MOEJ/GEC JCM Project Planning Study (PS) 2013
Final Report

「Power generation by waste heat recovery in cement industry」

（implemented by JFE Engineering Corporation）

Study partners		PT Semen Indonesia (Persero) Tbk.
Project site		Tuban, Republic of Indonesia
Category of project		Energy Efficiency
Description of project		The proposed project is planned to introduce a waste heat recovery (WHR) boiler steam turbine generator system at an existing cement production plant (PT Semen Indonesia, Tuban Plant) located in Tuban, East Java, Indonesia. The WHR system will utilize waste heat currently emitted from the cement factory without utilization. WHR boilers will generate steam using the waste heat exhausted from the cement plant, and the steam will be fed to the steam turbine generator to generate electricity. It can reduce power import of approximately 165,000MWh/year from the grid which will lead to the reduction of fossil fuel combustion at grid-connected power plants.
JCM methodology	**Eligibility criteria**	1. The project utilizes waste heat from a cement production facility by waste heat recovery (WHR) system to generate electricity 2. WHR system consists of a Suspension Preheater boiler (SP boiler) and/or Air Quenching Cooler boiler (AQC boiler), turbine generator and cooling tower 3. WHR system utilizes only waste heat and does not utilize fossil fuels as a heat source to generate steam for power generation 4. WHR system has not been introduced to a corresponding cement kiln of the project prior to its implementation 5. Cement factory where the project is implemented is connected to a grid system and the theoretical maximum electricity output of the WHR system, which is calculated by multiplying maximum electricity output of the WHR system by the maximum hours per year (24 * 365 = 8,760 hours), is not greater than the annual amount of the electricity imported to the cement factory from the grid system: - During the previous year before the validation, if the validation of the project is conducted before the operation of the project, or - During the previous year before the operation of the project, if the validation of the project is conducted after the operation of the project
	Default values	・The quantity of electricity consumption by the WHR system →Calculated by multiplying the total maximum rated capacity of equipments of the WHR system which consumes electricity by maximum operational hours (8760 hours) ・CO_2 emission factor for an Indonesian regional grid system
	Calculation of reference emissions	Reference emissions are calculated from net electricity generation by the project which replaces grid electricity import during a given time period. Quantity of electricity consumption by the WHR system is subtracted from gross electricity generation by the WHR system to calculate net electricity generation.

<table>
<tr><td></td><td></td><td>In order to ensure conservativeness, quantity of electricity consumption by the WHR system is calculated by using the theoretically maximum load for the capacity of equipments in the WHR system.</td></tr>
<tr><td></td><td>Monitoring method</td><td>Electricity generation by the WHR system is monitored.</td></tr>
<tr><td colspan="2">GHG emission reductions</td><td>◆The quantity of net electricity generation by the WHR system which replaced grid electricity import
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E(A*B*C*D)</th></tr>
<tr><td colspan="2">Quantity of electricity generation</td><td>Generation capacity (MW)</td><td>Operating day/year (day/yr)</td><td>Time (hrs/day)</td><td>Operating Rate</td><td>Electricity (MWh)</td></tr>
<tr><td rowspan="2"></td><td>Dry season</td><td>28</td><td>182.5</td><td>24</td><td>0.85</td><td>104,244</td></tr>
<tr><td>Rainy season</td><td>22</td><td>182.5</td><td>24</td><td>0.85</td><td>81,906</td></tr>
<tr><td colspan="2">Electricity consumption by WHR system</td><td>2.4</td><td>365</td><td>24</td><td>1</td><td>21,024</td></tr>
<tr><td colspan="6">Quantity of net electricity replaced grid electricity import</td><td>165,126</td></tr>
</table>
◆Reference emissions（RE_y） ＝ EG_y * EF_{grid}
＝165,126 MWh/y * 0.741 tCO_2e/MWh
＝122,358 tCO_2e/y
◆Project emissions（PE_y） ＝ 0
◆Emission reductions (ER_y） ＝ RE_y - PE_y
＝ 122,358 – 0
＝ 122,358 tCO_2e/y</td></tr>
<tr><td colspan="2">Environmental impacts</td><td>There is no requirement for the project to conduct an EIA as stipulated in ministerial decree No. 11, 2006 which defines that power generation facility of its capacity smaller than 100MW does not need to undergo the EIA process.</td></tr>
<tr><td colspan="2">Project and its financial plan</td><td>◆Project Plan
The specification of major equipment and auxiliaries is almost confirmed. PT Semen Indonesia and JFE Engineering almost reach an agreement on the layout of major equipment and will proceed to a detail design and procurement as a next step.
◆Financial Plan
The initial investment for the project will be all covered by PT Semen Indonesia with a condition of JCM subsidy.</td></tr>
<tr><td colspan="2">Promotion of Japanese technologies</td><td>Although initial investment for WHR system with Japanese technology is higher than the one with similar technologies by India or China, WHR system with Japanese technology can be stably operated much longer therefore it can be considered as economical in a long-term view and CO_2 emission reduction in a life cycle will be greater. If higher initial investment can be overcome, Japanese technology can hedge a risk of rising industrial electricity cost and contribute to the reduction of production cost in a long-term view.</td></tr>
<tr><td colspan="2">Sustainable development in host country</td><td>The project can reduce the cement production cost as well as CO_2 emission. In Indonesia where a cement market is strong, investment in cement production facility has higher priority than the one in WHR system. However WHR system has benefit of deducting unit cost for cement production, which results in tolerance for fluctuation such as slowdown in economic growth in the future. By showing successful completion of the project and proving return on initial investment, WHR system is expected to spread out in Indonesian cement industry and it will contribute sustainable development not only in environmental aspect but also economical aspect.</td></tr>
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JCM Project Planning Study (PS) 2013
"Power generation by waste heat recovery in cement industry"
(Host country: Indonesia)

