



## Article

# How Policies Guide and Promoted Wind Power to Market Transactions in China during the 2010s

Shuo Zhang <sup>1,2</sup> , Li Chen <sup>1</sup> , Yidan Zheng <sup>1</sup>, Yingzi Li <sup>3,\*</sup>, Ying Li <sup>1</sup> and Ming Zeng <sup>1</sup>

<sup>1</sup> School of Economics and Management, North China Electric Power University, Beijing 102206, China; zhangshml@163.com (S.Z.); 120202206312@ncepu.edu.cn (L.C.); 120202206345@ncepu.edu.cn (Y.Z.); liyingncepu@126.com (Y.L.); zengmingbj@vip.sina.com (M.Z.)

<sup>2</sup> Beijing Key Laboratory of New Energy and Low-Carbon Development, North China Electric Power University, Beijing 102206, China

<sup>3</sup> School of Economics and Management, University of Science and Technology Beijing, Beijing 100083, China

\* Correspondence: liyz@ustb.edu.cn; Tel.: +86-187-0150-7791

**Abstract:** Chinese wind power policies have productively promoted the development of wind power and also promoted the process of wind power participation in electricity market transactions. However, with policy emphasis on investment and neglect of utilization, there have been some difficulties in the development of Chinese wind power. To highlight the guiding role of policy and improve the wind power policy system, an analysis of Chinese wind power policies is conducted in this paper. First, aiming at the main components of wind power chain, including wind power construction, grid connection, transmission, and sales, a comprehensive and systematic frame of Chinese wind power policy system is proposed from the three aspects of development planning, administrative management and market transactions. Second, the indicator system of Chinese wind power development effectiveness is extracted, including installed capacity, power generation, power utilization hours, carbon emission reduction, investment, on-grid power price, wind curtailment rate, etc., and the effectiveness of policy implementation is verified. Third, new policy recommendations are proposed from parts of transmission, consumption, and market, for the development of Chinese wind power industry in the 14th Five-Year Plan period and the goal to reach the crest value of carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060. In this paper, advice to supplement and improve the Chinese wind power policy system is provided, which may it promote better development of Chinese wind power in the following decade from the policy point of view.

**Keywords:** Chinese wind power policy; Chinese policy analysis; Chinese policy effect; Chinese policy recommendation



**Citation:** Zhang, S.; Chen, L.; Zheng, Y.; Li, Y.; Li, Y.; Zeng, M. How Policies Guide and Promoted Wind Power to Market Transactions in China during the 2010s. *Energies* **2021**, *14*, 4096. <https://doi.org/10.3390/en14144096>

Academic Editor: Ben McLellan

Received: 24 May 2021

Accepted: 5 July 2021

Published: 7 July 2021

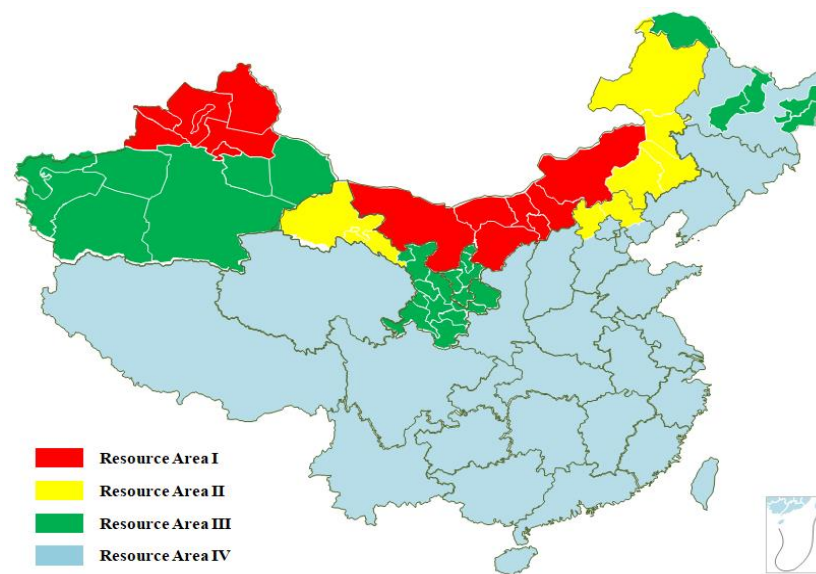
**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

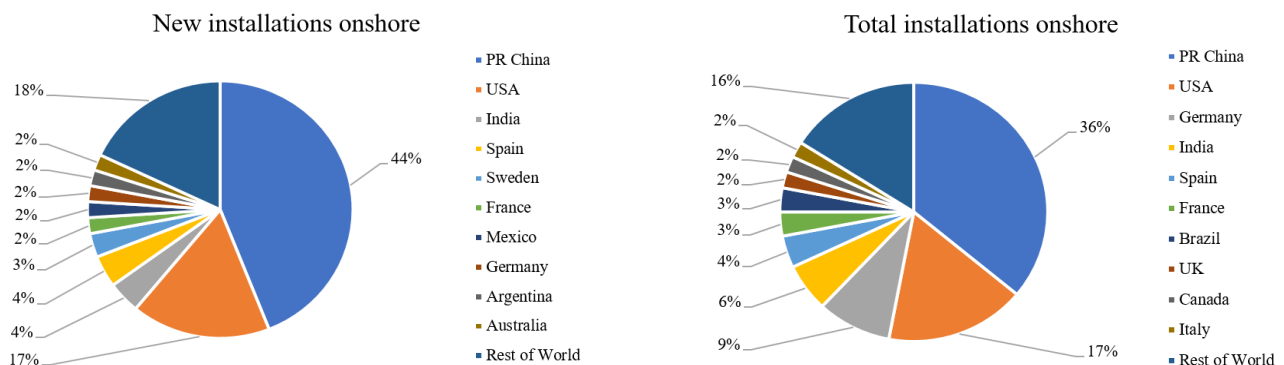
During the past decade of the 2010s, China has experienced rapid economic development, but also encountered environmental and energy problems. As part of the long-term energy strategy direction of China, it is important to develop clean renewable energy to solve the environmental problems such as haze and greenhouse gas emissions and transform the current energy structure, dominated for a long time by fossil energy. To accomplish the goal of “carbon dioxide emission peak by 2030 and carbon neutrality by 2060”, China should adopt more effective renewable energy development policies. As a typical primary energy and renewable energy source, China’s wind energy resources are widely distributed. Among them, the southeast coast and nearby islands, as well as the North (northeast, North and northwest) are regions rich in wind energy resources. According to the situation of wind energy resources and construction, China’s onshore wind energy resources are divided into four types, as shown in Figure 1. In addition, wind power is green, zero carbon emission and renewable, therefore, developing wind power is an important strategy to solve China’s environmental and energy problems.



**Figure 1.** Distribution map of China's 4 types of onshore wind energy resources.

Compared with traditional fossil energy sources, wind power has some disadvantages, such as high construction cost, immature technology, volatility and intermittency that affect the safe and stable operation of the power grid, high price, and so on. As a result, there are many difficulties in wind power development, such as construction, grid-connection, transmission, accommodation and so on. Energy policy plays an important role in reducing the impact of global warming and energy supply crisis [1]. It is worth noting that energy policies can help increase wind power generation and stimulate the energy industry. To make full use of wind power's advantages of green, zero carbon emission, and sustainability, policy is important driving factor to promote the development of wind power [2]. In the U.S., the number of state policies on renewable energy has been increasing, providing states with multiple options to encourage renewable energy power generation [3]. An empirical test using the panel data set of 50 states in the U.S. from 1990 to 2011 proved that the national and state-level policies are effective in encouraging wind energy development [4]. In recent years, European Renewable Energy (RES) deployment has made strong progress, and its growth is mainly driven by effective policies. The onshore wind power market in some states of Spain, Germany, Portugal, Denmark and Ireland has reached a state of advanced deployment [5]. After the 2011 Great East Japan Earthquake and the Fukushima nuclear accident, the Japanese government stated that the potential of onshore and offshore wind energy were greater than other renewable energy sources, and provided a whole host of policy measures to reduce risks and non-determinacy, and to promote business cost reduction through efficiency and innovation [6]. Meanwhile, the Chinese government has issued a number of policies to promote the growth of wind power so as to transform energy structure and deal with environmental problems. Based on the 31 Chinese provinces' data from 2004 to 2015, Shen and Lyu [7] analyzed the relationship between the factors affecting the growth of wind power, including the government supervision standard and vested interest groups, and found that the authorization of the approval authority brought about the development of regional wind power installed capacity. Li et al. [8] discussed 134 onshore wind power policies issued in China from 2005 to 2015, evaluating the policies from three perspectives of overall planning, supporting policies and policy implementation by using a fitting method and empirical analysis, so as to provide support for the formulation of wind power policies in the future. According to the cumulative wind power installed capacity and the annual new wind power installed capacity from 2005 to 2016, Zhang et al. [9] evaluated the effectiveness of China's wind FIT policies, and figured out that the regional power grid can effectively improve the wind power installed capacity. With the promotion of wind power policies in the 2010s, China's wind power industry

has made considerable progress. The installed capacity of onshore wind power in China accounted for 37% of the total wind power capacity in 2019 [10]. As shown in Figure 2, the new installed capacity of global onshore wind power is 54.2 GW in 2019, China accounting for 45%; the cumulative installed capacity of global onshore wind power is 621 GW, China accounting for 36% [10]. China's new installed capacity and cumulative capacity of wind power rank first in the world. It shows that China is continuing to improve policies to promote the stable development of wind power.



**Figure 2.** Top ten new installed capacity and cumulative installed capacity by onshore in 2019.

China has constructed a relatively comprehensive wind power policy system including legislation, administration, and market transaction, which has contributed to the rapid growth of wind power in the 2010s [11]. However, there are still many issues, such as wind curtailment, power system operation with grid-connection wind power and high price of wind power [12]. In addition, the scale of China's wind power generation has been expanding in recent years, and the problem of wind power subsidies has become increasingly prominent [13]. The lack of new energy subsidies has become a serious shackle for the healthy development of the industry, and the wind power is in urgent need of marketization [14]. To solve the problems that restrict the development of wind power, optimize the energy structure and build a safe, clean, low carbon and efficient modern energy system, the Chinese government should continue to improve policies to guide the benign development of wind power [15]. In recent years, many scholars have conducted fruitful research on renewable energy sources (RES) in China, such as RES development, policies, etc [12]. However, along with China's energy revolution and power system reform, the development of wind power encounters new opportunities and problems, such as opportunities of electricity transaction market, renewable portfolio standard, and problems of grid-connection at the same price with thermal power and wind power accommodation [16]. Therefore, by analysing Chinese wind power policies in 2010–2019, this paper aims to: (1) systematically analyze Chinese wind power policy system as well as the direction of policy guidance; (2) evaluate the implementation effect of wind power policies and identify wind power development problems; (3) introduce recommendations to improve the wind power policy system in China.

The paper is structured as follows: Section 2 presents wind power policies in China mainly issued in 2010–2019; in Section 3, the effect of China's wind power policies is evaluated; in Section 4, wind power development problems are extracted; in Section 5, policy recommendations on wind power development are proposed; Section 6 presents our conclusions. In addition, compared with China's onshore wind power, the installed capacity of offshore wind power is still small, accounting for only 2.8% of the total installed capacity of wind power in 2019. Therefore, the policy study mainly focuses on the onshore wind power in this paper. The abbreviations of departments as well as organizations mainly used in this paper are shown in Table 1.

