

THE 3RD MONITORING REPORT OF THE HYUNDAI STEEL WASTE ENERGY COGENERATION PROJECT



Document Prepared By CERPD Inc.

Project Title	<i>Hyundai Steel Waste Energy Cogeneration Project</i>
Version	<i>Version 1</i>
Report ID	<i>001</i>
Date of Issue	<i>2017.09.24</i>
Project ID	<i>786</i>
Monitoring Period	<i>1-June-2013 to 30-June-2017 (1490days included)</i>
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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The HYUNDAI STEEL WASTE ENERGY COGENERATION PROJECT (hereafter referred in this document as the 'proposed project') is a 400MW cogeneration plant at Dangjin Hyundai Steel Mill, which is developed by Hyundai Green power CO., Ltd(hereafter referred in this document as the 'project owner').

The project activity started on 24 March, 2010, the 1st monitoring period is from 24 March, 2010 to 31, Dec, 2011, the 2nd monitoring period operation is from Jan 1, 2012 to May 31, 2013 and the 3rd monitoring period operation is from June 1, 2013 to June 30, 2017, Timeline of the project implementation status is described below.

Activity	Date
Start of construction	April 23, 2008
#1 turbine Commissioning	November 23, 2009
#2 turbine Commissioning	December 12, 2010
#3 turbine Commissioning	August 04, 2010
#4 turbine Commissioning	September 17, 2010
#1, #2 Commercial operation	March 24, 2010
#3, #4 Commercial operation	October 31, 2010
1 st monitoring period operation	March 24, 2010 ~ December 31, 2011
2 nd monitoring period operation	Jan 1, 2012 ~ May 31, 2013
3 rd monitoring period operation	June 1, 2013 ~ June 30, 2017

During the 3rd monitoring period, 8,855,734 MWh electricity was exported to grid, and 5,798,682 tCO_{2e} GHG emission reductions were generated during the monitoring period.

1.2 Sectoral Scope and Project Type

The project activity pertains to sectoral scope 1 (Energy industries (renewable / non-renewable) & 4 (Manufacturing industries)

1.3 Project Proponent

Organization name	Hyundai Green power CO., Ltd:
Contact person	Donggug Kim
Title	energy management team

Address	North road 1480# Song amepChunchongnamdo Korea
Telephone	82-41-680-6143
Email	zugglae@hotmail.com

Organization name	Hyundai Steel Mill CO., Ltd
Contact person	Donggug Kim
Title	energy management team
Address	North road 1480# Song amepChunchongnamdo Korea
Telephone	-
Email	Dongkuk.kim@hyundai-steel.com

1.4 Other Entities Involved in the Project

Organization name	CERPD Inc.
Role in the project	Project developer
Contact person	Jongbum Kim
Title	CEO
Address	1420 156th AVE NE Ste H, Bellevue, WA, USA 98007
Telephone	82-10-6455-7855
Email	jbk@cerpd.com

1.5 Project Start Date

- Project start date¹ : March24, 2010

1.6 Project Crediting Period

- Project crediting period: 10 years (March. 24, 2010 ~ March. 23, 2020),
- The 3rd monitoring period is from June, 1, 2013 to June, 30, 2017

¹The construction period of the Project was from April 23,2008to December 10,2010 and the date on which theProject began reducing GHG emissions bycommercial operationwas March 24,2010.

1.7 Project Location

The project is located in Donggok-riSongsan-myeonDangjin-gun Chungchongnam-do, Republic of Korea. The geographical coordinates are 126°42'11.60" E, 36°58'58.27" N. The maps show below the location of the project activity.

