Feasibility Study of Nuclear Power Included in Carbon Trading Market: A Case Study of China's Carbon Market

Zekai Huang [1, *, †], Xiangqi Meng [2, †], Zongzhen Wang [3, †], Hao Yang [4, †]

[1] No4 High school, Hangzhou, China

[2] Beijing Royal School, Beijing, China

[3] International Business School Suzhou, Xi'an Jiaotong-liverpool University, Suzhou, China

[4] Niagara Christian Collegiate, Ontario, Canada

* Corresponding Author Email: zongchen.wang20@student.xjtlu.edu.cn

[†] These authors contributed equally

Abstract. As an innovative economic and clean source of energy, now nuclear power is the most worthy of large-scale development in the world. Especially in China, the development of nuclear power is not only related to China's energy security, but also of great significance to economic development and international status. Mature and stable carbon emission market is also very important for the implementation of new energy technology. Therefore whenever it comes to carbon trading, as a derivative means for countries in the world to participate in global carbon emission control, it has developed rapidly in China in recent years. Through theoretical analysis and sample data analysis, this paper studies current policies and historical sources, finds out the possible mechanism for nuclear power to enter the carbon trading market, and describes the economic benefits of the combination of nuclear power and carbon trading market. The results show that there is a correlation and causality between nuclear power and other power generation methods and carbon market, and there is a large profit space when carbon trading is included. Nuclear power has potential value for inclusion in the carbon market.

Keywords: Renewable Energy Power Generation, Nuclear Power, Coordinated Dispatching.

1. Introduction

Despite the fact that China is not one of the initial countries to establish its relevant market, but it is one of the most active country which participate fully in this kind of region. The concept of carbon trading is firstly mentioned by Kyoto Protocol, a supplement to the 1997 United Nations Framework Convention on Climate Change. In order to achieve member countries' ambitions of emission reduction, the item illustrates that in a contracting party, two developed countries can perform "emissions trading(ET)" between them, which also means these "high emitted" countries which are difficult to achieve this goal can purchase the extra amount from other countries that are well on track to exceeding Kyoto. For both developing and developed countries, the convention provides a CDM mechanism that allows project-level offsets to be transferred between them. Furthermore, China has already signed the Convention in 1998. In January 2005, the European Union was the first to establish a carbon market based on this convention. The carbon trading volume of this market took up approximately 85% in the world's total carbon trading volume, covered more than 11,000 factories in 31 countries, which was the largest carbon trading market in the world at that time [1]. Initially, China can only participate in CDM projects for carbon trading, and majority of them are classified as wind power projects. But even so, China was the country with the largest number of project declarations at the time, and then more and more company's now receiving allowances for energy conservation and emission reduction projects and selling them to other countries to gain profits. China began to prepare for the construction of carbon market in 2011, on the one hand, the quantity of CDM projects are experience a continuous decrease, on the other hand, China also needs to achieve its own carbon emission reduction target urgently. In 2013, local administration in China set up 7 pilot carbon emission trading programs in Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Hubei and

Guangdong, and in 2016 added a carbon trading market in Fujian. As the first local carbon trading markets, this 8 pilot projects collectively limited about 1.4 billion tons of CO2 emissions [2], which is a good proof of limiting carbon emissions in the carbon trading market. In July 2021, the national carbon emission trading market was opened and in July 2022, it became the largest carbon trading spot market in the world. In additional, the Chinese president Xi Jinpin also figured that we should aim to have carbon dioxide emissions peak before 2030 and achieve carbon neutrality before 2060. However, there are also some researches illustrating that the current carbon trading market in the world cannot achieve the optimal effect. According to Fama's three levels of efficient market hypothesis -"weak form market efficiency, semi-strong form market efficiency and strong form market efficiency [3]." Some scholars have studied the effectiveness of EU carbon market. They believe that the market in the three stages of development presents weak form market efficiency is not reached, weak form market efficient, and weak form market efficiency is invalid. [4]." Zhao and Wang conducted an effectiveness study on four pilot carbon trading markets in China, three of which did not reach the weak-form market efficiency level [5]. Some studies suggest that the existing carbon market still need some space for further improvement. At the same time, there still existing a gap in the research on carbon trading of nuclear power. Currently, nuclear power has become an integral part in China's development. At present, China's national carbon trading market only includes high-emission power generators and renewable energy generators, except for nuclear-related companies. Therefore, this research will study the current situation and relevant policies of nuclear power and carbon trading market to find out the feasibility, methods and suggestions respectively about including nuclear power enterprises in the carbon trading market from two aspects of theoretical research and data analysis.

