

A regulatory policy to promote renewable energy consumption in China: Review and future evolutionary path



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ABSTRACT

Renewable energy has become the world's strategic choice to solve environmental pollution, address the energy crisis and achieve social sustainable development. The establishment of a regulatory system coincides with the development stage of renewable energy and electricity market operation is significant in standardizing the market competition and guaranteeing healthy development of renewable energy in China. This paper analyses the current situation of renewable energy development and the existing renewable energy regulation system in China, pointing out that the main problems restricting renewable energy development are institutional mechanisms and market factors. The existing regulatory mechanisms also have deficiencies, such as the inclination towards economic regulation and the lack of a market adjustment mechanism. This paper proposes that China should comprehensively consider the renewable energy development stage, electricity market trading mechanisms and other factors in electricity regulatory requirements when policy making, actively exploring a new renewable energy regulation model adapted to different development phases. In addition, this paper suggests China's regulatory policy path based on the forecasting of renewable energy developing models.

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1. Introduction

Although China's rapid development of renewable energy has promoted power source structure optimization, the associated power regulatory laws and supporting measures are imperfect. To some extent, the existing regulation policies and mechanisms are inadequate for promoting the development of renewable energy. Therefore, it is necessary to study the electricity market regulation issue under the condition of large-scale renewable energy grid connection to improve China's regulatory policy system further.

In the early stage of renewable energy development, the study of renewable energy mainly focused on encouraging policies, such as financial subsidies, tax deductions, technological support, etc. Researchers generally believe that breakthroughs in technology are the key to achieving rapid development, and the R&D (research and development) stage is the field that needs increased government policy support. Hillring, Graham and Martine et al. demonstrated

the important role of renewable energy technologies in the further development of the renewable energy industry, proposing that in the primary stage the government should promote renewable energy development via supporting technology research, encouraging information dissemination, introducing effective administrative policies, perfecting incentive mechanisms, etc. [1–3].

With the advance of policy and the maturity of the renewable energy market, research is turning to the links between renewable energy, low-carbon development, energy supply security and carbon tax. Scholars are expecting to introduce a packaged policy to achieve a sustainable low-carbon future. Kalkuhl et al. used a global general equilibrium model to study optimal policies from a broad set of policy instruments including carbon taxes, renewable energy subsidies, etc., and found that small deviations from the second-best subsidy could lead to strong increases in emissions and consumption losses. The conclusion included the assertion that renewable energy subsidies were highly efficient when they addressed market failures directly related to renewable energy technologies or markets; meanwhile, it might be an important additional instrument to solve the serious political issues of carbon pricing [4]. Gawel et al. analysed the interaction of the EU emissions

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trading scheme (ETS) and supported policies for renewable energy sources (RESs). He suggested that support for renewable energies should contribute to a more effective ETS design and may even increase the overall efficiency of climate and energy policy if other externalities and policy objectives besides climate protection were considered. Besides, the analysis also showed that a public choice view did not necessarily entail negative evaluations concerning the efficiency and effectiveness of a policy mix [5]. Aslani et al. described the relationship between renewable energy encouraging policies, energy dependence and demands through the analysis of qualitative and quantitative factors [6].

The study of power industry regulation is a long-standing topic. Tye undertook an in-depth analysis of generation, transmission, distribution functions and organizational forms in the power industry. He believed that these functions were not inseparable under the circumstance of existing technologies and proposed that the power generation side should be deregulated and open to competition [7]. In addition, Hazam, Ritschel et al. and Kemezis studied the impacts on the electricity market caused by regulatory philosophy and changes in cognition. They predicted that the globalization trend in the power industry was deregulation [8–10]. Rose studied and analysed three main regulation models combined with the U.S. electricity market. He pointed out the characteristics of various regulation methods and demonstrated the deregulating trend of the electricity market. To some extent, his research provided a basis for the trend towards gradual liberalization of the power industry [11]. Nakajima studied the electricity retail market without strict regulation in the U.S., indicated that deregulation was not a major factor in the price elasticity [12]. Högselius et al. focused on the response behaviours of key stakeholders in political and commercial areas in the process of electricity industry deregulation [13].

Recently, with the in-depth study of power industry regulation, close attention has been paid to the study of renewable energy regulation, covering a variety of forms of energy power generation and relevant market players. Shaw et al. studied the relationship among UK energy policy, regulatory objectives and distribution network operator (DNO) regulation since privatization and suggested reform to the regulatory framework to support future lower-carbon development [14]. Geraldo et al. presented the main regulatory changes that had occurred in the Brazilian power sector, especially related to small hydro power. They proposed that a collective effort was necessary on behalf of everyone involved in the production chain and there was a need to define clear rules that were both perennial and non-discriminatory for the different sources of renewable energy to provide stability to the energy system and achieve the country's sustainable development [15]. Tükenmez et al. proposed that administrative hurdles, obstacles to grid access, lack of information and training and social acceptance were the barriers that Turkey needed to overcome to increase its renewable energy supply [16]. Byrnes et al. outlined the key policy frameworks, incentives and regulatory environment of the renewable energy sector in Australian, and presented an in-depth analysis of the barriers faced by the industry. They pointed out that measures should be taken to remove the obstacles to the development of renewable energy, otherwise Australia would miss the opportunity to develop its abundant renewable resources further and gain social, environmental and economic benefits [17]. Agrell et al. analysed the main impacts of new investment policy on the power network construction tasks, assets and costs, and contrasted these with the assumptions of economic regulation. They also developed an analytical model of investment provision under regulation based on standard principal agency theory, and the results confirmed the hypothesis that network regulation should find a focal point, integrate externalities into the performance

assessment and avoid wide delegation of contracting billing for smart-grid investments [18]. Wijayatunga et al. found that the implementation of policy and regulatory frameworks and different approaches had been mostly successful experiences in Sri Lanka, resulting in rapid expansion of the renewable energy supply industry not only in terms of overall capacity additions but also in the form of diversification of renewable energy sources [19]. Zhen-Yu Zhao et al. established a critical analysis of the policy framework for the renewable energy in China, meanwhile analysed its impacts on the power generation structure [20].

