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How far is China from hitting its climate targets? – An overview of China's energy sector

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Abstract

China is by far the world's largest consumer of primary energy. Its vast energy demands are a leading issue for global energy use, driving pollution trends and prices on commodity markets. Despite huge increases in non-fossil capacity from nuclear and renewables, China still burns tremendous amounts of coal to meet its primary energy needs. Domestic energy consumption has risen faster than energy production, and thereby increased China's dependence on energy imports. China is the world's largest polluter, so any effort on the country's part towards cleaner energy has major implications for global decarbonisation efforts. This overview comprises ten briefs on China's energy sector. They cover recent developments in energy use and the shifting dynamics in primary power generation aimed at meeting China's energy needs.

Keywords: China, energy, oil, natural gas, coal, electricity, renewable energy, production, investment, foreign trade, emissions

[1] The authors thank Mikko Mäkinen for his valuable comments.

1. Introduction

According to International Energy Agency (IEA) statistics, China surpassed the United States as the world's largest primary energy consumer in 2009. China today accounts for nearly 25 % of global energy consumption, up from just 11 % two decades ago. At the same time, its primary energy consumption per capita has tripled. British Petroleum (BP) estimates that China's per capita primary energy consumption in 2019 was nearly 100 gigajoules, an amount that exceeds the world average of 76, but is still nowhere near the levels of advanced economies (e.g. 200 for Finland or nearly 300 for the US).2

Even as energy consumption declines in Europe, North America and other advanced economies, energy consumption in China will continue to rise. China accounted for over 40 % of all growth in global energy consumption over the past decade. While China's energy consumption during 2000–2010 roughly matched the 10 % a year pace of economic growth, the growth in energy consumption slowed to an average of 4 % a year between 2010 and 2019. Even if that growth is still high, China's energy intensity (energy consumption relative to GDP) has improved.

Some of China's energy goes to manufacturing products for export. For example, the steel made in China and used by the rest of the world requires vast amounts of energy in its production. China also generates carbon emissions well in excess of its consumption – the opposite of the situation in the EU and US. Roughly a third of carbon embedded in final products consumed in the EU was generated elsewhere. Unsurprisingly, much of these embedded emissions come from China, which accounts for about a quarter of EU final demand emissions.3

China mainly relies on coal for energy production (about 60 % of energy consumption). After that, the main energy sources are crude oil (just under 20 %), natural gas (8 %) and hydropower (8 %). Even if China possesses the world's greatest renewables capacity, renewables still represent only a small slice of the energy mix. Moreover, because China's energy production has not kept up with consumption, energy imports have soared. This has spurred China's investment in energy projects around the world. In recent years, China has sought to increase its energy independence and boost domestic energy production.

Under the Paris climate agreement adopted in December 2015, China committed to reducing its carbon emission intensity (carbon dioxide emissions relative to GDP) to 60–65 % of the 2005 level and increase the share of non-fossil fuels to 20 % of its energy consumption by 2030. China expects its carbon emissions to peak at latest by 2030. As these targets are fairly unambitious, further measures will be needed to ease the pollution situation in China in order to reach global climate targets. The economic shock from the covid-19 epidemic could at least temporarily weaken the situation. Among other things, construction of coal-fired power plants has further accelerated as part of efforts to stimulate economic activity. In light of this trend, it came as mild surprise to many observers when president Xi Jinping announced in September 2020 at the UN General Assembly that China would seek to achieve carbon neutrality by 2060. Later last autumn president Xi also tightened China's targets under the Paris climate agreement. China now seeks to reduce its carbon intensity by at least 65 % of the 2005 level by 2030, and to boost the share of non-fossil sources in its energy mix at least 25 % of energy consumption. China is currently the world's biggest polluter, accounting from nearly 30 % of all CO2 emissions. This puts the country solidly in the driver's seat in determining the success or failure of global efforts to deal with climate change.

[2] BP Statistical Review of World Energy 2020. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

[3] See Simola, H. (2020), CO_2 emissions embodied in EU-China trade and carbon border tax, BOFIT Policy Brief 4/2020. http://urn.fi/URN:NBN:fi:bof-202001221029.

In December 2020, UN Secretary General António Guterres urged the countries of the UN General Assembly to strive for carbon neutrality by 2050. By some estimates,4 this would require China to phase out its use of fossil fuels incrementally so that by 2050 renewables and nuclear would meet over 85 % of the country's energy consumption and account for over 90 % of electrical power generation. Electrical power generation would have to reach zero emissions already by 2050, and thereafter produce "negative" emissions, e.g. by integrating carbon sequestration and storage into bioenergy production. This change would help offset CO2 emissions generated by China's other economic activities. Over the next 30 years, solar power production capacity would have to increase ten-fold and the production capacity of wind and nuclear by about seven times from their present levels to meet the carbon-neutral target. Realisation of this scenario would require investments worth trillions of dollars.

This overview of China's energy sector proceeds as follows. First, the roles of coal in China's primary energy production and crude oil use are discussed. Next, we consider the significance of renewable energy sources, China's electricity markets, natural gas production and gas trade, as well and the role of nuclear power. The next briefs consider the implications of Chinese energy investment abroad and the various role of China's massive energy corporations. China's emissions are discussed in the final brief.

2. Coal's persisting dominance in China's energy mix

Seija Parviainen

China's dominance as the world's largest coal producer and coal consumer continues to rise. During 2008–2018, Chinese coal production growth averaged over 2 % a year. In 2019, growth in coal production accelerated to over 4 %. While most of the world struggled to wean itself off coal for environmental reasons, China and India remain among a handful of countries that have boosted their thermal coal power capacity. The driving factor in China's case had not been a rising demand for coal power, but expedience in using construction of coal power plants to provide economic stimulus made worse by distorted incentives for local governments to ease plant permitting rules.

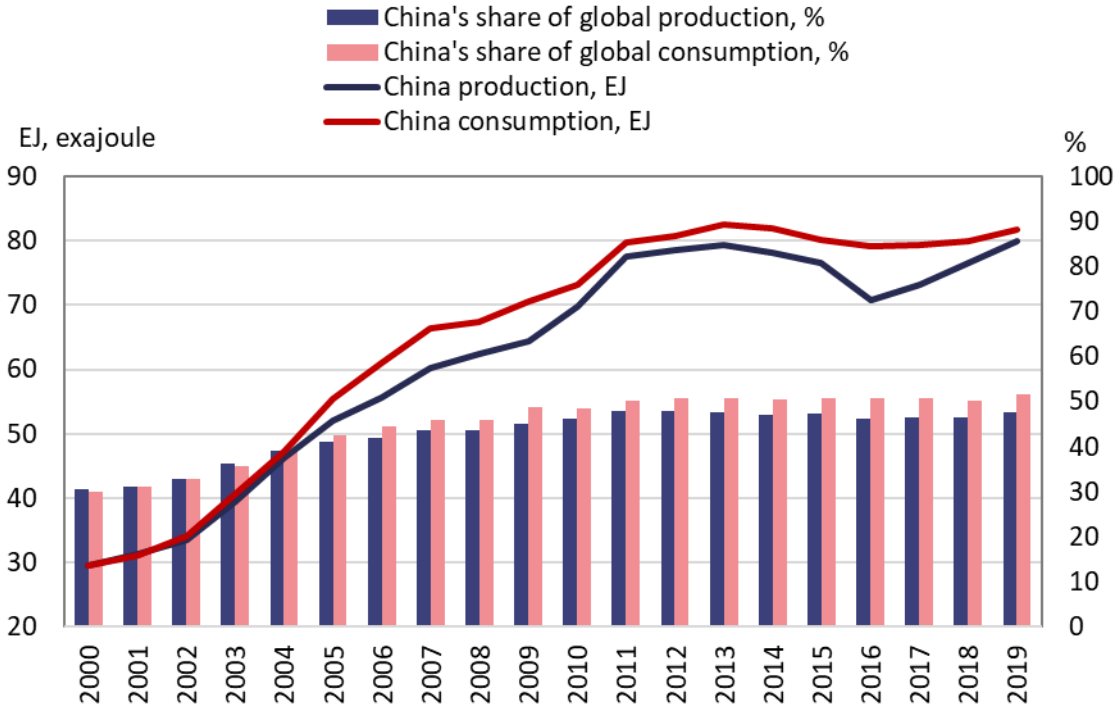
In 2019, China accounted for nearly half of global coal production and over half of global coal consumption (Figure 1). Up until about ten years ago, China's domestic coal reserves were sufficient to allow exports. Ever since, however, China has been a net coal importer. By 2019, imports accounted for about 8 % of China's coal consumption. Over a third of China's coal imports came from Indonesia, nearly a third from Australia and the rest mainly from Mongolia or Russia. China's domestic coal reserves represent just over 13 % of the world's total coal reserves. China's reserves are roughly the same size as those of Europe or Australia.

Coal accounted for about 60 % of China's total energy use in 2018. Although consumption of thermal coal power has risen sharply in China, its relative share of the energy mix has actually declined. Just a decade ago, coal accounted for about 70 % of China's energy consumption. It exceeded 66 % of electricity production in 2018 and accounted for 83 % of heating. The International Energy Agency (IEA) reports that every fourth ton of coal consumed in the world goes to producing electricity in China.

[4] Lauri Myllyvirta "Influential academics reveal how China can achieve its 'carbon neutrality' goal," China policy guest post in *Carbon Brief,* 14 October 2020. https://www.carbonbrief.org/influential-academics-reveal-how-china-can-achieve-its-carbon-neutrality-goal.

