CDM/JI Study in FY2007

"Low Temperature Waste Heat Recovery and Utilization for Power Generation Project at Cement Industry in Jiangsu Province, China" (Summary)

1. Project outline

The Project Activity is a low temperature waste heat recovery and utilization for power generation project located at Gaozi County of Zhenjiang in Jiangsu Province of the People's Republic of China. Project Owner which was the Zhenjiang Cement Factory in 1958, now has an asset of 6.8 hundreds million yuan and take an area of 400 units. Now they has the 1000 tons per day clinker production line commenced operation and a 1000 tons per day clinker production line commenced operation with a aggregate 2,650,000 tons high-quality cement production using the new dry process technique.

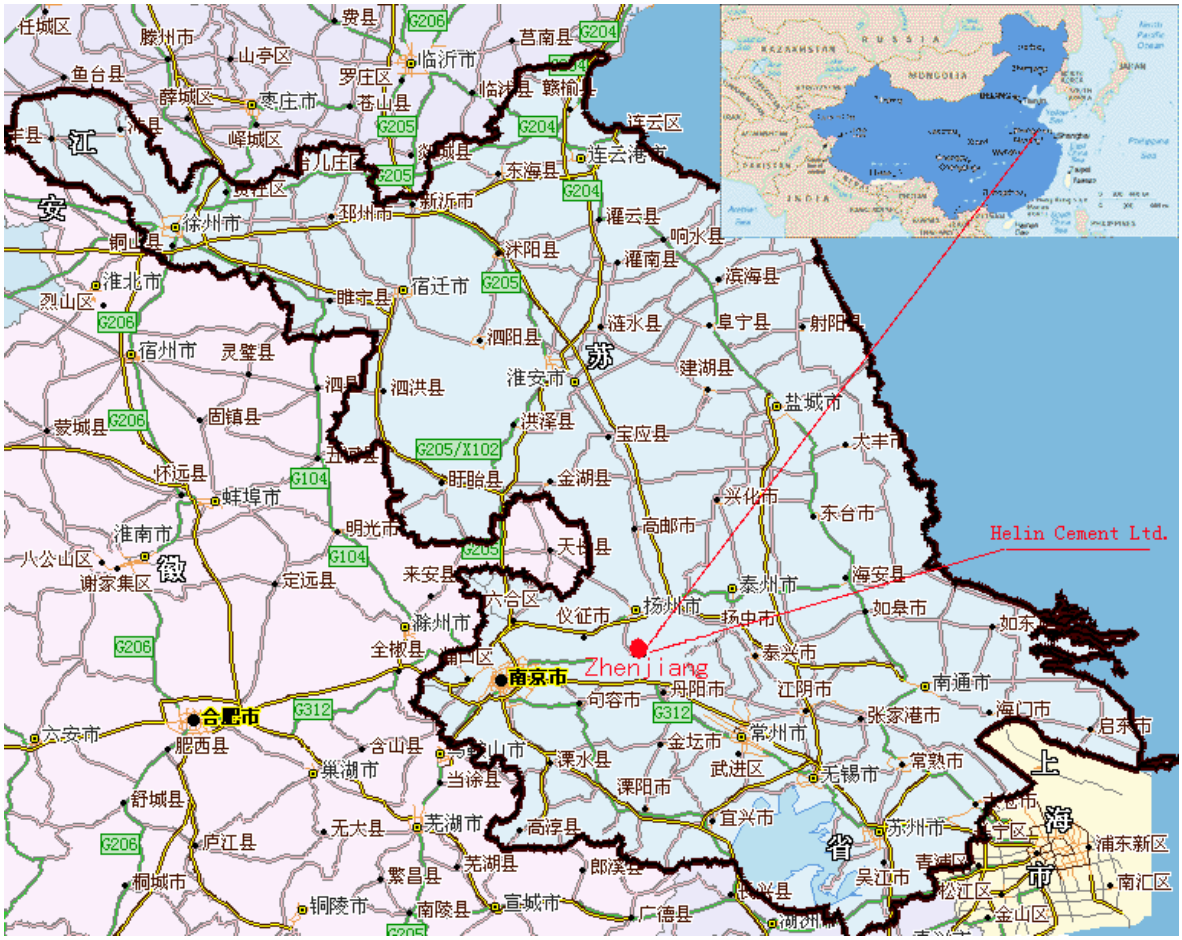

Figure 1: The detail location of the Project Activity

The main objectives of the Project Activity are to meet the increasing electrical supply needs of the Project Owner and to reduce greenhouse gas emissions through the recovery and use of low temperature waste heat from the kilns of the cement clinker production lines. The waste heat is currently vented to atmosphere but once captured can be used in a power generation plant. The system can reduce heat and powder pollution around the plant as well as bring great benefit to the enterprise. The Project Activity can help to recycle and reclaim waste heat strongly, improve efficiency and dedicate to "Green Consumption" of resources. The power generation plants will be respectively rated at 15MW, and will produce totally 98.14 million kWh of annual electricity generation with no significant associated emissions of CO2.

The production of cement relies on several processes:
Raw material preparation→grinding clinker→production→clinker storage→grinding cement silos and dispatch

