CCER Development Based on Scenery, Fire and Storage Integration Project

Ning Qiao*, Chao Zhang, Jisheng Zhang, Haidong Chen, Jing Zhang, Hongjie Tian

State Grid Ningxia Electric Power Company, Yinchuan, Ningxia, China

Abstract: Since 2012, China has established a national voluntary greenhouse gas emission reduction trading mechanism, which realizes the filing of voluntary emission reduction projects such as carbon sinks and the issuance of certified voluntary emission reduction (CCER). Due to the challenges in the development, operation, trading, and other stages of carbon sequestration projects, and the suspension of voluntary emission reduction-related applications by the competent authorities in 2017, the development of CCER carbon sequestration projects in China is relatively insufficient, and the number of registered projects accounts for only 2%. Therefore, this article, based on the CCER methodology development perspective of the Wind-Solar-Storage Integration Project, investigates and analyzes the structure of the project, the baseline methodology, and procedures for CCERs, economic evaluation, and additional challenges of the project, and verifies the feasibility of CCER development for the Wind-Solar-Storage Integration Project in the Ningxia region based on actual conditions. The article also proposes policy recommendations for the development of new energy carbon sequestration projects.

1 Introduction

According to the sixth assessment report (AR6) issued by IPCC [1], the global temperature rise reached 1.2℃ in 2020, and the climate change situation is becoming more and more severe. China has made a solemn commitment to peak carbon dioxide emissions and carbon neutrality to the international community, and carbon emission trading is an important means for China to realize this commitment. China's carbon emission trading market is mainly divided into two types: carbon quota trading based on total amount control and voluntary emission reduction trading based on projects. The former deals with carbon emission quotas allocated by the state to various emission control industries based on controlling the total amount of carbon emissions. The trading object of the latter is the national certified voluntary emission reduction (CCER) obtained by the industry through the implementation of voluntary carbon emission reduction projects and the quantitative verification of the emission reduction effect of the projects by relevant departments. CCER is a certified emission reduction with China characteristics based on the extension of the clean development mechanism (CDM) model, which can be used to offset carbon quotas. It is trading, and the offsetting mechanism is an important supplement to carbon quota trading.

At present, in the research related to emission reduction certification, from the perspective of the research object, due to the late start of CCER trading in China and poor data availability [2] (CCER trading was first realized in China in 2015, but the state suspended the filing and approval of CCER projects in 2017), most of the existing literature achievements take CDM as the research object [3-5], and the achievements taking CCER as the research object are limited [6-9]. From the perspective of research content, the discussion on the environmental benefits of CDM or CCER projects in the existing literature results is relatively concentrated [10-12]. Since renewable energy projects are an important source of certified emission reduction, whether CDM or CCER project development can promote the development of renewable energy is also a hot issue for scholars, and the research on these types of projects has affirmed their promotion to the development of renewable energy [13-14]. Therefore, this paper will start with the integration project of scenery, fire, and storage and analyze the feasibility and economy of CCER development with standardized CCER methodology.

2 Integrated wind-Photovoltaic-fire-storage project structure

The integration project of scenery, fire, and storage will give priority to the use of clean energy such as wind power and Photovoltaic, give play to the regulation function of coal and electricity, appropriately allocate energy storage facilities, and coordinate the development and scientific allocation of various resources, which is conducive to giving full play to the advantages of new energy-rich areas,

*2492618731@qq.com

realizing the large-scale consumption of clean electricity, and improving the flexibility and stability of regional power systems. As shown in Figure 1 below, the project's physical structure includes a Photovoltaic power station, a wind power station, a traditional thermal power station with flexibility transformation, a supporting energy storage power station, and all power plants connected to the power grid.