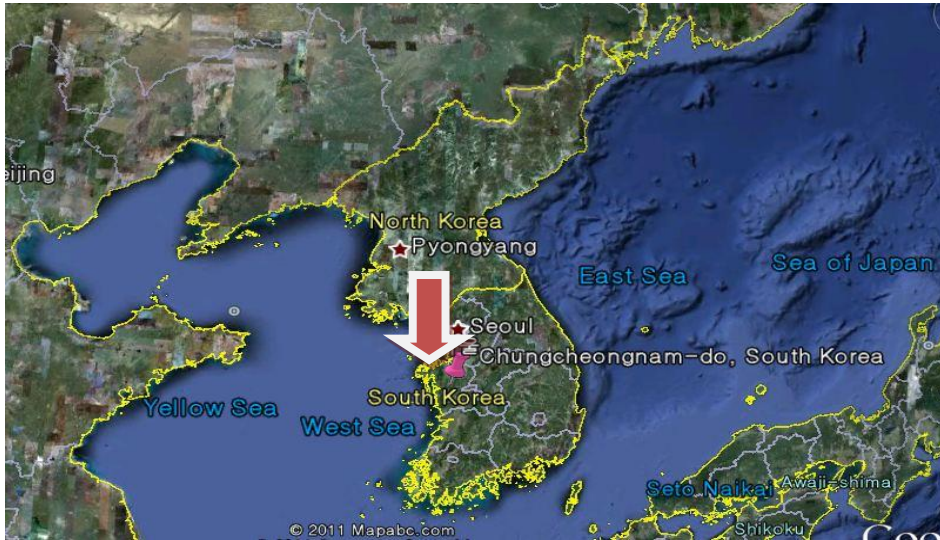


Figure 2. The location of the Chungchongnam province in Republic of Korea

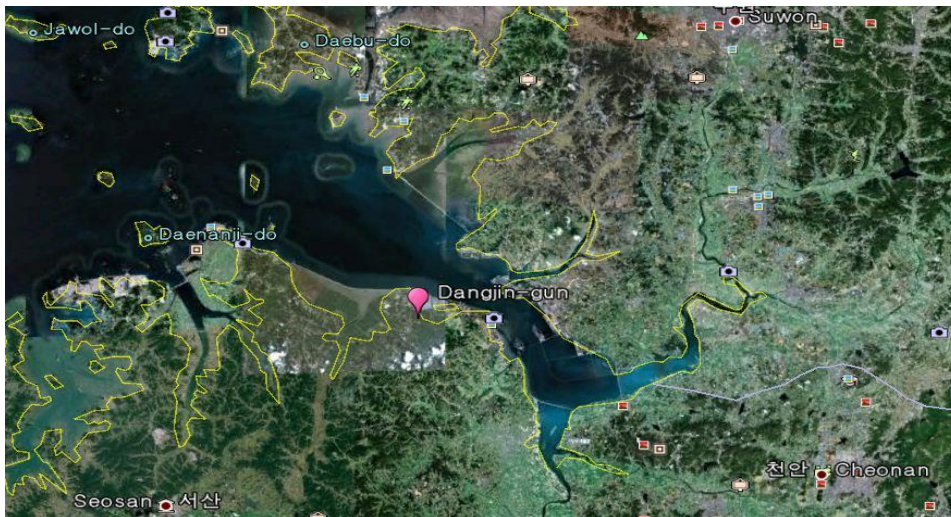


Figure 3. The location of Dangjincounty in Chungchongnam Do



Figure 4. The proposed Project in Dangjincounty

1.8 Title and Reference of Methodology

(a) The proposed project applies the following approved methodology for PDpreparation:

Version 4.0.0 of ACM 0012: “Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects”which was approved on the EB’s 60th meeting and detailed information refers to

<http://cdm.unfccc.int/methodologies/DB/L731WMCXLT0WE6ALG5AYAGLTJP7KW7>

(b) The tools drawn upon from Version 4.0.0 of ACM0012 are:

Version 02.2.1 of the tool to calculate the emission factor for an electricity system; detailed information refersto: <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v2.2.1.pdf>

Version 5.2 of the tool for the demonstration and assessment of additionality; detailed information refersto: <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.1.pdf>

Version 01 of “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”detailed information refersto:<http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf>

Version 02 of “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion”, detailed information refersto:<http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf>

1.9 Other Programs

Theproposed project is not included in any emissions trading programs or any other mechanisms that include GHG allowance trading. The net GHGemission reductions generated by the Project

during this monitoring period have not been used for compliance under any emission trading programs or mechanisms.

The project has not sought or received any other form of GHG-related environmental credit during this monitoring period.

List of all and any other programs under which the project is eligible to create another form of GHG-related environment credit: CDM, GS VER.

The project has been only registered under the VCS Program, and it has not been registered under any other approved or not approved GHG programs.

1.10 Sustainable Development

The proposed project will contribute to achieving sustainable development through the following aspects:

- Energy saving (recycling) by using waste energy,
- Using local energy as opposed to importing energy from foreign countries,
- Reducing environmental pollution, and meeting the current environmental policies of South Korea.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

During this monitoring period, the project was operated normally, generators shut down several times by inspection or other normal reasons, all the shut down times and the reasons have been recorded when shut down happened. During the shutdown time, no emission reductions were generated and recorded.

2.2 Deviations

2.2.1 Methodology Deviations

There is no deviation about methodology .

2.2.2 Project Description Deviations

According to the monitoring plan in the VCS PD, the quantity of electricity consumed by the project electricity consumption ($EC_{P,j,y}$), would be measured by standard meter continually. However, there is no standard meter for measuring electricity consumed in actual operation.

