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China's energy revolution strategy into 2030

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ABSTRACT

The Chinese Government just released its Energy Revolution Strategy (2016–2030) as an official policy response to President Xi Jinping's urge. Withdraw of the US from Paris Climate Agreement has turned the global focus on if China can comply with its climate change commitments. The purpose of this paper is to conduct a comprehensive assessment on this utterly important question. We find that the 2030 Strategy is consistent with the GDP CO_2 intensity target but cannot deliver CO_2 peak earlier than 2030. We also explore the possibility for China to realize leapfrog in energy efficiency and contribute more to global society in CO_2 emissions abatement. Given China's economic restructuring potential, continuous efforts in energy efficiency could lead to much lower primary energy demand than the Strategy proposed and thus peak energy-related CO_2 emissions around 2020. It can also make China a new champion in the world with highest energy efficiency level at comparable income level during the economic development process. A much lower primary energy demand can also facilitate China's non-fossil primary energy share target and the low-carbon power system transition.

1. Introduction

As the largest energy consumer and greenhouse gases (GHG) emitter in the world, China is confronted with unprecedented and tremendous challenges in its social & economic development. Domestically, coal-dominated primary energy supply and its unchecked growth have led to persistent environmental issues, among which serious air pollution has become the top public concern in recent years. Internationally, substantial GHG emissions and the strong growth have always put China in the epicentre of global climate change negotiation.

On June 2014, President Xi Jinping called for an 'Energy Revolution' in the sixth plenary meeting of the central finance leadership group (Xinhuanet, 2014a). Revolution in energy consumption has been taken as the top priority in his Energy Revolution plan. Checking unreasonable energy consumption and capping primary energy (coal in particular) growth have become the top guideline of China's national energy policy since then. A diversified energy supply system with a focus on clean coal and renewable energies is the revolution in energy production. Meanwhile, energy technology revolution is the driving force, and energy system revolution is the institutional arrangement to delivering the energy revolution while international cooperation calls for a new perspective on energy security. President Xi jinping also urged to formulate a strategic planning for delivering the energy consumption revolution and energy production revolution.

In the end of 2014, a Sino-US Climate Change Communiqué was declared during the APEC and the Chinese government announced its determination to peak CO_2 emissions by 2030 (Xinhuanet, 2014b).Then on 30 June 2015, China submitted its Intended Nationally Determined Contributions (INDC) file to UNFCCC, and officially committed to achieve the peaking of CO_2 emissions around 2030 and make best efforts to peak early (GOV.CN, 2015a). China also committed to lower CO_2 emissions per unit of GDP by 60% to 65% from the 2005 level and increase the share of non-fossil fuels in primary energy consumption to around 20%.

The academic enquiry on China's future energy scenario and GHG emissions trajectory is always a field of interest in literature (see, for example, Rout et al. (2011); Yuan et al., 2012b; Hu et al., 2013; Zhou et al., 2013; Liu et al., 2017; and so on). Yuan et al., (2012a) tested the consistence China's 2020 carbon intensity target with its social & economic plan while Yuan et al., (2014a) tested the consistency of China's 2020 clean energy target with its climate change policy. Yuan et al., (2014b) projected China's energy and GHG emissions scenarios into 2050 with a modified analytical framework based on Kaya identity. However, since 2014 when the Chinese economy stepped into a new normal, more scenario analysis is needed to project China's energy and

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GHG emissions scenarios with revised economic growth assumptions.

The decoupling of growth in the economy and growth in coal use has raised the important question of whether this is just a temporary dip, or a turning point that indicates that peak coal consumption has already arrived. In a recent review article, Qi et al. (2016) argued that year 2013 marked the end of coal-fired growth in China and China has switched to post-coal growth, a phase of development when China's economic growth — and the improving living standards of its population — will not depend on rising coal consumption. Two recent IEA reports also concluded that year 2013 could mark peak coal in China (IEA, 2015; IEA, 2016).

Inspired by the proposition of peak coal, Resources, Conservation & Recycling just run a special issue under the title of 'the future of coal in China' (Yuan, 2016). Relevant literature includes Han et al. (2016) on a comprehensive review on the status quo of China's coal production and in particular peak coal research, Tang et al. (2016) employing logarithmic mean Divisia index decomposition to explain the decline of coal consumption since 2014, Zhang et al. (2016) on the decoupling of economic growth and coal supply, Wang et al. (2016) on the future prospective of coal supply in China, Yuan et al. (2016) on the demand of coal for power generation in China and other interesting topics. Many other recent studies addressed China's energy and GHG emissions issues from perspectives including water-energy-emission nexus (Wang et al., 2017a; Jin et al., 2017), clean power transition (He et al., 2017), city level emissions (Chen et al., 2017a,b), energy extensive industries such as steel and cement (van Ruijven et al., 2016), construction sector (Li et al., 2017), urban rail transit (Li et al., 2016) and other sectors, emission trading system (Zhang et al., 2017), and regional disparity (Jiang et al., 2017).