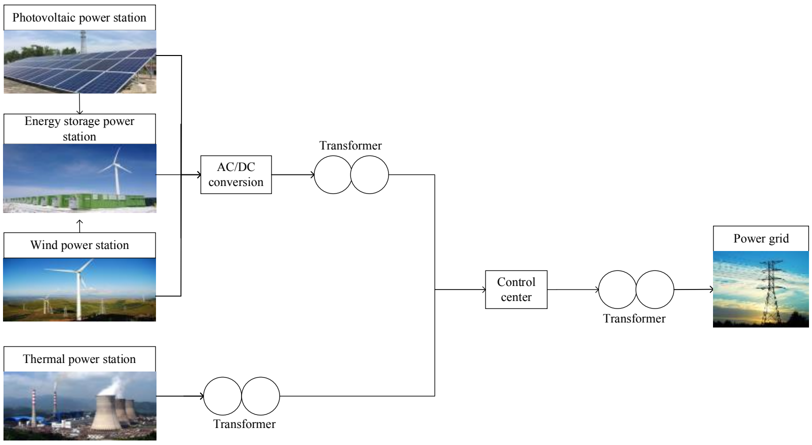


Figure 1. Integrated wind-Photovoltaic-fire-storage project structure

3 CCER baseline methodology program

3.1 Baseline identification and additionality demonstration

The baseline scenario is a scenario that produces the same result (e.g., the same amount of electricity generated) without building the existing project or continuing the historical situation.

It is important to implement integrated wind-fire-storage power generation projects, assess emission reductions, and carry out emissions reduction trading of carbon reduction products from integrated wind-fire-storage power generation projects. First, through the scenery fire storage integrated power generation project carbon reduction products emission reduction development and trading, it can help open voluntary carbon neutral, carbon offset and other related practices, and promote the implementation of national and provincial carbon peak carbon neutral major strategic decisions to further promote regional green low-carbon development. Secondly, the development of wind-fire-storage integrated power generation project carbon reduction product emissions trading can increase economic income and improve people's livelihood for project operators, developers, workers, and other project developers. It can alleviate the difficulties of insufficient subsidies and poor benefits of new energy projects. Thirdly, giving full play to the advantages of regional new energy and promoting the realization of ecological values are conducive to promoting the development of a new energy power generation industry.

3.2 Baseline scenario carbon emissions

Baseline emission (BE_y) includes the CO_2 emissions from the generation of electricity from fossil fuel-fired power plants in the grid by the integrated wind-fired storage project, and are the product of the base arene emission factor ($EF_{CO_2,\text{gridy}}$) and the effective power (EG_y) supply of the project, and its calculation is as follows:

$$BE_y = EG_y \times EF_{CO_2,\text{gridy}} \quad (1)$$

where BE_y represents the baseline emissions (tCO_2) in year y; EG_y represents the net feed-in tariff (MWh) in year y; $EF_{CO_2,\text{gridy}}$ represents the combined marginal CO_2 emission factor (tCO_2/MWh) of grid-connected power generation calculated by the Power System Emission Factor Calculation Tool in year y.

$$EF_{CO_2,\text{gridy}}=EF_{grid,OM,y} \times W_{OM} + EF_{grid,BM,y} \times W_{BM} \quad (2)$$

where $EF_{grid,OM,y}$ represents the marginal emission factor of electricity (tCO_2/MWh) in year y, using the latest marginal emission factor of electricity of the northwest power grid published by the Ministry of Ecology and Environment. $EF_{grid,BM,y}$ represents the capacity marginal emission factor (tCO_2/MWh) in year y, using the latest capacity marginal emission factor of the Northwest Power Grid published by the Ministry of Ecology and Environment. W_{OM} represents the weight of the electricity marginal emission factor, with W_{OM}=0.75 in the first and subsequent crediting periods. W_{BM} represents the weight of the capacity marginal emission factor, with w_OM=0.75 in the first and subsequent crediting periods. W_{OM}=0.25 is for the first and subsequent crediting periods.

3.3 Carbon emissions of the project

In the project scenario, thermal and energy storage can provide auxiliary services to wind power and PV units. Wind power and PV have great randomness, and with the fluctuation of scenery generation, thermal power units will climb up and down as a regulating class resource, and the coal consumption rate per unit of electricity will show a large increase compared to the baseline scenario.

