China's energy transition: status, characteristics and outlook

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As global attention to climate change intensifies, countries worldwide are accelerating their energy transitions. China, the world's second-largest economy and the largest developing country, has made significant progress in this area. This article explores the current status of China's energy transition, its characteristics, the role of green finance and the future outlook for the energy transition in China.

The current status of China's energy transition

China's progress in the energy transition is reflected in its installed capacity for renewable energy and power generation. China has maintained a leading position globally in these areas for four to five consecutive years, demonstrating substantial capacity for technological innovation and effective policy implementation. The renewable energy industry in China has become a notable aspect of the nation's economic profile, garnering international recognition similar to that of China's high-speed rail network.

China has achieved global leadership in installed renewable energy capacity and electricity generation, particularly in solar and wind power. By 2023, China had more than 609 gigawatts of installed solar power capacity and more than 441 gigawatts of wind power capacity. In 2022, China's installed renewable energy capacity accounted for 34 per cent of the world's total[1]. China's renewable energy electricity output accounted for 43 per cent of global renewable energy electricity generation in 2021[2].

1 https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation
2 https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation

China's share of installed renewable energy capacity is growing rapidly and renewable energy is now the main source of China's installed electric power capacity. According to the National Energy Administration, 51.9 per cent of China's installed power generation capacity came from renewable energy in 2023[3].

Government support and policy guidance have contributed to the rapid development of China's renewable energy industry, resulting in strong market competitiveness in solar photovoltaic panels and wind power generation. China has a clear direction for its renewable energy industry policy, with strong support for the industrial supply chain, a comprehensive development path and a financial support framework.

The renewable energy industry has also contributed to China's economic recovery following the COVID-19 pandemic. Notably, the solar panel, electric vehicle (EV) and lithium battery industries have achieved considerable success. These sectors, often called the 'new three treasures', have performed well in China's foreign trade, gaining important positions in the domestic market and securing influence internationally. In the first three quarters of 2023, exports from these three sectors reached a value of 798.99 billion yuan (US$122.3 billion), accounting for 4.5 per cent of China's exports.[4]

Renewable energy also plays a crucial role in ensuring energy security. In the first half of 2023, China experienced unusually high temperatures and tightly controlled coal consumption to meet climate targets. Despite hydroelectricity generation declining during this period due to the high temperatures and dry weather, China's power supply remained stable, with solar and wind playing a critical role. Solar power generation

3 http://paper.people.com.cn/zgnyb/html/2024-07/08/content_26069003.htm
4 http://stats.customs.gov.cn/

increased by 7.4 per cent year-on-year in the first half of 2023, while wind power generation increased by 16 per cent.

Additionally, rapid technological progress characterises the current status of China's renewable energy industry. In recent years, there have been multiple technological breakthroughs in solar photovoltaics, wind energy, solar thermal energy, biomass energy, geothermal energy and hydrogen energy. For example, a 2023 breakthrough by LONGi Green Energy Technology in solar conversion efficiency, surpassing a decades-old record held by Japan[5], highlights China's progress in renewable energy technology.

Characteristics of China's energy transition

China's green energy transition has achieved quantitative success and displays several distinct characteristics. These characteristics reflect China's innovation in the energy sector and its unique path in its energy transition.

Firstly, a new energy system characterised by multi-energy complementarity centred around energy storage is rapidly being developed. In China, no single renewable energy source, such as solar or wind, can independently manage the energy transition. To realise a stable and sustainable energy supply, multiple energy sources must be complementary, especially with the support of energy storage technologies. China is vigorously promoting a development model that integrates wind, solar, hydro, thermal and energy storage technologies. By combining energy storage with renewable energy power generation, this model aims to enhance the stability of the energy supply.

5 https://global.chinadaily.com.cn/a/202311/03/WS654488d3a31090682a5ec483.html

Secondly, China's renewable energy supply is becoming increasingly diverse. Renewable energy typically refers to wind and solar power generation. Yet, with technological advances and the expansion of application scenarios, renewable energy is now widely used in agriculture, fisheries, construction and community heating and cooling, alongside traditional power generation. For example, Tongwei Group has integrated solar energy with agriculture and fisheries, making it the world's largest agrivoltaics enterprise[6].

Thirdly, with IT and AI technologies, China's renewable energy sector is continuously evolving. New business models, such as shared energy, blockchain technology, smart energy and community energy are emerging and driving innovation in China's green energy sector. Applying these new technologies enhances energy efficiency and provides new approaches to the sustainable development of the energy industry.

In addition, China's green energy industry is increasingly concentrating on leading companies and the entire industrial chain, forming an oligopolistic competition pattern. According to the China New Energy Chamber of Commerce (CNECC), the 2022 market share of China's top five wind turbine manufacturers reached 72.3 per cent and the market share of the top 10 manufacturers reached 98.6 per cent. This indicates that the wind turbine industry has a very high market concentration.

Not all renewable energy sectors are oligopolistic. The EV market and energy storage battery sectors are currently low-concentration markets. In 2022, the CR3 (three-firm concentration ratio) in China's energy storage battery industry was only 34 per cent, the CR5 (five-firm concentration ratio) was 42 per cent and the CR10 (10-firm concentration ratio) was 50

6 https://www.undercurrentnews.com/2021/08/27/tongwei-expands-solar-fish-farm-business/

per cent. While the EV market remains low-concentration, it is gradually becoming dominated by a small number of companies, as indicated by the increasing CR3 and decreasing CR5[7].