This research has certain significance for renewable energy development and renewable energy regulation in China. However, China's electricity market is at a different stage from other countries' markets, and the development environment is very different too. In addition, in order to promote renewable energy development further, a policy system and regulation modes adapting to the electricity market and development stage should be proposed. Based on the research results, this paper undertakes in-depth research on China's renewable energy regulation and designs a regulation path for the future.

The remainder of this paper is organized as follows. Section 2 briefly introduces the current situation of renewable energy development and its strategic objectives in China and points out the main factors impeding the development of renewable energy. Section 3 elaborates the current regulatory policy system and mechanisms, which are related to renewable energy, and presents the problems in the existing regulatory system. Section 4 designs the dynamic regulatory policy path based on the prediction of China's electricity market operation mode and future development strategy for renewable energy. Section 5 concludes the paper with suggestions for renewable energy regulation policy.

2. Energy conservation target and renewable energy development in China

2.1. Energy conservation and the renewable energy development condition in China

In China, some energy conservation targets have been promoted by the Government: to decrease the carbon emissions' intensity by 17% during the '12th Five-Year' period from 2011 to 2015, to decrease the carbon emissions' intensity by 40%–50% by 2020, and to reach the peak of the carbon dioxide emissions about 2030 [21,22].

China's renewable energy has achieved a great leap forward in development driven by the "Renewable Energy Law" and other related policies. To some extent, this has made a great contribution to achieving China's emission reduction targets. In 2014, the total power generation is about 5649.6 TWh. Renewable energy (hydro, wind and solar) power generation is 1251.8 TWh, accounting for 22.16% of the national power generation [23].

According to the statistical results of the National Energy Administration (NEA) and Statistical Bulletin of National Economic and Social Development of China in 2014, by 2014, China's total installed capacity of power generation reached 1.36 TW, the total hydro, wind power, and solar power installed capacity were 915.69 GW, 114.609 GW, 28.05 GW. Meanwhile, the new wind power installed capacity was 23.19 GW in 2014, which was raised 44.2% compared with last year. The new solar power installed capacity was 10.6 GW, including 8.55 GW of photovoltaic power station and 2.05 GW of Photovoltaic distributed power in 2014.

In addition, According to "National Climate Change Plan (2014–2020)" which was promulgated in November 4, 2014, wind power, solar energy, biomass power generation will obtain rapid growth. The details are shown in Table 1.

Table 1

The installed capacity goal of renewable energy resource in China up to 2015 and 2020.

Year	Hydro	Wind power	Solar power	Biomass power	Total
Up to 2015 (GW)	290	100	21	13	424
Up to 2020 (GW)	350	200	100	30	680
The proportion of installed capacity (%)	20.7	100	376.2	130.8	60.4

With the increase of energy demand, the next major factors driving towards installed capacity is renewable energy power. According to “the Power Industry ‘12th 5-year (2015–2020)’ Planning Research Report”, the China Electricity Council (CEC) puts forward recommendations about targets of renewable energy in 2020. The specific recommendations are that the national power installed capacity will reach around 1885 GW by the years 2020, and the average growth rate is about 5.6%. Meanwhile, the total installed capacity non-fossil energy power will be around 685 GW, which accounts for around 36.3% of total installed capacity [24]. According to “the Power Industry ‘12th 5-year (2015–2020)’ Planning Research Report”, China’s power structure will be greatly improved, as shown in Fig. 1.

2.2. The renewable energy development plan in China

In the future, global investment in renewable energy and technology will usher in a period of high-speed development. According to ‘the Outlook of Renewable Energy of China’, which is promulgated by International Renewable Energy Agency (IRENA) on November 24, 2014, as the world’s largest energy consumer, China’s energy consumption will increase 60% by 2030. Renewable energy power generation will account for a proportionate share of the global energy demand from the current 13%–16% in 2030. Meanwhile, the report predicts that by 2030, the proportion of renewable energy power generation will rise from the current 20%–40% in China, which can make China becoming the largest renewable energy consumption country in the world. In addition, the BP 2030 energy outlook report, which is promulgated by BP Amoco, predicts that the contribution rate of renewable energy technologies (RETs) to energy growth will increase from 5% to 18% in the period of 2010–2030. The power generation structure in China during 2020–2050 will have a big change. It is shown in Table 2.

The International Energy Agency (IEA) published the “World Energy Outlook of 2015” on 16 July 2015. It proposed that up to 2030, the global power generation of renewable energy power will

be expected to be increased to reach 33% of the global total generation power. In the next 15 years, about two-thirds of the renewable power generation capacity in the world should be from China, the European Union, the United States and India, the rest from other countries.

(1) Wind power

According to the Government’s commitment in 2020 and 2030 to non-fossil energy accounting for 15% and 20% of the total primary energy consumption respectively, wind power will become one of the main energy technologies to achieve the low-carbon energy strategy in China, and the development will undergo three phases, the development plan for wind power in China is shown in Fig. 2:

The first phase (2011–2020): offshore (intertidal) wind power will occupy the second place while onshore wind power will dominate the development. During this time, the annual increased wind power installed capacity will reach 15 GW and the cumulative installed capacity will reach 200 GW. Wind power will account for the total power installed capacity of 10%, and meet 5% of the demand for electricity.

From 2011 to 2014, the development of wind power installed capacity meets the planning requirements. It is shown in Table 3.

The second phase (2021–2030): without considering the inter-provincial transmission costs, wind power generation costs less than coal. Wind power development will focus on both onshore and offshore in this period. The annual new installed capacity will be about 20 GW and the total installed capacity will reach 400 GW. The proportion of wind power generation will reach 8.4% and the ratio of the power structure will expand to around 15%.

The third phase (2031–2050): wind development will be directed towards the midwest onshore wind power and the eastern offshore wind power. The annual increased installed capacity will reach 30 GW and the cumulative installed capacity will reach 1000 GW, accounting for 26% of the power structure.

