THE HYUNDAI STEEL WASTE ENERGY COGENERATION PROJECT

Document Prepared by CERPD Inc.

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The Hyundai 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 utilizes surplus waste gases including BFG(Blast Furnace Gas), COG(Coke Oven Gas) and LDG(Converter Gas) produced by Dangjin Hyundai Steel Mill, to generate electricity. The waste gases created by Dangjin Hyundai Steel Mill are reused by the steel mill and the rest are consumed by the proposed project. Without the proposed project the rest of waste gases are emitted to atmosphere after incineration. And the electricity generated by the project is supplied to the grid.

The project activity started construction on April 23 2008, started first turbine commission on November 23 2009 and started first crediting period on 24 March, 2010, the 4th monitoring period is from July 1st, 2017 to 23 March, 2020, Time-line 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
1st monitoring period operation	March 24, 2010 ~ December 31, 2011
2nd monitoring period operation	Jan 1, 2012 ~ May 31, 2013
3rd monitoring period operation	June 1, 2013 ~ June 30,2017
4th monitoring period operation	July 1, 2017 ~ March 23,2020

During the 4th monitoring period, 6,318,716.92 MWh electricity was exported to grid, and 4,170,592 tCO_2e GHG emission reductions were generated during the monitoring period.

1.2 Sectoral Scope and Project Type

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

The project is not a grouped project.

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	82-41-680-6143
Email	zugglae@hotmail.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 date : March 24, 2010

1.6 Project Crediting Period

Project crediting period: 10 years (March 24, 2010 ~ March 23, 2020)

The 4th monitoring period: July 1, 2017 ~ March 23,2020

1.7 Project Location

The project is located in Donggok-ri Songsan-myeon Dangjin-gun Chungchongnam-do, Republic of Korea. The geographical coordinates are126°42'11.60" E, 36°58'58.27" N. The maps show below the location of the project activity.

