



# Critical factors affecting the development of renewable energy power generation: Evidence from China

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## ABSTRACT

As the largest energy consumption country, China is facing a number of energy related challenges including energy sustainability, global warming and environmental pollution, which have forced China to promote renewable energy (RE) utilization proactively. Stimulated by various incentive policies, renewable energy power generation (REPG) in China has achieved tremendous growth in terms of new installed capacity. However, RE power provides only about 26% of national electricity generation in China so far, with great potential in the future. This study presents a systematical investigation on critical factors (CFs) affecting REPG development in China. Through multi-facet content analysis, a total of 43 influence factors for REPG development have been identified. Then, 33 CFs affecting REPG development within the context of China have been extracted and prioritized using questionnaire survey and relative importance index (RII) model. Furthermore, the CFs are condensed to 12 principal components (PCs) by applying principal component analysis (PCA). Finally, a novel driving force model is established to demonstrate the interaction mechanisms for REPG development formed by the PCs and CFs. In addition, policy implications based on the research results are proposed to effectively promote REPG. The findings not only help to understand the significant forces on REPG development in China, but also offer useful references for other countries that intend to promote RE in the future.

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## 1. Introduction

China has been enjoying the global fastest economic growth over the past 30 years, with an annual growth of 10.6% in the gross domestic product (Zhang et al., 2013). In order to support the rapid economic development, China's energy demand is surging dramatically. It is estimated that China's primary energy demand will reach 4.5–4.9 billion tons of standard coal by 2020 (Liu et al., 2014). The depletion of fossil fuel resources and environmental pollution have made renewable energy power generation (REPG) become an important alternative to promote China's energy and environment sustainability (Zhen et al., 2016). This coincides with

statement in the document *Several Opinions on Further Deepening the Reform of China's Electric Power System*, issued by the State Council of China in 2015 that highlights to raise the proportion of RE power in power supply is a principle of the reform (SCC, 2015).

The development of REPG involves a wide range of industries and is influenced by various factors (Zhao et al., 2014). Research on factors affecting REPG development has attracted worldwide attention. For example, Wu et al. (2016) discovered that China's renewable energy (RE) is faced with constraints in aspects of low average technology level, weak independent innovation ability and imperfect technical standard system. Dong et al. (2016b) proposed that abundant RE resources and considerable demand are key points to develop RE. Goh et al. (2014) concluded that government policies, investment in RE, energy demand, geographical location and fund management are important criteria that affect REPG development. Pantaleo et al. (2014) and Carlisle et al. (2015) argued that the low level of social acceptance is a major obstacle restricting the development of biomass and solar PV power generation. Some other factors have also been found such as economic growth (Lin and Moubarak, 2014); construction cost, new technologies (Zeng

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et al., 2013); environmental impact (Bao and Fang, 2013); payback period and financing mechanism (Ansari et al., 2013).

Although existing studies have analyzed certain factors affecting REPG development, there is still a lack of study focusing on the comprehensive identification and prioritization of these factors. The objective of this research therefore is to fill this gap of knowledge: 1) to holistically identify the factors affecting REPG development; 2) to extract and prioritize critical factors (CFs) affecting the development of REPG within the context of China; 3) to establish a model to investigate the internal influence mechanisms among the CFs; 4) to propose policy implications based on the CFs investigation. This study contributes to a better understanding of what influences REPG development and highlights the most influential factors, thereby assisting industry practitioners in decision-making. Additionally, since China has the largest RE market in the world, the outcome of this study will provide valuable references for China as well as other countries to develop REPG effectively.

## 2. Overview of REPG development in China

China has abundant RE resources with huge potential for development, such as solar, wind, biomass and hydro. The total potential for solar energy is  $1.7 \times 10^{12}$  tons of standard coal equivalent per year (Zhao et al., 2013c). China's wind resources are mainly distributed in southeastern coastal areas and "Sanbei Regions" (Northwest China, North China, and Northeast China). Wind power density is above  $200\text{--}300\text{ W/m}^2$ , some even reaching  $500\text{ W/m}^2$  with the development potential of 0.2 billion kW in "Sanbei Regions" (Zeng et al., 2013). The potential quantity of biomass byproducts energy is 3511 million tons of standard coal equivalent (Bao and Fang, 2013). The exploitable hydro capacity in China is 542 GW and the corresponding annual generating production is 2.47 trillion kWh (Bao and Fang, 2013). The plentiful RE resources open the way for REPG development in China.