A large portion of the energy consumption for the production of cement occurs in the calcination process in clinker production. This involves passing the ground raw materials through a pre-heater stack containing cyclone heaters to a shaft kiln to create clinker and then cooling this in the clinker cooler. Waste heat is typically vented to atmosphere and if captured and used for power generation, as proposed in this Project Activity, can lead to significant greenhouse gas emission reductions.

According the scheme, in order to reach the gaol of energy-saving and waste heat recovery, together with the cement production technics, thermodynamic system can be confirmed as follows:

The technology to be used in the system is a combination of 4 heat recovery boilers, one situated in the middle of the waste heat outlet of the condenser, which lies in the head of the rotating kilns of the cement production lines. In order to reduce the boiler abrasion, the power separator is set ahead of AQC. The AQC is divided into two parts. One is the steam part, and the other is hot water part. At the end of the kiln, SP is set at the outlet of waste heat pre-heater. The SP only has a steam part. The 15MW condensing steam turbine generator, located between the two cement production lines.

The 15MW steam turbine generator will be built as follows:

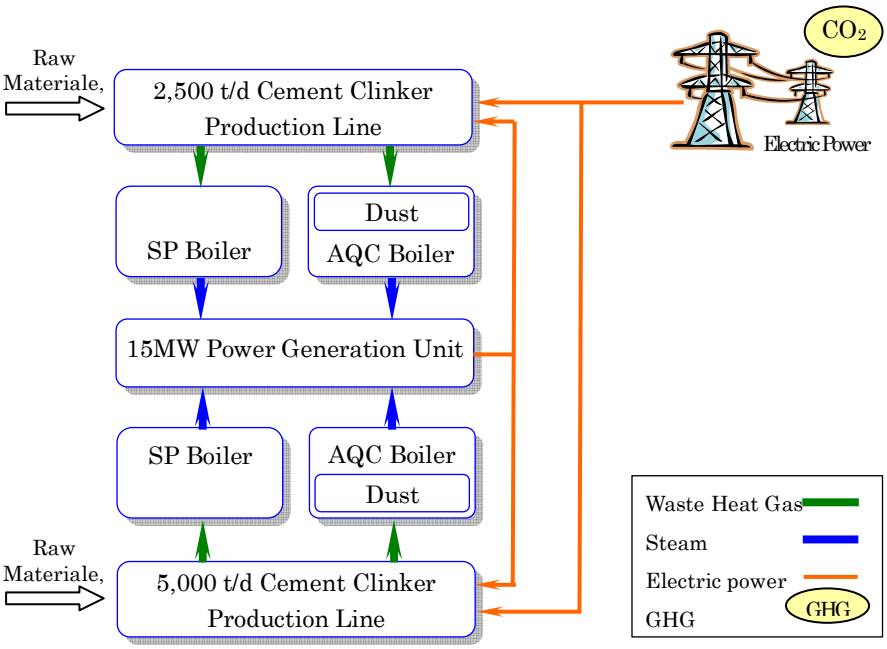

Figure 2: Partial Block Diagram of the Project activity

At the "hot" (SP) end of each kiln a high temperature waste heat recovery boiler will replace one of the cyclone heaters which are used to heat the raw clinker material. At the "cool" (ACQ) end of each kiln a lower temperature waste heat recovery boiler will replace the cooling tower which is used to cool the exhaust gases thus also saving precious local water resources.

