Energy Proceedings
Vol 36, 2023
ISSN 2004-2965

Comparative Analysis of Renewable Energy incentive policies strategic: Case Studies and Policy Recommendations for China Sustainable Development

Chuyi LUO[1], Liang XIA [2*]
1 Research Center of Fluid and Thermal Engineering, Department of Architecture and Built Environment, University of Nottingham Ningbo China
2 Research Center of Fluid and Thermal Engineering, Department of Architecture and Built Environment, University of Nottingham Ningbo China
(*Corresponding Author: Liang.Xia@nottingham.edu.cn)

ABSTRACT

This research paper presents the review of two renewable energy strategies, Feed In Tariff (FIT) and Renewable Portfolio Standards (RPS), in China and other countries. The two FIT schemes, which are Erneuerbare Energien Gesetz (EEG) in Germany and Benchmark Grid Electricity Prices (BGEP) in China, are compared. On the other hand, three RPS schemes, which are California's RPS Program, Australia's Renewable Energy Target (RET), and China's Weighting of Responsibility for Renewable Energy Electricity Consumption (WRREEC) framework are reviewed and discussed. Based on the review and findings, recommendations on the future development of renewable energy strategies in China are presented.

Keywords: China, Feed In Tariffs, Renewable Portfolio Standards, Carbon peak, Carbon neutrality

1. INTRODUCTION

Since the beginning of the 20th century, countries around the world have initiated the design of strategic schemes to promote renewable energy. Currently, the most typical and popular strategic schemes for renewable energy can be categorized into Feed In Tariff (FIT) and Renewable Portfolio Standard (RPS). FIT and RPS have different policy characteristics and definitions, which result in significant differences in their impacts. There are still many controversies and discussions in academia about these two renewable energy incentive strategies regarding their impacts on advancing renewable energy [9]. China actively drawn lessons from the renewable energy strategic schemes from other countries, developing a distinctive strategy system for herself. Although extensive review papers on the FIT and RPS among different countries have been published, few review paper focuses on analyzing the FIT and RPS of a country, lacking a summary and comparison of FIT and RPS across different countries. In other words, it lacks of the horizontal analysis based on the FIT and RPS in countries. Moreover, the comprehensive reviews on the two strategies in recent decades have not been seen. The majority of the discussions about FIT and RPS from the published review papers was not suitable for the current development in countries. As China's carbon peak and carbon neutrality goal was determined [13], the renewable energy strategic schemes in China was required to be developed more deeply and widely to meet the new goals and requirements.

Hence, the following sections will show the horizontal comparison the latest cases of FIT and RPS in China and other counties. The results would be beneficial to the enhancement of the promotion of renewable energy strategic schemes in China.

2. FEED IN TARIFF (FIT)

FIT referred to a measure that was used by the government to ensure that the renewable energy electricity price were sold at a fixed price for a period. Generally, the fixed price was determined based on capital costs and risk factors, and it was higher than the market price. The FIT aimed to improve the competitiveness of electricity produced by renewable energy when it entered the market, with providing subsidies to renewable energy power enterprises. FIT had mainly been implemented in European countries such as Germany, Spain, and Denmark [9, 15], among which, Germany's FIT scheme has the longest history and it is constantly enriching its content. Therefore, this analysis focuses on Germany's FIT scheme.

This is a paper for the 9th Applied Energy Symposium: Low Carbon Cities and Urban Energy Systems (CUE2023), Sep. 2-7, 2023, Matsue & Tokyo, Japan.

2.1 *Germany: Erneuerbare Energien Gesetz (EEG)*

The Erneuerbare Energien Gesetz (EEG) was preceded by the Electricity Feed-in Act (1991). This law initiated the first electricity FIT scheme in the world with the aim to promote the production of renewable energy electricity.

Fig. 1. shows the price variations and annual degression rates of a specific type of solar PV panels in the EEG FIT scheme from 2008 to 2014. It can be observed that the FIT scheme had been steadily decreased annually. The annual degression rate reflected the speed of price changes in the EEG FIT scheme. Prior to 2009, the annual degression rate remained around 5%. Subsequently, the annual degression rate started to increase and reached its peak value of 33.51% in 2012, followed by a sharp decline to 19%.

