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# China Energy Transition Status Report 2021

*Sino-German Energy Transition Project*

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Tayuan Diplomatic Office Building 1-15,
14 Liangmahe South Street, Chaoyang District
100600 Beijing, P. R. China
c/o
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

**Project Management:**
Anders Hove
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

**Authors:**
Anders Hove, Qian Wenyun, Zhao Kaiming, Philipp Geres, Liu Yuzhao
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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# Preface from the author

The last 12 months have been a momentous period for China's energy and climate policy. While President Xi's 2060 carbon neutral announcement represented a watershed moment in the worldwide energy transition, in many ways it builds upon earlier policies, technology trends, and international cooperation on the topic of low-carbon, sustainable development. Most importantly, it represents a concrete vision for realizing the Chinese concept of an Ecological Civilization, including a revolution in energy production and consumption.

Until 2020, China had already taken many steps towards revolutionizing energy production and consumption. However, in some respects the role of markets, clean energy, and demand response have remained constrained within a narrow niche. Many industry observers and official think tanks had continued to consider coal as the sine qua non of China's energy system. They could not envision a revolution, even one planned and organized at the highest levels, as changing that. Increasingly, that has begun to change, as analysts and industry players have begun to recognize that, through steady progress on clean energy integration, China's energy revolution can and should ultimately lead to carbon neutrality—though virtually all acknowledge the difficulty of the task.

The purpose of this report is to summarize for an international audience some selected aspects of the energy transition underway in China. The links to various official statistics and policy documents may also serve as a useful reference for international scholars and others with an interest in China's energy situation. The report is the second in a series published by the Sino-German Energy Transition, a component within the larger Sino-German Energy Partnership, a part of the long-term cooperation between the China National Energy Administration and the German Federal Ministry of Economic Affairs and Energy. The project is implemented by GIZ, the German Energy Agency (dena), and Agora Energiewende on the German side, and by the Electric Power Planning and Engineering Institute (EPPEI), the China Southern Grid Energy Development Research Institute (CSG EDRI), and the China Academy of Sciences Institute of Applied Ecology (CAS IAE) on the Chinese side. The views, data, and other contents of this report have been complied by the Sino-German Energy Transition Project at GIZ, and therefore any views expressed in the report are solely those of the authors, and have not been reviewed or approved by the project's partners.

On behalf of the team of the Sino-German Energy Transition Project, I hope that you find this year's report helps you understand both our own work as well as the overall China energy picture, which grows more fascinating with each passing year.

Sincerely,
Anders Hove
Project Director
Sino-German Energy Transition Project

# About the Sino-German Energy Transition Project

## Towards a more effective, low-carbon energy system in China

China is the world's largest coal consumer and the country with the highest greenhouse gas emissions. To meet its climate goal, in particular, the latest commitment to peak the country's carbon emissions before 2030 and to become carbon neutral by 2060, China needs to dramatically transform its energy system away from fossil fuels towards a renewable-energy based system. But despite its ambitious goals, China faces numerous challenges in the energy transition: in 2021, wind and solar energy are estimated to account for 11% of total electricity generation, while coal remained the main source of energy for industrial and heating power. A major problem is the design of effective energy policy measures to steer the energy transition and overcoming system inertia, which favors the survival of existing industrial and energy industry structures.

### Objectives

Against this background, the Sino-German Energy Transition Project supports the exchange between Chinese government think tanks and German research institutions to strengthen the Sino-German scientific exchange on the energy transition and share German energy transition experiences with a Chinese audience. The project aims to promote a low-carbon-oriented energy policy and help to build a more effective, low-carbon energy system in China through international cooperation and mutual benefit policy research and modeling.

### Approaches

To achieve the overall objective, the Sino-German Energy Transition Project introduces German experiences of the energy transition into advising the Chinese government and energy policy-related think tanks.The project implements this program under 4 work streams:

- Providing technical advice to Chinese policymakers on the low-carbon transformation of the Chinese energy system
- Sharing German energy transition experiences and expertise as inputs for the modeling of energy scenarios and corr·esponding
- Coordinating the contributions of German partner institutions to promoting the low-carbon orientation of China's energy policy
- Increasing visibility of the German energy transition and Sino-German cooperation in the energy sector

### Outcomes

The Chinese and German partners will collaborate in research of 9 topics. The project is expected to have a diverse range of outputs includes bilateral workshops, modeling workshops, policy reports and technical publications.

- Distributed Energy
- Rural Energy Transition
- Power Market Reform
- Provincial Energy Transition
- Electric Vehicles
- Heating and cooling
- Energy Efficiency
- Hydrogen
- Grid Planning (including flexibility and demand-side response)

The Sino-German Energy Transition project is supported by the German Federal Ministry for Economic Affairs and Energy (BMWi) in the framework of the Sino-German Energy Partnership, the central platform for energy policy dialogue between Germany and China on national level. From the Chinese side, the National Energy Administration (NEA) supports the overall steering. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH leads the project implementation in cooperation with the German Energy Agency (dena) and Agora Energiewende.

English Chinese

Download the project brochure

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# 1 Chinese Energy Transition Policy Overview

# 1. Chinese Energy Transition Policy Overview

## Introduction

2020 marked a major watershed in China's energy and climate policy, with the end of the 13th Five-Year Plan and the momentous announcement by President Xi Jinping at the U.N. General Assembly that China would pursue climate neutrality by 2060. Subsequently, policies in the fields of energy and climate have come out in rapid succession, in many cases building on past policies and in other areas covering new ground.

The purpose of this report is to both present some of the highlights of China's year in energy transition for an international audience while also introducing some of the current research topics of the Sino-German Energy Transition project, which is implemented by GIZ on behalf of the German Federal Ministry of Economic Affairs and Energy, in partnership with the China National Energy Administration. Any statements of opinion represent those of the authors alone. We hope you find the contents useful for your work.

## Major progress

Given the importance of energy in the 13th Five-Year Plan, 2020 represented a major chance to take stock of China's progress on its energy goals, which centre around the country's long-term efforts to ensure economic development, energy security, and technological modernization, leading ultimately to the realization of the vision of a Beautiful China. Clean energy represents a major element of the vision of humans living in harmony with the natural world, in keeping with the concept of an Ecological Civilization.

**Completion Status for 13th Five-Year Plan on Energy Development**

*binding target*

| Indicators | Unit | 13th FYP Target[1] | 2020 Figure[2] |
|---|---|---|---|
| Primary energy production | Billion tons of standard coal | 4 | 4.1 |
| Total installed capacity | GW | 2000 | 2200 |
| Energy consumption | Billion tons of standard coal | <5 | 4.98 |
| Coal consumption | Billion tons of coal | <4.1 | 4.04 |
| Power consumption | TWh | 6800-7200 | 7511 |
| Share of non-fossil energy (renewable and nuclear) in total installed capacity | % | 39% | 43% |
| Share of non-fossil fuel in power generation | % | 31% | 32% |
| Share of non-fossil fuel consumption | % | >15% | N/A |
| Share natural gas consumption | % | 10% | N/A |
| Share of coal consumption | % | <58% | 57% |
| Reduction in energy intensity | % | 15% | 16% |
| Reduction in carbon intensity | % | 18% | 18.2%* |

**End of 2019 data released by Ministry of Ecology and Environment[3].*

*Source: 13th Five-Year Plan for Energy Development and National Bureau of Statistics, 2021*

### Completion Status for 13th Five-Year Plan on Electricity Development

*The 13th FYP targets highlighted in red were not met in 2020.*

| Indicators | Unit | 13th FYP Target[4] | 2020[5] |
|---|---|---|---|
| Regular hydro installation | GW | 340 | 370.2 |
| Pumped-hydro installation | GW | 40 | |
| Nuclear installation | GW | 58 | 49.9 |
| Wind installation | GW | >210 | 281.5 |
| Solar installation | GW | >110 | 253.4 |
| Share of fossil fuel installation | % | 61% | 57% |
| Share of coal power installation | % | 55% | 49% |
| Coal power installation | GW | < 1100 | 1080.5 |
| Gas power installation | GW | >110 | N/A |

*Source: 13th Five-Year Plan for Electricity Development and China Electricity Council, 2021*

Over the past decade, China has remained reliant on fossil energy, especially coal and imported oil, but at the same time built a foundation for a complete transformation of its energy structure by developing the world's largest capacity of hydroelectricity, solar photovoltaic, and wind energy. For decades, China has spoken of itself as a Big Coal Country, a 煤大国 , and coal has represented the mainstay of its energy development and indeed powered its growth. Though clean energy continues to decline in cost and is roughly competitive with coal-based electricity in many regions (albeit without considering environmental external costs), the turning point in the clean energy transition is closer than ever. Thus, it is appropriate that President Xi announced in 2021 that China will build an energy system with clean energy at its centre—language far more ambitious than prior documents that merely called for a high proportion of renewable electricity.

## Here are a few of the other main points of progress in China's energy transition we tracked over the past year:

1. 2020 saw record installations of wind energy—over 72 GW of installations—and additions of solar PV far above expectations, given the previous reduction in subsidies in many regions. Although many projects were rushed to meet end-of-year deadlines after which some remaining subsidies were phased out, the grid parity program is approving more projects. This program guarantees long-term tariff payments at the current provincial coal grid tariff level. In other words, wind and solar are closer to cost parity than ever in many regions of China, leading to expectations that recent installation growth can become self-sustaining.

2. China continues to resolve its long-running challenge with curtailment of renewable energy sources, and the country basically met and exceeded targets for keeping curtailment low despite surging wind and solar installations. Curtailment of wind fell to just 3% nationally in 2020, and PV to 2%.[6]

3. China made slow but steady progress in power market reforms, continuing to transition electricity transactions towards mid-to-long term bilateral contracts. More technologies are now eligible to participate in ancillary services markets. And in the much-watched field of spot power markets, all pilot provinces have now undergone trial trading periods. More spot market pilot provinces have been announced, and it looks likely that the spot market experiments will be accelerated.

4. Offshore wind is starting to take off. In 2020, China added 3 GW of offshore wind, and more is on the way. [7] The provinces Jiangsu and Guangdong are leading on offshore wind.[8]

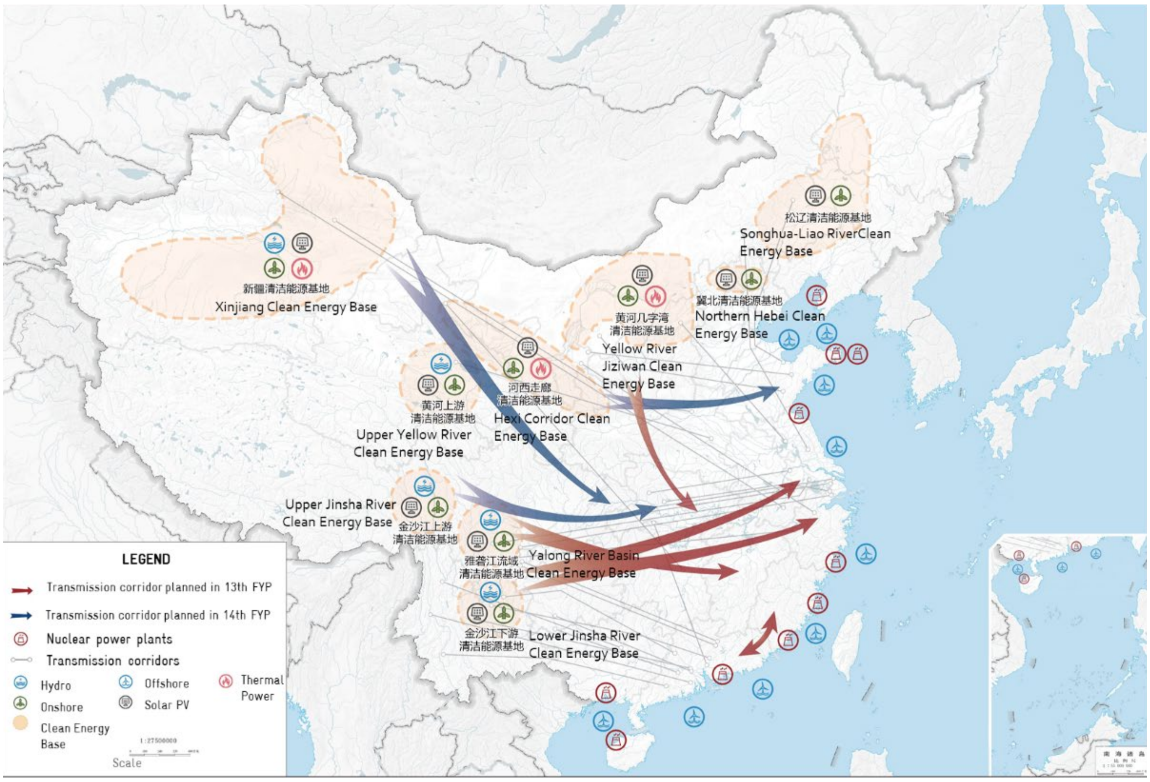
5. Rooftop solar is becoming more popular. China newly installed 10.1 GW of residential rooftop solar in 2020.[9] However, numerous barriers to rooftop solar remain, and most of China's solar consists of ground-mounted installations.

6. The electric vehicle market stabilized, and larger more attractive vehicles (both foreign and domestic) came to market. For the first time, the made-in-China Tesla Model 3 dominated sales, followed by the Wuling Hongguang Mini EV. [10] Up-and-coming EV brands Nio and Xpeng also saw growing sales of their full-sized, long-range EVs. Meanwhile, EV charging infrastructure continues to improve rapidly, and the number of public charging posts grew by an astonishing 54%.[11]

7. Hydrogen has become a hot topic in China, just as it has worldwide. Most of China's oil and gas majors have announced major investments in hydrogen, including both production and distribution at hydrogen fuelling stations. Chinese provinces and cities have also gotten in on the action with their own hydrogen strategies. Beijing, for example, is planning a major hydrogen push for over 70 fuelling stations and 3,000 vehicles. Most hydrogen in China is derived from coal. [12]

8. The operation of China's national carbon market is getting closer. Final regulations for the market were published in December 2020, and in early 2021 authorities announced that 2021 will be the first compliance year for the over 3,000 participating entities in the power sector, with market trading to commence in June. In March 2021, further documents from the Ministry of Ecology and Environment raised expectations that China's initial design, based on performance benchmarks and free allocations, would transition towards allowance auctions and a hard-total cap on emissions. [13]

### Location of clean energy base illustrated in 14th Five-Year Plan




*Source: Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Vision of 2035, March 2021*

The 14th Five-Year Plan outline proposes the construction of eight major clean energy bases across China and a plan to develop coastal nuclear power in several places. It also maps out a programme to transfer clean energy from the energy bases to eastern China through power transmission routes.[14] These bases are all located in the western and northern parts of China, indicating the government's emphasis on developing power generation in those regions and transmit power to the east. This is an interesting focus given the recent trend in more distributed renewable installations in central and eastern China.

## Challenges remain

The 2020 carbon neutrality announcement marked a watershed, and subsequent policy announcements have made it increasingly clear China will prioritize low-carbon development: However, many challenges remain, often reflecting ongoing policy contradictions.

**Electricity shortages**: In late 2020, several southern Chinese provinces experienced major power outages. In the case of Zhejiang, outages were ordered by officials seeking to meet administrative energy targets. In Hunan and elsewhere, officials blamed physical shortages on cold temperature, shut-in coal and hydro plants, and high regional demand that constrained cross-province power imports.[15] Electricity consumption continues to rise rapidly due to China's economic recovery, led by energy-intensive industries. In 2021, several provinces, including Zhejiang and Guangdong, are expecting higher summer peaks that could lead to new shortages.[16] Renewable energy, energy storage, transmission, and demand response are not yet large enough to meet such demand spikes, so these circumstances will likely be used to justify new coal plant construction.

**Wave of coal plant approvals**: 2020 saw a surge in new coal plant approvals at the provincial level, following NEA's decision to give most provinces the green light for new construction under the NEA's traffic light system. Some provinces simultaneously restricted renewable development, citing inadequate ability to absorb renewables, while accelerating coal plant development. The China Electricity Council and State Grid continue to expect to add hundreds of GW of new coal plants over the next few years to meet growing demand.[17] At the same time, the average utilization hours for thermal power plants have declined steadily to 4216 hours, well under 50%.[18]

**Inspection of NEA**: China's Ministry of Ecology and Environment (MEE), with the support of the central leadership communicated the results of an official inspection to the National Energy Administration (NEA) on 29 January 2021. MEE's statement sharply criticized NEA for making energy supply its top priority and neglecting environmental protection. MEE criticized NEA for inadequate policy support for renewable energy, particularly through the draft Energy Law and related measures. MEE also criticized NEA for failing to restrict the construction of new coal power plants in key regions subject to air pollution prevention and control. In 2020, 10 provinces shuttered around 9.6 GW coal power capacity,[19] but NEA also approved the installation of 48 GW new coal capacity.[20] The result, according to the inspection report, is that "what should be built is not built, and what should not be built is built."[21] Since the inspection report, NEA has issued several renewables-related documents, and held a press conference to summarize progress on renewables-related policies.

### MEE's inspection report criticises NEA for insufficient consideration of ecological criteria

China's Ministry of Ecology and Environment (MEE), with the support of the central leadership communicated the results of an official inspection to the National Energy Administration (NEA) on 29 January 2021. 2016, MEE and its predecessor MEP had reported various issues to local government and SOEs twice, but not to NEA. This central inspection requires NEA to respond to the Central Committee and the State Council within 30 working days.

MEE's statement sharply criticizes NEA for making energy supply its top priority and neglecting environmental protection. MEE directly criticized NEA for inadequate policy support for renewable energy, particularly through the draft Energy Law and related measures. MEE also criticised NEA for failing to restrict the construction of new coal power plants in key regions subject to air pollution prevention and control. In 2020, 10 provinces shuttered around 9.6 GW coal power capacity,[22] but NEA also approved the installation of 48 GW new coal capacity.[23] The result, according to the inspection report, is that "what should be built is not built, and what should not be built is built." The average utilisation hour for thermal power plants has declined steadily to 4216 hours, well under 50%.[24] Furthermore, NEA's Early Warning index for coal plant approval gave the green light to eight provinces for adding coal in 2023.

Notably, MEE's environment-related comments only mention air quality and omit greenhouse gas emissions. MEE's comments therefore adhere closely to existing requirements when NEA drafted the Energy Law or approved provincial energy plans, all of which took place before President Xi Jinping's carbon neutrality speech in September. In the future, MEE may place more emphasis on carbon emissions. In a recent article, Kevin Tu of Agora Energiewende has noted that China will likely see more inspections like this given the country's determination to meet the 2030 and 2060 targets.[25]

**Carbon emissions continue to rise**: Although China met its targets for carbon-intensity of GDP, the actual emissions of carbon continued to rise for the third year running. In 2020, according to Carbon Brief, emissions rose 1.5%, compared to 1.9% in 2019.[26] Rising energy consumption, particularly coal consumption, accounts for much of this increase. Now that China is committed to peaking carbon emissions by 2030 and ensuring provinces and SOEs work towards an orderly peak, it will bear watching whether energy security concerns lead to a near-term spike in carbon emissions.

**Power market reforms**: Although electric power market reforms are advancing steadily, and renewable energy is near or at grid parity in many regions, market reforms have yet to resolve several major challenges that hinder the low-carbon transition. First and foremost, provinces remain reluctant to trade electricity—as shown during the recent power outages—and the provincial structure of markets so far has tended to enhance provincial protectionism and self-sufficiency, because the present market consists mainly of mid-to-long-term within-province contracts rather than spot transactions or regional transactions. To further complicate matters, many provinces, such as Shandong and Guangdong,[27] are pursuing capacity markets that could result in high payments towards coal generators. Meanwhile, China's power system lacks flexibility to absorb renewables, and there are few mechanisms to reward flexibility.

**Renewable policies in transition**: While China is adding wind and solar at record rates, and prices are approaching grid parity, renewable energy in China continues to lack a stable, long-term regulatory environment. Since China's carbon market is based on thermal plant performance benchmarks and free allocation, the market plays little role in encouraging a shift in investment to renewables. In addition, renewable generators face new hurdles, such as uncompensated requirements for energy storage, that could eventually be resolved by improved market design that rewards flexibility and firm capacity. Recently, NEA has made progress in this regard through two measures. First, on the renewable obligation, NEA proposes to switch from setting relatively short-term annual provincial targets for non-hydro renewables to setting such targets for each year through 2030, giving clear guidance on how provinces will reach 40% renewables by that year.[28] Second, NEA has proposed new guidelines on pricing for wind and solar mandatory operating hours, setting a fixed price for mandatory hours and then setting the excess via auctions.[29] These hybrid policies mix heavy administrative planning with a relatively narrow role for market forces, and may represent a transition phase until mature spot markets develop more fully.

**Summary:**
This year, the most important thing: there are now more and more visions of how the energy transition will come about, and these are no longer minority academic views or curiosities. Companies and provinces must issue their own plans. Carbon neutrality is not just a single announcement, or a series of uncoordinated actions, nor is it a perfectly interlocking single plan that all can agree is perfect. Rather, it will be a process featuring high uncertainty, cumulative advancement, path dependence, and interdependence with developments outside of China. Most of all, it will require greater societal acceptance of the concept of energy transition—and that is the biggest change of 2020. While those outside of China have debated the semantics of whether 1.5 degrees is impossible or virtually impossible, in China many have gone from viewing carbon neutrality as improbable to viewing it as very hard but possible.

## China's 14th Five-Year Plan sets target framework for energy policy between 2021-2025

In March 2021, China's National People's Congress released the draft of the 14th Five-Year Plan. Both nationally and internationally, climate and energy observers had eagerly awaited this guiding policy document and how it would translate China's climate targets to reach its emission peak before 2030 and achieve carbon neutrality by 2060 into policy targets for 2021-2025. While the 14th Five-Year Plan provides overarching targets, we can expect the responsible ministries to release more detailed targets in sectoral plans later in 2021. Here, the energy sector five-year plan and the $CO_2$ emission peaking action plan are of particular interest. The five most important targets related to energy are as follows:[30]

**Reduce carbon intensity per unit of GDP by 18% from 2020 levels (the 13th Five-Year Plan target was 18%).**

Since the energy sector (including power, heating and cooling, industry, transport, and buildings) is the chief source of carbon dioxide emissions, carbon emission targets are directly relevant to it. The plan does not contain an absolute emission cap but mentions such a cap as a supplement and it is under preparation by the Ministry of Ecology and Environment, and will be announced later in 2021 or early 2022.

**Reduce energy intensity per unit of GDP by 13.5 % from 2020 levels (the 13th Five-Year Plan target was 15%).**

This target is slightly lower than in the last period and probably represents an expected deceleration in efficiency gains. Unlike the 13th Five-Year Plan, the new plan does not contain a cap on total energy consumption anymore but calls for a minimum energy production from various sources equal to 4.6 billion tons of coal equivalent.

**Increase the share of non-fossil sources in total energy consumption to 20% (the 13th Five-Year Plan target was 15%).**

This target is in line with the target of a 25% non-fossil (renewables and nuclear) energy share by 2030 - part of China's climate pledge and implies a linear increase of the targets. The plan also includes a capacity target of 70 GW for nuclear power in 2025.

**Continued promotion of what the document terms "clean and efficient use of coal."**

Despite strong growth in renewables, the plan continues the previous emphasis on the need to develop and safeguard the supply of coal and other fossil energy sources under the aim of maintaining energy security. While the previous sectoral energy five-year plan set a cap for total coal consumption, it is unclear whether such a cap will be included in the forthcoming sectoral plan. The 14th Five-Year Plan has not specified a target for the share of coal in total energy mix, but this can typically be expected to follow in the sectoral plan.

