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News and Highlights

# Carbon neutrality: China's energy transition over the past decade

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China's energy transition is based on accelerating the construction of a clean, low-carbon, safe, and efficient new energy system (Fig. 1), providing strong energy security for economic and social development; focusing on ecological civilization construction, and accelerating the formation of a new energy consumption model that is efficient, green, inclusive, and beneficial, while promoting carbon reduction, pollution reduction, expansion of green spaces, and economic growth.

## 1. Achievements in China's energy transition and development

Over the past decade, China has deeply promoted changes in energy production and consumption methods. The capacity for energy supply security has been comprehensively enhanced, and green and low-carbon energy development has achieved historical breakthroughs, effectively ensuring high-quality economic and social development.

In 2023, the proportion of clean energy consumption reached 26.4%, an increase of about 10.9% compared to 2013, and the proportion of coal consumption decreased by about 12.1%. The total installed power generation capacity reached $2.92\times10^9$ kW, of which clean energy accounted for $1.7\times10^9$ kW, representing 58.2% of the total installed capacity. The generation of clean energy was about $3.8\times10^{12}$ kWh, accounting for 39.7% of the total power generation, an increase of about 15% compared to 2013. Over the past decade, the increase in clean energy generation has accounted for more than half of the total electricity consumption increase in society, and the "Green" content of China's energy has continued to increase.

The primary energy production capacity has grown by 35% over ten years, strongly supporting the stable and healthy development of China's economy. Over the past decade, the cumulative fixed asset investment in the energy sector has been about $39\times10^{12}$ yuan, significantly driving investment growth in the upstream and downstream industries and related industries. A series of major energy projects have been completed and put into production, establishing a complete energy equipment manufacturing industry chain. Innovations in new energy, hydropower, nuclear power, power transmission and transformation, and new types of energy storage have accelerated, promoting the clean energy industry to become a new pillar of the modern industrial system.

Energy supply and demand have remained balanced, and energy prices have been generally stable, effectively ensuring the energy security of more than $1.4\times10^9$ people. The per capita living electricity consumption has doubled from about 500 kWh to nearly 1000 kWh, and the number of natural gas users has reached $560\times10^6$. In the World Bank's global business environment evaluation, the "Access to Electricity" indicator ranking has risen to 12$^{th}$ place. The energy industry has fully promoted poverty alleviation and rural revitalization. The central budget for the transformation and upgrading of rural power grids has exceeded $100\times10^9$ yuan, driving local and corporate investment. In 2015, the historical issue of electricity access for the entire population was resolved. The scale of household photovoltaics in rural areas has reached $120\times10^6$ kW, involving more than $5.5\times10^6$ households, which can increase the income of farmers by $11\times10^9$ yuan per year and create about $2\times10^6$ jobs. Continuously meeting the green energy needs of the public, by the end of 2023, the clean heating rate in the northern region has reached nearly 80%, and the national charging infrastructure has increased from less than 100000 units to nearly $8.6\times10^6$ units.

The average coal consumption for power supply has been reduced to 303 g of standard coal per kilowatt-hour, and the emission levels of sulfur dioxide and nitrogen oxides from advanced units are comparable to the limit values of natural gas power generation units. From 2013 to 2023, the energy

