Istituto Affari Internazionali

China's Quest for Global Clean Energy Leadership

by Barbara A. Finamore

ABSTRACT

The manufacture and deployment of clean energy technologies is a key element in China's quest to become a global technology leader. China has focused on renewable energy and cleaner, more efficient mobility systems to help transform its economic model from one based on highly-polluting, energy-intensive manufacturing to a high-tech system based on the production of goods and services at the top of the value chain. These technologies are also crucial for strengthening China's energy security, protecting its environment and safeguarding the global climate. The country now leads the world in solar and wind power, electric vehicles and battery production, catalysing dramatic cost reductions throughout the world. Yet China faces myriad challenges in scaling up these technologies and accelerating its energy transition away from fossil fuels, especially as it begins to phase out subsidies in favour of a more competitive market-based approach. Addressing these challenges is essential if the country is to ensure its long-term economic sustainability and reach its goal of becoming a world leader in technology and innovation.

China | Energy | Technologies | Energy security | Climate change | Sustainable development

keywords

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by Barbara A. Finamore*

1. The role of clean energy technologies in China's economic transition

China's rapid development over the last four decades – at a pace the World Bank called "the fastest sustained expansion by a major economy in history" – relied to a large extent on energy-intensive heavy industries and export-oriented, low-value manufacturing. This growth model enabled the economy to grow more than nine-fold from 1990 to 2016 and lifted an estimated 850 million people out of poverty.[1]

The country now produces roughly half of the world's iron and steel, cement and aluminium, both for export and to meet the needs of its rapidly urbanising population. This massive industrial sector has been responsible for about 70 per cent of the country's primary energy consumption for decades.[2] Most of that energy has come from coal, burned directly in factories and in a growing number of coal-fired power plants. A single province such as Shandong consumes nearly twice as much coal as Germany.

The negative impact of China's traditional growth model became increasingly apparent as the economy began to slow down, leaving a trail of environmental devastation in its wake. Widespread air, water and soil pollution; depletion of natural resources; accelerating loss of biodiversity and arable land; and rising greenhouse gas emissions have damaged public health and contributed to our global climate crisis. China is one of the countries most vulnerable to the impacts of climate change, including increasing food and water insecurity, more frequent

[1] World Bank website: *China: Overview*, 2019, http://web.archive.org/web/20191111215430/https://www.worldbank.org/en/country/china/overview.

[2] Nan Zhou et al., *China Energy Outlook: Understanding China's Energy Use and Emissions Trends*, Berkeley, Lawrence Berkeley National Laboratory, 2020 (forthcoming).

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natural disasters and rising sea levels threatening an estimated 43 to 57 million people living along the coastline.[3]

China is now transitioning to a more sustainable economic model focused on innovation, services, and green and low-carbon development.[4] The 13th Five Year Plan (2016–2020) laid out a vision for addressing China's "uneven, uncoordinated, and unsustainable development" and creating a "moderately prosperous society in all respects" through innovative, coordinated, green, open and inclusive growth.[5] Innovation is the cornerstone of this new development strategy, the leading driver of productivity-led growth. China's goals now include becoming a world leader in science and technology.

The 13th Five Year Plan also set the target to build a "clean, low-carbon, safe, and efficient" energy system. Clean energy technologies are a key element of China's strategy to transform to a high-tech system based on the production of goods and services at the top of the value chain. These technologies can enhance China's global competitiveness in 21st century industries, increase productivity by lowering energy and resource intensity, and contribute to growth in related service industries such as solar panel installation and maintenance.[6] China now leads the world with 4 million clean energy jobs, 40 per cent of the world total.[7] Renewable energy and cleaner, more efficient transportation systems are also essential for enhancing China's energy security, protecting the health of its people and natural systems, and safeguarding the global climate. The move to clean energy reflects and is helping to drive China's economic transition to a "new normal" of slower but higher-quality development.[8]

[3] Scott A. Kulp and Benjamin. H. Strauss, "New Elevation Data Triple Estimates of Global Vulnerability to Sea-Level Rise and Coastal Flooding", in *Nature Communications*, Vol. 10, Art. 4844 (October 2019), https://doi.org/10.1038/s41467-019-12808-z.