The feed-in tariff of the integrated wind-Photovoltaic-fire-storage project is composed of the following four parts: (1) The electricity of PV units connected to the grid EG_{PV}; (2) The electricity of wind turbines connected to the grid EG_{WD}; (3) The energy storage units are connected to the grid EG_{SE}, which is composed of the electricity that the PV units fail to connect to the grid during the wind and Photovoltaic abandonment hours EG_{DPV} and the electricity that the wind units fail to connect to the grid EG_{DWD}; (4) The electricity that is connected to the grid when the thermal units provide auxiliary services during the peak load hours EG_{TP}. The order of consumption of the four types of power sources is PV, wind power, energy storage and thermal power.

$$EG_y = EG_{PV} + EG_{WD} + EG_{SE} + EG_{TP} \quad (3)$$

$$EG_{SE} = EG_{DPV} + EG_{DWD} \quad (4)$$

For most renewable energy power generation project activities, =0. However, some project activities may produce significant emissions, that is, project emissions, which are calculated by the following formula:

$$PE_y = PE_{PV,y} + PE_{WD,y} + PE_{SE,y} + PE_{TP,y} \quad (5)$$

where PE_y represents project emissions in year y (tCO_2); $PE_{PV,y}$ represents project emissions from PV units in year y (tCO_2); $PE_{WD,y}$ represents project emissions from wind turbines in year y (tCO_2); $PE_{SE,y}$ represents project emissions from energy storage units in year y (tCO_2); $PE_{TP,y}$ represents project emissions from thermal peaking units in year y (tCO_2).

The calculation process of project emissions from each emission source is as follows.

Emissions from Photovoltaic units ($PE_{PV,y}$): For Photovoltaic units, they will consume some electricity from fossil fuels during operation, but this self-consumption electricity can be neglected, then $PE_{PV,y}$ can be set to 0.

Wind turbine emission ($PE_{WD,y}$): For a wind turbine, it will consume some electricity from fossil fuel during operation, but this self-consumption electricity can be ignored, then $PE_{WD,y}$ can be set to 0.

Emissions from energy storage units ($PE_{SE,y}$): For energy storage units, the electricity stored in the operation process comes from the over-generated electricity of new energy units during the time of wind and Photovoltaic abandonment, which can be regarded as a clean power source, and its carbon emission can be ignored.

Thermal power unit emissions ($PE_{TP,y}$): For thermal power units that mainly undertake the task of peaking, they need to carry out flexibility transformation in the process of project operation. With the flexibility transformation of thermal power units, traditional coal power units have faster variable load rates, higher accuracy of load regulation and better primary frequency regulation performance. The emission $PE_{TP,y}$ of thermal power units is calculated as follows:

$$PE_{TP,y} = EG_{TP} \times EF_{CO_2,\mathrm{TP}} \quad (6)$$

where EG_{TP} represents the generation capacity of thermal power units, i.e., the net load curve minus the output curve of PV units, wind power units and energy storage units.

$EF_{CO_2,\mathrm{TP}}$ represents the kilowatt-hour carbon emission factor of thermal power units after flexibility retrofit. The carbon emission factor of thermal units with flexibility modification is calculated as follows:

$$EF_{CO_2,\mathrm{TP}} = COEF_{TP,\mathrm{y}} \times F_{TP,\mathrm{y}} / EG_{TP} \quad (7)$$

where $F_{TP,\mathrm{y}}$ represents the coal consumption of the thermal power unit after flexibility retrofit in year y(t); $COEF_{TP,\mathrm{y}}$ represents the CO_2 emission factor factor of coal consumed by the thermal power unit after flexibility retrofit (gCO_2/t).

4 Economic evaluation model

According to the "Guidelines for Engineering Economic Evaluation", the benchmark rate of return for power generation projects is 8%. When the financial internal rate of return of the proposed project is equal to or higher than the benchmark rate of return, the project is financially feasible.