**Table 1.** The abbreviations of departments or organizations.

Full Name of the Department or Entity	Abbreviations
China National People's Congress	NPC
State Council of the People's Republic of China	SC
National Development and Reform Commission	NDRC
National Energy Administration	NEA
Global Wind Energy Council	GWEC
Ministry of Finance of the People's Republic of China	MOF
State Administration of Taxation	SAT
General Administration of Customs of the People's Republic of China	GAC
China Electricity Council	CEC
Wind Energy Committee of China Renewable Energy Administration	CWEA

## 2. Analysis of Wind Power Policies of China in 2010s

The *Renewable Energy Law*, first issued in 2006 and revised in 2009, provides a legal basis for the formulation and implementation of wind power policies from six aspects, namely, planning, industry guidance, promotion and application, economic incentives, price management and cost sharing, and supervision. Based on the this law China has formulated a system of wind power policies mainly focused on three aspects: development planning, administration, and market transaction [17]. Wind power policy is mainly formulated around these three aspects to advance the orderly development of wind power. Among them, the development planning policy mainly focuses on the construction of wind power sites, planning its development plan for the next five years or more. Administrative policies mainly aim at the integration and transmission of wind power and put forward safeguard measures. Market trading policy mainly aims at the consumption and sustainable development of wind power to provide market and revenue mechanism. Therefore, wind power policy plays an important role in the construction, grid connection, transmission and sales of wind power. In this section, wind power policies are analyzed mainly issued after *Renewable Energy Law* in 2010–2019.

### 2.1. Development Planning Policies

China usually formulates a Five-Year Plan (FYP) which takes five years as a stage to make the development planning of social economy and energy. In wind power development, China tends to plan its development for the next five years or even longer time, including development goals, strategic layout, key tasks, etc. [18]. The main development planning policies issued in 2020s are as shown in Table 2.

**Table 2.** Main development planning policies in 2020s.

Policy Name	Release Time	Department	Policy Duration
12th FYP for Energy Development [19]	2011	NDRC and NEA	2011–2015
12th FYP for Renewable Energy Development [20]	2011	NDRC and NEA	2011–2015
12th FYP for Wind Power Development [21]	2011	NDRC and NEA	2011–2015
Energy Development Strategy Action Plan (2014–2020) [22]	2014	SC	2014–2020
13th FYP for Energy Development [23]	2016	NDRC and NEA	2016–2020
13th FYP for Renewable Energy Development [24]	2016	NDRC and NEA	2016–2020
13th FYP for Wind Power Development [25]	2016	NDRC and NEA	2016–2020
13th FYP for Electric Power Development [26]	2016	NDRC and NEA	2016–2020
Energy Production and Consumption Revolutionary Strategy (2016–2030) [27]	2016	NDRC and NEA	2016–2030

The development goals are set up quantitatively to guide wind power developing as planned, which mainly include indexes such as new installed capacity, cumulative installed capacity, annual power generation, generation rate accounting for total generation, and so on. In 2010–2019, the indexes are set as shown in Table 3 [28].

**Table 3.** Development goals of wind power in 2010s.

Period (Year)	New Installed Capacity (GW)	Cumulative Installed Capacity (GW)	Annual Power Generation (TWh)	Generation Rate (%)
2010	-	30	50	1.2
2011–2015	-	100	190	3
2016–2020	79	210	420	6

The strategic layout of wind power is usually set to plan development direction of Chinese wind power in the following 5 years or longer time. The strategic layout in 2010–2019 is mainly shown in Table 4. Therefore, the development direction of wind power is set where to construct and how to consume wind power in 2010–2019.

**Table 4.** Strategic layout of wind power in 2010s.

Strategic Measure	Object	Coverage
Promoting large-scale growth of wind power	Power generation	The Three North Area (north, northeast and northwest of China)
Accelerating the development of onshore wind energy resources	Power generation	Central, eastern and southern regions of China
Orderly promoting nearby consumption and utilization of wind power	Power consumption	The Three North Area
Optimizing the allocation of resources by trans-provincial and trans-regional transmission channels	Power transmission	All regions of China

The key tasks are specific projects that are planned in priority so as to achieve the development goals according to strategic layout of wind power. The key tasks in 2010–2019 are shown in Table 5. As China's wind energy resources are mainly distributed in the north, the key tasks are planned to focus on the construction and accommodation of wind power in the Three North Area to promote the long-term steady and sustainable development of China's wind power.

**Table 5.** Key tasks of wind power in 2010s.

Task	Object	Coverage
The installed capacity of large wind power bases more than 79 GW	Power generation	Inner Mongolia, Jilin, Xinjiang, Heilongjiang, Hebei, Gansu, Shandong and Jiangsu
Construction of multi-energy complementation projects to improve local consumption ability of renewable energy	Power consumption	Sichuan, Yunnan, Guizhou, Qinghai, Gansu, Ningxia and Inner Mongolia
Solving curtailment problem of wind power by 2020, and meeting the requirements of minimum guaranteed purchase hours	Power generation	The Three North Area
Promoting the accommodation of wind power more than 40 GW by 9 trans-provincial and trans-regional transmission channels	Power transmission	The Three North Area

China has implemented top-level plan policies to facilitate the sustainable development of wind power, optimize its energy structure and establish a clean and low-carbon



modern energy system. These policies point out the direction for the long-term development of China's wind power in 2010–2019, and provide a basis for formulating targeted wind power policies.

## 2.2. Administrative Policies

Due to wind power's characteristics of intermittent, fluctuating, anti peaking, uneven distribution and high economic cost, there are many difficulties in grid-connection, transmission and accommodation, affecting the operation of power grid. With the dramatic increase of installed capacity of Chinese wind power, the aforementioned problems have become more and more serious, restricting the effective utilization of wind power. For example, wind power curtailment is still a major problem. The volume of wind power abandoned reached 41.9 TWh in 2017 [29], equivalent to 40% of Beijing's electricity consumption (106.69 TWh) in 2017 [30], and the rate of wind power curtailment was 12%. To effectively solve these problems, Chinese government has taken many measures and issued a number of administrative policies, mainly including electricity price policy, full guaranteed purchase policy, Renewable Portfolio Standard policy, grid-connection and accommodation policy, and supervision and evaluation policy.

### 2.2.1. Electricity Price Policy

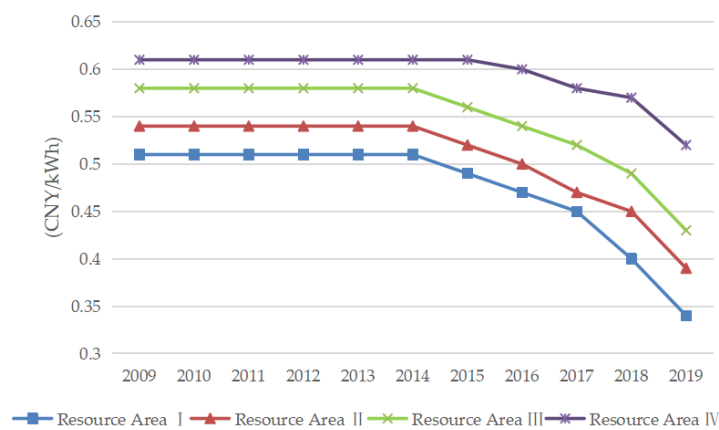
In regard to wind power tariff, China mainly implements the feed-in tariff policy and tariff subsidy policy [31,32]. In the *Renewable Energy Law*, it is stipulated that the feed-in tariffs of renewable energy power, such as wind power, are determined by price department of SC based on the characteristics of renewable energy and the conditions of different regions in China, and adjusted according to the development and utilization technology of renewable energy.

#### (1) Feed-in tariff policy

According to the *Renewable Energy Law*, the feed-in tariff of wind power, formulated by the NDRC, has shown declining tendency in 2010–2019. The feed-in tariff of Chinese wind power in 2006–2009 was guided by government in accordance with the price established by the bidding process [33]. According to the pricing method, the prices achieved by wind farms in the same area may be different, which prevents the long-term development of wind power. Therefore, the feed-in tariff of onshore wind power was formulated by NDRC respectively in different resource areas in 2010–2019. After July 2019, the on-grid price of onshore wind power was changed from benchmark to guide price. According to the four types of onshore wind energy resources, the feed-in tariff of onshore wind power is formulated [34].

Based on the feed-in tariff reduction mechanism, feed-in tariff is adjusted timely according to the development and utilization of wind power. In 2010–2019, the feed-in tariff of wind power in each resource area was adjusted as shown in Figure 3 [35], in which the line chart of feed-in tariffs of China's onshore wind power shows a declining trend. Besides, the feed-in tariff of wind power should be equal to that of coal-fired power by 2020 [36]. The feed-in tariff policy of Chinese wind power unifies the price of wind power, and takes the regional differences into account, providing institutional guarantee for investors to obtain economic benefits. Meanwhile, the feed-in tariff reduction mechanism guides wind power enterprises to reduce costs of power generation and encourages them to achieve sustainable and sound development by market competition.

In addition, competitive bidding is encouraged to determine the feed-in tariff, in which the feed-in tariff should not be higher than local feed-in tariff set by government [37]. The flexible way enriches the pricing regime of wind power, providing pricing mechanism for wind power to participate in market competition.



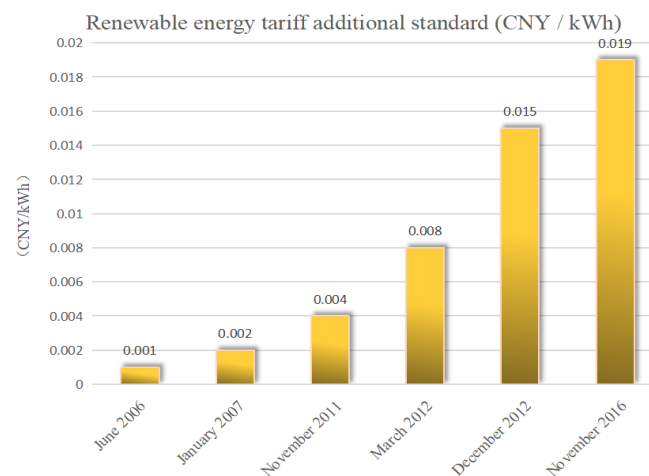
**Figure 3.** Feed-in tariff of China wind power in 2010–2019 (CNY/kWh).

## (2) Tariff subsidy policy

The tariff subsidy policy of Chinese wind power is implemented by means of cost-sharing mechanism. According to the mechanism, if the feed-in tariff of wind power is less than benchmark feed-in tariff of local desulphurization coal-fired unit, the cost for purchasing wind power is afforded by local provincial power grid; otherwise, the extra cost of the margin between feed-in tariff of wind power and standard feed-in tariff of local desulphurization coal-fired unit, is subsidized by the *National Renewable Energy Development Fund* [34]. The cost-sharing mechanism of wind power provides institutional guarantees for investors to obtain stable income and sustainable development of wind power projects.

The *Renewable Energy Development Fund* includes the special fund of the national fiscal public budget (referred as special fund for renewable energy development) and incomes of renewable energy additional fund imposed on power users by law [38]. The renewable energy additional fund, which is collected by power grid enterprises, is attached to the whole country except the Tibet.

Figure 4 shows the changes in the additional standards of renewable energy tariff from 2006 to 2016 [33,39,40]. To guarantee that wind power projects are properly subsidized, MOF and NDRC has stipulated that, from 1st January 2016, the fund expropriation standard of sales electricity in all provincial regions except Xinjiang and Tibet, is raised up to 0.019 CNY/kWh [40].



**Figure 4.** Renewable energy tariff additional standard from 2006 to 2016.

MOF, NDRC and NEA examine wind power projects and regularly include the eligible projects in the project list subsidized by the renewable energy additional fund [41]. With the gradual maturity of the wind power market, renewable energy grid-connection projects,

which have been included and have not yet been included in the national renewable energy price additional subsidy list, will no longer be subsidized through the renewable energy additional fund [42].

