

Reimagination and transformation at an accelerated pace (2011-2020)

In 2011, the EU debt crisis broke out and the PV market shrank rapidly as major countries cut subsidies to PV industry. Subsequently, Chinese PV companies were hit by the EU and US anti-dumping and counter-vailing actions and many companies went bankrupt or struggled to survive. In this context, the Chinese government took countermeasures against the EU and US attempts to contain Chinese companies, including providing policy support to promote the development of domestic PV market and strengthen standardized management and boosting upgrading by improving financial policies to revitalize China's PV industry. Meanwhile, Chinese PV companies focused efforts on research and development, adoption and optimization of advanced technology worldwide with an attempt to change the situation that China stayed at the bottom of global PV value chain. This led to a rise of companies to reshape the landscape of China's PV industry. During this period, under the policy guidance, China's PV domestic market grew rapidly and the industry achieved economy of scale, while PV companies were gaining the technology advantage. China's cumulative installed PV capacity leapt to over 250GW in 2020 from only 3.1GW in 2011, overtaking the EU countries and the US to become the world's largest PV manufacturer.

High-quality development and global expansion (2021-2025)

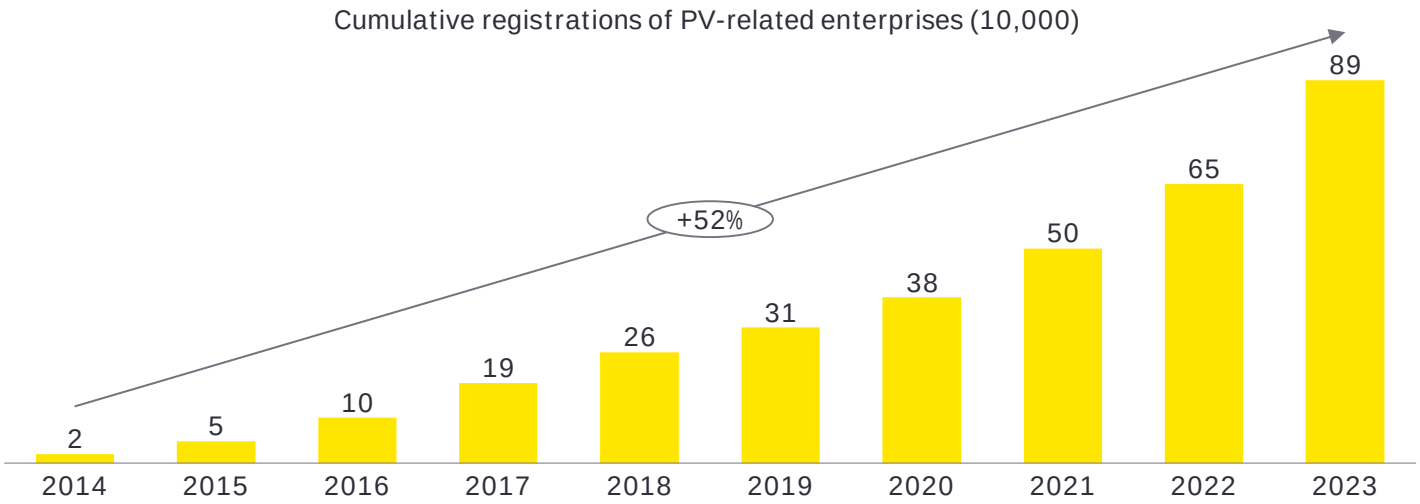
Domestically, 2021 marked the first year for the implementation of dual carbon initiative, underpinned by supportive policies, technology empowerment and market demands, as well as the rapid growth in new generation of information technology, including 5G and industrial internet, digital and intelligent transformation is an inevitable choice for the PV industry through innovation and upgrading. Globally, due to the rising anti-globalization, increasing trade conflicts, the EU countries, the US and India have imposed restrictions since 2021, including the US anti-circumvention investigation and the Indian anti-dumping action. Besides, driven by an increasing domestic competition, the PV companies made greater investment overseas to establish plants and integrate research, production supply and marketing worldwide, shifting from "Made in China, sold globally" to "Made globally, sold globally". During this period, the US and Southeast Asia became preferred investment destinations, while investment in emerging markets like India and the Middle East was growing.

