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China's Long Road to Carbon Neutrality will Reshape World Economy

China's recent pledge to achieve carbon neutrality before 2060 has surprised the world. As the world's largest carbon emitter and energy consumer, China's yet-unknown pathway to carbon neutrality is certain to disrupt the globe's energy economy from Dhahran to Queensland to Sand Hill Road and everywhere in between. This report is BloombergNEF's first look at the arduous road ahead of China and the implications for the rest of the world.

28.6%

China's share of global carbon emissions in 2018

2027

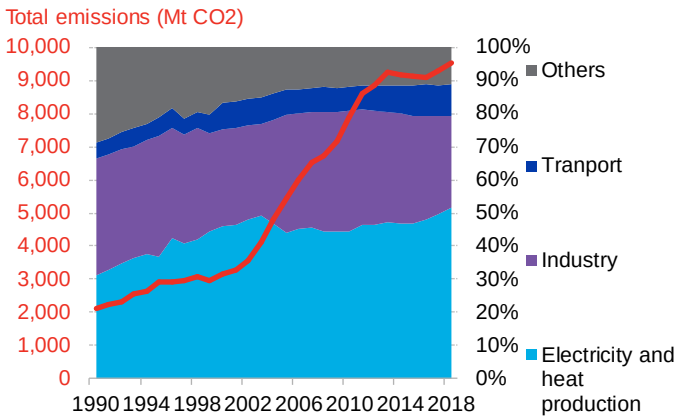
BNEF's expected peak-year for China's carbon emissions from electricity generation without any new policy measures

2031

BNEF's expected peak-year for China's carbon emissions from road transport without any new policy measures

- **What happened:** China's President Xi Jinping announced during the United Nations General Assembly on 22 September that "We aim to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060." This is China's first long-term climate pledge beyond its Paris Agreement commitment of achieving peak carbon emissions by 'around 2030'. And it's the first time that the country has committed to achieving carbon neutrality. The announcement lacks many details such as how China will treat offsets, from within or outside of the country, how agriculture emissions will be accounted for, and if any sectors may receive exemptions.
- **The scale of the challenge:** China is the world's largest carbon emitter, accounting for 28.6% of global emission in 2018. Its primary sources of emissions are power and heat production, industry, and transport. China's carbon emissions from the industry sector peaked in 2012 and has been declining thanks to a combination of recycling, energy efficiency and coal to gas switching. The electricity and heat production as well as transport sectors have yet to reach peak emissions, however based on current trends of renewable power and electric vehicle (EV) deployment, they are set to reach peak emissions within the next 10-years. To reach carbon neutrality, China will have to accelerate deployment of existing technologies such as EVs and solar. It will also need to develop and deploy new technologies for carbon-free hydrogen production as well as carbon capture, utilization and storage (CCUS). And it will need to make its economy much more efficient.

Figure 1: China's carbon emissions by sector



Source: International Energy Agency

Figure 2: China's sectoral carbon neutrality pathway

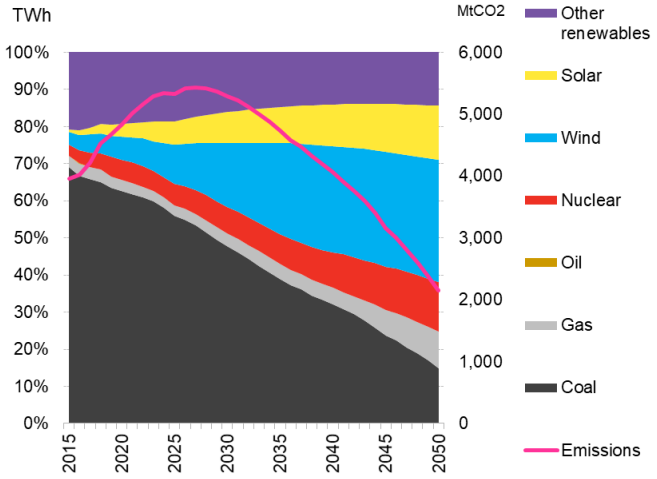
Sector	Technologies to reach carbon neutrality	Relative difficulty (1: easiest, 4: hardest)
Transport	Modal shift, electrification, hydrogen and biofuels	2
Industry	Reuse and recycling, electrification, biomass, hydrogen, low-carbon district heating and CCUS	4
Heat	Electrification, biomass, hydrogen, low-carbon district heating and CCUS	3
Electricity	Renewables, nuclear, energy storage (pumped hydro and batteries), CCUS and hydrogen (turbines and fuel cells)	1