### 2.2.2. Full Guaranteed Purchase Policy

According to the *Renewable Energy Law*, the full guaranteed purchase policy is implemented for Chinese renewable energy generation, which stipulates that the power grid corporations purchase all the power of renewable energy that meets the grid-connected technical standards, within their coverage. Therefore, the annual power generation of grid-connected wind power is composed of two parts: one part for guaranteed purchase and the other part for market transaction [43].

#### (1) Guaranteed purchase of electricity

The guaranteed part should be purchased by the power grid corporations in full by feed-in tariff of wind power. To utilize the guaranteed part, the annual minimum guaranteed utilization hours of wind power are approved in areas with wind curtailment problem [44]. The guaranteed part is purchased by the power grid enterprise in consideration of feed-in tariffs and the annual minimum guaranteed utilization hours. The market part that exceeds guaranteed utilization hours should be absorbed by market transaction.

#### (2) Market transaction electricity

The market part is completed by the power generation contract which is obtained by market transaction, and the power grid enterprise will execute the contract in accordance with the priority dispatching principle, and the margin between feed-in tariff of wind power and that of local thermal power will be paid by renewable energy subsidies.

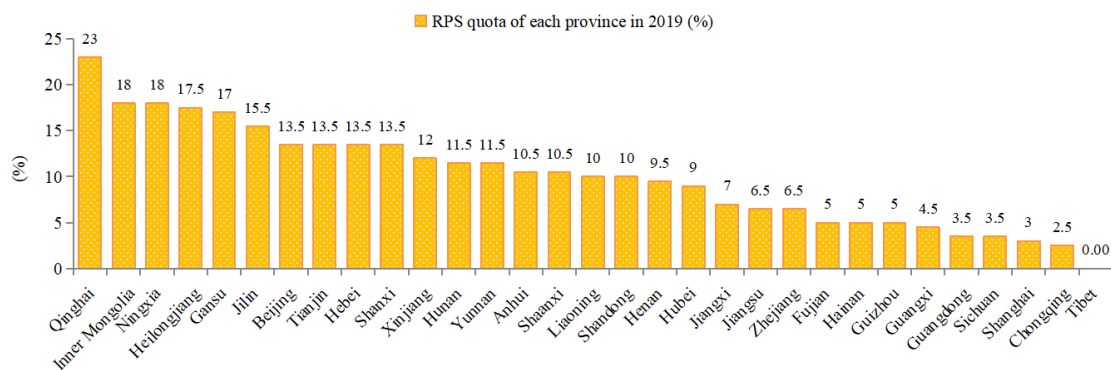
Based on the full guaranteed purchase policy, the guaranteed generation of wind power is purchased to ensure the basic income of wind power enterprises. Meanwhile, wind power for market transaction is proposed to encourage enterprises to gain revenue by market competition. In addition, the policy clearly defines that the full guaranteed purchase power should be settled by power grid enterprises, clarifying the responsibility subject. Therefore, the policy plays the role of regulation and guidance for ensuring the basic income and additional benefits of wind power enterprises.

### 2.2.3. Renewable Portfolio Standard Policy

The *Renewable Portfolio Standard* (RPS) is a kind of policy that brings the minimum amount of renewable energy (such as solar, wind, biomass or geothermal energy) into the power generation resource portfolio serving the country [45]. It has been one of the policy drivers for renewable energy (RE) growth in the United States [46]. The RPS policy of China was issued in 2019, after several rounds of discussion and modification in 2016–2019 [47].

Firstly, a RPS quota, which refers to the ratio of renewable energy power on total electricity consumption, is provided as evaluation index of renewable energy power consumption level. Secondly, the RPS responsibility is undertaken by power consumption entities, including power sale enterprises and power consumers. Thirdly, the power trading institutions shall guide the market entities undertaking the consumption responsibility to complete the corresponding electricity transaction of renewable energy power consumption first. Fourthly, the main way of completing RPS quota by market entity is consuming renewable energy. Besides, there are two supplementary (alternative) ways, one is purchasing renewable energy electricity quota from market entities that have exceeded their annual consumption, and the other one is purchasing renewable energy green power certificate for renewable energy electricity quota. Finally, strict punishment will be imposed against entities that can't complete the quota. As an index of RPS, the quota of non-water renewable energy is completed mainly by consuming wind power and photovoltaic power, the quota of each provincial administrative region in 2019 as shown in Figure 5 [48].





**Figure 5.** RPS quota of each provincial administrative region in 2019.

#### 2.2.4. Grid-Connection and Accommodation Policy

In 2019, the cumulative installed capacity of Chinese onshore wind power has exceeded 210 GW, but the problem of wind curtailment, especially in the Three North Area is still very serious [49]. How to improve the level of grid-connection and accommodation of wind power and solve the problem of wind curtailment has become a considerable issue for wind power [50]. Therefore, a number of measures are proposed accordingly: (1) accommodation and utilization of wind power by electricity market; (2) preliminary work on wind power construction; (3) plans of local utilization and transmission bases of wind power in the Three North Area; (4) construction of wind power in central eastern and southern China; (5) exploration of wind power consumption market; (6) construction and operation management of wind corporations [51]. In view of wind curtailment in the Three North Area, several measures are introduced, as shown in Table 6.

**Table 6.** Measures for wind curtailment in the Three North Area.

Measure	Object	Coverage
Clean heating projects by wind power [52]	Power consumption	The Three North Area
Pilot projects of renewable energy for nearby accommodation [53]	Power consumption	Gansu, Inner Mongolia and Jilin
Electricity exchange mechanism to improve the capacity of local power systems for wind power consumption [54]	Power consumption	The Three North Area
Auxiliary service compensation mechanism to explore peak load regulation potential of local power system [54]	Power generation	The Three North Area
Trans-provincial and trans-regional transmission work of wind power [54]	Power transmission	The Three North Area

In China, grid-connection and accommodation policy is implemented to direct the nearby accommodation of wind power, carry out the wind power utilization projects such as clean heating, improve the peak load adjustment capacity of power system, and strengthen the wind power transmission. The policy points out the direction to improve the power utilization capacity and solve the problem such as wind curtailment.

#### 2.2.5. Supervision Policy

To guarantee the implementation of wind power policies, the Chinese government has issued corresponding supervision policies with both rewards and punishments. Accordingly, supervision work in China is required on the basis of overall requirements of the complete closed loop supervision and regulation mechanism, to constantly improve supervision system and enrich supervision means [55]. The supervision policies of wind power mainly contain two aspects, namely, the supervision of wind power grid-connection and accommodation, and the supervision of wind power investment.

In the supervision of wind power grid-connection and accommodation, requirements are proposed as follows [56]: (1) power grid enterprises are required to take measures to optimize the power balance scheme and improve the capacity of wind power accommodation where wind curtailment problem is serious; (2) power grid enterprises are required to coordinate the projects of constructing new grid-connected wind power farms and put forward supervision proposals where the problem of grid-connection is serious; (3) the supervision for the wind power utilization should be strengthened, especially in terms of wind power utilization hours and the rate of wind power curtailment.

In the supervision of wind power investment, a supervising and warning mechanism is established for wind power investment to guide rational investment of wind power enterprises [57]. The index system of wind power investment supervising and warning mechanism includes policy indexes, resource and operation indexes, and economic indexes, and the measures are shown in Table 7, in which the warning degree is divided into three grades from high to low, represented by red, orange and green respectively. Accordingly, NEA has issued annual wind power investment supervising and warning results in 2016–2019, guiding the construction of wind power, promoting local governments and enterprises to complete important tasks of wind power such as guaranteed purchase hours and the rate of wind curtailment, and solving the problem of wind power grid-connection and accommodation [58].

**Table 7.** Wind power investment supervising and warning measures.

Color	Risk Degree	Object	Measure
Red	High	wind power investment	The annual development and construction plan of wind power investment is not approved by NEA in that year, the approval of new wind power projects is delayed by local governments, wind power enterprises are suggested to make careful decision whether to invest, and power grid enterprises no longer handle new grid-connection procedures.
Orange	Medium	wind power investment	The annual development and construction plan of wind power investment is not approved by NEA in that year
Green	Normal	wind power investment	Local governments and enterprises can continue to promoting the investment and development of wind power projects

### 2.3. Market Transaction Policies

At present, China implements policies such as development planning and administration to promote wind power development, but this is not a long-term way for the healthy and sustainable development of wind power industry. With the deepening of the concept of low carbon and zero carbon proposed by the Chinese government, in the new situation of exploring power market design in various regions and gradually improving the power trading rules, how to turn wind power's advantage into commercial value is a key issue. Therefore, China is gradually adopting market transaction policies to support the participation of wind power in market transactions such as electricity market and the green certificate transaction, realizing the green and low carbon commercial value of wind power, achieving sustainable and stable development and reducing the financial burden of government subsidies [59]. In addition, China has implemented policies of ancillary services to increase the accommodation of wind power [60].

#### 2.3.1. Electricity Market Policy

In 2015, the new round of power system reform began in China [61]. It can be pointed out that the reform of power system is key task to carry forward the reform of the electricity transaction system and improve the market-based transaction mechanism. Accordingly, the policy is issued to construct electricity market with great variety of transactions, which

is proposed to gradually establish a market-oriented power balance mechanism based on medium and long-term transactions and spot trading as the auxiliary [62].

#### (1) Medium and long-term electricity transaction

In the medium and long-term electricity transaction, it's stipulated to first arrange the generation of renewable energy within guaranteed purchase hours, as well units for peak load regulation of renewable energy, and gradually release the power generation plan [63], providing policy support for transactions of wind power. In addition, it is recommended to give priority to short-term and temporary inter-regional and inter-provincial transactions of renewable energy based on market bidding or bilateral negotiations under the condition that there is space for inter-provincial channels.

#### (2) Spot transaction

In the spot transaction, eight pilot areas are chosen to construct the electric spot market, and finally reflect the decisive role of the market in the allocation of electricity resources [64]. In order to further encourage renewable energy to participate in power market competition and increase market-oriented trading space, the verification of guaranteed utilization hours can be gradually canceled, and renewable energy can participate in cross-provincial spot with premium subsidies market model. In addition, China is actively exploring a new modality of energy industry that deeply integrates the internet with energy generation, transmission, storage, consumption and energy market, namely Energy Internet, which provides a new mode for the growth of wind power [65].

### 2.3.2. Green Certificate Transaction Policy

At present, there is a huge gap in renewable energy subsidies in China. For the purpose of alleviating the pressure of renewable energy subsidies and effectively implement RPS policy, NDRC, MOF and NEA have jointly proposed to try out the approval and voluntary subscription of green certificates nationwide [66]. The transaction method of the green certificate transaction is that the electricity market users who have not completed the quota purchase the green certificate from the renewable energy power generation company to complete the green certificate transaction. In the light of the market subscription situation, China launched the renewable energy power quota assessment and green power certificate compulsory binding transaction in 2018. Renewable energy green certificate transaction mechanism is a major measure to improve policies and innovative development mechanism of renewable energy including wind power. It is conducive to improving the utilization efficiency of wind power and reducing the state financial subsidies.

### 2.3.3. Auxiliary Service Market Policy

With the mushrooming growth of wind power, in power systems there are more and more demands for auxiliary service, which is an important factor that influences large-scale grid-connection of wind power [67]. Consequently, China has introduced policies to establish ancillary service market, and thereby enhance the grid-connected accommodation rate of wind power and other renewable energy.

