New Energy Outlook

China

BloombergNEF

Contents

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Section 1. Summary and key policy recommendations

A series of unprecedented events since 2020 has been reshaping China's energy system. The Covid-19 pandemic, extreme weather events, and global commodity crisis, have pushed up energy security as a priority for policymakers. At the same time, China's dual goals of reaching peak emissions before 2030 and carbon neutrality before 2060, have positioned decarbonization as a critical pillar of the country's energy policy framework.

This year's New Energy Outlook examines two scenarios on how China's energy system may evolve – a Net Zero Scenario (NZS) that pictures an ambitious pathway to reach net-zero emission by 2050, meeting the goals of the Paris Agreement, and an Economic Transition Scenario (ETS), which shows how economic forces and technology turning points can drive a transition without additional policy involvement.

1.1. Key findings of the ETS

China's power system has experienced significant structural changes over the past 15 years. China passed its Renewable Power Act in 2006, rolled out a generous feed-in-tariff program and has set ambitious targets under its five-year plans. These measures, together with rapidly declining generation costs, led to wind and solar capacity increasing 272-fold from 2006 to 2021. Since 2015, electric vehicles (EVs) have experienced a similar growth, driven by the combination of subsidies as well as non-financial incentives. The rise in manufacturing capacity and deployment has resulted in the cost of solar and wind power along with EVs reaching economic competitiveness in most of China.

Under the ETS, renewable energy becomes the largest source of power by 2050, with wind (43%) and solar (24%) supplying two-thirds of China's annual electricity demand. Total power demand peaks at 12,104 terawatt-hours (TWh) in 2044 and then falls to 11,546TWh in 2050, 62% higher than 2021. This is driven by continued economic growth and increased electrification, particularly in the road transport sector. The carbon dioxide (CO_2) emission intensity of China's annual electricity generation declines by 82% by 2050 from 2021 levels. Power-sector emissions peak at 5.2 billion metric tons of CO_2 ($GtCO_2$) in 2021 and decline to 1.7$GtCO_2$ by 2050.

From 2022 to 2050, China installs 6.3TW of new capacity, of which solar, wind and batteries account for 87%. The pace of installation peaks in 2031 when annual wind and solar installation reaches 297 gigawatts (GW), about 2.4 times of the annual build in 2021.

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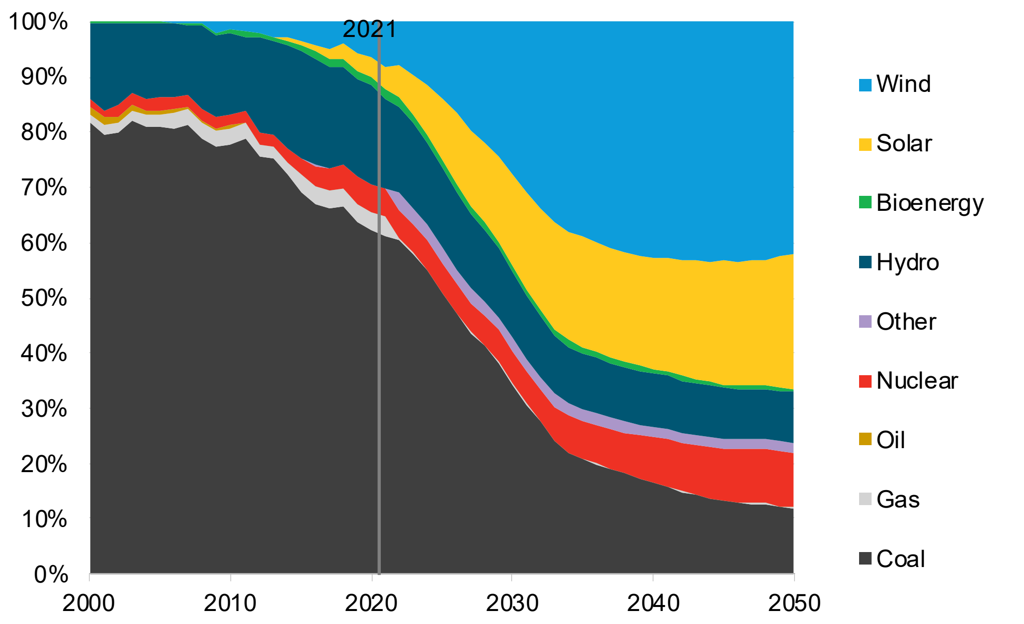
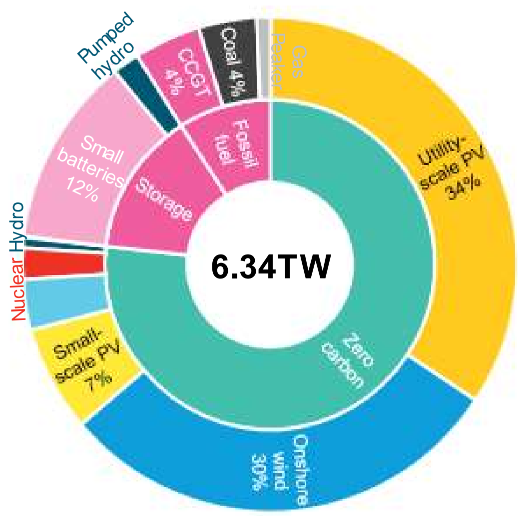
Figure 1: Power generation by technology in China, Economic Transition Scenario