Study Entity: JFE Engineering Corporation

1. Study Implementation Scheme

（Indonesia） PT. Semen Indonesia（PTSI）

→ The owner of the cement plant who cooperates for project plan, financial plan, MRV structure etc as a project implementation body.

2. Overview of Proposed JCM Project

(1) Description of Project Contents:

The proposed project is planned to introduce a waste heat recovery (WHR) boiler steam turbine generator system at an existing cement production plant (PT Semen Indonesia, Tuban Plant) located in Tuban, East Java, Indonesia. The WHR system will utilize waste heat currently emitted from the factory without utilization. WHR boilers will generate steam using the waste heat exhausted from the cement plant, and the steam will be fed to the steam turbine generator to generate electricity at output rate of 28MW. Out of the 28MW, the operation of the WHR system itself consumes power at rated capacity of 2.4MW, and the rest will be used in the operation of the cement plant.

(2) Situations of Host Country:

The cement industry in Indonesia is expected to grow for the next few years continuously supported by the robust domestic cement consumption. Although the cement industry in Indonesia already adopts energy-efficient technologies, additional technologies or improvement measures will be needed since the increase of CO_2 emissions and energy consumption cannot be avoided if the industry grows as it is. Waste heat recovery system does not need any additional fuel and can reduce electricity import from the grid. This will result in the reduction of fossil fuel combustion at grid-connected power plants.

3. Study Contents

(1) JCM methodology development

a. Eligibility criteria

This methodology sets the eligibility criteria as shown in the table below.

	Content	Rationale
Criterion 1	The project utilizes waste heat from a cement production facility by waste heat recovery (WHR) system to generate electricity	This criterion was set since GHG emission reductions can be achieved through the use of

		unutilized waste heat by a project. At the same time, the methodology provides only method for a case where waste energy is converted and utilized as electrical energy.
Criterion 2	WHR system consists of a Suspension Preheater boiler (SP boiler) and/or Air Quenching Cooler boiler (AQC boiler), turbine generator and cooling tower	Waste heat recovery requires a package of system which encompasses a SP boiler, and/or AQC boiler, turbine generator and cooling tower.
Criterion 3	WHR system utilizes only waste heat and does not utilize fossil fuels as a heat source to generate steam for power generation	The methodology does not assume projects that result in emissions, therefore, it needs to exclude the use of fossil fuel which leads to project emissions.
Criterion 4	WHR system has not been introduced to a corresponding cement kiln of the project prior to its implementation	This criterion was set to confirm that the waste heat that will be used in the project has not been utilized before the project implementation.
Criterion 5	Cement factory where the project is implemented is connected to a grid system and the theoretical maximum electricity output of the WHR system, which is calculated by multiplying maximum electricity output of the WHR system by the maximum hours per year (24 * 365 = 8,760 hours), is not greater than the annual amount of the electricity imported to the cement factory from the grid system: ➢ During the previous year before the validation, if the validation of the project is conducted before the operation of the project, or ➢ During the previous year before the operation of the project, if the validation of the project is	The methodology is applicable to projects that replace grid electricity, therefore, the projects or factory where the projects are located need to be connected to the electric grid. Further assuring the replacement of the grid electricity, either the existence of captive power generators or power balance of the factory electricity demand and power generation by the waste heat recovery system will be checked.