[4] World Bank, Development Research Center of the State Council, The People's Republic of China, *Innovative China: New Drivers of Growth*, Washington, World Bank, 2019, http://hdl.handle.net/10986/32351.

[5] China, *The 13th Five-Year Plan for Economic and Social Development of the People's Republic of China (2016–2020)*, 17 March 2016, https://en.ndrc.gov.cn/newsrelease_8232/201612/P020191101481868235378.pdf. See also Li Keqiang, *Report on the Work of the Government, delivered at the Fourth Session of the 12th National People's Congress*, 5 March 2016, https://www.chinadaily.com.cn/china/2016-03/17/content_23929042.htm.

[6] Smita Kuriakose et al., *Accelerating Innovation in China's Solar, Wind and Energy Storage Sectors*, Washington, World Bank, October 2017, http://hdl.handle.net/10986/28573.

[7] Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2019 Global Status Report*, Paris, REN21, 2019, https://www.ren21.net/reports/global-status-report.

[8] Fergus Green and Nicholas Stern, *China's 'New Normal': Structural Change, Better Growth, and Peak Emissions*, Grantham Research Institute on Climate Change and the Environment & Centre for Climate Change Economics and Policy (CCCEP), June 2015, http://www.lse.ac.uk/GranthamInstitute/?p=15057.

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2. How China became a clean energy leader

China has become a global leader in the production and deployment of clean energy technologies in little over a decade. It has done so through a comprehensive and evolving set of targets and plans, legal and regulatory measures, incentives, enabling policies, and infrastructure development, as well as support for research, development, demonstration and innovation. China's massive economies of scale and process innovations have driven down the costs of clean energy technologies, while domestic demand is accelerating growth in the rate of adoption.

Renewable energy. The country's renewable energy industry began to take off following enactment of its 2005 Renewable Energy Law (amended in 2009). The law established key policies including national renewable energy targets, a mandatory connection and purchase policy, a national feed-in tariff (FIT) system, and arrangements for cost-sharing and funding of renewable energy incentives.[9] As a result of these and other measures, by 2009 China had become the world's largest wind power market, the top producer of solar cells (mostly for export) and a leading manufacturer of wind turbines and photovoltaic modules.

The 12th Five Year Plan (2010–2015) targeted seven "strategic and emerging" industries as the drivers for China's economic transformation from low-end manufacturing to higher-value industries and sustainable growth. On the list were alternative energy industries (nuclear power, solar power, wind power, biomass power and smart power grids) and alternative fuel vehicles (hybrid, battery electric and fuel cell vehicles).

For each of these strategic industries, the government formulated and implemented a plan and supporting policies, set up a special fund for promoting their development, expanded the scale of venture capital investment and enacted industry standards.[10] For solar power, a special five-year plan laid out a comprehensive and highly detailed strategy designed to strengthen China's solar photovoltaic (PV) industry, reduce costs, improve quality, promote technological innovation, increase research and development (R&D) and expand China's solar market overseas. Each of these goals was accompanied by specific targets, timetables and policies, and later implemented with government funding and financial incentives.[11]

[9] Sara Schumann and Alvin Lin, "China's Renewable Energy Law and Its Impact on Renewable Power in China: Progress, Challenges and Recommendations for Improving Implementation", in *Energy Policy*, Vol. 51, (December 2012), p. 89-109.

[10] Joseph Casey and Katherine Koleski, *Backgrounder: China's 12th Five-Year Plan*, Washington, U.S.-China Economic & Security Review Commission, 24 June 2011, https://www.uscc.gov/node/321.

[11] China's National Energy Administration (NEA), *China: 12th Five-Year Plan on Solar Power Development* (in Chinese), September 2012, https://policy.asiapacificenergy.org/node/41.

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China has put into place a host of other enabling policies and measures to support the development of renewable energy. These include ongoing power sector reforms, the construction of the world's largest ultra-high voltage transmission network, promotion of distributed energy and microgrids, support for the development of energy storage technologies, a national carbon market and measures to reduce the country's reliance on coal.

