





Energy Planning and Climate Policy Special Report

China Nationally Determined Contribution (NDC) and Domestic 14th Power Five-Year-Plan (FYP)

Draworld Environmental Research Center Centre for Research on Energy and Clean Air

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About us

Draworld Environment Research Center (Draworld)

Draworld Center was founded in 2012, and comprises a small team working on applied research and policy consulting on China's energy and environment issues, and sectoral dynamics. In a more fragmented and less rule-based international regime, our recent work focuses on how China would interact with big players, such as those in the United States and the European Union in the energy and climate industries.

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CREA is a new independent research organisation focused on understanding the trends, causes, health impacts and solutions to air pollution. CREA uses scientific data, research and evidence to support the efforts of governments, companies and campaigning organizations worldwide in their efforts to move towards clean energy and clean air, believing that effective research and communication are the key to successful policies, investment decisions and advocacy efforts. CREA was founded in December 2019 in Helsinki and has staff in several Asian and European countries.

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Executive Summary

Background

Responses to the coronavirus pandemic took centre stage in most countries throughout 2020. While we hope that this damaging health and economic crisis will be alleviated and soon disappear from the headlines of the newspapers, the urgency of another defining global challenge – climate change – has not diminished.

One prerequisite to achieve climate security is the rapid decarbonisation of the energy sector to meet zero-emissions around the middle of this century and then decline to negative territory. To achieve the Paris Agreement target to limit the average global temperature rise this century to below 2 °C, emissions from the energy sector would need to peak as soon as possible and show a clear decline by 2030.

Comparing these global emissions guideposts with the current nationally determined contributions (NDCs) of countries, there are still obvious gaps. The upcoming years till 2023 provide a time window to increase the ambition with updated NDCs and to peer-review the national submissions.

China's pledge to aim for carbon neutrality by 2060 will inject much-needed momentum to the new international climate negotiations. One way to measure the potential for China's long-term vision to reduce carbon dioxide (CO_2) emissions is to analyse changes to the country's policy actions over the next five years, that is, the 14th five-year-plan (FYP) and/or ten-year plan. The energy and emissions pathway set out in the 14th FYP will be an indicator of China's commitment to a carbon-neutral vision. To achieve net-zero emissions, China will need to implement stringent measures as early as possible. The country's efforts will be closely monitored by international peers.

The purpose of the report

China will finalise its 14th economic, energy and electric power FYP (2021–2025) around the end of 2021. Therefore, the next 1-2 years will be important for China to formulate its domestic FYP and international NDC.

This report aims to contribute to the planning process, analysing the implementation of the NDCs and the long-term vision.

This report tracks China's progress and achievements towards its Climate Pledge 2020, made at the Copenhagen Conference of the Parties climate change meeting, and its NDC 2030. This

report also includes an empirical study on how the 14th FYP and NDC documents were prepared by government agencies and the changes expected in the new round 2020–2021.

This report discusses China's emissions constraints under the explicit effort-sharing approach. The so-called 'Compatible China Coal Power Pathway 2020–2030' was developed to reflect the emissions constraint for the coal power sector, which will need to be incorporated into the domestic FYP if China is to meet its zero emissions target.

The report's analysis focuses on renewable energy and coal power and quantifies their roles and pace before 2030, based on identifying the optimal power mix that minimizes system costs (using the screening curve approach) under constraints, with and without carbon pricing.

The final section provides reflections and key recommendations in terms of government operation so that the international NDC and domestic FYP can be fully aligned.

Main findings

The analysis shows that:

- Based on progress up to the end of 2019, China can overshoot the targets set in the Copenhagen COP meeting, i.e. the 15% non-fossil fuel and 40-45% carbon intensity decline targets. Connecting with the 13th FYP on energy and power, the renewable energy capacity and generation targets will be met or exceeded (esp. solar PV), while the targets for nuclear and gas are falling short. The targeted decline of the share of coal in the energy mix will also be exceeded.
- China's share of global emissions increased from less than 20% in 2010 to around 26% in 2019. Coal-fired power plants are China's single largest CO₂-emitting sector. The targets and development of coal power capacity will be seen as a key litmus test for the peaking target. China currently has approximately 130GW of excess coal-fired capacity, out of a total capacity of 1100 GW. In the absence of a carbon price signal, we project that the lowest cost capacity mix for 2030 would include 1020GW of coal, a small reduction from 2020. Stakeholders' expectations for coal power in 2030 have been 1300 GW or higher, which imply a life-cycle loss because of stranded assets over 2000 billion RMB. This issue requires the public attention and deliberations of the whole society. Furthermore, taking into account the CO₂ peaking target and the reasonable contribution of the power sector, a capacity level of 680GW would be optimal in 2030. This goal requires effective and additional carbon pricing, at the level of around 200 RMB per ton to achieve in a standard absolute-cap ETS system. In China's forthcoming "tradable"

efficiency standard" system, the price should be higher to achieve the targeted emission.