The ancillary service market remains in the exploration stage in China. In 2016, NEA proposed to establish and improve the auxiliary service market, and carry out the pilot reform of electricity auxiliary service market in Northeastern China, encouraging all kinds of power generation enterprises and consumers to provide peak load regulation service and obtain compensation income accordingly [68,69]. In order to make thermal power units provide auxiliary service, NEA has launched demonstration pilot projects to upgrade the flexibility of thermal power plants, and selected 15 typical projects where the problem of wind power accommodation is serious [70].

In addition, energy storage is an important component and key supporting technology to maintain a high proportion of renewable energy in power system and can provide a variety of auxiliary services such as peak load regulation, frequency modulation, reserve and black start. Consequently, NDRC has proposed to advance the development of energy

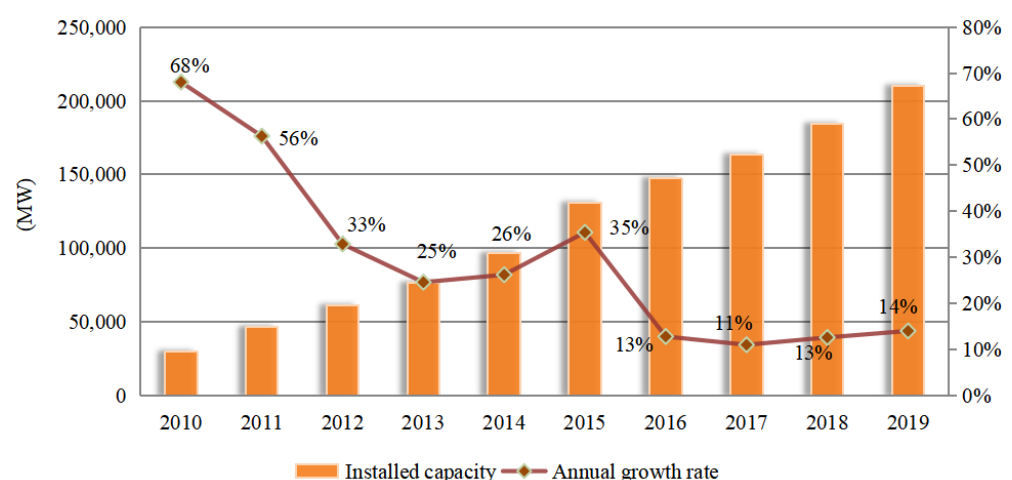
storage industry in two phases [71]. In the first stage, the development of energy storage is transferred from research and development (R&D) to commercialization; in the second stage, the development is to realize the large-scale development of commercialization. Moreover, key tasks have been proposed to promote the utilization level of renewable energy, establish and improve market mechanism for energy storage to provide auxiliary service, and promote energy storage to improve the flexibility and stability of power system.

### 3. Implementation Effect of Wind Power Policies

Based on the *Renewable Energy Law*, China has formed a relatively comprehensive wind power policy system, including development planning, administrative management, and market transaction. Driven by wind power policies, there are remarkable effects on the development of Chinese wind power in construction, generation, electricity market transaction, accommodation and environment in 2010s [72].

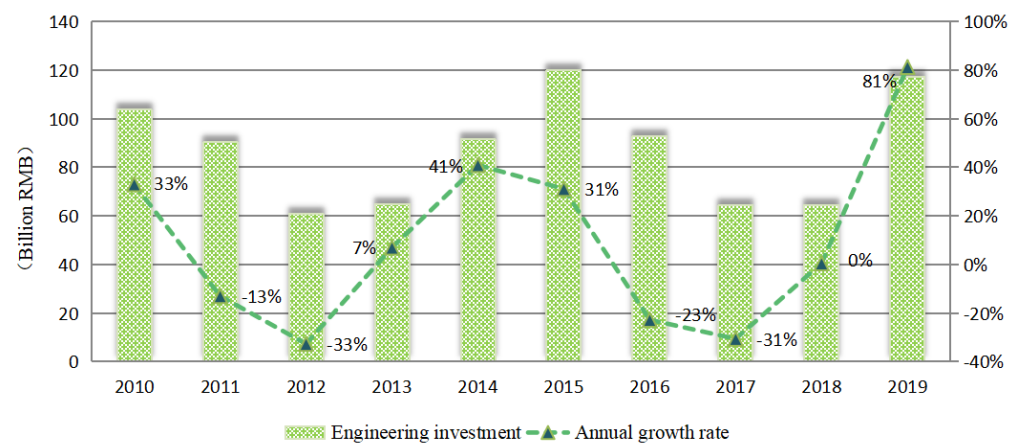
#### 3.1. Effect on Wind Power Construction

In 2010–2019, China’s wind power construction was experiencing a period of fast development, and the installed capacity has been top of the world since 2012. As shown in Figure 6 [28], the cumulative installed capacity of wind power in China has increased by more than 10% annually in 2010–2019, the growth rate showing a decreasing trend with the growing base. The reasons for different growth rates are that: the high growth rate from 2010 to 2015 is mainly due to the low base of wind power installed capacity, so the rate is higher. The rate of 2016–2019 has decreased, mainly because the overall base is large and the rate is low; moreover, with the swift growth of wind power installed capacity in previous years, the speed of installed capacity has slowed down. The peak growth rate is mainly related to two factors in 2015. One factor is the 12th Five-Year Plan. 2015 is the year when the 12th Five-Year Plan is completed. In order to achieve the planned goals, the growth rate was relatively faster. The second factor is that in 2014, in the onshore wind power price adjustment plan, which lowered the wind power feed-in tariff. Therefore, many wind power industries accelerated their wind power construction before the new price was implemented, resulting in a higher growth rate in 2015. As shown in Figure 7, in spite of fluctuation of annual investment of Chinese wind power in 2010–2019, it still exceeded 60 billion CNY each year [73].



**Figure 6.** Cumulative installed capacity of China’s wind power in 2010–2019.

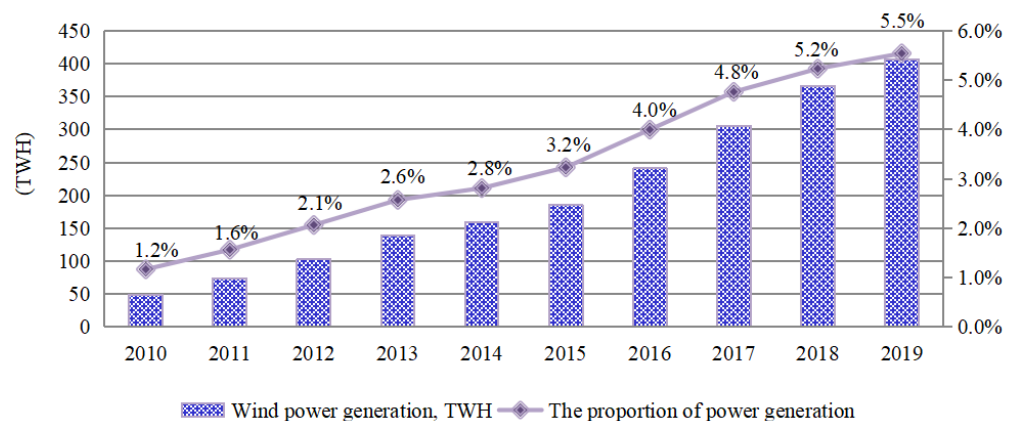
In summary, under the guidance of wind power policies, the construction scale of wind power in China is increasing in 2010–2019, and has achieved the goal of cumulative installed capacity exceeding 200 GW, a year early. In the future, China still need improve policies to guide the steady development of wind power construction.



**Figure 7.** Annual investment of China's wind power in 2010–2019.

### 3.2. Effect on Wind Power Generation

In 2019, Chinese wind power generation reached 405.7 TWh, accounting for 5.5% of the gross power generation. As shown in Figure 8, China's annual output of wind power, as calculated by the NEA, has shown a rapid growth trend in 2010–2019, and the proportion of the total power generation has increased year after year. It shows that the scale of wind power utilization in China is larger and larger, and that the importance of wind power in power system is increasing.



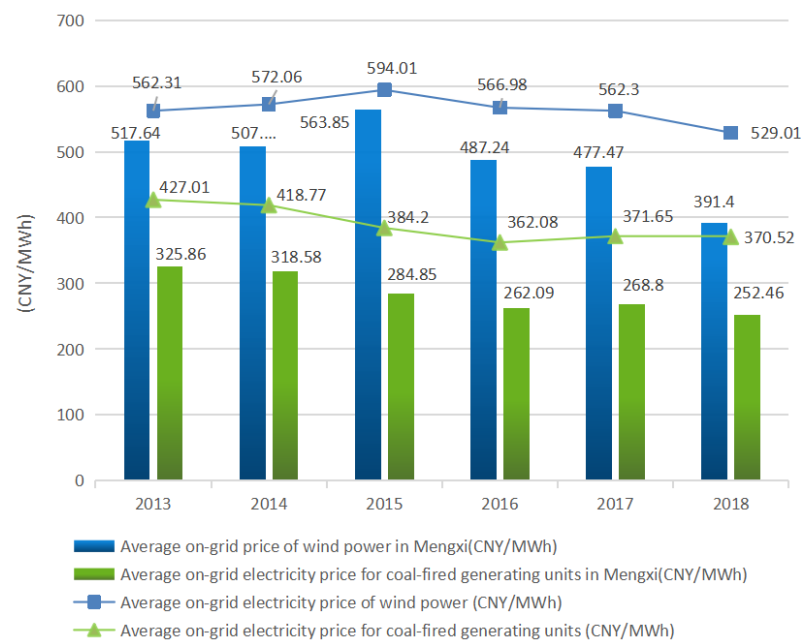
**Figure 8.** China's annual output of wind power in 2010–2019.

In conclusion, with the guidance of wind power policies, the Chinese wind power generation scale has begun to take effect, and has achieved the goal that annual wind power generation reaches 390 TWh in 2020 and accounts for more than 5% of the gross power generation, a year early. In future, China still needs to perfect generation policies of wind power to direct the green and clean development of Chinese power system.

### 3.3. Effect on Wind Power's Participation in Electricity Market Transaction

In 2018, the average on-grid price of Chinese wind power was 529.01 CNY/MWh, down 3.43% year on year. In a typical region, the on-grid price of wind power in West Mongolia of China reached the lowest price in the country in 2018, at 252.46 CNY/MWh. As shown in Figure 9, from 2013 to 2018, the average on-grid price of Chinese wind power showed a downward trend year by year, and the on-grid price for wind power and thermal power have gradually narrowed [34,35].



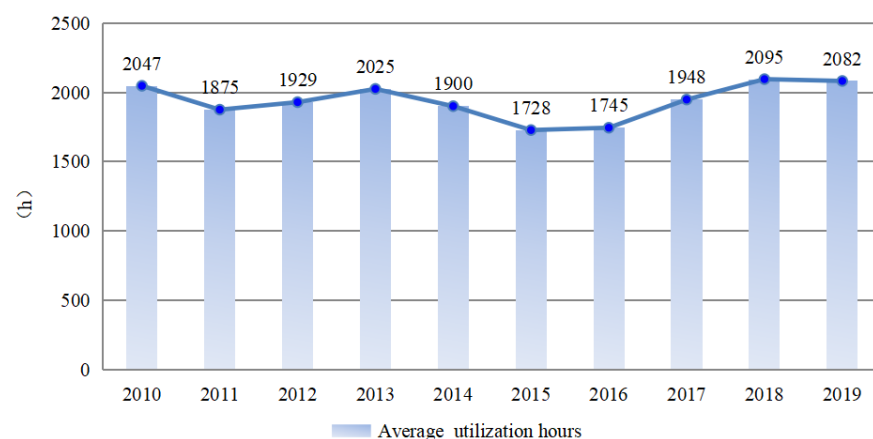


**Figure 9.** China's on-grid electricity prices for wind power and coal-fired power.

With the gradual implementation of various national measures to promote electricity market-oriented trading, the average on-grid power price of wind turbines has gradually approached the on-grid coal price, and the conditions for participating in the market have gradually become available from the cost. China still needs to introduce further policies to guide the wind power to go online at parity, so that the wind power speed can return to the nature of power and enter a new era of power marketization.