Source: BloombergNEF

Yvonne Liu

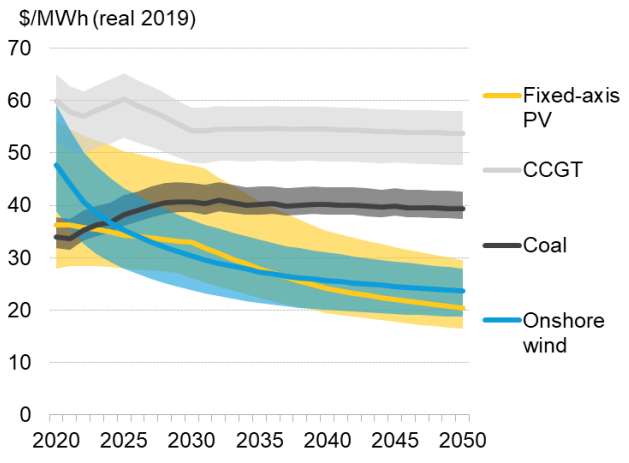
- **Electricity generation:** The power sector has the easiest pathway to carbon neutrality, although achieving 100% carbon-free electricity generation will still be very challenging.
- While **coal power generation** has been the linchpin of China's electricity system, its share in the power mix has already been declining thanks to the growth of renewables and nuclear. In 2009, coal accounted for 82% of China's electricity generation; by 2019 its share had declined to 64%. But over the same period, coal power generation still increased by 51% due to increased electricity demand. BNEF's New Energy Outlook 2019 projected China will reach peak coal generation by 2027.
- **Solar and wind's** levelized cost of electricity generation have already become cheaper than new coal power plants in China, and soon will become even cheaper than running existing coal plants. As a result, even without any new policy interventions, by 2050, BNEF expects fossil fueled power plants – primary coal and peaking gas plants – will account for only 25% of China's electricity generation. To eliminate emissions from these remaining fossil fuel power sources, China will need to consider a mix of options from deploying more renewables and nuclear to more novel approaches such as CCUS and hydrogen fueled turbines and fuel cells.
- **Electrification** of other sectors such as transport and industry will likely both help and hinder the carbon neutrality goal for the power sector. The additional electricity demand from these sectors will require more carbon-free sources of electricity. On the plus-side these sources can act as a crucial source of demand flexibility for balancing variable renewable electricity generation from solar and wind. Carbon-free options needed for seasonal energy storage are still at a very early stage of technology development, and China will need to scale-up these technologies.

Figure 3: China power generation mix and emissions



Source: BloombergNEF New Energy Outlook 2019. Note: this is the economic transition scenario mostly considering technology development and cost changes, without any policy assumptions.

Figure 4: Cost comparison between new-built renewables and marginal cost of coal and gas power in China

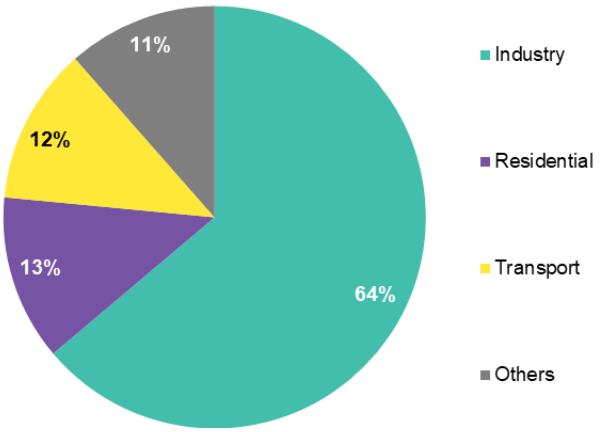


Source: BloombergNEF. Note: LCOE are in financing years and use realized capacity factors.