- To achieve China's non-fossil power target of 50% by 2030, the growth of wind power and solar PV needs to be doubled in comparison to the average over the past 10 years to achieve a share of more than 20% of all power generation by 2030. To compensate for the large probability of deceleration of hydro and nuclear power, 25% is a more robust figure.
- Based on data analysis, the report makes policy recommendations for China's updated NDC, which includes a moratorium or ban of new coal-fired power plants; the launch of a policy agenda to phase out coal-fired power plants, the introduction of a carbon market floor price and strict intensity benchmarks. These specific actions would help China to achieve peak emissions from the energy sector sooner than 2030 and contribute to the overall carbon neutrality target.
- Improved coordination on the level of implementing policies is needed to ensure the success of collective actions. The climate policy think tank, national climate strategy centre and its ministerial supervisor, China's Ministry of Ecology and Environment, should be more visible and exert influence in the preparation process of all kinds of FYP and sub-FYP in the energy domain. There is still room to improve in terms of the harmonisation in the work layer and on the operational issues.

Reflections

China has already set the long-term vision of carbon neutrality by 2060. This is a big step to define specifically how low is low carbon in China's widely-agreed energy strategy: building an energy system characterised by cleanness, low carbon, security and high efficiency. There is no leeway to construct new long-lived fossil fuel infrastructure such as coal power, which would need premature retirement to meet China's vision to achieve net-zero emissions.

Contents

About us	1
Executive Summary	2
Glossary	6
Acknowledgements	7
Chapter 1 Paris Agreement & China's NDC progress 1.1 Paris Agreement & China's climate commitment 1.2 China 2019/2020 progress	8 8
Chapter 2 China's Five Year Plan and International Commitments 2.1 China's Five Year Plan 2.2 Coordinating energy planning with climate targets	12 12
Chapter 3 China: Sharing responsibility on emission reduction and restricting coal power 3.1 The Paris Agreement and its implications for global emission reduction targets 3.2 China in the World: Sharing Emission Reduction Responsibilities 3.3 Considering climate for coal power: emission reduction based on efficiency	13 13 14 16
Chapter 4 Focusing development of coal power and renewable energy 4.1 Roadmap of renewable energy towards 50% non-fossil electricity target by 2030 4.2 Coal Power overcapacity: A long lasting problem 4.3 Recommendations for China's 2030 NDC updates	19 19 20 23
Chapter 5 Summary and Recommendations 5.1 Fulfill an ambitious 2030 NDC 5.2 Recommendations on the policy process	26 26 27
References	29
Appendix	32

Glossary

Term	Interpretation / Reference
UNFCCC	United Nations Framework Convention on Climate Change (www.unfccc.int)
Nationally Determined Contribution, NDC	Core emission reduction paradigm from Paris Agreement: A voluntary determined emission reduction target by all countries and subject to collective review and updates.
FYP	Five-year Plan
Energy Transition	Structural change of the energy system, mainly the substitution of fossil fuel energy with renewable energy, and related issues regarding technology, economy, policy and politics
Two "up and down flow" of the plan system harmonisation	A vertical coordination mechanism between central and provincial governments
Downscaling	Derive individual/subgroup (e.g. sector or national) constraints from overall (e.g. global) constraints
Optimal power mix	energy mix structure optimized to minimize system cost using Screening Curve without considering incumbent power generation units
Carbon pricing	Set price for carbon emission with theoretical implementations of carbon tax or carbon emission trading market, which are equivalent under certain circumstances
Non-fossil energy	Renewable energy + nuclear power in primary energy consumption
Non-fossil electricity	electricity generated with renewable energy (hydro, wind and solar PV) + nuclear power
Efforts-sharing approach	Shared responsibility of emission reduction or emission budget by country under a global target (budget)
Screening curve	A method to determine optimal system capacity structure based on cost structure of various power generation technology

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Chapter 1 Paris Agreement & China's NDC progress

1.1 Paris Agreement & China's climate commitment

Climate change is one of the most important and long-lasting global challenges. The IPCC's Fifth Assessment Report, published in 2014, concluded that cumulative global emissions must be limited to about 1,000 Gt CO_2 eq (gigatonnes of carbon dioxide equivalent), an amount that will be exceeded in just 20 years unless emissions start to decline substantially.

The Paris Agreement, adopted in 2015, recommended the maximum global average annual temperature increase to be no more than 1.5°C above pre-industrial levels. In later reports, 1.5°C was interpreted as a collective target for all countries around the globe to act with rapid and deep energy transition.

The 1.5°C target is stringent enough to be interpreted with the obvious response actions: peak emissions sooner followed by rapid drop, reach a zero-emission within 20-30 years, and even reclaim carbon with negative emission technology.