(2) Solar power

Distributed photovoltaic power generation will be an important direction for renewable energy development in the future. According to the 12th 5-year plan, China’s total PV installed capacity will reach 35 GW by the end of 2015, and the distributed PV projects will reach approximately 20 GW, which accounts for 57% of total PV installed capacity. In 2015, the target of total PV installed capacity up to 2020 is 150 GW, which replaces 100 GW [25]. Meanwhile, in the mid-eastern region, China will accelerate the construction of distributed photovoltaic power generation; in the western region, China will accelerate the construction of a large-scale solar power station and so on. Then, China will form a good development pattern to realize the simultaneous development of large-scale and distributed solar photovoltaic power generation.

2.3. The renewable energy regulation situation in China

China has introduced a large number of policies to promote the development of renewable energy and the industrialization of the industry since 2005. These favourable policies cover the feed-in tariff, financial subsidy, tax deduction and other technological support. In addition, to create a favourable market and investment

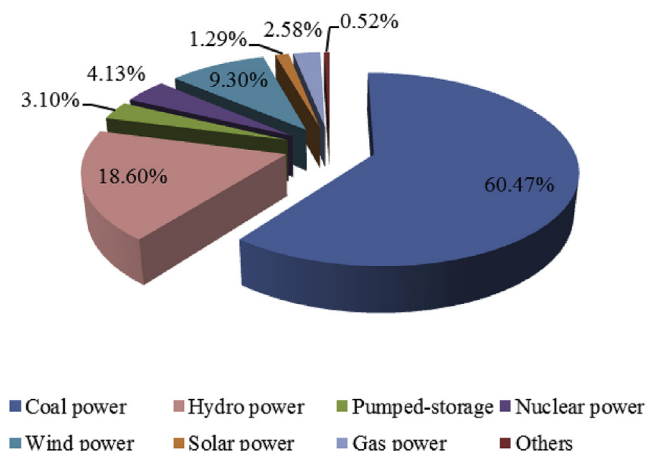
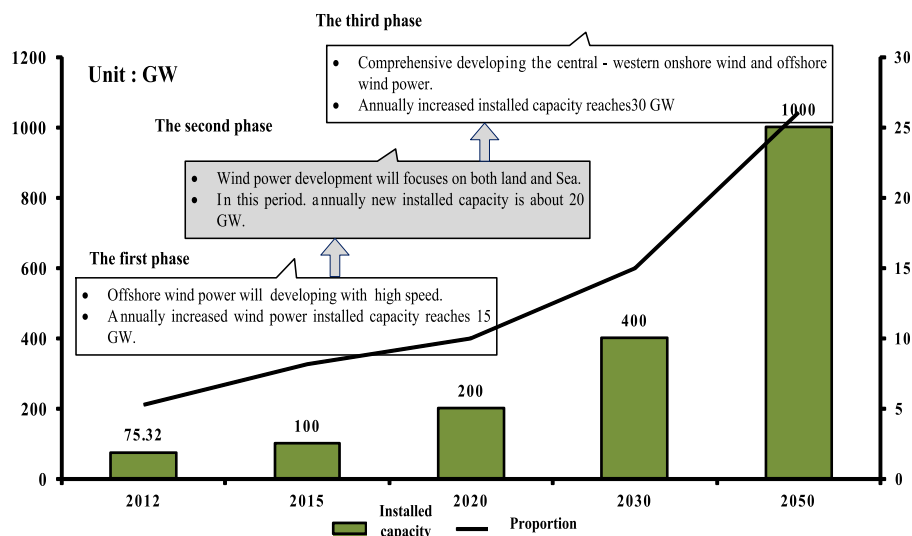
**Fig. 1.** The power source structure planning in China 2020.

Table 2

The power generation structure during 2020–2050 in China.

Category	2020		2030		2050	
	Electricity generation (GWh)	Rate (%)	Electricity generation (GWh)	Rate (%)	Electricity generation (GWh)	Rate (%)
Thermal	63,070	72.7	66,040	64.5	69,870	50.1
Gas	2450	2.8	3500	3.4	5950	4.3
hydro power	11,385	13.1	14,190	13.9	15,510	11.1
Renewable energy	9896	11.4	18,750	18.2	48,120	34.5
Among them:	5760	6.6	11,520	11.3	30,960	22.2
Wind	3200	3.7	5000	4.9	10,400	7.5
Solar	336	0.4	1050	1	4760	3.4
Biomass	600	0.7	1000	1	2000	1.4
Total	86,801	100	102,300	100	139,450	100

**Fig. 2.** The development plan for wind power in China.**Table 3**

The new installed capacity of wind power during 2011–2014 in China.

Year	2011	2012	2013	2014
The new installed capacity (GW)	17.6309	12.96	16.0887	19.81
Average annual new installed capacity (GW)	16.6224			

environment, China initially established the renewable energy regulatory system. The “Renewable Energy Law”, “Electricity Regulatory Ordinance”, “Renewable Energy Prices and Cost-Sharing Management Pilot Scheme”, “Grid Enterprises Purchase Renewable Electricity Regulatory Approach” and “Measures for the Supervision and Administration of Power Work Safety” formed the main legal basis for the current renewable energy regulation policy system. Combined with “Several opinions about further deepening the reform of electric power system (Zhong Fa (2015) No.9)” and “The opinions of pilots about the renewable energy consumption to the nearest (provisional)”, this covers policies such as renewable energy priority access, power grid construction subsidies and other specific quota policy content as shown in Fig. 3.

In China, the National Energy Administration (NEA) regulates market behaviours by relying on renewable energy regulation policies. The renewable energy regulation in the future will mainly include economic regulation, social regulation and antitrust regulation. Among these, the regulation on power generation enterprises focuses on economic fields, such as price supervision, subsidy regulation, etc. Regulation against the electricity market

highlights the social field, including the situation to fulfil the obligations of system security, electricity market entry and exit conditions, market information disclosure and various standards for renewable energy technologies, safety, electricity quality, etc. However, the regulation of power grid companies is the most strict and comprehensive, covering renewable energy grid connection circumstances, power scheduling, electrical power security and even the condition of market conservation. The details are shown in Fig. 4.