	conducted after the operation of the project	

b. Data and parameters fixed *ex ante*

The following parameters will be fixed ex ante.

Parameter	Description of data	Source
EF_{grid}	CO_2 emission factor for an Indonesian regional grid system, displaced due to the project during a given time period	National Committee on Clean Development Mechanism Indonesian DNA for CDM, Updates on Emission Factors of Electricity Interconnection Systems (2011) http://pasarkarbon.dnpi.go.id/web/index.php/dnacdm/read/23/updates-on-emission-factors-of-electricity-interconnection-systems-2011.html
grid	The power grid to which the project is connected.	Confirmed upon validation with an electricity bill of the power company.
EG_{CAP}	The total maximum rated capacity of equipments of the WHR system which consumes electricity	Rated capacity of all installed equipments of the WHR system which consumes electricity

c. Calculation of GHG emissions (including reference and project emissions)

1) Reference emissions

Reference emissions are calculated on the basis of net project electricity generation that replaces the import of grid electricity to the cement factory where the project is implemented.

$$RE_y = EG_y * EF_{grid}$$

Where,

RE_y	Reference emissions in a given time period	(tCO_2e/y)
EG_y	The quantity of net electricity generation by the WHR system which replaced grid electricity import during a given time period	(MWh/y)
EF_{grid}	CO_2 emission factor for an Indonesian regional grid system, displaced due to the project during a given time period	(CO_2e/MWh)

Determination of EG_y

$EG_y = EG_{GEN,y} - EG_{AUX,y}$

$EG_{GEN,y}$	The quantity of gross electricity generation by the WHR system in a given time period	(MWh/y)
$EG_{AUX,y}$	The quantity of electricity consumption by the WHR system in a given time period	(MWh/y)

EG_y is calculated conservatively through the use of the parameter $EG_{AUX,y}$ as it uses the maximum capacity of power consuming equipments multiplied by maximum hours per a given period of time as expressed below.

Determination of $EG_{AUX,y}$

$EG_{AUX,y} = EG_{CAP} * 24(hours/day) * D_y$

EG_{CAP}	The total maximum rated capacity of equipments of the WHR system which consumes electricity	(MW)
D_y	The number of days in a given time period	(day/y)

In the study, reference emissions are calculated as follows:

$RE_y = EG_y * EF_{grid}$
$= 165{,}126$ MWh/y * 0.741 tCO_2e/MWh
$= 122{,}358$ tCO_2e/y

2) Project emissions

Project emissions are not assumed in the methodology as the WHR system utilizes only waste heat and does not utilize fossil fuels as heat source to generate steam for power generation, which is prescribed in the eligibility criteria 3.

Therefore, the following formula is used to express the project emissions.

$PE_y = 0$

3) Emission reductions

Emission reductions are calculated as the difference between the reference emissions and project emissions, as follows.

$ER_y = RE_y - PE_y$

In this study, Emission reductions are calculated as the difference between the reference and project emissions.

$ER_y = RE_y - PE_y$
$= 122{,}358 – 0$
$= 122{,}358$ tCO_2e/y

(2) Development of JCM Project Design Document (PDD)

In this project planning study, JFE Engineering Corporation of Japan and PT Semen Indonesia (Persero) Tbk of the Republic of Indonesia (hereinafter referred to as the project participants) conducted research to gather data necessary for the development of the PDD.