Source: BloombergNEF

The transport sector (comprising road, aviation, shipping, and rail) experiences a 42% reduction in direct (Scope 1) emissions by 2050 relative to 2021 levels, driven primarily by the electrification of road transport. Electricity demand from the transport sector rises to 1,797TWh by 2050, equivalent to 16% of power demand that year. The higher energy efficiency of electric drivetrains compared with internal combustion engines (ICEs) results in the transport sector's final energy consumption by 2050 being only 5% more than in 2021.

Figure 2: Total capacity additions in China, 2022-2050, Economic Transition Scenario



Source: BloombergNEF. Note: CCGT refers to combined cycle gas turbine. PV is solar photovoltaic.

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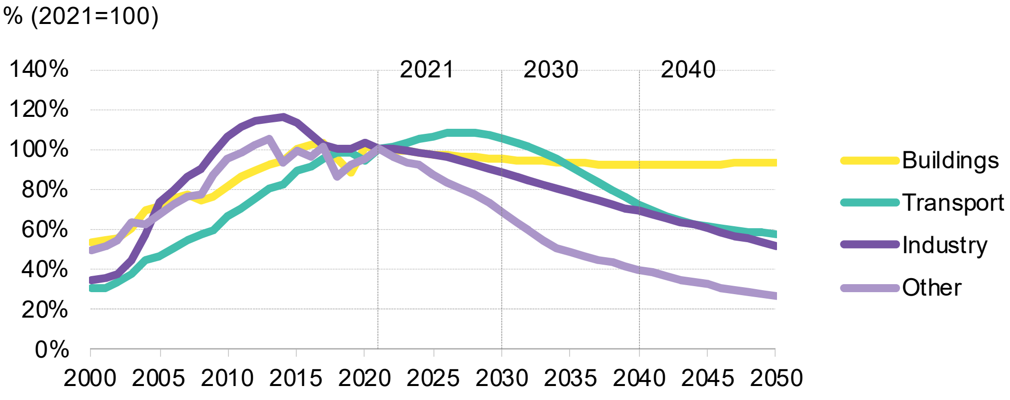
China's economic growth is already gradually decoupling from energy consumption, as it shifts to high-end manufacturing and a higher contribution from the service sector. While the ETS assumes China's GDP rises by 159% by 2050 from 2021 levels, final energy use only increases 3% to 98 exajoules (EJ). Primary energy consumption decreases 14%, thanks to higher energy conversion efficiency of clean power and electric drivetrains.

