



Role of renewable energy in China's energy security and climate change mitigation: An index decomposition analysis



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ABSTRACT

Renewable energy is an efficient tool to support China's endeavors to keep energy independence and mitigate climate change. This paper applies a Divisia index approach to investigate the factors governing renewable energy development in China, including the supply mix, energy security, carbon emission, and to forecast these requirements for the year 2020 and 2030. Grey relational model is employed to verify the relationships between renewable energy and its drivers. The results of the forecasts reveal the challenges of long-term deployment for renewable energy technologies. Other results show that during the research period, energy security makes a major contribution to renewable energy development. Energy security and substitution rate have relatively closer relationships with new and total renewable energy consumption respectively than that of other factors. Scenario analyses suggest that strong and continuing renewable energy policies will be helpful to achieve sustainable energy development in China and a strong synergy between renewable energy and energy security would emerge in the future.

1. Introduction

1.1. Renewable energy and its role in sustainable development

Renewable energy development could be an efficient and practicable path to achieving the sustainable development. With the rapid deployment of renewable energy technologies, renewable energy is not only taken as a sustainable choice of clean energy system, but also as an approach to addressing other social pressing needs, including improving energy security [1], reducing environmental impacts associated with fossil fuel consumption [2], as well as mitigating climate change [3]. In 2016, there were at least 176 countries in their efforts to setting renewable energy goals, and renewables have accounted for an estimated 30% of the installed capacity and 24.5% of the electricity supply at the global level. Given the huge technical and economic potential of renewable energy, it is reasonable to expect a golden opportunity for renewable energy in the future global energy mix.

Provided that a secure, sufficient and reliable supply of energy is very crucial for the sustainability of modern societies, renewables can efficiently address energy security issues extending to both supply and

demand side. On the supply side, due to the scarcity and exhaustibility of fossil energy, renewables will play an increasingly significant role in meeting the huge energy demand. IPCC suggested that 2.5% of renewable potential will meet 80% world energy demand in 2050 [4]. On the demand side, with the characteristics of sustainability and environmental-friendly, renewables could solve the security of energy use. Some scholars discussed energy security issues from the aspects of energy supply and energy use and concluded the role of renewables in energy use security [1]. The emerging symbiosis of renewable energy development and energy security has been analyzed in [5] by examining the evolution of energy security concept and verifying the deep symbiosis.

Renewable energy could also bring environmental benefits and other social benefits, such as increasing educational opportunities and jobs, reducing energy poverty and gender inequality [6,7]. Compared with the use of fossil fuels, renewable energy consumption would generate much fewer carbon emissions and environmental pollutants, which helps to mitigate climate change and curb environmental pollution [8,9]. With numerous regions seeking the transition to renewable energy, the employment numbers in renewable energy industry have

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reached 9.8 million in 2016, a growth of 1.1% over 2015 [2]. Lastly, when access to modern energy services is the marrow of sustainable development, distributed renewable energy technologies provide unprecedented opportunities for alleviating energy poverty in remote and rural areas [10].

1.2. Energy security, climate change and economic development in China

Since China was a net import country of crude oil in 1996, energy supply risk aversion has been included in national energy security strategy. In 2009, China, for the first time, translated into a net importer of coal, and the dependency of oil import was about 53% [11]. In 2013, the proportion of oil import and natural gas import reached 58.9% and 27.6%, respectively [12]. Energy security concerns along with energy structure adjustment are pressing tasks in China. In addition, the dominance of coal in energy structure results in the vast quantities of greenhouse gas and other pollutants, which is the major cause for dire environmental dilemmas. Traditional use of biomass for cooking and the low quality of electricity supply in remote and rural areas also create a barrier to poverty alleviation in these areas. In this case, energy security will be an important challenge to future sustainable development in China and renewable energy development may be valuable to address this issue.

As a developing country, China has implemented a dozens of policies and adopted voluntary emission reduction targets to cope with climate change. The National Development and Reform Commission (NDRC) of China issued the annual report of China's Policies and Actions for Addressing Climate Change since 2008 [13]. The national plan for coping with climate change (2014–2020) has been released in November 2014, which identified the principles, goals, pathways, and policy directions in a bid to address climate change [14]. Based on the U.S.-China Joint Announcement on Climate Change, China has intended to approach carbon emission peak around the year 2030. China's Intended Nationally Determined Contributions polished in year-end 2015 demonstrated that China is responsible in coping with climate change and renewable energy development will be a key part in China's low-carbon energy system.