In this monitoring report, the amount of electricity consumption of booster fan was calculated with the default value of manufacture's specification. (For conservative approach, it was calculated with the assumption of full operation for the whole year)

<Calculation for the electricity consumption of booster fans>

(1) FAN for COG
 $450\text{kW} \times 2\text{set} \times 24\text{hr} \times 365\text{ days} = 7,884,000\text{ kWh/yr}$

(2) Fan for LDG
 $240\text{kW} \times 24\text{hrs} \times 365\text{days} = 2,102,400\text{kWh/yr}$

The amount of electricity consumption of booster fan is 9,986,400 kWh for a year. According to that the monitoring period, is from 1 June 2013 to 30 June 2017, the total operating period is 4 years and 1 month. So, the total amount of the electricity consumption of booster fan is 40,766,400 kWh for the 3rd monitoring period. Detail data can be found in APPENDIX.

(1) FAN for COG
 $450\text{kW} \times 2\text{set} \times 24\text{hr} \times 1490\text{ days} = 32,184,000\text{ kWh}$

(2) Fan for LDG
 $240\text{kW} \times 24\text{hrs} \times 1490\text{ days} = 8,582,400\text{ kWh}$

Therefore, the total electricity consumed is $32,184,000\text{ kWh} + 8,582,400\text{ kWh} = 40,766.4\text{MWh}$

2.3 Grouped Project

Not Applicable.
 This is not a grouped project activity.

2.4 safeguards

2.4.1 No Net Harm

N/A

2.4.2 Local Stakeholder Consultation

Since this is the third verification of the project activity, hence, local stakeholders' consultation details are not applicable in this project activity.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data Unit / Parameter:	EF _{grid,OM,y}
Data unit:	tCO ₂ /MWh
Description:	Operating Margin emission factor

Source of data:	calculated
Value applied:	0.7224 tCO ₂ /MWh
Purpose of the data:	The data was used for calculating EF _y .
Any comment:	The value numbers were calculated around the time of the submission of the PD and would not change during the accreditation period.

Data Unit / Parameter:	EF _{grid,BM,y}
Data unit:	tCO ₂ /MWh
Description:	Build Margin emission factor
Source of data:	calculated
Value applied:	0.6059 tCO ₂ /MWh
Purpose of the data:	The data was used for calculating EF _y .
Any comment:	The value numbers were calculated around the time of the submission of the PD and would not change during the accreditation period.

Data Unit / Parameter:	EF _y
Data unit:	tCO ₂ /MWh
Description:	Carbon emission factor of Korea National power grid
Source of data:	calculated
Value applied:	0.6641 tCO ₂ /MWh
Purpose of the data:	The data was used for calculating carbon emission in accordance with electricity use.
Any comment:	The value numbers were calculated around the time of the submission of the PD and would not change during the accreditation period.

Data Unit / Parameter:	COEF _{1,y}
Data unit:	kgCO ₂ /TJ

Description:	Weighted average CO2 emission factor of fuel type i in year y
Source of data:	IPCC2006
Value applied:	54,300
Purpose of the data:	-
Any comment:	-

Data Unit / Parameter:	TDL _{j,y}
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to source j in year y.
Source of data:	Tool to calculate baseline, project and/or leakage emissions from electricity consumption.
Value applied:	20%
Purpose of the data:	To calculate electricity provided considered with transmission and distribution loss.
Any comment:	-

Data Unit / Parameter:	NCV _i (forEF _{grid} calculation)
Data unit:	kcal/l, kcal/kg
Description:	Net calorific value for fuel consumed in OM power plants.
Source of data:	STATISTICS OF ELECTRIC POWER IN KOREA(2007,2008,2009)
Value applied:	See attachmentEF _{grid} calculation
Purpose of the data:	The data was used for calculating EF _{grid}
Any comment:	-

3.2 Data and Parameters Monitored

Data Unit / Parameter:	EG _{j,y}
------------------------	-------------------

Data unit:	MWh
Description:	Quantity of electricity supplied to the grid by the project activity during the year <i>y</i> .
Source of data:	Measurement records
Description of measurement methods and procedures to be applied:	Direct measurement by project participants through standard meter continually. And the data can be monitored by the system of EMS-IRTV.
Frequency of monitoring/recording:	The electricity generation amount is monitored continuously and record every day.
Value monitored:	8,855,734 during the 3rd monitoring period.
Monitoring equipment:	<p>Main meter M1 Type : 3P4W110V5A Accuracy class : 0.2s Serial number : PT-0808A177-01</p> <p>Main meter M2 Type : 3P4W110V5A Accuracy class : 0.2s Serial number : PT-08082A717-01</p> <p>Main meter M3 Type : 3P4W110V5A Accuracy class : 0.2s Serial number : PT-0808A176-01</p> <p>Main meter M4 Type : 3P4W110V5A Accuracy class : 0.2s Serial number : PT-0808A178-01</p> <p>Backup meter M5 Type : 3P4W110V5A Accuracy class : 0.5s Serial number : 51001402</p> <p>Backup meter M6 Type : 3P4W110V5A</p>