China submitted its NDC in 2015 to the UNFCCC to pledge the following goals¹:

- To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;
- To lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level;
- To increase the share of non-fossil fuels in primary energy consumption to around 20%;
- To increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level;
 and
- Continue to proactively adapt to climate change ... and progressively strengthen early warning and emergency response systems and disaster prevention and reduction mechanisms

http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/33978/35364/xgzc35370/Document/1514539/1514539.htm

This report analyses factors contributing to carbon dioxide emissions and assesses the credibility of a roadmap towards peak emissions in 2030:

- Peak emissions will require a decrease in fossil fuel consumption. With continued growth in demand for natural gas for heating and household fuel, and growth of petroleum consumption in transportation, peak emissions will be largely dependent on decreased coal consumption.
- Peak emissions will require that the rate of decrease of carbon intensity of energy exceeds the growth of energy consumption.
- Peak emissions will require that the rate of decrease of carbon intensity of GDP exceeds the growth rate of GDP, whereas the energy intensity of GDP is highly correlated with the industrial structure

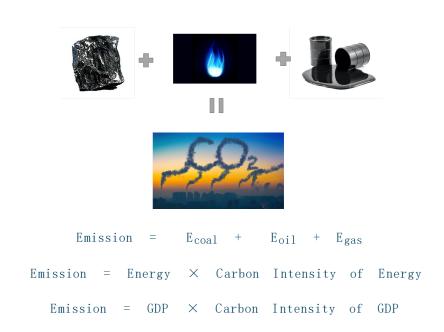


Figure 1-1. Identity on carbon emission determination

The carbon intensity of energy or of GDP is affected by the share of non-fossil fuel energy within the energy mix. In most scenarios, the non-fossil fuel target is the prerequisite of other targets, and is also the one of the hardest to achieve.

1.2 China 2019/2020 progress

China has been making rapid progress towards its Copenhagen and Paris targets. In He Jiankun's assessment (2019), CO_2 intensity of GDP has dropped 48% compared to the level in 2005, and is predicted to decline by more than 50% in 2020. The Ministry of Ecology and Environment also released calculations that carbon intensity has dropped 45.8% and 48.1% in 2018 and 2019, respectively.

The estimation made in this report suggests that CO_2 intensity of GDP in the energy sector has dropped 47.2% and 49%, respectively.

The use of renewable energy has expanded. Wind power capacity grew by an average of 20GW per year during the 13th FYP period (2015-2020), while solar power reached an installation of over 200GW. Non-fossil fuel energy (renewable + nuclear power) has taken 15.7% of primary energy consumption, while solar and power together generated more than 8.5% of total electricity.

Table 1-1. Economic, social and energy parameters

	2005	2010	2015	2019
GDP (2005 constant price, 100 million Yuan)	185896	317682	463889	596778
Electricity demand (TWh)	2494	4194	5802	7325
Total energy consumption (10,000 tce)	261369	360648	429905	486000
GDP energy Intensity (tce/10,000 Yuan)	1.41	1.14	0.93	0.81
GDP CO ₂ Emission intensity (tCO2/10,000 Yuan)	3.2	2.5	2.0	1.6
Proportion of non fossil fuel in primary energy mix	7.4%	9.4%	12.1%	15.7%
Proportion of non fossil fuel electricity	18.0%	20.5%	26.7%	30.5%
Proportion of wind and solar in power mix	0.0%	1.1%	3.9%	8.6%

Source: China Statistical Yearbook (2019), China Statistical Report (2019), China Energy Statistical Yearbook, China Electric Power Yearbook, etc.

The progress made by 2019 is sufficient for China to claim an achievement for its commitment from 2009's Copahagen climate summit ahead of time: reduction of carbon intensity of GDP and share of non-fossil fuel in the energy mix.

Although China is making progress well in reducing its carbon intensity, CO₂ emissions are increasing and are responsible for at least one-quarter of the world's total emissions.

China has set a domestic goal of reaching 50% non-fossil electricity in its power mix by 2030, which sets one more stringent constraint than the current NDC for energy transition roadmap. The implications of this target for the period of 2020-2030 are analyzed in Chapter 4.

Chapter 2 China's Five Year Plan and International Commitments

2.1 China's Five Year Plan

The Five-Year Plan (FYP) is being used by China as a periodic planning tool to set goals and visions for economic and social development. The drafting of the 14th FYP was started in 2019. The Central Committee has suggested overarching goals and guidelines in October, 2020 for economic and social development during 2020-2035, despite vague qualitative statements. Moreover, a climate-specific FYP and a corresponding action plan will be announced in the second half of 2021.

Once released, the FYP will become the main reference for any subsequent energy and climate policy targets.

2.2 Coordinating energy planning with climate targets

Electricity development planning is coordinated by China's National Energy Administration (NEA), whereas climate policy planning is led by the Ministry of Ecology and Environment (MEE).

Government agencies usually delegate the planning task to a research institute or think tank, which would enable the participation of various stakeholders.

Historically, this has brought several challenges into the planning process:

- Planning a specialized sector with fewer stakeholders is often developed by one institute with limited iterations
- The author who drafted the plan may not clearly illustrate the criteria, objectives or substantiation for key targets or measures.
- As China's climate policy-making is reorganized under MEE, it is still unclear how MEE will be involved in the energy or electricity development planning led by the National Energy Administration.

Chapter 3 China: Sharing responsibility on emission reduction and restricting coal power

3.1 The Paris Agreement and its implications for global emission reduction targets

Achieving the commitment from the Paris Agreement is a difficult task. Roelfsema et al. (2020) showed that the optimal path to achieve the 2°C goal of the Paris Agreement implies a 30%-60% reduction compared to the 2010 level by 2030. If the NDCs are fully implemented, there is still a gap of emission reduction of 7-10 Gt CO2eq between the NDC goal and the optimal emission reduction path.