China has suffered from an oversupply of coal power for several years. The Centre for Research on Energy and Clean Air (CREA) reports that overcapacity is currently about 400 gigawatts, which is huge given that China's total thermal coal plant capacity is just over 1,000 GW.

Figure 1. Coal production and consumption again on the rise.



Source: BP, 2020.

China's overcapacity issues can be blamed on governmental decision-making processes at various levels and state subsidy programmes. Before 2015, only the central government could grant permits for construction of coal-fired power plants. Due to the sluggishness and high costs of the centralised permitting process, plant approval was delegated to provincial governments. While the change eased and sped up the permitting process, it appears to have caused an overabundance of permit approvals. Because each province is subject to its own GDP growth target set by the central government, the ease of permit-granting affects the career prospects of senior provincial officials. As a result, provincial governments were incentivised to approve as many coal plant projects as possible in order to support economic growth in their province both directly and indirectly. The approval ratio for permits for thermal coal plant projects tripled after the process was shifted to provinces.

The problem highlights the danger of officials succumbing to short-term expediency without accounting for the long-term costs. In 2015, permits were granted to 210 new coal plant projects, which corresponded to roughly 200 GW of new production capacity, or nearly a quarter of all the existing coal power capacity at the time. Thereafter, the central government has sought to slow the pace of permitting, even revoking permits in some cases.

Market-distorting subsidy policies of local governments are another major cause of China's oversupply of coal power. Power grids are obliged to purchase a certain amount of coal-generated electricity at a guaranteed wholesale price. In addition, under China's production quota system, coal plants are guaranteed a certain number of operating hours each year. The quota system has allowed

aging, unprofitable coal plants to continue operating long beyond their expiry dates. The quota system has also restrained China's shift to renewables.

Although China's leaders have threatened for years to restrain the growth of new coal-fired power plants, restrictions on new plants were actually relaxed in 2019 to stimulate economic growth. Additional stimulus measures to deal with the covid-19 shock in 2020 only made matters worse. The latest round of stimulus, which emphasises fixed investment, has sought to boost the number of coal-fired power plants even higher. As of mid-June 2020, local governments in China had green-lighted more new coal-power capacity than in the previous two years combined. CREA reports that nearly 250 GW in new coal-power capacity is under planning in China, which is more that the total coal power capacity of the US or India.

About half of China's coal-fired power plants operate at a loss.[5] As new capacity is phased in, the capacity utilisation of China's coal-fired power plants will drop further from the current level of 50 % to 45 % by 2025. In other words, the positive impact of heavy investment in coal plants is likely to be much less than promised. The Center for Global Sustainability estimates that China's coal-power capacity will increased by 13.5 % from its current level.[6] The calculation assumes that coal plants are decommissioned after 40 years of service.

According to the Global Energy Monitor (GEM) Wiki,[7] the total number of coal-fired power plants in the world reached the historical maximum in 2020 and has since begun to decline. GEM estimates that about 90 % of planned coal power plants will be built in China, that about 86 % of new plants under construction will be sited in China's and that 62 % of imminent plant commissioning will take place in China. China's has faced harsh international criticism for its coal power policies as they are likely to seriously hobble global efforts to rein in climate change. The University of Maryland reports that China's next five-year plan (2021–2025) appears more likely to include further increases in coal power capacity that negatively impact China's long-term economic and social development.

3. The world's largest importer and second largest consumer of crude oil

Riikka Nuutilainen

The growth of China's oil consumption has been relatively steady. British Petroleum (BP) estimates that China consumed about 650 million metric tons of oil (about 14 million barrels a day) in 2019, which was about 15 % of global oil consumption.[8] The US Energy Information Administration (EIA), expects the United States, the world's largest oil consumer, will see a modest drop in consumption over the coming decade, while oil consumption in China will rise by 10 %.[9] Nevertheless, China's per capita oil consumption is only on par with many countries in Africa or the poorer countries of Latin America. Per capita oil consumption in Finland, for example, is about 3.5 times higher than in China.

China consumes most of its oil in the form of transportation fuels. The EIA, however, expects the share of transportation consumption to contract in the years ahead, while the share of petroleum and other liquids used by industry will rise to a level that matches transportation uses.[10]

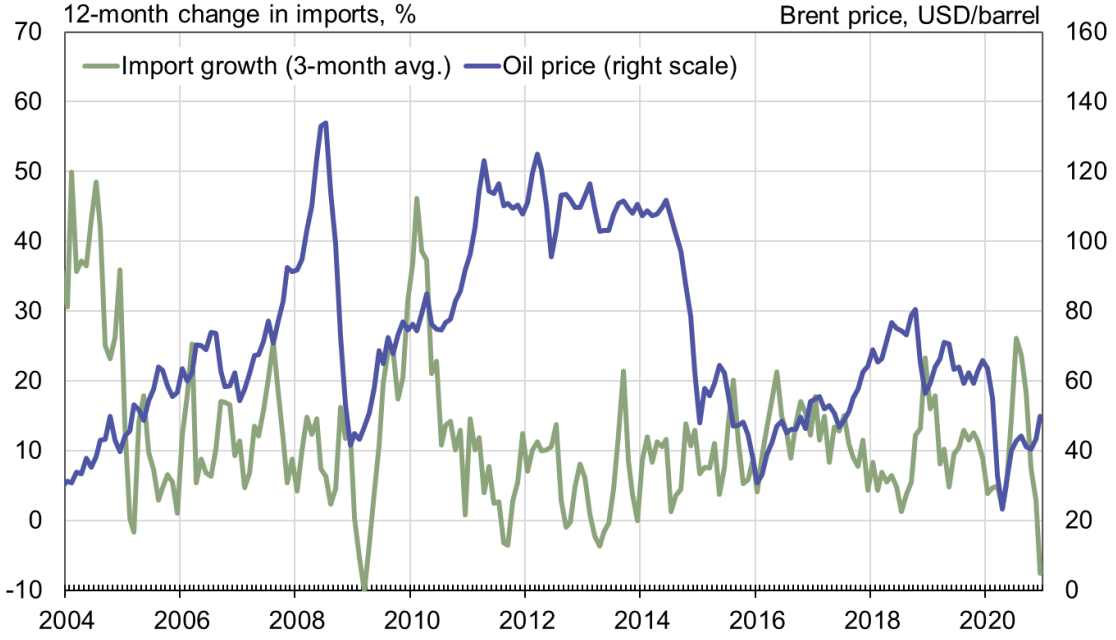
[5] 16.3.2019, https://voxeu.org/article/china-overinvested-coal-power-here-s-why.
[6] Works in cooperation with the University of Maryland: https://cgs.umd.edu/.
[7] Global Energy Monitor Wiki, https://www.gem.wiki/Main_Page.
[8] BP Statistical Review of World Energy 2020. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.
[9] EIA International Energy Outlook 2019. https://www.eia.gov/international/data/world.
[10] EIA International Energy Outlook 2019. https://www.eia.gov/international/data/world.

China is increasingly reliant on imported oil. Before 1995, China was a net exporter of crude oil. By 2009, China produced about the same amount of crude oil as it imported. Today, domestic production only covers about 30 % of consumption, a ratio that has remained relatively stable since 2010 (roughly 200 million metric tons a year or 4 million barrels a day). China's oil production has declined slightly in recent years. China has about 26 billion barrels in proved oil reserves, which is less than 2 % of global proved oil reserves.

The volume of crude oil imports has grown at a brisk 10 % a year over the past five years. China has been the world's largest oil importer since 2017. At the end of 2019, the volume of imports relative to domestic production had increased to 2.5 times to over 500 million tons (about 10 million barrels a day). China's dependence on imports will continue to rise in the years ahead.

Growth in China's crude oil imports remained strong in 2020 despite the global covid-19 pandemic. Oil storage and refining capacity has been increased in recent years, enabling Chinese firms to take advantage of low crude oil prices on international markets. China has been quick to boost its crude oil imports when world oil prices drop (Figure 2).

Figure 2. China's crude oil imports and Brent crude oil price.



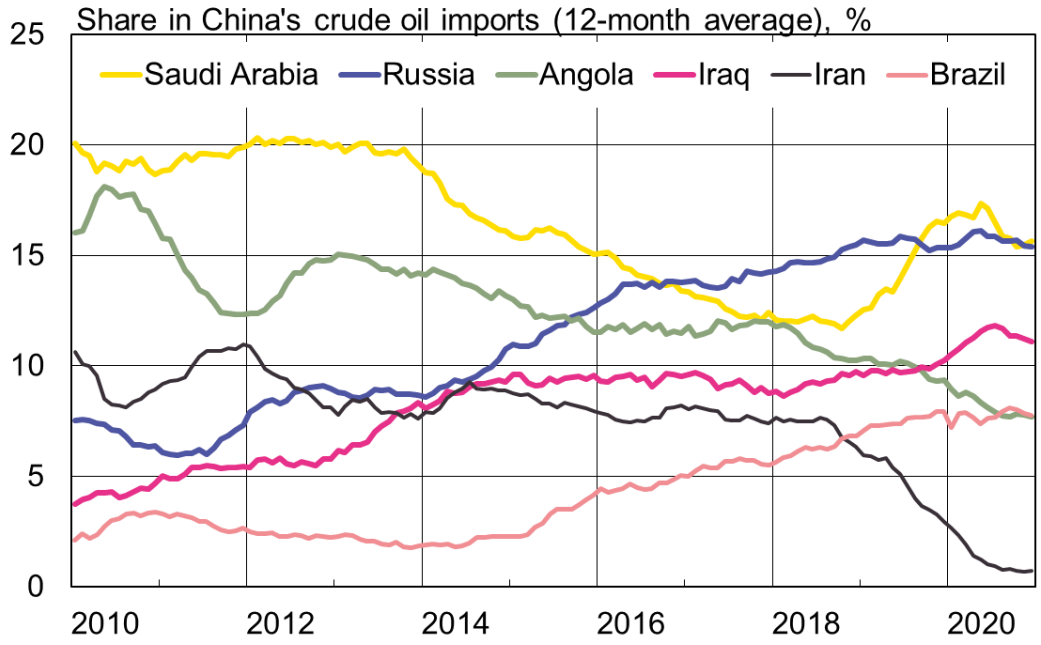
Sources: China Customs, World Bank and CEIC.

