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Role of non-fossil energy in meeting China's energy and climate target for 2020

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ABSTRACT

China is the largest energy consumer and CO_2 emitter in the world. The Chinese government faces growing challenges of ensuring energy security and reducing greenhouse gas emissions. To address these two issues, the Chinese government has announced two ambitious domestic indicative autonomous mitigation targets for 2020: increasing the ratio of non-fossil energy to 15% and reducing carbon dioxide emissions per unit of GDP by 40–45% from 2005 levels. To explore the role of non-fossil energy in achieving these two targets, this paper first provides an overview of current status of non-fossil energy development in China; then gives a brief review of GDP and primary energy consumption; next assesses in detail the role of the non-fossil energy in 2020, including the installed capacity and electricity generation of non-fossil energy sources, the share and role of non-fossil energy in the electricity structure, emissions reduction resulting from the shift to non-fossil energy, and challenges for accomplishing the mitigation targets in 2020; finally, conclusions and policy measures for non-fossil energy development are proposed.

1. Introduction

China has become the world's largest carbon dioxide (CO_2) emitter and energy consumer in 2009. This made China the focus of many international talks regarding global energy and environment. Limited by its energy resources, the Chinese government is facing three key challenges for sustainable economic and social development. First, China lacks energy resources, particularly oil and natural gas, and the increasing dependence on oil imports has become a threat to national energy security. Second, coal accounts for a significant share of energy use in China and the resulting pollution from coal use is severe. Finally, CO_2 emissions resulting from burning fossil fuel is growing, which puts pressure on the Chinese government in the international climate change mitigation initiatives (Ma et al., 2011).

To address the above challenges, the Chinese government has made great efforts to improve energy efficiency and encourage low carbon energy development in recent years. In 2006, the government set the energy efficiency and pollution control targets for the 11th Five-Year Plan period: compared with 2005 levels, the energy intensity (energy consumption per unit of GDP) in 2010 would decrease 20% and SO_2 emissions and COD discharges each would be reduced by 10%. In the same year, China's Renewable Energy Law took effect to encourage renewable energy development. In 2007, the Chinese Government issued the Medium- and Long-Term Renewable Energy Development Plan (MLREP) and the Medium- and Long-Term Plan for Nuclear Power (NDRC, 2007a, 2007b). As a result, China has made remarkable progress in reducing energy intensity. From 2005 to 2010, China's energy consumption only increased by 39%, whereas GDP has increased by 69%; this means that the energy intensity has decreased about 18%, a little lower than the expected target (NBS, 2010). At the same time, the development and utilization of non-fossil energy was growing. China's non-fossil energy consumption has increased 68% from 2005 to 2010 with an annual growth rate of 13.6% (NBS, 2010; CEC, 2011). In particular, the cumulative total installed capacity of wind farms has increased dramatically from 1.26 GW in 2005 to 44.73 GW in 2010 (CWEA, 2011), 35 times of the 2005 level.

For the next 10 years, the Chinese government has set two ambitious domestic indicative autonomous mitigation targets. One is that the carbon intensity (CO_2 emissions per unit of GDP) in 2020 should be reduced by 40–45% compared with the 2005 level. The other is that the share of non-fossil fuel consumption in primary energy consumption should be increased to 15% by 2020 (NDRC, 2010). It is challenging for the Chinese government to achieve these two mitigation targets in 2020. First, the share of non-fossil fuel energy is only 8.3% in 2010, far below the target of 15%. Second, although the Chinese government has made

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Nomenclature

MW	megawatt
GW	gigawatt
kWh	kilowatt hours
TWh	trillion watt hours (billion kilowatt hours)
Mtce	million ton of tce
gce	gram of coal equivalent
GDP	gross domestic production
SO_2	sulfur dioxide
COD	chemical oxygen demand
CO_2	carbon dioxide
GHG	green house gas
MESSAGE	model for energy supply strategy alternatives and their general environmental impact
LEAP	long-range energy alternatives planning system
CEC	China Electricity Council
CWEA	China Wind Energy Association
NDRC	National Development and Reform Commission, China
NBS	National Bureau of Statistics of China
SC	State Council of the People's Republic of China
WNA	World Nuclear Association

some achievements in reducing energy intensity, the energy consumption in China is expected to continue to grow, driven by the country's strong economic growth.