Over the past fifteen years, as solar and wind power have grown exponentially, China has adopted an increasingly ambitious series of renewable energy targets. The country has already exceeded its 2020 installed capacity targets for wind (210 gigawatts, GW) and solar (150 GW). Under the Paris Agreement, China pledged by 2030 to increase the share of non-fossil energy to 20 per cent of its energy mix, reduce its carbon intensity 60 to 65 per cent below its 2005 level, and peak its CO_2 emissions (making best efforts to peak earlier).

Electric vehicles. When the government designated hybrid, battery electric and fuel cell vehicles – collectively known as new energy vehicles (NEVs) – as a strategic emerging industry in 2010, it committed 15 billion US dollars over ten years for the country's leading auto and battery companies to create an electric car industry, starting in twenty pilot cities. In 2012, the State Council called for the production and sale of at least 500,000 electric and hybrid vehicles by 2015. When that target proved elusive, the government in 2013 began to provide purchase subsidies of up to 9,700 US dollars per vehicle, the most generous purchase subsidies of any country except for Norway. Some local governments provided additional subsidies, as well as preferential policies such as exemptions from license plate lotteries or peak traffic restrictions.

The Made in China 2025 initiative named NEVs as one of ten priority sectors. The goal was to comprehensively upgrade China's industry to make it more innovative and competitive, localise production of components and final products and move Chinese firms up the global value-added chain. The initiative focused on the entire manufacturing process, with more of an emphasis on market mechanisms than the "strategic emerging industries" plan. It also included specific measures for innovation, quality, intelligent manufacturing and green production.

Other enabling measures that support the development of China's NEV industry include tough vehicle emission standards, investments in charging infrastructure, mandated government procurement and a dual credit policy that requires large auto manufacturers to obtain enough credits from production of NEVs to equal 12 per cent of their total vehicle production in 2020.[12] Some provinces and cities are moving ahead even faster than the central government. The city of Shenzhen has converted nearly all its buses and taxis to electric. Hainan Province has pledged to

[12] Manufacturers can receive up to six credits per vehicle for those that utilise more advanced technology, as well as credits for vehicles with less emissions than government standards. Carmakers that fail to meet these targets must buy credits from other automakers or face fines.

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completely phase out fossil fuel vehicles by 2030.

Research and development. The Chinese government provides significant support to clean energy R&D, particularly through National Key R&D Programmes.[13] In 2015, China joined the global "Mission Innovation" initiative and committed to double its investment in clean energy research and innovation by 2020, to 50 billion RMB (7.6 billion US dollars). Focus areas include new energy-saving technologies, renewable energy and hydrogen energy, smart grids, building energy efficiency and green intelligent cars. China's investment grew to 42 billion RMB in 2018 (6.1 billion US dollars).[14]

3. Current status

China is by far the world's leading investor in clean energy. It committed 758 billion US dollars in renewables capacity (excluding large hydropower) between 2010 and the first half of 2019, followed far behind by the US at 356 billion and Japan at 202 billion.[15] In 2018, China led the world in spending on offshore wind, concentrating solar power, distributed solar, industrial and building energy efficiency, renewables for transport and heat, energy R&D, grid-scale battery storage and transmission grids.[16]

Between 2009 and 2017, Chinese national and local authorities also spent nearly 60 billion US dollars to promote the electric vehicle industry. This includes subsidies for NEV purchases and battery manufacturing, research and development, government procurement and tax exemptions.[17]

The impact of China's massive bet on clean energy technologies has been extraordinary. China now leads the world in wind and solar PV power, bioelectricity, solar water heating and geothermal heat output.[18] China has the largest wind and solar installed capacity in the world – 210 GW of wind and 200 GW of solar, which is twice as much as the US, the next largest market. In 2018, China accounted for

[13] Development Solutions Europe, *Improving EU Access to National and Regional Financial Incentives for Innovation in China. Third Ad Hoc Study: China's Initiatives in Clean Energy Research and Innovation*, January 2019, https://www.cdti.es/recursos/doc/Programas/Cooperacion_internacional/Chineka/Documentacion_relacionada/31807_124124201912507.pdf.

[14] Mission Innovation website: *Our Members: China*, http://mission-innovation.net/our-members/china.

[15] Frankfurt School-UNEP Centre/BNEF, *Global Trends in Renewable Energy Investment 2019*, Frankfurt am Main, September 2019, https://www.unenvironment.org/resources/report/global-trends-renewable-energy-investment-2019.