China's oil import sources are effectively diversified (Figure 3). China's largest oil suppliers in 2020 were Saudi Arabia (16 % share of imports) and Russia (15 %). Over the past decade, Russia's share has grown with the opening in 2011 and 2018 of the China branches of the East Siberia Pacific Ocean (ESPO) pipeline. Oil imports from Saudi Arabia have recently increased with the signing of major supply contracts between Chinese oil refineries and Saudi producers.

China is the largest oil customer for all the major oil producers (Saudi Arabia, Russia, Iraq and Angola). China has also long been an important oil customer for Iran, even if official figures show supplies from Iran have fallen significantly since the US imposed sanctions on Iran's oil sector in 2018. The sanctions also affect Chinese firms with operations in the United States or that trade in US dollars. US sanctions and domestic turbulence reduced the volume of Venezuelan oil imports in

China's official statistics to zero by the end of 2019. In 2018, 4 % of China's oil imports still came from Venezuela.[11]

Figure 3. China's main crude oil suppliers.



Sources: China Customs and CEIC.

China refines an ever larger share of petroleum products domestically. Some of this production is exported. China's oil refining capacity has nearly tripled over the past two decades. The growth in capacity accelerated after 2015 as the government allowed oil-importing by non-state refineries and increased state refiners' export quotas on petroleum products. China currently produces about 16 % of the world's refined petroleum products (about 13 million barrels a day). Although private production has increased, over two-thirds of refinery capacity is owned by state giants, e.g. China National Petroleum Corporation (CNPC) and China Petroleum & Chemical Corporation (Sinopec). Oil refineries have been investing heavily in production of higher value products such as petrochemicals. China's domestic pricing of gasoline and diesel fuel has become more market-driven over the years, with retail prices more closely tracking prices on global markets.[12]

The export volumes of petroleum products such as gasoline and diesel fuels have doubled over the past five years. Since 2015, China has been a net export of refined petroleum products, but the net exports are relatively small compared to domestic production (on the order of 5 %). In 2019, petroleum products represented nearly 2 % of the value of all of China's goods exports. Crude oil exports are marginal. The largest buyers of China's refined oil products are found in Asia. Customs figures show the main destination for exported petroleum products are Singapore and Hong Kong, from where they are exported also on to other countries. Other important export destinations include the Philippines, Australia, South Korea, Malaysia and Vietnam.

[11] Since 2015, a certain amount of crude oil has also been imported from the United States. 'Phase 1' of the countries' bilateral trade agreement, signed in January 2020, included a commitment from China to increase its energy imports from the US over the next two years. In 2019, the US accounted for just over 1 % of China's oil imports. The share rose to 3,6 % in 2020, even as there were no imports in January-April.

[12] Officials still set price ceilings and floors. For example, the floor on retail prices was not lowered in spring 2020, despite plunging global oil prices.

4. Despite massive investment, the small relative contribution of renewables has only grown slowly

Eeva Kerola

Renewable energy was added to the list of strategic industries in the wake of the 2008 global financial crisis. China thereafter rapidly ascended to the position of world leader in renewables in terms of production capacity. According to the International Energy Agency (IEA),13 China accounts for about half of all growth in global renewable energy production capacity. By some estimates, China's massive investment in renewables has driven down prices of solar and wind technology products by roughly 75 % from a decade ago.14

China's renewable projects have enjoyed direct state subsidies since 2011. This has helped the branch grow quickly, perhaps too quickly in some cases. State subsidies have reduced the role of competition by eliminating cost-efficiency incentives, particularly in the solar and wind power branches. Large amounts of solar and wind-generated power are simply wasted each year due to lack of demand, the absence of storage capacity or restrictions on access to transmission grids.15 State subsidies are now gradually being phased out completely. In summer 2018, subsidies for new solar projects were eliminated altogether and production incentives cut. New domestic wind power projects will lose state subsidies after 2021 (support had been lowered incrementally in recent years).16 The elimination of state subsidies is essential to returning the renewable energy sector to health. It is also necessary to eliminate such issues as price dumping of solar panels on international markets.

Most of China's renewable energy production facilities are located in western China, while the bulk of electricity use occurs in the large megalopolises of the east coast. For this reason, China is working to develop ultra-high-voltage power transmission systems that allow long-distance transmission of electricity produced by renewables. The country is currently implementing five huge power transmission projects that involve extending power lines up to 3,800 kilometres in one case. China wants to make reality the long-standing dream of a global electrical grid. In 2016, China proposed a 6,000-kilometer ultra-high-voltage-direct-current (UHVDC) line for transmission of electricity produced by renewables in China to customers as far west as Germany.17

Renewable production capacity in China already approached 900 GW in 2019 (Figure 4), making China the biggest producer of renewable energy.

Hydropower production capacity rose to 365 GW in 2019,18 which corresponds to about a quarter of hydropower production capacity worldwide. Although growth in new hydropower production capacity has slowed in recent years, China still leads in regional statistics for new hydropower plants. The IEA reports that total production capacity is over three times larger than that of the US, which has the world's second-largest hydropower production capacity.

Wind power in China, which started on a small scale two decades ago, took off in 2008. China's wind power industry today is in a league of its own, boasting 210 GW in production capacity in 2019, or nearly double the wind capacity of the US. Many of the world's largest wind turbine manufacturers are Chinese. While the largest wind farms are located onshore in China's interior, offshore wind farms in eastern China have recently gained popularity.

[13] https://www.iea.org/fuels-and-technologies/renewables.

[14] https://www.politico.com/story/2019/08/15/climate-china-global-translations-1662345.

[15] https://norwegianscitechnews.com/2020/02/chinas-rapid-development-of-solar-and-wind-power/.

[16] Hove, A. (2020), "Current direction for renewable energy in China" Oxford Energy Comment, The Oxford Institute for Energy Studies, June 2020.

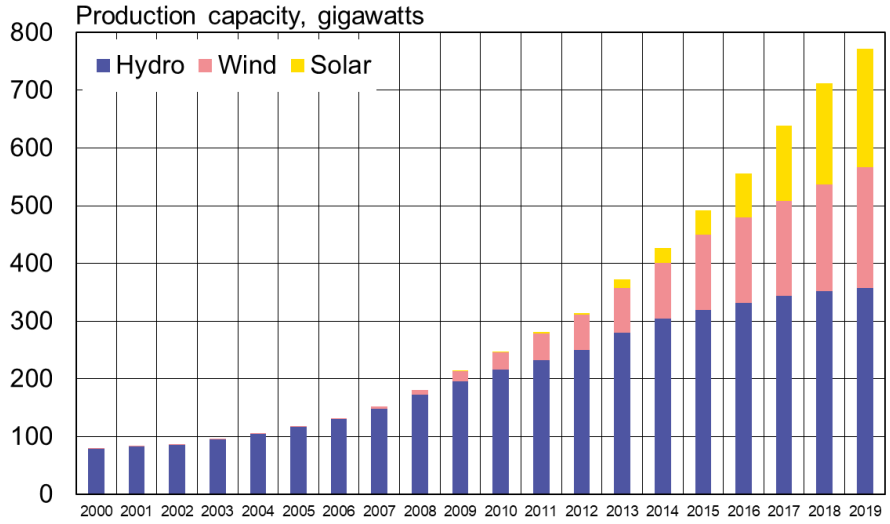
[17] https://www.energyuutiset.fi/etusivu/aasialaista-renewablea-eurooppaan.html.

[18] Renewable energy production capacity: China Electricity Council, https://english.cec.org.cn/.

Solar power production capacity, including both photovoltaic (PV) and concentrated solar power (CSP), nearly doubled in 2018–2019 to 205 GW. The world's next largest solar energy producers are Japan (62 GW) and the United States (61 GW). Over two-thirds of the world's solar PV panel manufacturing takes place in China, where production is located in the country's western and southeast provinces. As recently as 2009, nearly all solar panels produced in China were exported. In recent years, solar panel installation has grown into a major business domestically as China has begun to generate and use solar-generated electricity. Exponential growth began in 2014.

Bioenergy production capacity (17 GW) is on track exceed that of all other countries, but by smaller margins.

Figure 4. Renewable energy production capacity.



Sources: China Electricity Council, CEIC and BOFIT.

Despite massive investments, the relative combined contribution of renewables (hydro, wind and solar) to China's electricity generation has changed only slightly over the past two decades. In 2000, however, nearly all of China's renewable energy came from hydropower (16 % of all electricity generation according to the China National Bureau of Statistics). In 2019, the combined share of hydro, wind and solar climbed to 22 %. Over 15 % of all electricity generated in China in 2019 was produced by hydropower, about 5 % by wind power and about 2 % by solar. The volume of solar-generated electricity has quadrupled over the past five years, wind power by 130 % and hydropower by 8 %. In total, electricity from renewables has increased by about 30 % over the past five years, which is about the same rate of increase as all forms of electricity generation in China.