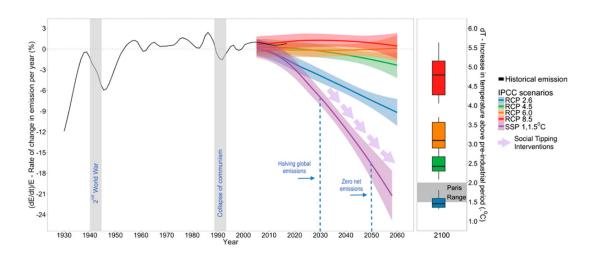


Fig 3-1. The unprecedented challenge of ensuring climate security

Source: Otto et al. (2020)

3.2 China in the World: Sharing Emission Reduction Responsibilities

Setting China's emission budget involves subjective judgments and various value standards which should include the allocation of rights of emission or obligations of reduction (Lyer et al., 2017), which could be explicit or implicit. We need to emphasize that the region where emission reductions occur may not necessarily be the region that bears the cost of emission reductions.

In this report, we assess the feasibility of China's emission reduction roadmap and associated risks. The simulation of Molina et al. (2020) shows that if China takes proactive actions, it may push other stakeholders for more actions and leans toward matching the commitment agreements. To derive the constraints of China's power industry from the perspective of risk management, we implement a top-down strategy: we downscaled the coal power pathways from the total amount to a year-by-year breakdown, from the world to China, from the entire economy to a single power sector. Through this process, we derived and named it as *Compatible China Coal Power Pathways 2020-2030* to set a constraint for the development of coal power.

Fig 3-2 Downscaling from the global target to power sector constraints



Among the five stages of the downscaling process, the 1st and 2nd stages are covered by plenty of global scope studies based on the large-scale integrated assessment model (IAM), most of which set the objective as "economic efficient" and/or "best time path" with varied settings such as whether to allow over-shooting, whether to have CCS and to what extent. We

have selected a representative emission trajectory from Rogelj et al. (2020), which is based on the IPCC AR5 database²

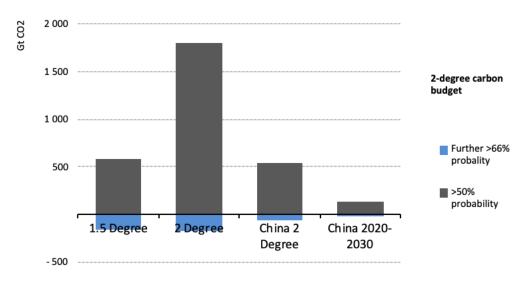


Fig 3-3 World and China's emission budget, 2018-2100

Source: Global budget from Rogelj et al. (2019), China constraints from this report

The derivation from step 2 to step 3 is politically sensitive and difficult, even in previous discussions at the COP meetings. It often involves the interpretation of equity, fairness, and common-but-differentiated principles.

Regarding China's international commitments and peer pressure, there are three questions to be answered:

- Will China achieve peak emissions by 2030?
- After increasing its share of global emissions from less than 20% in 2010, to more than 25% at the moment, is China's share going to increase further?
- Will China be able to drop its emissions level after 2030 sharply to keep in line with the 2°C target trajectory, and credibly achieve the 2060 carbon neutrality promise?

Our preliminary analysis shows that by 2019, China's annual CO_2 emissions from fossil fuel accounts for about 26% of the world's total. We base the analysis on the judgment that China should not exceed 30% of the world's total emissions at any point in time. This is a subjective

 $^{^2\,}https://iiasa.ac.at/web/home/research/researchPrograms/Energy/IPCC_AR5_Database.html.$

setting that could potentially shed light on the three questions above. In this setting, China will have a CO₂ budget of 493Gt and 125Gt for 2020-2100 and 2020-2030.

If China follows a path to achieve carbon neutrality by 2060, then there is no doubt that China will lead the world in climate governance.

45
35
25
15 China

1.6 Degree (no overshooting)
2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
2.1 Degree
1.8 Degree

Fig 3-4 Representative best available emission reduction pathways: World vs China

Source:

https://www.carbonbrief.org/analysis-global-fossil-fuel-emissions-up-zero-point-six-per-cent-in-2019-due-to-china for the historic data on CO2 emission from fossil fuel.

3.3 Considering climate for coal power: emission reduction based on efficiency

This section aims to discuss the climate obligations of China's power industry in the next decade (2020-2030) based on the budget set above.