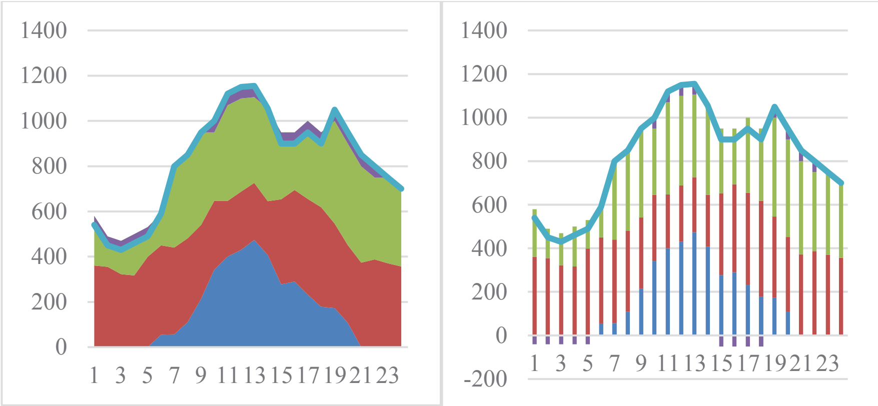
The life cycle cost of the integrated project consists of total investment cost, operation and maintenance cost and decommissioning disposal cost. The total investment cost, or one-time input cost, refers to the total cost of one-time input during the project construction period. Operation and maintenance cost refers to all the expenses required for the operation, maintenance and overhaul of power generation equipment after it is put into operation. Scrap cost refers to the total cost of cleaning or destroying the equipment after its service life reaches retirement age or its life cycle is interrupted for some reason.

$$\mathrm{LCC} = \mathrm{CI} + \sum_{t=1}^{N} \left(\frac{1}{1+r}\right)^t * COM_t + \left(\frac{1}{1+r}\right)^N * CD \quad (8)$$

where LCC denotes the whole life cycle cost of the water-landscape complementary power generation system. CI denotes the initial investment cost; COM_t denotes the first-year operation and maintenance cost; CD denotes the decommissioning disposal cost. r denotes the discount rate. N denotes the life year.

5 Basic data of an example

Taking Ningxia as an example, the project plans to develop wind, Photovoltaic, fire and storage to meet the local load needs, improve the reliability and flexibility of power system operation, and tap the consumption space of renewable energy. It is assumed that the configuration of each unit of the wind, Photovoltaic, fire and storage integration project is as follows: 500 kW Photovoltaic unit, 500 kW wind turbine unit and 500 kW thermal power unit (the maximum peak-shaving capacity of the thermal power unit is changed from 60% to 30% after flexible transformation), and the energy storage is configured according to 10% of the installed capacity of new energy. The output power curve and load curve of each unit in the wind, Photovoltaic, fire and storage integration project scenario and baseline scenario are shown in the figure 2.



(a) (b)

Figure 2. Output power curve of each unit in the project scenario

According to the regional grid baseline emission factors for emission reduction projects in 2019 released by the China Voluntary Emission Reduction Trading Information Platform, the power marginal emission factor $EF_{grid,OM,y}$ in Northwest China is 0.8922 tCO_2/MWh, and the capacity marginal emission factor $EF_{grid,BM,y}$ is 0.4407 tCO_2/MWh, so the combined marginal CO_2 emission factor of grid-connected power generation in Northwest China is 0.7793 tCO_2/MWh. The emission factor $EF_{CO_2,\mathrm{TP}}$ of the thermal peaking unit after flexibility modification is 0.9523 tCO_2/MWh. The unit feed-in tariff is set at RMB 0.35/kWh and the CCER carbon price is RMB 40/tCO_2. The relevant parameters for emission reduction and economic calculation are as shown in table 1 below:

Table 1. Parameter Table of Emission Reduction and Economic Calculation

Parameter	Numerical value	Unit	Parameter	Numerical value	Unit
The unit price of Photovoltaic constructionP_{sr}	3440	Yuan /kW	System residual rateQ_{cz}	Five	%
The unit price of wind power constructionP_{wd}	6708	Yuan /kW	Flexible thermal power carbon emission factor$EF_{CO_2,\mathrm{TP}}$	0.9523	t/MWhCO_2
The unit price of energy storage constructionP_{se}	3600	Yuan /kW	Capacity marginal emission factor$EF_{grid,BM,y}$	0.4407	t/MWhCO_2

6 Demonstration of project additionality

Based on the above parameters, the CCER economic calculation of the integrated wind, Photovoltaic, fire and storage project on the power supply side is carried out. The economic effect evaluation indexes of the project are shown in Table 2.

Table 2. Evaluation index of the economic effect of the CCER project

	Considering CCER	Regardless of CCER
Internal rate of return	8.93%	7.28%
Payback period of investment	9.16 years	10.23 years

The benchmark rate of return used in power generation projects is 8%, and the internal rate, without considering CCER, is less than the benchmark rate of return, which does not achieve an ideal economy. After considering the benefits of CCER, the internal rate of return of the integrated project is higher than the benchmark rate of return, and the project is additional.

