Research on the Development and Management of CCER Methodology in Ningxia Power Grid Enterprises

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Abstract. The excessive use of fossil fuels has resulted in global warming, which has become a worldwide concern. To address this issue, China has made commitments to peak its carbon emissions by 2030 and achieve carbon neutrality by 2060. Power grid enterprises are expected to play a crucial role in helping China reach its commitments. This paper studies the development and management of CCER methodology for power grid enterprises. Through the use of the Ningxia into Hunan UHV project as a case study, it is demonstrated that grid companies can transform ecological benefits into economic benefits by developing ultra-high voltage transmission projects into CCER projects, boosting their low-carbon competitiveness and advancing green development. This article explores the methodology of CCER development, providing a reference for the development, management, and accounting of CCER for grid companies.

Keywords: Power grids · power markets · climate mitigation · air pollution control · environmental economics · carbon assets · carbon emissions · CCER

1 Introduction

The global land-surface temperature has risen by about 0.81 °C since 1905 due to the excessive use of fossil fuels [1]. Global warming has become a pressing issue around the world in recent years [2, 3], prompting China to take action by committing to reaching its carbon emission peak by 2030 [4] and achieving its carbon neutrality by 2060 [5]. To meet its commitments, China has implemented several measures including the launch of eight pilot carbon markets in three provinces and five cities [6], as well as the establishment of a national carbon trading market in recent years [7].

The production, verification, and trading of carbon assets are crucial in achieving China's goals of carbon reduction. To this end, the electric power industry has been included in the national carbon trading market, making it the first sector to be integrated into this system [8]. Power grid enterprises play a critical role in the carbon trading market as they serve as the link between the power supply and electricity consumption

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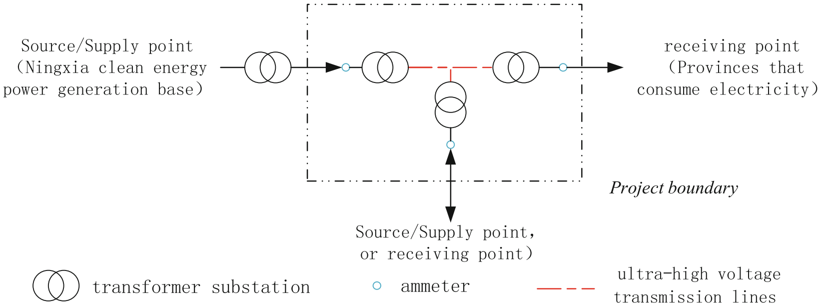

Fig. 1. Project boundary

sides. As a result, these enterprises carry significant responsibilities and obligations in achieving China's carbon reduction targets.

CCER (Chinese Certified Emission Reduction) allows Chinese companies to purchase CCER quotas from domestic emission reduction projects as a way to offset their own emissions and comply with national emission reduction regulations [9]. CCER is increasingly favored due to the lower cost of compliance [10], but there are few studies on the CCER methodology of power grid enterprises. This paper discusses the CCER methodology for the ultra-high voltage transmission project of the integrated wind, solar, and energy storage system in the Ningxia power grid.

2 CCER Methodology

2.1 Project Boundary

The project boundary's spatial extent covers the ultra-high voltage transmission lines that run from the source/supply point to the receiving point, along with the equipment, power plants, and lines directly connected to these transmission lines. A visual representation of this boundary is shown in Fig. 1.

Table 1 outlines the greenhouse gases and emission sources that fall within the project boundary, as well as those that are excluded from it. Among them, CO_2 is the most important emission to be closely monitored within the project boundary.

2.2 Baseline Identification and Additionality Demonstration

Baseline identification. The baseline scenario is the scenario that does not build a new project but produces the same result (such as the same amount of electric power provided by the receiving province itself). The emission decrease is calculated based on the baseline scenario.