The past ten years have witnessed the tremendous development of REPG in China. As shown in Fig. 1, the total installed capacity and the proportion of power generated by RE increased from 2010 to 2016. In particular, the cumulative installed capacity of wind power in China increased from 41.8 GW in 2010 to 148.6 GW in 2016, leading the world for seven consecutive years (Zhao et al., 2016; NCWPN, 2016a; NCWPN, 2017; CEC, 2017). Furthermore, the

cumulative installed capacity of solar PV has amounted to 77.42 GW by the end of 2016, ranking the first worldwide for two consecutive years (NEA, 2016; Shu et al., 2017; CSPN, 2017). In addition, China has set ambitious goals for wind power and solar power, stating that the installed capacities reach 2400 GW and 2700 GW respectively by 2050 (Zou et al., 2017). An identification and analysis of factors affecting REPG development is significant for the industry promotion in China.

## 3. Research methodology

This paper aims to investigate CFs affecting the development of REPG. Firstly, a multi-facet content analysis was adopted to identify factors affecting the development, and a comprehensive set of 43 factors was formulated. Then, a questionnaire survey was undertaken with practitioners involved in the Chinese RE industry, aiming to collect respondents' assessment towards the importance of the identified factors. Finally, using statistical software SPSS, 33 CFs under 12 principal components (PCs) affecting the development of REPG in China were identified and prioritized, and a driving force model illustrating the influence mechanisms of REPG development was established. The research process is outlined in Fig. 2.

Muti-facet content analysis has been proven to be an effective method for factor identification, especially in sociological research field (Shen et al., 2016). In order to have a comprehensive investigation of factors affecting REPG development, academic literature and policy documents were extensively surveyed:

- Academic literature. A systematic search was carried out in major databases by using keywords such as "renewable energy", "new energy", "power generation" and "critical affecting/influencing factors" to locate relevant academic papers. Accordingly, a comprehensive list of factors from high impact energy journals was formulated.
- Policy documents. This paper studied the laws and regulations issued mainly during the 11th and 13th "Five-year Plan" periods (2006 to present) by government authorities including the State Council of China (SCC), Ministry of Finance (MOF), National Development and Reform Commission (NDRC), and National Energy Administration (NEA), also reviewed the policies dealing with REPG development including financial subsidy, tax support and feed-in tariff, etc.

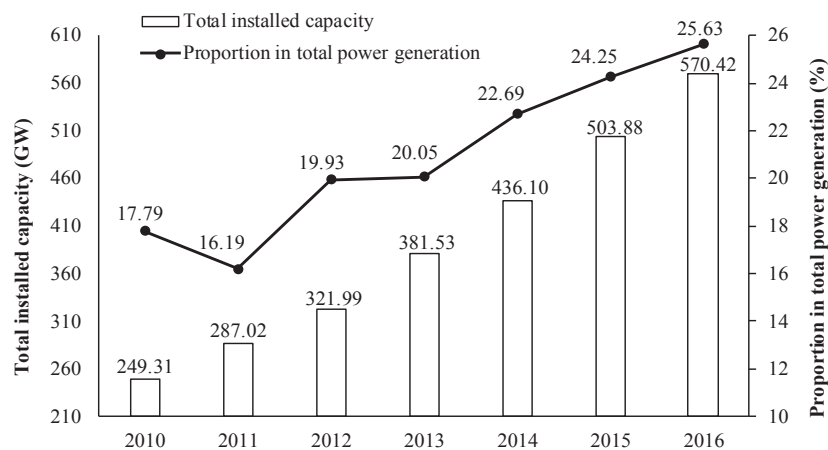


Fig. 1. Total installed capacity and the proportion of power generated by RE 2010–2016. Note: based on Compilation of statistical data in power industry 2016 by China Electricity Council.

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