The four waste heat recovery boilers mentioned before will produce super-heated steam which will be sent to the main steam pipe of the machine room. Without the consideration of the pressure and heat losses, the super-heated steam will do work in the steam turbine, then the waste steam will condense to water. Condensation will supply for the two waste heat boilers and this is consisted of the whole system.

2. Project Boundary, Baseline setting and Additionality

2.1. Project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Electricity generation, grid or captive source	CO_2	Included	Main emission source
		CH_4	Excluded	Excluded for simplification. This is conservative
		N_2O	Excluded	Excluded for simplification. This is conservative
	Captive electricity generation	CO_2	Included	Main emission source
		CH_4	Excluded	Excluded for simplification. This is conservative
		N_2O	Excluded	Excluded for simplification. This is conservative
Project Activity	Supplemental fossil fuel consumption at the project plant	CO_2	Included	Main emission source
		CH_4	Excluded	Excluded for simplification
		N_2O	Excluded	Excluded for simplification
	Supplemental electricity consumption	CO_2	Included	Main emission source
		CH_4	Excluded	Excluded for simplification
		N_2O	Excluded	Excluded for simplification
	Project emissions from cleaning of gas	CO_2	Included	Only in case waste gas cleaning is required and leads to emissions related to the energy requirement of the cleaning.
		CH_4	Excluded	Excluded for simplification
		N_2O	Excluded	Excluded for simplification

2.2. Baseline Settting

According to ACM0012, the baseline scenario alternatives should include all possible options that provide or produce electricity for in-house consumption and/or sale to grid and/or other consumers. The project participant shall provide evidence and supporting documents to exclude baseline options that:

- Do not comply with legal and regulatory requirements; or
- Depend on fuels (used for generation of heat and/or power), that are not available at the project
  site

The proposed project is going to use waste heat for electricity generation purpose only, according to ACM0012, the possible alternative scenarios in absence of the CDM project activity would be as follows:

1) The proposed project activity not undertaken as a CDM project activity; (P1)

2) Waste gas is released to the atmosphere after incineration or waste heat is released to the atmosphere (waste pressure energy is not utilized) (W2);

3) On-site or off-site existing/new fossil fuel based existing captive or identified plant (P4);

4) On-site or off-site existing/new renewable energy based existing captive or identified plant (P5);

5) Sourced Grid-connected power plants (P6); and continue the current situation to import electricity from East China power grid.

Alternative 1- The proposed project activity not undertaken as a CDM project activity(P1);

The project entity may adopt waste heat recovery utilization system for power generation to generate electricity. It is in compliance with all applicable legal and regulatory requirements. However, this alternative faces series of barriers(details in B.5.) making it predictably prohibitive. Hence this scenario should not be taken as a baseline scenario.

Alternative 2- Waste gas is released to the atmosphere after incineration or waste heat is released
to the atmosphere (waste pressure energy is not utilized) (W2);

The common situation for cement company to deal with waste heat is to release the waste heat to the atmosphere, however with technology advancement, it is possible to utilize these waste heat for generation of electricity and so could displace electricity

from the grid which comes from consumption of fossil fuel, and reduce Greenhouse Gas emission and cut the cost of the project owner. So, if waste heat is release to the atmosphere, the project owner will continue to import electricity needed from the grid, which is similar to Alternative 5).

Alternative 3-On-site or off-site existing/new fossil fuel based existing captive or identified plant
(P4);

According to the electric power rules in China, fossil fuel power plant with the capacity below 135MW is prohibited to be constructed if the district is covered by a large power grid, and thermal power units with the single-unit capacity below 100MW are strictly controlled to be constructed. Therefore, constructing a new fossil fuel (included coal, oil and gas) based captive power plant with equal capacity(15MW) will violate the requirements of national rules and laws. So it is not a feasible baseline scenario. So, Alternative 3) can not be taken as a baseline scenario for the proposed project.

Alternative 4- On-site or off-site existing/new renewable energy based existing captive or
identified plant (P5);

There is no accessible renewable resource like hydro, wind resource etc. in Zhenjiang district; so on-site or .off-site existing/new renewable energy based existing captive or identified plant can not be taken as a baseline scenario.

Alternative 5- Sourced Grid-connected power plants (P6); and continue the current situation to
import electricity from East China power grid;

The most usual way is to release the waste heat into the atmosphere. There are no other potential demands for heat or other industry utilization of the additional waste heat around the project site . So import electricity from sourced grid-connected power plants is the continuation of the current situation, which will need no excess investment and new technology, and the project owner will have no risk or barrier. So, Alternative 5) can be taken as a baseline scenario.