2. Methodology

Since this is a research feasibility study, it is necessary to conduct two aspects of research - theoretical research and data analysis. The specific methods for each study are described below.

2.1. Theoretical Research

As this is a study of the Chinese carbon trading market, it is important that we first provide an overview of the current situation in the Chinese carbon market. First, the largest share is CEA, or carbon emission allowance trading. CEA is mainly for high-emitting enterprises, and according to the "Measures for the Administration of Carbon Emission Trading [Trial Implementation]" [6], which will come into effect in February 2021, enterprises with annual GHG emissions of 26,000 tons of CO2 equivalent and belonging to industries covered by the national carbon emission trading market need to be included in the carbon trading market. The China carbon trading market currently allows only the power generation industries to participate, which provides the background basis for this study. Each annual government allocation of free allowances is made to companies, and companies with free allowances can sell their surplus allowances to companies that are unable to complete their emission reduction tasks. In addition to this, China has set up CCER trading and green electricity green certificate trading. CCER is obtained from CER, verified and confirmed greenhouse gas emission reductions issued by the United Nations to enterprises implementing CDM projects. This is also the main form of carbon trading that Chinese enterprises participate in during the CDM phase. China subsequently established the CCER mechanism or state-certified voluntary emission reductions in 2012. However, the CCER market was shut down again in 2017 due to small trading volumes and imperfect standards. But in January 2022, there was information about restarting the market. On the other hand, green power green certificate trading, mainly involving wind and photovoltaic power generation two industries, electricity-using enterprises can buy green power certificates, or directly from wind and photovoltaic power generation enterprises to buy green power. There are currently three main types of green certificates traded in the Chinese domestic market, namely GEC, I-REC, and TIGR. The first of these is led by the Chinese National Energy

Administration, while the latter two are led by institutions in the Netherlands and the United States, respectively [7].

In summary, there are currently three main trading methods in China: CEA, CCER, and Green Power Green Certificates. If nuclear power is to be included in carbon trading without creating new trading methods, it can be done only through the latter two. In terms of theoretical research, the current status of China's carbon trading market and the reasons why nuclear power is not currently included in carbon trading will be analyzed. Possible methods for nuclear power to participate in carbon trading will be discussed. In addition, we will discuss the current state of development of the nuclear power industry in China and find evidence and obstacles that support the inclusion of nuclear power in carbon trading.

2.2. Data analysis

Collect China's carbon trading data from August 2013 to July 2022, average the transaction price (avgprice) of 7 local pilots and the national carbon trading market, calculate the transaction volume (volume), and sum up the transaction amount (amount). At the same time, the monthly new thermal power generation equipment capacity (TPCA), the national power supply coal consumption rate (CCPS), the national thermal power generation (NTPE), the national nuclear power generation (NNPG), the national wind power generation (NWPG) were collected during the same time period. Wind power equipment capacity of 6,000 kW and above (WPE), nuclear power plant capacity of 6,000 kW and above (NPE), thermal power plant capacity of 6,000kW and above (TPE), and hydroelectric power equipment of 6,000kW and above (HPE), the capital construction investment of wind power (WC), and the national average cumulative utilization hours of power generation equipment (HE) was also collected. All the relevant data are all from the CSMAR database.

