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Feed-in tariff mechanisms for large-scale wind power in China

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ABSTRACT

In recent years, with the large-scale and centralized development of the wind power industry in China, wind power curtailment has become increasingly serious. In order to promote wind power consumption in China, this paper designs four kinds of feed-in tariff (FIT) mechanisms: a double-track FIT mechanism based on a ratio, a time-of-use benchmarking tariff mechanism, a net back pricing mechanism based on the inter-provincial wind power consumption market, and an FIT mechanism based on negotiation. Then, we establish a benefit distribution model to analyze the wind power stakeholders' benefits. Finally, based on the four kinds of FIT mechanisms and the benefit distribution model, we propose the best FIT mechanisms for the various electricity market circumstances in China, in order to provide a reference to formulate wind FIT, to promote the consumption of wind power and to advance the sustainable development of renewable energy in developing countries.

Contents

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1. Introduction

In recent years, there have been wind power curtailments to varying degrees in many countries. In China, the installed capacity of wind power has increased rapidly, with an average annual growth rate of 192%. However, the amazing development of wind power capacity also brings the problem of wind power curtailment, which now is one of the main factors affecting the sustainable development of the wind power industry in China. How to establish a reasonable feed-in tariff (FIT) mechanism to reduce wind power curtailment and promote a reasonable and optimal allocation of renewable energy has become an urgent problem awaiting a solution.

To promote the development of wind power and other renewable energy sources, countries around the world have issued different FIT mechanisms, or introduced the renewable energy policies to promote wind power competitiveness. The fixed-FIT is adopted in Germany, and this tariff is fixed for at least five and up to 20 years by government, after which it is diminished year by year based on a certain percentage, depending on how local wind conditions compare to a reference yield [1]. The Spanish feed-in tariff (FIT) system for wind power has two alternatives: one is a fixed feed-in tariff and the other is a premium payment on top of the electricity market price [2]. An FIT regime was established in China in 2009. Four standard tariffs were established nation-wide for on-shore wind projects. Regional wind resources have great differences in China. Based on the principle of formulating onshore wind power benchmark price in different resource areas, the country is been divided into four wind resource areas according to wind resources and construction conditions. The lowest tariff is 0.51 Yuan/kW h. The second and third tariff levels are 0.54 Yuan/kW h and 0.58 Yuan/kW h. The fourth level is 0.61 Yuan/kW h [3]. Wang [4] analyzed the urgent problems regarding to China's wind power development from the perspective of wind power planning, construction and operation, and proposed overall, comprehensive and system-wide political and regulatory solutions to the current problems in wind power development. Li et al. [5] analyzed the investment risk of wind power project in China based on the feed-in tariff and CDM project income. Akorede et al. [6] proposed that large-scale wind energy is not viable in Malaysia, however, small-scale wind energy system may be economically viable in a few regions when the feed-in tariff is extended to wind energy. Huang and Wu [7] examined the main features of Taiwan's FIT system and assessed some design options using several criteria. To meet the target of the share of renewable resources in electricity generation, the feed-in tariffs in the Renewable Law were set to facilitate the expansion of the deployment of renewable energy technologies. Mauricio et al. [8] proposed an FIT scheme named 'tropicalisation', based on the idea of awarding for each kW h produced by renewable energies a premium value for a guaranteed period of time. Lesser and Su [9] proposed an innovative two-part FIT, consisting of both a capacity payment and a market-based energy payment. Juliete and Reinhard [10] analyzed the fixed-FIT and premiums, and compared them as to their propensity to ensure the adequacy of RES-E production. Doherty and O'Malley [11] found that Ireland's Renewable Energy Feed-In Tariff (REFIT) for wind power generation is different in that the cost of the REFIT scheme to the electricity consumer in Ireland appears to be lower than the cost of schemes in other countries. Couture and Gagnon [12] found that fixed-FIT models could create greater investment security and lead to lower renewable energy deployment cost than premium models.

The main renewable energy policy in the USA is the Production Tax Credit (PTC) and the Investment Tax Credit (ITC). In 2009, the US Congress passed the American Recovery and Reinvestment Act (ARRA), which included a three-year extension of the PTC through to 2012 and an option to elect a 30% ITC in place of the PTC. Ringel [13] explored a couple of support models, i.e. FIT and green certificates, existing to foster the development of renewable energies. Chua et al. [14] found that a renewable energy policy could improve the utilization of renewable source, so that it could provide positive signals to implement FIT. Martin and Rice [15] analyzed the solar photovoltaic feed-in tariff policy based on a structured case and stakeholder analysis and concluded that FIT policy should largely reflect its costs. Stevanovi'c and Pucar [16] proposed the feed-in tariff for photovoltaic electricity in Serbian, but it was not sufficient to attract investments, so the alternative of more reasonable feed-in tariff frameworks was analyzed. Jawaher and Bassam [17] introduced a variety of policies to prompt renewable energy practices in the UAE, including deregulation, open access to the grid, financial incentives and implementation of FIT. Gupta and Purohit [18] assessed the performance of Renewable Energy Certificate (REC) mechanism in India, and concluded that REC price bounds should be revised. Mani and Dhingra [19] introduced some policies to promote the growth of offshore wind energy sector in India, and concluded that government support, fiscal and quota based incentives and building an enabling R&D ecosystem these three factors have a higher impact on the growth. Zahedi [20] reviewed the FIT in Australia, and presented that the gap between production cost of PV electricity and the FIT is relatively high, and the FIT could be implemented based on net metering. Zahedi [21] also used an economical model to analyze the FIT of solar photovoltaic (PV) in Australia.

In addition, from the benefit distribution point of view, Sheen et al. [22] used Particle Swarm Optimization with a power flow algorithm to analyze the long-term benefits of the demand side, and the objective function included the investment cost, maintenance cost, and the cost of loss reduction, subjective to operating limits and line flow constraints.

What can be seen from the above, the main FIT mechanisms include fixed-FIT, bidding-FIT, premium tariff, and so on. These FIT mechanisms are appropriate for different areas and different economic levels. They may be useful as references for China, but can't be entirely appropriate for China without adjustments. China is a developing country with rich wind sources dispersed over the country, and the wind FIT in China now is actually a fixed-FIT (Benchmark tariff), decided by the National Development and Reform Commission (NDRC). While the benchmark tariff mechanism can guide investors to develop high quality wind resources, but there are also much wind curtailment, and wind farms have late response to the unexpected circumstances for the unstable wind, and the classification of areas is not enough to be refined. The wind curtailment is caused by China's large-scale wind power development patterns and local governments' blindly launched projects to improve their performance. To reduce this wind power curtailment and to support the sustainable development of wind