[16] International Energy Agency (IEA), *World Energy Investment 2019*, May 2019, https://webstore.iea.org/world-energy-investment-2019.

[17] Scott Kennedy and Mingda Qiu, "China's Expensive Gamble on New Energy Vehicles", in *CSIS Commentaries*, 6 November 2018, https://www.csis.org/node/48217.

[18] REN21, *Renewables 2019 Global Status Report*, cit.

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one-third of global wind power capacity and one-third of global solar PV capacity.[19]

Seven of the top ten solar panel manufacturers in the world, and all the top three, are Chinese companies. Five of the top ten global onshore wind turbine manufacturers, including Goldwind, the second largest in the world, are also Chinese-owned or operated. These wind turbine manufacturers were together responsible for 90 per cent of the global market in 2018, although virtually all their sales were to the Chinese domestic wind market.[20]

China is now actively pursuing offshore wind, a potentially game-changing technology the International Energy Agency forecasts will increase fifteen-fold to 2040, becoming a 1 trillion US dollar market.[21] China hopes to install 40–50 GW of offshore wind capacity by 2030. In 2018, China invested 11.7 billion US dollars in offshore wind, nearly half of the world total, and installed more offshore wind capacity than any other country. China is also starting to build its internal capacity in manufacturing and technology, hoping to bring down the cost of offshore wind technology as it did for onshore wind and solar.[22]

On the transportation side, China is also the largest producer and deployer of high-speed rail, subways, lithium-ion batteries and electric vehicles – including electric cars, buses, taxis, low-speed vehicles and bicycles. Ninety-nine per cent of the world's electric buses are in China, with almost one-fifth of the country's bus fleet electrified. The country also has the world's largest EV charging infrastructure, with nearly 500,000 public charging connectors and over one million private slow chargers. In 2017, seven of the top ten EV battery companies were in China. Analysts forecast that the country will capture 65 per cent of the battery market by 2021.[23]

Thanks in large part to China's efforts, the price of clean energy technologies has dropped dramatically throughout the world. The cost of solar power has plummeted by nearly 90 per cent in the last decade, and wind by nearly 50 per cent. More than two-thirds of the world's population now live in countries where solar and wind are the cheapest source of new energy generation.[24] As a result, the world has added

[19] "End of the Year Wrap-Up: Five Figures Show China's Renewable Energy Growth in 2019", in *Renewable Energy World*, 1 December 2019, https://www.renewableenergyworld.com/?p=304052.

[20] "Vestas Leads Break-Away Group of Big Four Turbine Makers", in *BloombergNEF*, 14 February 2019, https://about.bnef.com/?p=160071.

[21] International Energy Agency (IEA), *Renewables 2019*, Paris, IEA, 2019, https://www.iea.org/reports/renewables-2019/power.

[22] Tim Buckley and Kashish Shah, *Offshore Wind Ready to be a Key Part of Energy Mix Globally*, Ohio, Institute for Energy Economics and Financial Analysis (IEEFA), October 2019, https://ieefa.org/?p=33332.

[23] Robert Rapier, "Why China is Dominating Lithium-Ion Battery Production", in *Forbes*, 4 August 2019, https://www.forbes.com/sites/rrapier/2019/08/04/why-china-is-dominating-lithium-ion-battery-production.

[24] Lynn Doan et al., "What's Behind the World's Biggest Climate Victory? Capitalism", in *Bloomberg*, 15 September 2019, https://www.bloomberg.com/graphics/2019-can-renewable-energy-power-the-world.

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more net capacity for renewable power than for fossil fuels and nuclear combined for a fourth year in a row.[25]

China has also played a major role in the rapidly dropping cost of electric vehicles worldwide, driven by falling battery manufacturing costs. Average lithium-ion battery pack prices fell 87 per cent between 2010 and 2019. Electric vehicles are now expected to become cost-competitive with fossil fuel vehicles as early as 2022.[26]

4. Challenges

Despite this remarkable progress, China still faces myriad challenges in scaling up renewable energy and electric vehicles to the point where they represent more than a fraction of China's energy and vehicle markets. The country is still building new coal-fired power plants at a rapid rate, thanks in large part to overenthusiastic local governments. Virtually none of these plants, however, are needed. Capturing the enormous opportunities to further improve energy efficiency in buildings and industry would reduce energy growth to where it could be met fully with renewable energy.