This part is to analyze the possible relationship between China's carbon market, especially nuclear power and carbon market, and to find a breakthrough in the carbon market. By analyzing the historical transaction data since the establishment of each local pilot, and correlating it with the data related to power generation in the corresponding month, it can evaluate whether the current carbon market price and transaction volume can affect the decision-making of power generation enterprises in terms of power generation and equipment capacity, and their Whether the decision will affect carbon market prices and turnover. Causal tests are performed for combinations in which there is a high correlation. The NullHypothesis H0a1 is that there is no moderate or above (>0.5) correlation between the transaction price and transaction value of carbon trading and the power generation and equipment capacity of various power generation methods. The NullHypothesis H0a2 is that the transaction price and transaction volume of carbon trading have no causal relationship with the power generation and equipment capacity of various power generation methods.

3. Results

3.1. Theoretical Research Results

In terms of policy, some possible reasons why the current policy does not allow nuclear power to be included in carbon trading are discussed. First of all, China's earliest policy document on carbon trading was the "Administrative Measures for the Operation of Clean Development Mechanism Projects" issued in October 2005 [8]? Since the purpose is to regulate the participation of Chinese enterprises in CDM transactions, most of the contents of the document are based on the "Kyoto Protocol", including the CER part. In 2001, the UNFCCC added an explanation to Article 12 of the Kyoto Protocol, which stipulates that Parties in Annex 1 cannot use the certified emission reductions generated by nuclear facilities to meet their emission reduction commitments [9]. In 2013, affected by the EU-ETS policy of only trading CDM with least developed countries, China began to try to establish a CCER trading system. However, it is worth noting that the Kyoto Protocol expired in 2012, and neither the Copenhagen Agreement nor the Paris Agreement mentioned banning nuclear power from participating in carbon trading or carbon reduction. Therefore, there are no rigid provisions in international treaties that prevent nuclear power from being included in carbon trading. In the CCER system, policies and regulations vary from place to place, which has also led to problems such as small market transactions and cumbersome filing of emission reduction projects. In 2017, the government suspended the CCER market [10]. This also shows that the CCER market still has a lot of room for improvement. In 2021, with the establishment of the national carbon trading market, the CCER market restarted. China Nuclear Power’s renewable energy power generation project under China Nuclear Power traded 3.3355 million tons of carbon dioxide through the international and domestic markets in 2022, of which 360,600 tons were traded through the CCER market [11]. This is the first attempt by Chinese nuclear power companies to participate in carbon trading, although not through nuclear power projects. At the same time, China General Nuclear Power, another major nuclear power company in China, had also stated that it will actively promote the entry of nuclear power into carbon emissions trading [12]. Some studies estimated that if all CO2 emission reductions generated by CNNP and CGN were included in carbon trading in 2020, a total of about 3.59 billion yuan in economic value would be generated [13].

Additionally, the Chinese government is also actively promoting the development of the nuclear power industry. On January 30, 2021, the first reactor of the Hualong No. 1 nuclear power unit was put into commercial operation in Fuqing, China [14]. Since the Fukushima nuclear leak in 2011, China's domestic investment in the nuclear power industry has declined year by year. However, China's nuclear power installed capacity and power generation have been increasing since 2013 [15]. As a nuclear power plant with the highest level of safety protection for nuclear power, Hualong No. 1 is undoubtedly a booster for the development of the nuclear power industry. At present, Hualong No. 1 has reached cooperation progress with more than 60 countries and regions in the world [16].

Moreover, in 2021, China successfully tested a thorium reactor unit in Wuwei, Gansu. The reserves of thorium in the earth's crust are about three times that of uranium, and almost all of them are thorium-232 suitable for nuclear fission reactions [17]. The first commercial thorium reactor will be built in 2030. As a fourth-generation nuclear power technology, it is expected to spark a boom in the construction of inland nuclear power in China. More excitingly, molten salts are used by concentrating solar power plants [CSPs] to store heat, and thorium-based molten salt reactors can cooperate with such plants nearby to obtain a similar composition of salts [18]. It may also mean that thorium reactor nuclear power plants may have the opportunity to participate in carbon trading with the help of CSPs as part of the overlap in the latter's power generation process.

The green power and green certificate market is not in good shape. According to data from the China Green Certificate Subscription Platform, as of August 2021, the average transaction prices of subsidized photovoltaics and wind power with subsidies were 680 yuan/unit and 177 yuan/unit, respectively, and both unsubsidized were 50 yuan/unit, and the number of transactions was serious. Lower than the number issued [19].