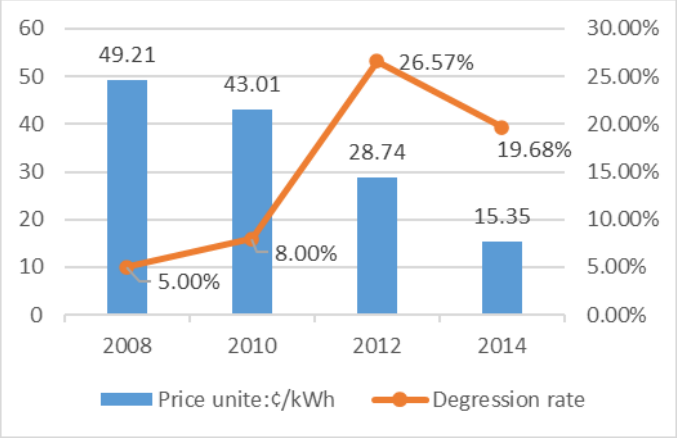

Fig. 1. Changes in EEG FIT scheme (solar PV) and the annual degression rate (2004-2014)

The key features of the EEG FIT scheme include 5 points. Firstly, it showed the priority grid access for renewable energy to enter the market. Secondly, a fixed price for the electricity generated from renewable sources was set in EEG FIT scheme for a fixed period (typically 20 years) to ensure a return on investment for producers. Thirdly, EEG FIT scheme considered various tariffs based on energy sources, plant sizes, and installation year. Fourthly, the surcharge from electricity users was a financial source to the EEG. Lastly, the periodic reduction rate of the EEG FIT scheme was decided by the government based on PV industry market.

The EEG encompasses not only the aspect of FIT scheme but also the establishment of targets framework. In the latest EEG2023, it shows Germany's ambition to become the climate neutral country [12].

The proportion of electricity generated from renewable energy in Germany rose from 5% in 2000, to 16% in 2007, and to 34% in 2016, marking a substantial green shift of nearly 30% in 16 years (Table 1). This achievement was considered the greatest accomplishment of the EEG [11].

Table 1. Renewable as % of total electricity generation in in Germany 2000-2020 [11]

Renewable as % of total electricity generation			
Year	Percentage	Year	Percentage
2000	5%	2010	17%
2002	8%	2012	21%
2004	9%	2014	23%
2006	11%	2016	34%
2007	16%	2020	46.2%

2.2 *China- Benchmark Grid Electricity Prices (BGEP)*

To promote the non-hydro renewable energy industries, such as solar PV and wind power, the China central government had formulated and implemented a system of FIT which includes laws and policies on renewable energy subsidies. In 2011, the Renewable Energy Development Fund (REDF) was formally established. The expenditures of the REDF primarily catered to the electricity subsidy for various types of renewable energy projects [8]. According to [3], the primary source of REDF was the renewable energy surcharge collected from electricity consumers. The surcharge price was 1.9 cents RMB /kWh [9].

On July 24, 2011, [3] which first proposed the concept of Benchmark Grid Electricity Prices (BGEP). The renewable energy power generation enterprises can sell their electricity generating from renewable energy at fixed prices to the power grid enterprises. The main feature of BGEP is that it can ensure the stable income to renewable energy power generation projects, to attract the social investment to the renewable energy project. In terms of different project approval times, the BGEP varied. From 2011 to 2019, the BGEP had been adjusted for five times. At the same time, the overall trend of BGEP shows gradually decreasing and the degression rate keep upward trend (Fig. 3.). The upward trend

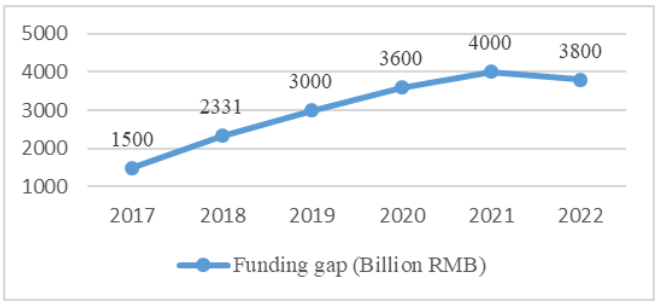

Fig. 2. Funding gap (Billion RMB) for renewable energy generation subsidies from 2017 to 2022

degression rate means the acceleration of BGEP reduction rate. In the period of 2018-2019, the BGEP reductions are greater than in previous years.