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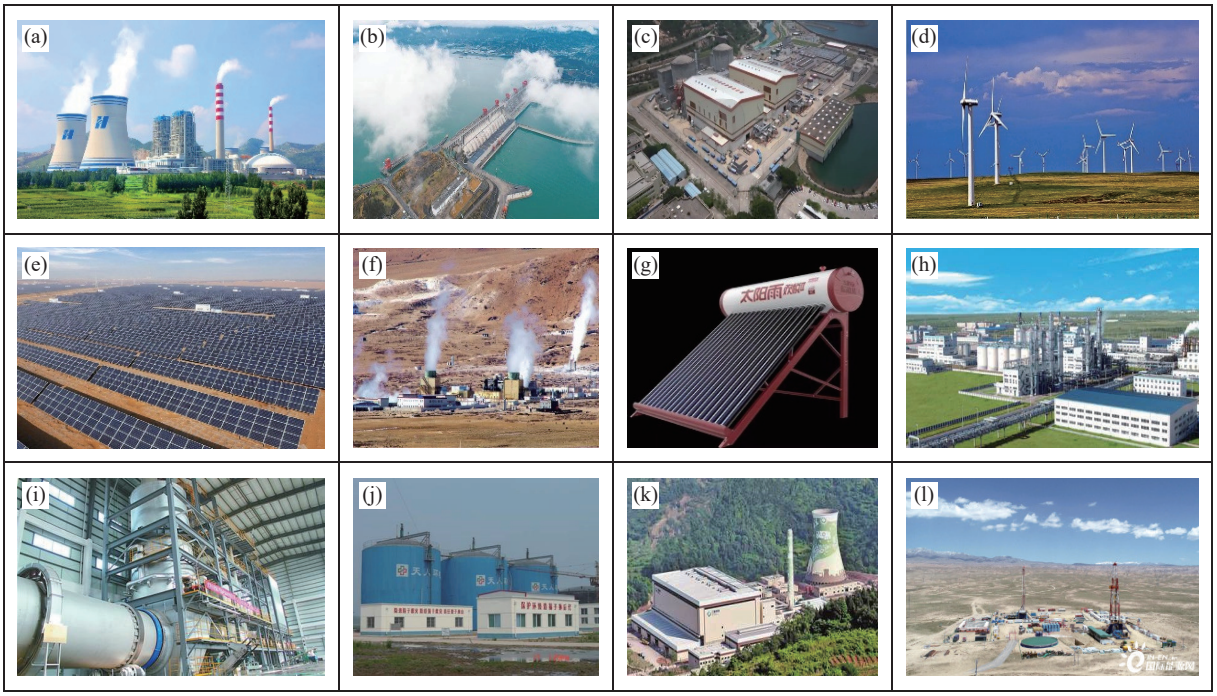


**Fig. 1.** Various power generation, heating, and fuel production plants and products implemented according to local conditions in China. a–Shandong Laiwu Power Plant's million-unit won the Gold Award of the Asian Power Awards 2018 coal-fired power generation project; b–Three Gorges Hydropower Station; c–Daya Bay Nuclear Power Station; d– Bayannur Wind Power Plant; e–desert photovoltaic power generation; f–Tibet Yangbajing geothermal power generation; g–rural areas exclusively used solar water heaters; h–Jilin biofuel ethanol factory; i–Shandong Jiyang County Catering Waste Disposal Center, which can turn 300 t of catering waste into 10 t of biodiesel every day; j–Shandong Wenshang County large biogas power generation station; k–Chongqing Fengsheng waste incineration power plant; l–China Geological Survey explores the construction of Qinghai Guide Dry Hot Rock Power Generation Project. The image above is sourced from the Internet.

consumption per unit of GDP has decreased by more than 26%. The continuous advancement of oil product quality upgrades has brought the quality of oil products to an advanced global level. More than 80% reduction in coal-fired boilers nationwide, and the basic completion of coal replacement for winter heating in plain areas of the Beijing-Tianjin-Hebei region and the Fen-Wei Plain. Green and intensive development of energy resources has been realized, green development technology has been widely applied, and the ecological environment of mines has been significantly improved. The "Photovoltaic +" ecological restoration new model has been promoted in deserts, Gobi, deserts, and coal mining subsidence areas. The average PM2.5 concentration has decreased by 54%, and the number of heavy pollution days has decreased by 83%, effectively supporting the construction of a beautiful China.

China's energy transition investment in 2023 reached $\$676\times10^9$, making it the country with the most energy transition investment in the world. China continues to expand open cooperation, carrying out green energy project cooperation with more than 100 countries and regions. A large number of symbolic projects such as nuclear power, hydropower, and new energy have been successively completed and put into production. In 2023, the export of wind and photovoltaic products helped other countries reduce carbon dioxide emissions by about $810\times10^6$ t. China's new energy industry has not only enriched the global supply and eased global inflationary pressures but also made outstanding contributions to global climate change response and green transformation.

Promote green energy-saving buildings. By the end of 2023, the cumulative construction area of energy-saving buildings reached $32.68\times10^9$ $m^2$, and the proportion of energy-saving buildings in urban existing building area exceeded 64%, an increase of nearly 30% points compared to 2013, with a cumulative construction of ultra-low energy consumption and nearly zero-energy buildings exceeding $43.7\times10^6$ $m^2$.