3. The analysis of renewable energy regulation policy system in China

Compared with EU countries, China has made progress in renewable energy development. However, it has still not reached a high contribution rate in the optimization of the energy structure. In addition, there are some negative phenomena in the consumption of renewable energy. Taking wind power for example, the National Energy Administration (NEA) pointed that in the half of 2015 the utilization of wind power only was 993 h. And the wind

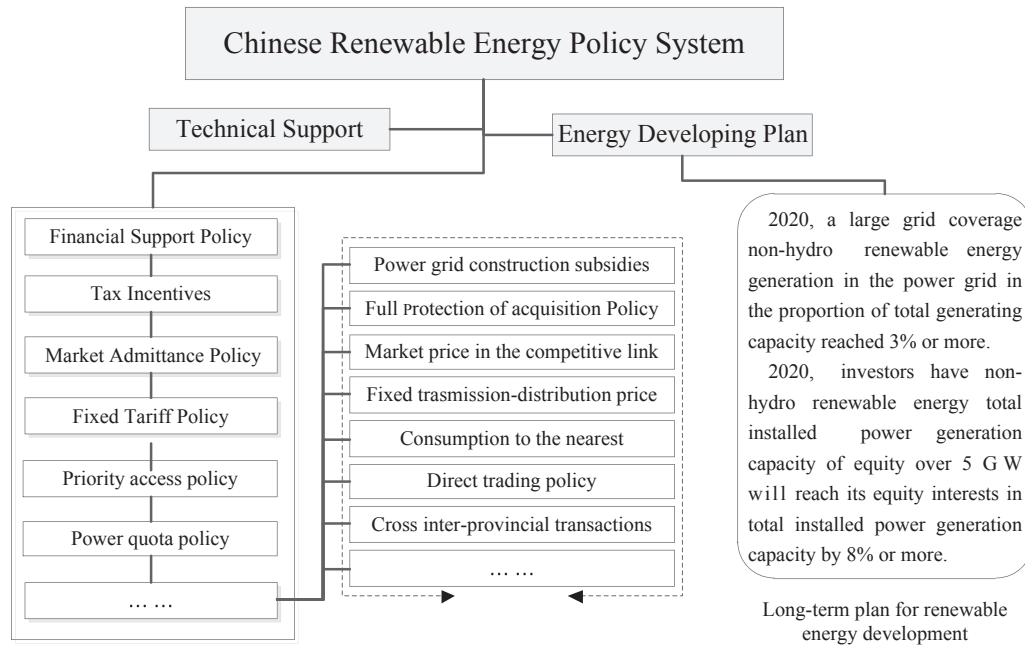


Fig. 3. China's renewable energy regulatory policy system.

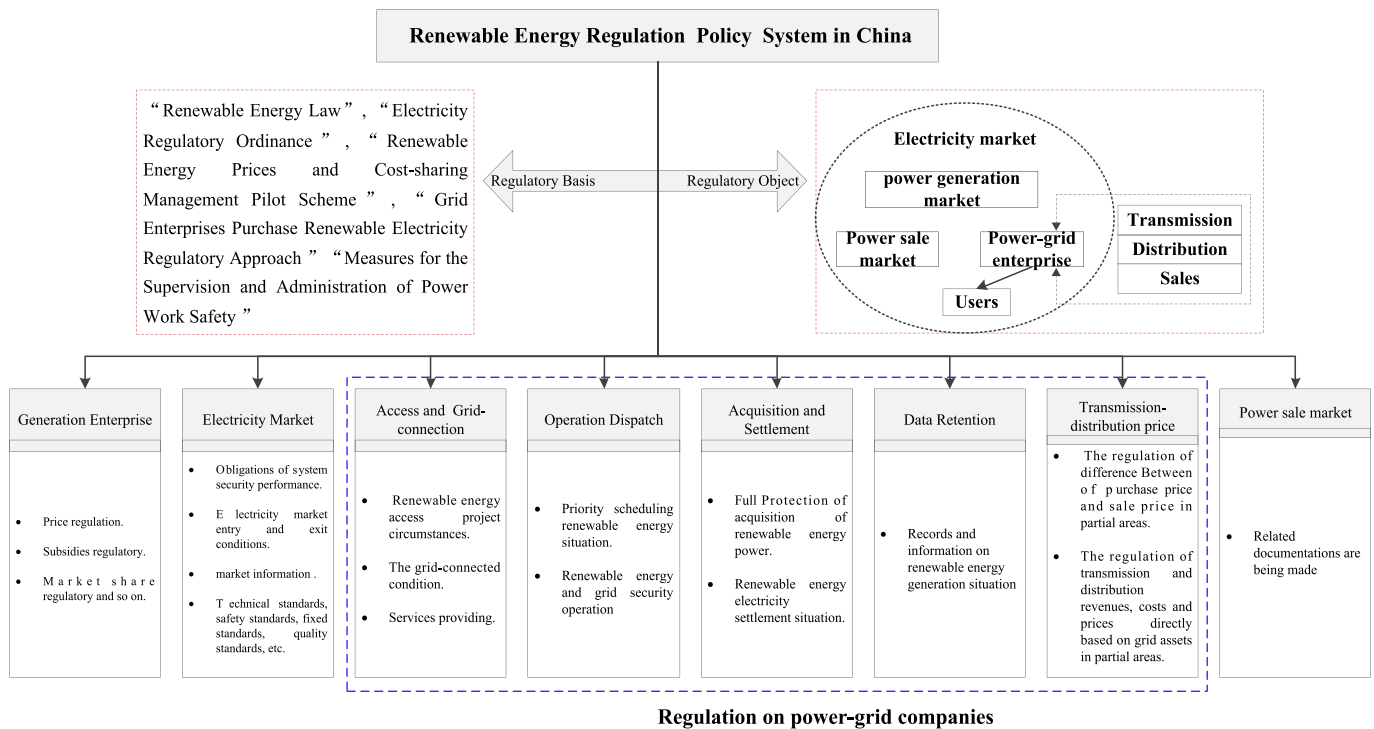


Fig. 4. The renewable energy power regulation system in China.

curtailment rate was 15.17% while the wind curtailment loss was 17.481 TWh. The main factors restricting China's renewable energy grid connection and consumption are institutional factors and market mechanisms.