Renewables accounted for a total of 27 % of electricity consumption in 2019.19 Although the share of renewables is somewhat higher in total electricity consumption than in the United States (18 %) or Japan (20 %), it is still well below world leaders such as Canada (71 %) and Sweden (70 %). In November 2018, China published its provincial-level targets for minimum levels of renewable energy consumption. These targets require increasing the share of renewable energy consumption in

[19] Source: IEA Monthly Electricity Statistics, https://www.iea.org/reports/monthly-electricity-statistics.

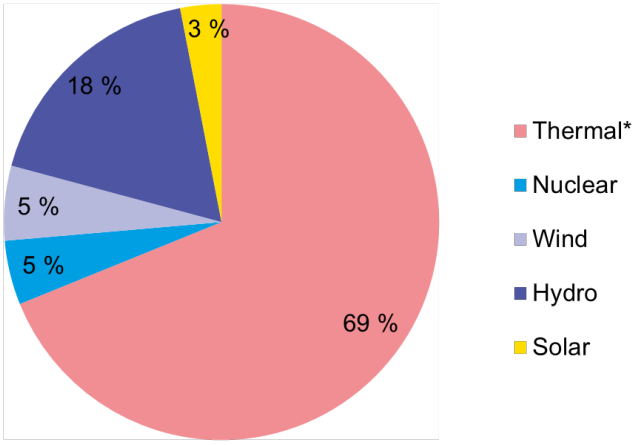
coming years, construction of inter-provincial transmission grids and the reduction of unused production that goes to waste because it cannot find customers or be stored.

5. Electricity market reforms focus on improving efficiency of electricity production

Eeva Kerola

China's electricity market has been the world's largest for almost a decade. No country matches China when it comes to thermal, hydro, wind or solar power production capacity. Most of China's primary energy is generated by thermal power plants (Figure 5) that typically burn coal. Chinese official figures show that coal was still the basis for 64 % of China's electricity production in 2019. While electricity generated with renewables has gradually risen over the years to around 22 %, most power generated in the renewables category is still hydropower despite the soaring contribution of solar in recent years. Nuclear accounts for about 5 % of electrical power generation in China. The industrial sector, China's biggest electricity consumer, accounts for two-thirds of total consumption. The service sector's share of electricity consumption is about 16 % and households about 14 %. For purposes of comparison, the share of power consumption in the United States and Europe is about a third for both households and the service sector.

Figure 5. Electricity production by category in 2019.



*Thermal includes electricity produced by combustion of coal, natural gas, oil or biomass.

Source: Chinaenergyportal.org.

The government broke up the State Power Corporation's monopoly of the electricity market in 2002, creating two grid operators (the larger State Grid Corporation of China and the smaller China Southern Power Grid), along with five separate power generating corporations.20 Since 2011, all provinces are integrated through transmission grids. As economic growth has slowed, the chief emphasis of electricity market reforms has shifted to boosting the efficiency of electrical power

[20] The five large state-owned electrical power generation enterprises are China Huaneng Group, China Datang Corporation, China Huadian Corporation, China Guodian Corporation and China Power Investment Corporation.

generation and lowering electricity prices. The largest remaining challenges relate to the pricing mechanism, excess electricity production capacity, and above all, ending the huge waste of electricity generated by renewables. An important goal of the most recent electricity market reform of 2015 is to support economic growth through lower electricity rates and increased industrial productivity.[21] The reform also hopes to boost the share of electricity produced by renewables and thereby reduce environmentally harmful emissions. The first phase of the reform involves deregulation of the wholesale and retail markets for electricity, opening them up to private power companies and allowing the market to determine electricity rates. Producers, large consumers and large distribution companies trade on the electricity wholesale market. Small electricity consumers trade on the retail market, purchasing electricity from wholesalers and distributors. The only remaining centrally controlled aspects of electricity in China will be transmission and distribution, as well as defining the levels of transmission rates. The new regulation essentially changes the role of electricity grid operators. Once the reform is complete, grid operators will focus exclusively on electrical power distribution. Earlier they managed to make hefty profits by providing distribution while engaging in the wholesale and retail markets for electricity. At the later stage, the goal is also to deregulate electricity distribution. According to the Global Wind Energy Council,[22] which represents the international wind power industry, separate goals of the reform include encouraging inter-provincial electricity transmission and forcing entities to purchase all renewably-produced electricity.

Even if the reform was rolled out five years ago, it is only off to a grinding start. In August 2017, eight provinces or areas were designated pilot areas for testing reforms of the wholesale electricity market: Guangdong, Zhejiang, Shanxi, Shandong, Fujian, Sichuan, Gansu and the western part of Inner Mongolia. In June 2019, all pilot areas had begun trial operations. In September, Guangdong and Shanxi provinces saw the first actual trades on the wholesale market.[23] Several new electricity wholesale firms established by the private sector are just waiting for licencing to begin. If the reforms go as planned, they should increase the efficiency of electrical power production, reduce the amount of wasted electricity and lower prices.

A recent IEA report on reforms of China's electricity markets stressed the importance of a well-functioning spot market as essential to making electricity markets more flexible and efficient.[24] Electricity is an unusual commodity in that it is scarcely storable, yet demand is hard to forecast. Spot market prices determine the equilibrium point between supply and demand at a given time. Usually, the spot market operates like the children's game "Musical Chairs". The spot price of electricity is the price offered by the last electrical power producer that can afford to sell at that price to satisfy demand. Thus, spot markets motivate all producers to improve their efficiency in pursuit of larger profit margins. At present, China's inter-provincial electricity markets operate on long-term futures contracts, so the goal is to make electricity production generally more efficient and give flexibility to provincial electrical grid capacity. Despite baby steps towards successful electricity market reform, the IEA notes that several barriers still prevent China from reaching its declared targets.

[21] https://gwec.net/chinas-electricity-market-reform/ and https://www.iea.org/reports/china-power-system-transformation.

[22] Global Wind Energy Council: https://gwec.net/chinas-electricity-market-reform.

[23] Abhyankar, Nikit; Lin, Jiang; Liu, Xu, and Sifuentes, Froylan (2020). "Economic and environmental benefits of market-based power-system reform in China: A case study of the Southern Grid system," *Resources, Conservation & Recycling* 153.

[24] IEA (2019). China Power System Transformation – Assessing the benefit of optimized operations and advanced flexibility options," International Energy Agency, February 2019.

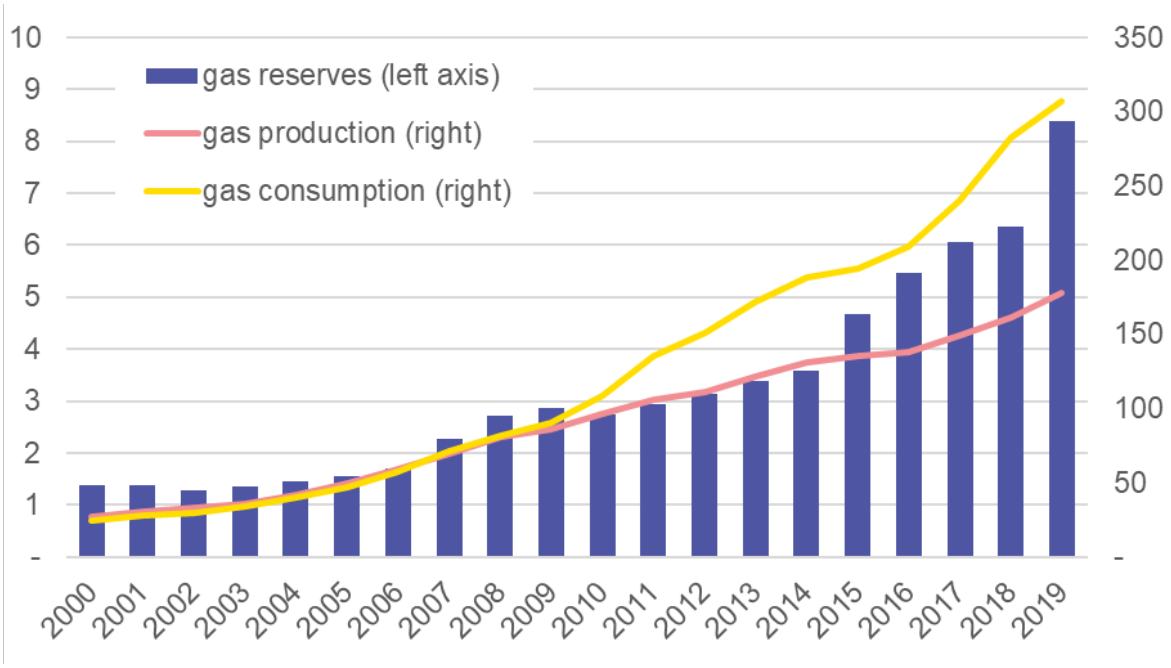
6. Unconventional gas sources will drive domestic production growth

Laura Solanko

Natural gas has traditionally been only a minor source of primary energy in China, and natural gas use was limited to areas around gas production fields. Early in the 2000s, however, natural gas consumption began to climb (Figure 6). During the 2000–2019 period, gas consumption growth averaged 14 % a year. The rapid adoption of natural gas reflects its increased availability and policy efforts to improve air quality. Urbanisation helped boost household gas use, especially in the wealthier cities along the eastern seaboard where air pollution caused by coal-burning is a pressing concern. In addition, a variety of policy measures were introduced to encourage the use of natural gas as a transportation fuel. Even if China had become the world's third-largest natural gas consumer by 2016, gas as a share of China's total energy consumption is still quite low by international standards. While gas accounts for a fifth of total consumption in the Asia-Pacific region, that share is well below 10 % for China.[25]

Industrial firms have long accounted for about 40 % of China's total natural gas consumption, while residential use has accounted for about 25 %. Over the past decade, transportation has increased its share of total gas consumption to around 15 %. The International Energy Agency (IEA) predicts that gas consumption in China will continue to rise in coming years, driven especially by rising industrial demand. The growth of natural gas use in electricity production is expected to be more modest as coal is unlikely to be dethroned anytime soon as the country's cheapest fuel.[26]

Figure 6. Natural gas consumption (bcm), production (bcm) and proved reserves (tr cm) 2000–2019.