The REDF had a shortfall from 2017 [8, 15] and the shortfall had gone through a steady increase trend annually, as shown in Fig. 2. The main reason for the rising shortfall were that the fund had a long overdue period and the PV installed capacity continued to grow rapidly. The Chinese government was also aware of the funding deficit crisis under strong economic subsidies, so the subsidy rebate was officially implemented on January 1, 2016 [2]. In May 2018, [4] revealed the government would reduce the subsidies. In 2019, the BGEP was adjusted to guidance price, and the government would actively promote the non-subsidy grid access. These actions were to motivate the market competition in China's PV industry.

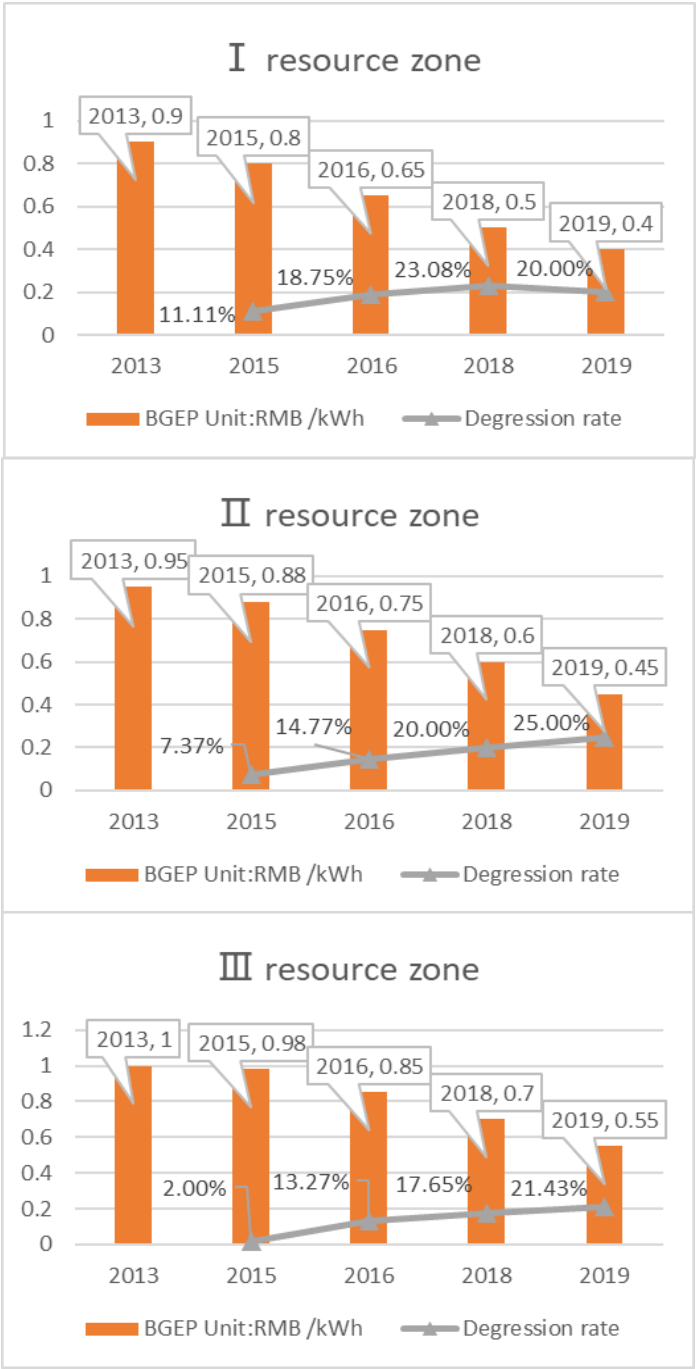

Fig. 3. Changes in BGEP for PV power stations and the degression rate (2011-2019)

3. RENEWABLES PORTFOLIO STANDARD (RPS)

RPS was a way of guiding enterprises to develop and utilize renewable energy electricity through market mechanisms. RPS meant the high-level government use laws to specify a numerical target for industry organizations and the lower-level government organizations should achieve this target within a certain period. If the organizations failed to meet the targets, they must get penalties, such as pay fines. Unlike FIT, PRS was a mechanism with more based on the market operation. RPS is mainly implemented in the USA and Australia [16].