Led by technology and win-win cooperation stage (2026-Future)

Amid the geopolitical challenges, the mode of simply exporting product and building factories overseas will be increasingly restricted and Chinese PV companies must seek diversified paths to going overseas. For example, adopting the service mode of technology licensing to help other countries build their own factories locally. Chinese PV companies rely on technology, production, management, branding, service and other dimensions of the accumulation of experience and capacity, to create a "light assets to go overseas" mode, to build a win-win cooperation ecosystem on a global level, is the future of the PV industry "globalization" development trend.

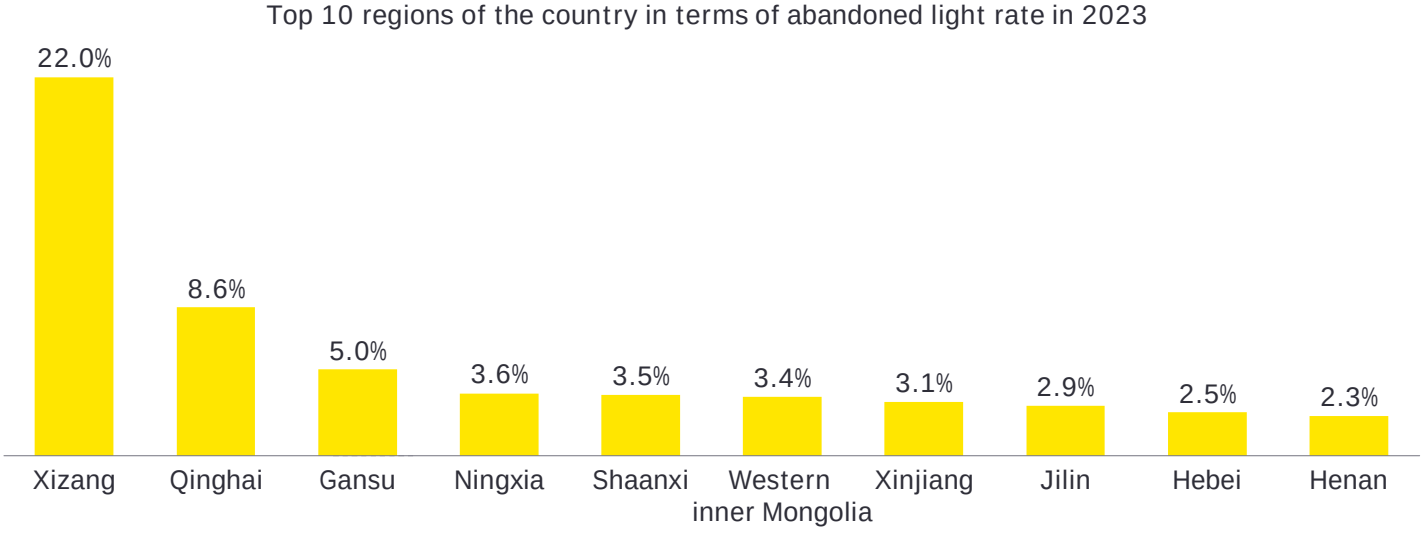
Looking back, for over two decades, China's PV industry developed rapidly in the ups and downs, transformed from the restricted to independent and controllable, from catching up to leading the world. At present, China's PV industry is striding towards a new journey. However, behind this, it is also necessary to note the problems and challenges encountered by China's PV industry in the process of development.

- Firstly, the current China's PV industry has many entrants, the overall state of overcapacity, while the industry is trapped in the dilemma of "price war". According to data provide by QCC.com, in 2023, the number of China's PV-related enterprises registered reaches about 900,000 and the number of companies has grown at a compounded rate of 52% in the last decade. The International Energy Agency (IEA) and InfoLink forecast, the global PV module production capacity in 2024 exceeded 1,120GW, of which China accounted for about 80%, while the global demand for PV modules in 2024 is estimated to be 500-550GW. Data by the Ministry of Industry and Information Technology (MIIT) shows that from January to December 2023, the price of polysilicon and module products dropped by more than 50%.