	<p>Accuracy class : 0.5s Serial number : 51001399</p> <p>Backup meter M7 Type : 3P4W110V5A Accuracy class : 0.5s Serial number : 51001400</p> <p>Backup meter M8 Type : 3P4W110V5A Accuracy class : 0.5s Serial number : 51001398</p>
<p>QA/QC procedures to be applied:</p>	<p>The amount of power generation is crosschecked with the receipt.</p> <p>The meters are calibrated every 3.5 years (with error testing at the 4th year and calibrating at the 7th year).</p> <p>The latest dates of calibration for the meters are as follows;</p>

	Meter	Calibration		Calibration Entity
		Date of calibration	Valid until	
	M1	2012-12-12	2015-12-11	Korea Testing Certification(KTC)
		2015-03-24	2019-03-23	
	M2	2012-12-12	2015-12-11	
		2015-07-03	2019-07-02	
	M3	2012-12-12	2015-12-11	
		2015-08-26	2019-08-25	
	M4	2012-12-12	2015-12-11	
		2015-08-24	2019-08-23	
	M5	2012-12-12	2015-12-11	
		2015-3-24	2019-03-23	
	M6	2012-12-12	2015-12-11	
		2015-07-03	2019-07-02	
	M7	2012-12-12	2015-12-11	
		2015-08-26	2015-08-25	
	M8	2012-12-12	2015-12-11	
		2015-08-24	2019-08-23	
Calculation method:	-			
Any comment:	-			

Data Unit / Parameter:	$EC_{P,j,y}$
Data unit:	MWh
Description:	Quantity of electricity consumed by the project electricity consumption source j in year y.
Source of data:	Designed value
Description of measurement methods and procedures to be applied:	Calculation with the designed data
Frequency of monitoring/recording:	-

Value monitored:	40,766
Monitoring equipment:	Due to the absence of electricity meters of facilities that consumed electricity for the project activity, designed value was applied for calculating the amount of electricity consumption.(with the assumption of full operation for the year.(24hrs a day, 365days a year))
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	AF _{i,j,y}																			
Data unit:	Nm ³																			
Description:	LNG consumed on-site for power generation.																			
Source of data:	Measurement records.																			
Description of measurement methods and procedures to be applied:	Direct measurement by project participants through standard flow meter continually.																			
Frequency of monitoring/recording:	Direct measurement by project participants through standard meter continually. The data is displayed by DCS with accumulated flow; the amount of LNG consumption is reported every month																			
Value monitored:	23,855,516																			
Monitoring equipment:	<table border="1"> <thead> <tr> <th>Tag No.</th> <th>Model</th> <th>Uncertainty</th> <th>remark</th> </tr> </thead> <tbody> <tr> <td>FQIT-01 (previous)</td> <td>SM-RI-X</td> <td>± 1%</td> <td>Has been replaced by new meters listed below in 2014.07.24</td> </tr> <tr> <td>FQIT-02 (previous)</td> <td>SM-RI-X</td> <td>± 1%</td> <td>Has been replaced by new meters listed below in 2014.09.03</td> </tr> <tr> <td>10513239 (new)</td> <td>G4000</td> <td>± 0.5%</td> <td>New installed in 2014.07.24</td> </tr> </tbody> </table>				Tag No.	Model	Uncertainty	remark	FQIT-01 (previous)	SM-RI-X	± 1%	Has been replaced by new meters listed below in 2014.07.24	FQIT-02 (previous)	SM-RI-X	± 1%	Has been replaced by new meters listed below in 2014.09.03	10513239 (new)	G4000	± 0.5%	New installed in 2014.07.24
Tag No.	Model	Uncertainty	remark																	
FQIT-01 (previous)	SM-RI-X	± 1%	Has been replaced by new meters listed below in 2014.07.24																	
FQIT-02 (previous)	SM-RI-X	± 1%	Has been replaced by new meters listed below in 2014.09.03																	
10513239 (new)	G4000	± 0.5%	New installed in 2014.07.24																	

	10513238 (new)	G4000	±0.62%	New installed in 2014.09.03
QA/QC procedures to be applied:	The meters would be calibrated by LNG supplier when the meter is at abnormal condition.			
Calculation method:	-			
Any comment:	-			

Data Unit / Parameter:	NCV _i (for $AF_{i,j,y}$ calculation)
Data unit:	TJ/Gg
Description:	Net calorific value for fuel LNG
Source of data:	IPCC 2006 ²
Description of measurement methods and procedures to be applied:	IPCC default values at the upper limit of the uncertainty at a 95% according to "Tool to calculate project or leakage CO ₂ emissions from fossil fuel combustion".
Frequency of monitoring/recording:	-
Value monitored:	50.4
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	The value will be upgraded when the value in IPCC changed.