Among all the plausible baseline scenarios mentioned above, Alternative 5)- Sourced Grid-connected power plants (P6); and continue the current situation to import electricity from East China power grid can be taken as the proposed project's baseline

scenario.

2.3. Additionality

This step is based on UNFCCC documents: "Tool for the demonstration and assessment of additionality(version 04)" 30 November 2007. Information/data related to industry practice and other regulatory and project related documents were used to establish the additionality of the project activity.

2.3.1. Identification of alternatives to the project activity consistent with current laws and regulations.

The project proponent is required to define realistic and credible alternatives to the project activity(s) that can be (part of) the baseline scenario.

As mentioned above the baseline options 5 was identified to meet Project Owner's power requirement in absence of CDM project activity

Further there is no legal binding on Project Owner to implement the project activity. In China it is not mandatory for cement units to implement waste heat recovery based power generation plants from waste gases of the kilns. Neither are there any planned regulations for cement manufacturing industries that will enforce them to implement project activity in China. The pollution control board does require cement units to operate such that the dust levels of the waste gases to be emitted into the atmosphere should be within a certain limit. These pollution control board norms were being met even in absence of the project.

2.3.2. Investment Analysis

Tools for the demonstration and assessment of additionality suggests three analysis methods, i.e. simple cost analysis (option I), investment comparison analysis (option II) and benchmark analysis (option III).

Since the proposed project will obtain the revenues not only from CDM but also from decreasing electricity purchase, the simple cost analysis method (option I) is not appropriate. Investment comparison analysis method (option II) is applicable to projects whose alternatives are also investment projects. Only on such basis, comparison analysis can be conducted. The alternative baseline scenario of the project is the Ease China Power Grid rather than new investment projects. Therefore the option II is not an appropriate method for the decision-making context. The project will use benchmark

analysis method based on the consideration that benchmark IRR of the power sector is available.

With reference to Inform on Economic Assessment method and parameter of Construction Projects by SDPC and MOC, the financial benchmark rate of return (after tax) of Chinese building materials industries accounts for 12% of the total investment IRR. Presently, the financial benchmark rate of return is used in the analysis of the majority of cement projects in China. On the basis of above benchmark, calculation and comparison of financial indicators are carried out.

The income of power generation is calculated by the product of the quantity of power generation and the power price which Project Owner buys electric power from East China Grid. Considering the production line is operated 24 hours we use the average power price of Jiangsu province as the basis of income calculation. The price of power system of Jiangsu province is listed as following[5,6] . Considering the project activity belongs to the same group with Project Owner, there should be some discount. So the final price of electricity is decided to about 85% of that from East China Grid, namely 0.45 RMB/kWh and the price of steam is 35 RMB/ton.

Description	Time	Price(Tax including, RMB)
On-peak Power	8:00~12:00 and 17:00~21:00	0.845
Normal Power	12:00~17:00 and 21:00~24:00	0.507
Off-peak Power	0:00~8:00	0.229

The operation period is 7200 hour per year, load rate is around 96% and the power consumption inside the low temperature waste heat power plant is 6%[1] of the total power generation according to the operation experience and conservative rule. We don't consider the increasing cost of the investment of the baseline scenario.

Installed capacity: 15MW
Estimated annual net-electricity: 98.14GWh
Project lifetime: 20yrs
Total investment: RMB 89.51 million yuan
Prospective electricity price: RMB 0.45Yuan/kWh (excluding VAT)
Prospective heat price: RMB 35Yuan/ton steam (excluding VAT)

Tax: income tax rate is 33%; value added tax rate is 17%, city construction maintenance tax is 7% of VAT, education appended fee is 3% of VAT

Crediting period: 11yrs

The Project IRR is chosen as the appropriate comparison measure as both investments would be carried out with funds from the Group which would be reflected on their balance sheet. The following Table outlines the assumptions used in deriving the Project IRR of the cumulative cash flow of the Project Activity over a 20 year period(without CERs). The most sensitive factor is the price of electric power, So we conduct the sensitivity analysis by increasing the price of electric power by 10%(without CERs). The results are listed as following:

Description	Investment Return Period (year, aft. tax)	Project IRR
Project Activity	9.2	9.7%
Project Activity (+10% electricity power price)	7.8	12.9%
Project Activity (-10% electricity power price)	11.54	5.9%

When pool (electricity) purchase price has risen 10%, the IRR of the project will exceed 12%. According to the supply-need status of power in China, pool purchase price will be stable in the future and will not rise greatly. So scenario of pool purchase price rising 10% is supposed not to appear. We can see from the above data, If the fluctuation of power price is within a realistic range, that the conclusion that the project activity is unlikely to be attractive compared with the benchmark is correct.