- **Heat:** achieving carbon neutrality in heat production will be more challenging than power generation. For the residential and commercial sectors, China has already had some success with solar thermal water heaters, and electrification options such as heat pumps may prove

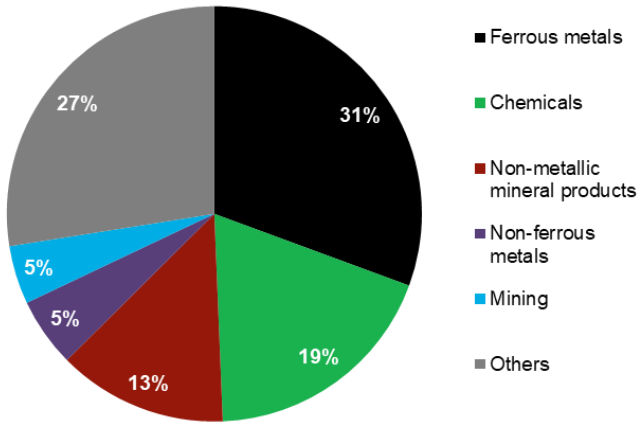
viable. District heat networks are also prominent but many are at high temperatures and use steam which makes it harder to retrofit to low-carbon alternatives away from coal, which dominates today. Industrial applications, will be more challenging. China has already started exploring a variety of options, including even nuclear. The appropriate option for heat production decarbonization will be more dependent on the specific application.

Figure 5: China's final energy consumption by sector, 2017



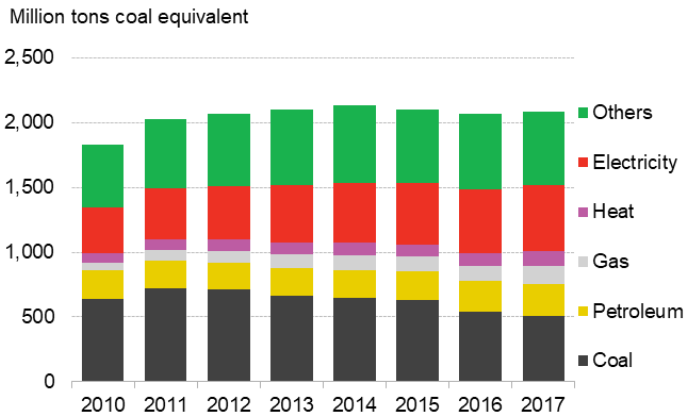
Source: China Energy Statistical Yearbook

Figure 6: China's industrial sector final energy consumption by subsector, 2017



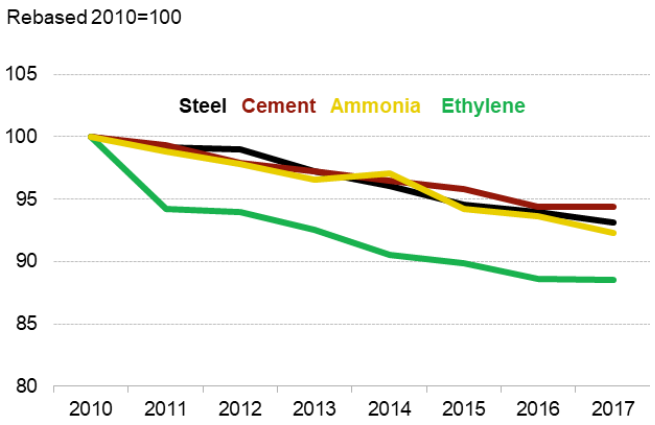
Source: China Energy Statistical Yearbook

Figure 7: Industry energy consumption by fuel type



Source: China Energy Statistical Yearbook. Note: Data includes non-energy use of fuels.

Figure 8: Energy intensity of key materials, 2010-17



Source: Industry associations, China Energy Statistical Yearbook

- **Industry** will be the most challenging area for China to decarbonize. China's industrial carbon emissions have been declining since 2012, but industrial sectors still account for over a quarter of total emissions, or 2.6 gigatonnes of CO2 equivalent in 2018. The manufacturing of steel, non-ferrous metals like aluminum and copper, chemicals and cement are the biggest emitters, accounting for 90% of industrial energy consumption. The 14% decline of carbon emissions from industrials from 2012 to 2018 was primarily driven by increased efficiency and to a lesser extent coal-to-gas switching.
- **Efficiency improvements** made a significant contribution to the decline in total emissions, with energy intensity dropping by 6-11% for key industrial products like steel and cement from

2010-17. Primary aluminum energy intensity dropped from 75GJ/ton to almost 65 GJ/ton on average, similarly primary steel energy intensity declined from 15 GJ/t to 12 GJ/t.