3.2. Data analysis conclusion

The results of Spearman correlation analysis are shown in Table 1-2.

Table 1. Spearman's correlation coefficient.

Spearman rho	NNPG	NTPG	HPE	TPE	WPE	NPE
NNPG	1.000	.872**	-0.902**	-0.696**	-0.637*	-0.253
NTPG	0.872**	1.000	-0.697**	-0.579**	-0.547**	-0.357**
HPE	-0.902**	-0.697**	1.000	0.701*	0.696**	0.245**
TPE	-0.696**	-0.579****	0.701**	1.000	0.893*	0.640'**
WPE	-0.637**	-0.547**	0.696**	0.893**	1.000	0.623**
NPE	-0.253	-0.357****	0.245*	0.640**	0.623**	1.000

Table 2. Spearman's correlation.

Spearman rho	avgprice	volume	amount
avgprice	1.000	-0.156	0.046
volume	-0.156	1.000	0.935**
amount	0.046	0.935**	1.000
TPCA	0.039	-0.018	0.038
CCPS	-0.140	0.336**	0.344**
NTPG	-0.135	0.477**	0.585**
NNPG	-0.251*	0.541**	0.638**
WPE	0.203	-0.144	-0.143
NPE	-0.132	0.024	0.030
TPE	0.165	-0.167	-0.202
HPE	0.503**	-0.216	-0.203
WC	-0.033	-0.144	-0.215
HE	-0.309**	0.078	0.004
NWPG	-0.386**	0.134	-0.064

According to the results, some variables have more than moderate correlations. Amount-NNPG, amount-NTPG, avgprice-HPE, those factors are related to the carbon trading. NPE-WPE, NPE-TPE, NNPG-NTPG, NNPG-WPE, NNPG-TPE, NNPG-HPE, all of these factors are related to nuclear power. Therefore, this test can reject NullHypothesises H0a1 and H0b1. To further explore whether there is a causal relationship between these variables, a granger causality test was performed on them. Since many variables failed the unit root test, each variable was differently processed after interpolation was used to fill in missing values. The variable name after the difference is represented by adding "d1" before the original variable. After difference processing, spearman correlation coefficient analysis was performed on each variable again. The results are shown in table3.

Table.3. Spearman correlation coefficient.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) d1NE	1.000								
(2) d1TE	-0.010	1.000							
(3) d1HE	0.083	-0.167	1.000						
(4) d1WC	0.425	0.132	-0.143	1.000					
(5) d1NWPG	-0.070	-0.061	-0.100	0.346	1.000				
(6) d1amount	-0.109	0.098	-0.037	-0.149	0.272	1.000			
(7) d1NNPG	-0.121	0.035	-0.120	-0.206	-0.083	0.384	1.000		
(8) d1NTPG	-0.298	-0.042	-0.060	-0.284	0.150	0.455	0.775	1.000	
(9) d1avgprice	0.087	-0.190	-0.202	0.107	0.159	0.122	0.347	0.353	1.000

Establish a VAR model to find out the smallest lag term of AIC and BIC in the variable pair related to carbon trading or nuclear power, and apply it in the granger causality test where the A variable is not the B variable because of the null hypothesis. The analysis results are shown in table 4.

Table 4. Granger causality test.

H0	F	Prob > F	chi2	Prob> chi2
d1NTPG does not Granger-cause d1amount	2.87	0.0404	9.24	0.0263
d1NNPG does not Granger-cause d1amount	3.00	0.0344	9.65	0.0218
dlavgprice does not Granger-cause d1HPE	12.72	0.0006	13.18	0.0003
dlavgprice does not Granger-cause d1amount	3.94	0.0028	22.04	0.0005

The results of spearman analysis showed that most of the correlations between variables decreased after differencing, indicating that the original correlations may be caused by trends. The results of the granger causality test show that, d1avgprice is the lag fifth factor of d1amount, d1avgprice is the lagged first-order factor of d1HPE, d1NTPG is the lag third-order factor of d1amount, and d1NNPG is the lag third-order factor of d1amount. There is no causal relationship between each group of other test group variables. Therefore, H0a2 should be rejected and H0b2 should be accepted.