Instead, a glut of existing coal plants and the falling cost of renewables means that 40 per cent of China's coal plants are already operating at a loss – a figure that is expected to rise to 95 per cent by 2040.[27] Yet the China Electricity Council, a powerful industry association, is calling for an increase in the cap on total coal-fired capacity from 1,100 GW to 1,300 GW by 2040. Even though these plants will likely become stranded assets that will never provide a return on investment, China nonetheless runs the risk of locking in high-carbon infrastructure for decades to come and threatening global climate goals.

The central government is working to level the playing field for renewables by revising grid rules that were designed decades ago to make building new coal plants virtually risk free. New rules call for priority dispatch of renewable energy and require utilities to pay compensation to generators if the grid companies fail to connect all renewable energy generated in their service territory. Provincial governments and grid companies must now meet renewable energy quotas based on actual consumption rather than generation, a move designed to reduce curtailment.[28] The government has also asked China's five largest state-owned

[25] REN21, *Renewables 2019 Global Status Report*, cit.

[26] Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost", in *Bloomberg*, 12 April 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost.

[27] "40% of China's Coal Power Stations Are Losing Money," in *Carbon Tracker*, 11 October 2018, https://www.carbontracker.org/40-of-chinas-coal-power-stations-are-losing-money.

[28] Curtailment means that wind or solar energy production had to shut down because the grid could not absorb the power or had no economic incentive to do so, the energy could not be stored, or other types of energy like coal were given priority.

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power companies to cut coal power capacity by one-quarter to one-third in several provinces.

China's efforts to reduce curtailment of renewable energy have begun to pay off. In 2018, the country generated more solar energy than the entire power generation of the United Kingdom and the Netherlands combined. By the end of 2019, national average curtailment was reduced to 4 per cent for wind and less than 2 per cent for solar, down from 17 per cent in 2016.

Yet China's solar and wind industries are now facing an even greater challenge, as the government scales back subsidies in response to the rapidly falling price of renewables and a 16 billion US dollar deficit in the renewable energy subsidy fund. China will now give priority to new solar and wind projects that agree to forego subsidies and compete directly with coal-fired power. These so-called "grid parity" projects do not need to obtain central government approval, must be given preferential treatment by local governments, and are guaranteed a power purchase agreement of at least 20 years with the grid company. Other new solar and wind projects must compete in auctions, with the lowest bidders awarded subsidies from an increasingly shrinking subsidy pool. The government plans to end renewable energy subsidies completely in the next year or two.

This shift away from subsidies has caused considerable turmoil throughout China's renewable energy industry, leading to fierce competition among solar PV suppliers. Auctions have triggered record low bid prices for new wind and solar power.[29] The shake-up meant that the amount of solar capacity China added in 2019 was an estimated one-third lower than the previous year.[30] But even with the slash in renewable energy subsidies, the country was still the world's largest investor in renewables in 2019, contributing more than 83 billion US dollars of the 282 billion global total.[31] Moreover, plunging solar module prices have triggered major increases in demand for solar PV technology in overseas markets, including India, Japan, Brazil, Mexico, the Netherlands and Spain. Solar exports in the first half of 2019 increased by over 10 billion US dollars.[32]

Even more important is the fact that new solar and wind projects in China are beginning to demonstrate that they can compete successfully with coal. China announced its first set of unsubsidised "grid-parity" solar and wind projects in May 2019. The country's largest unsubsidised solar project, a 500-megawatt (MW)

[29] REN21, *Renewables 2019 Global Status Report*, cit.

[30] Li Liuxi et al., "Solar Power Fades With End of State Support, but Seen Stabilizing in 2020", in *Caixin*, 6 December 2019, https://www.caixinglobal.com/2019-12-06/solar-power-fades-with-end-of-state-support-but-seen-stabilizing-in-2020-101491533.html.

[31] "Late Surge in Offshore Wind Financings Helps 2019 Renewables Investment to Overtake 2018", in *BloombergNEF*, 16 January 2020, https://about.bnef.com/?p=178713.