Figure 3: Direct CO2 emissions by macro-sector relative to 2021, Economic Transition Scenario

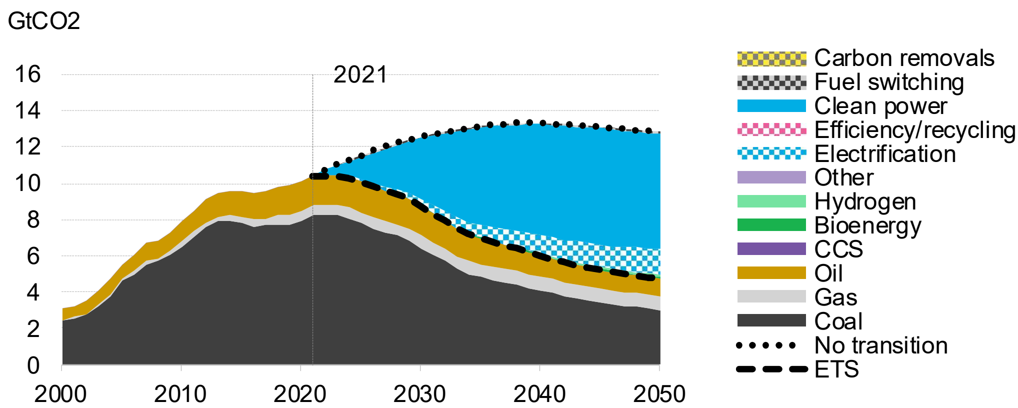


Source: BloombergNEF

Industrial energy emissions fall from 6.1GtCO2 in 2021 to 2.3GtCO2 by 2050. The 62% decline outperforms emission reductions in the transport and building sectors. The drop comes from fuel switching and the introduction of hydrogen. But emissions in 2050 are far from zero, as many industries continue to rely on unabated fossil fuels due to a lack of cost-competitive, zero-emission alternatives.

Under the ETS, emission reductions are mainly driven by the power and road transport sectors, which together eliminate around 74% of emissions that would exist in 2050 under a 'no transition' counterfactual scenario. By 2050, total emissions fall by 55% from 2021, but unabated fossil fuels still generate 5GtCO2.

Figure 4: China's carbon emissions from fuel combustion, Economic Transition Scenario versus no transition scenario



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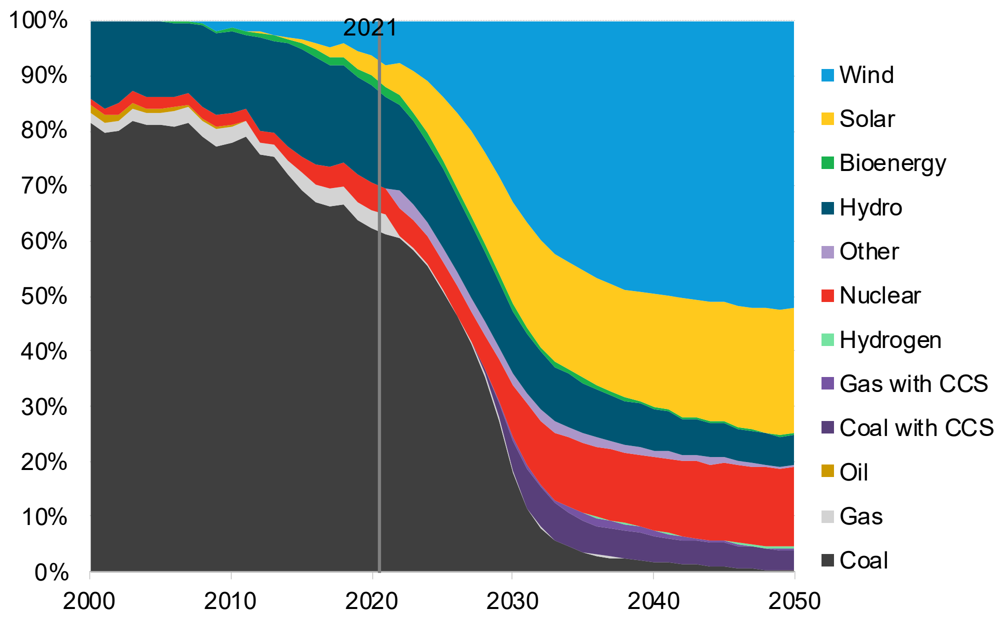
Source: BloombergNEF. Note: The 'no transition' scenario is a hypothetical counterfactual that represents a world in which no further actions are taken in the power and road transport sector to reduce carbon emissions, keeping the current fuel mix constant at 2021 levels and growing proportionally under the same ETS demand forecast. In steel, the world continues to rely on coal-based blast furnace-basic oxygen furnace (BF-BOF) steel making. CCS is carbon capture and storage.