3.1 California, America-Renewables Portfolio Standard (RPS) Program

Table 2 illustrates the features of the Renewables Portfolio Standard (RPS) Program in California, America.

Table 2 California, America- Renewables Portfolio Standard (RPS) Program

California, America Renewables Portfolio Standard (RPS) Program	
Consumption indicators	Renewable Energy Credits (RECs)
Renewable energy types	Wind, solar PV, solar thermal, hydroelectricity, geothermal, and bioenergy
Scheme subjects	California's retail sellers of electricity, which include large and small investor-owned utilities, electric service providers and community choice aggregators
Completion methods	1) generating renewable energy 2)purchasing renewable electricity 3) purchasing RECS
Penalties	A fine of 5 cents / (kw · h)
Monitoring, evaluation and assessment	CUPUC: setting the goals and evaluating the completion level of goals for the California's retail sellers of electricity CEC: identification of equipment and the creation of the RECs System

In the America, RPS program only existed at the state level. California RPS program was established in 2002 by Senate Bill 1078.

The California RPS program used Renewable Energy Credits (RECs) to quantifying the RPS scheme. The California Public Utilities Commission (CUPUC) was responsible for setting the goals and evaluating the completion of goals. The California Energy Commission (CEC) was responsible for the creation of the RECs System.

The RPS nevertheless had some shortcomings. Due to the separation of certification agency and regulatory agency, there were issues of failed of the certification of RECs and duplicate calculations of RECs. This objectively weakened the regulatory effect of the California RPS program and reduced market efficiency. California RPS program had introduced a penalty regulation. If the scheme subjects were failure to achieve the target, it would result in a fine of 5 cents/(kW·h). During the implementation process, the CUPUC did not impose fines on the scheme subjects that did not complete the goals. This action reduced the regulatory power of California RPS program [6, 7, 10].

3.2 Australia-Renewable Energy Target (RET)

Table 3 Australia-Renewable Energy Target (RET)

Australia-Renewable Energy Target (RET)	
Consumption indicators	Tradable certificates
Renewable energy types	PV panels, wind turbines, hydro systems, solar water heaters, and air source heat pumps
Scheme subjects	LRET: power stations(create LGCs)-Liable entities under the RET and Companies and individuals (purchase LGCs) SRES: creates a financial incentive for individuals and small businesses
Completion methods	Certificates are created and issued through the REC Registry
Penalties	\
Monitoring, evaluation, and assessment	Australia Government: review RET CER: check the buyers' certificates annually

Table 3 shows the features of the Renewable Energy Target (RET) in Australia. Australia's RET was a federal government policy designed to ensure that at least 33,000 GWh of Australia's electricity came from renewable sources by 2020. In September 2019, the Clean Energy Regulator (CER) announced that Australia had met the target more than a year ahead of schedule.

In January 2011 the RET was split into two parts: 1) The Large-scale Renewable Energy Target (LRET), LRET would create a financial incentive to establish and expand renewable power stations such as solar farms, wind farms and hydro-electric power stations. 2) The Small-scale Renewable Energy Scheme (SRES), SRES would support small-scale installations like household solar panels and solar hot water systems.

The LRET operated through the creation of tradable certificates. The renewable energy certificate market is a platform for the creation and sale of certificates called large-scale generation certificates (LGCs). LRET-accredited power stations could create LGCs for electricity generated from that power station with renewable energy. The electricity retailers were required to buy LGCs from the market and surrender these certificates to the CER on an annual basis. The Clean Energy Regulator CER announced that the RET had increased the number of installations of small-scale renewable energy systems, and successfully stimulated investment in renewable energy power stations [1, 6, 7].