[32] Frank Haugwitz, "Towards a Subsidy-free Era for China's Solar PV Market", in *Apricum*, 19 November 2019, https://www.apricum-group.com/towards-a-subsidy-free-era-for-chinas-solar-pv-market.

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plant, just opened in Liaoning Province. The province of Qinghai went without coal power for a record 15 consecutive days last summer, relying completely on renewables to meet its energy needs. Analysts forecast that by the mid-2000s, wind and solar will reach grid parity with coal-fired power throughout the country.[33]

China is also scaling back subsidies for electric vehicles, which were cut in half in June 2019, causing an immediate drop in sales and threatening the viability of weaker companies. Annual sales figures for 2019, however, revealed that electric vehicles fared much better than fossil fuel vehicles, sales of which slumped by an unprecedented 8.4 per cent in the world's largest automobile market. Sales of electric vehicles, in comparison, fell by only 4 per cent, from 1.26 million to 1.21 million, equal to the total number of electric vehicles on the road in the US today. Analysts predict electric vehicle sales in China to rebound in 2020 even as fossil-fuel vehicle sales continue to fall.[34] The internal combustion engine may already have peaked.

5. The next phase of China's energy transition

The next phase of China's clean energy transition will depend in large part on the blueprint provided by the upcoming 14th Five Year Plan (2021-2025). This will be finalised in March 2021, followed by more detailed regional and sectoral plans, including five-year plans for energy development, power development and science and technology. On 6 January 2020, China's National Energy Administration (NEA) gave some hint of what to expect for the power sector. The NEA indicated that in the next five years, China's power sector will focus, among other things, on continuing power sector reform, fully mobilising demand-side resources, strengthening energy savings and energy efficiency, promoting the green energy transition as well as "clean coal," and pursuing technological innovation and international collaboration.[35]

In the meantime, China is moving ahead with plans for its energy and transportation sectors to join the fourth industrial revolution. This refers to transformational changes brought on by the connection between people, objects and spaces, using advanced information and communication technologies.[36] China's State Grid Company, the world's largest utility, has launched an ambitious smart grid roadmap called the "Ubiquitous Power Internet of Things." The plan calls for

[33] Wood Mackenzie, *China's Renewables Cost to Fall Below Coal Power by 2026*, 22 August 2019, https://www.woodmac.com/our-expertise/focus/Power--Renewables/chinas-renewables-cost-to-fall-below-coal-power-by-2026.

[34] Maximilian Holland, "China 2019 Electric Vehicle Market Share Grows to 4.7% Despite Tighter Incentives", in *CleanTechnica*, 13 January 2020, https://cleantechnica.com/?p=200066.

[35] China's National Energy Administration (NEA), *14th Five-Year Plan Power Planning Work Started* (in Chinese), 15 January 2020, https://mp.weixin.qq.com/s/CT-AQBxHc1ulA-NjhhUPtw.

[36] Samsung SDI website: *Battery and the Fourth Industrial Revolution*, https://www.samsungsdi.com/column/technology/detail/55162.html.

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building a smart ultra-high voltage transmission system alongside urban and rural distribution grids to link the internet to the nation's electricity supply and support the development of smart cities.[37] Pilot projects will include the integration of clean energy, energy storage and microgrid technologies, as well as smart demand management, EV charging and battery-switching facilities.[38] The first phase of the project is scheduled to be completed in 2021.

Developing energy storage technologies with large capacities and high efficiency is key to the global clean energy transition. After a period of exuberant development in 2018, in which China added as much battery-storage capacity as all previous years combined, the government put on the brakes. It ruled that grid company investments in energy storage infrastructure cannot be included in transmission and distribution power prices, presumably until the industry is on a more solid footing.

The China Energy Storage Alliance recognises that grid-side energy storage in China does not yet have a clear business model to support stable, long term development. The NEA is now working to develop new energy storage policies, create implementation plans for energy storage standardisation and select new energy storage pilot projects. The Ministry of Science and Technology has proposed a special project for energy storage R&D in the 14th Five-Year Plan, focusing on high safety, long life, high efficiency, low cost, large-scale, long duration and sustainable development.[39]

On the mobility side, in December 2019 the Ministry of Industry and Information Technology (MIIT) released for comments a draft New Energy Vehicle Industry Development Plan for 2021-2035.[40] The draft plan calls for increasing the target for NEV adoption to 25 per cent of all new vehicle sales by 2025, a large jump from their 4.7 per cent share today. It also addresses battery supply chain and recycling issues, supports increased R&D in priority areas and calls for a comprehensive strategy leading to the commercialisation of hydrogen fuel cell vehicles.

