CHINA'S ENERGY IN TRANSITION SERIES

China's Peaking Emissions and the Future of Global Climate Policy

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Introduction

China committed itself in the 2015 Paris Agreement – an international treaty to which nearly 200 other countries are also signatories – to reach peak carbon emissions around 2030 and meanwhile to increase the non-fossil share of its primary energy to 20%. This is a highly ambitious commitment for the largest national emitter, and one with profound ramifications for the rest of the world. It is also notable that China remains a developing or "emerging" economy, with a fraction of the per-capita income of Western countries. The significance of its potential achievement, and of its present earnestness, is further highlighted by the withdrawal of the United States – the world's second largest emitter, most affluent country, and which bears the greatest historical responsibility for anthropogenic climate change – from the same agreement. Whether or not the world will be successful in its efforts to mitigate the worst effects of climate change will to a very significant degree depend on the two countries' ability to live up to their goals.

In the Anthropocene, or the present geologic epoch in which people have become the primary drivers of planetary change[2,3], far-sighted national policies by the largest players may become triggers and even fundamental factors that shape the future of the social-natural systems in which we live, particularly in a time with a multitude of political, social, economic and physical uncertainties[4-7]. The Chinese government has supported the Paris Agreement and rigorously adhered to its Nationally Determined Contribution (NDC) by setting and strengthening the domestic policy targets for an earlier peak and faster reduction, in order to contain the average global temperature increase to well below 2°C[8-10]. Within weeks of the Paris Agreement taking effect in 2016, the Chinese government issued its authoritative *National Strategy on Energy Production and Consumption Revolution (2016-2030)*, specifying its targets for energy consumption and non-fossil energy in 2030[11].

Encouragingly, China's energy and environmental policies have already delivered many results. For instance, coal consumption has been capped in order to mitigate emissions and for air pollution control. In tandem with slower but higher quality economic growth and an accelerated transition to clean energy, this led to a peak in coal consumption in 2013, at least 7 years earlier than expected[12]. Meanwhile, the energy intensity of the economy has decreased by more than 45% since 2005[13], meeting China's Copenhagen (COP15, 2009) target three years earlier than promised. The avowed target for increasing the non-fossil fuel share of primary energy consumption is also on track. The credibility of the targets China continues to set is supported not only by this track record, but largely guaranteed by the system of policy implementation. When policy targets are set as "restrictive" by the central government, they are taken as binding at all levels of local governments and are consequently implemented by relevant administrative units and enterprises[14]. Historically, China nearly always achieves its energy policy targets, especially with respect to energy efficiency[15].

Studies modeling China's energy-related carbon emissions have tended to estimate the year of peak as falling between

2020 and 2030[19-26]. These conventional assessments are based on a bottom-up modeling approach, the emissions calculated with variables from a common analytical method for emissions known as the Kaya decomposition. This approach entails assumptions about future economic growth, industrial structure, technology, energy structure, and additional details about social-economic factors[22], each with a great deal of uncertainty. The high degree of freedom to adjust the variables and the uncertainty associated with each variable make it difficult to assess the credibility of both the modelling and the range of carbon emissions estimates. To address these challenges, we develop a different approach by transforming the static Kaya Identity to a dynamic inequality model for assessing the peaking time and pace of reduction of China's carbon emissions based on credible national policy targets. Our results show that China's emissions have already plateaued, with minor fluctuations for the coming years, and could enter a phase of steady decline as early as 2025. In other words, and in line with its track record of "overachievement" in climate policy, China's emissions are likely to have already, effectively peaked.

How we arrived at our conclusions

We arrive at this conclusion by transforming the conventional Kaya Identity into a Kaya Inequality. In order to improve directness and transparency, we now focus only on two key variables: the total primary energy consumption and the carbon intensity of the energy system. China's energy consumption growth has already slowed down significantly and is likely to maintain a long-term trend of decline. Additionally, the carbon intensity of energy use (carbon emissions per unit of energy consumption) will continue to decrease. This is all due to rapid economic and energy transitions. While the Kaya Identity describes the static relationship between carbon emissions and the driving factors, the Kaya Inequality provides a criterion to determine the time and conditions of peak emissions based on the trends in these factors.

