Research on Certification Method of Greenhouse Gas Emission Reduction in Dry Bulk Cargo Terminal Horizontal Transportation Optimization Project

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Abstract: In the process of dry bulk cargo terminal horizontal transportation, a large amount of greenhouse gas and pollutant emissions will be produced if the equipment which can consume liquid fossil fuel is used. This paper quantifies the calculation method of greenhouse gas emission reduction in dry bulk cargo terminal horizontal transportation process optimization project by comparing the research before and after the dry bulk cargo terminal horizontal transportation process optimization project, and provides technical support for such port projects to participate in carbon emission trading.

1. Introduction
After many years of carbon emission trading pilot, China officially launched the national unified carbon emission trading market in 2017. Although the transportation industry has not been included in the trading scope, as a large greenhouse gas emission industry that has not yet reached the peak of greenhouse gas emission, it will be gradually included into the national carbon trading market. In accordance with the Interim Measures for the Administration of Certified Greenhouse Gas Emission Reduction Exchange the emission reductions involved in certified emission reduction should be certified for in accordance with the methodologies put on record by the competent authorities. Therefore the methodology is the core of carbon emission exchange. At present, the port field in the filed methodology is still blank. As the most critical node of integrated global transportation and our window open to world, port accounts for a certain proportion in the whole transportation industry in the aspects of energy consumption and carbon emission. Therefore, the research on the methodologies of greenhouse gas emission reduction in port can provide scientific standard and basis for the standard carbon emission trading, facilitating port enterprises to take the road of high-quality development of green and low carbon.

The dry bulk cargo terminal horizontal transportation optimization project, characterized by large quantity, remarkable energy saving and environmental protection effect, is suitable for certified emission reduction exchange as a typical project. On the one hand, China's general bulk cargo terminal accounts for a relatively high proportion. For example, in Jiangsu province where there are lots of ports, the designed carrying capacity in general bulk cargo terminals accounts for more than 50% of that in the dry bulk cargo terminals along the sea and rivers, even up to 80% in inland river. On the other hand, horizontal transportation accounts for the largest proportion of comprehensive energy consumption in port production. According to the Technical Regulations on Energy Efficiency Management of Port Terminals (JTS/T196-13-2017), the proportion of energy consumption in horizontal transportation of standard coal and ore dry bulk cargo terminals accounts for 64.76%.
Based on the analysis of China’s relevant requirements of greenhouse gas certified emission reduction and the methodologies that can be used for reference, this paper puts forward the applicable conditions, project boundary, baseline scenario, additionality demonstration, baseline emission (determination of baseline emission factors), project emission, leakage emission and monitoring methods of “Methodology of Greenhouse Gas Certified Emission Reduction in Dry Bulk Cargo Terminal Horizontal Transportation Process Optimization Project”[1-2]. Subsequently, some dry bulk cargo terminal horizontal transport process optimization project is selected for example calculation. The result shows that the methodology is suitable for the certification of greenhouse gas emission reduction in horizontal transportation projects, and it can effectively guide such projects to participate in certified greenhouse gas emission reduction exchange. Enterprises can be guided to carry out horizontal transportation process transformation through market mechanism, so as to reduce energy consumption, carbon emissions and pollutant emissions in the process of the dry bulk cargo horizontal transportation.

2. Methodology Research

2.1. Applicable conditions
This methodology is applicable to the project activities where the equipment of dry bulk cargo terminal horizontal transportation is changed from the consumption of liquid fossil fuel to that of electricity. The specific applicable conditions are as follows:

(1) Investment: This project requires the completion of direct investment in new infrastructure, including facilities or equipment for horizontal transportation (pipe belt conveyor, belt conveyor, dust removal system, etc.).

(2) Transportation mode for the project: Conversion from horizontal transportation mode driven by liquid fossil fuels to power-driven equipment.

(3) Activity routes: It must be within the port area, either from the front of the wharf to the rear yard (plant), from the yard (plant) to the front of the wharf, or from the yard A to yard B.