2.3.3. Barrier analysis

The project activity had its associated barriers to successful implementation. The barriers are outlined in the following Table.

Barriers	Applicable	Detailed Description
Technological Barriers	Yes	This Project is an early example of the internationally well known concept of heat recovery boilers and turbines fitted to a large cement works that has been developed by a domestic design institute using domestically manufactured and installed equipment. The barriers fall into two main categories – design risks inherent in designing the special heat recovery boilers and the steam turbine (which is also special in that it has a second inlet to accept the output of the flash steam generator) and risks associated with the manufacture and installation of such new equipment. The Project Owners are taking a not insignificant risk in proceeding with the Project Activity, which CDM can help to offset via increasing the returns of the Project Activity.
Investment Barriers	Yes	The capital cost of the equipment for the Project Activity is much higher than the baseline. With the CDM revenue of the effective revenue of the Project, the CDM can help the Group overcome this barrier by increasing the returns of the Project Activity.
Other barrier	Yes	Project Owner personnel lacked the necessary technical background to develop and implement a waste heat recovery based power plant with technological innovation. They had to strengthen their internal capacity by inviting external expertise to implement the project activity. Project Owner personnel at various levels lacked relevant managerial background for project activity implementation, operation and maintenance. They were provided with training to ensure smooth operation. They had no background strength in the power sector economics and power generation sector.

3. GHG emission reductions

3.1. Project Emissions

Because the project employs the waste heat of kiln to produce steam to generate electricity by steam turbine and there is no fossil fuel added, the new emissions do not exist.

3.2. Baseline emissions

Baseline emissions are given as:

$$BE_{electricity,y} = EG_y \cdot EF_{electricity,y}$$

Where, *EGy*—— Net quantity of electricity supplied to the manufacturing facility by the project during the
year y in MWh

EFy——CO2 baseline emission factor for the electricity displaced due to the project activity during the year *y* (tCO2/MWh)

According to the operational experience of Project Owner and considering conservative rules, the power plant operates 300 days every year. The power generation capacity of the project is 15MW, the average value is 14.5MW and so the total power generation per year is 104.40×10^6kW·h[1]

After subtracting 6%[2] for the quantity of electricity required for the operation of the power plant, the net total power generation supplying to the manufacturing facility by the project is 98.14GW·h per year.

So, we can get:

$$EGy = 98.14\text{GW}\cdot\text{h}$$

According to ACM0012, If the baseline scenario is determined to be grid power supply, the Emissions Factor for displaced electricity is calculated as in Annex 12 Methodological tool **"Tool to calculate the emission factor for an electricity system" (Version 01,** EB 35, Annex 12 19 October 2007**)**:

$$EF_y = w_{OM} \cdot EF_{OM,y} + w_{BM} \cdot EF_{BM,y}$$

By the newest data of DNA of China[8]:

$$EF_{OM,y} = 0.9421$$

$$EF_{BM,y} = 0.8672$$

And because of the nature of off-peak output and relatively intermittence, so:

$$w_{OM} = 0.5$$
$$w_{BM} = 0.5$$

Therefore, we can get:

$$EF_y = 0.9047$$

$$BE_{electricity,y} = 88{,}782$$

3.3. Leakage

Since no other source of leakage can be identified in this project, leakage is therefore not taken into account.

3.4. Emission reductions

The table below shows the emission reductions achieved by the Project Activity. In 2009, the project is supposed to be worked at 90% of operation capacity.