- Despite very limited **coal-to-gas switching** in the metals sector – which accounts for 58% of industrial energy consumption – industrial coal consumption peaked in 2011, thanks to increased natural gas usage by other industrial applications.
- Increased **recycled material usage** also helped. The government has set strict targets for increased recycling. Recycled aluminum needs to make up 27% of aluminum supply in 2025 and 30% by 2030, up from about 20% currently. By 2030, scrap steel recovery will be 250-320 million metric tons about 29% of production, up from about 15% today.
- But to achieve carbon neutrality China needs to go further, such as relying on renewable electricity for aluminum production and recycling, **hydrogen** in steel making and **bio-based feedstocks** for plastic manufacturing. It will also need to explore **CCUS** options for other hard-to-abate sectors, particularly cement, where only 50% of emissions can be removed by decarbonizing heat. These pathways will require strong policy support to scale-up.
- **Transport:** China is already the world's largest market for battery electric vehicles from 2-wheelers to cars to commercial vehicles and buses. It also has the world's largest fleet of fuel cell powered commercial vehicles and buses, although their overall fleet share is negligible. This head-start, along with policies such as the stringent New Energy Vehicle (NEV) mandate and Corporate Average Fuel Consumption (CAFC) standard, and the expected decline in lithium-ion battery prices, we expect rapid electrification of China's road vehicles, leading to peak emissions by 2031. However by 2040 emissions from road vehicles in China will still be 7% higher than 2019 levels. To achieve carbon neutrality in the road transportation sector, China would not only need to accelerate EV and fuel cell vehicle deployment – particularly for heavy duty commercial vehicles – it would also need to explore modal shifts away from less efficient modes of transportation of people and goods.
- For **aviation and marine**, there are still very limited technological options beyond short-haul routes. Any progress by China on technology options such as biofuels, hydrogen and electrification for aviation and marine will benefit the rest of the world. China's accounting of emissions from international aviation and marine will also have ramifications for the world.

Figure 9: EV share of China vehicle fleet by segment

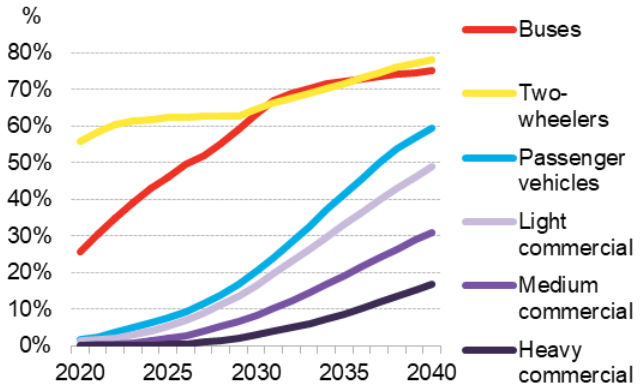
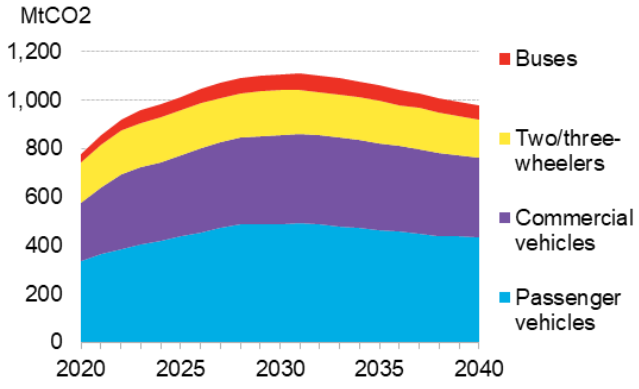


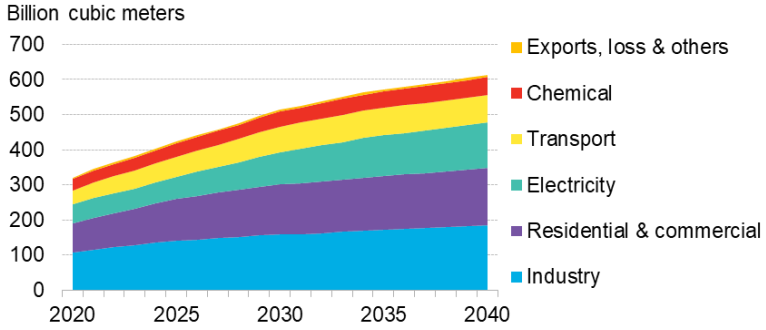
Figure 10: China CO2 emissions from road transportation by segment



Source: BloombergNEF Long-term Electric Vehicle Outlook 2020. Note: This is primarily an economics-led outlook and does not take into account any policy changes. Liquid fuel emissions include passenger vehicles, commercial vehicles and two/three-wheelers. Power emissions include passenger EVs, commercial EVs, electric two-wheelers and e-buses.

