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The policy effects of feed-in tariff and renewable portfolio standard: A case study of China's waste incineration power industry

Zhao Xin-gang *, Zhang Yu-zhuo, Ren Ling-zhi, Zuo Yi, Wu Zhi-gong

School of Economics and Management, North China Electric Power University, PR China

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ABSTRACT

Among the regulatory policies, feed-in tariffs (FIT) and renewable portfolio standards (RPS) are the most popular to promote the development of renewable energy power industry. They can significantly contribute to the expansion of domestic industrial activities in terms of sustainable energy. This paper uses system dynamics (SD) to establish models of long-term development of China's waste incineration power industry under FIT and RPS schemes, and provides a case study by using scenario analysis method. The model, on the one hand, not only clearly shows the complex logical relationship between the factors but also assesses policy effects of the two policy tools in the development of the industry. On the other hand, it provides a reference for scholars to study similar problems in different countries, thereby facilitating an understanding of waste incineration power's long-term sustainable development pattern under FIT and RPS schemes, and helping to provide references for policy-making institutions. The results show that in the perfect competitive market, the implementation of RPS can promote long-term and rapid development of China's waste incineration power industry given the constraints and actions of the mechanisms of RPS quota proportion, the TGC valid period, and fines, compared with FIT. At the end of the paper, policy implications are offered as references for the government.

1. Introduction

1.1. Background

Countries around the world have proposed various policies to promote the development of renewable energy, because renewable energy policies can significantly contribute to the expansion of domestic industrial activities in terms of sustainable energy (Lund, 2009). Among the regulatory policies, feed-in tariffs (FIT) and renewable portfolio standards (RPS) are the most popular. More than 60 countries and regions worldwide have implemented one or other of the two policies (Sun and Nie, 2015). Fig. 1 is the distribution map of countries implemented the FIT policy and the RPS policy. FIT and RPS have common attributes, in that both are policy tools with dual characteristics of government intervention and market regulation.

FIT policy, represented by China, South America, and most European countries, is a scheme designed to accelerate investment in renewable energy technologies. It is a government-led regulatory mechanism that requires power grid enterprises to buy electricity from renewable energy producers at government-specified prices. In the early stages of renewable energy development, it ensured the sale of renewable energy at a protected price, providing a living space for renewable energy with high costs of electricity generation associated with certain renewable energy technologies do not prohibit the development and use of those technologies, eliminating the usual uncertainties and risks associated with renewable energy (Intelligent Energy Europe, 2011). The goal of the FIT is to offer cost-based compensation to renewable energy producers, providing them with price certainty and long-term contracts that help finance renewable energy investments (Wesseh and Lin, 2015).

RPS policy, represented by the United Kingdom, Belgium, and multiple states in the USA, is a main promotion scheme of a quota obligation on electricity suppliers to supply an increasing proportion of their electricity from renewable sources (Intelligent Energy Europe, 2012). It is structured as a quantity regulation, letting the market determine a reasonable price for renewable energy power. In this approach, governments set targets or quotas to ensure that power grid enterprises purchase a certain market share of capacity or generation of electricity coming from renewable energy sources. In most cases, governments create tradable green certificates (TGC) to track the fulfillment of quotas (Dong, 2012). The competitive market determines the transaction price. The

* Corresponding author.
E-mail address: rainman319@sina.com (Z. Xin-gang).

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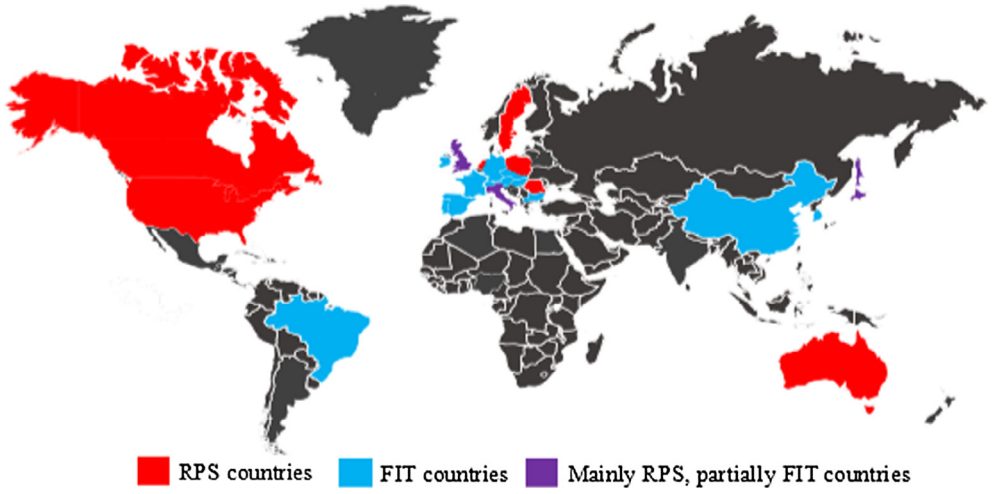

Fig. 1. The distribution map of countries implemented the FIT policy and the RPS policy. Source: China Energy Net (2016).

advantage of RPS policy is that it is a framework policy that is easy to integrate with other policy measures and can be implemented in conjunction with the FIT.