Taking the "Ningxia Power into Hunan" ultra-high voltage (UHV) project as an example, the UHV transmission line passes through five provinces and one city, including Ningxia, Gansu, Shanxi, Chongqing, Hubei, and Hunan, with a total length of 1467 km. It is designed to transmit 40 to 44 billion kilowatt-hours of electricity per year. The source point relies on the Ningxia Yellow River Clean Energy Base. This project has

Table 1. Greenhouse gas emission table

Emission source		Gas	Fall within the boundary?	Justification/explanation
Baseline	CO_2 produced by fossil fuel power plants, which will be replaced by the project activity	CO_2	Yes	CO_2 is main emission source
		N_2O	No	To exclude for simplicity
		CH_4	No	To exclude for simplicity
Project activity	CO_2 produced by thermal power plants of the project activity	CO_2	Yes	Thermal power units with flexible adjustment capabilities consume some fossil fuels when undertaking ancillary services
		N_2O	No	To exclude for simplicity
		CH_4	No	To exclude for simplicity

driven new energy investment in Ningxia and promoted a win-win situation for Ningxia and Hunan. The baseline scenario for this project is that the on-grid electricity generated by the project activity is replaced by power generation sources from power plants located in the central China regional power grid and its newly added power generation sources.

Additionality demonstration. To prove the additionality of the project, several crucial methods could be taken, including investment analysis, obstacle analysis, and universality analysis. Among these methods, investment analysis holds particular significance as it helps determine whether the project activity is economically viable and whether it would not be financially feasible without the benefits of carbon emission decrease (the CCER benefits). For the ultra-high voltage transmission lines projects, the benchmark analysis method is generally used. The full investment after tax financial internal rate of return is 7%, which is stipulated in the “economic evaluation guidelines for transmission & substation projects (DLT5438-2009)”. It is essential to demonstrate that the financial IRR (Internal Rate of Return) is less than 7% before taking the emission decrease benefits into account. However, the financial IRR improves significantly after accounting for the benefits of carbon emission decrease.

2.3 Baseline Emissions

The baseline emissions refer to the CO_2 emissions produced by thermal power plants in the central China power grid that are substituted by the Ningxia Power into Hunan ultra-high voltage transmission line project, as well as losses in transmission lines (defined as line losses) and substations (defined as station losses) that occur within the power grid system.

$$\mathrm{TBE_y} = \mathrm{TBE_{y1}} + \mathrm{TBE_{y2}} \tag{1}$$

where:

TBE_y = Total baseline scenario CO_2 emissions in year y (t CO_2)
TBE_{y1} = Total CO_2 Emissions produced by thermal power plants that are replaced (t CO_2)
TBE_{y2} = Total CO_2 Emissions generated by line and station losses (t CO_2)

$$TBE_{y1} = EG_y \times EF_{CO_2,\,gridy} \tag{2}$$

where:

EG_y = Quantity of electricity that fed into the power grid (MWh).
$EF_{CO_2,gridy}$ = The combined margin CO_2 emission factor for power generation connected to the power grid in year y.

$$TBE_{y2} = \sum_H P_{L,BL,H,y} \times EF_{EL,y} \tag{3}$$

where:

$P_{L,BL,H,y}$ = Quantity of electricity that losses at the H hour of the y year (MWh).
$EF_{EL,y}$ = The CO_2 emission factor of the power transmitted by UHV transmission line in year y (t CO_2/MWh)

2.4 Project Emissions

The project emissions refer to the CO_2 emissions produced by the Ningxia Power into Hunan ultra-high voltage transmission line project.

For most renewable projects, emission is equal to zero. However, some projects may involve significant project emissions. Equation (4) will be used to account for these emissions as project emissions.

$$TPE_y = PE_{PV,y} + PE_{WD,y} + PE_{SE,y} + PE_{TP,y} \tag{4}$$

where:

PE_y = Total project CO_2 emissions in year y (t CO_2)
$PE_{PV,y}$ = The project CO_2 emissions from photovoltaic power generation (t CO_2)
$PE_{WD,y}$ = The project CO_2 emissions from wind power generation (t CO_2)
$PE_{SE,y}$ = The project CO_2 emissions from energy storage power generation (t CO_2)
$PE_{TP,y}$ = The project CO_2 emissions from thermal power units in year y (t CO_2)

For all renewable energy power generation project activities, the emissions ($PE_{PV,y}$, $PE_{WD,y}$ and $PE_{SE,y}$) associated with the use of fossil fuels can be considered negligible and therefore excluded from the project emissions calculation.