Source: QCC.com

- Secondly, China's new energy consumption problem is getting prominent. China's PV base and load center distribution is incompatible, giving rise to long-distance transmission needs. Due to the pressure on the power transmission channel, the power system regulation capacity is insufficient, resulting in abandoned light is still severe. Viewed from an overall perspective, the national abandoned light rate is only 2%, but Xizang's, Qinghai's and Gansu's abandoned light rate reached 22%, 8.6% and 5%. Although the government has carried out many extra-high voltage and other power transmission channel construction projects and a series of reforms from power market side, such as improving the power medium and long term and spot market, power auxiliary services market, green power and green certificate trading system and related market construction, it still takes a long time to be able to play a role.



Source: National New Energy Consumption Monitoring and Early Warning Center

- Thirdly, countries of EU and America set up trade barriers to China's PV products. Since the "double negative" action, the US has taken measures such as Section 201, 301 investigation and other tariff to curb China's exports of PV products. The EU also followed suit by enacting the Net Zero Industry Act[5] and the Regulation of the European Parliament and of the Council on prohibiting products made with forced labor on the Union market.
- Fourthly, the EU has constructed invisible "green barriers" to Chinese PV enterprises. Compared to the EU, China's PV products have high carbon emission values under the same conditions. If the EU Carbon Border Adjustment Mechanism (CBAM) once expanded to PV products, will straightly impact on the higher carbon emissions of silicon exports. In addition, the French Energy Regulatory Commission (CRE) will include the carbon footprint of PV modules in the evaluation of the PV bidding, this behavior is also gradually prevailing in other countries in the EU.

3. Core competitiveness of Chinese PV enterprises

Vital competent of PV enterprises

Given the numerous domestic and international challenges, it is prudent for Chinese PV businesses to strengthen their own competencies. Therefore, as a PV enterprise, what specific capabilities should you possess?

Competency assessment framework of PV enterprises

A Hard Power
"Technology"

1. R&D
- R&D investment level and number of R&D outcomes
- R&D innovations and advanced technology reserve

2. Products
- Product performance advantages
- Product quality and safety

B Soft power
"Operation and management"

3. Operations
- Resource allocation
- Program execution analysis

4. Financing
- Capital operation
- Cost control

5. Marketing
- Branding
- Customer relations and service operation

6. Organization
- Corporate governance
- Core team building

C Ecosystem
"Supply chain and management"

7. Ecosystem
- Supply chain security and stability, including ecological cooperation, core resource control and the layout of upstream and downstream industry chain
- Lean supply chain management, using digitalization and intelligence to enhance the flexibility and agility of the supply chain and achieve cost reduction and better efficiency

Source: EY-Parthenon analysis

[5] For single-sourcing products with more than 65% of the EU market share, public procurement tenders may face certain downgrading measures.

Following the numerous industrial transformations and the collaborative constraints imposed by Europe and the US, China's PV industry has transitioned from merely expanding its scale and depressing the prices to enhancing quality and efficiency, with a strong emphasis on technological advancement. The EY team has compiled a summary of 10 emerging technological trends in the PV sector, drawing insights from TD's interviews conducted with technical experts from prominent PV firms, alongside our extensive industry knowledge and experience.

Ten future technology trends in the PV industry

Trend 1: Large-size wafers become the future hotspot	Trend 6: In terms of chalcogenide batteries, multiple paths will increase efficiency in parallel in the short term; in the long term, the efficiency ceiling will be touched by all-chalcogenide stacks
Trend 2: N-type wafers + (ultra) thinning continues to advance	Trend 7: In the patterning route, wet film + projection mask lithography is the future mainstream
Trend 3: Tubular PECVD coating process and alumina 3-in-1 process are expected to become mainstream	Trend 8: In terms of thin-film battery substrate materials, FTO+online coating is the mainstream in the future
Trend 4: Benefiting from better optical and electrical properties, microcrystallization can further improve HJT efficiency	Trend 9: The current research on sputtering targets is moving towards diversification, high purity, large-scale, etc., and less indium is the core in the future
Trend 5: OBB, electroplated copper, and silver-coated copper together to reduce the use of silver	Trend 10: Photovoltaic cell manufacturing is developing towards digitalization

Source: TD, EY-Parthenon analysis

The technological evolution within the PV industry continues to progress rapidly, necessitating that enterprises prioritize the development of their core competencies, particularly in technical expertise.