Renewable electricity production is in China at present supported by a FIT support scheme. Taking China's waste incineration power as an example, the National Development and Reform Commission (NDRC) issued the *Notice on Improving Feed-in Tariff of Waste Incineration Power* in March 2012, to standardize waste incineration power prices within the whole country (NDRC, 2012). The main contents of the notice cover two aspects: one of these is that waste incineration power FIT would be applied at 0.65 yuan/kW h for all the power plants, and the other is that the waste incineration power price cost sharing system would be implemented continually. However, the current situation is likely to change in the future. Along with the economic transformation and adjustment of its industrial structure, China has implemented new power system reforms. The NDRC issued the *Notice on Trial Implementation of Renewable Energy Tradable Green Certificate Issuance and Voluntary Subscription Trading System* on January, 18th, 2017 (NDRC, 2017). The notice stipulates that the wind power and photovoltaic power sectors trial RPS policy from July 1st, 2017, and that all renewable energy resources must subscribe to TGC from January 1st, 2018. The introduction of RPS policy will greatly change the waste incineration power industry, which is an important industry for resource-saving and eco-friendly society in China, and there are many important problems worth studying, such as the direction of the development of waste incineration power in the long term under the two policy schemes, potential problems that may arise during the development process, and future policy-making.

1.2. Literature review

Many scholars have built various models to study the renewable energy power industry under FIT and RPS schemes. Some scholars have used multi-objective programming approaches to serve the decision makers in the renewable energy industry. Zhang et al. (2016) emphasizes a method that integrates the backward dynamic programming algorithm and Least-Squares Monte Carlo method to assess the optimal levels of FIT for photovoltaic power generation industry in China. Ritzenhofen et al. (2016) quantitatively compares the impact of RPS and FIT on renewable energy power industry via a dynamic long-term capacity investment model, which includes various objects and constraints. Some scholars have used bottom up models. Bianco et al. (2009) develops a long-term consumption forecasting model to study the influence of FIT variables on energy industry in Italy. Farooq et al. (2013) analyzes the potential of renewable energy for power generation under RPS scheme in Pakistan using a bottom up type of long term energy system based on the MARKAL framework. Other models have also been used. Sun and Nie (2015) establish a two-stage model to compare the affect of FIT and RPS on renewable energy power industry. Dong (2012) examines the relative effectiveness of FIT and RPS in promoting wind power industry's development using non-linear econometric and statistical model with panel data.

Numerous system dynamics (SD) simulation models built by scholars have been developed and applied successfully to a variety of problems related to energy planning and management (Qudrat-Ullah, 2014). Ford et al. (2007) simulates the TGC price dynamics of a market designed to support an aggressive mandate for wind power generation in the northwestern USA. Naill (1992) describes the conceptual development of the SD model of U.S. energy supply and demand, and its use in analyzing national energy policy issues. Ford (1997) shares reflections on why SD practitioners have been successful in energy power industry. Ochoa (2007) uses SD models to study various aspects of security of energy supply faced by the Swiss electricity market. Ponzo et al. (2011) establishes a SD model to analyze the regulation and intervention in the markets affect the long-term prospect for the secure supply of gas in Argentina. Olaya and Dyner (2005) addresses SD models considered for the assessment of policy options in the natural gas industry in Colombia, which focus on both modeling and policy, specifically with respect to industry sustainability, and also on environmental impacts.

1.3. Rationale and structure of the paper

In the existing literature, scholars have presented various methods to provide useful analysis for renewable energy industry's development under FIT and RPS schemes. However, the dynamics of development of the renewable energy industry are complex. Most of the literature examines the static impact of a single factor on renewable energy power industry's development, and few examples visually indicate the complex relationship between various important factors and long-term renewable energy power industry's development. Thus, our goal is to fill this gap. In this paper, we synthetically consider various important factors with the analysis of the existing literature, and use SD to establish models of long-term development of China's waste incineration power industry under FIT and RPS schemes. The model not only clearly

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