**Discontinuation of a five-year GDP growth target.**

Unlike its predecessors, the 14th Five-Year Plan does not set a GDP growth target for the whole five-year period and targets will instead be determined on an annual basis. This is also relevant for climate and energy policy because energy-intensive smokestack industries still account for a considerable part of economic growth and the more flexible annual approach might support a shift to less emission-intensive and more qualitative growth. Economic growth directly affects energy consumption and emissions: under the assumption that the 14th Five-Year Plan targets are all met, 5% growth would cause an energy consumption increase of 2.3% and 1% emission increase, while 6% growth would increase energy consumption by 3% and emissions by 1.7%.

**President Xi Jinping**

China has made important contributions to reaching the Paris Agreement on combating climate change and is an active practitioner in implementing the Paris Agreement. In September this year, I announced that China will increase its autonomous national contribution, adopt stronger policies and measures, strive to peak $CO_2$ emissions by 2030, and work towards achieving carbon neutrality by 2060.
China has always kept its promises and will take the new development concept as its leader, promote a comprehensive green transformation of economic and social development in promoting high-quality development, implement the above-mentioned goals on the ground, and make greater contributions to the global response to climate change.

*The State Council of China, 12 December 2020*

## National Energy Administration reports on energy transition progress and 2021 policymaking priorities

At a press conference on March 30, Zhang Jianhua, Director of the National Energy Administration (NEA) reported on the progress of China's energy transition and the authority's policymaking intentions for 2021.[31] The most important statements were as follows:[32]

- **Renewable energy utilisation has increased.** The share of non-fossil energy sources (renewables and nuclear) in primary energy consumption reached 15.9% in 2020, overachieving the target of 15%. The share of non-fossil energy in power generation was at 29.5% in 2020, an increase by 9.5 percentage points from 2012. Circa 40% of installed capacity are renewable. Installed capacity of renewables was at 930 GW (370 GW hydro, 280 GW wind, 250 GW solar, 30 GW biomass).

- **China has made progress in developing its domestic renewable energy industry.** Seven out of ten of the world's leading photovoltaic module producers now are from China and more than 90% of China's installed wind turbines come from domestic manufacturers. In the past 10 years, the average cost per kilowatt has decreased by 30% for onshore wind power and 75% for solar photovoltaics.

- **China's 2030 and 2060 climate targets give a clear strategic direction for the future energy policy.** Zhang announced that the NEA will accelerate the implementation of carbon emission peaking in the energy sector and will formulate "more active new energy development goals." Renewable energy will be the mainstay of the energy system and develop on large scale, with high-proportion, and in a market-oriented way.

- **Energy sector carbon peaking through measures in the fields of non-fossil energy, efficiency, and improved policy.** The accelerated development of solar and wind will be crucial, alongside hydro and nuclear power, while simultaneously enhancing storage and power system flexibility. More stringent efficiency consumption standards and increased application of non-fossil energy in industry, heating, buildings, and transportation are to promote more efficient use of energy. To improve the political framework conditions, the NEA is now studying pathways and supporting policy measures to achieve the carbon peak and neutrality targets and at the same time will work on linking up national and provincial energy five-year plans and integrate energy saving, emission reduction and carbon peaking goals into the plan.

**Professor Ji Zou**
**Chief executive and president of the NGO Energy Foundation China (EFC)**

It's too early to say whether the 14th Five-Year Plan is ambitious enough for carbon neutrality in 2060. We are standing at the beginning of a five year plan. We can't simply conclude whether China could achieve the goal in 40 years based on its performance in five years, which is only one-eighth of the length up to 2060. We have to look at the trajectory forward.

*Carbon Brief, 12 March 2021*

This is a large energy system change, entailing advances in renewable energy, energy storage, hydrogen and ultra-high voltage transmission lines, but also innovation of other technologies… like smart controls and blockchain.

**Dr. Jiang Lin**
**China energy expert at the University of California-Berkeley**

*UC Berkeley, March 2021*

**Dr. Hu Min**
**Executive director of the Innovative Green Development Program (iGDP)**

Looking back, most of the targets – from renewable energy installed capacity through to $CO_2$ intensity – were overperformed. We cannot calculate the trajectory simply based on the targets illustrated in the 14th Five-Year Plan outline and say that they will not be sufficient for [the 2060 climate neutrality pledge].

*Carbon Brief, 12 March 2021*

# 2 Key Energy Transition Statistics in 2020

# 2. Key Energy Transition Statistics in 2020

## Introduction: pandemic has small impact on China's energy transition in 2020

Notwithstanding the COVID pandemic slowdown in 1Q 2020, China's electricity and energy demand grew steadily in 2020, though electricity demand growth slipped from 4.5% to 3.1%. Although coal still accounts for over 50% of primary energy consumption and remains the main source for electricity generation, electricity generated by renewable energy increased substantially. In part reflecting the removal of feed-in-tariff subsidies for onshore wind, wind capacity installation increased at a faster rate than in 2019.

## Primary energy supply

Consumption of energy reached 4.98 billion tons of standard coal equivalent, up by 2.2% compared to 2019.[33] Among the total primary energy consumption in 2019, 57.7% came from coal, 18.9% was oil, 8.1% was natural gas, and 14.3% was renewables.[34]

- Coal consumption increased by 0.6%, from 4.01 billion tons in 2019 to 4.04 billion tons in 2020, with the share of primary energy consumption decreased from 57.7% in 2019 to 56.8% in 2020.

- Oil consumption rose by 3.3%, from 673 million tons in 2019 to 695 million tons in 2020, with the share of primary energy consumption reaching 18.9% in 2019.

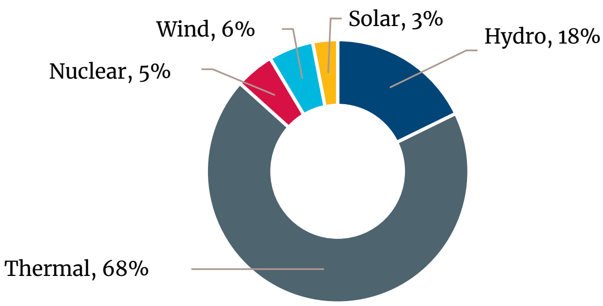
- Natural gas consumption rose by 7.7%, from 306 billion $m^3$ in 2019 to 328 billion $m^3$ in 2020,[35] with the share of primary energy consumption reaching 8.1% in 2019.

- Renewable energy consumption rose in each of the major renewable categories of hydro, wind, and solar. Hydro capacity rose by 13.8 GW and output increased by 4.1%. Wind capacity rose by a record 72 GW and output increased by 15%. Solar PV capacity rose by 49 GW and output increased by 16.1%.

## Electricity

Despite the pandemic, the growth rate of electricity consumption remained positive. Electricity consumption grew 3.1% in 2020, down from 4.5% in 2019.[36] Electricity consumption growth in primary industry (mining and other extraction-related activities) surpassed all other sectors at 10%, due to interrupted growth in secondary (mainly manufacturing) and tertiary (mainly services) sectors, which faced various restrictions due to the pandemic, particularly in the first half of 2020.

### 2020 electricity production by fuel




*Source: China Electricity Council, January 2021*

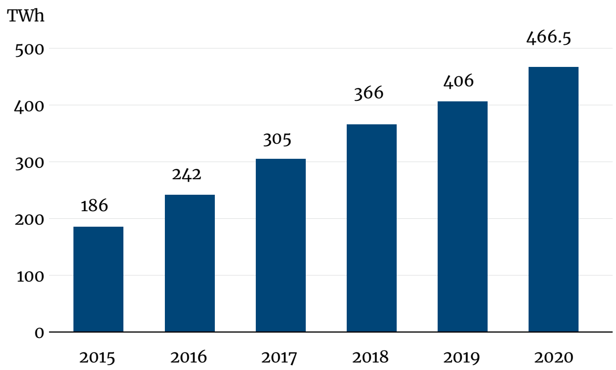
### 2020 electricity production and capacity by fuel

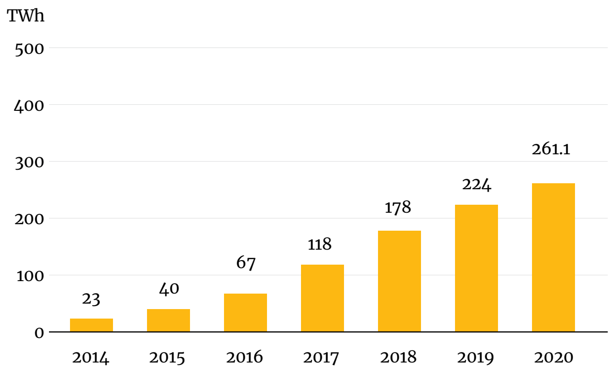
| | Generation (TWh) | % of generation | Additional capacity (GW) | Installed capacity (GW) |
|---|---|---|---|---|
| Hydro | 1355.2 | 18% | 13.8 | 370.2 |
| Thermal | 5174.3 | 69% | 54.6 | 1245.2 |
| Nuclear | 366.2 | 5% | 1.2 | 49.9 |
| Wind | 466.5 | 6% | 71.5 | 281.5 |
| Solar | 261.1 | 3% | 48.8 | 253.4 |
| Total | 7623.6 | 100% | 190.2 | 2200.6 |

*Source: China Electricity Council, January 2021*

The share of electricity generated by non-fossil fuels grew to 32%,[37] surpassing the 13th Five-Year Plan target of 31%.[38] Electricity generated by renewable energy grew steadily in 2020 despite the impact of the pandemic. Compared with the prior year, power generated by hydro power rose 4.1%, wind rose by 15%, and solar increased by 16.7%.[39] Non-carbon sources met the majority of incremental growth in electricity production in 2020. However, thermal output (mainly coal) nevertheless grew by 129.3 TWh.

### Electricity generation by wind (left) and solar PV (right), in TWh

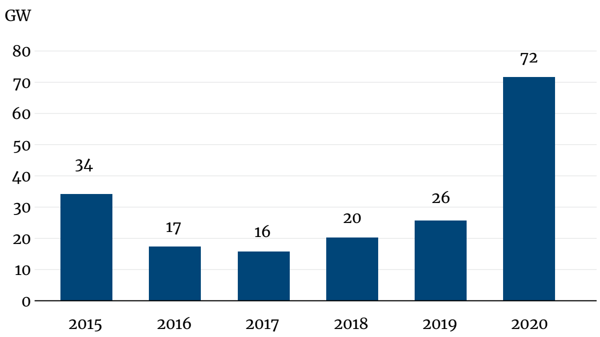


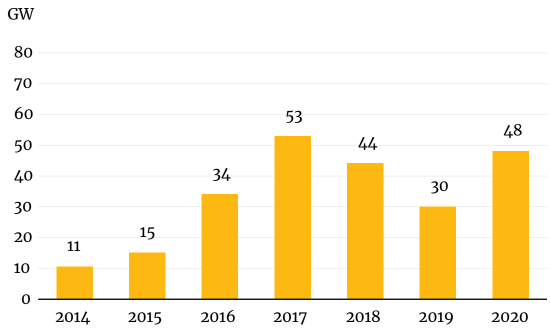

*Source: China Electricity Council, January 2021*

The total power generation capacity by the end of 2020 was 2,200 GW.[40] The installed capacity of wind reached 281.5 GW and solar PV reached 253.4 GW.[41] In 2020, China added 190 GW of new capacity. Thermal capacity (mainly coal) grew by 54.6 GW. Wind and solar combined grew by 120 GW. As noted, there has been a major increase for wind capacity installation due to the phase-out of feed-in tariff subsidies.[42]

**Annual additions of wind capacity (left) and solar PV (right), in GW**




*Source: China Electricity Council, January 2021*




*Source: China Electricity Council, January 2021*

## China will add at least 67 GW of wind and solar capacity (combined) annually to reach 2030 goal

President Xi Jinping pledged that China will peak its carbon emission before 2030 and achieve carbon neutrality by 2060 in the UN General Assembly held in September 2020.[43] Later in December, President Xi proposed more ambitious goals of reducing carbon intensity by over 65% from the 2005 level by 2030 and the share of non-fossil fuels in primary energy consumption should increase to around 25% in his speech at the UN's Climate Ambition Summit.[44] He also stated in his speech that China aims to increase total installed capacity of wind power and PV to over 1200 GW by 2030. Subtracting from the current wind and solar installed capacity of 534.9 GW, China would need to add an average of at least 67 GW annually. NEA sets the 2021 target for wind and solar in total electricity production to be 11% in its wind and solar development plan for 2021, versus 9.4% in 2020.[45]

**Jiang Liping**
**Vice President of State Grid Energy Research Institute**

The assessment of energy security should base on the ability to guarantee the balance of supply and demand, rather than simply examine the annual percentage of energy imports. The ability to guarantee a balance between supply and demand includes the amount of reserves and the capabilities on emergency response.

*Energy Research Club, 6 January 2021*

# 3 Fossil Fuels

# 3. Fossil Fuels

## Coal

- Coal consumption grew just 0.6% but remained below its peak.
- Coal power output grew strongly (1250 TWh), outpacing any other fuel source.

### Coal consumption almost at a peak as leaders emphasized carbon peak and neutrality targets

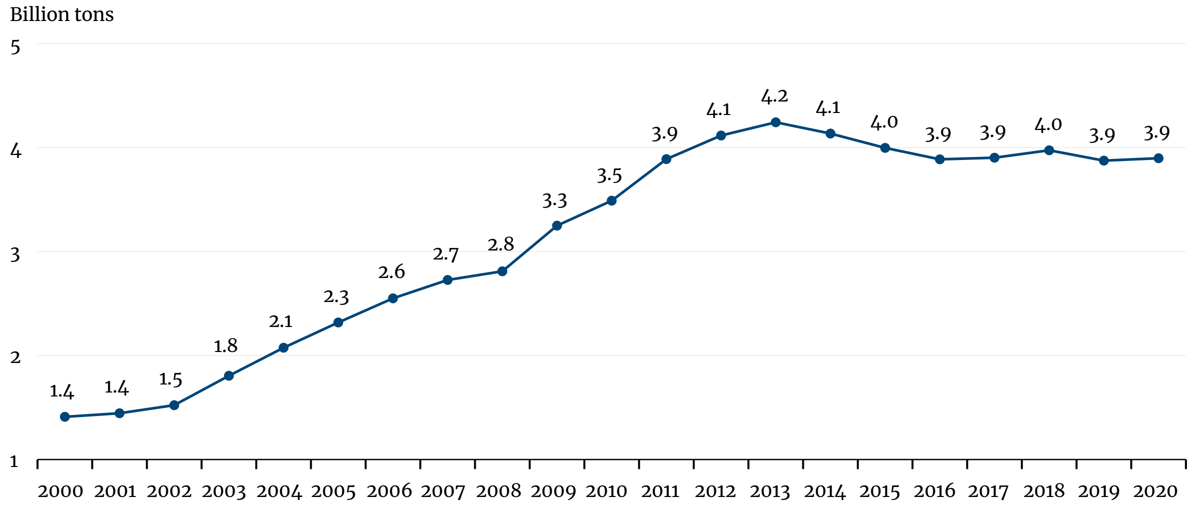
As part of its energy transition—which President Xi Jinping has called a revolution in energy production consumption and technology—China has set the goal of peaking $CO_2$ emissions by around 2030, reducing $CO_2$ emissions per unit of GDP by at least 60% compared to 2005 and to increase the share of non-fossil energy (including nuclear power) in primary energy consumption to 20%. The aim is to reduce coal's share in primary energy consumption to below 58% by 2020, compared to 64% in 2015 and 59% in 2018. China has just achieved this target, since coal's share of primary energy consumption has fallen from 74% in 2013 to 57% in 2020.[46]

Coal policy is driven primarily by environmental and economic priorities, as opposed to climate. The target is to reduce inefficient coal consumption by closures of old power plants, as well as of small coal boilers for public heating and industrial steam. The policy also targets the reduction of coal use at the household level because small-scale coal use contributes significantly to emission of air pollutants. Shanxi province, the heart of China's coal industry, has released a notice to decommission all coal mines with a yearly production below 60 tons, in an attempt to centralise the provincial coal production for future management.[47]

Despite existing overcapacity, new coal plants additions continue. The 13th Five-Year Plan (2016-2020) set a cap on the total coal-fired power plant capacity at 1,100 GW in 2020, though this cap could be set at a higher level in further years. As of January 2021, China had an estimated 88 GW of coal under construction and a further 158 GW in planning.[48] In its 2021 work plan, NEA anticipated that coal's share in primary energy consumption will be reduced to 56% by the end of 2021.[49] In the medium term, coal will remain the largest source of electricity and overall energy production.

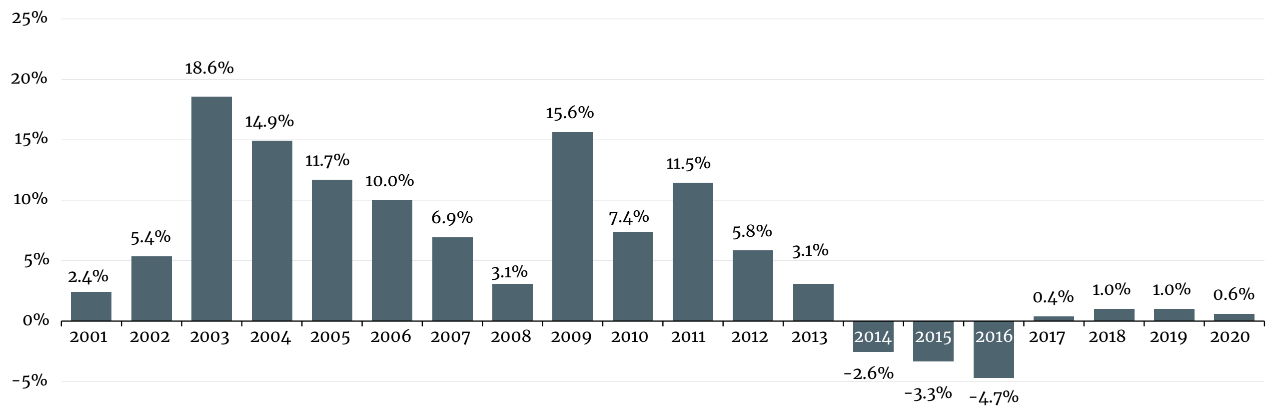
Around half of the coal consumption in China is used to produce electricity, according to NEA analysis in 2017. The other uses of coal include steel production, the chemical industry, construction material, and household uses.

**Yearly coal consumption (billion tons) from 2000 to 2020**



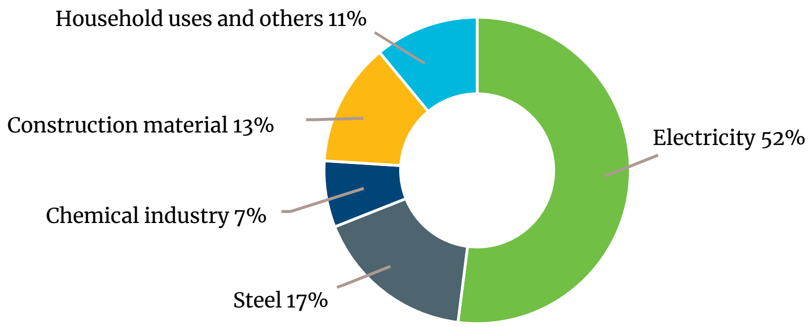

*Source: China National Bureau of Statistics, 28 February 2021*

### Annual growth rate of coal consumption from 2001 to 2020




*Source: China National Bureau of Statistics, 28 February 2021*

### Breakdown of coal consumption in 2020




*Source: Sina Finance, 11 August 2020*[50]

## Challenges for the coal industry and structural change

Despite the continued coal expansion, many coal companies are already in economic difficulties. Carbon Tracker estimates 43% of China's coal fleet is uncompetitive today, and that number will likely reach nearly 100% by 2025.[51] More than 75% of all existing Chinese coal-fired power plants were built after 2000. Overcapacity in China's coal industry has serious negative impacts on the rational allocation of coal resources and stable operation of the national economy. Since 2016, the Chinese government has focused on eliminating excess capacity, especially in the central and southwest regions. As a result, the number of coal mines in China has dropped from 13,000 in 2013 to 5,300 in 2020.[52]

The closure of outdated or over-capacity coal plants and mines can lead to structural unemployment. The number of employees in the coal sector was 6.1 million in 2013, 3.95 million in 2016 and decreased to 2.6 million in 2020.[53] Most coal mines are state-owned, hence there is a significant worker placement problem, particularly given the high average age in the sector. New economic strategies are being devised to counter the loss of coal jobs, such as coal-to-hydrogen in Shanxi province or renewable-powered data centers in Zhangjiakou. It remains uncertain whether such strategies can meet the immense challenge of transitioning coal economies. A fierce debate also continues about whether new coal is needed to meet electricity demand growth, considering that existing coal plants operate at low capacity factors, and that renewable energy is now economically competitive for newly added generation capacity. Recent industry estimates from China Electricity Council show several Chinese regions could experience electricity supply shortfalls in 2021.[54]

> In order to achieve the national goal of peaking $CO_2$ emissions by 2030, the total amount of coal-fired power generation must be strictly controlled, and most of the coal-fired units should switch to flexible scheduling operation to provide technical support for the consumption of non-fossil energy generation. In the next ten years, non-fossil fuel should be the dominate energy source for new energy consumption, and new power generation will be dominated by non-fossil energy generation. Controlling coal-fired power generation will leave some space in the market for the development of non-fossil fuel.

**Li Junfeng**
**Researcher in National Center for Climate Change Strategy and International Cooperation (NCSC)**

*China Thinktanks, 31 May 2021*

**Dr. Fuqiang Yang**
**Aistinguished researcher of the Institute of Clean Energy at Peking University**

> A coal cap for 2021-2025 will eventually be announced in the subsequent Five-Year Plan on energy development and coal development, which the National Development and Reform Council (NDRC) and National Energy Administration (NEA) are now formulating. The outline's binding indicators on energy will still have an actual effect on restricting coal consumption and its share in the energy mix – even without an explicit coal cap.

*Carbon Brief, 12 March 2021*

# Oil

- Domestic oil production grew 1.6%. NEA's 2021 annual work plan calls for maintaining investment in exploration and production to ensure energy security.
- Domestic consumption grew 3%, a ten-year low, in part due to lower driving during the pandemic in 1H 2020. Gasoline consumption fell by 7% and diesel by over 3%.
- EV sales rebounded from a slight dip in 2019, and the EV share of sales should rise through 2025.

## Oil consumption growth slowed, as EV market revived

The production and consumption of oil remains a severe challenge for China's energy transition, as the decades-long macro trend of slowing domestic production and rising import dependence continues. Due to efforts to boost flagging domestic production, crude oil production in 2020 saw an increase of 1.6% compared to 2019.[55]

In recent years, the quality of China's exploitable oil fields has dropped significantly, which results in increased production costs and reduced incentive for companies to develop new oilfields. Under the guidance of low-carbon policy, the government will prioritise clean energy to meet incremental energy demand, potentially dampening long-term demand for high-cost domestic crude oil.[56]

Electrification in the transport sector dented oil demand to a very limited extend: China sold 1.37 million new electric vehicles nationwide in 2020, an increase of 13% from 2019. Electric buses in China displaced 0.26 million barrels per day of oil demand—a relatively large displacement compared to cars, resulting from high daily usage.[57] As EV sales continue to rise, they should increasingly begin to displace demand growth, though the turning point will require a few more years.[58] At the same time, import dependency remains high, with China importing 75% of its oil from foreign countries.