Source: BP 2020.

[25] BP Statistical Review of World Energy 2020. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

[26] IEA 2020 Gas 2020, Rebound and Beyond, June 2020: https://www.iea.org/reports/gas-2020/2021-2025-rebound-and-beyond.

China is the world's sixth-largest natural gas producer after the US, Russia, Iran, Canada and Qatar. Gas production soared in 2004–2010, but over the past decade production growth has considerably lagged consumption growth. As shown in Figure 6, domestic production was sufficient to cover natural gas consumption in full up to around 2008. Thereafter, we see an unprecedented rise in gas imports. In 2019, domestic production approaches 180 billion m3, which was sufficient to cover less than 60 % of gas consumption.

China is already exploiting most of its conventional natural gas deposits, so no significant increase in conventional gas production is expected in the near future. Notably, China possesses vast reserves of unconventional gas, mostly in the form of tight gas (gas locked in hard rock) or shale gas (gas trapped in shale formations). Because exploiting such reserves is quite challenging, they were previously considered uneconomical. In recent years, however, import dependence and energy security have revived the interest of policymakers in supporting domestic gas production, making available both the political capital and economic support to move forward on unconventional gas production. In summer 2018, president Xi Jinping elevated the theme of increasing domestic gas & oil production to a centrepiece of China's energy security.27

Gas production is dominated by the state-owned China National Petroleum Corporation (CNPC). CNPC, including its subsidiary PetroChina, produced 119 billion m3 of natural gas in 2019, or two-thirds of China's total gas production. Two other state-owned oil companies, Sinopec and the China National Offshore Oil Corporation (CNOOC) accounted for slightly over a fifth of gas production in 2019. The goal of reducing import dependence is especially evident in the action plans of state-owned enterprises, where increased gas production plays a large role.

In addition to direct guidance of state-owned firms, the government uses a wide variety of subsidies and tax breaks to encourage both state-owned and private firms to engage in unconventional gas production projects. The 2019 subsidy programme was reformulated to encourage increasing output, with production increases in the winter especially rewarded. Tight gas, along with shale gas and coalbed methane (CBM), were accepted into the subsidy programmes.28 In May 2020, foreign companies were allowed to participate directly in gas exploration and production. So far, the international oil giants such as ExxonMobil, Shell and BP have partnered in tight gas production projects with CNPC. The change is unlikely to have significant impact unless potential investors are assured about equal treatment of domestic and foreign corporations.

In addition, considerable research in the past decade has gone into production of coal-based synthetic gas (coal gas or synthetic natural gas, SNG). Especially in the coal regions of Northern China, the extraction of methane from coal is seen as an attractive way to move away from coal combustion during heating season. Despite high hopes, SNG only accounted for 2 % of gas production in 2018.29 The government also wants to increase production of biotic gas ("green" gas or biogas).30

In recent years, much of the growth in gas production has come from exploiting unconventional sources. In 2018, conventional gas only accounted for about 60 % of China's gas production (EIA, 2019). The strong investment in development of unconventional gas can also be seen in the growth

[27] Downs, Erica. High anxiety: The trade war and China's oil and gas supply security. Columbia University, Center on Global Energy Policy, Commentary November 2019. Available at: https://globallnghub.com/wp-content/uploads/2019/11/ChinaTradeWar_CGEP_Commentary_111219-3.pdf.

[28] Lewis, Sebastian, 2020. Insight from Shanghai: Can shale gas secure China's energy security? Platts Blogs, April 28, 2020. https://blogs.platts.com/2020/04/28/shale-gas-china-energy-security/.

[29] EIA, 2019. China adds incentives for natural gas production as imports increase. Today in Energy, US Energy Information Agency, October 23, 2019. Available at: https://www.eia.gov/todayinenergy/detail.php?id=41773.

[30] Cornot-Gandolphe, Sylvie, 2019. China's quest for gas supply security. IFRI, September 2019. Available at: https://www.ifri.org/sites/default/files/atoms/files/cornot-gandolphe_s_china_quest_gas_supply_security_2019.pdf.

of China's proved reserves. Even if gas production is not expected to grow elsewhere in the Asia-Pacific region, the IEA estimates that China's production will grow by 54 billion m3 by 2025.31

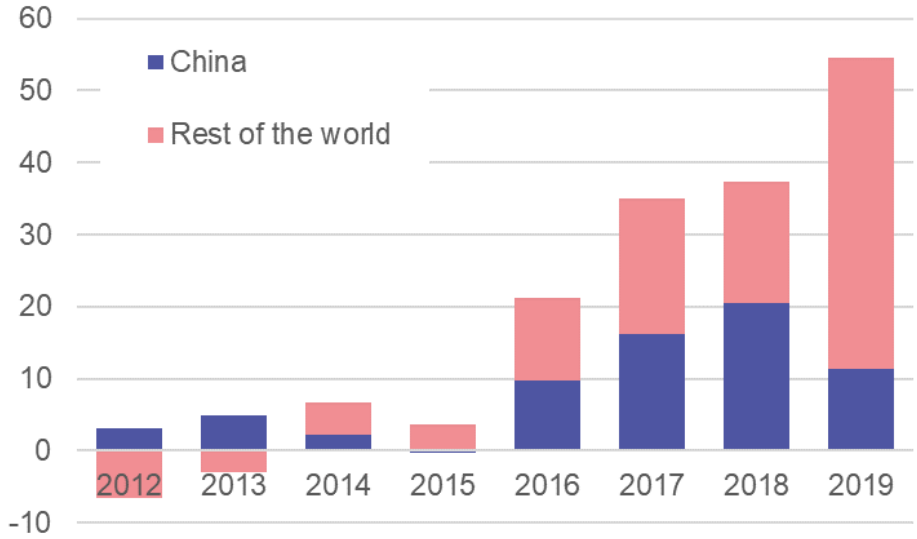
7. Diversity favoured in gas import routes

Laura Solanko

China imports natural gas via pipeline and as liquefied natural gas (LNG) transported by ship. China surpassed South Korea as the world's second-largest LNG importer in 2017. If import growth continues at the same pace as in previous years, China would become the world's largest LNG importer by 2022. Growth in China's LNG imports corresponds to about half of all growth in global demand (Figure 7). China's LNG import growth in 2019 was more modest than in previous years, but imports still increased by 11 billion m3, a roughly 15 % rise from 2018.32 Covid-19 lockdowns and lower economic growth reduced import growth further in 2020.

China's three large state-owned energy companies, China National Petroleum Corporation (CNPC), China Petroleum & Chemical Corporation (Sinopec) and China National Offshore Oil Corporation (CNOOC) have made vigorous efforts since 2008 to secure long-term supply contracts and acquire stakes in large LNG production ventures in Australia, Russia, Mozambique and Canada.33 The latest example involves the participation of CNOOC and CNPC in Novatek's Arctic LNG 2 project on the Yamal peninsula in Russia. Both CNOOC and CNPC hold 10 % stakes in the venture. CNPC and the Chinese government's Silk Road Fund combined hold a 29.9 % stake in Yamal LNG, the sister project of Arctic LNG 2.

Figure 7. Growth in LNG import volumes, billion m3.



Source: BP, 2020.

[31] International Energy Agency IEA, Gas 2020, June 2020. https://www.iea.org/reports/gas-2020/2021-2025-rebound-and-beyond.

[32] The growth in global demand in 2019 was driven by European countries, particularly the UK, France and other EU countries.

[33] Tsafos, Nikos (2019). CSIC Report January 2019. Downloadable file at: https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/190108_China_LNG.pdf.

Australia, the largest LNG producer in the Asia-Pacific region, holds a dominant position in China's LNG imports. Nearly half of China's LNG supplies come from Australia. Gas exports from the United States only began in 2016 and LNG imports from the US to China grew rapidly in 2017–2018. As the US-China trade war escalated in June 2019, China imposed a 25 % punitive tariff on LNG imports from the US. The move effectively ended all of China's US LNG imports. In May-June 2020, imports briefly returned to their 2018–2019 levels, but the on-year US share of gas imports remained quite small.