1.2. Key findings of the NZS

Under the NZS, emissions reach net zero by 2050 and the global average temperature increases 1.77C. This is consistent with the Paris Agreement's goal of keeping the temperature rise to well-below 2C by the end of the century compared to pre-industrial levels. The NZS involves a shorter emission reduction timeline than China's goal of realizing carbon neutrality before 2060. This means that the entire energy system, including power, transport, industry and buildings, use carbon-free energy sources, achieve significant efficiency improvements, and adopt some degree of carbon capture and storage (CCS) in the harder-to-abate sectors.

Figure 5: Power generation by technology in China, Net Zero Scenario



Source: BloombergNEF. Note: CCS is carbon capture and storage.

As the world's largest emitter looks to speed up economic recovery and development, reaching net-zero emissions in less than 30 years appears to be ambitious. The NZS is designed to be realistic, without causing dramatic step changes that may burden the supply chain or China's overall economy. Getting to net zero by mid-century means no unabated fossil fuel use in the energy sector. The NZS indicates that China's demand for coal, gas and oil peaks in 2023, 2029 and 2024, respectively.

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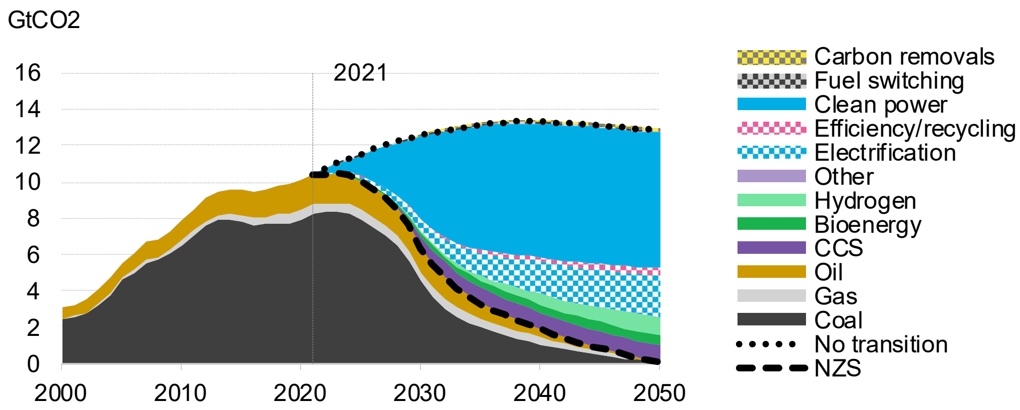
Clean power contributes the most to China's emissions reduction. Replacing unabated coal and gas generation with wind, solar, hydro and nuclear power eliminates 65% of the emissions under a counterfactual scenario where no decarbonization takes place. Electrification of transport, industrial processes and buildings contributes another 15% to abatement.