3.3. Analysis of the expected benefits of nuclear power included in carbon trading.

Although Huang, Yang and Liu [2009] proposed a calculation method for China's nuclear power in mitigating carbon emissions [20], it is difficult to obtain the baseline emission factor of nuclear power generating units to replace the power grid electricity and the parent parameters required for its calculation, the parameters vary from place to place and often change, so accurate results cannot be obtained with NER=NEG·EF. However, according to the 2020 China's nuclear power emission reduction and power generation data released by CCTV, this article can roughly calculate the 2020 emission factor and generate predictions based on it. The results are shown in table 5

Table 5. Nuclear power emission reductions and electricity generation data.

Time	**NNPG**	**Emissionfactor**	**Expectedreduction**	**Avgprice**	**EV**
	KWh	tCO2/KWh	tCO2	yuan	yuan
2013	728376700000000	0.000749	545554148300	65.52672414	35748376177958.00
2014	794351800000000	0.000749	594969498200	41.61946754	24762313718779.40
2015	860165700000000	0.000749	644264109300	30.36138768	19560752390061.60
2016	925818800000000	0.000749	693438281200	26.78819474	18575959717360.60
2017	991311500000000	0.000749	742492313500	24.85730247	18456356017677.90
2018	1056644100000000	0.000749	791426430900	26.74144699	21163887949508.40
2019	1121817100000000	0.000749	840241007900	28.23770449	23726477277668.90
2020	1186830800000000	0.000749	888936269200	31.56505225	28059319781199.20
2021	1251685600000000	0.000749	937512514400	27.14336057	25447240213917.20
TOTAL			**6678834572900**		**215500683244131.00**

Since CCER trading was interrupted in 2017 and is being restarted in 2022, it is difficult to obtain historical price data. However, the CCER price is suppressed by the forward CEA price, so it can be replaced by the CEA price [21]. According to historical data, since the local carbon trading pilot was opened in 2013, the annual emission reductions generated by nuclear power and the estimated value of carbon assets are shown in the table. As can be seen from the table, if starting from 2013, all emissions reductions brought by nuclear power generation in China can be traded, which will bring about economic benefits of more than 2 trillion yuan in total. However, such calculation method has some errors. For example, not all emission reduction amounts have corresponding demand, and the current policy only allows emitters to buy CCER of 5%-10% of total emissions. Moreover, before the establishment of a national market, carbon prices varied widely, making it impossible to assume where nuclear companies would trade. However, this can show that nuclear power into the carbon trading market, there are considerable profit spaces.

Based on this data and the power generation data from 2006 to 2021, an ARIMA model is designed to predict nuclear power generation from 2022 to 2026, as well as the expected maximum carbon benefit and the expected minimum carbon benefit. The results are shown in table 6.

Table 6. Expected maximum carbon benefit and the expected minimum carbon benefit.

Time	**NNPG**	**Emissionfactor**	**Expectedreduction**	**Avgprice-low**	**EV-low**	**Avgprice-high**	**EV-high**
	KWh	tCO2/KWh	tCO2	yuan	yuan	yuan	yuan
2022	330240400000	0.000749	247350059.6	26.74144699	6614498507	65.52672414	16208039121
2023	340625700000	0.000749	255128649.3	26.74144699	6822509251	65.52672414	16717744622
2024	344354000000	0.000749	257921146	26.74144699	6897184654	65.52672414	16900727783
2025	342703900000	0.000749	256685221.1	26.74144699	6864134234	65.52672414	16819741673
2026	336826600000	0.000749	252283123.4	26.74144699	6746415771	65.52672414	16531286632
Total					33944742417		83177539832