CNPC, which oversees China's gas pipeline grid, has actively exploited opportunities to increase pipeline gas imports (Table 1). China has built pipelines for gas importation from Central Asia, Myanmar and most recently Russia. Gas imports from Turkmenistan, Uzbekistan and Kazakhstan via the Central Asian pipeline began in 2010. By 2015, the pipeline's transmission capacity had reached 55 billion m3 a year. The third extension of the Central Asian pipeline, which runs through Turkmenistan, Tajikistan and Kyrgyzstan (line D) should increase capacity to 85 billion m3. Gas imports from Myanmar began in 2013, but Myanmar's output is still tiny relative to China's overall demand. China and Russia agreed in 2014 to begin gas transmission from Siberian gas fields to China, which required, among other things, construction of a new import pipeline from East Siberia to Heilongjiang. The Power of Siberia gas pipeline was completed at the end of 2019 and is scheduled to reach its full annual transmission capacity of 38 billion m3 by 2025. Pipeline gas imports from Russia are seen as an essential part of China's energy security and the country's efforts to diversify its energy supply routes.[34]

Russia has repeatedly sought to finalise an agreement with China on construction of the Altai gas pipeline. The proposed pipeline would increase China's import capacity by about 30 billion m3, but China has been reluctant to agree on the terms of the arrangement. With the inauguration of the Power of Siberia pipeline, Russia's share of pipeline gas imports will eventually roughly match the volume of imports from Turkmenistan. The use of the Altai pipeline would raise Russia's import share to over half of all of China's pipeline gas imports, or on par with Central Asian pipeline grid after its expansion is complete. To date, China has skilfully balanced its efforts in construction of the two competing pipeline systems. China does not see allowing a particular country or group of countries to hold the dominant position as gas supplier to be in its best interests.

Table 1. Volume of gas imports, billion m^3.

	2013	2014	2015	2016	2017	2018	2019
Pipeline gas imports	26.4	30.3	32.4	36.8	39.9	47.9	47.7
Myanmar	*0.2*	*2.9*	*3.8*	*3.7*	*3.2*	*2.9*	*4.4*
Turkmenistan	*24.4*	*25.5*	*27.7*	*29.4*	*33.3*	*34.5*	*31.6*
Russia	-	-	-	-	-	-	*0.3*
LNG imports	25.1	27.3	27.0	36.8	52.9	73.5	84.8

Source: BP, 2020.

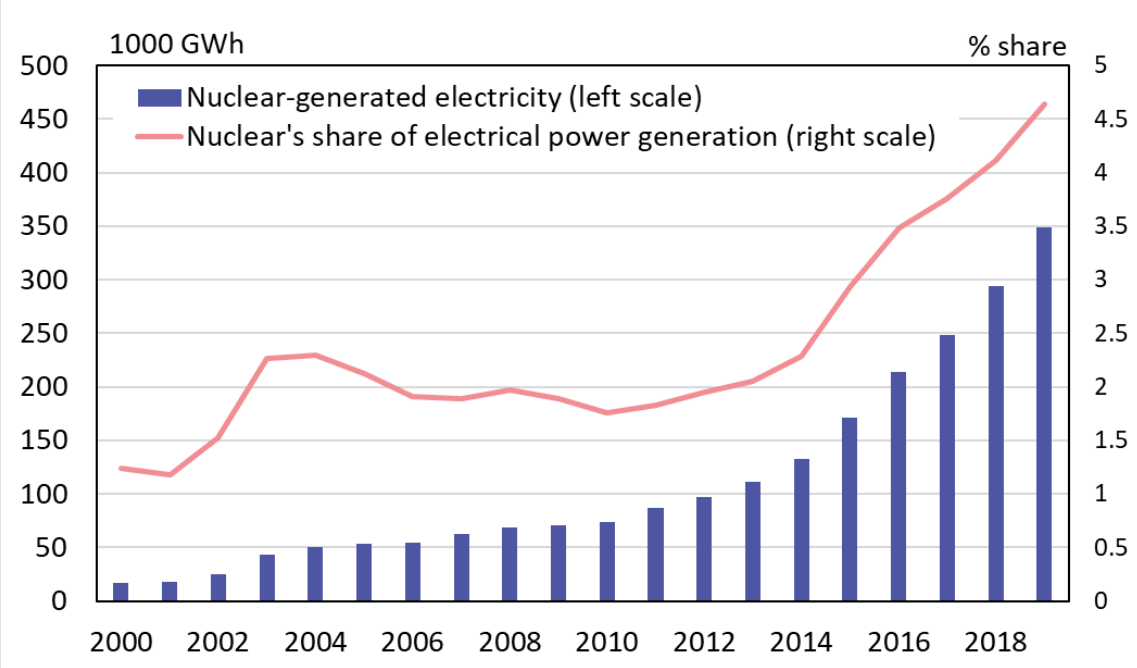
[34] Stephen O'Sullivan, Oxford Energy Comment, June 2019. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/06/China-growing-import-volumes-of-LNG-highlight-China%E2%80%99s-rising-energy-import-dependency.pdf.

8. Nuclear power plays increasingly important role in China's energy mix

Juuso Kaaresvirta

For the past 15 years, China has been one of a small handful of countries that has pushed to significantly increase construction of new nuclear power plants. While China had just three operating reactors in the 1990s, In the past decade, almost 40 new reactors have been connected to the electrical grid.35 As of January 2021, China had 49 reactors supplying electricity to the national grid. The China Electricity Council reports that nuclear power production capacity reached 49 GW at the end of 2019, up from just 11 GW in 2010. Nuclear power production more than quadrupled over the past decade. Its share of electricity production rose from under 2 % to nearly 5 %, closely tracking the rapid rise in China's electricity consumption (Figure 8).

Figure 8. The contribution of nuclear power generation to China's energy mix rose in the past decade.



Sources: China National Bureau of Statistics, CEIC and BOFIT.

With the recent boom in construction of nuclear power plants, China accounted for over 12 % of global nuclear power production by 2019. China now only trails the US and France as the world's third-largest producer of electricity generated by nuclear power. As new plants currently under construction come on stream over the next few years, China is expected to surpass France to become the world's second-largest producer of nuclear-generated electricity.

There are multiple motivations for China's eagerness to ramp up nuclear power production. First, the country's electricity needs continue to soar as its economy grows and develops. Nuclear power is thus seen as an attractive way to diversify the country's electricity production. Second, increasing reliance on nuclear power is seen as a way to stem the increase in carbon emissions and

[35] Figures on the number of operational and planned reactor, as well and reactor exports, are based on information from the World Nuclear Association (WNA). https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

help the environment. The third factor is geography. Coal, long the basis of Chinese electricity production and of which China has huge reserves, is for the most part located inland. Most of China's economic activity and electricity demand is located in eastern coastal regions.

All of China's nuclear power generation capacity is currently sited along its eastern shores. The largest amount of production is in the Guangdong province, which has four nuclear power facilities (14 reactors in total) that together produce 32 % of all of China's nuclear-generated electricity. The Daya Bay nuclear facility also generates the lion's share of Hong Kong's electricity requirements. Fujian and Zhejiang are also significant producer provinces, both accounting for nearly 20 % of China's nuclear-generated electricity.

The 2011 nuclear disaster in Fukushima, Japan had major implications for China. After the accident, all of China's new nuclear power plant projects were put on hold. Site safety inspections were conducted at all sites where plants were under construction and safety regulations were tightened. Plans to build reactors inland still remain shelved. Since reactors use water for cooling, an accident in China's interior could potentially poison the water supply for millions of people. After the Fukushima accident, China's plans for expanding nuclear were downsized. The 2011–2015 five-year plan called for raising nuclear power capacity to 80 GW by the end of 2020. In 2012, however, the target was lowered to just 58 GW. Even with the reduced target, China failed to reach the target capacity on schedule.

The rapid rise of nuclear power in China is likely to continue. According to the World Nuclear Association, China had 16 new reactors under construction as of January 2021 that were on track to be completed before the end of 2026. In addition, ground has already been broken on some of the near 40 reactor project under planning at the moment. Over 150 reactor proposals are also under consideration. The China Nuclear Energy Agency (CNEA) forecast a couple years ago that by 2050 China's nuclear power capacity would reach 240 GW, which would be sufficient to meet about 15 % of the country's projected electricity needs at that time. By some estimates, president Xi Jinping's goal of carbon neutrality for China by 2060 will require a much larger nuclear component in electrical power production than currently envisioned.

China has developed its own home-grown nuclear technologies. According to the World Nuclear Association (WNA), the country is already for the most part self-sufficient with respect to nuclear power plant engineering and construction. Most reactors operating in China are Chinese, but they often utilise foreign technology, foreign reactor designs (e.g. French) or have been designed in cooperation with foreign partners.

China's growing presence in the global nuclear power industry, and active marketing efforts, is seen also international interest in Chinese power plants. Pakistan already has four operating Chinese reactors, and two more are under construction. Plans are also well along for construction of reactors in Romania and Argentina (China is financing 85 % of the projects). The construction of two Chinese nuclear reactors at the Hinkley facility near Somerset, England is currently at the stage where the China General Nuclear Power Group (CGN) has applied to local authorities for reactor permits. China made an initial agreement of understanding in 2015 with Iran on construction of two nuclear reactors, but the project appears to have gone nowhere. Memoranda of understanding have been signed with Kenya, Egypt and Sudan, and negotiations are ongoing with South Africa, Turkey, Armenia and possibly others. Indonesia and Jordan are conducting studies into the possibility of constructing Chinese nuclear power plants.

Although China earlier enjoyed a degree of self-sufficiency in uranium production, its current production is inadequate to meet the fuel demands of all its current nuclear plants. As a result, uranium imports have grown rapidly in recent years. China's most important uranium suppliers are Kazakhstan and Namibia. China also has a uranium supply agreement with Australia. China is developing new solutions for dealing with spent fuel from nuclear reactors. China's National Nuclear Safety

Administration announced in 2019 that it had chosen the Beishan site in Gansu province to study final underground storage of nuclear waste.