## Crude oil production grew but import dependency also rose

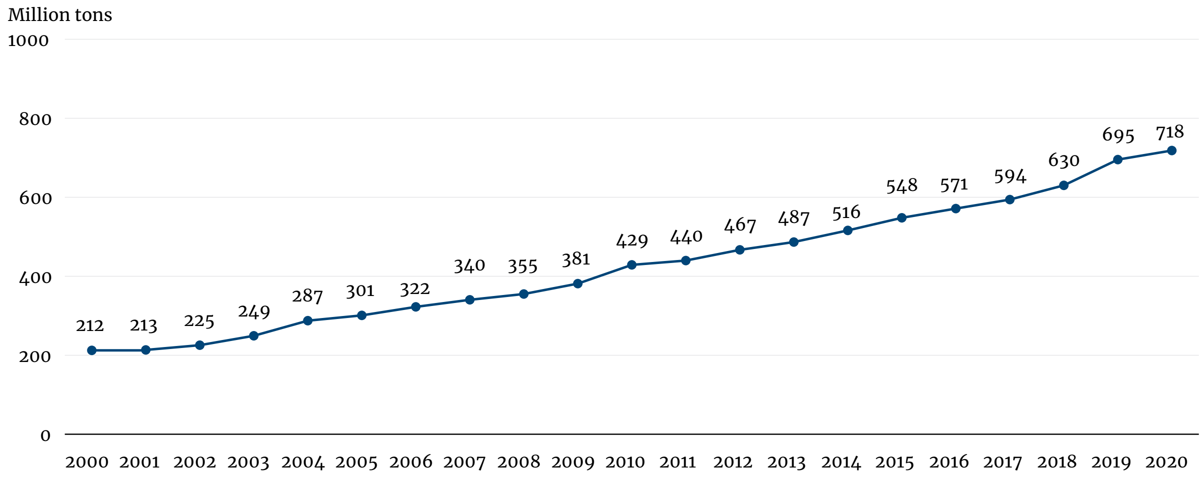
According to China's National Bureau of Statistics, China produced 195 million tons of crude oil in 2020, an increase of 1.6% compared to 2019. Notwithstanding low international oil prices in 2020, China's domestic oil production continued to grow.

Oil demand growth slowed to 3% in 2020, down from 6.8% in 2019. China remains the largest oil importing country, with approximately 542 million tons of oil imported in 2020. This means that China obtains roughly 75% of oil consumption from imports. The largest source of imported oil in 2020 is Saudi Arabia, accounting for 15.7% of all imports. This is followed by Russia and several other OPEC countries like Angola, Iraq, and Iran.[59]

In March 2020, international oil prices plummeted as a result of Saudi Arabia's move to boost output and reduce prices, opening a price war with Russia coinciding with the outset of the Covid-19 pandemic. The price of Brent crude fell to US$ 33 per barrel in early April, about half of China's average 2019 import price of US$ 65 per barrel.[60] Many Chinese crude oil processing companies took the opportunity to increase refining runs, and the amount of crude oil processed in the first three quarters of 2020 increased by roughly 10% compared to 2019.[61]

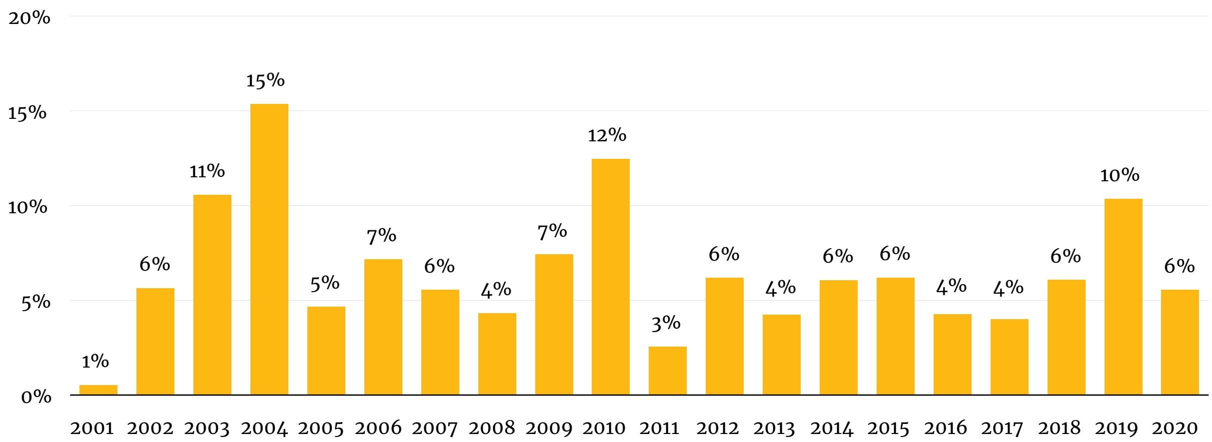
While low oil prices provide some relief to the Chinese economy amid the pandemic-induced downturn, international oil prices rebounded in the second half of 2020, and reached an average of US$ 63 per barrel by March 2021.[62] On the other hand, the brief interruption of Suez Canal traffic in March 2021 underscores the ongoing physical vulnerabilities of the world's oil supply chain--particularly in Europe and Asia. Some oil market analysts anticipate market volatility to continue this year.[63]

### Total crude oil consumption in China from 2000 to 2020



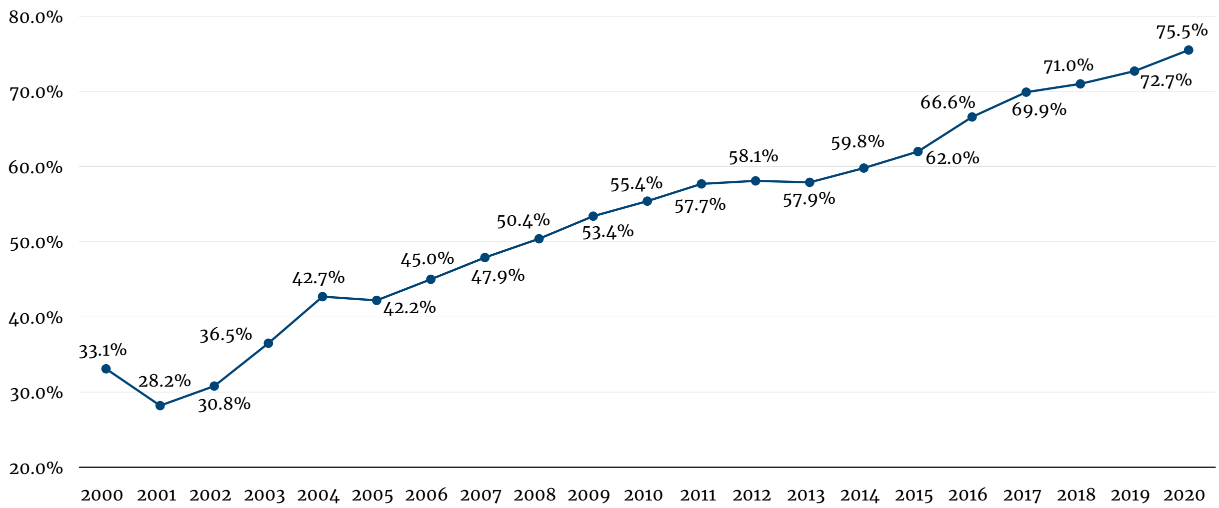

*Source: National Bureau of Statistics of China, 28 February 2021*

### Annual growth rate of crude oil consumption from 2001 to 2020




*Source: National Bureau of Statistics of China, 28 February 2021*

### China crude oil import dependency rate from 2000 to 2020




*Source: National Bureau of Statistics of China, 28 February 2021*

## Use of oil in the transport sector and fuel efficiency

Transport remains the largest sector in total oil demand in China, accounting for around 54% of the total demand. This proportion remained roughly constant from 2010 to 2020, because demand for petrochemical products kept pace with rapid growth in demand for transport fuels. The boom in plastic product output has driven growth in natural gas liquids and naphtha consumption.[64]

China's consumption of transportation fuels increased on average by 2.7% per year since 2012, led by an increase of 3.0% per year for heavy-duty vehicles that amount to 34% of the country's total increase in transportation sector energy consumption.[65] China's transportation demand is now transitioning to a gasoline-driven structure as passenger vehicles outpace diesel-powered trucks and industrial machinery in incremental fuel demand. In 2010, gasoline accounted for 30.9% of total oil demand in the transport sector but this figure rose to 40.1% in 2020, while diesel fell from 62.8% in 2010 to 48.5% in 2020.[66] (Diesel is used primarily for heavy-duty transport and not a major factor in the light-duty vehicle market due to air emissions regulations.) In 2020, however, while both gasoline and diesel saw a decrease in consumption as the COVID-19 pandemic reduced transportation needs, gasoline demand was hit harder than diesel. Gasoline consumption fell by 7.59% and diesel consumption reduced by 3.71% compared to 2019.[67]

Researchers from China National Petroleum Corporation (CNPC) estimate that China oil demand may peak at 16.4 million barrels per day around 2030 and fall to 13.7 million barrels per day by 2050, as economic growth slows and transport demand shifts to other fuels.[68]

In terms of vehicle oil usage, in 2019, the average fuel economy of new passenger cars sold in China was roughly 5.56 L/100km, a 4% improvement over the 2018 average.[69] The Ministry of Industry and Information Technology (MIIT) issues fuel efficiency standards for all new passenger vehicles sold in China and they are tightened every few years since 2005. MIIT specifically identifies $CO_2$ emissions reduction as among the expected social benefits of the standards and estimates that China's 2020 fuel efficiency standards will reduce $CO_2$ emissions by 113 million tons versus what would have been expected under the 2015 standards.[70]

The fuel efficiency standards have two main aspects. First, each vehicle must meet specific fuel efficiency standards based on its weight. Second, each vehicle manufacturer must achieve Corporate Average Fuel Consumption (CAFC) limits. These limits apply on an annual basis to each manufacturer's new fleet as a yearly whole. The official standard for 2020 is reduced to 5 L/100 km from 6.7 L/100 km in 2016. Notably, manufacturers are offered flexibility schemes where credits can be earned for vehicle electrification, as well as for including more efficiency technologies in conventional vehicles.[71] As a result, fuel consumption averages for conventional vehicles should be higher than implied by the 5 L/100 km standard.

Enforcement of fuel efficiency standards is uneven, with some experts saying manufacturers face few penalties for failing to comply. In 2018, nearly 50 out of 113 domestic auto manufacturers exceeded their CAFC limits, according to MIIT.[72]

The next phase of China's vehicle fuel efficiency program is currently under development. Some stakeholders have expressed concern that an oversupply of NEV credits could adversely affect fuel efficiency of the Chinese new vehicle fleet under the existing program and recommended changes to address this.[73]

# Methane gas

- Gas demand continues to rise, and domestic production has increased.
- China has undertaken gradual efforts to switch heating from coal to gas, shifting an earlier fuel-switching program to focus more on ensuring gas is economically sustainable.
- Gas imports flattened, and rising China-U.S. tensions left promises of big LNG imports high and dry.
- The new Power of Siberia pipeline opened a new path for gas imports from Russia.
- Policymakers focused on efforts to develop a comprehensive national pipeline network as an element of energy security.

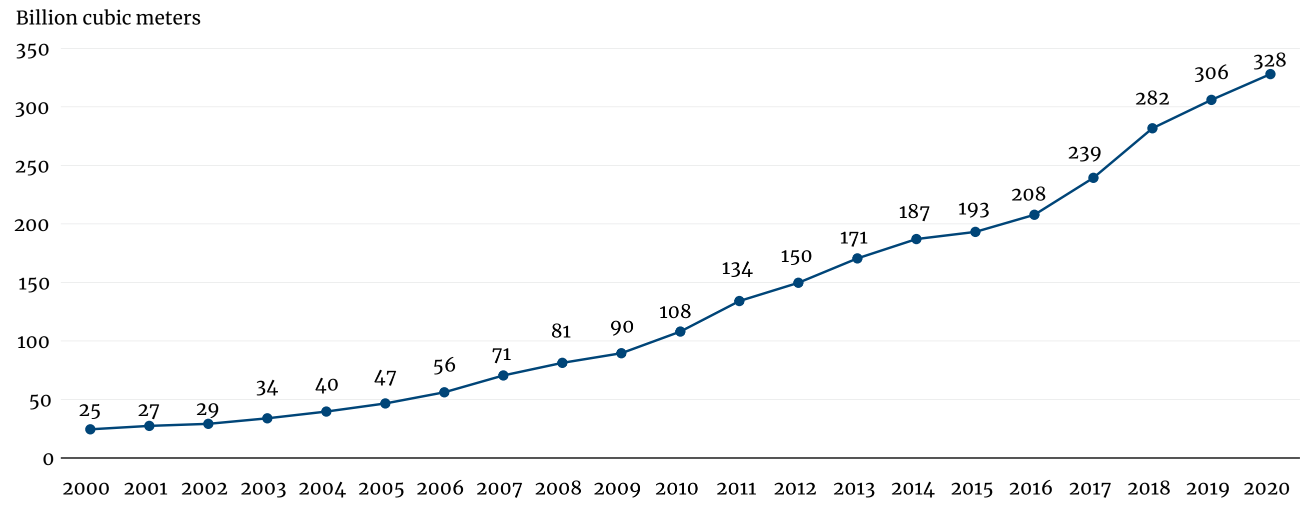
## Gas demand growth continues, but import dependency fell slightly

China's total production of gas in 2020 reached 192.5 billion $m^3$, an increase of 10% compared to the previous year. Gas imports reached 140.3 billion $m^3$, an increase of 5.3% compared to the previous year. This growth rate of gas imports in 2020 was significantly lower than the 32% growth experienced in 2018.[74]

Gas is the fastest-growing fossil energy in China, particularly shale production and liquefied natural gas (LNG) imports. To achieve the national target of gas accounting for 10% of primary energy consumption by 2020 and 14% by 2030, the NEA promoted fuel switching from coal to gas during the 13th Five-Year Plan period.[75] In 2020, gas consumption accounted for 8.6% of primary energy consumption, short of the 10% target set in 2014.[76]

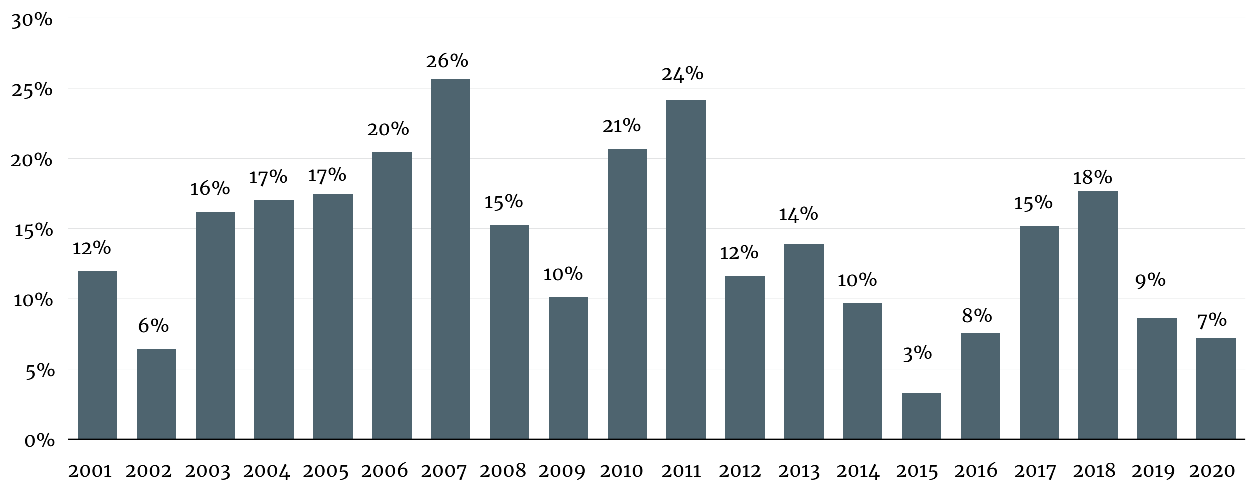
Through the support of central and regional policies, gas pipeline infrastructure investment has grown, gas storage added, and supply to the northern parts of China increased to meet winter peak demand of gas.[77] As of 2020, the total length of pipelines exceeded 87,000 km, with a supply capacity of more than 350 billion $m^3$ per year.[78] The main pipeline infrastructure is now owned by the newly-established China Oil & Gas Pipeline Network Group, a centrally-administered state-owned enterprise (SOE).[79] The company plans to increase pipeline length to 250,000 km by 2025, spending over US$ 20 billion annually on investment. In addition, the company will own nine LNG regasification terminals.[80] In its 2021 annual work plan, China's NEA announced plans to prioritize the build-out of a national pipeline network, in part to support national energy security objectives.[81]

### Total natural gas consumption in China from 2000 to 2020



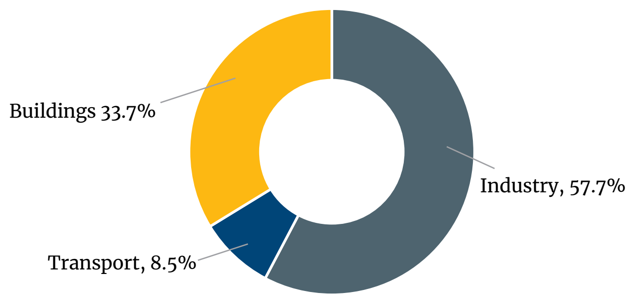

*Source: National Bureau of Statistics of China, 28 February 2021*

### Annual growth rate of gas consumption from 2001 to 2020



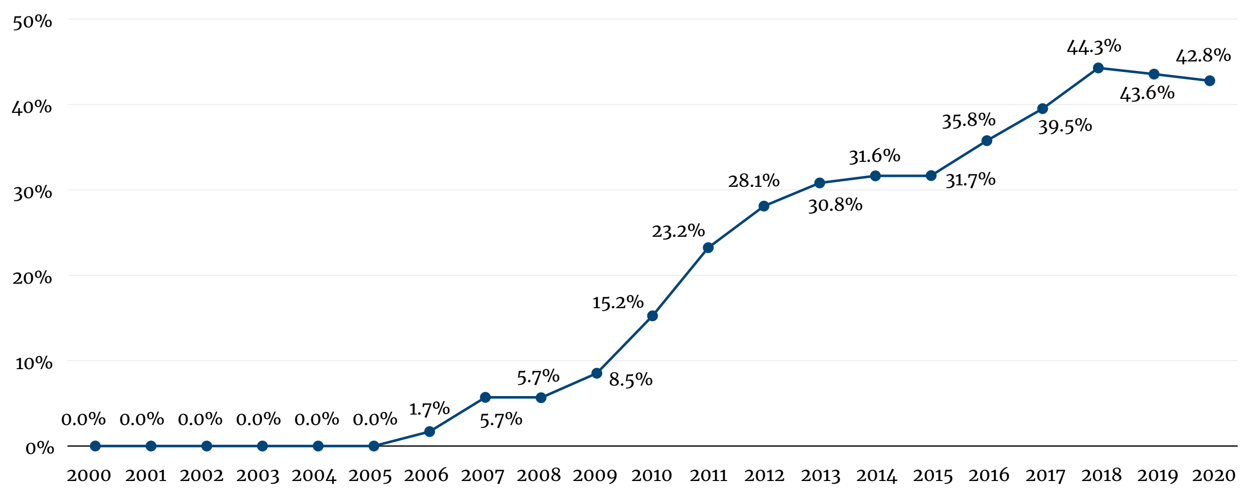

*Source: National Bureau of Statistics of China, 28 February 2021*

### Breakdown of natural gas consumption in 2018




*Source: China National Renewable Energy Centre, December 2018*

### Gas import dependency from 2000 to 2020




*Source: National Bureau of Statistics of China, 28 February 2021*

## Gas domestic production grew, with rapid development in shale gas

As a result of exploration and development investment, China saw domestic production increase by 9% in 2019 and 10% in 2020.[82] Shale gas development is growing most rapidly, supported by tax breaks and subsidies for gas extraction companies. China's shale gas production reached 20 billion $m^3$ in 2020, a 30% increase over 2019, making China world's second largest producer of shale gas.[83] Most shale gas production takes place in Sichuan and Chongqing. The 14th Five-Year Plan contains a 2025 target of 250 billion $m^3$ domestic gas production target, and industry analysts anticipate much of the increase will have to come from shale gas.[84]

Domestic gas production continues to face a variety of important challenges. Reuters anticipates that China's shale gas development will slow in the next five years due to more challenging geology, SOEs shifting investment back to conventional gas, and lack of technological improvements in deeper gas drilling.[85] Other analysts have noted that the priority policymakers attach to increasing domestic output and boosting domestic oil & gas investment tends to work against efforts to push China's national oil companies towards market reforms, given the high cost and relatively low returns available to China's domestic production.[86]

For the past three years, gas consumption growth has slowed while production steadily increased. In 2019, import growth slowed as domestic production rose more rapidly, and the percentage of imported gas compared to total consumption declined for the first time in 12 years. In 2020, the import share declined further to 42.8%[87] In 2019, imports consisted of 37.6% from pipeline gas and 62.7% from LNG.[88] Sources of LNG imports diversified: Australia, Qatar and Malaysia all served as the largest suppliers in 2020.

China imports gas mainly from neighbouring countries like Russia, Turkmenistan, Kazakhstan and Myanmar.[89] Russia's energy giant Gazprom is contracted to supply the China National Petroleum Corporation with 38 billion cubic meters of natural gas annually for 30 years via the Power of Siberia pipeline project.[90] While December 2019 marked the construction of the first section running 2,200 kilometers from the Chayandinskoye gas field to the Chinese border,[91] the transmission capacity has slowly ramped up in 2020. Throughout 2020, the project supplied 4.1 billion $m^3$ of gas to China. The second pipeline in the project entered the design stage, and will be capable of delivering as much as 50 billion $m^3$ of gas once completed.[92] Gazprom intends to become China's biggest gas supplier, accounting for more than 25% of Chinese imports by 2035.[93]

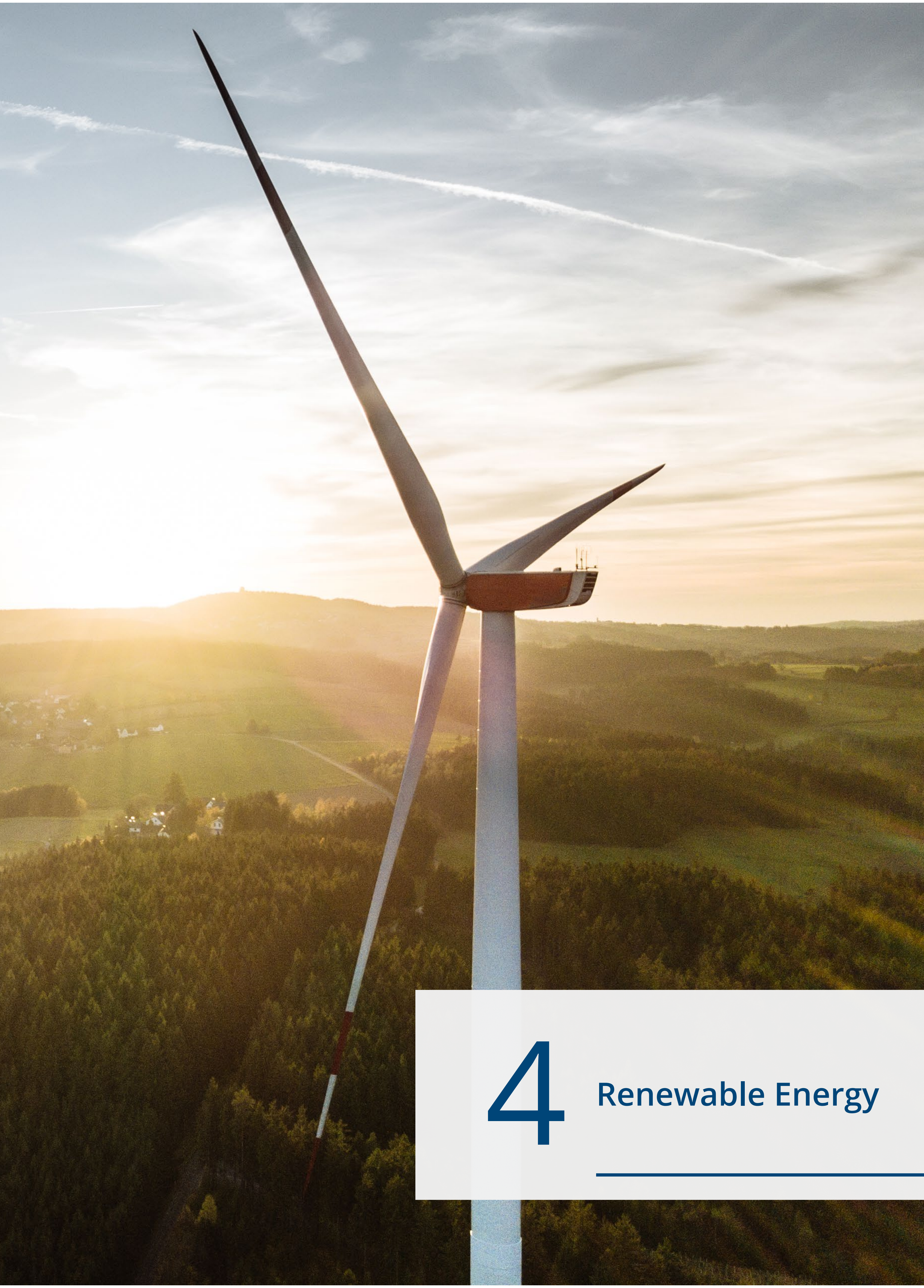
LNG imports have been a hot topic of trade talks between the U.S. and China. Under the terms of a January 2020 trade agreement, China pledged to buy US$ 52 billion in energy products from the U.S. over the following two years, with LNG accounting for a large proportion. However, China only purchased around US$ 6.61 billion in energy products in the first 10 months of 2020, or about 26% of the 2020 target, according to Reuters.[94] One reason was the 25% tariff imposed by China on U.S. LNG imports,[95] though winter 2020 deliveries accelerated due to high demand.[96]

At the same time, China continues to sign long-term LNG contracts with Russia and Australia to secure gas supply. The abundance of supply has put LNG prices in Asia at 10-year lows. Analysts have expressed concerns over the low prices locking in more gas demand.[97]

**Dr. Jiang Lin**
**China energy expert at the University of California-Berkeley**

Natural gas has a positive contribution to reducing air pollution and to meet the peak demand for power in certain situations. However, if we want to arrive at a net-zero future, we have to also bring down the emission from natural gas to zero. [Continuing to develop natural gas] is not 100% aligned with the carbon neutrality goal in the long-term.