The use of this revised model is simple: for possible combination of policy targets for energy consumption and non-fossil fuel share, one can find the corresponding point in Figure 1, either below, on, or above the PPC. If it is one of latter two, the policy scenario would bring a carbon peak by 2030. In addition, the greater distance from the point to the PPC, the earlier the peak would appear, and the faster the pace of emissions reduction. Domestic energy policy is essential to delivering the international commitment made under the Paris Agreement. Considering the credibility of policy implementation and target-setting, as discussed above, we estimate China's carbon emissions peak and the path of reduction based on the national policy targets for energy consumption and its share of non-fossil energy. In this study, emissions from fossil fuel consumption are used to represent the trend of total carbon emissions growth because they constitute the majority (80%) of China's total greenhouse gas emissions[24].

In its *National Energy Strategy*, China set an ambitious energy consumption target of 6 billion tonnes of coal equivalent maximum in 2030[11]. To put this in context, China's total energy consumption was 4.486 btce in 2017, leaving a room for growth of 1.514 btce over the 13 years from 2018 to 2030. Recent studies and current trends in economic restructuring (towards less energy-intensive sectors), along with energy efficiency improvements, suggest that national energy consumption is unlikely to exceed 5.5 btce by 2030[27-30]. Taking this into account, we chose 6 and 5.5 btce as the upper and lower targets of our model for energy consumption in 2030. The decreasing level of carbon intensity reflects the increasing share of non-fossil fuel energy in the overall energy mix. The share in 2017 was 13.8%, and the corresponding carbon intensity was 1.96 tCO2/tce. The *National Energy Strategy* therefore also set two targets for non-fossil energy in 2030. The basic policy target is to achieve a 20% share, aligned with the INDC under the Paris Agreement (the corresponding carbon intensity would be 1.72 tCO2/tce). The other target is an accelerated transition to generate 50% of electricity from non-fossil fuels[11], which would lead to a 25% share of non-fossil energy in primary energy consumption, assuming electricity use represents 50% of total energy by 2030. The corresponding carbon intensity would be 1.60 tCO2/tce under this strengthened target. This accelerated low-carbon energy transition would be two-four times faster than that of 2005-2017. With the increasing rate of reduction of carbon intensity, the annual reduction rate is unlikely to be lower than 1.5%[27]. In other words, the strengthened policy target for energy transition is plausible in the coming years.

Combinations of the basic and strengthened policy targets described above form four possible scenarios, resulting in the year of emissions peak falling between 2014 to 2052, at a level between 8.79 and 11.35 GtCO2 (Table 1). Clearly, the basic (or NDC) target of 20% non-fossil share of energy would be insufficient to deliver the carbon emissions peak around 2030 (row 2 of Table 1), and would have to be exceeded. If the strengthened policy target for energy transition is achieved with a non-fossil share of 25% (Column 2 of Table 1), China's carbon emissions would peak in 2024 or 2033, respectively, depending on whether the total energy consumption is controlled under 5.5 or 6.0 btce. Therefore, and quite learly, accelerated decarbonization is key to delivering the emissions peak target under the Paris Agreement.