Year	Estimation of overall emission reductions (tCO2e)
2009	79,904
2010	88,782
2011	88,782
2012	88,782
Total (tCO2e)	346,255

4. Monitoring

Following figure shows the monitoring points:

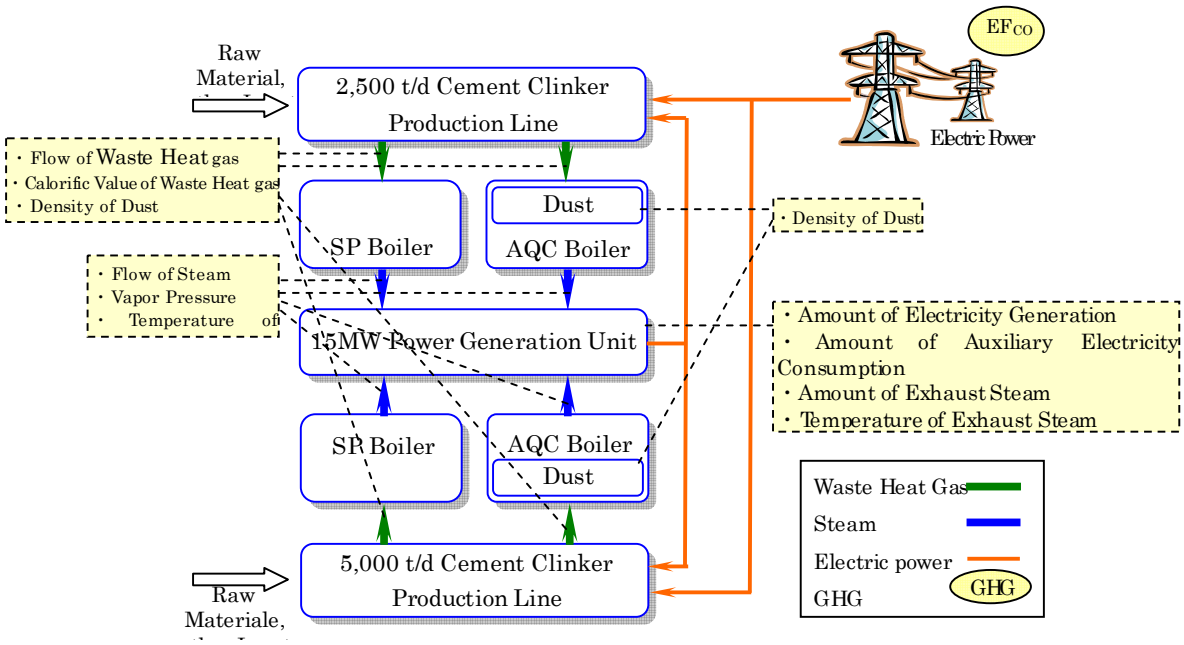

Figure 3: Data Collected for 15MW Power Generation Unit

5. Environmental impacts

The two cement production lines have undergone and passed full Environmental Impact Assessments (EIA) in line with the requirements of the Chinese Government, which are available for the Validator to review. The Project Activity is an internal project to the company and is undergoing a separate EIA, which will be detailed in the final version of this PDD. However, in the interim, the Project Owners have established the assessment of the key environmental impacts for the Project Activity and these are supported by the Feasibility Study and other documents.

In summary the project is expected to have a net environmental benefit in addition to the greenhouse gas emissions reductions.

6. Issues for operation

The gross investment of this project construction is US$12 million, and the company itself supplies it by investment and loan.

Project Owner management discussed various aspects of project activity

implementation in the Board of Director's Meeting. Project Owner's management took the decision of taking the investment risks and secure financing partially from bank funding and partially through internal accruals so as to invest in the CDM project activity after computing the proposed carbon financing. The foreign currency exchange rate is 7.3 and the results of the financial analysis is listed under 9, 10, 11 U.S. dollar per ton CO2 emission reduction as following:

	No Income of CO2 Emission Reduction	9$ per CO2 Emission Reduction	10$ per CO2 Emission Reduction	11$ per CO2 Emission Reduction
Investment Return Period](year, aft. tax)	9.2	7.4	7.2	7.0
Project IRR	9.7%	14.1%	14.6%	15%

So we conclude that the financial result of Project Activity can be improved obviously by CERs and It is ascertained that the project activity would not have occurred in the absence of the CDM simply because no sufficient financial, policy, or other incentives exist locally to foster its development in China and without the proposed carbon financing for the project Project Owner would not have taken the investment risks in order to implement the project activity. Further CDM fund will provide additional coverage to the risk due to failure of project activity and loss of production. Since the plant has no grid connectivity project failure would affect all plant operations.