Figure 6: China's carbon emissions from fuel combustion, Net Zero Scenario versus no transition scenario



Source: BloombergNEF. Note: The 'no transition' scenario is a hypothetical counterfactual. In the power and transport sector, it keeps the fuel mix constant at 2021 levels, with emissions growing proportionally to forecast energy demand. In industry, BNEF does not model the switch from coal-based blast furnace-basic oxygen furnace (BF-BOF) to gas-based direct reduction-electric arc furnace (DR-EAF) in steel production. For all other sectors, the counterfactual to the NZS is the ETS. 'Clean power' includes renewables and nuclear. 'Bioenergy' refers to direct use outside the power sector. 'Efficiency/recycling' includes demand-side efficiency gains in aviation, shipping and buildings, and greater recycling in industry. CCS is carbon capture and storage.

CCS quickly rises from almost zero today to 0.6GtCO2 in 2030, 0.9GtCO2 in 2040 and 1.0GtCO2 in 2050. It is mainly used in the decarbonization of hard-to-abate sectors, such as cement and steel, as well as coal power plants and hydrogen production from fossil fuels. In total, CCS contributes 8% to emission abatement by 2050. Carbon removals only account for 1% of the emission over the same period, as they are only used to offset the residual emissions of CCS.

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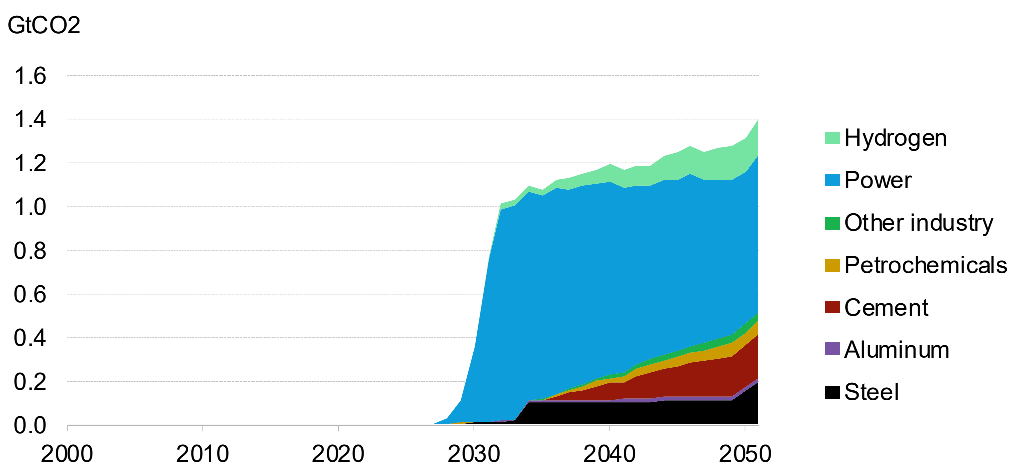
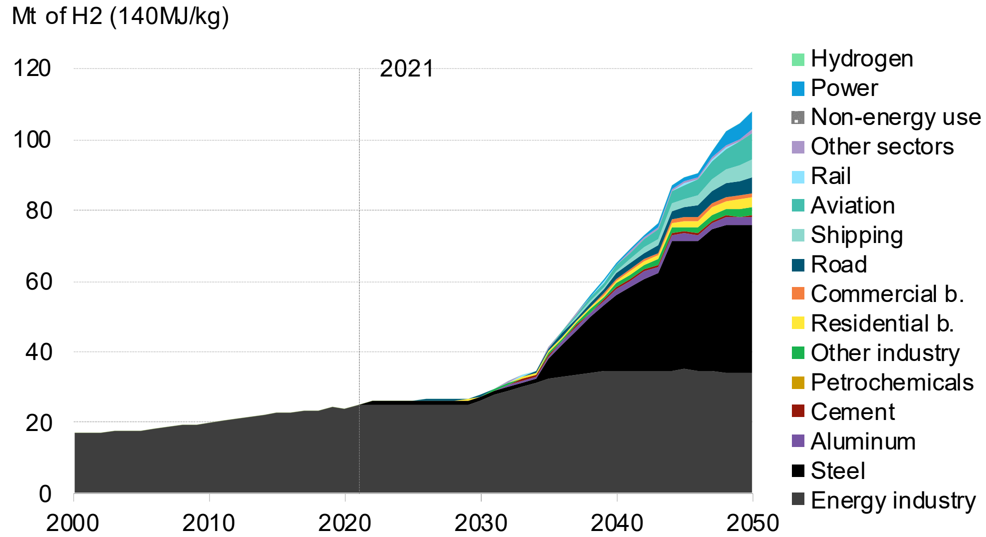
Figure 7: Annual CO2 emissions captured by CCS by sector in China, Net Zero Scenario