This concentration does not prevent small and medium-sized green energy companies in China from finding unique development opportunities in niche markets. Many small companies have succeeded in specialised areas such as solar panel frames and backplanes, with some even becoming publicly traded companies. The coexistence of leading enterprises and innovation in niche fields contributes to the diversity and dynamism of China's renewable energy industry.

Finally, China's green energy sector has greatly benefited from international technological cooperation and is actively promoting green energy globally through initiatives such as the Belt and Road Initiative. According to the CNECC, 195 renewable energy projects were signed by Chinese enterprises outside China in 2022, amounting to approximately US$19.24 billion. Among them, photovoltaic projects were the most prominent, with 131 projects signed, amounting to about US$9.97 billion.

The role of green finance in the energy transition

Green finance has been essential in advancing China's energy transition. The initial Clean Development Mechanism (CDM) provided critical support for the development of renewable energy in China, particularly in wind power projects. The carbon reduction subsidies provided by the CDM significantly improved the internal rate of return for wind power projects in China, ensuring their stable operation. The CDM has

7 According to the New Energy Chamber of Commerce of the All-China Federation of Industry and Commerce, the CR3 of the Electric Vehicle industry is 20% in 2019, 20% in 2020, 27% in 2021, and 26.8% in 2022. The CR5 of the Electric Vehicle industry is 55% in 2019, 45% in 2020, 39% in 2021 and 40% in 2022.

also played a pivotal role in promoting the construction and stable development of small hydropower and biomass projects. Although the CDM market is less active today, its contribution to the early development of China's renewable energy sector remains significant.

Industrial investment funds have also been vital in driving the energy transition. China has established several industrial investment funds specifically to support the development of the energy transition. These funds provide substantial financial support for renewable energy projects and assist in developing small and medium-sized green energy enterprises and innovative technologies. Investment by these funds has been particularly supportive in fields such as solar energy, wind energy and biomass energy, fostering technological innovation and industrial upgrading.

China places great emphasis on establishing green financial organisations, which have played a crucial role in scaling up the country's green energy industry. The participation of third-party financial organisations, such as insurance companies, economic organisations, investment funds and banks, has further amplified the impact of green finance. For example, the CNECC[8], a national-level industry association in China, has over 100 members specialising in green finance. These organisations collaborate to identify projects, develop technologies and provide support.

China's green finance environment is unique, with its policy framework varying across regions, each playing different roles in the energy transition process. For example, although the United States does not have a formal carbon pricing mechanism, it has supported its

8 http://www.cnecc.org.cn/

decarbonisation process through massive subsidies, leading to rapid investment growth. In contrast, despite having a carbon pricing mechanism, Europe has faced significant challenges in wind power development due to insufficient subsidies exacerbated by supply chain inflation.

China leveraged the CDM to promote green energy development in its early days. At the time, green energy was significantly more expensive than fossil fuels, and CDM subsidies helped bridge the gap. With technological advances, the price of green energy has fallen rapidly and subsidies have become less important. Technological advances and capital investment have become the main forces driving the industry.

In addition, capital market support and economies of scale are crucial to the success of green finance. Capital markets play an integral role in China's green energy transition. For example, in 2014, the price of solar thermal power was comparable to that of photovoltaic power. However, as photovoltaic prices declined significantly due to technological advances and scale effects driven by a massive influx of capital, the cost of solar thermal power generation — lacking similar capital market attention — has not kept pace with the downward trend in photovoltaic prices.

Future outlook for China's energy transition

The policy shift from 'dual control of energy consumption' to 'dual control of carbon emissions' marks a new phase in China's energy transition. This policy shift is likely to have long-term implications for China's energy transition and support the stable development of green energy.

Multiple renewable energy sources are gradually being developed. For example, biomass energy, represented by giant reed, is poised to become a significant component of future green energy. The Shaanxi Coal and Chemical Industry Group is developing large-scale cultivation of giant reed in China's Weihe River, Yellow River, Yangtze River and Pearl River basins to replace traditional coal-fired power generation. This new biomass crop grows quickly and burns efficiently, ensuring a steady supply of biomass raw materials while reducing carbon emissions.

China's total amount of renewable energy is set to sustain long-term, large-scale development. Since the launch of the 14th Five-Year Plan, the development of renewable energy in China, particularly photovoltaic energy, has been significant. The plan set a target for a new energy base of 744 million kilowatts, a target that has led to a doubling of the annual growth rate beyond the country's expectations.

The application of renewable energy has also become increasingly widespread, especially in rural areas. The CNECC anticipated that China's rural areas will be the first to achieve carbon neutrality, with renewable energy use potentially reaching 87–94 per cent. Historically reliant on firewood, a traditional form of biomass energy, rural areas now benefit from distributed solar energy, small wind turbines, biomass energy and geothermal energy, significantly improving the energy structure and environmental conditions.

In the future, renewable energy in China is expected to continue its growth, potentially becoming a major or even conventional energy source. However, challenges remain. Carbon tariffs pose a significant challenge to China's green energy transition. Although many production processes appear green and environmentally friendly, a lifecycle analysis

may reveal that they still result in substantial carbon emissions. To comply with international carbon tariff rules, especially the Carbon Border Adjustment Mechanism by the European Union, China will need to proactively prepare by improving relevant policies and standards to align with international norms.

Throughout the renewable energy development process, the inclusive development of traditional energy has also been emphasised. The equipment, knowledge and land advantages of traditional energy are crucial for the development of renewable energy. Integrating traditional energy with renewable energy can establish a more diversified and inclusive development model, advancing toward a greener future.

In conclusion, China’s green energy transition has achieved significant progress and is likely to continue playing a crucial role in the future. With the support of green finance and effective policies, China is expected to remain a key player in the global energy transition, moving towards a greener and more sustainable future.