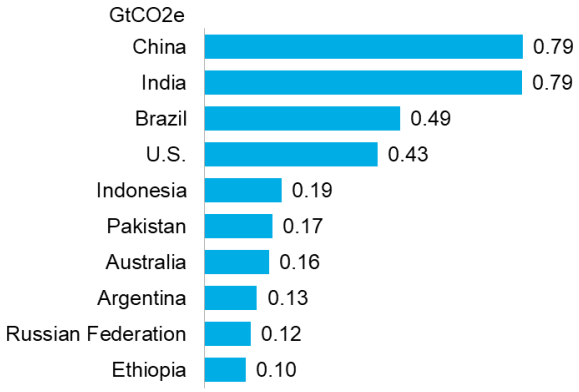
- **The role of natural gas:** China has already been reducing carbon emissions by replacing coal and oil usage with natural gas in select applications such as residential heating and heavy duty commercial vehicles, mostly as a means of improving local air quality, a priority for the government. The government wants to increase natural gas's share of primary energy mix to 15% by 2030 from around 8% in 2019. And BNEF expects this will lead to China's natural gas consumption increasing by 67% by 2030 compared to 2019. By 2040, China's natural gas consumption will likely be double that of 2019.
- **Increased natural gas usage** at the expense of coal and oil, will help reduce China's carbon emissions. But unlike the U.S., which has abundant domestic gas supplies that has helped lower its emissions, the Chinese government is **unlikely to rely on imported gas** to achieve meaningful decarbonization, much less carbon neutrality. Experience from European countries shows that biomethane and hydrogen are a crucial next-step to enable long-term climate goals to be reached. The emissions intensity of natural gas can also be lowered substantially with CCUS technologies. A combination of these three approaches would help the natural gas industry to evolve and deliver low-carbon growth.

Figure 11: China gas demand by sector



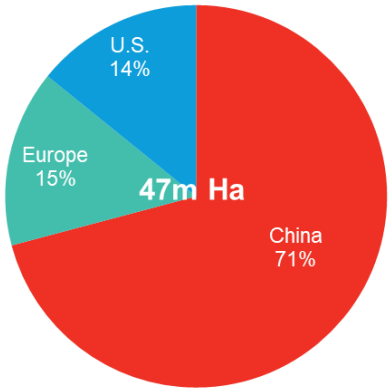
Source: National Development and Reform Commission, BloombergNEF.

Figure 12: Largest agriculture emissions by country, 2017



Source: UN FAO, World Bank, BloombergNEF

Figure 13: Net forest land gain since 1990, top three regions



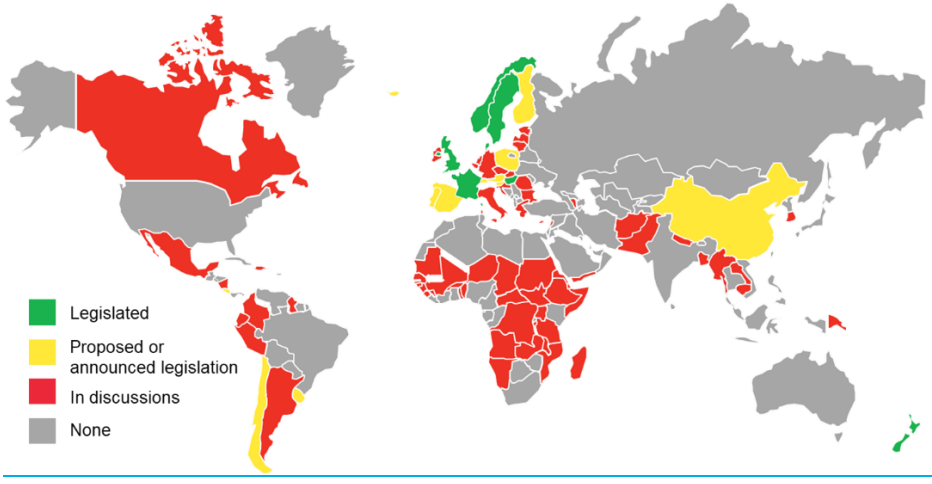
Source: UN FAO, BloombergNEF

- **Among other sources of carbon emissions**, China's accounting of emissions from agriculture, forestry and other land use will be the most critical to watch. China, along with India, produced the most agricultural emissions in 2017, with just over 60% more emissions than the third-largest country, Brazil. Similar to the rest of the world, the majority of emissions

in both countries stem from the raising of livestock, energy usage and fertilizers. However, fertilizer emissions have seen the greatest growth and are linked to over-application of nitrogen fertilizers. How China will address emissions from agriculture is unclear. It may very well try to offset these emissions with its negative carbon emissions from forestry and other land use (FOLU).