4. Discussion

4.1. Anomalies and explanations

The lag causal relationship between the average transaction price and the transaction value, as well as the lag causal relationship between thermal power generation and transaction value, may be caused by seasonal fluctuations in transaction value. According to the research, there are obvious off-peak seasons in China's carbon trading market, and the peak period of carbon trading is formed from May to June every year. The reason for this cyclical fluctuation may be that the Chinese government generally requires companies to complete carbon verification in March-April, and contract fulfillment in mid-June, causing most emitting companies to choose to purchase carbon allowances near the deadline [22]. Prices do not fall back immediately after the peak trading season, which usually takes several months. The high correlation between thermal and nuclear power generation comes from the fact that both are both base-load supply [23]. Thermal power generation is stable, but with high emissions, and will gradually be replaced by other power generation methods. Hydropower, wind power, photovoltaic and other power generation methods are greatly affected by the season and the environment, and the power generation is unstable and cannot carry the power generation base load. Therefore, the most ideal way to replace thermal power is nuclear power. Moreover, if nuclear power is included in carbon trading, combined with a real-time carbon accounting system, the problem of cyclical fluctuations in carbon prices can be alleviated, because both of them have a third-order granger cause for the transaction volume. Emission reductions from nuclear power can more quickly be used to offset emissions from thermal power.

The relationship between nuclear power equipment capacity and other power generation methods, especially wind power equipment capacity, apart from trends, should be related to nuclear power's investment in other power generation methods. According to information, CNNC Huineng, a subsidiary of CNNC, was established in 2011 and has been investing in wind power and photovoltaic power generation. CGN Wind Power Co., Ltd. was also established in 2010. In addition, Bai pointed out in a 2020 study that there is currently a contradiction between wind power and nuclear power consumption in China, as well as a considerable degree of abandonment of wind energy and solar energy resources. There is an anti-peak shaving phenomenon in wind power generation, and the cost of nuclear power participating in peak shaving is extremely high, so the issue of the installed capacity ratio of renewable energy and nuclear power should be fully considered [24].

4.2. Possible ways for nuclear power to be included in carbon trading.

According to the above analysis and discussion results, under the premise of not opening up a new trading form, the best way for nuclear power to be included in carbon trading is still CCER. Also, according to a July 2022 report, China's CCER market currently has a certain supply gap [21], and the participation of nuclear power can fill this gap. However, due to the current cyclical fluctuations in the CEA market, the transaction price of the upcoming CCER will also be affected, which is not conducive to the profitability of nuclear power companies. Therefore, a better way is to set up CCER categories for nuclear power, strengthen the construction of carbon accounting systems, and encourage thermal power companies to actively participate in transactions. In the early stage of the opening of the transaction, certain subsidies can be given to nuclear power companies, similar to the subsidies for photovoltaic wind power in the early stage of the opening of CCER transactions. Additionally, nuclear power companies can be encouraged to increase investment in the field of wind power and photovoltaics. In the initial stage, nuclear power-wind power or nuclear power-photovoltaic hybrid transaction mode can be used as a transition to explore a more reasonable way of participating.

5. Conclusion

For this feasibility study on the inclusion of nuclear power in the carbon trading market in China, for example, China has established carbon emission trading pilots in eight major cities in the country and has become the world's largest carbon trading spot market. This makes China's carbon trading market of great research value. At the same time, the theoretical values, as well as the practical value of the study results, are extremely extensive, such as the three main trading methods of CEA, CCER, and Green Power Green Certificates. For practical value, the cumulative turnover of the Guangdong carbon market is over 100 million tons, followed by several other cities. As a result, China participates in CDM trading and tries CCER as well, but there is still a lot of room for improvement. Through the data analysis section, to explore whether there is a causal relationship between these variables, through the assumptions of multiple models, it is concluded that there is no causal relationship between each of the other test group variables. Therefore, H0a2 is rejected and H0b2 is accepted.

And the lagged causality between the average transaction price and turnover, and the lagged causality between thermal generation and turnover, probably due to the seasonal fluctuations in turnover. We still need to fully consider the issue of the ratio of installed renewable energy to nuclear power to reduce costs. In addition, nuclear power companies need to be encouraged to increase their investment in wind power and photovoltaics by giving them appropriate subsidies.

References

[1] Hong Yuanxiao. Research on the EU carbon trading mechanism [J]. Modern Commerce and Industry, 2018, 39(22):2.