Historically, Chinese PV companies have leveraged their labor advantages and favorable policies to achieve significant growth, often at the expense of enhancing their internal capabilities, specifically in business management. This includes areas such as operational management, financial oversight, market strategy and organizational governance. In the current landscape, as Chinese PV enterprises expand their global presence, there is an increasing demand for robust operational and management skills, as well as effective risk management throughout their processes. Consequently, enhancing their capabilities in global management is essential for the sustainable growth of Chinese PV enterprises.

In the current phase of "win-win cooperation" globally among PV enterprises, evaluation criteria extend beyond mere technological and operational capabilities; they also include the competitiveness of the supply chain, encompassing everything from sourcing and manufacturing to customer delivery. Supply chain competitiveness involves, firstly, the ability to maintain security and stability amidst geopolitical tensions, regulatory obstacles and other potential risks. This includes fostering ecological partnerships, controlling essential resources and strategically managing both upstream and downstream components of the industrial chain. Secondly, it pertains to the supply chain's capacity for lean management, which can be enhanced through digitalization and intelligent empowerment, thereby improving flexibility and responsiveness while simultaneously reducing costs and increasing efficiency.

For PV enterprises, the cultivation of robust competencies and the refinement of exceptional skills are crucial for achieving sustainable and high-quality growth. The EY team offers comprehensive consulting services aimed at the transformation and enhancement of PV enterprises, leveraging its extensive industry expertise, diverse experience, holistic business capabilities and global resource network to support the sustainable development of these enterprises.

How EY can help	
Strategy (overall examination, leveraging strengths and weaknesses, transformation consensus)	► Identifying corporate development genes, benchmarking and learning from leading peers, and comprehensively evaluating the health of business development and management operations as well as future growth ► Examining the development prospects of the industry, accurately positioning the core competitiveness of the enterprise, further clarifying the strategic objectives, helping the enterprise to reach an all-in consensus on transformation and determining the direction of future development
Hard power (benchmarking and learning, system optimization)	► Through the benchmarking of R&D and products, summarizing and finding out the weaknesses of the R&D team, process, mechanism, assessment, and so on ► Proposing the construction and optimization of R&D system to stimulate innovation vitality and realize market-oriented technology
Soft power (system capability, support for strategic transformation)	► Helping companies identify the key capabilities (especially in terms of operation mode, investment and financing, marketing system, organizational effectiveness, etc.) and resources required to support strategy implementation ► Proposing capacity enhancement and resource allocation, and setting up an implementation roadmap
Ecosystem (global business layout, win-win situation between cooperators)	► Assisting enterprises in drawing global business “navigation charts”, finding new growth curves and “optimal routes” ► Building global competitiveness by cooperating with eco-partners through various ways of going globe

Source: EY-Parthenon analysis

In light of the evolving circumstances, the advancement of China's PV industry has reached a pivotal juncture. Chinese companies must enhance their internal capabilities, establish a robust industrial foundation, cultivate core competitiveness and develop a comprehensive PV industry ecosystem to achieve sustainable and high-quality growth in the sector.

For more information, please contact us:

Carol Zhao

Partner, Strategy and Transactions
Ernst & Young (China) Advisory Limited
+86 139 1015 4955
carol-zy.zhao@cn.ey.com

Cassie Zhu

Senior Manager, Strategy and Transactions
Ernst & Young (China) Advisory Limited
+86 177 0181 9895
cassie.zhu@cn.ey.com

Claire Ning

Senior Consultant, Strategy and Transactions
Ernst & Young (China) Advisory Limited
+86 136 9219 6732
claire.ning@cn.ey.com

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