- China has the largest net negative **forestry and land use emissions** of any country in the world, primarily due to its decades of tree planting. It has planted more forest area over the last three decades than any other country – more than four times as much as Europe or the U.S., which have the second-and third-largest net forestry gains. While nearly a quarter of China is now forested, some experts have expressed concerns about the vast monoculture forests that have been planted as they limit biodiversity and can threaten native plant species that are pulled up to make room for them. Planted monoculture forests do not store as much carbon as natural forests.
- **The impact of China's transition to carbon neutrality on the rest of the world** will very much depend on the details of its plan and execution. As discussed earlier, if China scales up any new technologies such as CCUS, there will certainly be long-term global benefits. In the short-term, China's carbon neutrality announcement will likely have more impact on international negotiations in the run-up to the next United Nations Climate Change Conference, COP26 set to take place in November 2021 in Glasgow, under the presidency of the UK Government. The UK Government has asked countries to pledge more ambitious targets beyond their Paris Agreement commitments, specifically asking countries to come up with target dates for phasing out coal power generation and internal combustion engine vehicles. China's formal submission to COP26 will be an early indicator of its commitment to carbon neutrality. Prior to President Xi's UN speech, the EU had already asked China to commit to a carbon neutrality target date as part of their latest round of trade negotiations. A cynical view would consider China's carbon neutrality before 2060 pledge as less of a serious policy plan and more of a rhetorical boon to the China-EU trade negotiations. Taken at face value, however, this could also be seen as the EU successfully applying pressure on a key trade partner to address climate action. And China's new pledge may help governments of countries already discussing carbon neutrality targets to move forward with new target submissions in time for COP26.

Figure 14: Countries with carbon neutrality targets



Source: BloombergNEF. Note: this map is only for illustration purpose and only shows national targets.

- **Common but differentiated responsibilities – the elephant in the room:** Any climate target set within the United Nations Framework Convention on Climate Change (UNFCCC) framework is subject to the 'principles' of the original 1992 agreement, the most salient of which is the guiding principle of 'common but differentiated responsibilities', or CBDR (UNFCCC, Article 3). This same principle underpins the Paris Agreement, and China has long argued within the international negotiations that as a developing nation its targets should be considered conditional on action by and assistance from developed countries. It is therefore necessary to maintain a degree of skepticism when bold targets are announced by China or any other country defined as a developing nation under the UNFCCC, as the CBDR principle provides an easy get out if targets prove unachievable.
- **What to watch for next:** China typically lays out five-year plans, with its current longest energy plan covering the period until 2030. The earliest clear sign of China's ambition will likely come in its submission to COP26. Announcing a carbon neutrality target is just the first step on a long road. From a policymaking perspective, there are several critical questions that will need to be addressed over the coming year or two. Like other countries that have embarked on this journey, China will have to clarify the scope of its net-zero target, and what is meant by 'neutrality'. Is international aviation included, for example? To what extent can international offsets be used to achieve neutrality? Then, the government will need to put in place clear, numerical interim targets on the way to 2060. Without these, there will be no yardstick against which to measure its trajectory and the efficacy of its policies. These targets should ideally be divided into sectoral targets, specifying what reductions are to be achieved in the power, transport, buildings, industry and agriculture/land use sectors. This will allow near-term policymaking exercises, such as the all-important 14th Five Year Plan, to introduce specific measures compatible with the plans. Ultimately, it is these specific measures that will guide the world's largest emitter as it begins its controlled glide towards carbon neutrality over the next four decades.

Reference shelf

- New Energy Outlook 2019 (web | terminal)
- Hydrogen: The Molecule to Power a Clean Economy? (web | terminal)
- Carbon Capture, Utilization and Storage (web | terminal).
- Circular Economy Series (web)
- Long-Term Electric Vehicle Outlook 2020 (web | terminal)
- Advancing Agriculture: Decoding Carbon Emissions (web | terminal)
- China's Long-Awaited Carbon Trading Plan Gives Coal a Pass (web | terminal)

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