### 3.4. Effect on Wind Power Accommodation

In 2019, the average utilization hours of Chinese wind power were 2082. As shown in Figure 10 [28], in 2010–2019, the average annual utilization hours of Chinese wind power were 1937, showing a stable trend. The accommodation of wind power is growing in consideration of the increasing installed capacity of wind power.



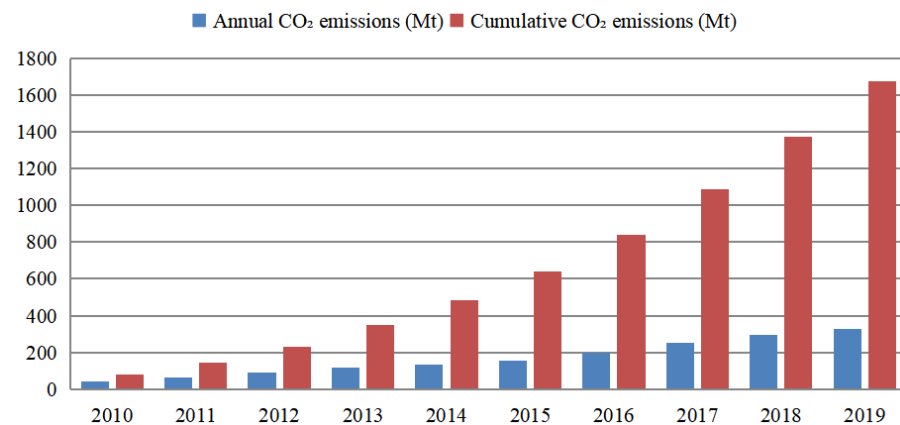
**Figure 10.** China's wind power utilization hours in 2010–2019.

In summary, under the guidance of wind power policies, the effect of wind power accommodation in China is significant, and the annual utilization hours were relatively stable in 2010–2019. However, there is still space for making better. Because of problems such as wind power curtailment, more attention should be paid to wind power accom-

modation, and hence China needs to formulate and improve corresponding policies to increase utilization level of wind power.

### 3.5. Effects on Environment

Compared to coal-fired power, of which emissions, such as CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and dust, directly affect the climate and environment, wind power has the advantages of clean and zero emission, which can effectively alleviate greenhouse gas emission, haze and other environmental pollution problems in China [74]. Under the guidance of wind power policies in 2010s, the proportion of wind power in power system is gradually increasing in China, and its environmental effect is increasingly significant. According to indicators of coal-fired power plants, such as gross coal consumption rate, CO<sub>2</sub> emission coefficient, etc [75], the environmental benefits of CO<sub>2</sub> emission reduction contributed by wind power in 2010–2019 are shown in Figure 11. In 2010–2019, the cumulative CO<sub>2</sub> emission reduction is 1676 Mt [76].



**Figure 11.** CO<sub>2</sub> emission reduction benefits of China’s wind power in 2010–2019.

To sum up, driven by wind power policies, environmental benefits contributed by wind power generation are significant in 2010–2019, showing that it’s an important way to control the change of climate and environment by developing Chinese wind power. To accomplish the goal of peak emission of CO<sub>2</sub> by 2030 [77], China needs to further improve the corresponding wind power policies to improve the capacity of wind power accommodation and reflect its green commercial value, thus releasing its environmental effects.

### 3.6. Effects of Typical Policies

Chinese wind power policies have effectively promoted wind power development, especially in the factors such as installed capacity growth rate, utilization hours and wind curtailment rate. In this section, wind power installed capacity growth rate, utilization hours and wind curtailment rate of 30 provincial regions in China are selected as indicators to analyze the effects of typical policies. Based on the two-pair sample T-test method, the differences before and after the implementation of development planning policy, guaranteed purchase policy, and supervision policy are analyzed to evaluate the effectiveness of the policies. Among them, the 13th Five-Year Plan of Wind Power Development [25], Regulatory Measures for the Acquisition of Renewable Energy Power Generation [78], Notice to Promote the Sustainable and Healthy Development of the Wind Power Industry [57] are selected as typical policies for planning policy, guaranteed purchase policy, and supervision policy respectively.

(1) The planning policy hypotheses:

**Hypotheses 1 (H1).**  $\mu_1 = \mu_2$  (Planning policy has no significant impact on the increased wind power installed capacity).

**Hypotheses 2 (H2).**  $\mu_1 \neq \mu_2$  (Planning policy has significant impact on the increased wind power installed capacity).

(2) The grid-connected consumption policy hypotheses:

**Hypotheses 1 (H1).**  $\mu_1 = \mu_2$  (Guaranteed purchase policy has no significant impact on the wind power utilization hours).

**Hypotheses 2 (H2).**  $\mu_1 \neq \mu_2$  (Guaranteed purchase policy has significant impact on the wind power utilization hours).

(3) The supervision policy hypotheses:

**Hypotheses 1 (H1).**  $\mu_1 = \mu_2$  (Supervision policy has no significant impact on the wind abandonment rate).

**Hypotheses 2 (H2).**  $\mu_1 \neq \mu_2$  (Supervision policy has significant impact on the wind abandonment rate).

Table 8 shows the symbols and descriptions of two-pair sample  $t$  test. Table 9 shows the data of installed capacity growth rate, utilization hours and wind curtailment rate before and after the implementation of the policy. According to the 95% confidence level, the results of the two-pair sample  $t$  test are shown in Figure 12.

**Table 8.** Symbols and descriptions.

Symbol	Description
1	Before the policy is implemented
2	After the policy is implemented.
C	The installed capacity of wind power
H	The wind power utilization hours
R	The wind abandonment rate

The mean value of the new installed capacity of wind power before and after the implementation of planning policy is 683.52 and 751.46 respectively, and the mean value of the  $t$  test is  $-67.94$ . The  $p$  value of the  $t$  test is 0.634, which is greater than 0.05. The  $H_0$  hypothesis is accepted, which means that the planning policy has no significant impact on the increased wind power installed capacity. The reason is that the 13th Five-Year Plan of Wind Power Development was based on ensuring the appropriate increased scale, centered at the improvement of wind power quality, and required the total target to increase steadily. Therefore, the impact of the policy on the new installed capacity of wind power is not significant.

The mean value of the wind power utilization hours before and after the implementation of guaranteed purchase policy is 1897.33 and 2033.81 respectively, and the mean value of  $t$  test is  $-136.478$ . The  $p$  value of the  $t$  test is 0.001, which is less than 0.05. The  $H_0$  hypothesis is rejected, which means that the guaranteed purchase policy has significant impact on the wind power utilization hours. The Regulatory Measures for the Acquisition of Renewable Energy Power Generation emphasize the importance of the full guaranteed purchase system in renewable energy power generation. It is essential to deeply tap the potential of the system to absorb wind power, and actively develop wind power consumption methods such as wind power heating. Therefore, the impact of the policy on the wind power utilization hours is significant.

The mean value of the wind abandonment rate before and after the implementation of supervision policy is 4.94 and 3.00 respectively, and the mean value of  $t$  test is 1.94.

The  $p$  value of the  $t$  test is 0.012, which is less than 0.05. The  $H_0$  hypothesis is rejected, which means that supervision policy has significant impact on the wind abandonment rate. The Notice to Promote the Sustainable and Healthy Development of the Wind Power Industry established by the NEA takes wind abandonment rate as an indicator to form early warning results that guide wind power development and investment. Therefore, supervision policy has significant impact on the wind abandonment rate.

**Table 9.** Data in two-pair sample  $t$  test.

	C <sub>1</sub>	C <sub>2</sub>	H <sub>1</sub>	H <sub>2</sub>	R <sub>1</sub>	R <sub>2</sub>
1	9.5	0	1794	1845.33	0	0
2	19.88	63.5	2184	1963.33	0.67	0
3	990.1	2224	1927	2223.33	11.9	5.67
4	1407.54	1619.5	1828.67	2035.33	2.75	2.73
5	1249.51	1666.5	1815.33	1950.33	0.25	0.5
6	2050.48	1569.5	1899	2211	15.81	10.8
7	568.7	493	1814.33	2166.33	8.5	3.13
8	459	131	1421.33	2027	24.7	10.1
9	656.85	186.5	1646.33	2239.67	19.4	6.57
10	72.4	75.25	2081	2206	0	0
11	730.15	1566.5	1932.33	2044.33	0	0
12	200.98	175.75	2083.33	2082.33	0	0
13	315.65	446	1838.67	2134	0	0
14	248	554	2546.33	2445	0	0
15	197.43	581.5	2005.67	1998	0	0
16	343.23	1889.5	1917	1649	0	0
17	404.03	799.25	2007.33	2072.33	0	0
18	519	839.25	1973.67	2037	0	0.6
19	58.83	103.5	1866.33	2077	0	0
20	241.25	664.75	2346.67	2413	0	0
21	437.1	851.5	1975.33	1927.67	2.99	2.27
22	1812.45	160	1289.33	1676	28.41	19.87
23	209.75	1371.75	1800.33	1643.67	0	1.37
24	1124.6	854	1713.33	1783	6.68	3.07
25	3483.75	1001.75	1651.67	1949.33	22.56	21.97
26	450.25	641	1717.33	1741	0	0
27	194	829.5	2102	2319.67	0	0
28	14.5	-5	1780	1672.33	0	0
29	778.53	521.25	1526.67	1833.33	0	0.5
30	1258.33	669.5	2435.67	2648.67	3.67	1.07

Paired Samples Statistics					Paired Samples Correlations					
		Mean	N	Std. Deviation	Std. Error Mean		N	Correlation	Sig.	
Pair 1	C <sub>1</sub>	683.5257	30	752.45141	137.37820	Pair 1	C <sub>1</sub> & C <sub>2</sub>	30	0.378	0.040
	C <sub>2</sub>	751.4667	30	617.33435	112.70932		Pair 2	H <sub>1</sub> & H <sub>2</sub>	30	0.667
Pair 2	H <sub>1</sub>	1897.3333	30	270.59125	49.40298	Pair 3	R <sub>1</sub> & R <sub>2</sub>	30	0.922	0.000
	H <sub>2</sub>	2033.8111	30	246.38090	44.98279					
Pair 3	R <sub>1</sub>	4.9428	30	8.52648	1.55671					
	R <sub>2</sub>	3.0067	30	5.67996	1.03701					

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	C <sub>1</sub> - C <sub>2</sub>	-67.94100	772.36062	141.01311	-356.34519	220.46319	-0.482	29	0.634
Pair 2	H <sub>1</sub> - H <sub>2</sub>	-136.47778	212.10831	38.72550	-215.68032	-57.27523	-3.524	29	0.001
Pair 3	R <sub>1</sub> - R <sub>2</sub>	1.93617	3.96016	0.72302	0.45742	3.41491	2.678	29	0.012

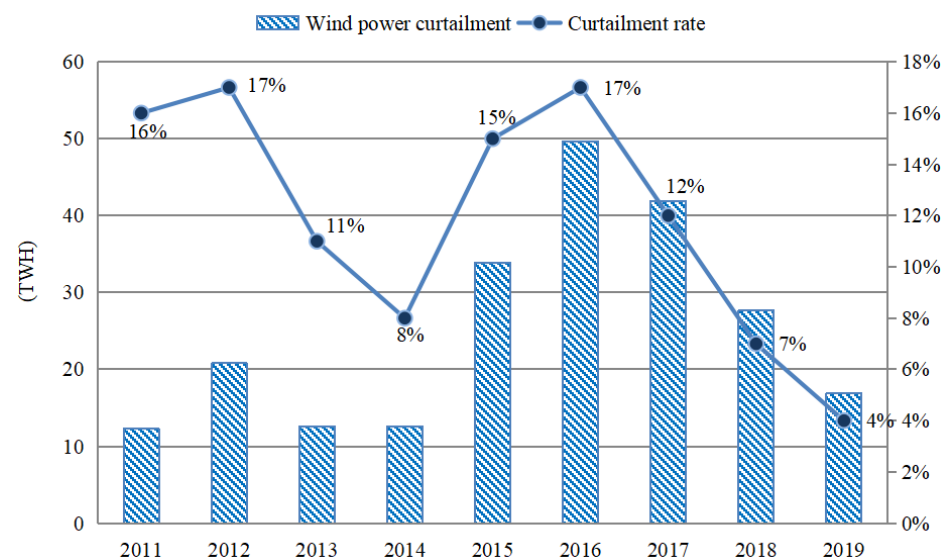
**Figure 12.** The results of the two-pair sample  $t$  test.