(4) Types of cargo: The types of cargo which may cover a variety of goods must be consistent under the baseline and project activities. The types of cargo shall be specified in the project design document for the validation phase and fixed throughout the inclusion period. The types of cargo must be dry bulk, including coal, ore, bulk cement, bulk grain and bulk fertilizer, etc.

(5) Fuel type: The baseline scenario must be liquid fossil fuels such as gasoline or diesel, and the project activity scenario must be electricity consumption.

2.2. Project boundary

(1) Space scope
The space scope includes wharf area or the scope from wharf to such fixed places as power plant, steel plant, grain reserve center.

(2) Equipment scope
Project discharge equipment scope only includes horizontal transportation equipment which refers to pipe belt conveyor, belt conveyor, single bucket loader or dump truck and other transport machinery.

(3) Greenhouse gas species
Table 1 illustrates the baseline established and the sources of emissions included into and excluded from the project's emission within the main boundary of the project. In the baseline scenario for this project, emissions of greenhouse gases other than carbon dioxide, while relatively weak, are taken into account. Conversion between different greenhouse gases is calculated using global warming potentials (GWP) [3].
2.3. Identification of baseline scenario

The baseline scenario for this project is horizontal transport equipment capable of providing the same port operation services with comparability.

(1) For ports that are mature and have well-established basic data, the baseline scenario is for transport equipment that continues to operate at present and maintains normal port operations.

(2) For ports with short operating time and incomplete basic data, the baseline scenario is a port comparable to its throughput, type of cargo, type of equipment, distance of transport, etc., and maintains normal port operations.

2.4. Additionality demonstration

This project can be demonstrated in the following ways: proving in advance that the share of bulk terminals that have completed horizontal transportation optimization in the project area prior to the project activities is less than or equal to 20% of the total number of terminals, and there are no relevant laws and regulations that force dry bulk cargo terminal to carry out horizontal transportation process optimization.

2.5. Baseline scenario emissions accounting

(1) Baseline emissions are calculated according to formula (1).

\[
BE_y = \sum_i EF_{BL,i} \times AD_{LY} \times N_{LY}
\]

Wherein:
- \(BE_y\): Baseline emissions for the \(y^{th}\) year (t-CO\(_2\)).
- \(EF_{BL,i}\): Emission factors of the type \(i\) horizontal transportation equipment in the baseline scenario (t-CO\(_2\)/10\(^4\), ton of CO\(_2\) out of 10,000 tons per operation).
- \(AD_{LY}\): The average annual volume of work of the type \(i\) horizontal transportation equipment for the \(y^{th}\) year under project activities (10\(^4\) t).
- \(N_{LY}\): The number of operations of type \(i\) horizontal transportation equipment for the \(y^{th}\) year under project activities.

(2) Emission factors of the type \(i\) horizontal transportation equipment \(EF_{BL,i}\) were calculated according to formula (2).

\[
EF_{BL,i} = SFC_{BL,i} \times NCV_{BL,i} \times (EF_{CO_2,i} \times GWP_{CO_2,i} + EF_{CH_4,i} \times GWP_{CH_4,i} + EF_{N_2O,i} \times GWP_{N_2O,i}) \times IR^i
\]

Wherein:
- \(EF_{BL,i}\): Emission factors of the type \(i\) horizontal transportation equipment in the baseline.

### Table 1. Sources included or not included in the project boundary.

| Source of emissions                                      | Gas    | Whether it is included or not | Proof/interpretation               |
|---------------------------------------------------------|--------|-------------------------------|-----------------------------------|
| **Baseline**                                            |        |                               |                                   |
| Consumption of fuel (diesel, gasoline) for horizontal transport equipment | CO\(_2\) | Yes                           | Major sources                     |
|                                                         | CH\(_4\) | Yes                           |                                   |
|                                                         | N\(_2\)O | Yes                           |                                   |
|                                                         | CO\(_2\) | Yes                           |                                   |
| **Project activities**                                  |        |                               |                                   |
| Electricity consumption for horizontal transport equipment | CH\(_4\) | No                            | A small share of CH\(_4\) in electricity emissions is negligible |
|                                                         | N\(_2\)O | No                            | A small share of N\(_2\)O in electricity emissions is negligible |
scenario (t-CO₂/10⁴ t, ton of CO₂ out of 10,000 tons per operation).