Comprehensively construct a clean and efficient transportation system. The energy consumption intensity of transportation continues to decrease, and the comprehensive energy consumption per unit of transportation work of railways in 2023 decreased by about 19% compared to 2013. Vigorously develop the charging infrastructure network, improve the layout and service facilities of hydrogen and gas stations. By the end of 2023, a total of nearly $8.6\times10^6$ charging infrastructures and more than 450 hydrogen stations have been built.

## 2. Promote the high-quality development of non-fossil energy

Promote the rapid development of wind power and photovoltaic power generation. China is rich in wind and solar energy resources, and wind power and photovoltaic power generation have become the main forces of clean energy. Large-scale wind power and photovoltaic bases are being

built in an orderly manner, with a focus on the Kubuqi, Ulan Buh, Tengger, and Badain Jaran deserts, planning and constructing $450\times10^6$ kW large wind power and photovoltaic base projects. The development of offshore wind power is being scaled up and clustered, with a cumulative installed capacity of $37.28\times10^6$ kW. The development of distributed new energy is actively promoted, carrying out the "Thousands of townships and villages wind action" and "Thousands of households bathed in light action", promoting new models such as photovoltaic-agriculture complementarity, photovoltaic-fishery complementarity, and photovoltaic-animal husbandry complementarity, opening up a broad space for new energy development in rural areas. By the end of 2023, the cumulative installed capacity of wind power and photovoltaic power in China reached $441\times10^6$ kW and $609\times10^6$ kW, respectively, ten times the total of ten years ago (Fig. 2). Among them, the cumulative installed capacity of distributed photovoltaic power generation exceeded $250\times10^6$ kW, accounting for more than 40% of the total photovoltaic power generation installed capacity.

Develop hydropower according to local conditions. Scientifically coordinate the development and ecological protection of hydropower, and orderly promote the construction and upgrading of large hydropower bases and large hydropower stations. By the end of 2023, the installed capacity of conventional hydropower reached $370\times10^6$ kW. The green transformation and modernization of small hydropower have been steadily promoted, and by the end of 2023, nearly 4000 small hydropower stations have been transformed and upgraded, with significantly improved ecological comprehensive benefits.

Actively, safely, and orderly develop nuclear power. Nuclear power is a high-quality and efficient clean energy. China has always regarded nuclear safety as the lifeline of nuclear power development, insisting on using the most advanced technology and the strictest standards to develop nuclear power, and the nuclear power units in operation have maintained safe and stable operation for a long time. The construction of coastal nuclear power projects is being promoted in an orderly manner, the autonomous third-generation nuclear power technology "Hualong No.1" first-unit has been put into operation one after another, the "Guohuo No.1" demonstration project is under construction, and the world's first commercial demonstration project of the fourth-generation nuclear power technology high-temperature gas-cooled pile has been completed and put into operation. Breakthroughs have been made in the comprehensive utilization of nuclear energy for clean heating, and the application field of nuclear energy has been further expanded. By the end of 2023, the installed capacity of nuclear power in operation was $56.91\times10^6$ kW, 3.9 times that at the end of 2013; the total installed capacity of operation and construction reached $100.33\times10^6$ kW.