$PE_{TP,y}$ shall be calculated by using the Eq. (5).

$$PE_{TP,y} = EG_{TP} \times EF_{CO_2,TP} \tag{5}$$

where:

EG_{TP} = Quantity of electricity generated from thermal power units (MWh).
$EF_{CO_2,TP}$ = Carbon emission factor of thermal power unit after flexibility transformation(t CO_2/MWh).

The leakage emissions are not included in project activities.

2.5 Emission Decreases

The emission decreases are calculated by Eq. (6).

$$\mathrm{TER_y} = \mathrm{TBE_y} - \mathrm{TPE_y} - \mathrm{TL_y} \tag{6}$$

where:

$\mathrm{TER_y}$ = Total CO_2 emission decreases in year y(t CO_2)
$\mathrm{TBE_y}$ = Total baseline scenario CO_2 emissions in year y (t CO_2)
$\mathrm{TPE_y}$ = Total project CO_2 emissions in year y (t CO_2)
$\mathrm{TL_y}$ = Total leakage emissions in year y(t CO_2)

3 Economic Evaluation Model

The project's life cycle cost encompasses the costs associated with the project's entire life span, including investment, operation, maintenance, and decommissioning disposal cost. The total investment cost, also known as one-time input cost, refers to the total cost of one-time input during the construction of the project. The operation and maintenance cost refers to all the costs required for the operation, maintenance and repair of power grid equipment after it is put into operation. The decommissioning disposal cost refers to the total cost of cleaning or destroying the equipment when the service age reaches the retirement age or the life cycle is interrupted for some reason.

$$\mathrm{LCC} = \mathrm{CI} + \sum_{t=1}^{N} \left(\frac{1}{1+r}\right)^{t} * \mathrm{COM_t} + \left(\frac{1}{1+r}\right)^{N} * \mathrm{CD} \tag{7}$$

where:

LCC = The project's life cycle cost;
CI = The total investment cost;
$\mathrm{COM_t}$ = The operation and maintenance cost in year y;
CD = The decommissioning disposal cost
r = The discount rate;
N = Maximum service life

The total investment cost CI includes the construction investment, construction period interest and current capital of UHV transmission lines and associated equipment. For simplicity, the total investment cost can be calculated as follows.

$$\mathrm{CI} = \mathrm{P_{grid}} * L_{grid} + \mathrm{P_{station}} * N_{station} \tag{8}$$

where:

$\mathrm{P_{grid}}$ = The unit length cost of UHV transmission line
L_{grid} = The length of UHV transmission line
$\mathrm{P_{station}}$ = The unit price of transformer substation
$N_{station}$ = The number of transformer substation

To simplify the calculation process, the operation and maintenance cost is calculated by multiplying the total investment cost with the operation rate.

$$\mathrm{COM_t} = \mathrm{CI} * P_\mathrm{t} \tag{9}$$

where:

P_t = System annual operation and maintenance cost rate

The decommissioning disposal cost refers to the cost required to recover the residual value of each power equipment and clean up the power equipment of the project after the expiration of the service period of the power grid project.

$$\mathrm{CD} = CD_{ql} - CD_{cz} \tag{10}$$

where:

CD_{ql} = Clean up project costs
CD_{cz} = Residual value of power grid project

The annual income of the project consists of network fee income and CCER income.

$$\mathrm{R_{all}} = \mathrm{R_{eq}} + \mathrm{R_{ccer}} \tag{11}$$

where:

R_{all} = The annual income of the project
R_{eq} = network fee income
R_{ccer} = CCER income.

$$\mathrm{R_{eq}} = 360 * \left[\sum_{t=1}^{24} Q_1(t) + \sum_{t=1}^{24} Q_2(t) + \sum_{t=1}^{24} Q_3(t) + \sum_{t=1}^{24} Q_4(t)\right] * \mathrm{P} \tag{12}$$

where:

Q_1(t) = Quantity of electricity that generated from photovoltaic power generation in t hour
Q_2(t) = Quantity of electricity that generated from wind power generation in t hour
Q_3(t) = Quantity of electricity that generated from energy storage power generation in t hour
Q_4(t) = Quantity of electricity that generated from fossil fuel consumption in t hour in t hour
P = Wheeling rate

$$\mathrm{R_{ccer}} = \mathrm{TER_y} * \mathrm{P_{CO_2}} \tag{13}$$

where:

ER_y = Total CO_2 emission decreases in year y
P_{CO_2} = Carbon price

4 Case Study

Taking Ningxia into Hunan UHV project as an example, the relevant parameters of emission decrease and economic calculation are as shown in Table 2.