The study mainly focused on the following areas:
a. Environmental Impact Assessment
b. Stakeholders Consultation
c. Monitoring plan
d. Calibration of metering equipments

a. Environmental Impact Assessment

There is no requirement for the project to conduct an EIA as stipulated in ministerial decree No. 11, 2006[1] which defines that power generation facility of its capacity smaller than 100MW does not need to undergo the EIA process.

b. Stakeholders Consultation

The project participants conducted a local stakeholder consultation on 10 September 2013.
As there are no neighboring communities adjacent to the Tuban factory, the project participants selected factory workers as the stakeholders to the project. Project participants selected wide range of stakeholders to participate in the consultation. The stakeholders ranged from the managers and engineers to workers.

During the consultation, project participants explained the overview of the project, technical aspects of the WHR system, and ancillary benefits of the project.
Stakeholders generally welcomed the introduction of such technology and its benefits.

c. Monitoring plan

The parameter required to be monitored in the methodology is the amount of electricity generated by the WHR system. In the study, the project participants conducted a research on the actual monitoring method of electricity, data storage method and monitoring structure of the cement factory of PT Semen Indonesia.

d. Calibration of metering equipments

To monitor generated electricity accurately, an effective power meter can be installed which complies with the International Electrotechnical Commission (IEC) Standard. Meter quality can be

[1] "PERATURAN MENTERI NEGARA LINGKUNGAN HIDUP NOMOR 11 TAHUN 2006"

assured through results of its performance test by manufacturers. Calibration and correction of meters can be done in line with manufacturers' specification or guarantee.

(3) Project development and implementation

a. Project planning

(1) Project plan

JFE Engineering made a proper waste heat condition setting considering difference of heat demand for cement material drying between rainy season and dry season. Based on the set condition, the specification of major equipment and auxiliaries is confirmed. Layout of major equipment is almost confirmed through many discussions held between JFE and PT Semen Indonesia cement production facility operation team. Additionally, JFE and PT Semen Indonesia almost reach an agreement on the division of work and basic design and will proceed to a detail design and equipment procurement as a next step unless there are no further amendments.

(2) Financial Plan

The initial investment for the project will be all self-financed by PT Semen Indonesia with a condition of JCM subsidies therefore it is necessary to secure an investment budget by PT Semen Indonesia.

There are not much barriers since PT Semen Indonesia reached the stage of budget determination process and the final step to be taken is only the approval by the commissioners. Schedule coordination and arrangement are now ongoing so that the project schedule can be in accordance with JCM subsidy schedule.

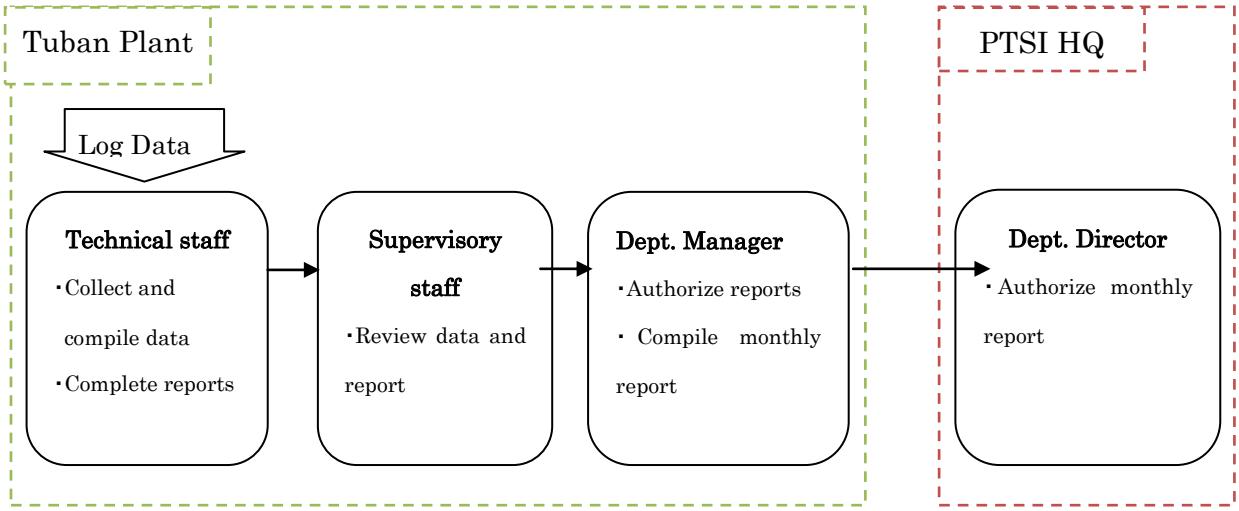
b. MRV structure

The parameter required to be monitored in the methodology is the amount of electricity generated by the WHR system. The quantity of electricity consumption by the WHR system is to be calculated using the total maximum rated capacity of equipments of the WHR system which consumes electricity. However, the power meters to monitor the quantity of electricity consumption are also installed in this study in order to be prepared in case it is needed.

