An energy sector roadmap to carbon neutrality in China

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A world in motion, moved by China

China’s rapid economic development lifted hundreds of millions of people out of poverty. Today, China is the largest source of fossil fuel use & CO₂, but also the world’s centre for the manufacturing & deployment of clean energy.
China’s carbon neutrality pledge is significant for the world

China’s carbon neutrality pledge is an important contribution to the fight against climate change; but the global emissions budget for limiting the global temperature rise to 1.5 °C is very tight.
A history repeated… but low-carbon

China’s carbon neutrality pledge means solar becomes the largest primary energy source by around 2045. Demand for coal drops by more than 80% by 2060, oil by around 60% and natural gas by more than 40%.

*Low-carbon includes fossil fuels with CCUS
Reaching carbon neutrality relies on many technologies.

Emission reductions by measure for China’s carbon neutrality pledge, cumulative to 2060

- **Renewables**: 38%
- **Energy efficiency**: 16%
- **Reduced service demand**: 11%
- **Other fuel shifts**: 11%
- **Hydrogen**: 3%
- **Electrification**: 13%
- **CCUS**: 8%

*Other fuel shifts include bioenergy

Renewables and energy efficiency are the foundation of China’s energy system transformation. Innovative technologies - like hydrogen and CCUS - are critical for heavy industry and long-distance transport.
New clean energy infrastructure is critical

Existing hydrogen demand and potential CO$_2$ storage sites, and cost of renewables-based hydrogen
A power mix dominated by renewables

Renewables-based generation, mainly wind and solar PV, increases seven-fold between 2020 and 2060. There is no coal-fired power generation without carbon capture as of 2050.
The power and buildings sectors’ transitions are closely interlinked.

CO₂ emissions from buildings are eliminated by the second half of the 2050s in the APS as fossil fuels in direct uses are phased out and power and heat generation are decarbonised.
New metrics for buildings energy codes

Accelerated retrofits and the construction of new zero-carbon-ready buildings reduce the energy intensity of heating by over 65% and cooling by 45% in 2060.
Efficiency improvements in all buildings end-uses are key

Despite the growing demand for services, energy use in buildings starts to fall back in the late 2020s thanks to efficiency improvements in all building end uses.
Growing heat pumps demand to exploit economy of scale

China accounts for over one-fifth of the global increase in heat pump capacity to 2060, with economies of scale and learning-by-doing driving costs down by more than 15%.
Average heating and cooling efficiency needs to more than double

Increased sales of heat pumps help drive up the overall efficiency of space heating equipment, while standards underpin cooling efficiency gains.
Technologies on the market today bring the largest benefits

Nearly 90% of the emissions reductions in buildings to 2030 come from existing technologies, but the full decarbonisation of building end uses also requires new technology designs.
A new electricity paradigm could emerge

Direct current buildings make use of solar PV systems to power direct-current appliances and storage devices, therefore avoiding the need for conversion to alternative current.
Electric vehicles need to support rooftop PV integration

In 2060, about 60% of building-integrated PV in China could be consumed by buildings themselves, while 40% of the EV fleet could absorb the rest. Making use of them is essential to reduce systemic costs.

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Average daily solar PV generation in buildings in China in 2060 under China neutrality pledge

- **Generation**:
  - Self-consumed
  - Surplus generation

- **EV absorption capacity**:
  - V1G only
  - V1G and V2G

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Conclusions

• China’s impressive economic growth story has lifted hundreds of millions of people out of energy poverty.

• China’s efforts to cut solar PV & battery costs changed the way the world thinks about clean technologies.

• China’s carbon neutrality pledge demands an energy system transformation that results in growth for clean energy in the coming decades similar to what fossil fuels experienced over the past two decades.

• Clean energy policies will reduce fuel poverty and improve urban air quality, on top of bringing down emissions. They should include:
  - More stringent buildings energy codes and minimum energy performance standards
  - Regulatory changes to decarbonise electricity supply
  - Planning at the country, city and district levels to exploit all available clean energy sources efficiently