(1) Institutional factors

Currently, the renewable energy regulation policy system in China to support renewable energy development is still incomplete. The existing policy system lacks coordination among the relevant policies and planning. It cannot form a long-term efficient

mechanism to support the sustainable development of renewable energy. Therefore, government-leading, organization and the cost of direct advances become the prerequisite for China's renewable energy industry to take off. The industrial benefits induced by government financial support are planning indicators' traction rather than equity investments or the traction of the market price.

(2) Market mechanisms

China's power market are open to competition in electricity generation and electricity sale at present, however, the related sale

policies about electricity have not been carried out fully. There is still a natural monopoly in the transmission and distribution sectors. No mandatory market safeguard policy has been issued, and renewable energy development is merely guaranteed by the protective acquisition policy. The lack of continued market-driven results in renewable energy development cannot form a stable market demand. Furthermore, it hinders the long-term development to some extent. In addition, factors such as the small scale and high prices hinder the capability of independent commercial development. It is difficult for renewable energy to compete with other fossil fuels. At the same time, various technology bottlenecks have limited the establishment of renewable energy markets.

To some extent, the existing regulation system has restricted the development of renewable energy. In the current renewable energy regulation policy system, economic regulation policies occupy the dominant position. To a certain extent, the neglect of social and antitrust regulation has resulted in certain deviations appearing in the renewable energy market regulation mechanisms, expressed as:

(1) Market regulation is not in position. The existing renewable energy regulation system in China lacks the overall operations of the electricity market. It puts too much emphasis on the control of grid enterprises in the implementation process, thus weakening the control of other market players. Meanwhile, it is inclined towards mandatory regulation and lacks a market adjustment mechanism.

(2) The existing renewable energy regulation system focuses on the front part of approval procedures, so that the supervision during and after the project is relatively weak. There is a phenomenon of “approval-emphasized, supervision-contempt” in the development of renewable energy. At the same time, energy management pays more attention to economic regulation, such as investment, pricing and production scale. It is relatively weak in the social regulation of the environment, safety, quality, resource conservation and other external issues.

(3) Economic regulation is in the dominant position that ignores the coordinative development of society. To some extent, it results in renewable energy planning being uncoordinated with the market consumption, grid construction and other power generation planning. Moreover, the lack of coordination between local planning and national planning has seriously hampered the development of renewable energy.

Meanwhile, from the perspective of promoting renewable energy development in the long run, China's existing economic regulatory policies in terms of tariff and subsidy incentives are relatively weak:

1) The tariff mechanism is in a low-oriented level. Firstly, the main tariff mechanism for renewable energy power is a fixed tariff pricing mode, and the fixed tariff pricing mode is fixed tariff per kWh by regional or the provincial average cost based on the operating period electricity price. The mechanism can be effective in stimulating enterprises to develop in the early stage. However, from a long-term perspective, it is not flexible enough to reflect the scarcity of resources, market supply and demand. It cannot truly reflect the environmental costs and reasonable compensation so it is unfavourable to the sustainable development of renewable energy. Secondly, electricity price, which was formed by the market in stage except welfare price, was proposed in March 2015. The mechanism can improve the market level of electricity price. However, the mechanism is in a pilot phase, and lacks of appropriate specific market-based policies.

2) Subsidy incentives are not in place. In the current subsidy policy system, there are no subsidy incentives for producers or consumers, but there are investment subsidies. Although subsidies for investors can stimulate the production of enthusiasm, it is

difficult to play the role of encouraging renewable energy technologies to update or costs to reduce. Subsidy incentives for output and consumers are beneficial to the future development of renewable energy. On one hand, they help to increase the product yield, reduce costs and improve economic efficiency. On the other hand, they will expand the market demand by stimulating consumption, and in turn the renewable energy development will drive the expansion of productivity, in order to achieve the cost reduction effect.

4. Designing a renewable energy regulation policy development path

In order to better promote the development of renewable energy and regulate the behaviours of the market, rational renewable energy regulation policies should consider market operation, environmental strategies. And renewable energy regulation policy reform should be implemented in stages.

4.1. Design principles of a renewable energy regulation policy development path

The essence of renewable energy regulation is to promote the development of renewable energy from government guidance to market-driven development, from policy leading to industrial growth and from regulatory imitation to innovation. Therefore, the path of renewable energy regulation policy design should adhere to the following principles:

(1) The principle of development

Renewable energy regulation is a process with stage characteristics. It needs dynamic adjustment and constant development. Regulatory agencies need to adjust the renewable energy regulation contents appropriately, relying on different developing stages, not only matching the stage of electricity markets and the renewable energy development strategy, but also adapting to the national energy planning and energy conservation goals. Gradually, the development of renewable energy in China will move from government support to market-driven development.

(2) The principle of coordination

Renewable energy regulation needs to reflect the wholeness and coordination of renewable energy development. On one side, renewable energy regulation must play a role in balancing the relationship between economic regulation, social regulation and antitrust regulation. Changing the old regulatory mode, which was inclined towards economic regulation, is necessary to achieve full-flow control of renewable energy from the development plan to terminal consumption. On the other side, renewable energy regulation should properly handle the interaction between mandatory regulation and market-driven regulation and properly solve the problem of energy substitution, so that the intensity and speed of development are combined with China's development stage and future economic strength, technology, environmental requirements, resources, energy security and cost advantages to weigh other factors.