9. China has major energy-sector investments on all continents

Juuso Kaaresvirta

With the opening up of China's economy to the world, decades of rapid GDP growth and an increased appetite for commodities and advanced technologies, Chinese firms have substantially increased their investments abroad over the past ten years.[36] The government has steered investment to certain branches to back the expansion. In 2004, China's influential National Development and Reform Commission (NDRC) instructed firms to look for investment opportunities abroad, particularly those that would help China secure its raw material and energy requirements. The message was simple: China needed new reliable foreign energy sources as the country's domestic energy supplies were no longer adequate.

During 2005–2013, about half of China's outward FDI went to the energy sector. Thereafter, energy's share fell to around 20 % of total FDI, while FDI directed to other types of business soared. Even so, Chinese energy investment abroad has averaged $20–40 billion a year over the past decade. For all of the 2005–2019 period, the value of outward FDI of Chinese corporations focused on the energy sector amounted to nearly $400 billion.

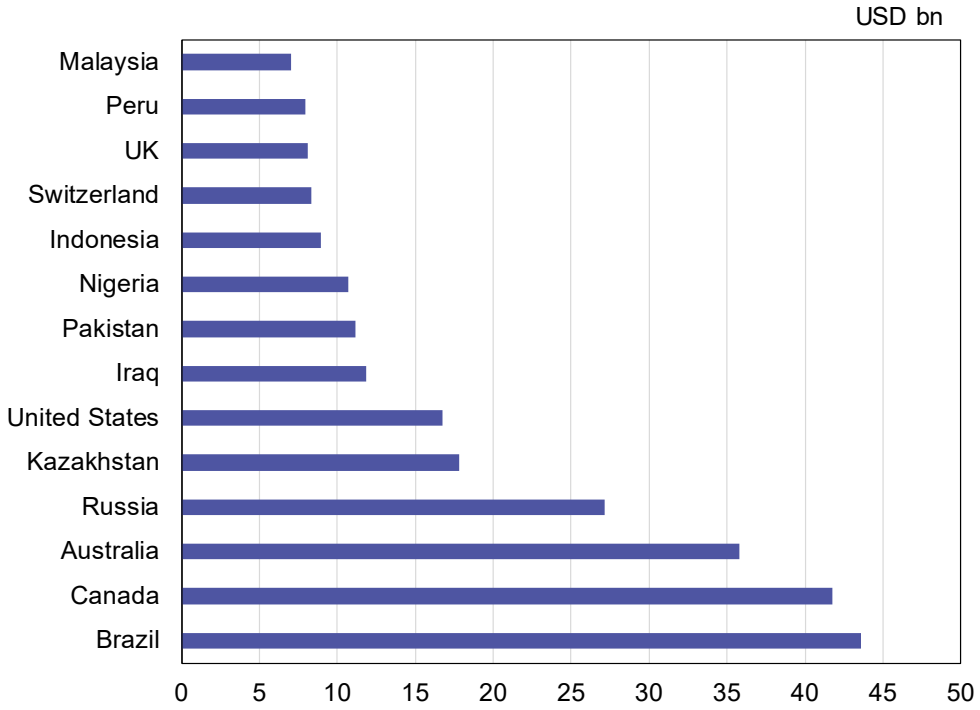
The energy investments of Chinese firms are dispersed across the world (Figure 9). The largest chunks of investment have gone to Asia (nearly 30 %), Europe (including Russia, 20 %) and South America (just under 20 %). While Chinese investments in Africa have attracted considerable media attention, energy-sector investments have been less than for other continents (Africa received 8 % of China's energy-sector FDI).[37] By country, the biggest amounts of FDI went to Brazil (11 % of China's outward FDI), Canada (11 %), Australia (9 %) and Russia (7 %).

Most Chinese energy-sector investment during 2005–2019 involved oil, so the country's largest investors in the energy projects abroad were state-owned oil companies. Chinese firms also invested heavily in coal and natural gas projects. In recent years, the investment focus has shifted to renewables, particularly wind and solar power farms and hydropower projects (well over half have been greenfield projects). It appears that what was once strategic targeting of overseas energy resources has now turned more to commercial-based investment supporting Chinese energy technology exports. For example, when Chinese firms invest in a wind farm project, it is quite likely the wind turbines for the project will be produced in China.

[36] China's own published figures do not offer comprehensive, detailed information on the country's foreign investments in the energy sector. The figures used here are taken from the China Global Investment Tracker database maintained by the American Enterprise Institute https://www.aei.org/china-global-investment-tracker, which records every international FDI investment of Chinese corporations of at least $100 million.

[37] It is possible that Africa actually accounts for a larger share of Chinese investment than reported. Many smaller investments in Africa receive little media coverage and may not be recorded. Moreover, China has made numerous individual investments in African countries with values of less than $100 million, and thus these projects are not included in the China Global Investment Tracker figures.

Figure 9. Accumulated foreign direct investments of Chinese firms in the energy sector, 2005–2019.



Sources: China Global Investment Tracker and BOFIT.

Chinese FDI efforts have been led by the oil giant China National Petroleum Corporation (CNPC), which has invested over $70 billion internationally and co-invested with other Chinese oil companies nearly $10 billion. China's next largest state-owned oil company, China Petroleum & Chemical Corporation (Sinopec), with over $60 billion in FDI, and China National Offshore Oil Corporation (CNOOC), with $40 billion in FDI, have also been active. It is worth noting that the state investment firm, China Investment Corporation (CIC), along with the State Administration of Foreign Exchange (SAFE), have together invested about $30 billion in energy-sector, including stakes in coal companies. Finally, the state-owned power grid operator, State Grid, and the hydropower-focused China Three Gorges Corporation have each invested over $20 billion.

Beyond FDI, Chinese firms participate actively in hundreds of large overseas construction projects in the energy sector, mostly in emerging economies. A large share of the projects are located in Asia or Africa. As mentioned, construction projects involving renewables are gaining importance. From the beginning of 2019 to the end of June 2020, half of all energy-sector construction projects involved renewables. China has also offered loans to foreign entities to invest in energy production or logistics development. For example, China has helped to finance oil & gas pipeline construction linking Russia and China.

About 10 % of Chinese participants in international energy investment and energy construction projects have run into problems and their completion appears uncertain. The numerous reasons for such project failures include the inexperience of Chinese companies in operating abroad, poor planning, investor issues back in China, geopolitics and the difficult operating environments of developing countries. For example, Chinese entities considering investing in Finland's large bio-refinery projects have either pulled out or the projects are proceeding very slowly.

10. China's state-owned energy giants rank among the world's largest firms

Riikka Nuutilainen

Chinese energy production and distribution are largely at the mercy of large state-owned corporations. The OECD estimates that state-owned corporations controlled nearly 60 % of China's energy production capacity in 2014.[38] State-owned corporations also account for most of China's foreign investment in the energy sector, with most of the FDI financing provided by China's large state-owned banks. China's state-owned energy giants are some of the biggest corporations on the planet, both in terms of assets and revenues (Table 2).

Central government-owned enterprises outside the financial sector are overseen by the State-owned Assets Supervision and Administration Commission of the State Council (SASAC). Of the 96 firms it currently supervises, about a fifth could be classed as part of the energy sector (oil production & refining, as well as electricity and coal), even if these companies tend to be massive conglomerates. Several corporations or subsidiaries that are majority-owned by the central government are listed on Chinese and international bourses. In addition, local governments also own a plethora of energy firms.[39]

Table 2. World's largest firms by revenues according to the 2020 Fortune Global 500 list.

Rank	Corporation	Revenues (USD million)	Assets (USD million)	Employees	Domicile	State corporation*
1	Walmart	524 000	236 500	2 200 000	United States	
2	Sinopec Group	407 000	317 500	582 600	China	x
3	State Grid	383 900	596 600	907 700	China	x
4	China National Petroleum	379 100	608 100	1 344 400	China	x
5	Royal Dutch Shell	352 100	404 300	83 000	Netherlands	
6	Saudi Aramco	329 800	398 300	79 000	Saudi Arabia	x
7	Volkswagen	282 800	547 800	671 200	Germany	
8	BP	282 600	295 200	72 500	UK	
9	Amazon.com	280 500	225 200	798 000	US	
10	Toyota Motor	275 300	487 500	359 500	Japan	
11	Exxon Mobil	264 900	362 600	74 900	US	
..						
17	Glencore	215 100	124 100	88 200	Switzerland	
25	Total	176 200	273 300	107 800	France	
55	Gazprom	118 000	352 400	473 800	Russia	x

[38] OECD (2018), State-Owned Enterprises and the Low-Carbon Transition (https://doi.org/10.1787/06ff826b-en).

[39] The OECD reports that central-government-owned firms under SASAC numbered more than 50,000 at the end of 2015 when subsidiaries are included. In other words, corporate groups may control several hundred subsidiaries. In addition, there were over 100,000 firms owned by local governments. See OECD (2017), "The Size and Sectoral Distribution of State-Owned Enterprises," Available at: https://www.oecd.org/publications/the-size-and-sectoral-distribution-of-state-owned-enterprises-9789264280663-en.htm). Holz (2019) lists the corporations owned by central or local governments as of 2015. At that time, based on SASAC figures, nearly 10,000 of these firms were classified as part of the energy sector (i.e. petroleum, coal, and power industry). Measured in terms of total assets, energy-sector firms accounted for a fifth of firms owned by the central or local governments. See Holz, C.A. (2019), "The unfinished business of state-owned enterprise reform in the People's Republic of China."