Monitoring will be done by the staff of PT Semen Indonesia in the monitoring plan. For monitoring structure, firstly, technical staff collects data recorded and compiles data to complete monitoring reports. Supervisory staff reviews all the collected data, monitoring reports and related evidence for quality control, and then department manager reviews and authorizes monitoring results and monitoring reports including prepared evidence. Department manager compiles monthly report and submits to department director of PT Semen Indonesia headquarter for data storage.

When the equipment of WHR system is shut down due to automatic safety shutdown system activated by waste heat trouble, its operation condition can be figured out by monitoring electricity consumption. Also, it is planned to build up the MRV structure which can prove that it is not a power meter problem in case a meter for electricity consumption shows zero by recording the operation condition of WHR system.

For calibration and correction of meters, as mentioned above, an effective power meter can be installed which complies with the International Electrotechnical Commission (IEC) Standard. Meter quality can be assured through results of its performance test by manufacturers. Calibration and correction of meters can be done in line with manufacturers' specification or guarantee.



c. Permission and authorization for the project implementation

There is no requirement for the project implementation to obtain special permission and authorization since WHR system will be installed inside of cement plant premises and there is no emission increase by WHR system. Normal permission and authorization for facility expansion will be obtained by PT Semen Indonesia. It is confirmed that the project will be considered as normal facility expansion.

d. Japan's contribution

Recently, Chinese and Indian maker come into cement waste heat recovery market with similar technologies. It is said that some of them offer low price and begin construction without due consideration of specification, waste heat conditions and operation conditions. As a result, such project is now facing defects of design and equipment, unexpected extra maintenance cost and so on.

Although initial investment for WHR system with Japanese technology is higher than the one with similar technologies by India or China, WHR system with Japanese technology can be stably operated much longer therefore it can be considered as economical in a long-term view and CO_2 emission reduction in a life cycle will be greater. If higher initial investment can be overcome, Japanese technology can hedge a risk of rising industrial electricity cost and contribute to the reduction of production cost in a long-term view.

e. Environmental integrity

There is no requirement for the project to conduct an EIA as stipulated in ministerial decree No. 11,

2006[2] which defines that power generation facility of its capacity smaller than 100MW does not need to undergo the EIA process. There are no negative impacts on the environment since discharge from WHR facility is only water.

f. Sustainable development in host country

The project can reduce the cement production cost as well as CO_2 emission by replacing grid electricity consumption in cement production. Cement production consumes huge amount of electricity. 30% of production cost comes from electricity cost in cement plants in Indonesia. By introducing WHR system, electricity cost can be reduced by 20%, which means 6% of cement production cost can be reduced.

In Indonesia where a cement market is strong, investment in cement production facility has higher priority than the one in WHR system. However WHR system has benefit of deducting unit cost for cement production, which results in tolerance for fluctuation such as slowdown in economic growth in the future. By showing successful completion of the project and proving return on initial investment, WHR system is expected to spread out in Indonesian cement industry and it will contribute sustainable development not only in environmental aspect but also economical aspect.

g. Toward project realization (planned schedule and possible obstacles to be overcome)

The project is planned to start from May 2014, complete on March 2016 and start operation on April 2016. The detail project planning is being finalized in accordance with the planned schedule.
Toward project realization, there are two main issues to be settled – final approval of investment plan by PT Semen Indonesia and subsidy concurrence.

As mentioned above, the budget approval is proceeding smoothly in PT Semen Indonesia. Toward the commencement of equipment procurement after subsidy concurrence, JFE will support PT Semen Indonesia for their construction material procurement, local contractor selection and so as to realize smooth project implementation.

[2] "PERATURAN MENTERI NEGARA LINGKUNGAN HIDUP NOMOR 11 TAHUN 2006"