



# Strategic deliberation on development of low-carbon energy system in China

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## Abstract

In recent years, there have been considerable developments in energy provision with the growing improvements in energy supply security and support systems in China. However, China's energy system continues to retain a high-carbon feature where coal dominates energy production and consumption, which has led to the rapid growth of greenhouse gas emissions and associated serious environmental pollution. It has therefore become an important task for China to consider how to promote the low-carbon development of energy system. This paper summarized the basic trends and challenges for development of low-carbon energy system in China and studied the primary energy consumption and carbon emissions in different scenarios at 10-year intervals between 2010 and 2050. The analysis showed that controlling coal consumption will have an important influence on the control of total carbon emissions and of carbon emission peaking; promotion of non-fossil fuel energies will offer a growing contribution to a low-carbon transition in the medium and long term; the development of carbon capture, utilization, and storage will play a key role in realizing a deep decarbonization pathway, particularly after 2030; and the establishment of a low-carbon power system is crucial for the achievement of low-carbon energy transition. Finally, the strategic considerations and policy suggestions on the development of low-carbon energy systems in China are explored.

**Keywords:** Low-carbon energy; Scenario analysis; Strategic deliberation

## 1. Introduction

The Chinese government has launched revolutionary measures for energy production and consumption by imposing a ceiling on total energy consumption, enhancing energy conservation, supporting the development of new and renewable energy. Meanwhile, the Chinese government has officially announced to achieve CO<sub>2</sub> emission peak around 2030 with the intention trying to peak early, and increase the share of

non-fossil energy in primary energy consumption to about 20% by 2030, as determined in the China–U.S. Joint Statement on Climate Change in 2014 (XNA, 2014). China has released its new commitment of reducing emissions intensity by 60%–65% from 2005 level by 2030 in its recently released China's Intended Nationally Determined Contributions<sup>1</sup> (INDCs) in 2015 (NDRC, 2015). These strategies and targets clearly reflect China's ambition in the development of a low-carbon energy system in China.

There have been many studies on the development targets and approaches of low-carbon energy system with the utilization of various models and scenarios, such as those done by

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<sup>1</sup> In preparation for creating a new international climate agreement under the UNFCCC in Paris in December 2015, countries have agreed to publicly outline the post-2020 climate actions they intend to take under a new international agreement, known as their Intended Nationally Determined Contributions (INDCs). China submitted its INDCs to the UN on June, 30th, 2015.

ERI (2009), Li and Qi (2011), Chai and Xu (2014), Wang and Zou (2014), Yuan et al. (2014), Elzen et al. (2016), etc. These studies provided a broad picture of development trend in energy system under different assumptions and conditions and put forward different solutions for China to achieve the low-carbon energy development. However, along with the new international and domestic circumstances that China has gone through in recent years and the enhanced commitment and actions by the Chinese government on low-carbon development, it is necessary to reexamine the energy and carbon emission scenarios to strengthen the analysis on low-carbon energy development pathway in China.

In this respect, this study develops 3 scenarios, i.e. baseline, positive and enhanced scenarios, to simulate primary energy consumption and CO<sub>2</sub> emission from 2010 to 2050 in China, by deeply analyzing economic and social driving forces and exploring the sectoral and technological potentials for carbon emission reduction. The next sections will analyze the development trends and challenges for China's low-carbon energy system, summary and compare 3 different scenarios, and provide strategic deliberation on development of low-carbon energy system in China.

## 2. Development of low-carbon energy system in China: general perspective

### 2.1. Basic trend in development of low-carbon energy system in China

Energy consumption in China has entered into a new era, which will continue to grow for quite a considerable time period but will experience a much slower growth rate in the future. Since the 21st century, energy consumption in China has soared from 1.46 Gtce in the year 2000 to 4.26 Gtce in 2014, thereby exceeding the consumption of any other country globally and accounting for 22% of total global energy consumption (NBSC, 2015). This figure represents a comparatively low energy consumption per capita in China (approximately 3 tce per capita, which is only 2/3 of that in Organization for Economic Co-operation and Development (OECD) countries) (IEA, 2014a); however, it is predicted that there will be continued growth in total energy demand over a prolonged time period, particularly with further increases in industrialization and accelerated urbanization within the country. Through an analysis of major driving factors involved in energy consumption, it has been indicated that the actual growth rate in energy consumption within China will gradually decrease and become more reasonable. As China enters into a new era, which is described as the new normal, it is expected that the economy will gradually transit from a pattern focusing on quantity to one focusing on quality. Nevertheless, in view of the application of emerging low-carbon technologies in sectors such as power generation, the manufacturing industry, and the building and transportation sector, it is considered that energy consumption in China will continue to grow for more than 20 years but will experience a quite low growth rate or even stable in the future.

The development of clean and low-carbon energy has gained a good basis and is expected to undergo rapid advancement in the future. To boost the development of clean and low-carbon energy, China has established major institutional mechanisms and policy frameworks that promote the development of low-carbon energies such as natural gas and non-fossil energies. China's natural gas consumption increased from 34.1 billion m<sup>3</sup> in 2004 to 180 billion m<sup>3</sup> in 2014, making the country the world's third largest natural gas consumer. However, primary energy consumption of non-fossil energies has increased in proportion from 4.0% in 1980 to 11.2% in 2014 (NBSC, 2015). In 2014, the installed capacity of hydropower, nuclear power, wind power, and solar power in China delivered 301.8, 19.9, 95.8, and 26.5 GW, respectively, which was 1.4, 1.8, 3.2, and 102.0 times the amount in 2010, respectively (CEC, 2015; NBSC, 2011, 2015). Thus, China is the world leader in terms of its cumulative generation of renewable power, cumulative installed capacity and generation of hydropower, cumulative installed capacity of wind power, and cumulative capacity of solar-heated water (REPN21C, 2015).

Electrification, networks, and intelligence will be future trends in energy system transformations. Global and domestic development trends show that electrical power as a clean, efficient, and convenient end-use carrier of energy will gradually become the major end-use energy type. Therefore, it is possible to use electrification as a symbol for measuring the level of energy technology development. In addition, it is considered that highly developed information and network technologies will lead to a new era of the energy internet. In the UN Sustainable Development Summit in September 2015, the Chinese government proposed the promotion of exploration to establish a global energy internet to satisfy global power demands via a clean and green mode. As such, this provides a clear direction for China's energy reformation.

### 2.2. Challenges for development of low-carbon energy system in China

The coal-dominant energy structure is occupying the development space for low-carbon energies. The energy industry in China has long relied on high-carbon energies. Industrial deployment, infrastructure construction, research and development, and environmental protection measures are mostly coal oriented, and therefore, this focus hinders the development of non-fossil energies. The widespread problem of abandoning the use of wind, solar, hydro, and nuclear energies to maintain coal power at a high operation level has predominated in recent years. Changing the coal-based high-carbon energy structure is therefore a huge challenge for the development of a low-carbon energy system.

Rigid energy demands and extensive development pathways intensify dependence on high-carbon energies. Because of rapid industrialization and urbanization processes, there has been a rigid and fast growth rate in the demand for energy consumption, and it is not easy to alter this ethos. Simultaneously, long-standing GDP-oriented development policies

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