Source: BloombergNEF

Bioenergy demand also grows, driven by increasing biomass use in power, as feedstock for sustainable aviation fuel (SAF), and use in industry. Bioenergy cumulatively contributes 4% of the total emissions reductions between today and 2050. It accounts for 7% of final energy in 2050.

Figure 8: Hydrogen consumption in China, Net Zero Scenario



Source: BloombergNEF, IEA. Note: 'Energy industry' includes legacy uses (especially as feedstock for ammonia and methanol production or in oil refining) as well as energy-producing industries' own use, such as process heating, lighting and equipment operations. Commercial b. is commercial buildings. Residential b. is residential buildings.

China's annual hydrogen demand grows from 25 million metric tons (Mt) in 2021 to 108Mt by 2050. The largest growth driver is the decarbonization of the steel sector. The power sector consumes 5Mt of hydrogen in 2050, which is used to provide back-up capacity to the power

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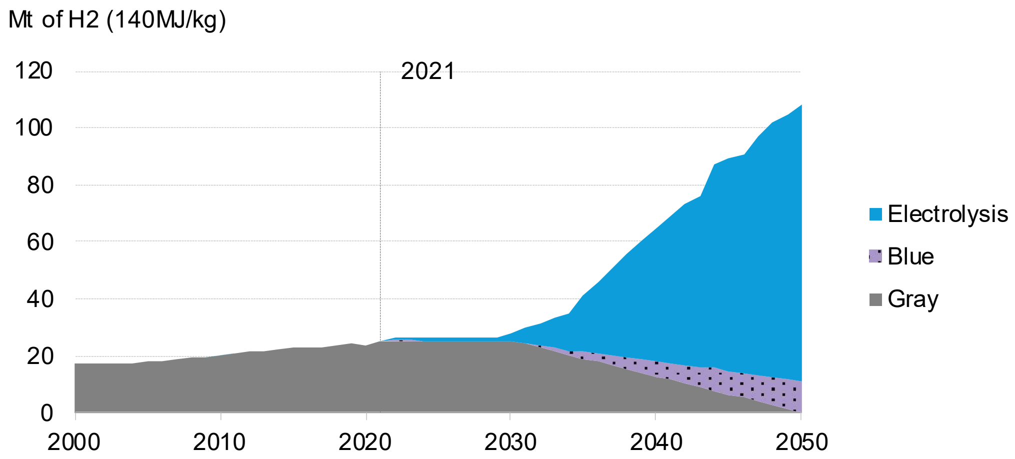
system. Hydrogen use in shipping starts from 2038 and sees rapid growth to 5Mt in 2050, either in the form of pure hydrogen or as derivative fuels like ammonia and methanol for heavy-duty vessels. Road vehicles, mostly trucks, consume 5Mt of hydrogen in 2050, which is equal to 5% of fuel use in the sector.