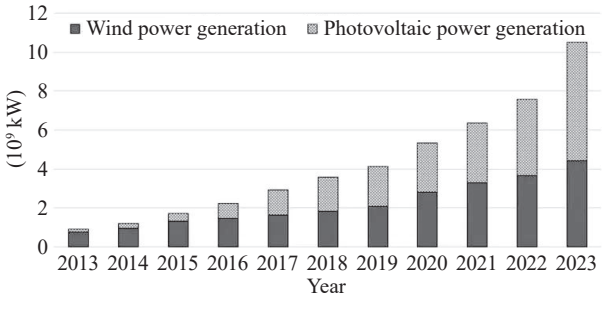


**Fig. 2.** China's cumulative installed capacity of wind and photovoltaic power (2013–2023).

Promote the development of biomass energy, geothermal energy, and ocean energy. Promote the diversified development and utilization of biomass energy according to local conditions, and steadily develop biomass power generation such as agricultural and forestry biomass power generation, biogas power generation, and urban domestic waste incineration power generation. By the end of 2023, the cumulative installed capacity of biomass power generation reached $44.14\times10^6$ kW. Promoting clean heating with biomass energy according to local conditions, and developing biogas from livestock and poultry breeding waste. The orderly promotion and application of biofuel ethanol and biodiesel and other clean liquid fuels have been carried out. New breakthroughs have been made in the development of deep and shallow geothermal, and a number of projects mainly based on geothermal energy for centralized heating have been completed. Positive progress has been made in the large-scale utilization of ocean energy.

## 3. Promote the coordinated development of traditional and new energy

Traditional and new energy are complementary and alternative relationships. While vigorously developing new energy sources, it is essential to leverage the supportive and safeguarding role of traditional energy sources to promote the coordinated development of both new and traditional energies.

Promote the clean and efficient development and utilization of coal. Establish a long-term mechanism for the green development of coal mines, build safe, intelligent, and green modern coal mines, implement comprehensive management of mining areas and ecological environment restoration, and the quality of the ecological environment continues to improve. Over the past decade, the cleaning rate of raw coal, the comprehensive utilization rate of mine water, and the land reclamation rate in the whole country have all increased by more than 10%. Strengthen the comprehensive management and safe utilization of coal mine gas, and the comprehensive benefits of gas extraction and utilization on production safety, resource utilization, and ecological and environmental protection have continued to appear. Over the past decade, more than $100\times10^6$ kW of backward coal power capacity has been eliminated. Actively promote the "Three transformations" of coal power units, that is, energy-saving and carbon reduction transformation, flexibility transformation, and heating transformation. By the end of

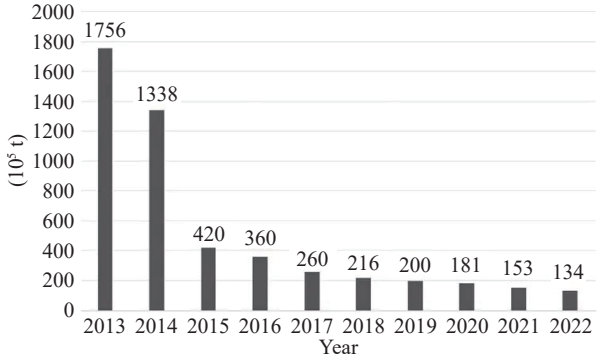


**Fig. 3.** Significant reduction in pollutant emissions from China's Power Industry.

2023, more than 95% of coal power units have achieved ultra-low emission, and more than 50% of coal power units have the ability to deeply adjust peak capacity, and the pollutant emission volume of the power industry has decreased by more than 90% (Fig. 3).

Promote the green transformation and development of oil and gas. The annual output of crude oil has been stable at about $200\times10^6$ t, and the annual output of natural gas has increased by more than $10\times10^9$ $m^3$ for seven consecutive years. Promote the construction of green oil and gas fields, vigorously promote carbon capture, utilization, and storage (CCUS) technology, and build a "near-zero" emission oil and gas field demonstration area. Promote the transformation and upgrading of the petroleum refining industry, strengthen the research and application of renewable energy hydrogen production, and the preparation of chemical products by hydrogenating carbon dioxide. Scientifically plan and orderly promote the quality upgrade of oil products, achieving a "Three consecutive upgrades" from national Ⅲ to national Ⅵ in stages, and the quality of oil products has reached an advanced global level. In less than 10 years, the quality upgrade of oil products has been completed, which took developed countries nearly 30 years.

## 4. Conclusion

China has formulated a medium and long-term development plan. By 2035, China's energy production and consumption methods will be widely formed in a green way, non-fossil energy will accelerate towards the main energy, and the new power system will provide strong support for energy transition. By the middle of this century, China's new energy system, which is clean, low-carbon, safe, and efficient, will be fully established, the energy utilization efficiency will reach an advanced global level, non-fossil energy will become the main energy, and it will support the goal of achieving carbon neutrality before 2060.

Source: Excerpted from the White Paper on "China's Energy Transition". https://www.gov.cn/zhengce/202408/content_6971115.htm.