#### 4. Problem Analysis

Under the guidance of Chinese wind power policies, Chinese wind power industry has obtained rapid growth in 2010s, and wind power has become a major part of Chinese power system. However, there are still problems in Chinese wind power industry, such as accommodation difficulty, inadequate financial subsidies, imperfect market systems, and so on, for reasons of imperfect policies, inadequate implementation of policies, etc. [79].

##### 4.1. Problem of Wind Power Accommodation

The problem of wind power accommodation is serious in China. Since Chinese wind power development route is mainly centered at the construction of wind farms, dozens or even hundreds of wind farms connected to the grid have caused the difficulty of absorbing wind power on the grid, and areas with rich wind power resources are generally economically backward areas. The electricity consumption is not large, and it is difficult to absorb it locally, which has caused the matter of wind curtailment and power restriction. As shown in Figure 13, in 2011–2019, the wind curtailment rate in China shows a decreasing trend after 2016 [80].



**Figure 13.** Statistics of China's wind power curtailment in 2011–2019.

In 2017, the cumulative grid-connected installed capacity of Chinese wind power accounts for 9.2% of the gross installed power capacity, yet the annual wind power curtailment is 41.9 TWh, and the wind curtailment rate is 12%. Moreover, the wind power curtailment problem in the Three North Area is particularly serious. In 2018 [81], there are 3 provincial regions with the wind curtailment rate more than 10%, which are 22.9%, 19% and 10.3% respectively in Xinjiang, Gansu and Inner Mongolia, corresponding to wind power curtailment of 10.7 TWh, 5.4 TWh and 7.2 TWh [82]. The problem of wind curtailment has caused a huge waste of energy, severely restricting the effective utilization of clean energy and the transformation of Chinese energy structure.

Under the Chinese policy emphasis on investment and neglect of utilization, the construction of wind power has obtained rapid growth in 2010s, but it has not been able to form an effective way to accommodate wind power due to the lack of supporting policy. In response to the matter of wind power curtailment, China has issued policies to guide the wind power transmission and nearby accommodation to improve the capacity of wind power accommodation, and they began to take effect in the past two years. In the future, it is essential to continue to perfect the wind power accommodation policies, resolve the problem of wind power curtailment and complete the effective utilization of wind power.



#### 4.2. Problem of Inadequate Subsidies

It's an important way to obtain financial subsidies for wind power enterprises by tariff subsidy policy. The financial subsidies, which are provided by National Renewable Energy Development Fund, are their important income source as well as important guarantee for sustainable operation. However, due to the lack of implementation of supporting financial subsidy policy, the National Renewable Energy Development Fund has not been fully levied. In addition, with the construction scale of Chinese wind power and other renewable energy continuously increasing, the demand for capital subsidies is also increasing. The above reasons have led to incomplete subsidies for enterprises of wind power and other renewable energy, and the subsidy gap is getting larger. According to the statistics of MOF, the subsidy insufficiency has reached 200 billion CNY at the end of 2019 [81]. Due to inadequate subsidies, many wind power enterprises are in loss operation and even no longer able to continue, thus greatly affecting the stable development of Chinese wind power industry.

#### 4.3. Problem of Imperfect Market System

The current trend of the Chinese wind power industry to gradually cancel government subsidies such as financial subsidies and allow the market to drive its sustainable development. At present, China's market transactions are at the exploration stage, the electricity price of wind power participating in the market transaction is low, and the system of electricity transaction as well as carbon transaction and auxiliary service market has not yet been formed. China is undergoing the reform of electricity market mechanism, in which medium and long-term electricity transactions are conducted nationwide, spot transactions have not yet been carried out, and the generation and sales of wind power are still dominated by plans. In 2019, the electricity by market transaction has amounted to 2177 TWh, accounting for 30.1% of gross electricity consumption in China [82]. The data show that there is a lot of work to construct electricity market in China, such as easing electricity generation and electricity sale plans. In addition, policies should be further strengthened to form carbon transaction market and auxiliary service market and release the green and zero-carbon commercial value of wind power.

### 5. Policy Recommendations

Facing the 14th Five-Year Plan, renewable energy will usher in an era of high proportion development. Wind power has become a major trend of power development in the world [83], and the annual new scale ranks first in the world, which injects new vitality into China's energy transformation. To solve the problems of wind power such as accommodation difficulty, inadequate financial subsidies, imperfect market systems, and so on, China should introduce corresponding policies to guide the orderly development of wind power in future. Accordingly, some policy recommendations are proposed in this section, mainly from five aspects, namely, wind power transmission, nearby accommodation, RPS implementation, carbon transaction market construction and auxiliary service market construction.

#### 5.1. Policy Recommendation on Wind Power Transmission

There are some problems in the system of renewable energy participating in electricity market transaction that the power transmission capacity of governments and regions does not match the market demand. Chinese onshore wind power resources are mainly concentrated in Three North Area, where the power supply exceeds the demand, hence a large amount of wind power must be sent out. Therefore, China should improve the construction policies and supervision and evaluation mechanism of wind power transmission channel, so as to make full use of UHV power grid and other transmission channels to transmit wind energy to areas with high load demand. In addition, the coordination mechanism between inter-provincial power trading platforms should be studied and improved, which can ensure the reasonable connection of wind power in provincial market transactions.

Meanwhile, policies should be improved to encourage more flexible methods for wind power transmission, such as wind power transmission combined with thermal power. The methods are suitable for features of Chinese power system in which the distribution of energy source and load is separate, and wind farms and thermal power plants are often adjacent.

### *5.2. Policy Recommendations on Nearby Accommodation*

To realize the large-scale accommodation of wind power, China should further perfect the policy of encouraging the nearby accommodation of wind power. On the one hand, it is recommended that the local government should introduce more preferential policies for industrial development to enhance local load capacity and thus utilize more wind power. E.g., the policy of taxation reduction should be introduced to increase more industrial and commercial loads, and the policy of time of use (TOU) pricing should be introduced to guide users to utilize more wind power by shifting loads. On the other hand, it is recommended to innovate the local wind power utilization ways. E.g., the preferential policy should be introduced to promote the utilization of wind power heating, and enterprises should be encouraged to resolve the problem of wind power accommodation through energy storage. In addition, it should encourage the direct nearby transaction, improve the transmission and distribution price policy to support the direct transaction of wind power, and reduce the cost of intermediate transmission.

### *5.3. Policy Recommendation on Carbon Transaction Market*

Under the goal of “30.60” carbon control, renewable energy power has become a crucial supporting force on the path of carbon emission reduction in China. It can reflect the commercial value of the green and zero carbon emission of wind power by carbon transaction, replacing the current price subsidy system. Firstly, it is recommended to introduce policies to establish carbon transaction market nationwide as soon as possible; secondly, it is recommended to introduce policies to publish the transaction standards and the list of enterprises involved in carbon transaction market; thirdly, it is recommended to introduce policies to define the carbon emission limits by regions; fourthly, it is recommended to introduce policies to improve the detailed rules of transaction entities, transaction varieties, transaction procedures and supervision mechanisms in carbon transaction market.

### *5.4. Policy Recommendation on Mandatory RPS*

Along with the growth of wind power technology, the parity of wind power will be realized progressively in the early stage of the 14th Five-Year Plan. It should improve the green power certificate trading system, make the quota system into laws and regulations, and build a parallel system of voluntary subscription and mandatory restraint transaction. By the implementation of RPS, it can provide generation guarantee for wind power, and deal with the problem of wind power curtailment. On the other hand, by transaction of renewable energy power certificate, it can further realize the commercial value of green and zero carbon emission of wind power, and gradually replace tariff subsidy policy of wind power. Therefore, it is recommended to introduce the policy of mandatory RPS to determine RPS quotas that enterprises must undertake, ensure the implementation of RPS, and promote market transaction of renewable energy certificate.

### *5.5. Policy Recommendation on Ancillary Service Market*

It is an effective approach to realize large-scale wind power accommodation of power system by construction of ancillary service market. Therefore, it is recommended to introduce the policy of ancillary services market to encourage various resources such as thermal power plants, natural gas plants, and energy storage, to provide auxiliary services autonomously, like peak load regulation, frequency modulation, black start, standby of power system, and so on, so as to form a complete auxiliary service revenue compensation mechanism, guarantee the economic benefits of enterprises providing services, and ensure

the extensive accommodation of wind power as well as the stable and safe operation of power system.

## 6. Conclusions

The wind power industry is at the phase of technological innovation and its development has much to do with policies. Chinese wind power policies have productively promoted the growth of the wind power industry. The cumulative installed capacity of onshore wind power has reached 20.4 GW in 2019 and accounted for 36% of global cumulative installed capacity of onshore wind power, ranking the first in the world for a long time. However, with the rapid growth of wind power industry, there are also numerous matters such as difficulties in wind power accommodation, inadequate subsidies, imperfect markets, etc. Consequently, how to introduce corresponding policies to solve the aforementioned problems and thus advance the sustainable development of the wind power industry is a key issue. Based on the three aspects of development planning, administration and market transaction, this paper presents a systematic and comprehensive analysis of Chinese wind power policies in 2010s, aiming at the four main components of wind power chain, such as wind power construction, grid connection, transmission and sales. In addition, on the basis of the main indicators of wind power development effect, this paper analyzes the effect of Chinese wind power policies on wind power development. The results show that wind power policy has effectively promoted the development of Chinese wind power industry and the process of wind power participating in the electricity market transaction. Meanwhile, the problems in the growth of wind power, such as accommodation difficulty, inadequate subsidies and imperfect market system, are extracted. At last, facing the 14th Five-Year Plan and the goal of reaching the crest value of carbon dioxide emissions by 2030 and achieving carbon neutrality by 2060, this paper puts forward policy suggestions to advance the stable development of Chinese wind power from the aspects of transmission, consumption, carbon quota trading, renewable energy quota system and auxiliary service market. The policy recommendations on wind power transmission, nearby accommodation, carbon transaction, mandatory RPS and ancillary service market, are proposed to deal with aforementioned problems from policy perspective, providing reference for the improvement of Chinese wind power policy system.