2000 2010 2019 2025 2030 2070 2100 2020 2050 39.6 33.3 -7.4 2.1 degree Global 40.0 39.4 39.8 12.8 scenario emission (Billion tone)

Chart 3-1 Carbon emission constraints setting

China fossil fuel CO2 emission (Billion tone)	3.4	8.2	10.3	9.8	11.4	11.0	6.6	0.9	-3.6
Power sector - coal power industry (Billion tone)	1.2	3.2	4.0	3.7	3.1	2.5	0.0	0.0	0.0
Ratio of coal power emission to fossil fuel emission	36%	39%	39%	38%	27%	22%	0%	-	-

Source: China's historical emission data

https://www.carbonbrief.org/analysis-global-fossil-fuel-emissions-up-zero-point-six-per-cent-in-2019-due-to-china;https://www.carbonbrief.org/in-depth-bp-data-reveals-clean-electricity-matched-coal-for-the-first-time-in-2019

Typical trajectory under 2.1 degree climate target emission budget, Rogelj et al. (2019b).

Historical emissions from coal power in the power sector: author's calculation and Zhang & Qin (2016)

The power sector often accounts for more than 40% of all-sector emissions, and has a variety of low/zero carbon technology options (Ang and Su, 2016) such as wind and solar power which are increasingly cost-competitive. Compared with transportation and building, the power sector tends to have lower emissions reduction costs. Given that China has set the goal of carbon neutrality by 2060, the power sector needs to achieve zero emissions as soon as possible. In particular, coal power should be phased out more rapidly in a cost-effective manner, to lay a realistic foundation to eliminate all coal power and achieve zero emissions by the middle of this century.

The term "rapid" isn't well defined, so we use a "linear decline" path from the peak in 2020 to zero emissions by 2050. By 2030, annual emissions from coal power need to be restricted to around 2.5Gt CO₂ to anticipate zero emissions by 2050 and a further goal of carbon neutrality.

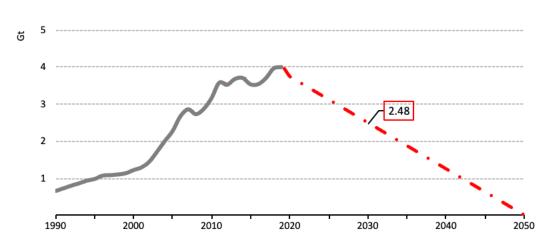


Fig 3-5 Emission reduction pathways for coal power (2020-2050)

Source: Historical emission from the coal power sector: updated based on Zhang and Qin (2016).

Chapter 4 Focusing development of coal power and renewable energy

4.1 Roadmap of renewable energy towards 50% non-fossil electricity target by 2030

After submitting the 2015 climate NDC, China announced its Energy Production and Consumption Revolution Strategy (2016-2030) in 2016, which set a goal that "by 2030, the ratio of non-fossil power generation to total should reach 50%." With a current share of 32%, the non-fossil sector needs to expand more rapidly than traditional energy sources. Zhang et al. (2018) suggested that the 50% non-fossil target is more stringent than the various targets of the climate NDC.

Nuclear power and large hydropower are inevitably slowing down in China. The security costs of nuclear power are increasing, the fixed investment is huge, and the site selection is difficult. The actual progress is much lower than the expectations set before the Fukushima accident in Japan. The cost of investing in hydropower is rising so rapidly that building a cheap hydropower plant is no longer valid. Also, hydropower units are often located in remote areas where transmission costs greatly reduce their economic value.

Under such conditions, the growth of wind and solar power needs to at least double by 2030, and the annual installed capacity of new wind and solar power should reach 100GW, sharing 20%-25% of all power generation. Then it might be robust to achieve the goal of 50% non-fossil electricity in 2030 in an uncertain future.

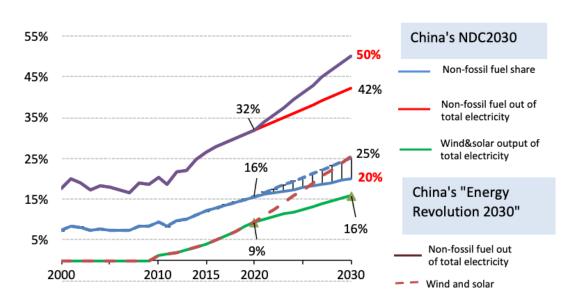


Fig 4-1 China's Climate NDC target and domestic 50% non-fossil power target

Source: revised based on Zhang, et al. (2018), updated with 2018-2019 data using data from National Bureau of Statistics and China Electricity Council.

4.2 Coal Power overcapacity: A long lasting problem

Modeled as "ballast stone" and "stabilizer", coal power still occupies a significant share in China's power mix³. Although this metaphor is not necessarily legitimate⁴, it reflects the status quo of China's energy structure, management system and thinking pattern.

The local government and plant owners have exhausted their excuses for obtaining project and/or construction approval, even with the severe overcapacity and regulatory restriction policies. Coal power capacity exceeded 1,000GW by 2019, more than 50% of the total installed capacity. Despite an average increase of 35GW per year during 2016-2019, equal to the entire coal-fired capacity of South Korea or Poland every year, there are still a plethora of projects under planning or construction.

Due to the overcapacity, the average utilized hours per year of coal power units was only 4,200 hours during the 13th FYP period, down from 5,000 hours in the 12th FYP period. At present, the weighted average age of coal power units is about 15 years old, whereas the technical life expectancy is 30-60 years. This implies that most coal power units are still at the start or

³ https://www.china5e.com/news/news-1062879-1.html

⁴ Users don't use electricity for free, rather, they pay with a price. Coal power already profits from such trading. Given the surge in building new power generation units, such profit is able to offset the total cost without an external motivation.

middle part of their conventionally assumed service lives, meaning that they will still generate an enormous amount of emissions over their remaining years of operation, unless they are retired early.