There have been a number of studies on China's future energy consumption and carbon emissions. These studies can broadly be classified into two groups. One group assesses China's energy use and emissions under an integrated assessment framework and includes studies such as Chen et al. (2007), MARKAL model; Jiang et al. (2008), IPAC-AIM model; Li (2010), 3E model; Chai and Zhang (2010), LCEM model; and Li (2007), TH-IESOM model. These studies made comprehensive analyses of China's energy use and carbon emissions in the future, but as is typical for integrated assessment studies, the non-fossil energy was studied in an aggregate form. Moreover, most of these studies assessed China's energy demand in the long term (e.g. 2030, 2050, or 2100), and understanding China's energy consumption in a short- or medium-term is a pressing issue.

Another group focuses on specific topics. Zhang and Zhou (2010) and Liu et al. (2011) analyzed the role of renewable energy (excluding nuclear energy) in China's sustainable energy supply. Liu et al. (2011) focused on the renewable energy use in the electricity generation. However, these studies did not study a full set of non-fossil energy technologies and resulting CO_2 emissions, nor consider recent policy development such as two mitigation targets in 2020.

To enhance the understanding of non-fossil energy development and utilization in China, this paper reflects the most recent policy development and assesses the role of non-fossil energy in achieving these two mitigation targets in 2020. The paper is structured as follows: Section 2 gives an overview of the current status of non-fossil energy development in China, including the nuclear energy and renewable energy; Section 3 gives a brief review of the primary energy forecast; Section 4 discusses in detail the role of non-fossil energy in accomplishing the two indicative mitigation targets; and Section 5 gives the conclusion and some policy suggestions for China.

2. Current status of non-fossil energy

The non-fossil energy discussed in this paper is consistent with the definition in the China Energy Statistical Yearbook, and includes nuclear and renewable energy. In particular, the non-fossil energy technologies studied in this paper include nuclear, hydropower, wind farm, biomass (biomass generation, briquette, bio-diesel, and bio-ethanol), solar photovoltaic (PV), geothermal, tidal energy, and wave energy. Sections 2.1–2.6 provide an overview of current status of these technology developments in China.

2.1. Nuclear energy

The nuclear power generation grew rapidly in China in the past decade. In 2010, 13 nuclear power units were in operation with a total installed capacity of 10.82 GW and nuclear electricity output was 76.8 TWh, less than 2% of China's total electricity production (CEC, 2011). Additional 27 nuclear power units with installed capacity of 28.92 GW are under construction (WNA, 2011). Based on this progress, the target of 40 GW nuclear power capacity by 2020 set in the Medium- and Long-Term Plan for Nuclear Power will be reached in 2015, five years earlier than the plan. In response to this, in June 2010, the Chinese government revised the target to 70–80 installed capacity of nuclear power in 2020.

However, the Fukushima nuclear accident brought negative effects on the development of nuclear power around the world and raised the nuclear safety issue. The technologies for China's nuclear generation are diverse and have multiple origins (France, Canada, Russia, the United States, and China), which require more work to ensure nuclear safety (Zhou and Zhang, 2010). Affected by the increasing safety concern, the Chinese nuclear development is expected to slow down to 60–70 GW in 2020.

2.2. Hydropower

China has abundant hydropower resources. Based on the fourth national survey of hydropower resources, the technically exploitable capacity is estimated to be 542 GW, ranked the first in the world (NDRC, 2005). Among them, small-sized hydropower (referring to stations with an installed capacity below 50 MW) resources are 128 GW and two-third of them are located in west China where the economy is underdeveloped.

At the end of 2010, China had a total hydropower installed capacity of 216 GW, ranked the first in the world, and a corresponding power generation capacity of 687 TWh, which accounts for 22% and 16% of total installed electricity capacity and annual electricity generation respectively (CEC, 2011). Through many years of development, hydropower has begun to play an important role in the electricity supply. However, the current development scale is relatively small; the exploited amount accounts for 40% of technically exploitable potentials. This is far below the development rate of 80% in some developed countries, such as USA, Japan, Switzerland and France, and is also lower than the average level of 60% in other developed countries (Jia, 2004).

According to the recent plan of the Chinese government, the gross installed capacity of hydropower will reach 260 GW in 2015 and 350 GW in 2020. Although the newly added hydropower cost will increase inevitably due to the scarcity of high-quality resource (Zhou et al., 2009) the hydropower cost is still relative low and its technology is full commercialized, compared with