With a rapid economic development in China within the last three decades, Chinese economy has entered a new era, namely the “New Normal” [15]. This new stage will not only become the hallmarks to be engraved in history, but also depict the direction of future economic development in three aspects: medium-to-high speed growth, on-going economic restructuring and innovation-driven development pattern. The Twelfth Five-Year Plan for National Strategic Emerging Industries Development has outlined renewable energy industry as one of the key strategic emerging industries [16]. This is to say that renewable energy will become the new source of economic growth in China.

1.3. China's energy sector: The need for renewable energy development

1.3.1. Primary energy sector

China is the world's largest energy producer and energy consumer in 2014. Fig. 1 shows the primary energy production and consumption in China [17]. The first obvious result is the dominant role of coal in China's energy structure and an increasing imbalance between production and consumption. This situation is the major cause of environmental pollution and greenhouse gas emissions. Second, renewable energy and nuclear power become an increasingly important part in energy structure, which correspond to the rapid growth of renewable energy utilization. As suggested by [13], China's renewable energy capacity contributed about 24% of the world total, and its additional renewable energy capacity represented about 37% of the world total additional capacity in 2013. Third, with the excess of energy consumption over energy production, the proportion of crude oil in the picture indicates that the security of oil import will be a major challenge in the near future.

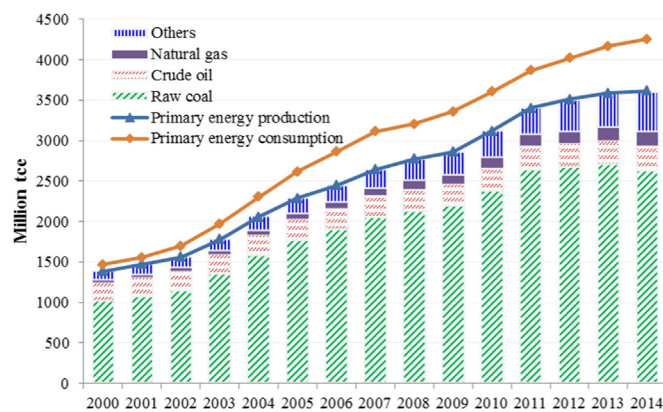


Fig. 1. Primary energy production and consumption in China (1980–2014). Note: Others include hydropower, nuclear power and other renewable energies.

1.3.2. Electricity sector

From 1993 to 2013, electricity demand growth averaged 9.31% while GDP has grown at an average rate of 14.36% [18]. One factor contributing to such a growth includes the rural electrification program, which helps to the wide application of electricity in rural areas. Fig. 2 depicts the electricity generation in past two decades. The dominant role of coal in energy system reflects the major role of thermal power in power mix. Electricity generation from other technologies has a slightly larger growth than that from thermal power, which is 10.14% and 9.12%, respectively. At the same time, the government has closed the outdated thermal power capacities. For example, China retired 4.47 GW of small thermal power units and more than 1000 small coal mines in 2013 [13]. In this regard, the efficiency of electricity generation has improved in recent years.

1.3.3. Renewable energy system

From a global perspective, China has taken a leading role in international renewable energy market, such as hydropower capacity, wind power capacity, solar photovoltaic capacity as well as different kinds of renewable energy generations [2]. This fact coincides with the large investment in China's renewable system and the ambitious renewable energy program, including the development plan for marine renewable energy over the period 2013–2016 [19] and other renewable policies stated in below. However, the share of renewable energy in China's energy structure should be further boosted because of the small proportion of renewables in energy consumption.

Hydropower, including small hydropower plants, is the most important renewable energy source in China. This significance supports the electricity demand and helps to tackle energy poverty issues in Southwest China [20]. Hydropower plants are generally located in Yangtze River, and Southwest China (Yunnan, Sichuan, Guizhou) is the

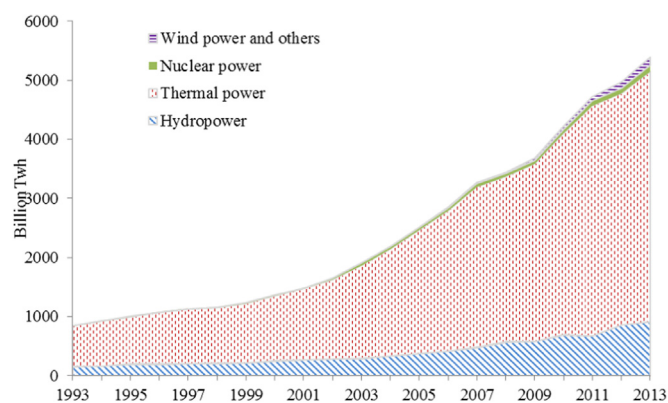


Fig. 2. Electricity generation in China (1993–2013).

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