Data Unit / Parameter:	EF _{CO₂,i,y}
Data unit:	Nm ³
Description:	CO ₂ emissions factor for LNG.
Source of data:	Measurement records.
Description of measurement methods and procedures to be applied:	IPCC default values at the upper limit of the uncertainty at a 95% according to "Tool to

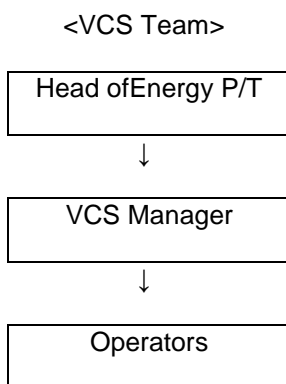
²The NCV_is used only in calculating project emission caused by LNG consumption. And in the calculation for EFOM and EFBM, the specific NCV of LNG for each power plant was adopted.

	calculate project or leakage CO2 emissions from fossil fuel combustion".
Frequency of monitoring/recording:	-
Value monitored:	58,300
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	The value will be upgraded when the value in IPCC changed.

3.3 Monitoring Plan

1. Allocation of project management

The Engineering Team at Hyundai Green Power plant is responsible for the monitoring plan of the proposed project. The team manages the measurement and record of all data and the maintenance of equipment associated with the project. Operators under the Engineering Team are composed to implement the accurate monitoring, and are assigned to the task of monitoring as follows;



	Tasks
Head of Energy P/T	- Cross-check and management of monthly and annual data related to ER calculation. - Check the annual emission reduction and approve the monitoring report.
VCS Manager	- Check and verification of monthly and annual data related to

	<p>ER calculation.</p> <ul style="list-style-type: none"> - Calculation of annual GHG emissions reduction and documentation of monitoring report, and report to Head of Energy P/T.
Operator	<p>Operation of facilities and logging.</p> <ul style="list-style-type: none"> - Logging and record of daily data related to ER calculation. - Maintenance and management of meters. - report to VCS manager every month about the monitored data.

All of the team members are from Hyundai Green Power and Hyundai Steel Mill. A head of Energy P/T and the VCS Manager who are from Hyundai Green Power are mainly in charge of the monitoring for the proposed project. Some of the operators are from Hyundai Steel mill who are in charge of providing the data of electricity consumed in the proposed project.

All monitored data is kept during the crediting period and 2 years after the end of crediting period.

2. Management and operational system

2.1 Data collection and storage

For power generation, the data is monitored and collected by EMS-IRTV system. Also, the data collected by EMS-IRTV is sent to Korea Power exchange for the purchase of electricity and will be stored for 3 years after the end of the project crediting period.

For LNG consumption, the data is displayed by DCS with accumulated flow; the amount of LNG consumption is reported every month and will be stored for 3 years after the end of the project crediting period.

1.2 Cross checking

The amount of power generation and LNG consumption is crosschecked with the receipt, if there is any difference between monitored data and receipt, the reason of the difference must be found out. If it cannot be found out, for conservative consideration, the data leading to lower Emission Reductions will be used for calculation.

2.3 Training

Internal training is provided to operational staff to enable them to undertake the tasks required by the monitoring plan and to share the latest information on relevant laws and regulations.

3. Procedures for handling internal auditing and non-conformities

Internal auditing procedures are followed after the data were collected and the emission reduction was calculated. The procedures of internal auditing are as follows:

- (a) Set up an internal audit team, the team members are mainly consisted by the VCS team
- (b) Set up an internal auditing plan, the main process of the internal auditing is to check the accuracy of the calculation and data collection. Members should not audit the parts which they are in charge of.
- (c) If some non-conformities are found, the one who in charge of should be informed and be ordered to correct
- (d) The Emission Reduction calculation and monitoring report should be revised according to the result of the internal auditing.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

According to methodology ACM0012 ver.4.0.0, the baseline emission calculation shall be determined as follows:

$$BE_y = BE_{En,y} + BE_{flst,y} \quad (1)$$

Where:

- BE_y** The total baseline emissions during the year y in tCO_2 .
- $BE_{En,y}$** The baseline emissions from energy generated by the project activity during the year y in tCO_2 .
- $BE_{flst,y}$** Baseline emissions from fossil fuel combustion, if any, either directly for flaring of waste gas or for steam generation that would have been used for flaring the waste gas in the absence of the project activity (tCO_2).