The real-time balance and storage difficulties of the power system renders different roles for each type of power generation unit. Power sources with large fixed costs and low operation costs (e.g. renewable and nuclear power) bear the base load, while some small fixed cost power sources with high operation costs (e.g. open cycle natural gas or flywheel energy storage) bear the peak load. This variety of roles in the power system requires a diversified optimal structure. The level of coal power surplus in such a system is the actual surplus, which is much more severe than the surplus estimated from the supply and demand figures.

The desired capacity of coal power can be calculated by combining the Residual Load Duration Curve (the total load minus the renewable energy that needs to be dispatched firstly) and the Screening Curve, with the carbon constraint. By applying this methodology (See Appendix 1), we calculated a typical 8760-hour load curve as well as the power supply structure, technical and economic parameters for 2019/2020. Without carbon pricing, the current coal power overcapacity is about 130GW, about 12% of the total coal power installed capacity.

Even considering the increase of the demand, coal power is expected to take a lower share due to the expansion of renewable energy in the optimal energy mix, without explicit carbon pricing. By 2030, coal-fired power will only need to remain at the level of 1,020 GW, which is 280 GW smaller than current expectations from the main stakeholders⁵ in the system. A coal power surplus of this magnitude will inevitably depress the entire industry's return on assets and lead to a stranded asset of more than 2 trillion RMB (around 300 billion USD).

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⁵ See a summary from main stakeholders https://www.carbonbrief.org/analysis-will-china-build-hundreds-of-new-coal-plants-in-the-2020s

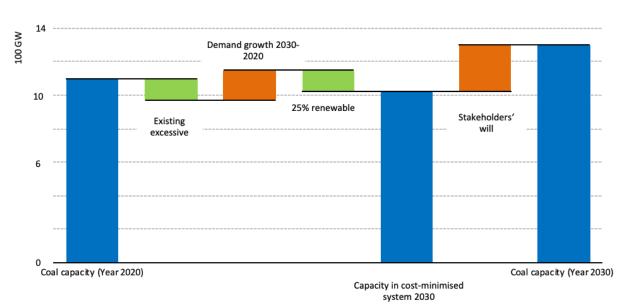


Fig 4-2 Share of coal power in the optimal power mix, without carbon price, 2020-2030

The next question is whether it is compatible with the goal to peak the emissions at 2.5Gt CO_2 for the power sector by 2030, which is set out in Chapter 3. The 1020GW coal power plants generated 4930TWh, and the annual equivalent hours are 4200 hours. If by 2030, the overall average coal consumption for power generation is 300 gce/kWh, which is equivalent to a thermal efficiency of 41%, then its coal power emissions will be 3.6Gt CO_2 – which is almost no reduction compared to the level in 2019-2020.

The Screening Curve was used to simulate how to achieve 2.5Gt of coal-fired power emissions in the presence of a carbon tax. The results show that with a carbon price of 200 yuan per ton (approx. 28 US dollars), the optimal share of coal power further drops to 680GW with emissions approximately equal to 2.5Gt CO₂, which complies with the emissions constraints set for the power sector in Chapter 3. Therefore, the suggestion based on the analysis in this report is that a carbon price of 200 yuan per ton is formed in the upcoming carbon trading market. Finally, China's current ETS design is a "tradable efficiency standard" system (Goulder et al., 2019), which would effectively alleviate the burden of coal power despite a visible high carbon price. Under such ETS design, the carbon price needs to be even higher than the results above to achieve the same reduction in emissions.

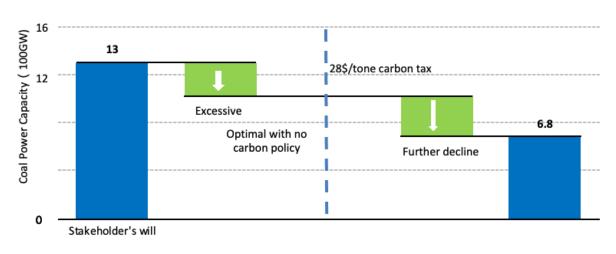


Fig 4-3 Restrict coal power emission through carbon price

4.3 Recommendations for China's 2030 NDC updates

Based on the analysis above, we propose the following recommendations for the update of China's 2030 NDC:

Halt any new coal power project

Coal power is currently in serious overcapacity because the share of wind and solar continues to increase, and overcapacity may become more severe due to upcoming carbon pricing. Preventing the approval of new coal power plant projects will be the "safety valve" and the minimum action required from the public, corporate and society to avoid the worst case of asset premature retirement.

For China to meet its goal to be carbon neutral, any new coal-fired power plant built from 2020 would need to be shut down prematurely. It is unlikely that the coal industry will want to retire its power plants earlier than planned and the expectation is that the industry will obstruct any emissions reduction policy.