**Author Contributions:** Conceptualization, S.Z.; methodology, S.Z.; software, S.Z. and L.C.; validation, S.Z. and Y.L. (Yingzi Li); formal analysis, S.Z. and L.C.; investigation, S.Z. and L.C.; resources, S.Z. and Y.Z.; data curation, S.Z., L.C. and Y.Z.; writing—original draft preparation, S.Z., L.C. and Y.Z.; writing—review and editing, S.Z. and Y.L. (Yingzi Li); visualization, Y.L. (Ying Li); supervision, S.Z.; project administration, S.Z. and M.Z.; funding acquisition, S.Z. and M.Z. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was supported by the national key research and development program of China (2020YFB1707801), National Natural Science Foundation of China (No. 71601078), Social Science Funds of Beijing (No. 18GLC061), the Humanities and Social Sciences of Education Ministry in China (No. 16YJC630060), the Fundamental Research Funds for the Central Universities (Nos. 2019MS056, 2020MS067), the National Social Science Fund of China (19ZDA081), and the 2018 Key Projects of Philosophy and Social Sciences Research, Ministry of Education, China (No. 18JZD032).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Saidur, R.; Islam, M.; Rahim, N.; Solangi, K. A review on global wind energy policy. *Renew. Sustain. Energy Rev.* **2010**, *14*, 1744–1762. [CrossRef]
2. Zhao, X.; Li, S.; Zhang, S.; Yang, R.; Liu, S. The effectiveness of China's wind power policy: An empirical analysis. *Energy Policy* **2016**, *95*, 269–279. [CrossRef]
3. Delmas, M.A.; Montes-Sancho, M.J. U.S. state policies for renewable energy: Context and effectiveness. *Soc. Sci. Electron. Publ.* **2011**, *39*, 2273–2288. [CrossRef]
4. Shrimali, G.; Lynes, M.; Indvik, J. Wind energy deployment in the U.S.: An empirical analysis of the role of federal and state policies. *Renew. Sustain. Energy Rev.* **2015**, *43*, 796–806. [CrossRef]
5. Klessmann, C.; Held, A.; Rathmann, M.; Ragwitz, M. Status and perspectives of renewable energy policy and deployment in the European Union—What is needed to reach the 2020 targets? *Energy Policy* **2011**, *39*, 7637–7657. [CrossRef]
6. Mizun, E. Overview of wind energy policy and development in Japan. *Renew. Sustain. Energy Rev.* **2014**, *40*, 999–1018. [CrossRef]
7. Shen, X.; Lyu, S. Wind power development, government regulation structure, and vested interest groups: Analysis based on panel data of Province of China. *Energy Policy* **2019**, *128*, 487–494. [CrossRef]
8. Li, L.; Ren, X.; Yang, Y.; Zhang, P.; Chen, X. Analysis and recommendations for onshore wind power policies in China. *Renew. Sustain. Energy Rev.* **2018**, *82*, 156–167. [CrossRef]
9. Zhang, R.X.X.; Ni, M.; Shen, G.Q.; Wong, J.K. An analysis on the effectiveness and determinants of the wind power Feed-in-Tariff policy at China's national-level and regional-grid-level. *Sustain. Energy Technol. Assess.* **2019**, *34*, 87–966. [CrossRef]
10. GWEC. Global Wind Report 2019. Available online: <https://gwec.net/> (accessed on 1 April 2020).
11. SC. The 13th Five-Year Plan for National Economic and Social Development of the People's Republic of China. 2016-03-17. Available online: [http://www.gov.cn/xinwen/2016-03/17/content\\_5054992.html](http://www.gov.cn/xinwen/2016-03/17/content_5054992.html) (accessed on 17 March 2016).
12. Sun, S.; Liu, F.; Xue, S.; Zeng, M.; Zeng, F. Review on wind power development in China: Current situation and improvement strategies to realize future development. *Renew. Sustain. Energy Rev.* **2015**, *45*, 589–599. [CrossRef]
13. Kang, J.; Yuan, J.; Hu, Z.; Xu, Y. Review on wind power development and relevant policies in China during the 11th Five-Year-Plan period. *Renew. Sustain. Energy Rev.* **2012**, *16*, 1907–1915. [CrossRef]
14. Guo, X. Nuclear power development in China after the restart of new nuclear construction and approval: A system dynamics analysis. *Renew. Sustain. Energy Rev.* **2016**, *57*, 999–1007. [CrossRef]
15. Zhang, X.; Liang, Y.; Yu, E.; Rao, R.; Xie, J. Review of electric vehicle policies in China: Content summary and effect analysis. *Renew. Sustain. Energy Rev.* **2017**, *70*, 698–714. [CrossRef]
16. Zhang, Y.; Tang, N.; Niu, Y.; Du, X. Wind energy rejection in China: Current status, reasons and perspectives. *Renew. Sustain. Energy Rev.* **2016**, *66*, 322–344. [CrossRef]
17. NPC. Renewable Energy Law of People's Republic of China [EB/OL]. 2013-12-04. Available online: [http://www.npc.gov.cn/npc/zt/qt/2015zhhsjx/2013-12/04/content\\_1935957.htm](http://www.npc.gov.cn/npc/zt/qt/2015zhhsjx/2013-12/04/content_1935957.htm) (accessed on 4 December 2013).
18. Gosens, J.; Käberger, T.; Wang, Y. China's next renewable energy revolution: Goals and mechanisms in the 13th Five Year Plan for energy. *Energy Sci. Eng.* **2017**, *5*, 141–155. [CrossRef]
19. SC. The 12th Five-Year Plan of Energy Development. 2013-01-01. Available online: [http://www.gov.cn/zwggk/2013-01/23/content\\_2318554.htm](http://www.gov.cn/zwggk/2013-01/23/content_2318554.htm) (accessed on 1 January 2013).
20. NEA. The 12th Five-Year Plan of Renewable Energy Development. 2012-08-08. Available online: [http://www.nea.gov.cn/2012-08/08/c\\_131767651.htm](http://www.nea.gov.cn/2012-08/08/c_131767651.htm) (accessed on 8 August 2012).
21. NEA. The 12th Five-Year Plan of Wind Power Development. 2012-9-01. Available online: <http://news.bjx.com.cn/html/20120914/388348.shtml> (accessed on 1 September 2012).
22. SC. Energy Development Strategy Action Plan (2014–2020). 2014-11-19. Available online: [http://www.gov.cn/zhengce/content/2014-11/19/content\\_9222.htm](http://www.gov.cn/zhengce/content/2014-11/19/content_9222.htm) (accessed on 19 November 2014).
23. NDRC. The 13th Five-Year Plan of Energy Development. 2016-12-26. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201701/t20170117\\_835278.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201701/t20170117_835278.html) (accessed on 26 December 2016).
24. NDRC. The 13th Five-Year Plan of Renewable Energy Development. 2016-12-10. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201612/t20161216\\_830264.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201612/t20161216_830264.html) (accessed on 10 December 2016).
25. NEA. The 13th Five-Year Plan of Wind Power Development. 2016-11-29. Available online: [http://www.nea.gov.cn/2016-11/29/c\\_135867633.htm](http://www.nea.gov.cn/2016-11/29/c_135867633.htm) (accessed on 29 November 2016).
26. NDRC. The 13th Five-Year Plan for Power Development (2016–2020). 2016-12-22. Available online: <http://zfxgk.ndrc.gov.cn/PublicItemView.aspx?ItemID=%7b298336f2-fc4-49eb-a818-451255fb3705%7d> (accessed on 22 December 2016).
27. NDRC. Energy Production and Consumption Revolutionary Strategy (2016–2030). 2017-4-25. Available online: [https://www.ndrc.gov.cn/xxgk/zcfb/tz/201704/t20170425\\_962953.html](https://www.ndrc.gov.cn/xxgk/zcfb/tz/201704/t20170425_962953.html) (accessed on 25 April 2017).
28. CWEA. China Wind Power Industry Mapping 2019. Available online: <http://www.cwea.org.cn/> (accessed on 21 August 2020).
29. NEA. Wind Power Grid Operation in 2017. 2018-02-01. Available online: [http://www.nea.gov.cn/2018-02/01/c\\_136942234.htm](http://www.nea.gov.cn/2018-02/01/c_136942234.htm) (accessed on 1 February 2018).
30. Beijing Government. Statistic Bulletin of Economic and Social Development in Beijing in 2017. 2018-02-27. Available online: <http://zhengwu.beijing.gov.cn/sj/tjgb/t1509890.htm> (accessed on 27 February 2018).