3.3 China-Weighting of responsibility for renewable energy electricity consumption framework (WRREEC)

Table 4 China-Weighting of responsibility for renewable energy electricity consumption framework

China-Weighting of responsibility for renewable energy electricity consumption framework(WRREEC)	
Consumption indicators	Renewable Energy Consumption Responsibility
Renewable energy types	Special for Non-hydropower renewable energy consumption
Scheme subjects	1) Electricity sales enterprises 2) Electricity users
Completion methods	1) Purchase renewable energy generation amounts 2) Produced by consumption subjects 3) Green power certificate
Penalties	Listed as a bad credit record and included in the joint punishment for dishonesty
Monitoring, evaluation, and assessment	1) Provincial level: record Bad Credit History 2) National level: annual report

The manifestation of RPS in China was the Weighting of Responsibility for Renewable Energy Electricity Consumption (WRREEC) framework. The subscription of the Green Power Certificate (GPC) of the PV power generation industry had been officially started 2017. However, due to the lack of mandatory constraints, the unclear responsibilities, and the unclear pricing mechanisms, the scale of GPC subscription was limited [14]. After two years, [5] confirmed that power grid enterprises, direct users of the electricity wholesale

market were the responsible entities for the WRREEC framework. The responsible subjects were required to fulfil their Renewable Energy Consumption Responsibility (RECR) based on the annual electricity consumption and the responsibility weight decided by the government. [5] was the beginning of the implementation of WRREEC in China. According to [8], in 2022, the number of the subscription to the green power certificate reached 9.69 million, corresponding to 9.69 billion KW, an increase of 15.8 times compared to that in 2021. The subscription of the GPC effectively promoted the sustainable, low-carbon transformation and high-quality development of the Chinese economy and society. Table 4 illustrates the features of the WRREEC framework. WRREEC framework was implemented in less than 5 years in China with rapid development. Although more amount of evidence should be gained to assess its impacts.

The GPC system was expected to be an important guarantee for the WRREEC. The GPC system was conducive to ensuring that the responsible subjects can flexibly complete the WRECR goals. If the responsible subjects failed to complete WRECR in the current year, the remaining RECR goals was able to be accumulated and require the responsible subjects to complete the goals together in the next year. When the responsible subjects failed to complete the RECR goals within the specified time frame, the responsible subjects were included in the dishonesty credit record [5].

4. SUGGESTIONS FOR SUSTAINABLE ENERGY STRATEGY IN CHINA

To address China's carbon neutrality and peak carbon goals, the following recommendations base on the study FIT and RPS in Germany, USA and Australia are proposed for the future development of sustainable energy strategy in China. Firstly, close collaboration among governmental departments is essential to set ambitious yet realistic goals. Regular monitoring, evaluation, and timely adjustments are crucial to identify gaps between targets and actual progress. Besides. It is critical to investigate underlying reasons and propose appropriate solutions. During goal adjustments, government departments should work together to avoid excessive subsidy reductions and the perception of policy fragmentation caused by rapid plan transformations. Secondly, a sustainable approach is needed to avoid excessive subsidies and the rapid growth in the number of installations, to prevent the financial disruptions. Thirdly, greater emphasis should be placed on supporting, unified management, and future planning for small-scale sustainable energy systems, such as household PV system. Neglecting support for small-scale systems while solely focusing on large-scale power plants is undesirable and unsustainable. Small-scale sustainable energy systems possess considerable power generation potential, and early planning can maximize their contribution. Moreover, small-scale systems are the most common form of renewable energy accessible to the public. If the small-scale systems can be popular in the public, and it is an opportunity to rise the public awareness, responsibility, and participation in addressing energy and environmental challenges.