**SFC**<sub>BL,i</sub> Liquid fossil fuel consumption per unit of operation of the type i horizontal transportation equipment in the baseline scenario (t/10⁴ t, ton of fuel in every 10,000 ton per operation).

**NCV**<sub>BL,i</sub> Net thermal values of fossil fuels consumed of the type i horizontal transportation equipment in the baseline scenario (GJ/t).

**EF**<sub>CO₂,i</sub> CO₂ emission factors of the fossil fuels consumed by the type i horizontal transportation equipment in the baseline scenario (t-CO₂/GJ).

**GWP**<sub>CO₂,i</sub> Global warming potential of CO₂ in the baseline scenario (t-CO₂/t-CO₂).

**EF**<sub>CH₄,i</sub> CH₄ emission factor of fossil fuels consumed by the type i horizontal transportation equipment in the baseline scenario (t-CH₄/GJ).

**GWP**<sub>CH₄,i</sub> Global warming potential of CH₄ in the baseline scenario (t-CO₂/t-CH₄).

**EF**<sub>N₂O,i</sub> N₂O emission factors of fossil fuels consumed by the type i horizontal transportation equipment in the baseline scenario (t-N₂O/GJ).

**GWP**<sub>N₂O,i</sub> Global warming potential of N₂O in the baseline scenario (t-CO₂/t-N₂O).

**IR**<sub>t</sub> Technical improvement factor of horizontal transport equipment in the tth year in the baseline scenario. The technical improvement rate is applied to each calendar year and the technical improvement factor is 0.99 for all horizontal transport equipment types on the baseline.

(3) Determination of unit consumption of baseline can use sampling measurements.

the actual unit fuel consumption of representative samples for each type of equipment that can complete port horizontal transportation operations. For each type of equipment that can complete the port horizontal transportation operation, the fuel consumption per unit operation quality of the representative sample is measured. Based on the use of fuel types, horizontal transportation equipment models, rated power, and other relevant factors that can be used to distinguish fuel consumption per unit of operation. Equipment sampling should be randomly selected according to the latest version of the "small scale certified emission reduction project activity sampling and survey general regulations ", using 90% confidence interval and ±10% error to determine the sample size. Fuel consumption per unit of operation quality shall use a 95% confidence interval lower limit.

2.6. Project emission accounting methodology

(1) Emissions from project activities

Emissions from project activities are caused by the consumption of electricity, which are calculated according to formula 3.

\[
PE_y = \sum_i EC_{i,y} \times N_{EC_{i,y}} \times (1 + TDL_{i,y}) \times EF_{elec,y}
\]  

Wherein:

**PE**<sub>y</sub> CO₂ emissions from electricity consumption in the yth year under project activities (t-CO₂).

**EC**<sub>i,y</sub> Amount of electricity consumed by the type i horizontal transportation equipment for the yth year under project activities (10⁴ kWh).

**N**<sub>EC,i,y</sub> Number of the types i electrical horizontal transport equipment for the yth year under project activities.

**TDL**<sub>i,y</sub> Average loss percentage of power transmission and distribution in power supply to horizontal transportation equipment in the yth year under project activities (%).

**EF**<sub>elec,y</sub> CO₂ emission factors of electricity consumed by the type i horizontal transportation equipment in the yth year under project activities (kg-CO₂/kWh).

If the electricity consumed by the project activity comes from renewable energy, PE<sub>y</sub> = 0.