The total electricity transmitted by the project includes four parts: (1) the electricity generated by the photovoltaic units connected to the grid, (2) the electricity generated by the wind power units connected to the grid, (3) the electricity generated by the energy storage units connected to the grid, which is composed of the electricity that was not able to be connected to the grid by the photovoltaic and wind power units during periods of abandoned solar and wind power, and (4) the electricity generated by the thermal power units that provide auxiliary services during periods of peak load. The four types of power sources are consumed in the following order: photovoltaic, wind power, energy storage, and thermal power. The annual on-grid electricity generation of photovoltaic is 8 billion kWh, the energy storage system is 2 billion kWh, and wind power or thermal power has the highest annual on-grid electricity generation, reaching 150 billion kWh and 170 billion kWh, respectively. The annual on-grid electricity generation of each unit is shown in Fig. 2.

In evaluating the economic viability of the project, the internal rate of return (IRR) has been identified as the primary financial metric. IRR is the discount rate that results in the net present value (NPV) of the project's cash flows being equal to zero, and is thus

Table 2. Relevant parameters of emission decrease and economic calculation

Name	Quantity	Unit
The total investment cost	30	billion yuan
Annual power transmission	4.2	TWh
Flexible thermal power carbon emission factor	0.9523	t CO_2/MWh
Combined margin CO_2 emission factor	0.715375	t CO_2/MWh
System annual operation and maintenance rate	2	%
Annual growth rate of operation and maintenance costs	2	%
Maximum service life	30	year
Energy storage unit charge and discharge depth	90	%
carbon prices	40	yuan/t
wheeling rate	0.1	yuan/KWh
floating capital	500	millon yuan
The annual attenuation rate of energy storage	2	%
discount rate	8	%
clean-up cost	0	yuan
ratio of remaining value	5	%
tax rate	10	%
Line and station loss rate	3	%

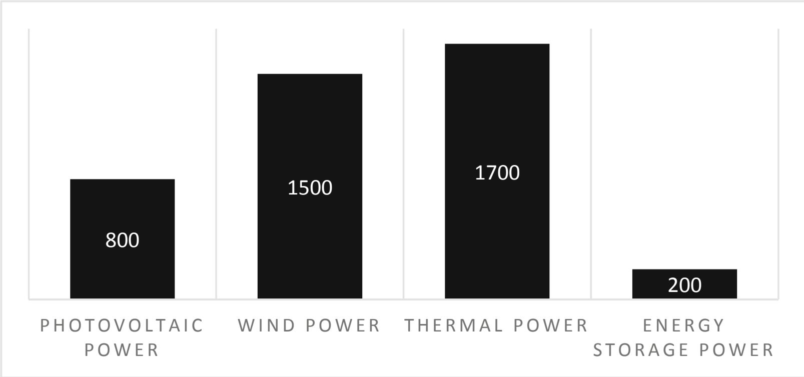

Fig. 2. Annual power transmission (GWh)

Table 3. Economic effect evaluation index

Evaluation index	Wihout considering CCER	Considering CCER
IRR	4%	7%

a crucial measure of the project's profitability. IRR is commonly employed in financial analysis to compare different investment opportunities and determine whether investing in a project is warranted.

The benchmark rate adopted by the project is 7%, and the IRR without considering CCER is less than the benchmark rate of return, which does not achieve the ideal economy. And as shown in Table 3, the IRR of the integrated project after considering the CCER income is not less than the benchmark rate of return, and the project has additionality.

5 Conclusion

This paper studies the development and management of CCER methodology for power grid enterprises and provides evidence for the effectiveness of CCER methodology in improving the IRR of ultra-high voltage transmission projects by incorporating them into CCER projects. CCER methodology not only converts ecological benefits into economic benefits but also enhances the low-carbon competitiveness of grid companies and promotes sustainable and green development. The study focuses on exploring the CCER development methodology for grid companies, providing practical guidance for the development, management, and accounting of CCER projects. By doing so, we hope to assist grid companies in making better-informed decisions, and further contribute to the mitigation of greenhouse gas emissions, and the protection of our environment.

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