*Carbon Brief, 12 March 2021*



# 4 Renewable Energy

# 4. Renewable Energy

### Renewable additions accelerated, and output continues to grow rapidly

- Both solar output and solar additions grew rapidly in percentage terms, and cumulative residential solar capacity doubled.
- Wind and hydro output also posted strong growth, and curtailment of renewable energy continued to decline.
- China is gradually shifting its policy focus from large, central plants to distributed energy, agricultural energy, building-integrated energy, offshore wind, and floating PV.

## Hydroelectric power

China continues to add renewable energy capacity, while also advancing reforms to its electricity and energy sectors. Both installed capacity and yearly generation for renewables have grown, and the curtailment rate continues to decline. Nevertheless, renewable energy, especially distributed renewables, continues to face policy and market barriers that slow its adoption and hinder its efficient integration.

- Hydroelectric generation grew by 2.5%, increasing from 1,302 TWh in 2019 to 1,355 TWh in 2020.

- Wind generation grew by 15%, increasing from 406 TWh in 2019 to 467 TWh in 2020.

- Solar generation grew by 16.1%, increasing from 224 TWh in 2019 to 261 TWh in 2020.

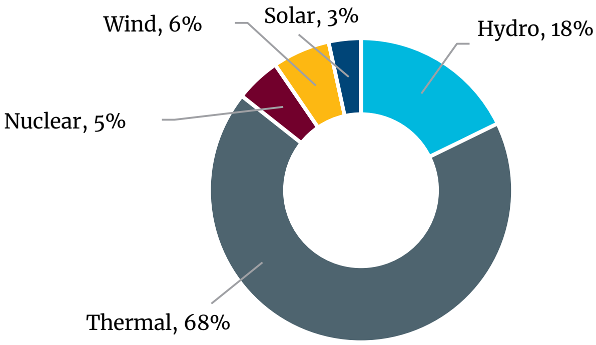
- Renewable energy made up of 29.5% of electricity generation in 2020, a 1.6% increase over 2019.[98] The renewable energy share of primary energy consumption reached 15.9%, fulfilling the 15% target set for 2020 in 2014.[99]

- Wind and solar provided a combined 9.4% of electricity output. China's National Energy Administration has set a target for 2021 of 11% and expects then to reach a 16.5% share by 2025.[100]

Since president Xi Jinping announced the 2030 carbon peak target and 2060 carbon neutrality during the 75th session of the United Nations General Assembly on 22 September 2020,[101] the NEA has accelerated work on policies to support renewable energy and accompanying infrastructure. During a press conference hosted by the State Council Information Office of China on 30 March 2021, NEA Director Zhang Jianhua emphasized NEA's determination to increase renewable energy consumption. Renewable energy accounted for 42.4% of all newly installed electricity production capacity in 2020, and every type of renewable energy saw the largest number of newly installed capacity in the world in 2020.[102]

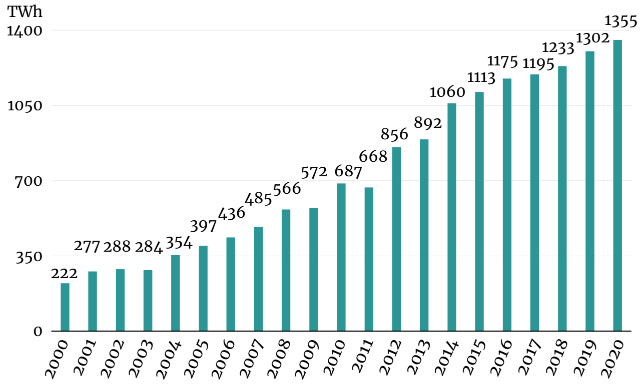
On 19 April 2021, NEA released detailed targets for installed wind power and solar PV capacity up to year 2025.[103] NEA reiterates Xi Jinping's target of 1,200 GW of combined wind and solar installed capacity by 2030,[104] and specifies that the share of electricity generated by wind and solar in total consumption should reach 11% in 2021, and grow to 16.5% in 2025. The notice also emphasized the provincial renewable obligation and development of residential solar.

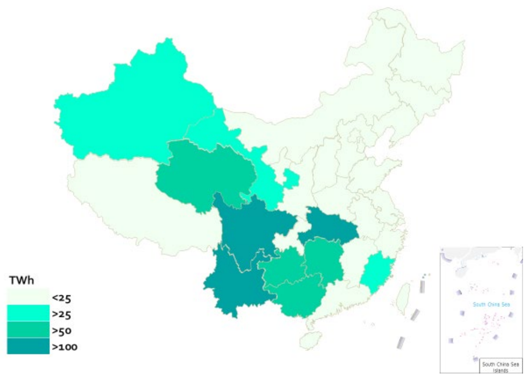
### 2020 China electricity production by fuel




*Source: China Electricity Council, January 2021*

### 2005-2020 China hydro power generation (left); 2019 China hydro power generation by province (right)




*Source: China Electricity Council, 2015-2021*

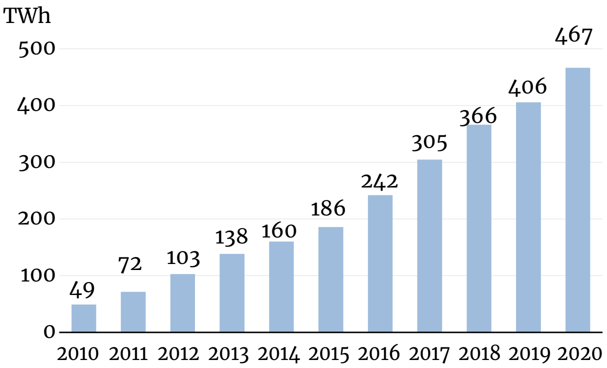
Hydro is the largest renewable power source in China, and output and capacity continue to grow. In 2020, China added 13.2 GW and hydro electricity output increased 53 TWh.[105] China has large hydroelectric potentials, with total water resource standing at 2.8 trillion $m^3$.[106] China leads the world in hydro capacity, at 370 GW, among which 31.5 GW is pumped storage.[107] In 2020, hydro generated 18% of total electricity in China, the largest proportion of all renewables, and a 2 percentage-point increase over 2019.[108] Sichuan province has the highest hydropower generation capacity at 78.9 GW in 2020, followed by 75.6 GW in Yunnan and 37.6 GW in Hubei. The Three Gorges Dam, the largest hydropower station capacity in the world, generates around 100 TWh of electricity annually.[109]

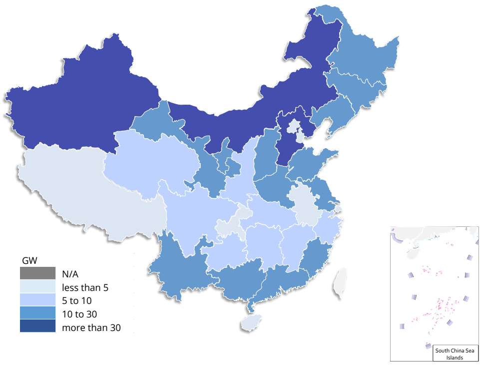
The hydropower 13th Five-Year Plan targeted adding 60 GW conventional hydro plus 60 GW of pumped hydro by 2020. Curtailment of hydropower production has fallen, and investments into hydropower construction have steadily increased since 2016. In 2019, investment reached RMB 81.4 million, a 20% increase compared to 2018.[110]

China has almost fully exploited its potential domestic hydropower resources.[111] Considering the resource restriction and environmental protection, many of the Chinese hydropower companies are exploring the overseas market, establishing businesses in Europe, South America and Southeast Asia in recent years to share their expertise in the area.[112] Many hydroelectric power projects are planned for development in Belt and Road countries, and several are controversial in terms of environmental and social impact.

# Wind

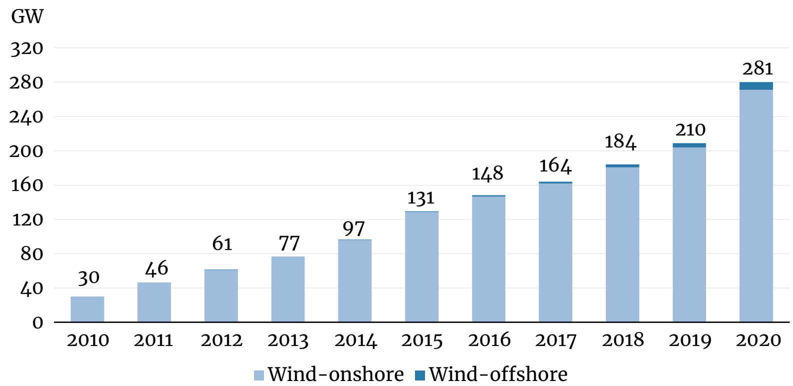
### 2010-2020 China wind power generation (left); 2020 China wind power generation by province (right)



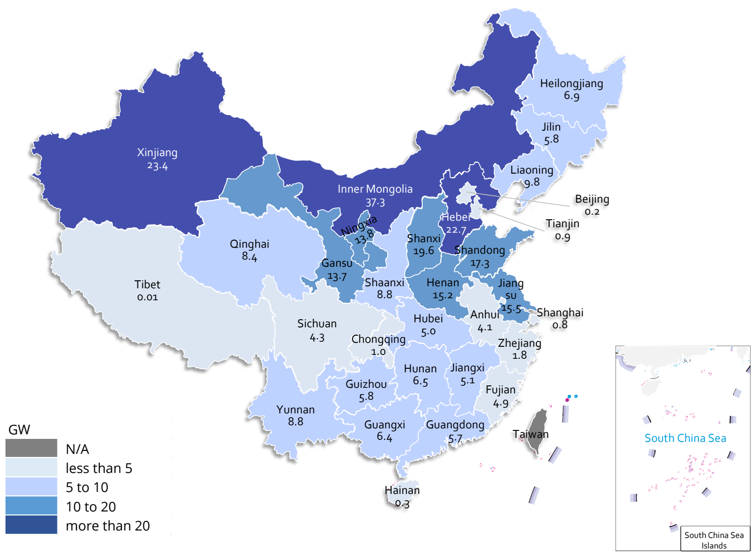

*Source: National Bureau of Statistics, China Renewable Energy Monitoring Centre, 2021*

### 2010-2020 China wind installed capacity in GW



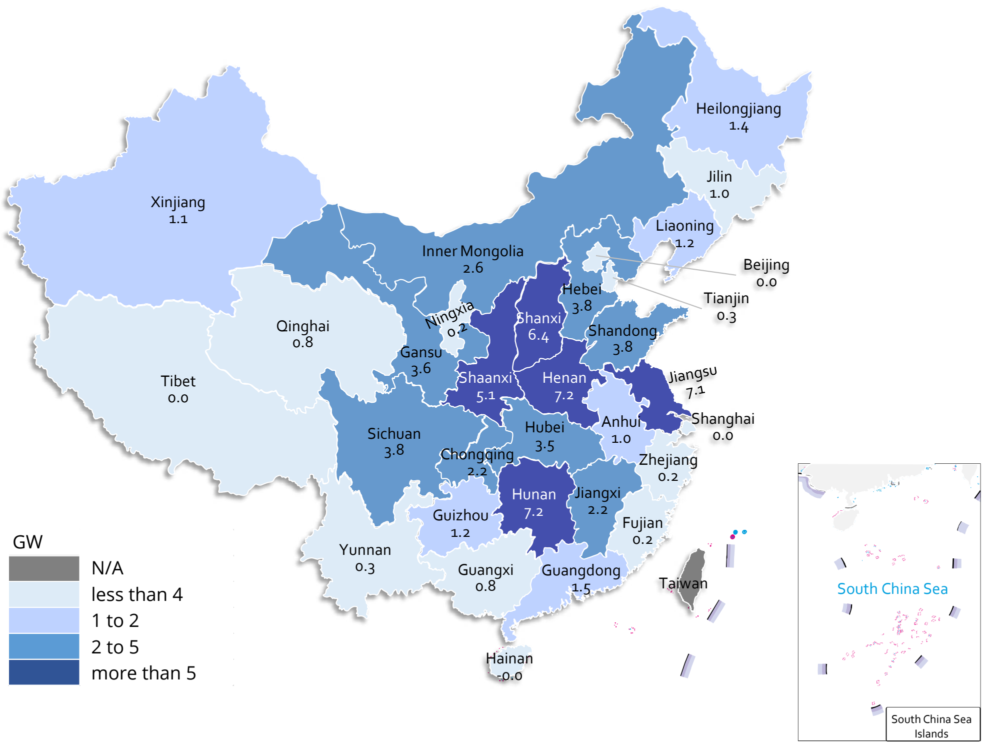

*Source: China National Energy Administration, 2021*

### 2020 cumulative grid-connected wind capacity (GW) by province



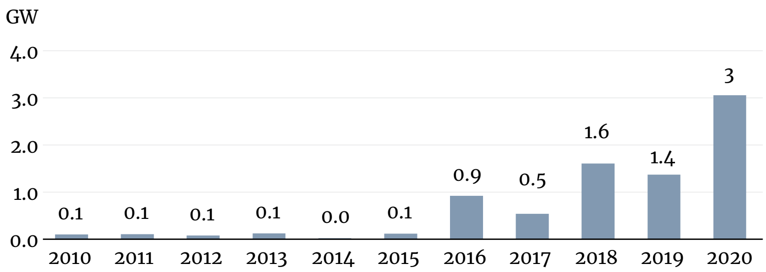

*Source: Energy Storage China, based on China Renewable Energy Monitoring Centre, 2021*

### 2020 additional grid-connected wind capacity (GW) by province



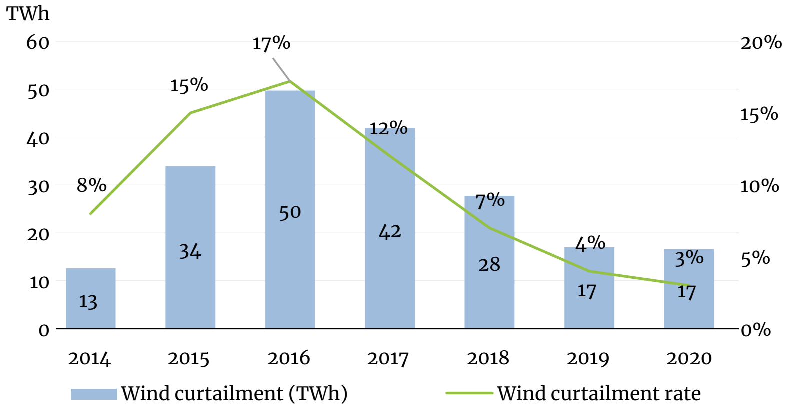

*Source: Energy Storage China, based on China Renewable Energy Monitoring Centre, 2021*

### 2010-2020 offshore wind additions in GW




*Source: China National Energy Administration, 2021*

### 2014-2020 Wind curtailment rate



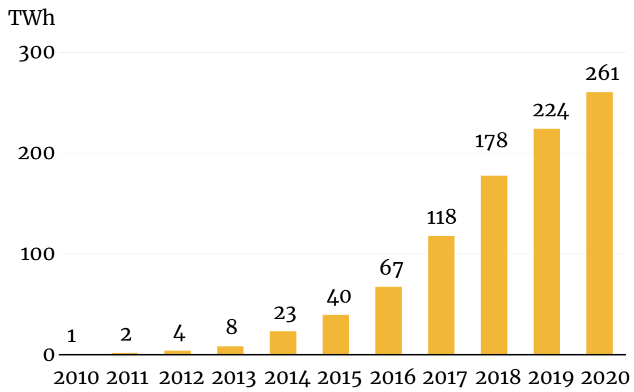

*Source: China National Energy Administration, 2021*

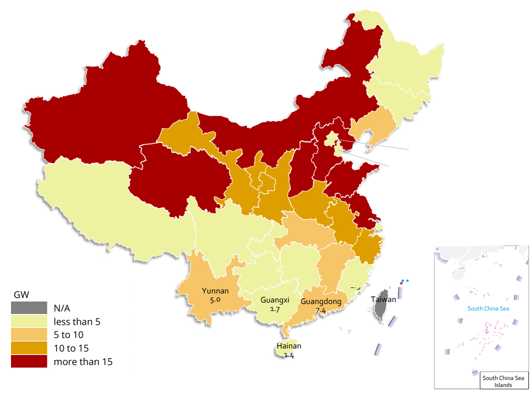
2020 was a very good year for wind as the growth rate in installed capacity reached a 10-year high. Wind output also continued to rise, reaching 467 TWh, up from 406 TWh in 2019, representing growth of 15%. Wind's share of national electricity production reached 6.1% in 2020, up from 5.5% in 2019. Wind curtailment decreased from 4% to 3% nationally from 2019 to 2020, indicating that China has successfully resolved the wind curtailment problem. Xinjiang, Gansu and Inner Mongolia are the provinces that saw the largest decrease in wind curtailment.[113]

The largest wind electricity-producing provinces are in northern China, including Inner Mongolia, Xinjiang and Hebei provinces. China's total wind capacity rose significantly from 210 GW in 2019 to 281 GW in 2020. New wind capacity additions in 2020 mainly concentrated in central and eastern provinces, such as Jiangsu, Henan, Shanxi and Hunan provinces—provinces with greater ability to absorb wind output locally. The leading provinces for new wind installations in 2020 were Henan and Hunan, with 7.2 GW of new additions in each, followed by Jiangsu with 7.1 GW. Five provinces added more than 5 GW and a further eight provinces added over 2 GW.

## Solar PV

### Total solar PV power generation in 2020 (left); Provincial solar PV power generation 2020 (right)

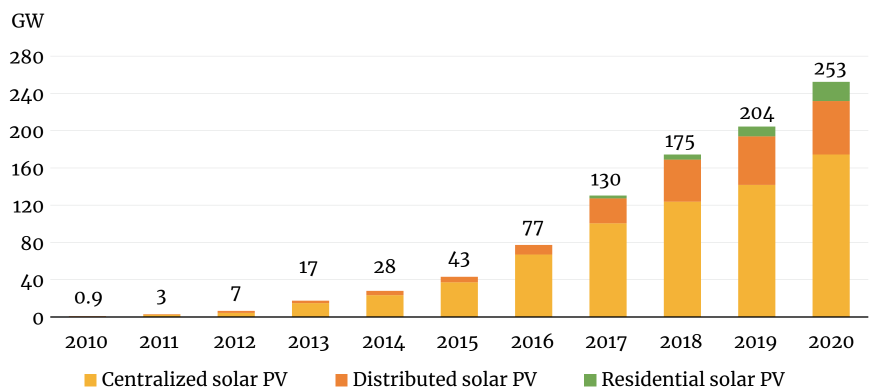



*Source: National Energy Administration, February 2021*

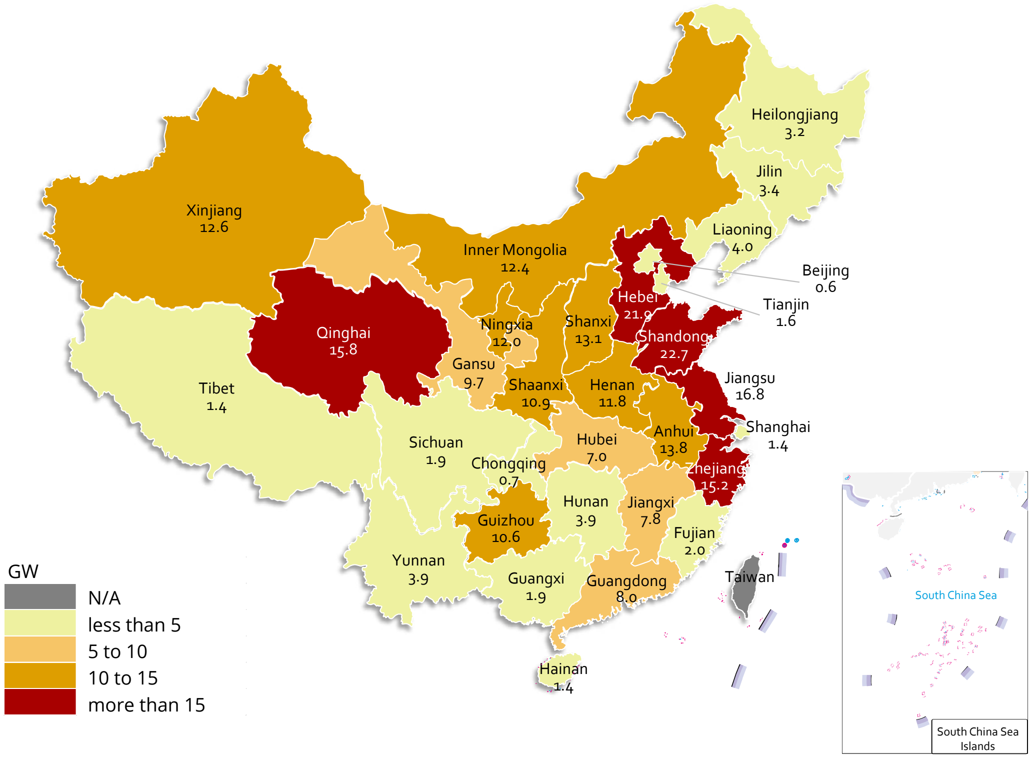
*Energy Storage China, based on National New Energy Consumption Monitoring and Early Warning Center, 17 February 2020*[114]