31. He, Y.; Pang, Y.; Zhang, J.; Xia, T.; Zhang, T. Feed-in tariff mechanisms for large-scale wind power in China. *Renew. Sustain. Energy Rev.* **2015**, *51*, 9–17. [[CrossRef](#)]
32. Liu, Z.; Zhang, W.; Zhao, C.; Yuan, J. The Economics of Wind Power in China and Policy Implications. *Energies* **2015**, *8*, 1529–1546. [[CrossRef](#)]
33. NDRC. Renewable Energy Pricing and Cost Sharing Management Trial Measures. 2006-01-04. Available online: [http://www.ndrc.gov.cn/zfwzwx/zfdj/jggg/200601/t20060120\\_128916.html](http://www.ndrc.gov.cn/zfwzwx/zfdj/jggg/200601/t20060120_128916.html) (accessed on 4 January 2006).
34. NDRC. Notice on Improving on-Grid Tariff Policy of Wind Power Generation. 2009-07-20. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/200907/t20090727\\_292827.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/200907/t20090727_292827.html) (accessed on 20 July 2009).
35. NDRC. Notice on Adjusting the on-Grid Tariff of Onshore Wind Power of Photovoltaic Power Generation. 2016-12-26. Available online: [http://www.ndrc.gov.cn/gzdt/201612/t20161228\\_833065.html](http://www.ndrc.gov.cn/gzdt/201612/t20161228_833065.html) (accessed on 26 December 2016).
36. NDRC. Opinions on Comprehensively Deepening the Reform of Price Mechanism. 2017-11-08. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201711/t20171110\\_866776.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201711/t20171110_866776.html) (accessed on 8 November 2017).
37. NDRC. Notice on Adjusting the on-Grid Tariff of Onshore Wind Power. 2014-12-31. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201501/t20150109\\_659876.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201501/t20150109_659876.html) (accessed on 31 December 2014).
38. MOF. Interim Measures for the Administration of the Collection and Use of the Renewable Energy Development Fund. Available online: [http://zhs.mof.gov.cn/zhengwuxinxi/zhengcefabu/201112/t20111212\\_614767.html](http://zhs.mof.gov.cn/zhengwuxinxi/zhengcefabu/201112/t20111212_614767.html) (accessed on 12 December 2011).
39. MOF; NDRC; NEA. Interim Measures for the Management of Supplementary Funds for Renewable Energy Prices. Available online: [http://www.gov.cn/zwgk/2012-04/05/content\\_2107050.htm](http://www.gov.cn/zwgk/2012-04/05/content_2107050.htm) (accessed on 5 April 2012).
40. MOF. Notice on Related Issues of Raising Renewable Energy Development Fund Collection Standards. 2016-01-05. Available online: [http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/wg2016/wg201602/201606/t20160601\\_2118609.html](http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/wg2016/wg201602/201606/t20160601_2118609.html) (accessed on 5 January 2016).
41. MOF. Notice on Organizing the Application for the Seventh Batch of Renewable Energy Tariffs. 2017-03-13. Available online: [http://jjs.mof.gov.cn/zhengwuxinxi/tongzhigonggao/201703/t20170320\\_2560292.html](http://jjs.mof.gov.cn/zhengwuxinxi/tongzhigonggao/201703/t20170320_2560292.html) (accessed on 13 March 2017).
42. MOF; NDRC; NEA. Notice on the Publication of the List of Additional Funding Subsidies for Renewable Energy Additional Fund (the Seventh Batch). Available online: [http://m.mof.gov.cn/tzgg/201806/t20180615\\_2929482.htm,2018-6-11](http://m.mof.gov.cn/tzgg/201806/t20180615_2929482.htm,2018-6-11) (accessed on 11 June 2018).
43. NDRC. Measures for Full Guarantee Purchase Management of Renewable Energy Power Generation. 2016-03-24. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201603/t20160328\\_796404.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201603/t20160328_796404.html) (accessed on 24 March 2016).
44. NDRC. Notice on the Work of Full Guarantee Purchase Management of Wind Power and Photovoltaic Power Generation. 2016-05-27. Available online: [http://www.ndrc.gov.cn/gzdt/201605/t20160531\\_806133.html](http://www.ndrc.gov.cn/gzdt/201605/t20160531_806133.html) (accessed on 27 May 2016).
45. Yin, H.; Powers, N. Do state renewable portfolio standards promote in-state renewable generation? *Energy Policy* **2010**, *38*, 1140–1149. [[CrossRef](#)]
46. Barbose, G.; Wiser, R.; Heeter, J.; Mai, T.; Bird, L.; Bolinger, M.; Carpenter, A.; Heath, G.; Keyser, D.; Macknick, J.; et al. A retrospective analysis of benefits and impacts of U.S. renewable portfolio standards. *Energy Policy* **2016**, *96*, 645–660. [[CrossRef](#)]
47. NEA. Notice on Requirements for Establishing Quota Assessment System of Non-Water Renewable Portfolio Standards for Coal-Fired Power Units. 2016-04-22. Available online: <http://guangfu.bjx.com.cn/news/20160425/727787.shtml> (accessed on 22 April 2016).
48. NEA. Quota and Assessment Methods of Renewable Energy Power Portfolio Standards (Draft for Soliciting Opinions). 2018-03-23. Available online: [http://zfxgk.nea.gov.cn/auto87/201803/t20180323\\_3131.html](http://zfxgk.nea.gov.cn/auto87/201803/t20180323_3131.html) (accessed on 23 March 2018).
49. Liu, T. Study on Abandoning Wind Power in China. *Adv. Mater. Mach. Electr. Eng.* **2017**, *114*, 459–461.
50. Luo, G.; Dan, E.; Zhang, X.; Guo, Y. Why the Wind Curtailment of Northwest China Remains High. *Sustainability* **2018**, *10*, 570. [[CrossRef](#)]
51. NEA. Notice on the Work of Wind Power Accommodation in 2015. 2015-03-23. Available online: [http://zfxgk.nea.gov.cn/auto87/201504/t20150407\\_1900.html](http://zfxgk.nea.gov.cn/auto87/201504/t20150407_1900.html) (accessed on 23 March 2015).
52. NEA. Notice on the Work of Wind Clean Heating. 2015-06-05. Available online: [http://zfxgk.nea.gov.cn/auto87/201506/t20150615\\_1938.html](http://zfxgk.nea.gov.cn/auto87/201506/t20150615_1938.html) (accessed on 5 June 2015).
53. NDRC. Reply to the Agreement on Pilot Programs for Nearby Accommodation of Renewable Energy in Gansu Province, Inner Mongolia Autonomous Region and Jilin Province. 2016-04-05. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201604/t20160411\\_797827.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201604/t20160411_797827.html) (accessed on 5 April 2016).
54. NEA. Notice on the Work of Renewable Energy Accommodation in Three North Area. 2016-02-05. Available online: [http://zfxgk.nea.gov.cn/auto92/201602/t20160216\\_2202.html](http://zfxgk.nea.gov.cn/auto92/201602/t20160216_2202.html) (accessed on 5 February 2016).
55. NEA. Notice on Recent Work of Market Supervision. 2016-02-05. Available online: [http://www.gov.cn/zwgk/2013-08/08/content\\_2463385.html](http://www.gov.cn/zwgk/2013-08/08/content_2463385.html) (accessed on 5 February 2016).
56. NEA. Notice on Strengthening the Construction of Supervision and Evaluation System in Wind Power Industry. 2013-05-23. Available online: [http://zfxgk.nea.gov.cn/auto87/201305/t20130529\\_1608.html](http://zfxgk.nea.gov.cn/auto87/201305/t20130529_1608.html) (accessed on 23 May 2013).
57. NEA. Notice on Establishing Supervising and Warning Mechanism to Promote Sustainable and Healthy Development of Wind Power Industry. 2016-07-18. Available online: [http://zfxgk.nea.gov.cn/auto87/201607/t20160721\\_2276.html](http://zfxgk.nea.gov.cn/auto87/201607/t20160721_2276.html) (accessed on 18 July 2016).



58. NEA. Notice on the Release of Supervising and Warning Results of Wind Power Investment in 2017. 2017-02-17. Available online: [http://zfxgk.nea.gov.cn/auto87/201702/t20170222\\_2604.html](http://zfxgk.nea.gov.cn/auto87/201702/t20170222_2604.html) (accessed on 17 February 2017).
59. Mou, D. Wind Power Development and Energy Storage under China's Electricity Market Reform—A Case Study of Fujian Province. *Sustainability* **2018**, *10*, 298. [CrossRef]
60. He, Y.X.; Xia, T.; Liu, Z.Y.; Zhang, T.; Dong, Z. Evaluation of the capability of accepting large-scale wind power in China. *Renew. Sustain. Energy Rev.* **2013**, *19*, 509–516. [CrossRef]
61. SC. Opinions on Further Deepening the Reform of Electric Power System. 2015-03-15. Available online: [http://tgs.ndrc.gov.cn/zywj/201601/t20160129\\_773852.html](http://tgs.ndrc.gov.cn/zywj/201601/t20160129_773852.html) (accessed on 15 March 2015).
62. NDRC. Opinions on Promoting the Construction of Electricity Market. 2015-11-01. Available online: <http://www.ndrc.gov.cn/zcfb/zcfbtz/201511/W020151130295800083469.pdf> (accessed on 1 November 2015).
63. NDRC. Basic Rules for Medium and Long-Term Electricity Transaction (Provisional). 2016-12-29. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201701/t20170112\\_834884.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201701/t20170112_834884.html) (accessed on 29 December 2016).
64. NDRC. Notice on Launching Pilot Work of Electricity Spot Market Construction. 2017-08-28. Available online: [http://www.ndrc.gov.cn/gzdt/201709/t20170905\\_860117.html](http://www.ndrc.gov.cn/gzdt/201709/t20170905_860117.html) (accessed on 28 August 2017).
65. NDRC. Guiding Opinions on Promoting the “Internet Plus” Smart Energy Development. 2016-02-24. Available online: [http://www.gov.cn/xinwen/2016-03/01/content\\_5047633.html](http://www.gov.cn/xinwen/2016-03/01/content_5047633.html) (accessed on 24 February 2016).
66. NDRC. Trial System of Renewable Energy Power Certificate Issuance and Voluntary Transaction. 2017-01-18. Available online: [http://www.ndrc.gov.cn/gzdt/201702/t20170203\\_837121.html](http://www.ndrc.gov.cn/gzdt/201702/t20170203_837121.html) (accessed on 18 January 2017).
67. He, Y.; Hu, J.F.; Yan, Z.T.; Shang, J. Study on Cost Compensation Mechanism of Large-Scale Wind Power Grid Auxiliary Services. *Power Grid Technol.* **2013**, *37*, 3552–3557.
68. NEA. Notice on Approving the Rules of Auxiliary Service Management and Grid-Connected Operation of Power Plants in Northeast China. 2008-11-19. Available online: [http://zfxgk.nea.gov.cn/auto79/201307/t20130702\\_1629.html](http://zfxgk.nea.gov.cn/auto79/201307/t20130702_1629.html) (accessed on 19 November 2008).
69. NEA. Opinions on Promoting Coordinated Development of Electric Power in Northeast China. 2016-06-21. Available online: [http://zfxgk.nea.gov.cn/auto84/201607/t20160711\\_2274.htm?keywords](http://zfxgk.nea.gov.cn/auto84/201607/t20160711_2274.htm?keywords) (accessed on 21 June 2016).
70. NEA. Pilot Project to Improve the Flexibility of Thermal Power Transformation Started. 2016-06-20. Available online: [http://www.nea.gov.cn/2016-06/20/c\\_135451050.html](http://www.nea.gov.cn/2016-06/20/c_135451050.html) (accessed on 20 June 2016).
71. NDRC. Guidance Opinions on Promoting Energy Storage Technology and Development. 2017-09-22. Available online: [http://www.ndrc.gov.cn/gzdt/201710/t20171011\\_863348.html](http://www.ndrc.gov.cn/gzdt/201710/t20171011_863348.html) (accessed on 22 September 2017).
72. Mu, Y.; Cai, W.; Evans, S.; Wang, C.; Roland-Holst, D. Employment impacts of renewable energy policies in China: A decomposition analysis based on a CGE modeling framework. *Appl. Energy* **2018**, *210*, 256–267. [CrossRef]
73. Prospective Industry Research Institute. Report of Market Prospects and Investment Strategy Planning on China Wind Power Industry (2015–2020). Available online: <https://bg.qianzhan.com/report/detail/0b14bbc8ab674a6b.html> (accessed on 15 December 2014).
74. Ma, Z.; Xue, B.; Geng, Y.; Ren, W.; Fujita, T.; Zhang, Z.; De Oliveira, J.A.P.; Jacques, D.A.; Xi, F. Co-benefits analysis on climate change and environmental effects of wind-power: A case study from Xinjiang, China. *Renew. Energy* **2013**, *57*, 35–42. [CrossRef]
75. NDRC. Interim Measures for the Promotion and Management of Energy Saving and Low-Carbon Technologies. 2014-01-06. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201401/t20140110\\_575363.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201401/t20140110_575363.html) (accessed on 6 January 2014).
76. CEC. Annual Power Statistics Basic Data List. Available online: <http://www.cec.org.cn/guihuayutongji/tongjixinxi/nianrushuju/> (accessed on 12 June 2020).
77. People's Daily. Speech at the Opening Ceremony of the Paris Convention on Climate Change. 2015-11-30. Available online: <http://politics.people.com.cn/n/2015/1201/c1024-27873625.html> (accessed on 30 November 2015).
78. NDRC. Regulatory Measures for the Acquisition of Renewable Energy Power Generation. 2016-03. Available online: [http://www.ndrc.gov.cn/zcfb/zcfbtz/201603/t20160328\\_796404.html](http://www.ndrc.gov.cn/zcfb/zcfbtz/201603/t20160328_796404.html) (accessed on 15 March 2016).
79. Xia, F.; Song, F. The uneven development of wind power in China: Determinants and the role of supporting policies. *Energy Econ.* **2017**, *67*, 278–286. [CrossRef]
80. NEA. Wind Power Grid Operation in 2018. 2019-01-28. Available online: [http://www.nea.gov.cn/2019-01/28/c\\_137780779.htm](http://www.nea.gov.cn/2019-01/28/c_137780779.htm) (accessed on 28 January 2019).
81. Energy News. The Faces of All Beings under the Subsidy Gap. 2019-08-28. Available online: [https://www.sohu.com/a/337041431\\_240923](https://www.sohu.com/a/337041431_240923) (accessed on 28 August 2019).
82. CEC. A Brief Analysis of the National Electricity Market Trading Information in 2019. 2020-01-21. Available online: <http://www.cec.org.cn/guihuayutongji/dianligaige/2020-01-21/197071.html> (accessed on 21 January 2020).
83. Li, Y. *Research on the Wind Power Generation Costs and Related Industrial Policies in China*; North China Electric Power University: Beijing, China, 2011.