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Present situation and future prospect of renewable energy in China

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ABSTRACT

Energy demand in China has risen rapidly and reached an unprecedented level due to the high-speed economic growth and modern development. As a result, the Chinese government faces a growing pressure to address the energy shortage and environmental deterioration, mainly resulting from an over-dependence on fossil energy. China has become both the largest energy consumer and CO_2 emitting country in the world in 2015. Utilization of potential for renewable energy is necessary for changing inappropriate energy consumption structure, protecting environment and achieving sustainable economic and social development. In view of such mentioned situation, this paper firstly introduces the energy structure as well as the development status of renewable energy in China, which includes hydropower, wind power, solar power, biomass power and other renewable energy. Besides, based on the current situation in China, the paper makes a preliminary prediction of the development of renewable energy in the country for the future decades, and proposes targeted countermeasures and suggestions.

1. Introduction

Along with high-speed economic development and tremendous energy consumption, China is facing the ever-increasing twin challenges of energy supply and demand. The total energy production between 1978 and 2014 increased from 627.7 million tons of coal equivalents (tce) to 3.6 billion tce in China with an annual increase rate of 4.83%. The energy consumption increased with the annual rate of 5.58% in the same period, reaching 4.26 billion tce in 2014 jumping by 7.45 times [1]. By the end of 2014, China accounted for 23% of global energy consumption and 61% of net energy consumption growth. China is now the largest energy consumer and CO_2 emitting country in the world. As the largest emitter of CO_2 in the world, China has established the target that CO_2 emissions per unit of GDP would be decreased by 40–45% of 2005 levels by 2020 [2]. The unprecedented pressure on reducing CO_2 emissions brings huge challenges to China [3].

With a tremendous and ever-increasing energy demand, the Chinese Government faces a growing pressure to address the energy shortage and environmental deterioration, mainly resulting from an over-dependence on fossil energy. Coal currently accounts for approximately 70% of China's primary supply, and will continue to play a crucial role in powering China's economic development [4].

The coal-based energy production and consumption energy system, however, faces many significant problems, such as shortages of resources, low energy efficiency, high emissions and environmental damage, and lack of effective management systems [5]. In light of China's current energy conditions, the inappropriate energy consumption structure should be changed. China is endowed with an abundant reserve of renewable energy sources which are currently underexploited and which offer a significant potential for renewable energy system development [6,7]. As an alternative, a suitable infrastructure for the implementation of renewable energy may serve as a long-term sustainable solution.

Although China has made great efforts in this aspect and great progress has been made on wind and solar power, the renewable energy's proportion in China's overall energy mix is far below the world average [8]. In September 2007, Chinese government announced plans to nearly double the proportion of renewable energy in the whole energy mix from 8% in 2006 to 15% in 2020 [9]. While China has taken substantial actions to develop its renewable energy, as many other developing countries, renewable energy deployment in China faces the constraints both from finance and technology [10]. Due to the energy dilemma, it is thus a long journey for China to optimize the energy consumption structure and advance the renewable energy to meet the requirement for sustainable development.

The objectives of the review are:

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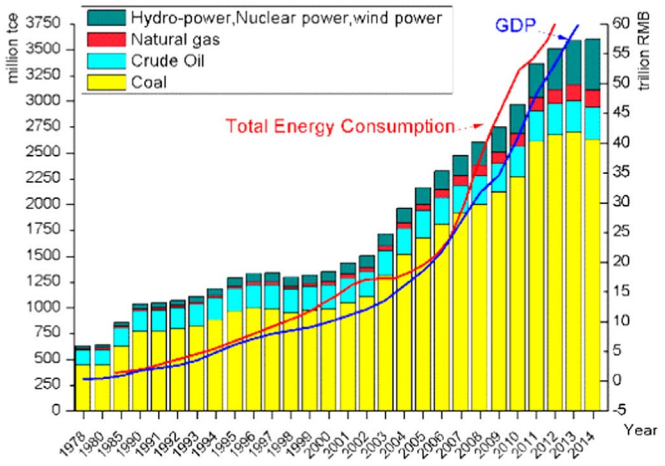

Fig. 1. Total production of energy and its composition.

- To introduce the energy structure in China;
- To discuss the perspective of renewable energy in China when China intends to approach a renewable energy system in the future;
- To indicate the challenges facing with the development of renewable energy in China;
- To predict the development of renewable energy in China and propose targeted countermeasures and suggestions.

2. Energy structure in China

A graphical presentation of the Chinese primary energy supply, gross energy consumption and economic development over the past 30 years is illustrated in Fig. 1 [11]. With rapid economy growth of China, the energy production and energy consumption soared. Thus, the total energy production increased from 627.7 million tce to 3600 million tce in China Between 1978 and 2014. The energy consumption also experienced fast increase, which increased by 5.69 times in the same period, reaching 4260 million tce in 2014.