The National Development and Reform Commission (NDRC) released the Energy Production and Consumption Revolution Strategy (the Energy Revolution Strategy or ERS hereafter) on 25 April 2017 as an official policy response to President Xi's urge (NDRC, 2017). Now with President Trump's recent decision to withdraw the US from the Paris Climate Agreement, the global attention has turned to China on if China can assume the leadership in global climate change policy. Therefore, it is of particular importance to test if China's 2030 Energy Revolution Strategy can fully deliver its climate commitment.

The purpose of this paper is to conduct a comprehensive assessment on the implications of China's 2030 Energy Revolution Strategy on its climate change targets. To be specific, the first question that will be answered is if the 2030 Strategy can lower China's GDP CO_2 intensity by 60%-65% as of 2005 level and peak its CO_2 emissions earlier than 2030. We find that the 2030 Strategy is consistent with the GDP CO_2 intensity target but cannot deliver earlier CO_2 peak. The second contribution of this paper is to test the possibility for China to realize leapfrogging in energy efficiency and contribute more to global society in CO_2 emissions abatement. The third contribution is to test if the 2030 Strategy is compatible with China's 20% non-fossil primary energy share target and draft a high-level roadmap for the low-carbon power system transition.

The remainder of the paper is organized as follows. Section 2 will address the methodology issues of our study. Section 3 will present the key message of the 2030 Strategy and its CO_2 emissions trajectory. Section 4 explores the possibility of energy efficiency leap and its implications on CO_2 emissions peak in China. Section 5 will draft two power planning scenarios consistent with the 20% non-fossil primary energy share target and test the consistence between primary energy consumption target and non-fossil primary energy share target. Section 6 concludes the paper with policy implications.

2. Methodology

2.1. Literature overview

Scenario analysis is the most appropriate technique given the nature of our study. One stream of scenario technique is bottom-up modelling for some specific sectors with high resolution representation of activity, technology and efficiency. For example, Cai et al. (2007) presented a scenario analysis on CO_2 emissions China's power sector with LEAP model under different development paths. Huang et al. (2017) presented an analysis on the CO_2 emissions in China's textile industry under optimal technology application scenario into 2030. Wang et al. (2017b) presented a scenario analysis on energy consumption and CO_2 emissions in China's transport sector into 2050 considering transportation mode, efficiency improvement and policy impact. With bottom-up modelling technique, Zhou et al. (2013) employed the LBNL China End-Use Energy Model to assess the role of energy efficiency policies in transitioning China to a lower emission trajectory and meeting its 2020 intensity reduction goals with two different policy pathways into 2050.

Another stream of scenario technique is top-down modelling. Guan et al. (2008) employed IO-IPAT structural decomposition technique to analyze the drivers of China's CO2 emissions drivers into 2030. Chen et al. (2017a,b) employed an improved environmental IO model to analyze the latest adjusted data for emissions from China's economy in 2012. Because of the radical change in economic structure, IO-based technique may not be applicable for long-term scenario analysis. Given our specific objectives, we employed a simplified top-down methodology similar to Yuan et al. (2014b) in our study. Section 2.2 will present a brief description for it.

2.2. Research framework

In recent years, a series of energy development policies promulgated by the energy authorities have depicted China's low carbon development goal into 2030. The Energy Revolution Strategy (2016–2030) released by NDRC defined the energy development route of China in 2030, and proposed the corresponding targets. However, whether the energy development roadmap mentioned in the energy revolution strategy can ensure the smooth realization of China's low carbon development goal in 2030 is worth studying. The main purpose of this paper is to explore the feasible path of China's energy low-carbon transition based of the Energy Revolution Strategy. The main research framework is as follows (Fig. 1).

First of all, assumptions on China's economic growth and energy consumption structure are constructed. Then, the energy-related CO_2 emission trajectory of China into 2030 can be calculated according to Eq. (1). Furthermore, the GDP CO_2 intensity can be calculated according to Eq. (2) combined with the outlook of economic growth.

$$E_{CO_2} = \sum_{i}^{n} pec_i \times ef_i \tag{1}$$

Where $E_{CO_2}$is CO_2 emission, i is the type of primary energy, pec_i is primary energy consumption of the corresponding type, and ef_i is the emission factor of the corresponding primary energy type.

$$I_{CO_2} = \frac{E_{CO_2}}{GDP} \tag{2}$$

Where I_{CO_2} is GDP CO_2 intensity, GDP is the projection of China's economic growth.

Energy Revolution Strategy points out that in 2020 and 2030, China's primary energy consumption will be 5000Mtce and 6000Mtce. The calculation results show that the average annual growth rate of CO_2 emissions caused by energy consumption in China will be about 1.94% during 2016–2020, and then drop to 0.92% in 2020–2030. Although the growth rate of CO_2 emissions has dropped significantly, it is worthwhile to consider whether it is feasible to achieve the goal of peaking CO_2 emissions as early as possible. There is a direct relationship between the emission of CO_2 and primary energy consumption, and it's worth discussing whether the anticipated target of the primary energy consumption is too high.

In order to explore a more energy-efficient and effective path of