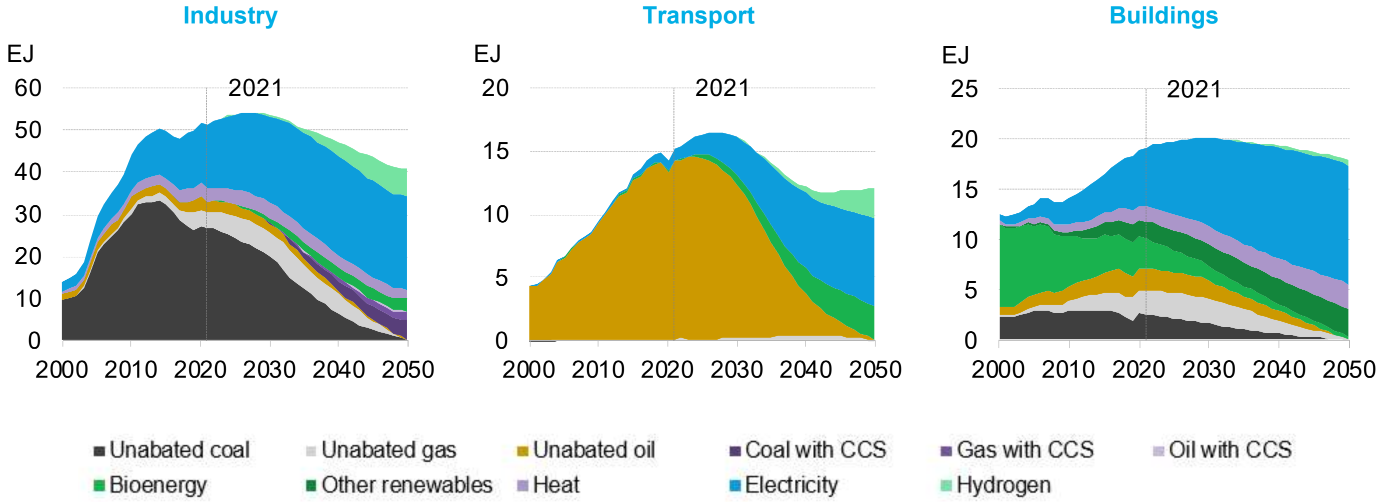
Figure 9: Hydrogen production by type in China, Net Zero Scenario



Source: BloombergNEF

Most of the hydrogen is produced via flexible grid-connected electrolyzers powered by renewables and nuclear power in the NZS. By 2050, hydrogen from electrolysis reaches 97Mt, representing 90% of the total hydrogen supply in 2050. Electricity demand from hydrogen production rises to 4,345TWh by 2050, which represents 25% of the total power demand that year. Hydrogen from fossil fuels with CCS also grows from 2030. By 2050, it produces the remaining 10% of the total hydrogen supply.

Figure 10: Final energy use by sectors in China, Net Zero Scenario



Source: BloombergNEF. Note: CCS is carbon capture and storage.

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Energy consumption in industry peaks in 2027 and then declines by 25% to 2050. The energy supply mix of industry sees significant changes. Meeting over half of all demand in 2050, electricity becomes the most important final energy source by mid-century. In 2021, electricity's share in industrial fuel consumption was 30%. The shares of coal and gas decline to 11% and 5% respectively by 2050. Hydrogen represents 16% of the industry final energy share in 2050.

Transport sector energy demand changes the most. Driven by a rapid switch to EVs, oil consumption peaks in 2024 and then gradually phases out by 2050. Electricity, biofuels and hydrogen replace the fossil fuel over time. Despite growing passenger travel and commercial shipping, total final energy use by the transport sector is 27% lower in 2050 than the peak in 2027. This is because of the greater efficiency of electric motors compared with ICEs.

Energy demand from buildings hits its maximum in 2029 and then moderately and consistently declines with the country's declining population and greater energy efficiency. Electricity plays a central role by 2050, accounting for 66% of final energy. Unabated fossil fuel use vanishes by the mid-century. Due to the high costs of using hydrogen for heating buildings, the fuel only represents 3% of the sector's final energy demand in 2050.

1.3. Policy recommendations

BNEF's NZS and ETS show two different pathways. The former meets the headline goal of the Paris Agreement, while the latter one breaches it and leads to 2.6C of warming globally.

For China, the NZS needs $37.7 trillion of investments in clean energy and builds a cumulative of 6,878GW of wind and solar from now to 2050. In comparison, the ETS requires $28.7 trillion of investment to add 4,698GW of wind and solar over the same period.