However, the relative share of the primary energy production sources hasn't changed much, one feature is that coal remains dominate the primary energy production. The other distinct feature is that the amount of crude oil produced has not increased much, while the share of total energy production has obviously declined over time, in particular after 2000; and natural gas production shows steady slow increase, and renewable energy supply has grown has gained an impressive share in the composition.

3. The renewable energy resources and current situation in China

Renewable energy sources are steadily becoming a greater part of the global energy mix, in particular in the power sector. According to the "World Energy Outlook 2015" (International Energy Agency, IEA), the share of global renewable energy in electricity supply was 22% by 2015 and it was expected to increase to 31% by 2035 [12]. In the Middle and Long-Term Program of Renewable Energy Development, the key areas of renewable energy's development from 2010 to 2020 are defined as hydro energy, bio-energy, wind energy, solar energy and other renewable energy, including geothermal energy and ocean energy [13]. In recent years, the utilization of renewable energy has received attention in China. Renewables grew 15.1% over 2014. Chinese renewables now account for 16.7% of the global total, up from 1.2% just ten years ago [14]. According to the 13th Five-Year Plan (2015–2020), non-fossil fuel energy is supposed to account for 15% of the total primary energy consumption by 2020, respectively. In China, grid integrated wind, solar, and hydro power generation were 96.57 million kW, 24.96 million kW, and 304.86 million kW in 2014, respectively.

Table 1
Power generation of renewable in China from 2005 to 2013.

	Hydropower (billon kWh)	Wind power (billion kWh)	Solar power (billion kWh)	Total renewable energy (billion kWh)
2005	397.0	1.9	0.1	401.7
2006	435.8	3.7	0.1	442.3
2007	485.3	5.5	0.1	493.5
2008	585.2	13.1	0.2	601.1
2009	615.6	27.6	0.4	646.2
2010	722.2	44.6	0.9	779.9
2011	698.9	70.3	3.0	808.2
2012	872.1	96.0	6.2	1020.3
2013	911.6	131.9	11.9	1101.3

Power generation of renewable energy in China has achieved rapid growth in recent years, as shown in Table 1. The total renewable energy generation in 2013 is almost three times of that in 2005. As we know, renewable energy resources are abundant, but utilizing them involves some special technical, economic and environmental problems. The following part will briefly introduce the development status of renewable energies in China.

3.1. Hydropower

China has the richest hydro resources on the planet with a total theoretical hydropower potential of 694 GW. The 4th national survey of hydro resources concluded in November 2005 indicates that the technically exploitable installed capacity and annual average energy generation is estimated approximately as 542 GW and 2470 TWh/year respectively, while the economically exploitable ones as 402 GW and 1750 TWh/year [15,16].

The growth of hydropower in China during the past 6 decades is shown in Fig. 2 [17]. In 2014, China has registered an installed hydraulic capacity of 304.86 million kilowatt of electricity, and an annual grid power generation capacity of 1370.18 million kilowatt hours of electricity, accounting for 22.25% of the total electricity generated in the country. In addition, it is worthwhile to mention that the Three Gorges Dam has contributed an electricity output of 84.37 billion kilowatt hours of electricity. The share of hydropower in the total installed capacity rose from 8.8% in 1949 to 22.24% in 2014 [1], while the installed hydraulic capacity accounts for a quarter of the one in the whole world. As planned, the installed hydraulic capacity will reach 350 million kilowatt hours of electricity, which shows it has a great potential to develop hydraulic power [18].

Sitting in the world's first place in terms of both installed and

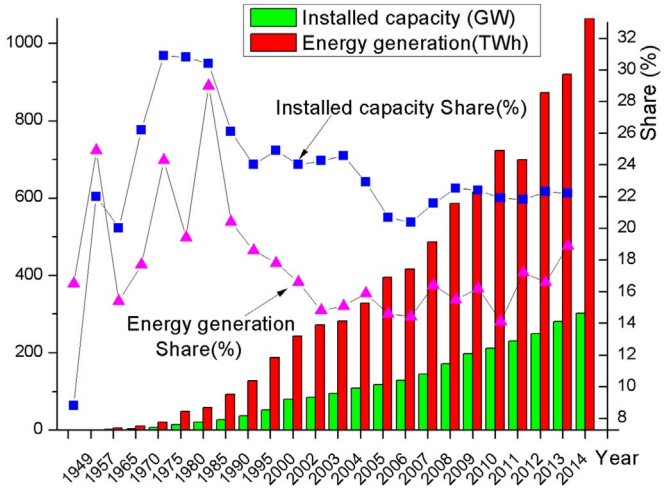

Fig. 2. Growth of hydropower in China during the past 6 decades.