(3) The principle of innovation

Renewable energy regulation should reflect the characteristics of innovation. Therefore, China should integrate the foreign experience of renewable energy regulation with its own development conditions, actively exploring suitable regulatory mechanisms. In order to achieve a new leap in development in the renewable energy regulation field, China needs to strengthen the reforming of the renewable energy regulation system to policy innovation. For example, policy makers can achieve innovation from the following aspects:

- Establish a “big energy outlook”, ensuring the security of the energy supply and power system. Renewable energy regulators agencies need to pay close attention to the scientific analysis of the domestic renewable energy supply and demand and investment changes, in order to make timely adjustments to regulatory policies.
- Clearly the main renewable energy regulatory objective is to promote sustainable development. To adapt to energy restructuring and the trend of low-carbon development, regulatory agencies should give policy support for investment, access, pricing and taxes to promote the development of renewable energy and provide strict supervision of the implementation of supporting policies.
- Actively carry out the regulation on social responsibility to ensure that the relevant players fulfil their social responsibility. To some extent, this will promote social harmony and environmental protection and achieve other social goals.

4.2. The design of renewable energy regulation development stages

In response to economic growth and climatic and environmental challenges to renewable energy development, renewable energy regulation policy will be continuously adjusted and optimized. It will roughly experience three important phases:

- (1) The government support phase: renewable energy development is in the government support and policy guiding phase.
- (2) The transition phase: renewable energy development is in the infancy combination stage of promoting and market-driven policies.
- (3) The market-driven phase: renewable energy development is in the stage of constantly reducing administrative intervention and gradually increasing effective regulation.

4.3. The government-supported phase of regulatory policy research

4.3.1. Key contents of renewable energy regulation in the government-supported phase

In the government-supported phase, China's industrialization and urbanization will enter a period of accelerated development, during which resource and environmental constraints will continually grow. Energy saving and emission reduction, as well as a rapid response to climate change, will become the main point of the national economic policies. At the same time, renewable energy development is given a higher priority as a strategic choice with the trend of the electricity market reform and internationalization. China will intensify the regulation in the economic, social and antitrust fields, and the details are as follows in Fig. 5:

(1) Economic regulation

Economic regulation will be undertaken through direct intervention, such as pricing, entry and competition rules, to change the parameters of electric power enterprise decision making and orientation so as to achieve the objective of government monitoring. The specific controls are as follows:

- Implementation of the Renewable Portfolio Standard (RPS).
- Regulation on the feed-in tariff, in particular the implementation of pricing policies for promoting energy conservation.
- Regulation on the electricity prices of transmission and distribution. At the same time, the wholesale electricity prices and the terminal retail prices should be regulated.

- Regulation on inter-provincial transmission line loss standards, regulating line loss-sharing behaviour in inter-provincial trade.
- Regulating the implementation of electricity price policies for trans-regional trade and a special fund for renewable energy development and tariff cross-subsidies.
- Strengthening the supervision of electricity costs, statistically aggregating and disclosing information about cost and price timeliness.
- Strengthening the supervision of the renewable energy power market trading.
- Strict control of the waste of wind and light resources. Concretely, prescribing the proportion of renewable energy power generation and specifying the condition in which operators can take action to abandon electricity.
- Strengthening the supervision of the ancillary service market. Integrating renewable energy into the electricity grid ancillary services' evaluation and compensation system.
- Compensating renewable energy power generation enterprises in special conditions. Grid operators will pay compensation if their fault resulted in the loss of electricity, and renewable energy power generation enterprises will be compensated by consumers in the condition of non-grid operators' fault.

(2) Social regulation

Social regulation mainly includes the regulation of electricity safety, universal service and environment. Electrical safety regulations include:

- Strengthening the management of business qualification.
- Enhancing the regulation of small-scale power generation enterprises' basic situation, the existing problem and the implementation of the licensing system.
- Regulating the safety of renewable energy grid connection.

Universal service regulations are as follows:

- Supervising the construction of the power grid.
- Regulating the preparation time of renewable energy grid connection.
- Controlling the construction of peak load regulating power plants, such as pumped storage and gas-fired power stations. Additionally, taking the renewable energy network feed-in construction planning into the regulation of power-grid construction planning.

Environmental regulations are as follows:

- Exercising supervision and inspection of the implementation of environmental policies, rulers and standards.
- Improving the control of sulphur dioxide and nitrogen oxide emissions.
- Strengthening the regulation of coal-fired power plant reconstruction with desulphurization and denitration processes.

(3) Antitrust regulation

Antitrust regulations include:

- The situation of grid feed-in. Regulating the renewable energy power projects, especially distributed power grid feed-in, and overseeing the power grid to achieve the maximum extent of fairness and openness.
- Regulating grid operators in providing timely services to renewable energy enterprises for their access.
- Supervising the grid-connected service system for distributed generation, including grid-connected access systems to

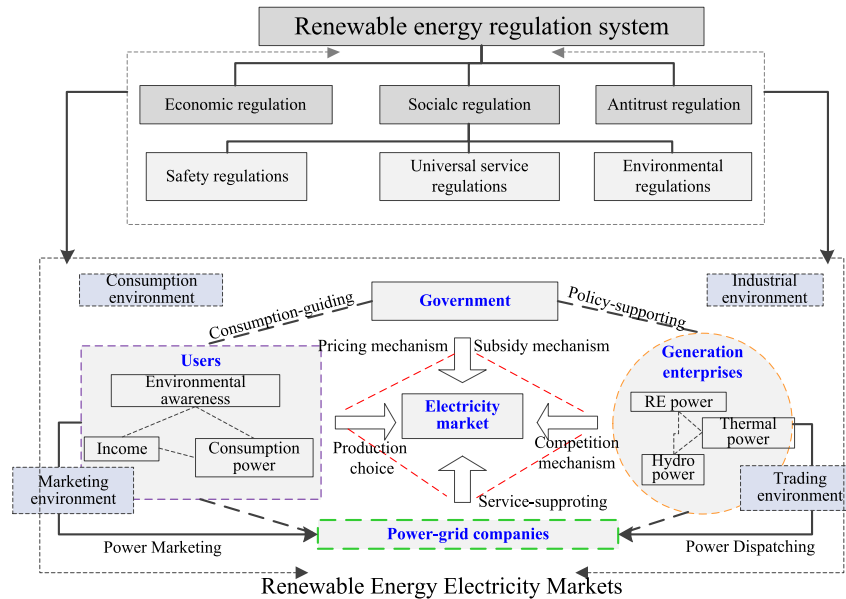


Fig. 5. The renewable energy power regulation system in the government-supported phase.

distributed PV, management procedures and grid-connected service processes.