Constructing new coal-fired power plants does not support China's long-term goal of carbon neutrality.

Accelerate the development of wind and solar power to achieve the established domestic goals

China's wind power industry has averaged about 20GW of added capacity per year in the past five years. The solar power equipment manufacturing capacity is much higher than demand and the resulting situation is that equipment manufacturers are becoming developers.

Accelerating penetration of wind/solar to 100-150 GW per year is generally possible, which would lead to an over 20% share in the power mix by 2025. Such an acceleration is one of the few feasible solutions available in the near future to achieve the 2030 goal, compared to carbon capture, utilisation and storage (CCUS) technologies and other measures that, while probably necessary to achieve net zero in the following decades, have not been proven at scale.

The State Grid has been delaying renewable energy with excuses such as volatility and instability. This should also be overhauled by setting a target of emission reduction over system operational balance.

The government just issued a stimulus plan focusing on "new infrastructure" and the renewable energy industry is undoubtedly a major channel to kickstart the post-epidemic economy.

 Initiate discussions on policies and plans related to employment, placement, settling state-owned assets to promote a fair transition during the phase- out of coal power

Business losses are not a legitimate reason for a bailout. In the post-epidemic era, it is necessary to grasp the basic principles of helping people rather than enterprises.

Phasing out coal power is inevitable, but it must also be ensured that this process is manageable and fair in the sense of individual rather than enterprise. Coal power needs to compete internally in a market-based regime. For unemployment, social policy is needed instead of additional energy policies which often distort the market.

• Setting a carbon price floor to reflect the social cost of emissions

According to the understanding of the current carbon market rules, most of the "shadow" burden brought about by carbon price is consumed through free allowances proportional to output, so that electricity prices no longer rise significantly, and the carbon burden of enterprises is far less than it appears from the carbon price.

Regarding fluctuation of carbon price, it is also recommended to directly set the upper and lower limits of market prices to maintain market stability to avoid sharp price fluctuations rather than other indirect policy designs. This strategy does not seriously distort the performance of other aspects of the market, and benefits investors by giving traders clear signals and saving compliance costs due to uncertain carbon price expectations (Aldy and Armitage, 2020).

⁶ http://www.cac.gov.cn/2020-04/17/c_1588668422359835.htm.

 Set interim targets for the emissions reduction between 2030-2060 and develop a policy tools roadmap.

Peak emissions can be achieved by 2030 if a significant decline in coal consumption is guaranteed. More research is needed to form a plan to achieve a rapid decline in emissions after the peak.

A strong signal of transition needs to be sent to sectors of energy, transportation, industry, construction, and agriculture. Good collective goals will need appropriate policy instruments to optimize their implementation.

Moreover, to prevent it from being unrealistically hard to reduce emissions in the later period (such as after 2045), it is recommended to set a mid-term target for 2030-2040, such as the 2035 target corresponding to "building a moderately prosperous society in all respects," reflecting the need for some certain sectors, such as coal power and some energy-intensive sub-sectors or regions, to be the prioritized for emission reduction. Or, there could be an intermediate target, such as an average annual reduction of 3%-4% in total carbon emissions.

Chapter 5 Summary and Recommendations

5.1 Fulfill an ambitious 2030 NDC

The growth of renewable energy needs to be further accelerated. Long-term credible policy is essential for short-term investment. China's wind and solar manufacturing has formed a complete supply chain and is competitive enough in the global market to become the world's center of low-cost renewable energy technology, while providing employment opportunities for a growing population. Doubling the rate of renewable energy installations is a necessary step to achieve the desired non-fossil energy targets, and could help the manufacturing and power generation industries plan their investments and strategies.

Coal power requires a non-linear acceleration in its phase out to achieve a linear decline in emissions. Any new coal power plant built at present will either end up a financial loss due to premature retirement, or part of the lobbying power to obstruct the introduction of a strong emissions reduction policy and risk not achieving China's commitment to NDCs and carbon neutrality.

Without a carbon tax, the optimal share of coal power in 2030 is 1020GW. This capacity needs to be reduced to 680GW to meet emission constraints, or to share a loss of more than 2 trillion yuan after 2030 due to declining return on assets.

The transition must be fair and manageable. The policy makers need to pay attention to the social impact of quitting coal power. In particular, the upstream coal industry is often distributed in areas where the economy is underdeveloped and employment opportunities are scarce.

Social policies need to keep up with the energy transition to ensure social stability, and energy policies should not be used for this purpose.

Good instruments are required to achieve good targets. Carbon pricing is widely regarded by economists as the most efficient carbon reduction tool. China is also about to launch the national carbon trading market. It is necessary to formulate a carbon price floor policy and gradually increase it to more than 200 yuan/ton by 2030 under the current intensity-based market design. Incentives to reduce coal-fired power generation will help to phase-out coal.

The way to measure the value of a long-term vision is to see how it changes policies and actions in the short-term, such as the next five years (the 14th FYP) or next decade (before 2030). The recent energy and emission trajectories will serve as indicators for testing the credibility of the long-term 2060 carbon neutrality targets. It is necessary to implement strict emission reduction policies and measures from now on to lay a solid foundation for long-term goals. If emission reduction is postponed from 2020 to 2030, it means that in the later period (2045-2060) the annual emission reduction rate would exceed 25% (Fig 5-1), which undoubtedly reduces the possibility of achieving the 2060 target.