### Centralised, distributed, and residential solar PV capacity from 2010 to 2020



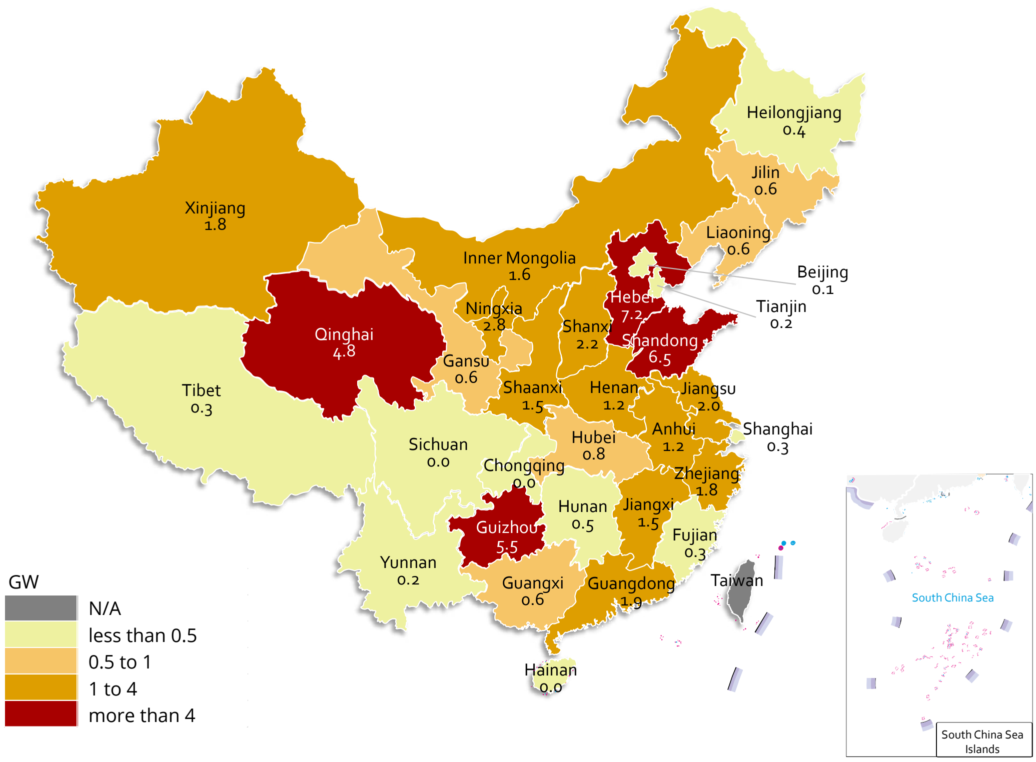

*Source: National Energy Administration, February 2021*

## Solar PV cumulative installed capacity at year-end 2020 (GW)



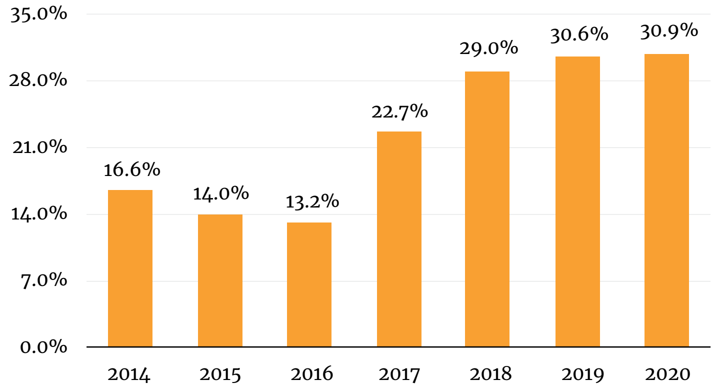

*Source: National Energy Administration, 2021*

## Solar PV newly added capacity in 2020 (GW)



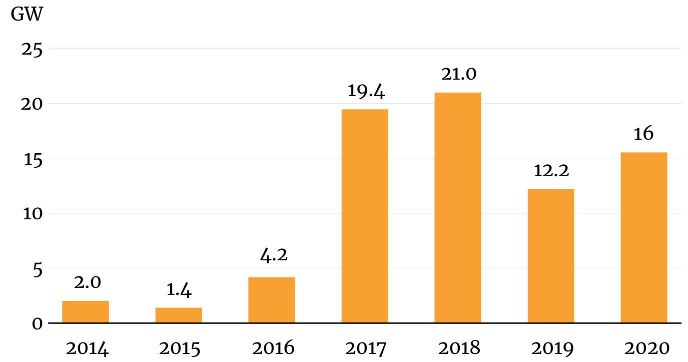

*Source: National Energy Administration, 28 February 2020*

### Distributed solar PV share of cumulative PV capacity



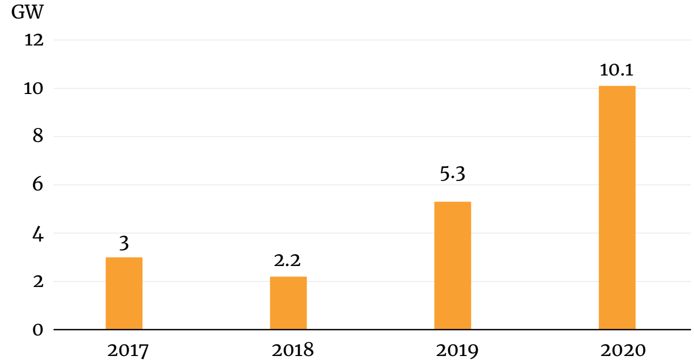

*Source: calculated from National Energy Administration, 2015-2021*

### Annual distributed solar PV capacity additions




*Source: National Energy Administration, 2015-2021*

### Annual residential solar PV capacity additions




*Source: National Energy Information Platform, 2015-2021*[115]

Solar PV output continued to rise strongly, reaching 261 TWh, up from 224 TWh in 2019, representing growth of 16%. In the six years since 2014, China's PV output has risen by a factor of 11. PV's share of national electricity production reached 3.4% in 2020, versus 3.1% in 2019. Solar curtailment remained at 2% nationally. Distributed solar capacity grew faster than central PV capacity, with 16 GW newly installed in 2020.

According to 2020 provincial data released by National Energy Administration, the largest PV electricity-producing provinces are in northern China, including Inner Mongolia, Xinjiang, Qinghai, Hebei, and Shandong provinces.

Solar curtailment is the highest in the north-western regions of China, especially Xinjiang and Gansu. In 2020, both of these provinces lowered their curtailment rate: Xinjiang experienced solar curtailment of 4.6%, a 2.8 percentage-point decrease versus 2019, and Gansu was at 2.2%, a decline of 2.0 percentage points over 2019.

Annual solar PV capacity additions rose from 29 GW in 2019 to 49 GW in 2020, and installations in 2020 concentrated in the fourth quarter.[116] The percentage of new distributed solar additions remained strong at 32%, reflecting declining quotas for central projects supported by subsidized feed-in tariffs.

Whereas until recently only a tiny proportion of solar additions were rooftop solar, industry reports suggest that in 2019 approximately one-third of distributed solar projects were household rooftop projects.[117] In 2020, this percentage rose to 63%, with 10.1 GW residential solar out of 16 GW of total distributed solar.[118] China's cumulative household solar capacity doubled from the prior year.

Eastern provinces generally saw more solar PV capacity additions than southern provinces in 2020. The leading province for new solar installations in 2020 was Hebei, with 7.2 GW of additions. Guizhou also continued its high installations, at 5.5 GW, increasing from 3.4 GW in 2019. Four provinces added more than 4 GW and a further 11 provinces added over 1 GW. Nevertheless, several southern provinces with high solar resources added less than 100 MW of solar in 2020, including Hainan, Sichuan and Chongqing.

## Renewable energy incentives shift away from feed-in tariffs

China introduced its Renewable Energy Law in 2005, and in subsequent years held wind power capacity auctions for a limited number of projects. Wind and solar power in China only began to grow substantially after the country introduced fixed, 20-year feed-in tariffs for wind in 2009 and then solar photovoltaic in 2011.[119] Feed-in tariffs were set at different levels in various regions to account for different wind and solar resources, and generally high enough to incentivize investment. State Grid announced separate subsidies for distributed solar.[120]

Funds for the feed-in tariff subsidy are paid from a surcharge on most retail electricity sales, but rapid expansion of renewable energy capacity under the feed-in tariff has caused a deficit in the surcharge fund. Though the central government raised the surcharge on several occasions, and instituted provincial quotas on new wind and solar projects that would qualify for the feed-in tariff, the deficit problem has remained.[121]

### History of the renewable surcharge (RMB/kWh)

| 30 Jun 2006 | 01 Jun 2007 | 20 Nov 2009 | 01 Dec 2011 | 25 Sep 2013 | Since Jan 2016 |
|---|---|---|---|---|---|
| 0.001 | 0.002 | 0.004 | 0.008 | 0.015 | 0.019 |

*Source: NEA, accessed in April 2019*

Although China modelled its feed-in tariff on the example of German renewable FITs, the Chinese surcharge amounts to 3.7% of average household retail electricity prices of RMB 0.51/kWh as of 2019.[122] That compares to current average German retail electricity prices of 30.85 ct/kWh, of which the EEG (Renewable Energy Law) surcharge accounted for 21%.[123]

**Renewable tenders/auctions:** As NEA pushes to retire feed-in tariffs for new projects, it has turned to renewable tenders/auctions to set tariffs and reduce subsidy levels, starting with wind. From May 2018, new provincial centralized onshore and offshore wind power projects were required to participate in tenders to receive construction quotas and feed-in tariff subsidies. The weight of price in assessing bids was at least 40%.[124] For solar PV, in an announcement by NEA in April 2020, projects still need to go through tendering for additional capacity connected to the grid. The total subsidy for residential solar in 2021 is estimated to be RMB 0.2 to 0.3 billion, and the subsidy per kWh further declines to RMB 0.02 to 0.03.[125]

**Subsidy-free renewable program:** China plans to scale up wind and solar projects that receive no subsidies. In January 2019, the NEA and NDRC jointly announced a plan to launch subsidy-free wind and solar pilots in regions with superior wind or solar resources and high local electricity consumption.[126] These projects do not receive subsidized tariffs, but can receive long-term contracts at prices at or below the local benchmark feed-in tariff for coal plants. However, the policy limits the capacity for such projects, given that they receive supporting policies such as exemption from land transaction fees and 20-year feed-in tariff power purchase agreements.[127] NEA announced the first batch of subsidy-free projects in May 2019, including 4.5 GW of utility-scale onshore wind, 14.8 GW of utility-scale PV, and 1.5 GW of distributed renewables.[128] Northeast China has the largest amount of subsidy-free projects. In 2020, China added 11.4 GW of subsidy-free wind projects and 33 GW of subsidy-free solar PV projects.[129]

**Targets and incentives for reducing curtailment:** China's 2005 Renewable Energy Law, and its implementation rules set in 2007, required mandatory purchase of renewable energy including wind and solar, but implementation proved difficult.[130] Since 2016, NDRC and NEA rules have indicated that grid companies and dispatch centers were mandated to buy and absorb all renewable energy.[131] In 2019, China began to apply administrative penalties to grid companies and dispatch centers based on quotas for curtailment, implementing targets to keep curtailment below around 5% by 2020.[132] In late 2019, China issued a further clarification requiring mandatory purchase of renewables and requiring payment by grid companies for curtailed wind and solar.[133] NEA issued a long-term clean energy consumption mechanism draft in May 2020 focusing on improving planning for provincial renewable energy quotas.[134]

**Provincial quotas for renewable energy and renewable certificates:** After three rounds of proposals, NEA adopted provincial quotas for renewable energy consumption that apply to provincial grid companies and large industries (which often own their own power supplies).[135] While these are often compared to the Renewable Obligation (RO) of the U.K., or the U.S. Renewable Portfolio Standards, until now they have consisted of short-term administrative measures that provide provincial mandates over just 1-2 years into the future, whereas a traditional RO or RPS is designed with 10-20-year targets to guide investment. However, in 2021, NEA issued a new draft Renewable Obligation that sets out provincial requirements to 2030, showing how non-hydro renewable energy can reach 25% by that time.[136]

China continues to rely on the five-year planning process to guide long-term investment decisions. Voluntary green credits or certificates are still available for purchase, but the market for these certificates has been thin, because the credits represent a transfer of subsidy payment obligation from the government to the purchaser, and therefore lack additionality.[137] Currently, the voluntary green certificates do not link to the renewable consumption obligation, but this may change in the future.

> Preliminary forecast shows by 2060 new energy capacity additions will account for more than 70% of all capacity additions, while coal and gas power will be transformed from a main power source to an auxiliary regulating power source, and the annual utilization hours will drop significantly.[10]

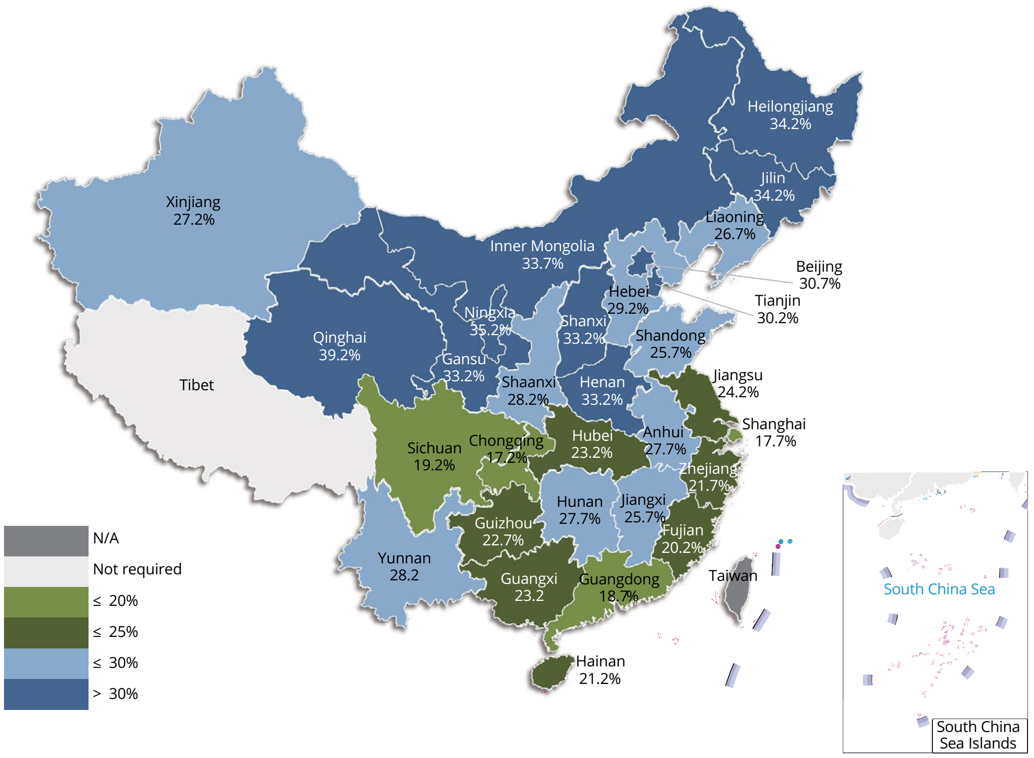
**Rao Hong**
**Chief Technical Expert of South China Power Grid Corporation**

*China Energy Report, 3 May 2021*

### Provincial non-hydro renewable obligations for 2021 (official targets released in May)


*Source: National Energy Administration, May 2021*

### Provincial non-hydro renewable obligations for 2030 (February draft)




**The targets are only provisional targets suggested by NEA for public consultation.*

*Source: National Energy Administration, February 2021*

### Provinces with RE plus energy storage policies as of April 2021

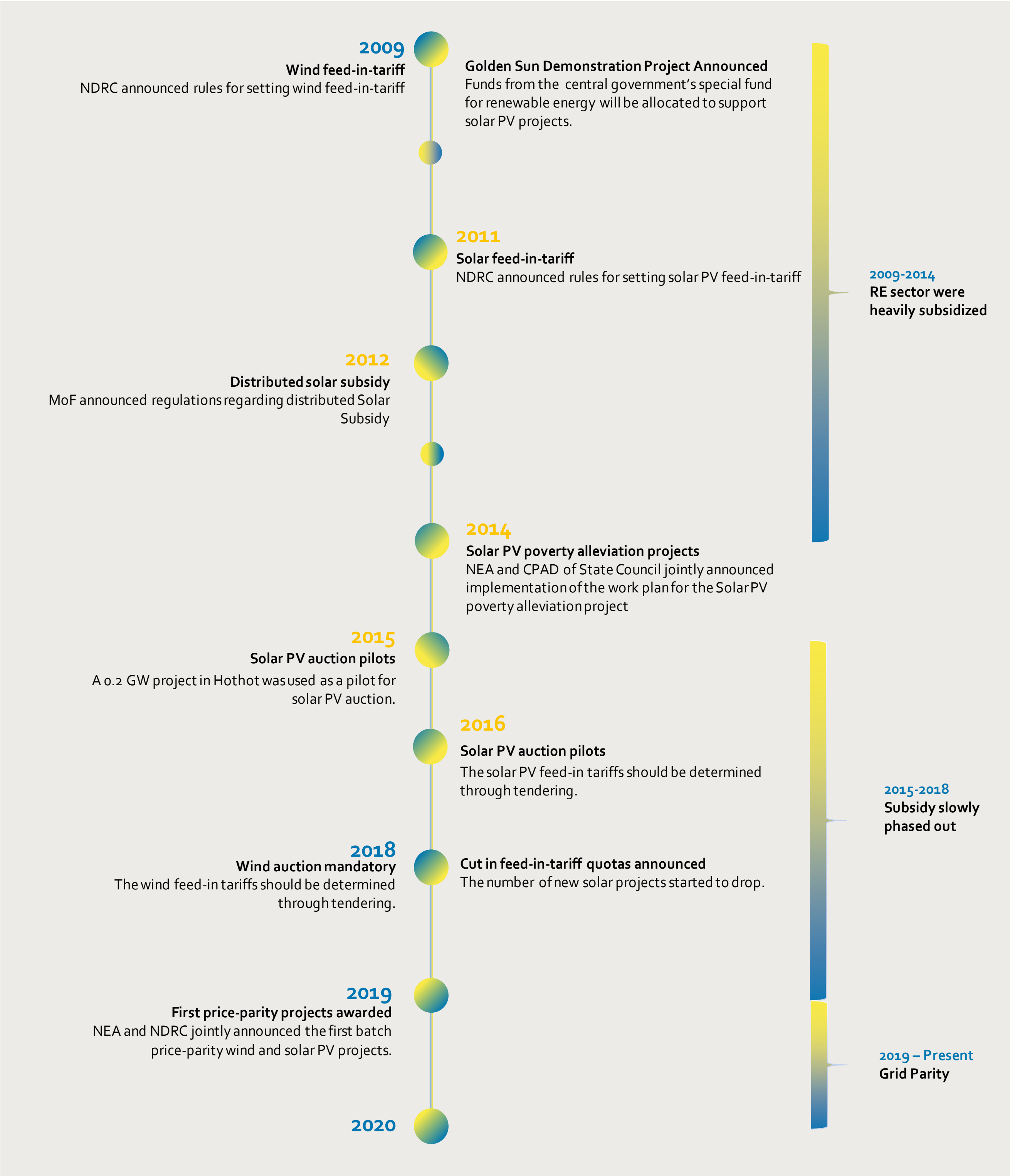

*Source: Various sources, April 2021*[138]

**Provincial and national energy storage policies accelerating:** In 2020, generation-sited storage coupled with renewable energy accounted for 40% of total installation of storage. Many provinces have mandated the installation of storage with RE, requiring at least 10%-20% of generation capacity. However, these provincial policies have received criticism from industry experts, who have noted the lack of financial support for such requirements, which can add up to 8-10% to project costs.[139]

The safety of customer-sited storage stations also came into public attention following a serious fire and explosion at a lithium-iron-phosphate (LFP) battery installation near a shopping mall in Beijing on 16 April 2021, in which three people lost their lives.[140] The accident may push out lower-quality players and lead to a slowdown in distributed storage installations in the near term.[141]

In April 2021, NEA issued a new draft target for energy storage to reach 30 GW of total capacity by 2025, which represents over 10x growth versus capacity in 2020. The policy places most emphasis on piloting storage on the generation side, while also encouraging grid-sited storage.[142] The policy also mentions distributed storage, but this remains a lower priority for now. Also in 2021, NEA finalized a policy on integrating generation, grids, storage, and loads that calls for greater planning around integrated and/or hybrid projects, both on the generation and demand side.[143]

## Timeline for renewable energy incentives




*Source: various sources*[144]

# 5 Electricity Market Reform

# 5. Electricity Market Reform

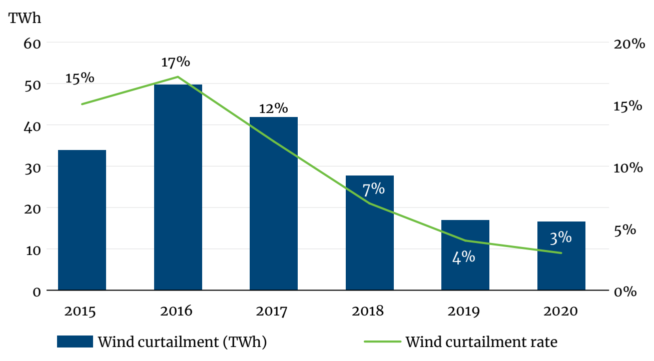
## China continues to make steady progress on market reform, benefiting renewables

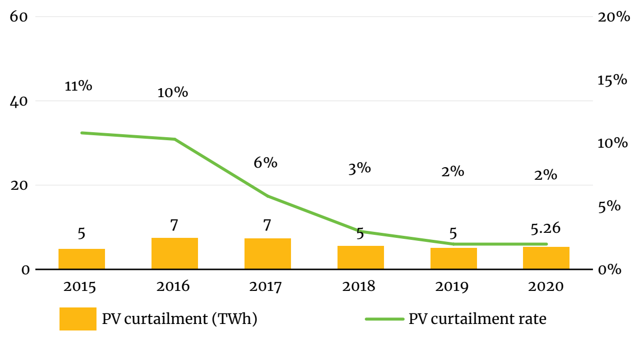
- Wind and solar curtailment fell dramatically, resulting from greater incentives to integrate renewable energy as well as increased power trading.
- Provinces are developing spot markets, using several models.
- Quotas for renewable consumption are replacing subsidies for renewables.

Market reform of the electricity sector is essential to enabling a clean energy transition and reducing the country's carbon emissions. Historically, the lack of a wholesale power market has contributed to curtailment of renewable energy, which makes renewable energy artificially less economical. China's administratively planned power system had historically encouraged the over-building of coal plants through inflexible planned operating hours contracts that enabled cost recovery for coal plant investments.[145] To ensure the solvency of state-owned power companies and maximize provincial tax revenue, provincial governments had also favoured dispatch of within-province coal plants over trading power between provinces—creating a system known as "provincial fortresses."[146] Power market reforms that were restarted in 2015 have been aimed at gradually resolving these issues through a combination of market and administrative measures, including phasing out planned operating hours and encouraging power trading among provinces.

Falling curtailment of renewable energy has been one indicator of success of power market reforms. In 2020, wind curtailment declined to 3%, down from 7% in 2018 and a peak of 17% in 2016.[147] Solar curtailment in 2020 fell to 2%, down from the peak 11% in 2015.[148]

### Curtailment of electricity output from wind (left) and solar PV (right), 2015-2012




*Source: China National Energy Administration (NEA), 2015-2020*

## Power markets: China's spot markets gradually start to take shape

China's current phase of electric power market reforms kicked off in 2015, when authorities announced plans to establish market-based mid- to long-term contracts for electricity, leading eventually to establishment of market for spot-trading of electricity and ancillary services (such as load-following, voltage support, and regulation services). These reforms were motivated by the desire to rationalize power sector investment, reduce power prices, and improve integration of renewable energy.

**Mid-to-long-term contracts:** China began its 2015 power market drive with the transfer of monthly and annual fixed operating hours contracts with generators to so-called bilateral monthly and annual contracts, with prices set bilaterally, subject to various approvals.[149] While this in theory allows some price fluctuation, in practice the central government maintains a tight lid on prices. Most contracts are for 1-month or 1-year, and in this respect the new market resembles the prior planned operating hours system more than it does long-term power purchase contracts in other power markets, which might be on a 10-, 15-, or 20-year basis.