In order to bend the curve toward the NZS, BNEF has identified the following key action areas for China.

Accelerate deployment of mature climate solutions

Wind, solar and EVs are the technologies that are already commercially available today and economically competitive. Both central and local policymakers should remove the barriers that prevent the deployment of these technologies. Priority actions include:

- **Limit measures that favor locally manufactured equipment:** China's central government has already banned such local regulations. But local governments still prioritize approving projects whose owners invest in the local manufacturing supply chain. Such measures not only increase renewable power costs but also lead to inefficient capital allocation and supply chain overcapacity. Renewable developers and local government should explore innovative approaches to share the benefits of low-cost renewable power.
- **Increase access to information clean power developers need:** Local governments and their affiliated grid companies can expedite renewable power development by providing more information to developers on grid infrastructure such as access points, available substation capacities, proper places to build energy storage, as well as their future grid expansion plans.
- **Improve grid development to support renewable integration:** While China has been building transmission networks including high-voltage direct current (HVDC) lines at an unprecedented rate, the combination of technologies used and current power market regulations have limited renewables from increasing their utilization of such grid

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infrastructure. China needs to ensure its national and local grids can boost – not hinder – renewable uptake.

- **Local government should educate consumers about the benefits of renewable power.** Although renewable power is already cost-competitive, its deployment by users, such as rooftop solar photovoltaic (PV), still relies on diffusion, rather than economics. Local governments should demonstrate these technologies by first adopting them and actively educating users about the benefits.

Support the development of new climate solutions

Some key technologies, such as clean hydrogen, CCS and advanced nuclear, are still in the early demonstration stages, and have not reached cost-competitiveness with existing fossil fuel technologies. Some measures could be applied to help them scale up:

- **Commercial risks mitigation through long-term offtake agreements with state-owned enterprises (SOEs):** SOEs could invest by themselves as well as provide offtake agreements to third parties. Growing demand from SOEs will lead to more private investment.
- **Industry-specific decarbonization roadmaps:** An ambitious decarbonization roadmap that builds on new climate solutions is crucial for the industry. SOEs will again need to take the lead to explore these technologies as it may seem too risky for private players in hard-to-abate sectors such as steel producers. The current SOE investment regulation should be changed to allow more risk-taking to pilot these new technologies.

Manage the transition or phase-out of carbon-intensive activities

Carbon-intensive businesses require policy certainty and supportive regulatory framework to plan their transition. The following actions would support these industries in their transition:

- **Set clear roadmaps for decarbonization, especially how and when to reach net zero:** China has already issued carbon peak roadmaps for specific industries, which is a helpful step. These plans include relatively mild targets, such as limiting output and capacity expansion, and increasing efficiency and clean power procurement. What is challenging is how to transition from peak emissions to carbon neutrality. Collaboration between relevant government entities and industry to design sector-specific net-zero roadmaps will be crucial.
- **Timely enrollment of all heavy emitters into the national carbon market:** China has already taken the crucial step of setting up a national carbon market. The next step is to phase out free allocations and gradually expand the entities covered to include all heavy emitters. China will also need to implement carbon market reforms, such as shifting from carbon intensity targets to absolute annual emission caps to ensure the carbon market leads to actual emission reductions.

Create appropriate climate transition governance structures

Achieving net zero will be a multi-decade journey, so it is important to ensure the long-term goals could be maintained and remain unchanged during the process. Actions include:

- **Legislate the key targets, direction, guidelines:** Enshrining China's announced dual goals of peaking emissions before 2030 and carbon neutrality before 2060 into policy will support long-term action. Existing laws that do not align with these goals should also be updated accordingly.

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- **Improve coordination between different government agencies:** This is a long-standing challenge for China. For example, the Ministry of Ecology and Environment governs the national carbon market, but the National Energy Administration regulates the green power market. Without proper coordination, these two markets that are inherently reliant on each other may not develop in a mutually supportive manner, leading to uncertainty for market players.

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