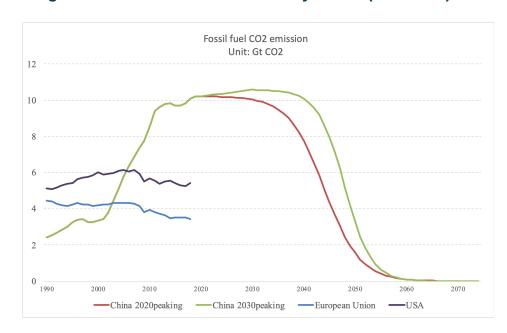


Fig 5-1 Various emissions reduction trajectories (2020-2060)

5.2 Recommendations on the policy process

Incorporate the new NDC targets into the 14th Five-Year Plan for Energy and Power. At present, planning the energy-specific FYP is carried out by energy administration agencies and think tanks. A clear mechanism will need to be implemented by the National Climate Strategy Center and the Ministry of Ecology and Environment to create an energy plan compatible with climate constraints.

Clarify a more ambitious action plan before 2030, as well as mid-term goals and roadmaps for 2030-2060. China's long-term goal of carbon neutrality by 2060 has ambitious implications for investment and industrial transition. Clarifying the action plan before 2030 to help achieve the coal power reduction target as soon as possible is a precondition for

achieving the emissions peaking target. Formulating a long-term zero-carbon economy roadmap for 2030-2060 and setting interim goals or milestones can increase the credibility of long-term goals and reduce the difficulty of future implementation.

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Appendix

A1. Methodology

We set or endogenously simulate the most likely prospects for the economy, energy, and environment from 2020 to 2030, based on government planning, and expectations of power demand growth and renewable energy development from major stakeholders.

First, we simulated the speed of expansion of solar and wind power to achieve the 50% non-fossil electricity target in 2030 and its growth in installed capacity driven by policy.

Then, we generated the residual load curve (RLDC) based on the expected power demand growth.

With the technical and economic parameters of various fossil fuel technologies, the Screening Curve is used to generate the optimal fossil fuel power source structure and the overall optimal power mix. Based on this optimal structure, we measured the emissions of the entire system, the electricity prices, the market value of renewable energy and other indicators. Comparing the value of renewable energy and our expectations of the decline in the cost of renewable energy, we can get the indication of whether renewable energy will continue to require subsidies to enter the market.

We acquired the policy implications by comparing the emission level with the emission budget of the power sector deduced in Chapter 3.

We furthermore bring about carbon pricing recommendations and re-simulates the optimal system structure with the carbon tax, so that the development of the coal power industry is compatible with the emission constraints.

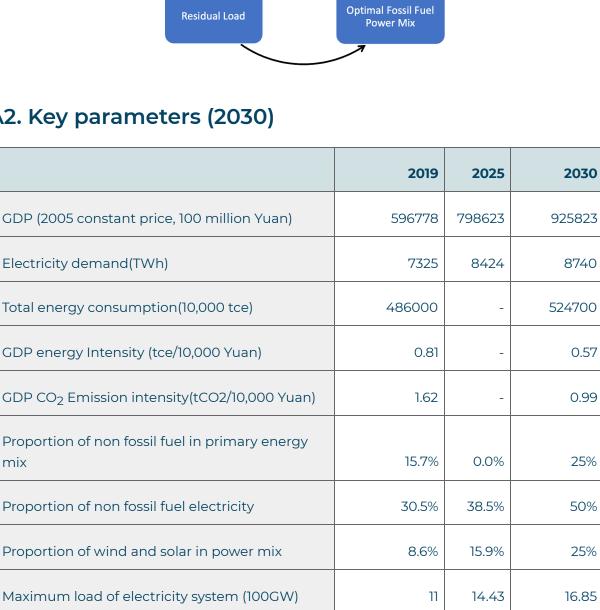


Fig A1-1 Analysis framework regarding updated climate NDC and 14th FYP

Cost of Renewable

1200 1000

800

400

-201 GW

Power Mix (Coal) **System Emission**

Electricity Price

Market Value of Wind &

PV

A2. Key parameters (2030)

mix

Policy-driven Renewable

Scenarios

A3. Economic parameters for fossil fuel power generation (2030)

	Investment cost (RMB/KW)	Fuel cost	CO2 (kg/kgce)	Efficiency of new unit
Load Shedding	0	6000 RMB (VOLL)	0	100%
Coal power	5200	700 RMB/tce	2.80	41%
Natural gas combined cycle	3900	2 RMB/m ³	1.56	65%
Single cycle natural gas	3300	2 RMB/m ³	1.56	45%

Note: Investment cost for China's coal power plant is much lower than the cost in developed countries (50% or even less). We used a relatively high investment cost to indicate the impact of Ultra-low Emission standard issued after 2017. VOLL: Value of Lost load.