In addition, the Government will focus on the construction of renewable energy tracking supervision mechanisms in important areas and key projects. To develop the coordinated services well, it will particularly strengthen the whole-process monitoring of the renewable power supply projects connected to the grid.

4.3.2. Regulatory policy in the government support phase

In the government support phase, China should gradually perfect the competitive incentives and energy technology policies to improve the proportion of renewable energy products. To solve the existing problems in three northern regions (Northeast China, Northwest China and North China) and the distributed energy resource grid-connected issues, the Government will introduce policies such as a renewable portfolio standard (RPS) and energy-saving dispatching and further improve the ancillary services market to establish a market-oriented compensation mechanism in which wind power should participate. Accountability through administrative means can achieve top-down binding emission reduction targets, strengthening energy-saving targets and introducing a systematic policy to promote the development of renewable energy at the same time. Meanwhile, attention should be paid to the role of demand-side policies, taking measures such as tax incentives and financial subsidies to stimulate consumers' demand.

4.4. Transitional phase regulatory policy research

4.4.1. Key contents of renewable energy regulation in the transitional phase

In the transitional phase, the electricity market in China will be gradually established. To some extent, the developing pricing mechanism reform and market mechanism will gradually promote renewable energy development, diverting towards the combination of policy support and market-driven development. During this period, renewable energy regulation will implement appropriate elastic power regulatory policies, relaxing electricity market access, investment and generation bidding. In order to solve the problems

of external diseconomies and information asymmetries that exist in the electric power industry, the Government will focus on the control of power supply obligations, electricity general obligations, environmental protection and technological progress. The details are as follows:

- Regulation on the entry and exit of the renewable energy power market, authorizing and overseeing the NECC (New Energy Chamber of Commerce) on the certifying of green electricity.
- Sales price for renewable energy electricity.
- Implementation of a renewable energy power generation programme.
- Whether the total amount of renewable energy electricity production is lower than the actual number of green certificates.
- Renewable energy electricity companies will progress in carrying out marketing and providing after-sales service.
- Ensuring the regions' implemented renewable energy portfolio standard is fully compliant with the contract.
- Supervising the marketing behaviour to prevent non-renewable power being sold to users at the same price as renewable energy electricity.
- Renewable energy market information disclosure, including the annual sales volume and prices, the total acquisition and the implementation of large consumers' direct power purchase.

4.4.2. Regulatory policy in the transitional phase

The renewable energy regulation policy system in China will transform the old mode focussing on economic regulation and pre-approval into a new one that pays attention to social regulation and whole process-based regulation. Safety, green development and economic efficiency will become the basic starting point and key constraints for renewable energy policy making, or even a series of economic policies. The renewable energy regulation policy system will mean a big change in the future work. It will start from the focus on a single target to increase the renewable energy supply proportion to multiple targets promoting renewable energy development. At the same time, it will optimize the energy structure and improve the efficiency of resource allocation via the introduction of market competition mechanisms. The new era

renewable energy regulation policy system will focus on resolving the long-standing problems in the current condition, such as regulation inadequacy caused by the lack of social regulation. The Government will comprehensively take safety, environment and efficiency savings into consideration, to form a new model that combines things in advance and afterwards.

4.5. Market-driven phase regulatory policy research

4.5.1. Key contents of renewable energy regulation in the market-driven phase

After 2030, China will have established a reasonable price regulation mechanism and a market-driven mode of renewable energy regulation will have been published. In this time, renewable energy regulation will make progress in market order regulation. It will strengthen antitrust regulation to promote effective competition and accelerate the establishment of users' confidence. Meanwhile, social regulation will focus on improving resource utilization to ensure energy supply security and protect the ecological environment. The details are as follows:

(1) Regulations on the power generation market

- Prescribed electricity suppliers, to provide their product, must include at least a certain percentage of renewable energy electricity. The ratio should be based on the specific location of the electricity supplier, resource endowments and power consumption.
- The availability of renewable energy power plants in the competitive market and its electricity must meet quality standards.

(2) Regulations on the trade market

- Regulation of market order, mainly market fairness, justice and openness.
- Regulation of the trading centre, ensuring that data and information are published accurately and in a timely manner.

(3) Regulations on the sales company

- Regulation of the sales company's behaviour on propaganda for renewable energy electricity and the condition of the information announced.

(4) Regulations on the power transmission company

- Supervising the security and stable operation of the power grid, in order to reduce the adverse effects caused by market bidding.
- Regulating the service-providing condition, examining whether the power transmission company is fulfilling its obligations for technical modernization with capacity expansion to commit actively to promoting renewable energy consumption.
- Regulating the income ceiling. Establishing a method to dedicate the power transmission costing and provide strict supervision of the cost.
- Regulating the fees the power transmission companies charge for renewable energy grid connection.

4.5.2. Regulatory policy in the market-driven phase

In the market-driven phase, the renewable energy regulation policy will focus on two points: namely, to reduce government intervention and increase the effective supervision. The Government will pay attention to the construction of market-adjusting mechanisms, and then the market will play an important role in

adjusting the relationship between the renewable energy electricity demand and the sales prices. In addition, to stimulate renewable energy market scale and industrialization, the Government will gradually improve the renewable energy development mechanism in the fields of product market incentives, pricing, market competition, industry financial compensation, the industry resources flow mechanism and the linkage of industry management and service.

4.6. The design of China's renewable energy regulation policy development path

With the reform and development of the electricity market, China will gradually develop a social regulation-based renewable energy regulation model. Its key work will shift from the supply side of power generation to the demand side and from administrative regulation to market-driven regulation as well. The change will benefit enhanced power demand side management (DSM) and relieve the contradiction of demand and supply for renewable energy regulation power to a certain extent. Meanwhile, the Government will highlight the management of energy-saving, energy-efficient technology in order to make a notable improvement in power demand-side management. Accordingly, the renewable energy regulation policy will realize the target to change from the current administrative-based simplification system to a comprehensive policy system that integrates the factors of economic, legal, administration, finance, technology and technical standards. The renewable energy development will turn to market-driven development and the renewable energy regulation policy system will be notably more market-oriented and socialized. The renewable energy regulation policy development path in China is shown in Fig. 6.