NDRC and NEA issued the basic rules for mid-to-long-term power purchasing agreement in June 2020, which is a revision on the previous provisional trading principles.[150] The document now allows more players to participate in the market, including distribution, wholesale and energy storage companies. The type of medium- and long-term trading products are also diversified to include trading of electricity itself, generation trading rights, and contract transfer. Transmission rights and capacity can also be traded when there is need in the market. Price is determined solely by the market, and not subject to third-party interference. Market users now need to pay for ancillary services. Wholesale power producers, end-users, and grid companies are responsible for ensuring full consumption of clean energy. Areas with a risk of experiencing power shortages can explore the option of constructing a capacity market. While areas with low thermal power utilisation hours shall try to establish a capacity payment mechanism. In terms of balancing the amount of agreed electricity trading amount and the actual needs in the market, the document permits users to make adjustments one week before contract execution upon mutual agreement. The document also encourages trans-regional and trans-provincial power trading.

**Spot market pilots:** After the full roll-out of bilateral markets, China established seven spot market pilot provinces; these established trading centres and began developing models for spot markets based on various practices in other countries. Guangdong has, for example, adopted a power pool arrangement with locational-marginal-pricing, whereas Zhejiang has hired the U.S. regional transmission operator PJM to consult in the design of its provincial power market.[151] While the central government subsequently expanded the spot market pilots nationally, progress is slow. All provincial pilots have officially launched, and live trading has taken place for periods of weeks and months in most markets. The results have been published in a few cases, such as in Guangdong province, where spot prices remained at such levels that suggest participating thermal plants were bidding below their operating costs,[152] potentially reflecting the small size of the spot markets and market distortions from existing long-term contracts that dominate the bilateral markets. Some markets have also suspended spot trading due to problems: Shandong experienced imbalances between supply and demand bid into the spot market.[153] Gansu suspended spot market trading after prices hit a high of RMB 0.5/kWh over several days.[154] Shanxi suspended spot trading after a sandstorm caused outages at renewable plants on 15 April 2021.[155]

In March 2021, NDRC announced five new provincial spot power market pilots: Liaoning, Jiangsu, Anhui, Shanghai, and Henan.[156] NDRC will also explore the possibility of developing regional spot market in Jing-Jin-Ji (Beijing-Tianjin-Hebei) and in southern provinces, which could help promote cross-provincial power trading, seen as critical for integrating more variable renewable energy and enabling more flexible transmission system operations. China aims to eventually establish a national spot market, building on the experience of provincial pilots.[157]

**Capacity payments:** Guangdong and Shandong province have each introduced capacity payments.[158] Only fossil fuel units (gas and coal units in Guangdong and coal units in Shandong) will receive the capacity payment. Officials see capacity payments to ensure sufficient capacity as well as to guide investments and ensure cost recovery for conventional power plants. The Southern Energy Observer, a Chinese media focusing on energy related topics believe the introduction of capacity payment in Guangdong province will enable generators recover stranded cost, and incentivise investment in power capacity to ensure capacity adequacy.[159] However, if not carefully designed to support clean energy, such payments have the potential to distort spot power markets, disincentivize renewable energy and energy storage, and encourage the construction of excess coal power capacity.

**Ancillary services markets:** Ancillary services markets are important to ensuring flexibility in systems with a high proportion of renewable energy. Previously, China's system provided only limited funds for ancillary services, and effectively the market required coal plants to pay one another for such services. New reforms have established ancillary service market pilots, starting with Northeast China.[160] Different provinces have adapted some of the ancillary services rules from Northeast China, but most ancillary services markets are at the early stages of development and may only allow participation of some generators.[161] Development of the ancillary service market will also incentivise the investment in retrofitting coal plants for greater flexibility: Thermal units that can adjust their minimum operating load when needed will receive bonuses, while those that lack such flexibility will earn less.

**T&D reform:** China has carried out a transmission and distribution pricing reform nationwide, standardizing payment to grid companies for transmission and distribution services as well as cross-provincial transmission investments.[162] Presently, China is working on incremental distribution grid pilots, which allow private players such as industrial parks to receive market-based compensation for building out new grid assets. This could benefit clean energy by enabling more innovative models for distributed energy, storage, and micro-grids.

**Power trading between provinces:** Northern provinces have created a kind of spot power market by proxy that enables functional trading of power between provinces; the system is known as generation rights trading, and allows generators to maintain the revenue they would receive under their existing contracts, while allowing provinces to freely buy and sell excess power without reducing the revenue of generators.[163] Under this system, provincial dispatch centers act as unitary buyer and seller of generation rights, allocating hours among generators based on a fairness principle. This differs from a normal spot market in that the generators do not bid or trade individually, but in some respects resembles the "power pool" concept used in some markets previously such as the U.K. or U.S. New England states (Nepool). Provinces in the north have seen dramatic declines in curtailment of wind power as a result.

"

During the 14th Five-Year Plan period, we should reform and improve the structure, level and formation mechanism of energy prices, and restore the attributes of energy commodities as a key task. Only continuous improvement in the level of system optimization, reasonable internalization of externalities, suppression of inefficient and ineffective incentive for energy investment, and continuous improvement in the efficiency and effectiveness of energy asset utilization, can minimize the system costs and give more room for the decline of energy prices.

**Zhou Dadi**
**Executive Vice President of China Energy Research Society**

*Energy Research Club, 1 February 2021*

### Timeline of electric power market reforms

**1985**
**Provisional Regulations on Promoting Investment in the Power Sector and Implementing Different Power Prices** separates the responsibilities of government from business in the power sector

**1997**
**Establishment of State Power Corporation from the former Ministry of Electric Power**
NDRC announced rules for setting solar PV feed-in-tariff

**1998**

**2002**
**Breakup of the State Power Corporation into five state-owned generation groups and two state grid companies**
(State Grid Corporation of China and China Southern Grid)

**2003**
**Establishment of State Electricity Regulatory Commission**

**2005**
**Renewable Energy Law mandates purchase of all renewable energy at government-established tariffs**

**2009**
**Amendment of Renewable Energy Law**

**2014**
**Shenzhen T&D pricing pilot**

**2015**
**Document 9 on Deepening Power Sector Reform** establishes long-term goals of market pricing of electricity, spot markets, and opening up market for retail electricity

**2016**
**Rule 625**
mandates purchase of all renewable energy and compensation for curtailed energy by grid companies.

**Rules for market-based mid-to-long term contracts**
to gradually replace administratively-planned dispatch

**2017**
**T&D pricing reform implemented nationally**
**Ancillary services reforms begin**
**Seven spot market pilots announced**

**2019**
**New spot market pilot guidance issued by NEA**
**New Mandatory Purchase requirement for Renewable Energy issued**

**2020**
**NDRC and NEA issued the basic rules for mid-to-long-term power purchasing agreement**

**2021**
**NDRC announced another five new provincial spot power market pilots:**
Liaoning, Jiangsu, Anhui, Shanghai, and Henan

*Source: various sources*[164]

## Challenges remain for market reforms and renewable integration

**Spot market reform:** Spot markets are developed at the provincial level. Provinces have previously had several motivations to protect within-province generators through market design and dispatch practices.[165] Ensuring market supervision and fair competition are key to effective spot market design.

**Distributed energy:** China recognizes the need for more distributed energy, given constrained transmission and the trends in other countries towards distributed solar and storage. China has thus maintained feed-in tariffs for distributed PV, but other obstacles to rooftop PV remain, such as regulatory complexity, slow approvals, objections from grid companies, and limited financing tools. These obstacles also apply to distributed energy storage and micro-grids.

**Lack of transparency:** Despite a great deal of discussion of smart grid and Energy plus Internet, China's grid, dispatch, and power pricing are operated without public information platforms that could enable market players or the public to analyze their operations or potentially participate via new business models. Transparency can not only enable the effective operation of spot markets, but also is likely necessary for market monitoring, for business models such as aggregation of EV charging, or for certain forms of energy demand-side management.

### Challenges faced by the spot market in China

The eight spot market pilots all completed several rounds of monthly settlement trial operation in 2020 and some challenges came to light.

**Trade prices are too low :** The minimum trade price for Guangdong's first month's trial operation was only RMB 0.07/kWh, far below the operating cost of thermal gas and coal plants in the region (renewable generators do not bid into the market). Consistently low prices suggest that most generators have contracted plant output via mid- and long-term contracts and only bid a small surplus into the limited-volume spot markets, where there is insufficient demand for the plants to recover operating costs for the supply offered. Currently, 90-95% of the electricity generation is bound in medium and long-term power purchasing contracts. Electricity traded in the spot market only represents 5-10% of total electricity output during the period.

**Supply-demand imbalances due to hybrid market design :** Shandong province experienced severe supply-demand imbalances of around 30% due to a hybrid market design, that applied spot market clearing prices to other obligatory transactions such as power imports, nuclear, and renewables.[166] The province's *priority generation plan*, designed to guarantee the purchase of imported, nuclear and renewable electricity, played a central role in the spot market imbalance. Government planners set the price and quantity traded under the priority generation plan, and used the spot market clearing price as the price for all power purchases.[167] As a result of this scheme, revenue collected from electricity sales fell short of payments to generators.

**Rao Hong**
**Chief Technical Expert of China Southern Grid**

[An] effective power market … [unleashes] the potential of adjustable capacity of different power sources and promotes clean energy consumption. A flexible and diverse market-based demand response trading model will guide the interaction between supply and demand, economical and efficient energy consumption, and further enhance the overall efficiency of the power system.

*Southern Energy Observer, 27 April 2021*

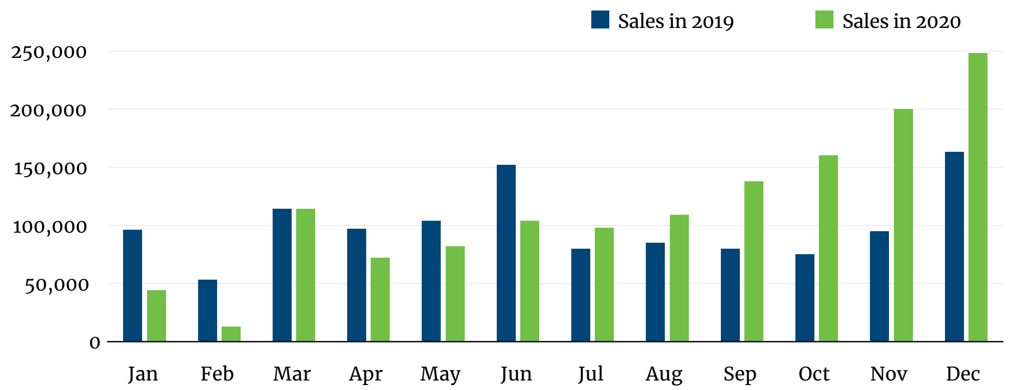

# 6 New Energy Vehicles

# 6. New Energy Vehicles

## EV sales rose in 2020

- New-energy vehicles (NEV) sales rose by 13% in 2020; sales increased significantly in the second half of the year.
- The government reduced the 2025 NEV sales target to 20%, under the new dual credit policy, which regulates vehicle efficiency and new-energy vehicles.

### Monthly China NEV sales in 2019 and 2020




*Source: China Association of Automobile Manufacturers, January 2020*[168]

China strives to become a world leader in the global automobile market, and the central element of this effort is the country's policy on new energy vehicles (NEVs), which includes electric vehicles (EVs) and fuel cell vehicles (FCVs). The government has directed various subsidies to companies in this field, including subsidies paid to manufacturers for every qualifying NEV sold, and supported the industry with an annual quota for NEV sales and, in some areas, preferential policies for NEV license plates.

In December 2019, the Ministry of Industry and Information Technology (MIIT) published a draft NEV Industry Development Plan (2021-2035) aimed at promoting battery electric vehicles and commercializing fuel cell vehicles.[169] The plan aimed to shift industry support from subsidies and administrative targets towards a more market-oriented approach that could promote innovation. The plan specified that the market share for new energy vehicles in annual vehicle sales should reach 25% by 2025,[170] implying an annual sale of around 5-6 million, assuming a steady vehicle market. However, the actual NEV Industry Development Plan released in November 2020 revised this target to 20% of EV market share by 2025.[171]

Canalys, a market analyst firm, expects China's EV market to grow strongly in 2021.[172] A growing network of standardized public chargers, ongoing government support, and rising consumer demand are helping the market expand. Tesla started deliveries of the made-in-China Model Y in February 2021, and Wuling has increased the production of the Hongguang Mini EV to keep up with demand, particularly from young Chinese urbanites.

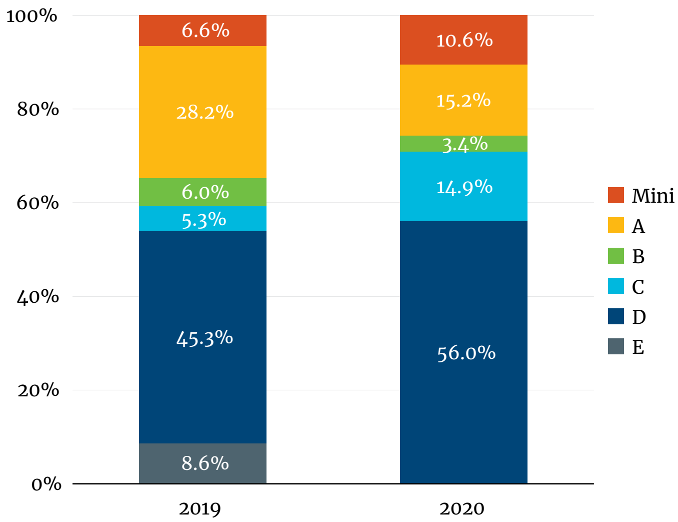
China's EV sales growth takes place within a global context: worldwide, 2020 EV sales rose 43% compared to 2019, led by sales growth in Europe.[173] Although China total vehicle sales have declined over the past four years, NEV sales have grown: between 2012 and 2020, China NEV sales rose from just 13,000 units in 2012 to 1.37 million units in 2020. EVs now account for 5.4% of annual vehicle sales.[174] So far, sales have been concentrated in some comparatively developed cities, especially Beijing, Shanghai, Shenzhen, and Hangzhou. However, second and third tier cities are increasingly relevant NEV markets.[175]

A July 2019 cut in NEV purchase subsidies led to a sharp decline in sales. Annual sales fell 4% in 2019 from the prior year to 1.2 million. Sales surged right before the expected cut in subsidies in June, but sales in the second half of 2019 following the subsidy cut fell 57.3% versus the prior year.[176] Sales in the first half of 2020 remained low as the EV market felt the effect of the coronavirus. NEV sales quickly rebounded in the second half of 2020 and reached 250,000 vehicles in the month of December, a 52% increase over December 2019.

The Tesla Model 3 notched the most sales of any China EV in 2020, capturing 11% of the market, followed by Wuling Hongguang, a mini EV model, with a 9.4% share.[177] Notably, many small and more affordable city cars, such as the Baojun E-Series from SGMW and the Ora R1 from Great Wall Motors (GWM), proved popular in 2020, ranking as the third and fourth top selling models.[178] This may relate partly to Covid-19, which discouraged long-distance travel, making city cars more attractive. However, among top-selling models, sales in the C- and D-segments continued to capture larger market share, while the A- and B-size categories shrank.

New NEV players are increasingly diverse, and market concentration has fallen. Newcomers such as NIO, Xpeng and Singulato have all seen strong growth, with NIO selling 42,000 vehicles, double from 2019.[179] This signifies a more competitive and mature NEV market in China.

## Passenger EV sales by car type (top-selling models only)




*Source: Various sources and GIZ analysis, April 2021*

*Note: The percentage is calculated from the top 20 selling passenger EVs in 2019 and 2020,[180] taking PHEVs out of the list. Author analysis using European Commission passenger car classifications based on vehicle length.[181]*

## Modification to the subsidy

Given the sharp rise in NEV sales and consequent increase in subsidy outlays, the government seeks to shift from a subsidy-driven market to one driven by a combination of consumer demand as well as administratively set targets and other non-monetary incentives. In 2017, the government released a dual credit policy to take into account both the average fuel consumption and the EV sales percentage for each passenger car enterprise.[182] The core of the policy is to establish a credit trading market, and balance the development of both energy efficiency measures and electric vehicles. The quota required manufacturers to meet NEV sales of 10% in 2019 and 12% in 2020, referring to credit points that each manufacturer must acquire through the production of battery-electric vehicles and plug-in hybrids.[183] On 15 June 2020, the State Council modified this dual credit policy to specify that the companies need to obtain at least 14% of EV credits in 2021, 16% in 2022, and 18% in 2023. The government anticipates the policy to successfully help achieve the target of 4 L/100 km of average fuel consumption in new passenger cars by 2025, and a 20% market share of EV by 2025.[184]

In 2019, policy makers have tightened standards for receiving NEV incentives, such as by raising thresholds for receiving subsidies in terms of vehicle range minimums and battery energy density. On 26 March 2019, the Ministry of Finance of China announced a modification of the NEV purchase subsidy scheme, tightening the requirements for receiving subsidy in terms of range, battery energy density, and energy efficiency. The subsidy ends for NEVs with New European Driving Cycle (NEDC) range under 250 km, and the maximum subsidy—available only to vehicles with an NEDC range above 400 km—was cut in half. In terms of battery energy density, no subsidy is available for vehicles with batteries under 125 Wh/kg, and the maximum subsidy requires at least 160 Wh/kg.[185]

### Change in subsidy from 2017-2019 in terms of range

| Type of vehicle | Range (NEDC) | Subsidy in 2017 (thousand RMB) | Subsidy in 2018 (thousand RMB) | Subsidy in 2019 (thousand RMB) |
|---|---|---|---|---|
| Pure Electric Vehicles | 100≤R<150 | 2 | / | / |
| | 150≤R<200 | 3.6 | 1.5 | / |
| | 200≤R<250 | | 2.4 | / |
| | 250≤R<300 | 4.4 | 3.4 | 1.8 |
| | 300≤R<400 | | 4.5 | 1.8 |
| | R≥400 | | 5 | 2.5 |
| Plug-in Hybrid Electric Vehicles | R≥50 | 2.4 | 2.2 | 1 |

*Source: Ministry of Finance, March 2019*[186]

Although the shift from subsidies to other incentives is likely to continue, the sharp drop in NEV sales in 2019-2020 may have caught policy makers by surprise, and undercut the national target of 25% NEV sales by 2025. Given the coronavirus and its impact on auto sales, in March 2020 the Chinese State Council decided to extend the EV subsidies for two years. This new policy signifies China's determination to support NEV development, though support will still gradually shift from subsidies to vehicle usage, charging infrastructure, and industry development.[187] The extension likely contributed to 2020's high NEV sales growth, given the improved economics of NEVs that resulted.[188]

## Battery manufacturing continues to scale up

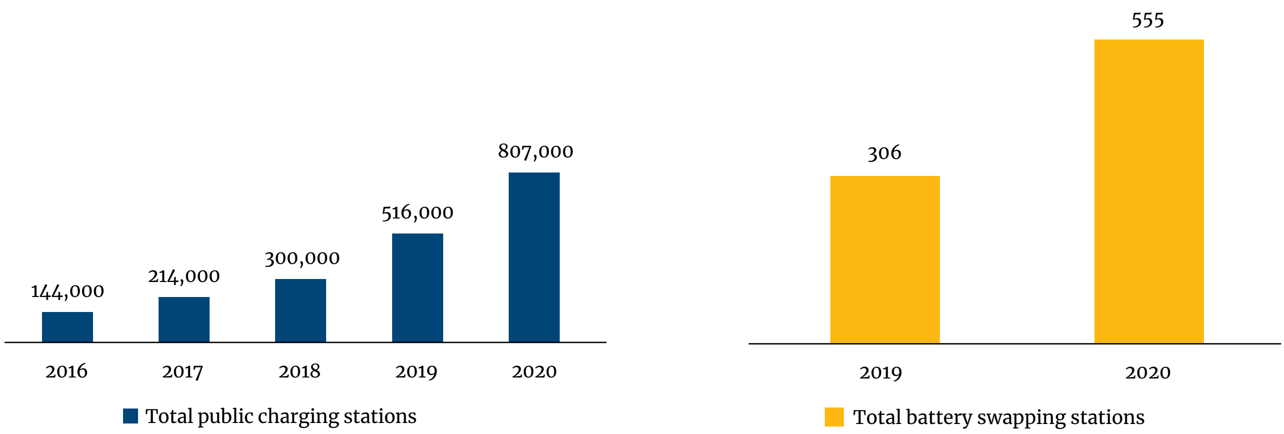
China strives to become the world market leader in battery cell production. According to the China Association of Automobile Manufacturers, yearly EV battery production in 2020 was at 63.6 GWh, a 2.3% increase over 2019. Lithium iron phosphate (LFP) batteries saw a total sale of 24.4 GWh in 2020, accounting for 38.3% of all EV batteries sold. This represents a 20.6% increase over 2019.[189] In comparison, nickel manganese cobalt (NMC) batteries saw 38.9 GWh sold, accounting for 61% of all EV batteries sales.

In terms of market share, China Association of Automobile Manufacturers registered 72 producers of EV batteries in 2020. The top three manufacturers were CATL, BYD and LG Chem, with CATL alone accounting for half of production. CATL is now the world's largest EV battery producer, thanks to rapid expansion of production capacity over the past two years.[190]

## Charging infrastructure expansion accelerates

The government has set ambitious expansion targets for charging infrastructure, calling for construction of 4.8 million charging posts by the end of 2020, including 500,000 public charging stations and 4.3 million private charging points, as well as 800 intercity rapid charging stations.[191] This goal was overachieved as the total number of public charging stations by the end of 2020 reached 807,000, 61% more than the target, with 300,000 public charging stations added in 2020 alone. As of December 2020, there were a total of 1.68 million charging points in China.[192] China has the largest public charging infrastructure network of any country, which reflects ambitious government targets as well as the need for public charging infrastructure in cities where many lack access to dedicated parking spots with electricity access.

**Total public charging stations in China 2016-2020 (left); Total battery swapping stations (right)**




*Source: EVCIPA, January 202[193] and State Council, March 2021[194]*

In terms of regional availability of charging infrastructure, public charging stations are distributed unevenly across provinces, reflecting greater availability of charging where EV adoption is already highest—such as in Shanghai, Guangzhou, and Shenzhen. Shanghai's public charging station density has reached 14 per square kilometer, Guangzhou reached 13 per square kilometre and Shenzhen reached 11 per square kilometre.[195] The total number of battery swapping stations has also grown to 555 nationwide by the end of 2020, an 81.4% growth over 2019.[196] However, the swapping stations are highly concentrated in a few big cities/provinces, with 200 in Beijing, 86 in Guangdong, and 52 in Zhejiang.

In terms of ownership and operation of charging infrastructure, just three companies own 74% of public charging stations in China: two private companies—TGood and Star Charge—and one state-owned company State Grid Corporation of China, which operates the majority of the country's power grid.[197] The expansion of the charging infrastructure is subsidized by the state; unlike the sales subsidies for electric vehicles, this funding is likely to continue—although charging infrastructure policy is likely to also focus on industry upgrading and improving reliability. For battery swapping stations, Aulton alone has 276 stations, and together with NIO and Hangzhou Botan, the three companies occupy 95% of the market share.[198]

A user-friendly and needs-based charging infrastructure is important for the further growth of electric mobility in China, especially since EV sales will increasingly be market-driven after the EV subsidies expire in 2022. However, several problems still exist in this regard: The expansion of the charging infrastructure has so far been largely driven by policy and not based on actual demand. For this reason, many charging station operators lack a sustainable business model and face difficulties generating profits. In addition, charging stations are poorly distributed and poorly located. Due to low utilization, operators lack incentive to provide adequate maintenance. This lack of incentive results not only in broken or balky chargers, but also reduces the incentive for operators to improve interoperability and the online information environment (such as charging apps) to ensure EV drivers can easily locate and access functional charging equipment.