As for the proposed project, there is no fossil fuel combusted for flaring the waste gas in the absence of the proposed project. So $BE_{flst,y}=0$.

1. Baseline emissions from energy generated by the project activity ($BE_{En,y}$).

According to the methodology BE_y of The proposed project should be calculated as follows

$$BE_{En,y} = BE_{Elec,y} + BE_{Ther,y} \quad (2)$$

Where:

- $BE_{Elec,y}$** Baseline emissions from electricity during the year y in tCO₂.
- $BE_{Ther,y}$** Baseline emissions from thermal energy (due to heat generation by elemental processes) during the year y (tCO₂).

(a) Baseline emissions from electricity ($BE_{Elec,y}$) generation.

$$BE_{Elec,y} = f_{cap} * f_{wcm} * \sum_j \sum_i (EG_{i,j,y} * EF_{Elec,i,j,y}) \quad (3)$$

Where:

- $BE_{elec,y}$** Baseline emissions due to displacement of electricity during the year y (tCO₂)
- $EG_{i,j,y}$** The quantity of electricity supplied to the recipient j by generator, which in the absence of the project activity would have been sourced from source i (the grid) during the year y in MWh.
- $EF_{Elec,i,j,y}$** The CO₂ emission factor for the electricity source i (gr for the grid), displaced due to the project activity, during the year y (tCO₂/MWh).
- f_{wcm}** Fraction of total electricity generated by the project activity using waste energy. This fraction is 1 if the electricity generation is purely from use of waste energy.
- f_{cap}** Factor that determines the energy that would have been produced in project year y using waste energy generated at a historical level, expressed as a fraction of the total energy produced using waste source in year y . The ratio is 1 if the waste energy generated in project year y is the same or less than that generated at a historical level.

For f_{wcm} calculation of the project, calculating f_{wcm} is not available due to technical constraints; the emissions due to auxiliary fossil fuel combusted will be calculated in project emission according to ACM0012 ver04 equation 41.

As the project is a Greenfield power plant, f_{cap} of this project is 1.

For this project, the power is exported to the grid, so $EF_{elec,i,j,y} = EF_{elec,gr,j,y}$. The CO₂ emission factor of the electricity $EF_{elec,gr,j,y}$ was calculated following the guidance provided in the “Tool to calculate the emission factor for an electricity system”.

The result of $EF_{elec,i,j,y}$ is 0.6641 (tCO₂/MWh).

(b) Baseline emissions for generation of thermal energy ($BE_{ther,y}$) and steam-generated mechanical energy

This project doesn't claim GHG emission reductions from thermal energy for conservative, so this step is skipped.

Calculation of Baseline emission reductions:

$$\begin{aligned}
 BE_y &= BE_{En,y} + BE_{flst,y} \\
 &= BE_{Elec,y} + BE_{Ther,y} + BE_{flst,y} \\
 &= f_{cap} * f_{wcm} * \sum_j \sum_i (EG_{i,j,y} * EF_{Elec,i,j,y}) + BE_{Ther,y} + BE_{flst,y} \\
 &= 1 \times 1 \times 8,855,734 \text{MWh} \times 0.6641 \text{ tCO}_2\text{e/MWh} + 0 + 0 \\
 &= 5,881,093 (\text{tCO}_2\text{e})
 \end{aligned}$$

Detail information for calculation of Baseline Emission calculation can be found in the excel file attachment of "3rd_ER calculation sheet for Hyundai monitoring".

4.2 Project Emissions

Project Emissions include emissions due to (1) combustion of auxiliary fuel to supplement waste gas/heat, and (2) electricity emissions due to consumption of electricity for cleaning of gas before being used for generation of energy or other supplementary electricity consumption.

$$PE_y = PE_{AF,y} + PE_{EL,y} \tag{4}$$

Where:

- PE_y** Project activity emissions from on-site consumption of fossil fuels by the unit process(es) and/or co-generation plant(s) if they are used as supplementary fuels
- PE_{AF,y}** emissions from on-site consumption of electricity for gas cleaning equipment or other supplementary electricity consumption (tCO₂) (as per Table 1: Summary of gases and sources included in the project boundary)
- PE_{EL,y}** The total project emissions during the year y

In this project, although LNG is not used for the purpose of generation, LNG is used for sparking when starting up and in case the NCV of waste gas is too low to burn. The emission due to consumption of LNG was calculated according to latest approved tool "Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion".