57	Lukoil	114 600	95 800	101 000	Russia	
64	China National Offshore Oil	108 700	184 900	92 100	China	x
76	Rosneft Oil	96 300	208 500	335 000	Russia	x

*State ownership of at least 50 %. Shaded background indicates the corporation operates in the energy sector.
Source: Fortune (https://fortune.com/global500/).

China's three large state-owned oil companies – China National Petroleum Corporation (CNPC), China Petroleum & Chemical Corporation (Sinopec) and China National Offshore Oil Corporation (CNOOC) – account for nearly all of the country's oil and natural gas production. They also own most domestic exploration rights.40 These giant firms were created with a division of the assets controlled by the Ministry of Petroleum Industry in the 1980s and reformed in the 1990s. At the beginning of the 2000s, the core businesses of these giants were listed on the Hong Kong and New York stock exchanges. PetroChina, for example, is the listed subsidiary of CNPC. The three oil behemoths are considered strategically important state corporations. Within the government administration, they enjoy ministerial or vice-ministerial rank.41

In the reform of the electricity sector at the beginning of the 2000s, the monopoly at the time was broken up and organised into entities owned by the central government: two power grid operators and five electrical power generation companies (see brief 5 on China's electricity markets). Of these, State Grid is currently the world's largest grid operator. It is responsible for the country's electrical grid throughout China with the exception of several southern provinces.

The number of SASAC-owned corporations has declined over the past decade, mainly due to mergers. These include, for example, the creation of China Energy Investment company by merging of the world's largest coal producer Shenhua Group and the electricity company China Guodian Corporation as well as the acquisition of nuclear power plant builder China Nuclear Engineering & Construction by China National Nuclear Corporation. In 2018, the government also announced plans to merge chemical and fertiliser producer Sinochem with specialty chemical producer ChemChina. The latest energy sector creation is the central-government-owned enterprise PipeChina, which oversees the country's oil & gas pipelines, as well as some storage facilities and LNG terminals. Assets and employees in the new corporation were transferred from the three large state-owned oil companies. Operations launched in late 2020.

11. China adopts a national carbon trading scheme to reduce emissions

Eeva Kerola

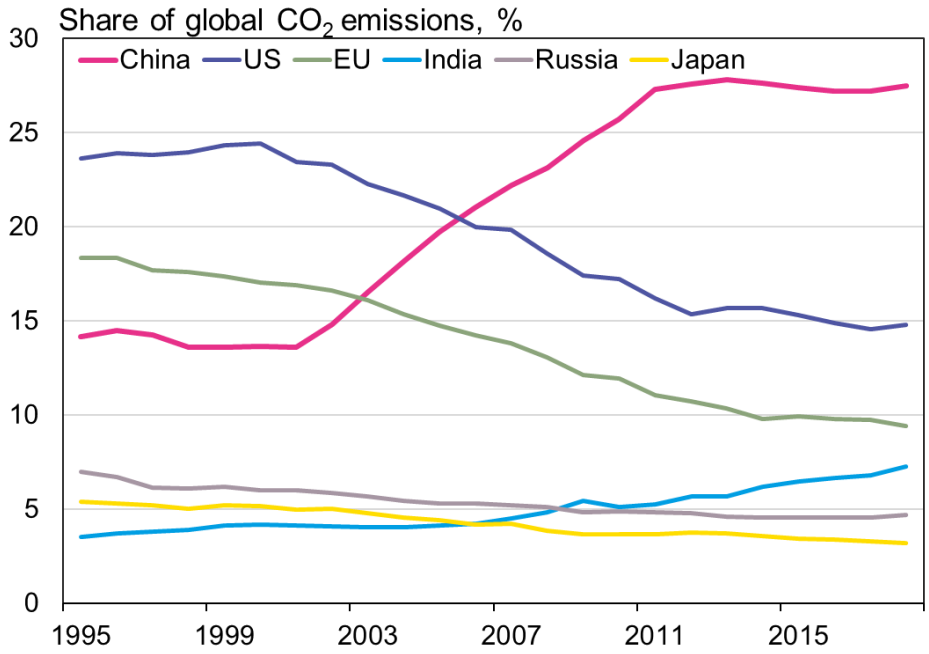
China is the world's biggest polluter. The country pumped about 10 billion metric tons of carbon dioxide into the atmosphere in 2019 – 29 % of all global CO2 emissions that year. China's carbon emissions have exceeded those of the US and EU combined for several years now (Figure 10). While emissions have fallen in OECD countries, China's emissions have continued to rise. In 2019, they increased by over 3 % y-o-y.

[40] Downs, E. & Yan, S. (2020), Reform is in the Pipelines: PipeChina and the Restructuring of China's Natural Gas Market. https://www.energypolicy.columbia.edu/research/commentary/reform-pipelines-pipechina-and-restructuring-china-s-natural-gas-market.
[41] Downs, E. & Yan, S. (2020) and Holz, C.A. (2019).

The International Energy Agency (IEA) reports that about 80 % of China's CO2 emissions come from burning coal, the country's top primary energy source. China's 13th five-year plan (2016–2020) sought to reduce the share of coal in total primary energy consumption to 58 % by 2020 (and even hit this goal a year ahead of schedule in 2019). Nevertheless, the share is still high, and China continues to open up new coal pits and build new thermal coal power plants.

Coal still plays has huge role in China's energy independence and efforts to achieve full employment. In the aftermath of the first wave of the covid-19 crisis, China's National Energy Administration (CNEA) eased restrictions on approval of new coal field development projects. The current economic stimulus package includes large investment in both renewables and coal (see brief 2). The goal has been to replace old polluting facilities with modern efficient facilities that rely on lower-emission coal-burning technologies such as fluidised-bed combustions.

Figure 10. The world's largest polluters in terms of CO_2 emissions, 1995–2018.



Sources: Our World in Data, CO_2 and Greenhouse Gas Emissions dataset.

The IEA reports that oil, China's second-most important energy source, accounts for 14 % of the country's CO2 emissions. While China is still a major oil producer, domestic production has been on the decline for years and now covers less than a third of China's oil needs. As a result, China has become the world's largest crude oil importer. It has vast oil refining and petrochemical production capacity. While China's oil consumption is expected to decline as more electric vehicles (EVs) take to the road, the overall impact on oil consumption is likely to be minor. Transport only accounts for about 10 % of China's carbon emissions. In addition, the ecological benefits of EVs are questionable as long as coal accounts for the bulk of China's electricity production.

China committed to the Paris climate agreement after reaching the concession that its greenhouse gas emissions only needed to start declining after 2030. Reaching this target should become more straightforward with CO2 emissions subject to effective pricing under China's new national carbon emissions trading scheme. The scheme requires polluters such as coal-fired power

plants that exceed their carbon-intensity benchmarks to purchase emissions permits at a price set by the market. By setting a price on carbon emissions, polluters are incentivised to take more environmentally friendly approaches. Emissions are expected to decline as polluters find it cheaper to reduce their emissions through fuel efficiency and new technologies than to spend their earnings on carbon emission permits. Importantly, the volume of emission permits issued is lowered each year.

China decided in 2017 to move ahead with its national emissions trading scheme. The scheme was originally planned to launch during 2020. Its initial phase focuses on the energy sector, which accounts for about half of the country's CO2 emissions. As the rollout approached, China's Ministry of Ecology and Environment announced that the launch of the emission trading scheme would been pushed back until the 14th five-year plan (2021–2025). The new scheme calls for expanding pilot local and provincial carbon trading schemes to cover carbon trading nationally. Several sectors of the economy will gradually be integrated into the trading scheme. In recent years, pilot schemes operated in Beijing, Shanghai, Chongqing, Guangdong, Hubei, Shenzhen and Tianjin. China's environment ministry reports that as of August 2020 these seven pilot provinces together had brought nearly 3,000 polluters into the scheme, allowing trading in emission permits for a total of 406 million tons of carbon.

Last September, president Xi Jinping announced China's goal to become carbon neutral by 2060 as part of the "Beautiful China Initiative." Carbon neutrality means that the highest amount of carbon dioxide emissions produced is the amount that the atmosphere can absorb without increasing CO2 levels. Soils, forests and oceans are the largest natural buffers for absorbing carbon. Man-made systems are currently inadequate for capturing and sequestering the carbon humans put into the atmosphere, thereby making it impossible to bring global warming under control. Reaching the ambitious goal of carbon neutrality in China's case would require that renewables and nuclear account for over 85 % of domestic energy production and over 90 % of electricity production by 2050.42 China's electrical power plants ultimately will have to produce "negative" emissions by e.g. combining bioenergy production with carbon capture and sequestration technologies. Such approaches would offset emissions created by other parts of the economy. Solar power generation capacity would have to increase ten-fold and wind and nuclear capacity seven-fold from current levels.

Late last autumn, president Xi announced lowering of China's other carbon targets to bring them into line with the Paris climate agreement. The present target is to reduce the ratio of CO2 emissions to GDP to 65 % of the 2005 level (the target announced in 2015 was 60–65 %) by 2030. At the same time, the share of non-fossil fuels will rise to account for at least 25 % of energy consumption (20 % earlier).

[42] Lauri Myllyvirta, "Influential academics reveal how China can achieve its 'carbon neutrality' goal," China policy guest post in *Carbon Brief,* 14 October 2020. https://www.carbonbrief.org/influential-academics-reveal-how-china-can-achieve-its-carbon-neutrality-goal.

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