Unlike the expansion of the public charging infrastructure, the expansion of charging points in private buildings has so far been slow because of high cost as well as administrative red tape. China also has few public chargers offering charging rates over 100 kW, which many experts estimate is necessary to enable convenient long-distance trips.[199]

## EV charging from clean energy

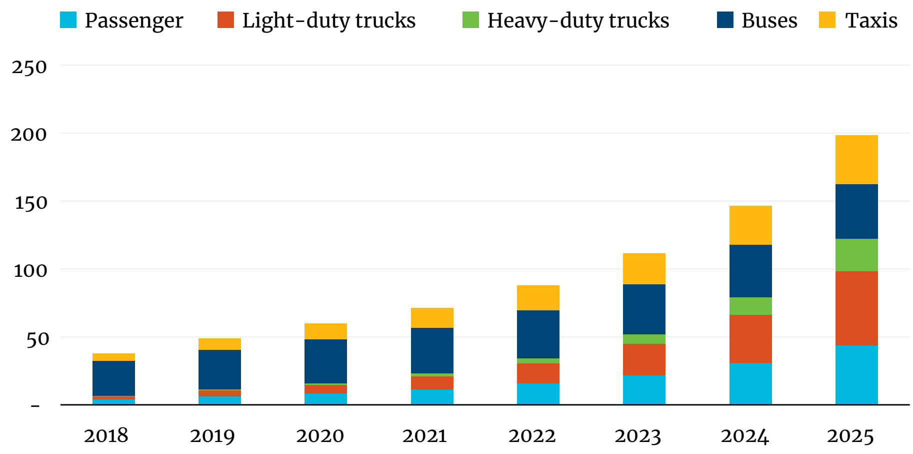
Although China is driving the expansion of renewable energies, it still generates 66% of electricity from coal. For this reason, an electric vehicle in China causes significantly more emissions than the same vehicle in Germany, which has a significantly higher share of renewables in the power grid (around 46% renewable share of electricity consumption in 2020[200] Due to their higher efficiency, electric cars produce fewer emissions in China than traditional combustion engines.

Assuming NEVs reach a 25% market share by 2025, or approximately 5-6 million units per year,[201] and using estimates of EV taxi, bus, and truck fleets from the EVCIPA,[202] we calculated 2025 EV electricity consumption of around 200 TWh. This additional electricity requirement can probably be more than covered by the expansion of renewable energies without new coal-fired power plants. Between 2019 and 2020 alone, electricity generation from renewables rose by 172 TWh.

The Chinese government wants to use electric vehicles to stabilize the power grid and increase the share of renewables in electricity consumption. However, these efforts are not yet well advanced. There are currently no direct incentives in China to charge an electric car when renewable electricity is produced. Electric vehicles are mostly charged at home in China, but the price of household electricity is fixed by the state and does not vary according to the time of day or night. China also does not yet have a real wholesale electricity market. There are currently no business models in which the storage capacity of electric vehicles would be bundled and sold on the market. According to a recent study by the International Energy Agency (IEA), electric vehicles could play an important role in China by 2035 to offset fluctuating renewables and thus increase the share of renewables in electricity consumption. According to experts, China could generate up to 35% of its electricity from wind and solar power in 2035 (currently around 9.5%).[203]

Though China is studying the potential for vehicle-to-grid (V2G) technology to contribute to integration of clean energy, but few models have V2G capability. Notably, in 2021 Volkswagen announced that all their EVs that use the MEB electrical platform will have vehicle-to-grid capability built in, meaning the vehicles will be able to not only charge from the grid, but also return electricity to the grid on demand. Volkswagen intends to use their V2G technology to reduce the amount of renewable energy wasted in Europe, which is as high as 6,500 GWh per year.[204]

**Estimated electricity consumption by EVs through 2025 under 25% NEV target**




*Source: GIZ calculations based on EVCIPA data, January 2020*

> The 14th Five-Year Plan period will present a strategic opportunity period for the EV industry. EVs will become more popular in China, and intelligent technology will bring about changes in the entire industry chain and even in market terminal services, laying a more solid foundation for China's automobile industry in the next five years and even by 2035. China has even come to the forefront of the world in terms of NEV and intelligent network connectivity. In the future, Chinese independent brands will enter a period of rapid development.[14]

**Fu Bingfeng**
**Executive vice president of China Association of Automobile Manufacturers**

*China Automobile Huabao, 2 April 2021*


# 7 Hydrogen

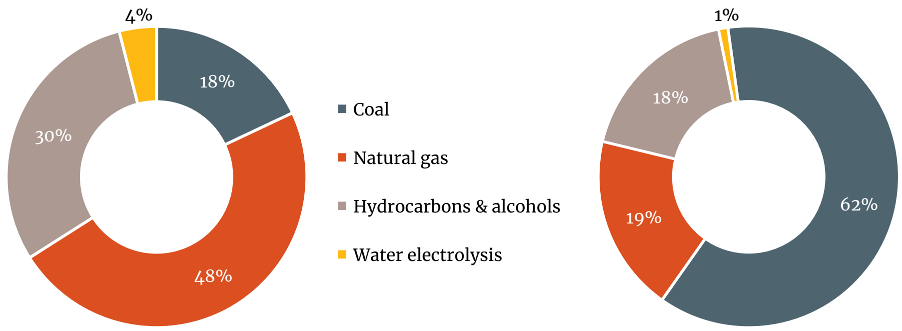
# 7. Hydrogen

## China puts heavy focus on hydrogen, but most hydrogens still comes from coal

China is the world's largest producer and consumer of hydrogen. In 2018, China accounted for about 21 million tons of hydrogen production, and China consumed 22 million tons. Energy Iceberg forecasts these figures to rise to 35 million tons in 2030 and 60 million in 2050.[205] However, China's low-carbon hydrogen market is still at an early stage of development, and coal accounts for 62% of China's hydrogen production.

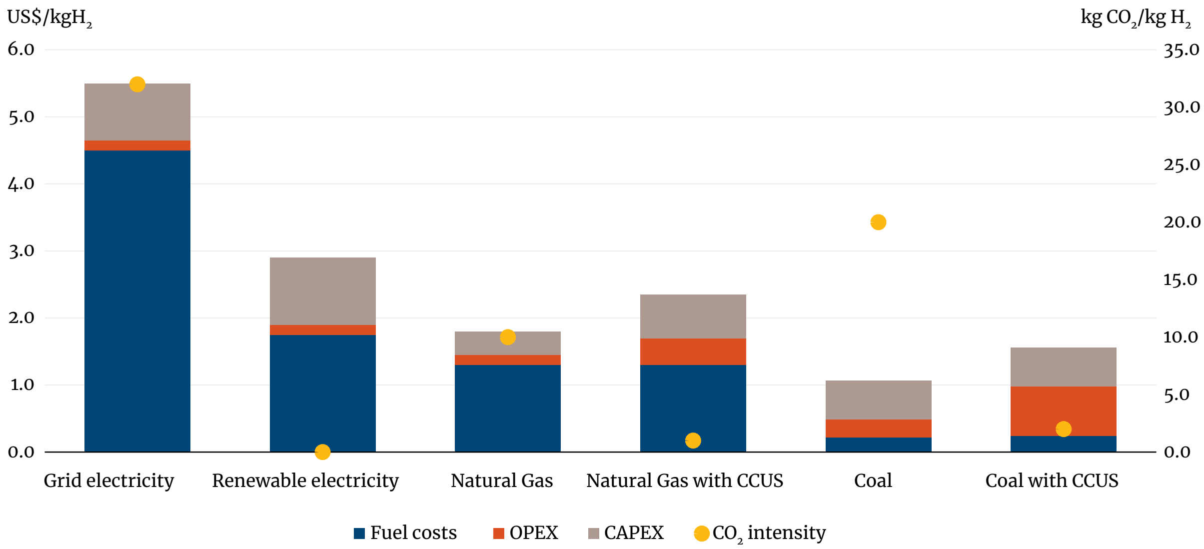
Most hydrogen in China is consumed as a feedstock by the petrochemical industry, especially in the fields of synthetic ammonia, oil hydrogenation, and electronics processing.[206] The China Hydrogen Alliance projects strong growth for hydrogen in transportation, particularly in heavy-duty vehicles. The alliance forecasts transport consumption could reach 24.6 million tons by 2050, or 19% of total transport energy consumption. Among the transport consumption, freight would account for 70% of hydrogen utilisation. Among industrial sectors, the steel industry will see the biggest increase in hydrogen consumption, followed by the chemical industry which will see an increase of hydrogen consumption until 2030 and a decline after 2030.[207]

### Energy sources for hydrogen production worldwide (left) and China (right)




*Source: International Conference on Advances in Energy and Environment Research, 2019*

### Hydrogen production costs in China today




*Source: IEA, 2019*

*Note: Renewable electricity cost = US$ 3.0/kg $H_2$ at 4,000 full load hours*

The high share of coal-based hydrogen in total production relates to the low cost of coal: China has an established coal infrastructure and lacks domestic gas supplies as an alternative for hydrogen production. According to the IEA, coal-based hydrogen combined with CCUS which has a $CO_2$ intensity of 2 kg $CO_2$/kg $H_2$ would represent the lowest-cost and cleanest potential hydrogen production route in China with about US$ 1.48/kg $H_2$.[208]

Several factors underpin China's recent focus on hydrogen: provincial policymakers and large energy companies see hydrogen as an industrial technology policy to repurpose existing energy assets, and view hydrogen as a way to repurpose existing energy assets for an eventual low-carbon energy transition. Provincial and energy company motivations are reflected in strategies for the manufacturing of fuel cell vehicles and expansion of hydrogen fuelling infrastructure. Although there is high interest in hydrogen, China's central government is still in the process of developing a comprehensive national hydrogen strategy.

China sometimes mentions hydrogen as a potential solution for improving integration of renewable energy, particularly wind and solar, which could face problems with curtailment as their market share rises. However, there are several reasons why this does not appear to present a major opportunity for hydrogen in the near term. China presently derives only a small percentage of electricity from wind and solar—NEA is targeting around 11% in 2021—and the largest barrier to wind and solar integration has been a lack of spot markets and obstacles to trading electricity between provinces. Provinces with high proportions of wind and solar, such as Gansu and Qinghai, have been able to resolve curtailment through improved dispatch and strengthened mandates for renewable energy consumption.[209] Provinces with high demand for industrial hydrogen, such as Guangdong and Jiangsu,[210] presently have low levels of curtailed renewable energy, and still derive only a small fraction of electricity from wind and solar. China does have a few examples of companies promoting the integration of renewable energy through hydrogen production: Beijing-based Jingneng has announced plans in March 2020 to build a 5 GW hydrogen production and storage plant in Inner Mongolia that will combine wind, solar, energy storage, and hydrogen.[211]

## Political framework

China has more than 20 national guidelines and documents that explicitly deal with the topic of hydrogen. The National Innovation Development Strategy and the Action Plan for Energy Technology Innovation (2016-2030) list hydrogen and fuel cell technology as central components of the future China energy system.[212] The 14th Five-Year Plan recognises hydrogen as one of China's future industries, which will result in supportive policies and pilot projects.[213]

Both the central government and local governments are increasingly focused on the development of the hydrogen industry. In 2020, 11 provinces/municipalities and 27 cities issued their own hydrogen development plans.[214] Currently, hydrogen plans mainly focus on technology innovation and industrial development rather than decarbonisation. Many cities focus mainly on hydrogen for road transportation, despite the greater potential market for industrial hydrogen for hard-to-decarbonize industrial sectors. Henan Province plans to take advantage of the chemical and coking industry to produce hydrogen.[215] Many of the provincial hydrogen industry plans call for development of a complete hydrogen industrial supply chain within the province, generally based on coal. Only Inner Mongolia's plan mentions electrolysis for hydrogen production.[216]

Local authorities see hydrogen as a path for industrial development and investment. For example, the city of Datong, in Shanxi Province, a major coal mining centre, is using hydrogen to promote local economic growth. Datong plans to focus on making hydrogen from local coal, for use in municipal buses and other vehicles.[217] Similarly, in January 2018 Wuhan published a plan for hydrogen industry development calling for the city to become the capital of hydrogen energy vehicles in three years. Wuhan is focused on R&D in hydrogen storage and proton exchange membrane (PEM) electrodes. The plan states that by 2025, the annual output from the city's hydrogen fuel cell industry chain should reach RMB 100 billion, making Wuhan a "world-class hydrogen energy city."[218]

Industrial strategies for hydrogen at a city level generally include the generation of hydrogen from coal. Many Chinese officials and experts see fossil hydrogen as a clean energy source because policymakers prioritize prevention of local air pollution and place less emphasis on carbon emissions. Therefore, a broad political debate about whether policy should support all forms of hydrogen or only low-carbon forms has yet to begin.

### Provincial Hydrogen Development Plans

| Provinces | Key development areas | Targets |
|---|---|---|
| Beijing | R&D in hydrogen fuel cell components, liquid hydrogen production, storage and transportation, as well as safety measures.<br>Mentions the need to explore hydrogen production from renewable electricity. | **2023**<br>- 3000 hydrogen fuel cell vehicles<br>- 37 hydrogen refueling stations<br>**2025**<br>- Over 10,000 hydrogen fuel cell vehicles<br>- 74 hydrogen refueling stations in total |
| Tianjin | Focus on hydrogen production, storage and transportation, including hydrogen fuel cell manufacturing, R&D and supporting services.<br>Have at least 2-3 internationally competitive companies in hydrogen fuel cells, core components, power system integration and/or hydrogen inspection and testing. | - At least 10 hydrogen refueling stations<br>- 3 pilot demonstration areas to promote the use of hydrogen fuel cell vehicles<br>- Demonstration operation in at least 3 bus or commuting routes<br>- At least 1000 commercial freight trucks, forklifts, buses, and other vehicles powered by hydrogen<br>- At least 2 demonstration projects for hydrogen fuel cell CHP |
| Hebei | **2021:** Deploy hydrogen production, hydrogen equipment, hydrogen refueling stations, fuel cells, vehicles.<br>**2022:** Reach mass production of hydrogen equipment and components. | - At least 30 hydrogen refueling stations<br>- 4000 fuel cell buses and commercial freight vehicles operating on a pilot basis<br>- Blend hydrogen in the natural gas pipeline network to provide H-CNG |
| Shandong | **2020-2022:** Deploy fuel cell in rail, shipping and distributed power generation.<br>Pilot fuel cell in buses and commercial freight vehicles, emergency power, storage and other fields.<br>**2023-2025:** Conduct R&D on fuel cell rail, port machinery, shipping and distributed power generation. Promote network of hydrogen production, storage, refueling and supporting facilities.<br>2026-2030: Establish a new intelligent ecological system to integrate hydrogen industry with big data, IoT, AI. | **2020-2022:** Production capacity of fuel cell engine reach 20,000 units and production capacity of FCV reach 5,000 units. Construct 30 hydrogen refueling stations in total. 3,000 fuel cell vehicles on pilot bases.<br>**2023-2025:** Fuel cell engine capacity reaches 50,000 units. Fuel cell vehicle capacity reaches 20,000 units. Promote a total of 10,000 fuel cell vehicles and build a total of 100 hydrogen refueling stations. Use of hydrogen energy in power grid peaking and frequency regulation, production of hydrogen from renewable sources will be gradually promoted. |
| Sichuan | **2025**<br>R&D on fuel cell and hydrogen production, storage, transportation and refueling.<br>Improve indicators for fuel cell stacks such as fuel cell vehicle lifetime, stack power density, system economy and low-temperature start-up. | **2025**<br>- FCVs reach 6000 units, 5 hydrogen distributed energy stations and backup power supply projects<br>- 60 hydrogen refueling stations of various types<br>- Demonstration of hydrogen in CHP, rail transportation, drones and other fields<br>- 2 hydrogen storage power stations |
| Inner Mongolia | **2020-2023:** Promote and apply fuel cells in public transportation, logistics, mining and other fields. R&D in the fields of hydrogen purification and separation, hydrogen storage materials, fuel cell stack and key components. Pilot projects on water electrolysis by renewable energy sources.<br>**2024-2025:** R&D in the integrated design and manufacturing of renewable-based water electrolysis devices. R&D on cost-efficient hydrogen production, storage, transportation, refueling, fuel cell stack and core raw materials. | **2020-2023:** 3830 FCVs and 60 hydrogen refueling stations. Hydrogen production capacity to reach 400 million cubic meters/ year.<br>**2024-2025:** Promote a total of 10,000 fuel cell vehicles and building 90 hydrogen refueling stations (including joint stations). 3-6 electrolysis hydrogen pilot projects. 1-2 large-scale hydrogen storage pilot projects. Pilot application of fuel cell distributed power stations. |

| | | |
|---|---|---|
| Shanghai | **2023**<br>Develop core technologies in production, storage, transportation and refueling. R&D and manufacturing of components such as high-power density fuel cell stacks.<br>Integrated design of long-range commercial vehicles and passenger cars. | **2023**<br>- Plan to build around 100 hydrogen refueling stations and operate 30 of them<br>- Promote around 10,000 FCVs |
| Henan | R&D and industrialization in the field of hydrogen fuel vehicle power system integration, vehicle power system matching, fuel cell commercial vehicle universal class development. Support key enterprises in using chemical and coking technologies to produce hydrogen, and encourage them to explore green hydrogen production technologies. | **2023**<br>- 5 pilot cities for hydrogen fuel cell vehicles<br>- 60 demonstration bus and logistic routes<br>- Over 3000 hydrogen fuel cell vehicles<br>- Over 50 hydrogen refueling stations |
| Chongqing | **2022**<br>R&D on fuel cell stacks, system integration.<br>Form a cluster of hydrogen production, storage, transportation, refueling, hydrogen fuel cell stack, core components and fuel cell vehicle industry.<br>**2025**<br>R&D on hydrogen fuel cell stack, system integration and control, core components and basic materials. | **2022**<br>- 10 hydrogen refueling stations<br>- 800 hydrogen fuel cell vehicles<br>**2025**<br>- 15 hydrogen refueling stations<br>- 1,500 hydrogen fuel cell buses, freight vehicles and other types of vehicles |
| Ningxia | R&D on hydrogen fuel cell vehicles and components. | **2025**<br>- 1-2 hydrogen refueling stations with refueling capacity of at least 500 kg /day<br>- 1-2 demonstration hydrogen fuel cell bus routes in Yinchuan |

*Source: various sources*[219]

## Hydrogen in the transport sector

The main challenges in the market scale-up of fuel cell vehicles are insufficient supply of domestic vehicle models and lack of fueling infrastructure. China's target for FCV development is to deploy 1 million FCVs by 2030, and China aims for zero emission in the transport sector through joint development of FCVs and electric vehicles by 2050.[220] Regarding hydrogen demand and supply, China's strategy is to match domestic supply with domestic demand. A recent IEA forecast suggests the cost of producing hydrogen from renewable electricity could fall by 30% by 2030 as a result of declining costs of renewables and the scaling up of hydrogen production. China's annual hydrogen consumption would reach 35 million tons by 2030.[221] China has several pilot projects with hydrogen for buses, trains, and boats. Of these, buses are at the demonstration stage, whereas hydrogen trains and boats are at the stage of one-off, small-scale and experimental pilots.

## Hydrogen refuelling infrastructure

Regarding the expansion of fuel cell vehicles, China mainly relies on heavy-duty vehicles such as buses and trucks that are operated by commercial fleets and are refuelled at a pressure of 350 bar, lower than the 700-bar stations deployed in the U.S., Japan and Europe. As of 2019, 24 hydrogen filling stations were in operation in China. Large state-owned companies such as Sinopec are among the manufacturers and operators of hydrogen refuelling stations. Sinopec recently built the first hydrogen filling station in China, which is integrated into a conventional filling station.[222] Demonstration projects are underway in Zhangjiakou to provide hydrogen fuel cell bus transportation for the 2022 Winter Olympics. Project activities include the construction of filling stations, deployment of hydrogen vehicles, and development of a demonstration project for a consistent supply chain for the hydrogenation industry.[223]

## Buses

Currently several companies manufacture and sell small numbers of fuel cell buses. In 2018, 1,527 fuel cell vehicles—1,418 buses and 109 trucks—were manufactured and sold in China. Many provinces/cities also set out their own plan for developing fuel cell buses. For example, Shanghai aims to have more than 20,000 fuel cell buses by 2025, and Suzhou aims to build more than 40 hydrogen refuelling stations and 10,000 fuel cell buses by 2025.[224] By 2022, there may be as many as 30 different bus models offered by Chinese manufacturers.[225]

## Trucks

China is also leading in the deployment of fuel cell trucks and has a number of fuel cell truck demonstration projects. In April 2018, the cities of Rugao, Nantong, Suzhou, Yancheng and Shanghai launched the Hydrogen Corridor Development Plan in the Yangtze River Delta. The project focuses on hydrogen fuel stations along highways to establish a hydrogen highway corridor. The project consists of four phases starting in 2019 and ending in 2030 with a hydrogen corridor connecting all cities in the region by at least 20 highways.[226] Air Liquide and the Chinese start-up Shanghai Sinotran New Energy Automobile Operation Co. (STNE) signed a partnership in 2018 to develop hydrogen freight transport; STNE owns HRS in Shanghai and a fleet of around 500 fuel cell delivery trucks. Air Liquide will provide supply chain expertise including hydrogen production, storage and distribution.[227]

Beyond the freight truck category, in October 2018, Weichai power, the National Energy Group and Beijing National Institute of Low Carbon Clean Energy signed an agreement to research and manufacture heavy-duty mining trucks running on hydrogen with a carrying capacity of more than 200 tonnes.[228]

## Trains

In 2015, Ballard Power Systems Inc., a Canadian manufacturer of fuel cells, signed a joint development and supply agreement with CRRC Qingdao Sifang Co., Ltd. to develop fuel cell engines for low floor trams which were ultimately used for the worldwide first commercial hydrogen-fueled hybrid low-floor tram launched in October 2017 in Tangshan, Hebei province.[229] 2017 saw another Ballard-CRCC contract for eight fuel cell trams for a demonstration line in Gaoming district, Foshan, with a total length of 17.4 km and 20 stations. The first phase - consisting of the commercial operation of the trams on a 6.57 km long route, and covering 10 stations, was completed in December 2019. The trams use a 200-kW engine, have a maximum operating speed of 70 km/h, and a maximum capacity for 285 passengers. Equipped with 6 gas cylinders and a hydrogen storage capacity of 20 kg, each tram and can run for 100km before refuelling.[230]

## Shipping

Whereas Europe, Japan and the USA already have several ongoing projects, China is lagging behind in the fuel cell-powered shipping industry. The Wuhan Institute of Marine Electric Propulsion and the Guangzhou subsidiary of China State Shipbuilding Corporation (CSSC) are researching on fuel cells application in the shipping industry. However, these developments are still in an early phase.[231]

## International Cooperation

Chinese companies and organisations are actively seeking domestic and international collaboration on hydrogen and fuel cell technology. For example, Weichai Power, China's largest engine manufacturer, will invest over €5 billion in fuel cell development by 2030 and is cooperating with Ballard and Bosch to achieve this. At the political level, the National Alliance of Hydrogen and Fuel Cells (NAHFC) was founded in February 2018. NAHFC is an association of companies from the energy and mobility industry supported by the Chinese government. It serves as a platform for companies and as a think tank for further developing China's hydrogen strategy.[232]

# 8 Carbon and Carbon Markets

# 8. Carbon and Carbon Markets

On 22 September 2020, at a speech to the U.N. General Assembly, President Xi Jinping announced that China will enhance its nationally determined contribution (NDC) on climate change, peak $CO_2$ emissions before 2030, and achieve carbon neutrality by 2060.[233] Additional policy highlights include:

- Provincial governments, state-owned enterprises, and industries will formulate their own carbon-peaking plans.
- 2021 will be the first compliance year for China's carbon emissions trading scheme (ETS), and trading will begin by June 2021.
- New announcements are expected to add sectors to the ETS, potentially aluminium and ferrous metals.
- It appears possible that the shift from free allowances to auctions, and an absolute cap on carbon for the ETS, could be introduced this year.