According to Bloomberg New Energy Finance (BNEF), the draft plan "does not simply see EVs as a direct replacement for internal combustion vehicles. The plan sees EVs as part of a broader integrated strategy around shared mobility,

[37] Laurie Chen, "China's Largest Utility Plans a National Power Grid Integrating Internet of Things Technologies", in *South China Morning Post*, 26 October 2019, https://www.scmp.com/print/news/china/society/article/3034684/chinas-largest-utility-plans-national-power-grid-integrating.

[38] REN21, *Asia and the Pacific Renewable Energy Status Report*, Paris, November 2019, https://www.ren21.net/asia-report-2019.

[39] China Energy Storage Alliance (CNESA), *How Can We Overcome an Industry Slowdown?*, 30 December 2019, http://en.cnesa.org/latest-news/2019/12/30/how-can-we-overcome-an-industry-slowdown.

[40] China's Ministry of Industry and Information Technology (MIIT), *Development Plan of New Energy Vehicle Industry (2021–2035)*, draft for comments (in Chinese), Beijing, 3 December 2019, http://www.miit.gov.cn/n1278117/n1648113/c7553623/content.html.

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autonomous vehicles, integration of renewables and power system flexibility, and aims to stimulate innovation throughout these areas."

Conclusion and recommendations

China's remarkable leadership has brought it – and the world – to the cusp of a clean energy revolution. The transition to renewable energy and clean transportation is creating jobs, improving the quality of life and bringing economic benefits to millions of people. As the cost of these technologies continues to plummet, they are beginning to crowd out fossil fuels. It will soon be cheaper to build new wind and solar plants than continue to run existing coal plants. The internal combustion engine may already have peaked in China.

To become a world leader in technology and innovation, China will need to further accelerate its transition to clean energy. The fourth industrial revolution is leading us away from the model of large centralised power plants to a decentralised but increasingly interconnected system where people generate, store and manage their own power, linking their homes, electric vehicles and workplaces. Smart buildings and cities, automation and advanced mobility systems will require increasing amounts of electricity. Renewable power is the fuel that will enable these new systems and technologies to flourish. In turn, artificial intelligence can help to improve the efficiency, flexibility and resilience of renewable power systems.

China recognises that reforming its outdated power sector is key to this energy transition. Priorities include operationalising power sector reform policies that that allow zero-marginal cost renewable energy to compete with coal power; establishing regional power markets to increase system flexibility and renewables integration; using markets to encourage coal plants to shift from baseload to supporting roles; and including distributed/demand-side resources in electricity planning to avoid the need for adding additional coal power capacity and generation.

China also recognises that setting ambitious targets for clean energy technologies encourages manufacturers to innovate and apply economies of scale to improve the technology and drive down costs. Setting increasingly stringent targets for phasing out fossil fuels can have the same impact. The upcoming 14th Five Year Plan provides an important opportunity to tighten the existing cap on the share of coal in China's primary energy consumption, from the current 58 per cent to under 50 per cent by 2025. China has also vowed to show "the highest possible ambition" in strengthening its climate pledges by December 2020, the fifth anniversary of the Paris Agreement. Many Chinese experts believe the country can peak its CO_2 emissions by 2025 and increase the share of renewable energy to far more than 20 per cent of its energy mix.

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Clean energy is the key for achieving China's transition to a "new normal" of slower but higher quality growth. Accelerating the retirement of inefficient and uneconomic coal power capacity would provide enormous economic benefits. Limiting the construction of new coal plants – which are otherwise destined to become stranded assets – could save billions of dollars while facilitating the integration of cheaper renewables on the grid. These measures, along with strong environmental and climate policies, would help ensure the robust and sustainable development of China's economy while reducing emissions, improving public health and protecting the global climate.

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