(2) Power grid baseline emission factors[4]
a. If a national authority or authority issues a weighted average emission factor for all generating units in the power grid of the project, preference is given.

b. If (a) is not available, the mixed marginal factor (CM) is calculated by operating marginal factor (OM) and the building marginal factor (BM) according to the procedure specified in the "Power System Emission Factor Calculation Tool", with weights of 50% each, see the latest published parameters and processes for calculating the baseline emission factors for each regional grid by the competent national authority;

c. In the case of self-provided equipment, the power emission factor shall be calculated in accordance with the latest edition of the Base Line, Project and/or Leak Emission Calculation Tool for Power Consumption.

(3) Average loss of power transmission and distribution
The average loss of power transmission and distribution is calculated on the basis of the "base line, project and/or leak emission calculation tool due to power consumption".

2.7. Leakage accounting method
The unit "emissions per operating ton" of the project emission is not affected by the project itself compared with the unit "emissions per operating ton" of the baseline emission, so the project will not cause leakage problem due to the change of load factor of the baseline traffic system, that is, this method does not require the calculation of leakage.

2.8. Calculation of emission reductions
The emission reductions are calculated on the basis of the difference between baseline emissions and project annual emissions and leakage, and calculated in accordance with formula 4.

\[
ER_y = BE_y - PE_y - LE_y
\]  

(4)

Wherein:
ER

\[ER_y\]  Emission reductions of the \(y^{th}\) year (t-CO₂).
BE

\[BE_y\]  Baseline emission of the \(y^{th}\) year (t-CO₂).
PE

\[PE_y\]  Project emissions of the \(y^{th}\) year (t-CO₂).
LE

\[LE_y\]  Leakage emissions of the \(y^{th}\) year (t-CO₂).

2.9. Monitoring methodology research
Monitoring methodology generally includes two parts. One part is the parameters determined in advance, while the other part is the parameters requiring post-event monitoring. In order to ensure the accuracy of emission reduction calculation, monitoring methodology generally agreed on the source of monitored parameters, monitoring procedures and quality assurance. The parameters to be monitored and monitoring methods for this project are shown in Table 2.

| Parameters | Description                                                                 | Monitoring method                                      |
|------------|-----------------------------------------------------------------------------|--------------------------------------------------------|
| \(AD_{i,y}\) | Average annual operational volume of the type \(i\) horizontal transportation equipment in the project in the \(y^{th}\) year | On-site recording, checking with company volume records or operating software |
| \(SFC_{BL,i}\) | Liquid fossil fuel consumption per unit of operation of the type \(i\) horizontal transportation equipment in the baseline scenario | On-site recording, checking with company refuel record or energy consumption statistics software |
| \(EC_{i,y}\) | Amount of electricity consumed by the type \(i\) horizontal transportation equipment in the \(y^{th}\) year under project activities | On-site recording, checking with company energy consumption statistics software |
| \(NCV_{BL,i}\) | Net heating value of fossil fuels consumed by the type \(i\) horizontal transportation equipment in the baseline scenario | IPCC default |

Table 2. Parameters to be monitored and methods.
### Parameters, Description, Monitoring method

| Parameters | Description | Monitoring method |
|------------|-------------|-------------------|
| EF\(_{co2,i}\) | CO₂ emission factors of fossil fuels consumed by the type I horizontal transportation equipment in the baseline scenario | IPCC default |
| GWP\(_{CO2,i}\) | Global warming potential of CO₂ in the baseline scenario | IPCC default |
| EF\(_{CH4,i}\) | CH₄ emission factors of fossil fuels consumed by the type I horizontal transportation equipment in the baseline scenario | IPCC default |
| GWP\(_{CH4,i}\) | Global warming potential of CH₄ in the baseline scenario | IPCC default |
| EF\(_{N2O,i}\) | N₂O emission factors of fossil fuels consumed by the type I horizontal transportation equipment in the baseline scenario | IPCC default |
| GWP\(_{N2O,i}\) | Global warming potential of N₂O in the baseline scenario | IPCC default |
| EF\(_{elect,y}\) | CO₂ emission factors of electricity consumed by the type I horizontal transportation equipment in the y\(^{th}\) year under project activities | Calculate according to 2.6 (2) |
| TDL\(_{i,y}\) | Average loss of electricity transmission and distribution in power supply to horizontal transportation equipment in the y\(^{th}\) year under project activities | Default based on "Power consumption-induced baseline, project and/or leakage calculation tool" |