We illustrate these possible scenarios and their outcomes in Figure 2. The top branch of the curve represents the basic policy scenario (BP), with 6.0 btce of energy consumption and 20% share of non-fossil energy in 2030. Point BP is far below the peaking possibility curve in Figure 1, and thus no peak would appear by 2030, failing to meet China's NDC target. The middle branch incorporates the strengthened policy (SP) target of 50% non-fossil for electricity, or 25% non-fossil in primary energy, with anticipated energy consumption of 5.5 btce in 2030. Since point SP is above the peaking possibility in Figure 1, this scenario would allow an emissions peak to appear in 2024, exceeding China's commitment under the Paris Agreement and meeting the necessary condition for the 2°C target. In fact, this scenario is consistent with the projection generated from trends in energy consumption and carbon intensity from 2012 through 2017 (see Supplementary

Information). Our simulation shows that the 2024 peak emissions under SP is only 0.1% higher than the 2017 level, indicating that the current plateau essentially represents peak emissions, which would enter a phase of steady decline around 2025. Under the strengthened policy scenario, the plateau would last for about a decade from 2014 to 2024.

The figure’s third branch best represents the aspiration that is needed in effective climate action (CA): energy consumption of 5.0 btce with 30% non-fossil energy in 2030 (CA1 in Figure 1), or a combination of 5.5 btce with 35% (CA2 in Figure 1). With prohibitive costs, the climate aspiration scenario would reduce carbon emissions back to the 2010 level by 2030, enough to meet China’s obligation under the 2°C scenario.[26] Considering the economic and technological feasibility, a stepwise acceleration of decarbonization may be possible through ambitious target-setting in China’s Five-Year-Plans (FYP)[14,31]. In devising the 14th FYP, China should consider a path towards 60% electricity use in total energy consumption, yielding 30% from non-fossil energy by 2030, and then seek a 35% target for the 15th FYP[32], building upon previous success. Historically, China’s FYP performance in emission reductions has correlated with international climate efforts (Figure 2); the rate of growth in emissions decelerated three years after COP15 in Copenhagen and plateaued around the time of COP21 in Paris (Figure 2).

The implications for global climate actions

Current trends and our analysis strongly suggest that China’s carbon emissions have reached a stable plateau with minor fluctuations, indicating in effect near-zero growth. Within the decade-long plateau, occasional fluctuations can be expected without undermining the essential conclusion about the long-term emissions trajectory. The plateau itself may be more meaningful than any specific year of peak. The encouraging trends are largely driven by economic deceleration and slower growth in power demand[33-35]. The economic “New Normal” – in which the government has focused on the quality of economic structure instead of simple quantity of economic output – together with a structural shift to sectors with lower energy intensity enables faster substitution of coal-fired power generation by non-carbon energy. Behind these changes is a major shift in the national development policy. China’s modernization target, advanced from 2050 to 2035, calls for fundamental improvements of environmental quality, necessitating an energy revolution to slowdown the growth of energy consumption and to phase out fossil fuel use. The domestic policies seem to be working in synergy with the global climate targets.

These developments in China have critical policy implications for the rest of the world. China’s economic slowdown and restructuring make it possible for a more expeditious substitution of coal-fired power generation by renewable sources. The real game changers are the evolving energy technologies[36], markets[34], and consumer behaviors[37] that break the inertia of the present energy structure, making deep decarbonization possible[38]. Our findings confirm the conclusion of the UNEP Gap analysis that China is on track to not only deliver but to exceed its NDC. Considering the fact that some of the major developed economies may be falling behind in meeting their NDC pledges[39,40], China has become the clear leader in delivering on the Paris Agreement. That China, still an emerging economy with per-capita incomes significantly lower than the long-affluent Western economies, is undertaking such ambitious climate goals and delivering demonstrates that development and environment do not form a zero-sum equation. Cutting carbon emissions and other forms of environmental impact need not tradeoff with social wellbeing and prosperity – increasingly, they are both compatible and necessary. The progress and prospects of China's climate change mitigation could serve not only as a credible example to other developing countries struggling to balance the economy and the environment, but also to affluent countries that are wavering in their commitment to one of the most pressing challenges facing the world today.