(1) Economic regulatory policies: these will emphasize policy orientation, openness and transparency, gradually realizing the renewable energy pricing mechanism with a combination of market-driven and government guidance. In the early stage, adopting transitional tariff reform policies by using the cost plus regulatory mode and a stronger incentive price-cap regulatory approach will be introduced with the maturation of development. Meanwhile, investment subsidies should be applied to achieve an appropriate increase in the level of subsidies to power grid enterprises earlier, and must take the renewable energy development condition into consideration during decision making. With the maturity of the markets, subsidy policies for renewable energy development will gradually be cancelled.

(2) Social regulatory policies: these will consider the coordinated development among renewable energy, economy, society and environment, establishing and continually improving regulatory policies in the social field, such as resource efficiency, environmental protection and electrical power security.

(3) Antitrust regulatory policies: in the early stage, the implementation of the quota system, relying on government support, will be vigorously promoted and dynamic adjustment made each year. Regulatory agencies' market behaviours will be constrained through the national legislative norms. In the period of transition, green certificates and green-price projects should be gradually implemented in order to achieve the freedom for users to make a choice. In the mature period, policies related to the renewable energy industrial investment fair market competition mechanism, renewable energy resources' flow mechanism and renewable energy industrial management and service system linkage mechanism should be perfected, which will help to achieve free market competition and guarantee the renewable energy development in the direction of scalization and industrialization.

In summary, the regulatory policy to promote renewable energy consumption in China is shown as Fig. 6.

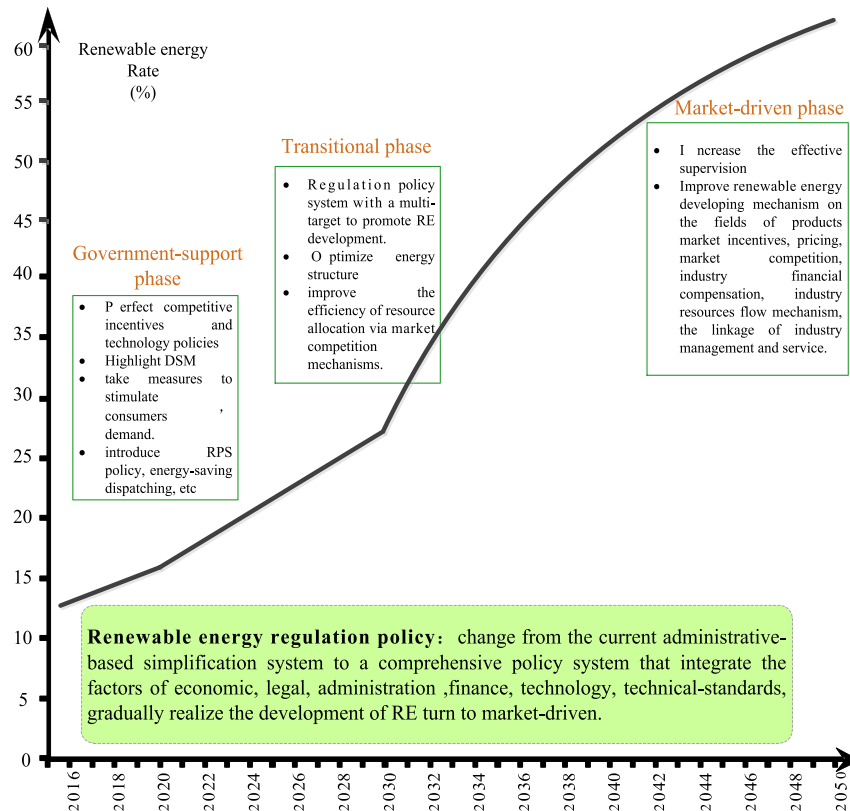


Fig. 6. The renewable energy regulation policy development path in China.

5. Conclusions and policy implications

There is a certain independent development path in the evolution of the renewable energy market and structural changes, and the vital factor is the Government's (policy) participation. In this paper, the author comprehensively takes the condition of China's electricity market and the renewable energy development stage into consideration. According to the degree of government involvement and the role of the market, renewable energy development can be divided into three main stages: the government support phase, the transitional phase and the market-driven phase. A policy path that adapts to China's electricity market and renewable energy development is designed based on the three development stages, and it strictly follows the principles of development, coordination and innovation.

(1) In the government-supported phase, renewable energy development takes off as a result of government guidance and policy support. Therefore, mandatory regulation and an incentive policy should be implemented to promote renewable energy development, on one hand accelerating the implementation of the Renewable Portfolio Standard (RPS) and clearing the quota obligations of power grid companies and power generation enterprises by administrative means and on the other hand strengthening the economic regulation of the renewable energy tariff, tax incentives, subsidies and other aspects, ensuring that renewable energy generation companies have greater productive enthusiasm.

(2) During the transitional phase, China should insist on the principle that renewable energy regulation policy incentives and market mechanisms need to be combined harmoniously, optimizing the developing mechanisms of renewable energy via strengthening the regulation of electrical power safety, market transactions and other social fields. The enthusiasm of investors

needs to be mobilized by market operation, in order to realize the development of renewable energy driven by policy support diverted to the market.

(3) In the market-driven phase, renewable energy regulation should strengthen the social regulation and antitrust regulation of market transactions rather than the direct control of the market body. It should guide the formation of a fair and open market mechanism to improve the free competition and fair trading mechanism and the benefit prevention mechanism.

The establishment and improvement of the power regulatory system is the main content of the electricity market reform. It would be progressively perfected along with the continued progress of the market reform. Therefore, China's renewable energy regulation should follow the steps of market development. To ensure the renewable energy regulation mechanism is adapted to the electricity market, it is necessary to maintain the continuity of policy development.

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