### Announcement of carbon peaking and neutrality targets helps to push carbon markets

As of early 2021, China has not yet adopted an absolute cap on carbon emissions and continues to rely on intensity-based targets. China accounted for 28.4% of the world's carbon emissions in 2018.[234] According to the UN Environment Programme 2019 Emissions Gap Report, the world has just a few years left to bring carbon emissions down sufficiently to reach the 1.5-degree goal set by the Paris Climate Agreement.[235] Amidst the COVID-19 pandemic, China was the only major economy in the world to record growth in carbon dioxide emissions in 2020. International Energy Agency reported a 0.8% increase in $CO_2$ emissions over 2019,[236] whereas Carbon Brief calculated a 1.5% increase based on China's annual statistical communique.[237]

By the end of 2019, China reduced the carbon intensity of GDP by 48.1% compared to 2005, and the share of non-fossil energy in primary energy consumption reached 15.3%. Both figures met or exceeded targets set by China's first NDC for 2020.[238]

**Yang Kun**
**Executive Vice President of China Electricity Council**

Establish a linkage between the power market and the carbon market. Deeply integrate the management institutions, participating entities, trading products, market mechanisms and other elements in the two markets. Build a bidding system with diverse participants, an incentive mechanism that relate emission reduction to revenue, and a *unified market, unified operation* trading model. Form a price system that integrate the electricity price with the carbon price.

*Eknower, 1 May 2021*

### Table for provincial carbon peaking plan

| Indicator | | Units | 2005 | Annual 2010-2019 | Annual 2020-2035 |
|---|---|---|---|---|---|
| | | | Actual value | Actual value | |
| Total energy consumption and energy mix | Total energy consumption | 100 million tons of standard coal | | | |
| | Share of coal consumption | % | | | |
| | Share of oil consumption | % | | | |
| | Share of natural gas consumption | % | | | |
| | Share of non-fossil fuel consumption | % | | | |
| Carbon emission directly from the use of energy | | 100 million tons | | | |
| Nominal total emission | | 100 million tons | | | |
| Key targets of the Five-Year plan | Five-year reduction of carbon intensity of GDP | % | | | |
| | Five-year reduction rate of energy intensity of GDP | % | | | |
| Rate of decrease of carbon intensity compare with 2005 | | % | | | |
| Imported electricity | Total emissions | 100 million tons | | | |
| | Share of emissions | % | | | |
| | Amount of imported electricity | 100 million kWh | | | |
| Energy production/ transformation | Total emissions | 100 million tons | | | |
| | Share of emissions | % | | | |
| | Fossil fuel consumption | 100 million tons of standard coal | | | |
| Agriculture | Total emissions | 100 million tons | | | |
| | Share of emissions | % | | | |
| | Fossil fuel consumption | 100 million tons of standard coal | | | |

*Source: Ministry of Ecology and Environment, 2021*[239]

**China's Big Five Generation SOEs' installed capacity and carbon peaking plans**

| Unit: GW | Wind | Solar | Hydro | Total installed renewable capacity | Total installed clean energy capacity (RE+nuclear) | Year of carbon peaking | 2025 target | 2030 target |
|---|---|---|---|---|---|---|---|---|
| China Huaneng[240] | 20 | 4 | 27 | 50.9 | 50.9 | / | 150 GW of installed capacity of clean energy | 375 GW of installed capacity of clean energy |
| State Power Investment Corporation (SPIC)[241] | 19.3 | 19.3 | 24 | 62.6 | 70 | 2023 domestic peaking | 150 GW of installed capacity of clean energy | 375 GW of installed capacity of clean energy |
| China Energy[242] | 41.2 | 1.3 | 18.6 | 61.1 | 61.1 | | Add 70-80 GW non-fossil during 14th Five-Year Plan period | |
| China Datang Corporation[243] | 18.4 | 1.5 | 26.7 | 46.5 | 46.5 | 2025 | Installed capacity of clean energy aim for 50% of total installed capacity | |
| China Huadian Corporation[244] | 11 | 3.2 | 13 | 27.2 | 60.6 | expected 2025 | Installed capacity of non-fossil fuel should reach 50% of total installed capacity | |

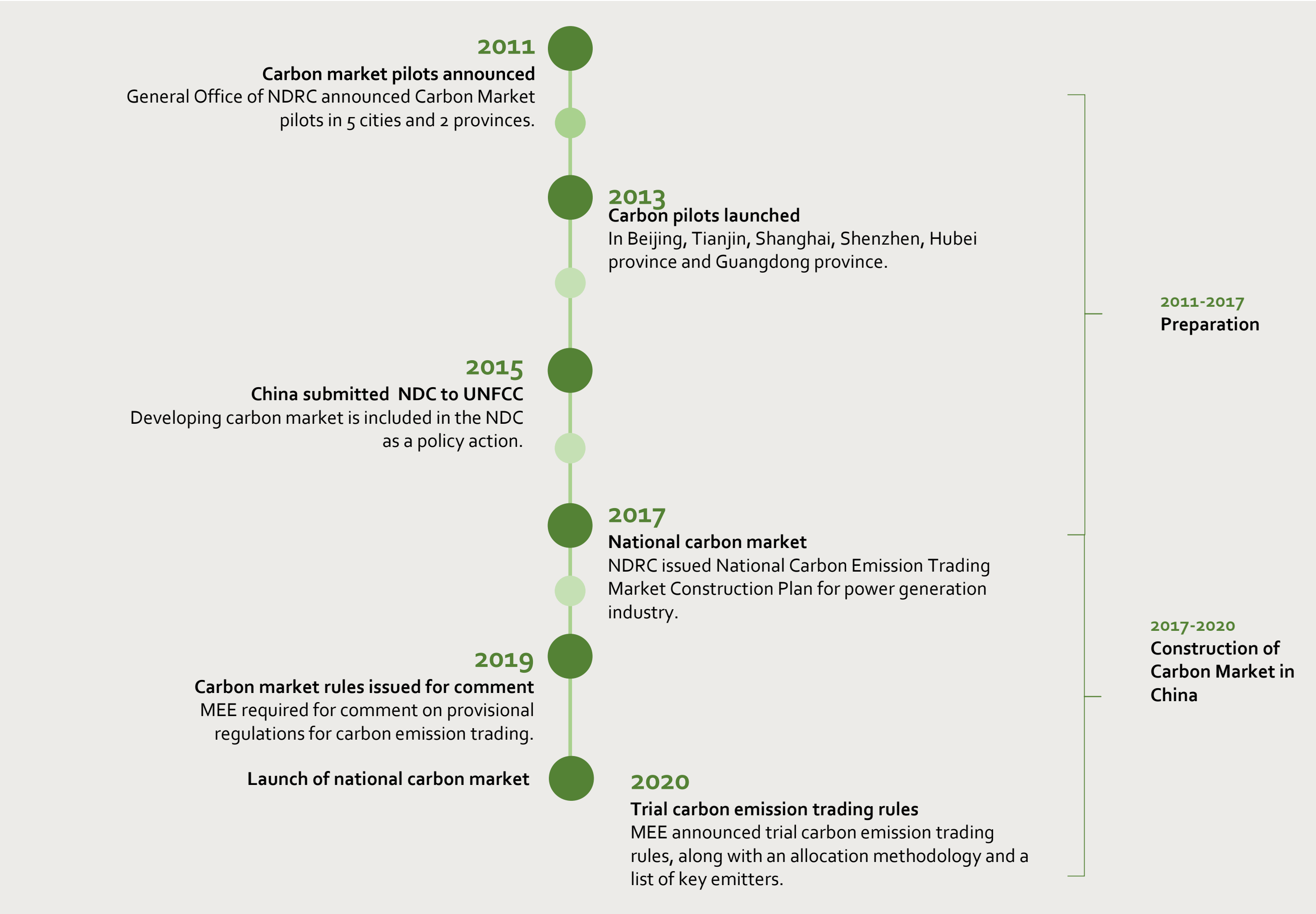
*Source: various sources*

China's big five SOEs for power generation are now investing more in renewable assets. By the end of 2019, the total installed renewable capacity of the Big Five accounted for over 30% of the total renewable capacity in China. The Big Five installed capacity of wind accounted for over 50% of China's total wind installed capacity. The Big Five all proposed a plan for carbon peaking with an anticipation of the share of clean energy installation to reach over 50% by 2025.[245]

## National carbon market

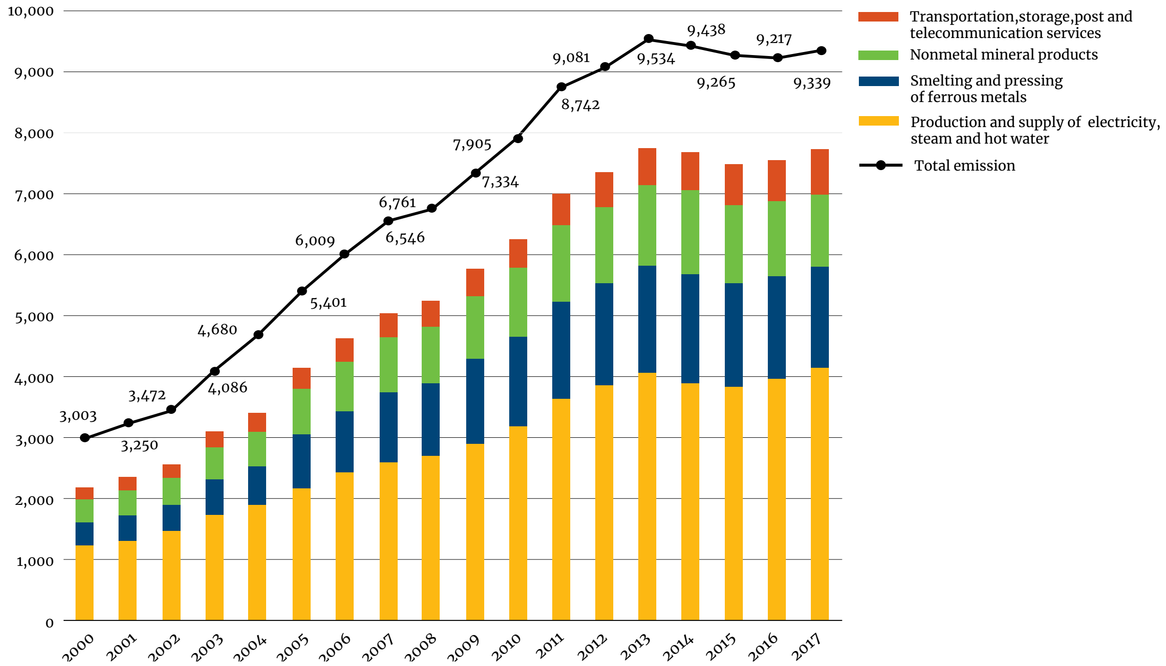
On 5 January, the Ministry of Ecology and Environment announced trial carbon emission trading rules, along with an allocation methodology and a list of key emitters.[246] The first compliance cycle of the national carbon market officially starts from 1 January 2021, covering the power generation sector nationally. 2,225 power generation companies will receive carbon emission quotas based on a benchmark methodology. The new regulations define covered entities as those emitting over 26,000 tons of carbon dioxide equivalent. The new regulations standardize the definition of key emitters compared with pilot markets. The regulation clarifies that emissions include seven categories of greenhouse gases (converted to $CO_2$ equivalent values), indicating the scheme will eventually cover a wider range of greenhouse gases. Subsequently, a regulation increases penalties for companies that falsely report or refuse to fulfil their obligations. The maximum amount for fines ranges from RMB 100,000-500,000 (US$ 15,200-76,000).[247]

## Timeline of China carbon markets



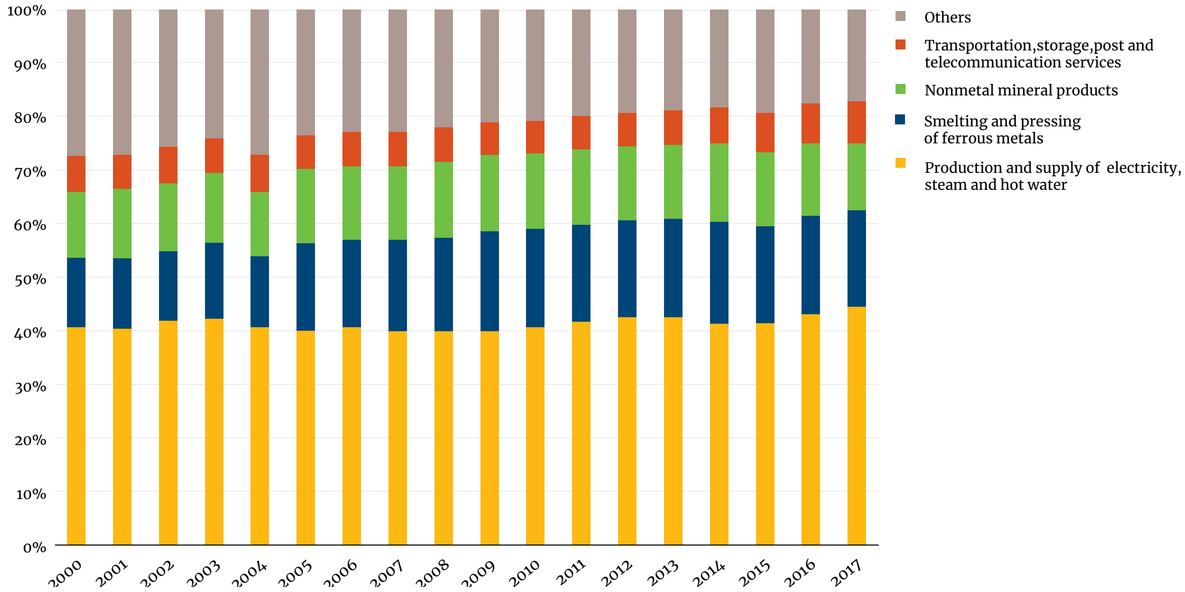

*Source: various sources*[248]

## Sector-level carbon emissions from 2000 to 2017



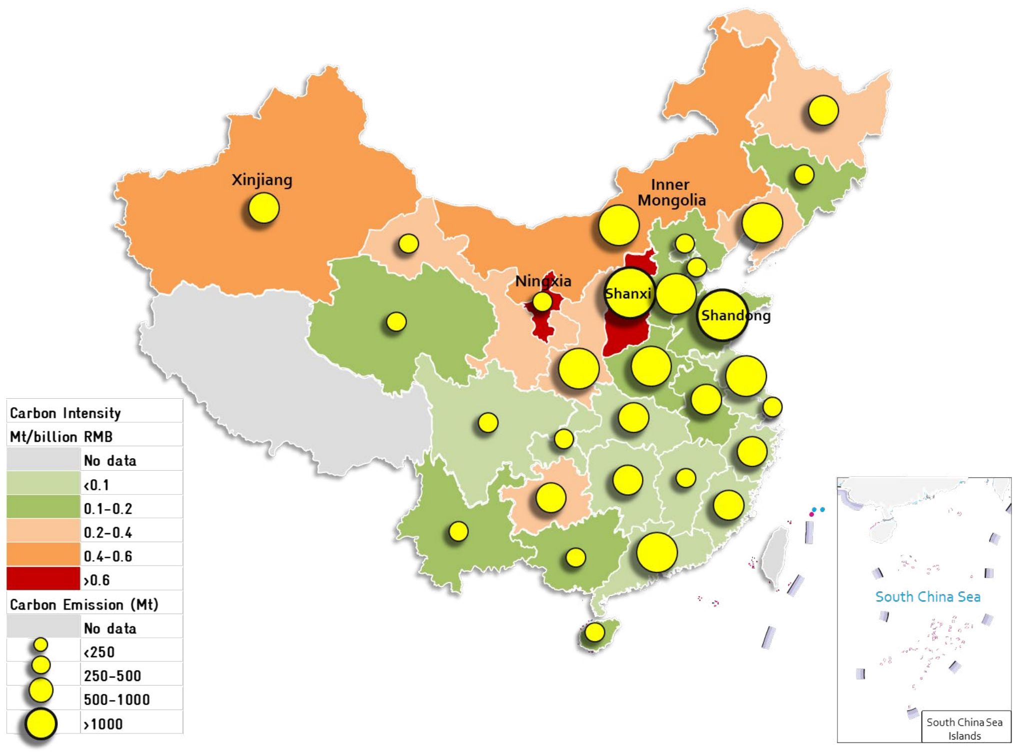

*Source: Carbon Emission Accounts and Datasets, April 2021*

### Percentage share of carbon emission by sector from 2000 to 2017




*Source: Carbon Emission Accounts and Datasets, April 2021*[249]

### Provincial carbon intensity and carbon emissions in 2017




*Source: Carbon Emission Accounts and Datasets, National Bureau of Statistics, and author calculation*[250]

According to data released by Carbon Emission Accounts and Datasets, China's total carbon emission decreased from 9,534 Mt in 2013 to 9,217 Mt in 2016, and rebounded to 9,339 in 2017, and the emission from electricity production is increasing each year. In terms of provincial carbon emissions, Shanxi and Shandong have the highest emission. In terms of carbon intensity, northern provinces are generally higher than southern provinces, with Shanxi, Ningxia, Inner Mongolia and Xinjiang having the highest carbon intensity.[251]

# 9 Air Quality

# 9. Air Quality

## China continues to post major improvements to air quality, resulting from multi-pronged approach

- Air quality improvements were strongest in PM2.5 and $SO_2$.
- Ozone remains a growing challenge.
- Weather has a major impact on day-to-day and even annual air quality changes, leading to occasional haze events even though air quality has continued to improve steadily since 2013.
- So far in 2021, air quality has worsened in Beijing, though it is too early to identify a trend change.

Air quality remains one of the leading motivations for the energy transition in China. Overall, since China declared the start of its long War on Air Pollution in 2013, the country has made immense progress on air quality. This includes enhancing enforcement of air emissions regulations, instituting new rules on environmental impact assessments for new industry, restricting high emissions activities ranging from large industry to street-side BBQ grills, and accelerating the transition to clean energy and electrified transport.

The results of this effort are clear. From 2013 to 2019, PM2.5 concentrations in China fell dramatically. Whereas in 2012 and 2013, concentrations in the worst months of winter regularly surpassed 500 micrograms/$m^3$, in the last three years the worst days have rarely exceeded 200 micrograms/$m^3$. In 2013, the worst month recorded by the monitor at the U.S. embassy averaged 199 micrograms/$m^3$, in 2019 the worst month was 58 micrograms/$m^3$—lower than the best month recorded for all of 2012-2013. The average concentration in August 2019 was 21 micrograms/$m^3$, just one third of the concentration in the best month of 2013.

The positive trend has also continued in the past year. In Beijing, annual average PM2.5 levels fell to 42 micrograms/$m^3$, down 12.5% from the prior year, while PM2.5 levels declined by 2.4% in the Yangtze River Delta region. Across all national air quality monitoring stations, 2019 PM2.5 concentrations averaged 36 micrograms/$m^3$, basically flat from 2018, while $SO_2$ levels fell 15.4%, NOx levels remained roughly constant, and ozone levels increased 6.5%.[252] Whereas air pollution measures in the past few years have focused on PM2.5, which is associated with China's episodic periods of intense regional haze, ozone is expected to become a more important policy priority over the next few years.

In 2020, the closing year of the 13th Five-Year Plan, the impact of the COVID-19 epidemic has reduced the intensity of emissions, which has helped to achieve the target. The National Air Pollution Prevention and Control Joint Centre scientifically assessed the impact of the pandemic on air quality through an internationally used air quality model; the results showed that the impact of the epidemic on PM2.5 concentration was 2 micrograms/$m^3$. After deducting the impact of the epidemic, the national PM2.5 concentration in non-compliant cities was 35 μg/m3 in 2020, a 25.0% decrease compared to 2015.[253]

**Beijing ambient PM2.5 concentration monthly averages, micrograms/m³, 2008-2020**

**Beijing average monthly PM2.5 concentration (U.S. Embassy data); colors based on default Excel conditional formatting**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | | | 90 | 45 | 119 | 199 | 118 | 108 | 72 | 124 | 34 | 53 | 60 | 48 |
| Feb | | 65 | 98 | 150 | 84 | 124 | 175 | 97 | 45 | 76 | 58 | 57 | 63 | 69 |
| Mar | | 81 | 95 | 58 | 97 | 127 | 110 | 89 | 93 | 64 | 87 | 53 | 34 | 97 |
| Apr | 104 | 87 | 80 | 91 | 87 | 67 | 96 | 79 | 66 | 56 | 66 | 53 | 35 | |
| May | 98 | 84 | 87 | 65 | 91 | 85 | 72 | 60 | 55 | 61 | 62 | 43 | 43 | |
| June | 100 | 97 | 109 | 108 | 97 | 112 | 59 | 55 | 59 | 40 | 49 | 35 | 40 | |
| Jul | 90 | 106 | 124 | 108 | 80 | 69 | 89 | 55 | 60 | 51 | 35 | 32 | 39 | |
| Aug | 65 | 108 | 98 | 104 | 81 | 62 | 63 | 45 | 39 | 33 | 30 | 19 | 25 | |
| Sept | 59 | 108 | 123 | 96 | 60 | 91 | 71 | 47 | 51 | 56 | 27 | 35 | 22 | |
| Oct | 84 | 93 | 119 | 145 | 95 | 107 | 141 | 72 | 83 | 53 | 41 | 42 | 41 | |
| Nov | 73 | 155 | 138 | 110 | 87 | 91 | 104 | 124 | 105 | 48 | 73 | 46 | 40 | |
| Dec | | 109 | 97 | 109 | 113 | 98 | 78 | 162 | 144 | 46 | 42 | 50 | 29 | |
| **Grand Total** | **85** | **102** | **104** | **99** | **91** | **102** | **98** | **83** | **73** | **59** | **50** | **43** | **39** | |

*Note: colours are based on default Excel conditional formatting, and do not represent the air quality index of any country.*

*Source: U.S. Embassy, 2021*

## The future of air quality policy

The policies China has adopted have already had a substantial effect, but China's air quality has yet to reach national targets or recommended ambient air quality levels published by the World Health Organization. To date, many policies have focused on the largest emitting sources, such as heavy industry and the coal power sector, as well as coal heating. Focusing on the largest emitting sectors has enabled China to rapidly improve air quality, but as a result the proportionate contributions of these sectors has fallen more rapidly than other, more dispersed pollution sources. In the Beijing area, for example, the contribution of local coal power and industry to PM2.5 has fallen dramatically, and the share of transport emissions has increased from under 30% to over 40%.[254] Similarly, policies targeting coal and industry have dramatically reduced sulphur and primary PM2.5 emissions, but emissions of $NO_X$ and volatile organic compounds (VOCs) have seen smaller declines.[255] Ammonia has also drawn increasing scrutiny for its role in formation of secondary PM2.5.

Beijing and other major Chinese cities are likely to continue to experience severe haze episodes due to the relatively unfavourable geographic and meteorological situation. Often, wind, humidity, and air inversion conditions can lead to rapid deterioration in urban air quality, and researchers believe even steady efforts to reduce emissions from all sources will not entirely prevent such haze events.[256] Haze events also favour the formation of secondary PM2.5, which therefore does not correlate directly to local changes in primary emissions.[257] While media and the public often look to short-term economic or topical explanation for daily, weekly, or even annual variation in air quality, these factors cannot be ignored.

Air quality remains a top environmental priority for national and provincial authorities, and the topic received prominent mentions in the outline of the national Five-Year Plan in February. Under the present Clear Sky Action Plan, the regions with the strictest targets for air quality improvement include Jing-Jin-Ji, Ningxia and Zhejiang.[258] However, the end of the 13th Five-Year Plan has coincided with a period of hazy conditions and unfavorable weather that left Beijing suffering from air quality conditions worse than any months going back to 2017.[259] This also coincided with enforcement visits by environmental officials to steel and industrial clusters in Tangshan, which had increased output during this period.[260] Since emissions are tightly linked to industrial structure, an economic recovery that depends mainly on infrastructure spending or energy-intensive basic industries could have a deleterious effect on air quality in the near term.

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