7 Conclusion

This paper provides experience in the development of CCER methodology for new energy projects in the context of CCER development for integrated wind-fire-storage projects. The results demonstrate that the CCER methodology for integrated wind-fire-storage projects is feasible and brings considerable economic results.

The integrated wind-fire-storage project uses wind power and Photovoltaic power generation as the main power supply source, supplemented by modified thermal power and energy storage equipment to mitigate the instability of wind and Photovoltaic power generation on the one hand and to regulate the changes in customer demand on the other. The project improves the stability of the power supply in the region, promotes the consumption of new energy, and improves carbon emission reduction.

The basic research on monitoring and accounting data applicable to the integrated wind-fire-storage project, the establishment of the integrated wind-fire-storage carbon sink accounting method system, the formation of the integrated wind-fire-storage methodology, and the implementation of the application of the methodology to develop CCER projects, opens up a new channel for new energy development, helps to carry out international cooperation in the field of new energy and obtains economic income.

Acknowledgments

State Grid Science and Technology Project (Research on the mechanism and analysis model of carbon emission reduction market with the cooperation of source, network, load and storage under the bridging of electricity and carbon market, SGNX0000JYJS2200216).

References

1. IPCC. Climate change 2021: the physical science basis [R]. Geneva: IPCC, 2021
2. Li L, Ye F, Li Y, et al. How will the Chinese Certified Emission Reduction scheme save cost for the national carbon trading system? [J]. Journal of Environmental Management, 2019, 244: 99-109
3. Lim X L, Lam W H. Review on Clean Development Mechanism (CDM) implementation in Malaysia [J]. Renewable and Sustainable Energy Reviews, 2014, 29: 276-285
4. Ye F, Xiong X Y, Li L X, et al. Measuring the effectiveness of the Chinese Certified Emission Reduction scheme in mitigating CO_2 emissions: a system dynamics approach [J]. Journal of Cleaner Production, 2021, 294: 125355
5. Zhao Z Y, Li Z W, Xia B. The impact of the CDM (clean development mechanism on the cost price of wind power electricity: a China study [J]. Energy, 2014, 69: 179-185
6. Zhang Ning, Pang Jun. Study on the economic impact of introducing CCER trading and offsetting mechanism into the national carbon market [J]. Progress in climate change research, 2022, 18(05): 622-636.
7. Liu Haiyan, Zheng Shuang, Sun Yijia, etc. Problems and countermeasures of forestry carbon sink market development based on Saihanba CCER project [J/OL]. Progress in climate change research: 1-9[2023-04-10].
8. Guo Shengwei, Men Xiujie, Sun Haiping, etc. Comparative study on the status quo and trend of green electricity, green certificate and CCER policies in China [J]. China Energy, 2022, 44(03): 75-80.
9. Xie Qiang, Yang Wai, Zou Fangrui. The methodology of carbon trading based on CCER and its application at home and abroad [J]. Construction Science and Technology, 2022, No.447(Z1): 85-89.
10. Deng Qiang. Comparative analysis of emission reduction by anaerobic digestion and incineration of municipal solid waste based on CCER methodology [J]. Resource regeneration, 2022, No.235(02): 30-31.
11. He Ke, Li Fanlve, Chang Huayi. Building a low-carbon community: local consensus and participation of large-scale pig farmers in agricultural carbon trading-taking rural biogas CCER carbon trading project as an example [J]. china rural survey, 2021(05): 71-91.
12. Huan M ,Qinghan S ,Lei C , et al. Cogeneration transition for energy system decarbonization: From basic to flexible and complementary multi-energy sources[J]. Renewable and Sustainable Energy Reviews,2023,187.
13. Shuaishuai F ,Weida C ,Junfei D , et al. Is carbon asset pledge financing contributing to the operation of emission-dependent engineering machinery remanufacturing with emission abatement?[J]. International Journal of Production Economics,2023,266.
14. Meng Y ,Yisheng L . Research on multi-energy collaborative operation optimization of integrated energy system considering carbon trading and demand response[J]. Energy,2023,283.