According to the tool CO₂ emissions from fossil fuel combustion in process j are calculated based on the quantity of fuels combusted and the CO₂ emission coefficient of those fuels, as follows:

$$PE_{AF,y} = \sum_i AF_{project,i,y} * NCV_i * EF_{AF,i} \tag{5}$$

$$= (23,786,516 \times 22.4 / 16 / 10^6) \text{ Gg} \times 50.4 \text{ TJ/Gg} \times 58,300 \text{ kgCO}_2/\text{TJ}$$

$$= 49,923 \text{ tCO}_2\text{e}$$

Where:

- AF_{productplant,i,j}** LNG consumed on-site for power generation
- NCV_i** Net calorific value for fuel LNG
- EF_{AF,i}** Carbon dioxide emissions factor for LNG
- PE_{AF,y}** Project activity emissions from on-site consumption of fossil fuels by the unit process(es) and/or co-generation plant(s) if they are used as supplementary fuels

As for **PE_{EL,y}**, according to Methodology ACM0012, project emissions due to electricity consumption of gas cleaning equipment or other supplementary electricity consumption are calculated by using latest approved tool “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

According to the Tool, baseline methodology procedure should be followed: first a generic approach to calculate emissions from consumption of electricity is introduced. Then guidance on the determination of the emission factor for electricity generation is provided. Finally, simplified alternative approaches to the generic approach are introduced. These simplified alternative approaches are only applicable to scenario B and to project and leakage emissions.

Generic approach

According to the tool, the project emissions from consumption of electricity are calculated based on the following formula

$$PE_{EL,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \tag{6}$$

$$= 40,766 \text{ MWh} \times 0.6641 \text{ tCO}_2/\text{MWh} \times (1 + 0.2)$$

$$= 32,488 \text{ tCO}_2\text{e}$$

Where:

- PE_{EL,y}** Project emissions from electricity consumption in year y (tCO₂/yr)

- $EC_{P,j,y}$** Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/yr)
- $EF_{EL,j,y}$** Emission factor for electricity generation for source j in year y (tCO₂/MWh)
- $TDL_{j,y}$** Average technical transmission and distribution losses for providing electricity to source j in year y

Calculation of Project emission reductions:

As detail described above calculation of emission reductions are calculated as follows

$$\begin{aligned}
 PE_y &= PE_{AF,y} + PE_{EL,y} \\
 &= \sum_i AF_{project,i,y} * NCV_i * EF_{AF,i} + PE_{EL,y} \\
 &= 49,923 + 32,488 \\
 &= 82,411 (tCO_2e)
 \end{aligned}$$

Detail information for calculation of Project Emission calculation can be found in the excel file attachment of “ER calculation sheet”.

4.3 Leakage

In accordance with ACM 0012, no leakage is considered.

4.4 Net GHG Emission Reductions and Removals

Emission Reduction of the proposed project can be determined as follows

$$\begin{aligned}
 ER_y &= BE_y - PE_y - LE_y \tag{7} \\
 &= 5,881,093 - 82,411 - 0 \\
 &= \mathbf{5,798,682 tCO_2e/yr}
 \end{aligned}$$

Detail information for calculation of Emission Reduction calculation can be found in the excel file attachment of “ER calculation sheet”.

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)
2013.6-2013.12	947,960	26,130	0	921,829

2014	1,591,642	27,372	0	1,564,269
2015	1,396,154	11,368	0	1,384,786
2016	1,262,199	12,375	0	1,249,824
2017.1-2017.6	683,139	5,166	0	677,974
Total	5,881,093	82,411	-	5,798,682

APPENDIX 1: INFORMATIONS ABOUT PROJECT ENERGY BALANCE

According to the approved methodology ACM0012, if there is a decrease in the energy recovery of WECM(s) in the extended boundary excluding the project WECM, a technical justification along with energy balance should be demanded explaining why the reduction in recovery is not due to the CDM project.