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Figures

Figure 1. A model to determine time of peak and pace of reduction based on policy targets for energy consumption and its non-fossil share. The bottom x-axis denotes the 2030 energy consumption target and the left y-axis the 2030 non-fossil energy share target. Each point in the two-dimensional domain represents a combination of the two policy targets. The top x-axis represents the annual growth rate of energy consumption, averaged over 13 years from 2018 to 2030 $(\bar{r}_E)$, as a non-linear function of the energy consumption target; and the right y-axis is the 13-year average of the decrease rate of carbon intensity $(\bar{r}_{CI})$, also as a non-linear function of the non-fossil share of energy target. The Peaking Possibility Curve $\bar{r}_E = -\bar{r}_{CI}$ illustrates the minimum requirements of policy targets that deliver emissions peak by 2030 (see Methods). Policy combinations above the curve could deliver a peak by 2030, whereas those below could not. The green dots illustrate the four policy scenarios discussed in the text.

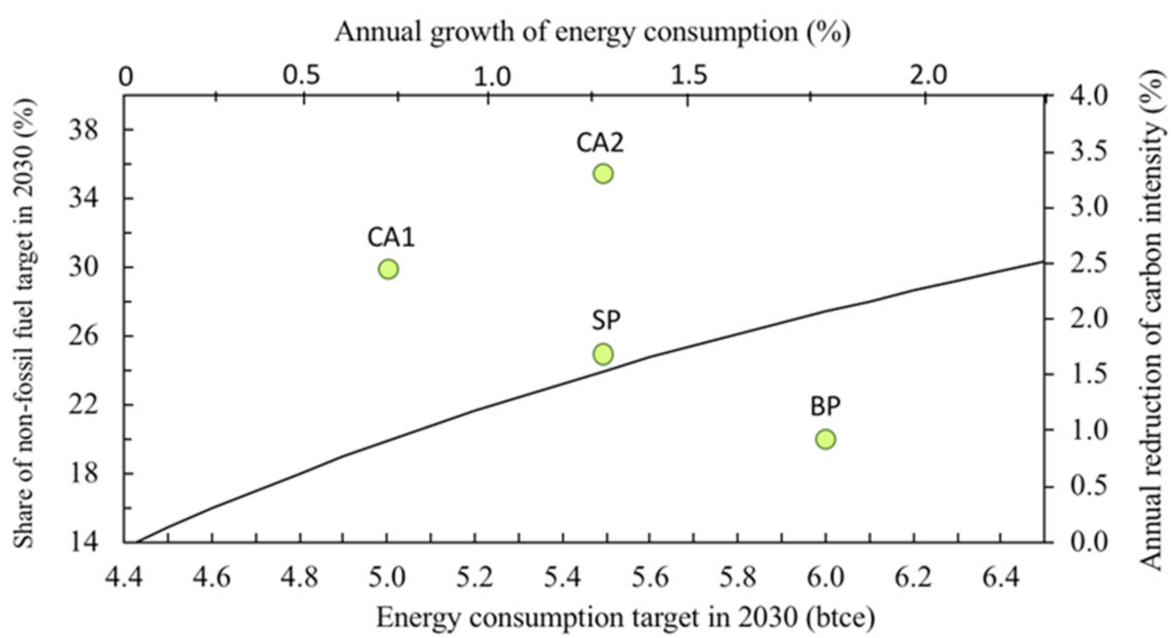

Table 1. Peak year (peak emissions level, Gt) under different policy scenarios

Energy Consumption	Carbon Intensity	
	NDC (20% NF)	Strengthened (25% NF)
5.5 btce	2042 (9.68)	2024 (8.74)
6.0 btce	2052 (11.35)	2033 (9.62)

Figure 2. Historical and projected emissions trajectories (2006-2030) under different policy scenarios. The top branch indicates the emissions trajectory under basic policy (BP) scenario (no peak by 2030). Under the strengthened policy (SP) scenario, emissions will peak in 2024, where emissions level would increase only by 0.1% from the 2017 level, indicating a stable and plateaued before the emissions finally drop from 2024 onwards. The climate aspiration (CA) scenario leads to a continued drop of emissions from now to the 2010 level by 2030.