### 3. Example Analysis

#### 3.1. Project Compliance

This paper takes the horizontal transportation optimization project of a port dry bulk cargo terminal as an example to calculate the greenhouse gas emission reduction. The project invested 360 million yuan to build a tubular belt conveyor system that consumes electricity for horizontal transportation, taking the place of diesel-consuming dump trucks. The project activity route is from the terminal to the steel plant in the back, and the cargo type is ore. Before the implementation of the project, all horizontal transportation from the site to the industrial area adjoining port shall be carried by dump trucks, in accordance with the requirements of "the share of the completed horizontal transportation optimization in the project area before the project activity is less than or equal to 20% of the total amount of the terminals" and "there are no relevant laws and regulations to enforce horizontal transport optimization". The project has additionality.

#### 3.2. Description of project activities

The baseline scenario of the project is the same as that before the start of the project activity, that is, diesel dump trucks are used for the transportation from the port to steel plant. Project activities are carried out using a tubular belt conveyor system. The data parameters to be monitored are shown in Table 3[5].

| Parameter | Unit | Value | Parameter | Unit | Value |
|-----------|------|-------|-----------|------|-------|
| AD\(_{1,y}\) | 10⁴t | 1920 | EF\(_{CH4,i}\) | t-CH₄/GJ | 1.6×10⁻⁶ |
| SFC\(_{BL,i}\) | t/10⁴t | 4.3 | GWP\(_{CH4,i}\) | t-CO₂/t-CH₄ | 21 |
| EC\(_{1,y}\) | Mwh | 2972.16 | EF\(_{N2O,i}\) | t-N₂O/GJ | 1.3×10⁻⁶ |
| NCV\(_{BL,i}\) | GJ/t | 43.33 | GWP\(_{N2O,i}\) | t-CO₂/t-N₂O | 310 |
| EF\(_{CO2,i}\) | t-CO₂/GJ | 0.0726 | EF\(_{elect,y}\) | t-CO₂/MWh | 0.70285 |
| GWP\(_{CO2,i}\) | t-CO₂/t-CO₂ | 1 | TDL\(_{i,y}\) | % | 3 |
3.3. Calculation of emission reductions

Annual emission reductions for this project is 4349.77 t-CO₂.

4. Relevant Suggestions

(1) In the horizontal transportation process of dry bulk cargo terminals, the use of automobile transportation will consume a large number of liquid fossil fuels and produce a large amount of greenhouse gas and pollutant emissions. Through the implementation of process optimization to achieve electricity replacing fuel, the greenhouse gas emissions of the port can be significantly reduced. In this paper, according to the characteristics of the port dry bulk cargo terminal horizontal transportation, the method of accounting for greenhouse gas emission reduction of the dry bulk cargo terminal horizontal transportation project is put forward, which provides the basis and technical reserve for such projects of the port to participate in the carbon emission trading.

(2) Through the example verification, it shows that this method has the pertinence and the maneuverability, and can guide such projects of the port to participate in the carbon emission trading, guiding the craft optimization of dry bulk cargo terminal. During the process of case analysis, the IPCC default value is mainly used in the selection of emission factors and other parameters, and the related parameter research needs to be further strengthened in the follow-up.

(3) In order to ensure the smooth integration of the waterway transportation industry into the national carbon trading market framework, the follow-up should also continue to study and declare new methodologies for greenhouse gas emission reduction, and build a complete system of accounting methods for greenhouse gas emission reduction in the waterway transportation industry[6].

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