[2] Song Deyong, Zhu Wenbo, Wang Banban. Carbon emission trading, quota allocation method and Green innovation of enterprises in China [J]. China's population, resources and environment, 2021, 31 (1): 37-47.

[3] JOYEUX R, MILUNOVICH G. Testing market efficiency in the EU carbon futures market [J]. Applied Financial Economics, 2010, 20(10): 803-809.

[4] Zhao Lixiang, Wang Lili. Research on the Effectiveness of China's Carbon Trading Secondary Market: A Case study of Carbon trading markets in Beijing, Shanghai, Guangdong and Hubei [J]. Scientific and technological progress and countermeasures, 2018, 35 (13): 34-40.

[5] The Central People's Government of the People's Republic of China wrote on December 31, 2020, and published the management method of carbon emission trading (trial) in 2021.http://www.gov.cn/zhengce/zhengceku/2021-01/06/content_5577360.htm

[6] ZhiHu. The Double Carbon Strategy study 2022, what is green electricity? What is green certificate? https://www.zhihu.com

[7] National Energy Administration.The National Energy Administration issued the Measures for the operation and management of CDM projects. http://www.nea.gov.cn

[8] ZhuHu. A user named China MRV answered on zhihu why nuclear power is not included in carbon trading 2022.https://www.zhihu.com.

[9] Polaris Carbon Stewardship Network, Polaris Carbon Tube network released the CCER system related -- CCER development and market, said the CCER system series of relevant knowledge 2022. https://news.bjx.com.cn

[10] China National Nuclear Power Corporation. China National Nuclear Power Corporation (CNNC) released the first installment of China's "carbon" secret nuclear power 2022. Carbon trading.https://www.cnnp.com.cn

[11] Yuncaijing. The yuncaijing website published CGN: It will actively promote nuclear power into carbon emission trading, and CGN has 0.35% of the stock 2021.https://www.yuncaijing.com

[12] Netscafe. A user named Netscarf posted about how the carbon cannon will impact nuclear power companies on xueqiu website 2021. https://xueqiu.com/

[13] Power.IN-EN.com. Power.IN-EN Grid released Decoding Hualong One: Inheriting the Aspirations of a powerful country! Adhere to self-reliance to build a national name card, the source is China National Nuclear Corporation Limited 2022. https://power.in-en.com

[14] GMW, GMW website published "Hualong One": China's nuclear power is like the name card of the world 2022.https://m.gmw.cn

[15] QQ.com, A user called Chenlongfangwu posted: Are Europe and the United States in a panic? The world's first thorium reactor is located in China, thus solving the problem of electricity shortage 2022. https://xw.qq.com

[16] Prachi Patel. Thorium Reactors in China [J]. Overview of Science and Technology, 2021(10):1.

[17] XianjiChina.com, A Xianji user named Lvshuiqingshan posted "Your circle is really messy"! Green electricity, green certificate is not clear, who can help enterprises reduce carbon? 2021. https://www.xianjichina.com

[18] Baidu. Jiemian News released the Fudan Carbon Price Index in July on Baidu: Affected by the supply shortage, it is expected that various CCER price indexes will rise 2022. https://baijiahao.baidu.com

[19] A brief discussion on the national carbon trading pilot from the market perspective [J]. Energy Conservation and Environmental Protection, 2018(5):58-61.

[20] Tan Ming. Discussion on development opportunities of electricity related industries under the policy of carbon peaking and carbon neutrality [J]. China Science and Technology Review, 2021(20):107-109,168.

[21] Coordinated dispatch and development of renewable energy generation and nuclear power generation [J]. China electric power, 2020, 53(2):105-111.

[22] Huang Wenjie, Yang Guang, Liu Da. Calculation method and role of nuclear power in carbon emission mitigation in China [J]. East China electric power, 2009, 37(4):529-532.

[23] A brief discussion on the national carbon trading pilot from the market perspective [J]. Energy Conservation and Environmental Protection, 2018(5):58-61.

[24] Coordinated dispatch and development of renewable energy generation and nuclear power generation [J]. China electric power, 2020, 53(2):105-111.