In order to improve there is no decrease in the energy recovery of WECM(s) in the extended boundary excluding the project WECM(s), the comparison of energy balance is as follows;

<The designed energy balance in the VCS PD>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal/hr)	Percentage	Amount (Gcal/hr)	Percentage	Amount (Gcal/hr)	Percentage
COG	60.9	10.70%	510.3	89.30%	571	100%
BFG	597.5	74.70%	201.9	25.30%	799	100%
LDG	186.6	100.00%	0	0.00%	187	100%
Total	845	54.30%	712.2	45.70%	1557.2	100%

<The actual energy balance in 2013>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	643,457	17.19%	3,100,414	82.81%	3,743,871	100%
BFG	2,817,507	45.50%	3,374,264	54.50%	6,191,771	100%
LDG	546,068	58.11%	393,569	41.89%	939,638	100%
Total	4,007,032	36.85%	6,868,247	63.15%	10,875,279	100%

<The actual energy balance in 2014>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	1,032,488	16.51%	5,222,188	83.49%	6,254,676	100%
BFG	4,686,585	44.34%	5,882,101	55.66%	10,568,685	100%
LDG	935,002	67.04%	459,618	32.96%	1,394,621	100%

Total	6,654,075	36.52%	11,563,907	63.48%	18,217,982	100%
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<The actual energy balance in 2015>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	912,811	14.47%	5,396,387	85.53%	6,309,197	100%
BFG	4,039,131	40.70%	5,885,417	59.30%	9,924,548	100%
LDG	732,457	64.29%	406,813	35.71%	1,139,270	100%
Total	5,684,398	32.72%	11,688,617	67.28%	17,373,015	100%

<The actual energy balance in 2016>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	732,701	11.87%	5,441,133	88.13%	6,173,834	100%
BFG	3,789,976	39.16%	5,889,313	60.84%	9,679,290	100%
LDG	639,140	62.32%	386,472	37.68%	1,025,612	100%
Total	5,161,817	30.58%	11,716,918	69.42%	16,878,736	100%

<The actual energy balance in 2017>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	329,396	7.76%	3,915,773	92.24%	4,245,169	100%
BFG	2,470,370	36.56%	4,285,894	63.44%	6,756,265	100%
LDG	432,911	58.10%	312,265	41.90%	745,177	100%
Total	3,232,677	27.52%	8,513,932	72.48%	11,746,610	100%

As described above, the ratio of 'WECM stream for alternative uses' in designed energy balance is 45.7%, and the ratio in actual energy balances from 2013 to 2017 are 63.15%, 63.48%, 67.28%, 69.42%, 72.48%. Therefore, there is no decrease in the energy recovery of WECM(s) in the extended boundary excluding the project WECM.

APPENDIX 2: MONITORING DATAS FOR EMISSION REDUCTION CALCULATION

Date	Power generation (Mwh)	LNG consumption (Nm ³)	Electricity consumption (Mwh)
2013-6	154,328	1,390,217	820.80
2013-7	175,701	1,258,133	848.16
2013-8	200,421	1,869,958	848.16
2013-9	182,575	1,530,332	820.80
2013-10	223,207	1,643,013	848.16
2013-11	216,323	1,879,280	820.80
2013-12	274,880	671,600	848.16
2014-1	203,574	1,425,183	848.16
2014-2	166,584	1,339,764	766.08
2014-3	209,040	1,395,151	848.16
2014-4	188,217	1,378,601	820.80
2014-5	191,226	1,307,619	848.16
2014-6	214,150	1,314,002	820.80
2014-7	176,491	456,139	848.16
2014-8	197,113	117,546	848.16
2014-9	206,584	71,744	820.80
2014-10	218,630	109,229	848.16
2014-11	222,867	80,143	820.80
2014-12	202,214	254,936	848.16
2015-1	160,821	238,643	848.16
2015-2	136,251	203,093	766.08
2015-3	140,657	331,771	848.16
2015-4	153,016	336,241	820.80
2015-5	192,765	155,025	848.16
2015-6	156,142	73,833	820.80
2015-7	193,877	69,693	848.16
2015-8	224,518	34,218	848.16
2015-9	199,405	26,953	820.80
2015-10	208,812	61,542	848.16
2015-11	171,409	28,610	820.80

2015-12	164,652	64,762	848.16
2016-1	127,159	272,634	848.16
2016-2	159,152	228,778	766.08
2016-3	133,763	216,200	848.16
2016-4	162,999	111,341	820.80
2016-5	110,722	114,174	848.16
2016-6	126,319	419,621	820.80
2016-7	211,275	117,807	848.16
2016-8	180,355	9,734	848.16
2016-9	202,066	2,038	820.80
2016-10	195,117	345,033	848.16
2016-11	150,181	36,845	820.80
2016-12	141,508	230,073	848.16
2017-1	161,230	143,636	848.16
2017-2	134,984	229,674	766.08
2017-3	180,837	80,534	848.16
2017-4	186,560	43,687	820.80
2017-5	190,975	48,733	848.16
2017-6	174,083	19,000	820.80
Total	8,855,734	23,786,516	40,766