5. CONCLUSION

This paper shows the horizontal comparison between the characteristics of FIT renewable energy development strategy in China and Germany, highlighting their centralization of multiple relevant government departments. China's BGEP framework is led by the China National Development and Reform Commission and China National Energy Administration, while Germany's EEG FIT scheme is overseen by the Federal Government. This centralized planning approach enables unified coordination and planned arrangements, but it necessitates close cooperation among departments and the avoidance of functional confusion. Additionally, both countries have transitioned from single FIT frameworks to comprehensive carbon reduction strategy. For example, Germany's EEG 2023 includes carbon reduction planning and target-setting. Before this, it focused on subsidizing electricity prices. While China progressed from the electricity subsidy distribution to the ambitious of carbon peak and carbon neutrality targets. Both reflect the ongoing process of policy enrichment and advancement. During the implementation of FIT strategy, Germany and China both experienced rapid promotion in sustainable energy, with Germany witnessing a substantial increase in the share of renewable energy generation, and China observing a significant rise in PV system installations during the BGEP implemented. Both outcomes demonstrate the stimulating effect of FIT policies on the promotion on the initial stage of sustainable energy. However, both countries have exhibited a decreasing trend in subsidies. Furthermore, China's REDF had encountered funding gaps, suggesting that a long-term reliant on substantial financial support from the government is unsustainable.

The successful implementation of RPS strategy necessitates the collaboration and coordination of multiple government institutions, without functional fragmentation. In the case of California's RPS Program,

the separation of certification and regulatory bodies has weakened the regulatory effectiveness of quota systems. Additionally, ineffective enforcement of penalty mechanisms for unmet targets hinders regulatory functions. China's WRREEC shared some similarities with California's RPS in form; however, due to China's centralized government system, its government institutions had demonstrated a clear and unified attitude towards WRREEC. Nonetheless, WRREEC in China predominantly focuses on large-scale energy systems, whereas Australia's RET emphasizes the balanced development of both large and small-scale sustainable energy systems, enabling their simultaneous growth.

ACKNOWLEDGEMENT

The authors would like to thank all the people for their support and valuable comments that helped improve the paper.

DECLARATION OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. All authors read and approved the final manuscript.

REFERENCE

[1]Australia government Clean Energy Regulator. (2022) History of the scheme. *Australia government Clean Energy Regulator*. Retrieved from https://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/History-of-the-scheme

[2]CNDRC. FGJG [2015] No. 3044. 2015.

[3]CNDRC. FGJG [2011] No. 1594. 2011.

[4]CNDRC, CNEA. The Notice on Matters Related to Photovoltaic Power Generation in 2018. 2018.

[5]CNDRC, CNEA. Notice of the National Development and Reform Commission and the National Energy Administration on Establishing and Improving the Renewable Energy Electricity Consumption Guarantee Mechanism. 2019.

[6]Cui J, Han L. Insights from the implementation of renewable energy quota system in developed countries to China. Journal of Shenyang University of Technology (Social Science Edition) 2014; 07.

[7]Ding F, Li X, Liang Z, Wu M, Zhu Y, Feng D, Zhou Y. Foreign experience of renewable energy development and its inspiration to China's relevant support policies. Electric Power Construction 2022; 43.

[8]Jiang H, Liu C. Study on subsidy gap of renewable energy. Water Resources and Hydropower Engineering 2022; 53.

[9]Liang Y, Sun Z, Feng L, Yang H. Comparative Analysis and Enlightenment of Renewable Energy Fixed Power Price Policy and Renewable Energy Rating System. Sino-global Energy 2018; 23.

[10]Luo C. California's Renewable Energy Quota System and Implications for China. Sino-global Energy 2016; 21.

[11]Mathews J. (2017) The spectacular success of the German energiewende and what to do next. *Energy Post*. Retrieved from https://energypost.eu/the-spectacular-success-of-the-german-energiewende-and-what-needs-to-be-done-next/

[12]The Federal Government- Germany. (2022) Development of renewable energies. *Die Bundesregierung informiert*. Retrieved from https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/amendment-of-the-renewables-act-2060448

[13]United Nations News. (2020) Speech by Chinese President Xi, Jinping at the United Nations: China actively participates in international anti-epidemic cooperation and strives to achieve carbon neutrality by 2060. United Nations News. Retrieved from https://news.un.org/zh/story/2020/09/1067222

[14]Zeng M, Xu Y, Ma J, Dong H, Wang Y. Research on Impact of "Tradable Green Certificate Trading + Renewable Portfolio Standard Assessment" on Trading Strategy of Responsible Subjects. Journal of North China Electric Power University 2022.

[15]Zhuo Y. Effectiveness Evaluation of China's Renewable Energy Financial Policy - Taking Feed-in Tariff and Renewable Portfolio Standard as Examples. 2019.