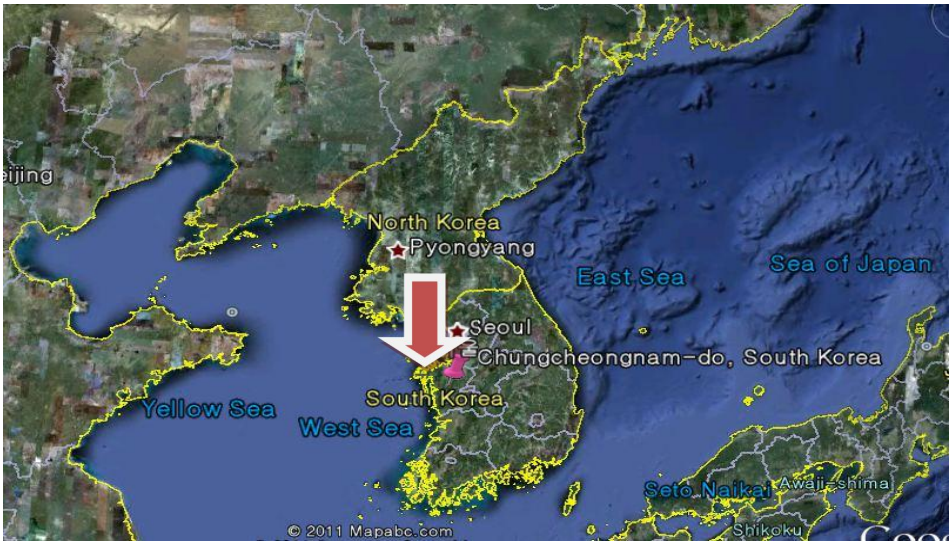


Figure 1. The location of the Chungchongnam province in Republic of Korea

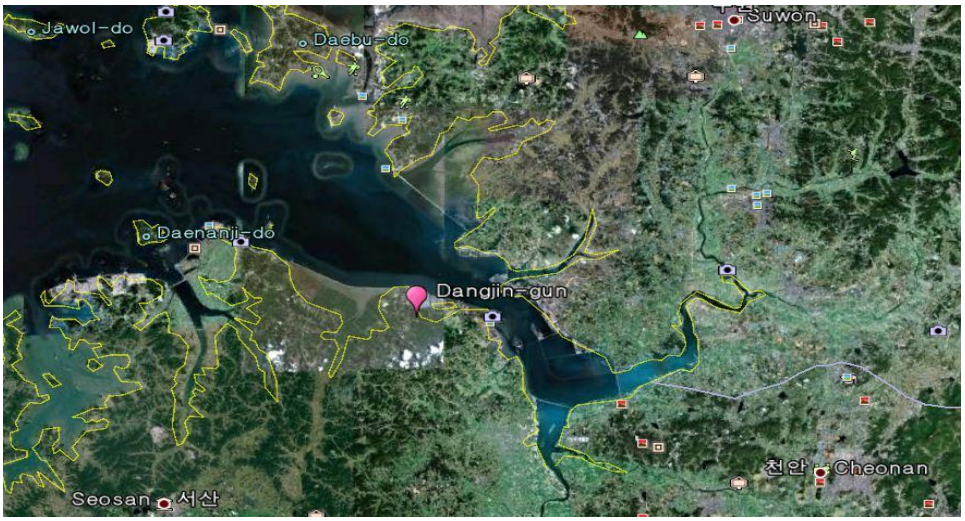


Figure 2. The location of Dangjin county in Chungchongnam Do

Figure 3. The proposed Project in Dangjin county

1.8 Title and Reference of Methodology

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

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 refers to: 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 refers to: 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 refers to: 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 refers to: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

1.9 Participation under other GHG Programs

The proposed project is not included in any emissions trading programs or any other mechanisms. The net GHG emission reductions generated by the Project during this monitoring period have not been used for compliance under any emission trading programs or mechanisms.

1.10 Other Forms of Credit

Emission Trading Programs and Other Binding Limits

According to Korean Emission Trading Scheme(KETS)[1], all power companies should be involved in KETS as compliance company even the fuel consumed is the waste gas[2]. So the project proposer: Hyundai Green power CO., Ltd is also a compliance company in KETS.

According to the allowance allocating regulation of KETS[3], the allowance allocated to Hyundai Green power CO., Ltd are only depends on the GHG emissions caused by the waste gas. But the emission reduction generated by the project are from power grid, so the emission reduction of the project will not cause any change of allowance allocation.

Also in KETS, only KOC(Korean Offset Credits) can be used under KETS except allowance[4]. The proposed project has never registered as KOC project. A letter of assurance has been received from project proposer to confirm that the proposed project is not registered with another GHG program other than VCS.

[1] https://www.law.go.kr/LSW/lsInfoP.do?efYd=20220325&lsiSeq=235597#AJAX

[2] http://www.gir.go.kr/home/board/read.do?pagerOffset=0&maxPageItems=10&maxIndexPages=10&searchKey=&searchValue=&menuId=19&boardId=84&boardMasterId=8&boardCategoryId=

[3] https://www.law.go.kr/LSW/admRulLsInfoP.do?admRulSeq=2100000195243#AJAX

[4] https://www.law.go.kr/LSW/admRulLsInfoP.do?admRulSeq=2100000201212

In summary, the GHG emission reductions or removals generated by the project have not and will not be otherwise counted or used under KETS.

Other Forms of Environmental Credit

The project has not sought or received another form of GHG-related environmental credit, including renewable energy certificates, during this monitoring period.

1.11 Sustainable Development

The proposed project is an energy saving project by using waste energy.

- Energy saving (recycling) by using waste energy to generate power, which can replace local fossi fuel based power plants and thereby reduce CO_2 emissions as well as associated emissions such as PM, SOx and NOx, creating local and global air environmental benefits. Ensure the access to affordable, reliable and sustainable energy for Korean residents. Thus, the project achieved SDG 7[5]

- Creating 105 Job opportunities during the project operation and construction, providing local residents with full and productive employment and decent work, provide high level salary and variety of employee benefits, such as insurance premiums, transportation, tuition fees and child support fees. Thus, the project achieved SDG 8[6]

- Achieve 4,170,592 tCO_2e emission reduction during this monitoring period. Thus the project achieved SDG 13[7],

2 SAFEGUARDS

2.1 No Net Harm

According to the EIA (Environmental Impact Assessment) conducted by a third party, the environmental impact of the proposed project was reduced to the minimum level. Thus, there are no negative environmental and/or socio-economic impacts due to the project. In fact, the project as a waste energy recovering project which can reduce greenhouse gas emissions and the environmental pollution caused by fossil fuels consumption. Meanwhile, the implementation of the project improves local socio-economic development through creating career opportunities and paying taxes.

[5] https://sdgs.un.org/goals/goal7
[6] https://sdgs.un.org/goals/goal8
[7] https://sdgs.un.org/goals/goal13

2.2 Local Stakeholder Consultation

The owner of the Project held a series of meetings with local residents for the purpose of informing the local residents about the environmental effects and the development plans including environment division and local governments, and also received feedbacks from them. The residents expressed their concerns about the noise, pollution, and spreading of thermal effluent which have been taken into consideration. A series of solutions to minimize such civil complaints have been made and implemented.

< Presentation location, date and time>

Location: Songsan-myun senior hall (Dangjin-goon Songsan-myun)

Date and Time : 2008/09/09

Audience: residents, organizations and entities that have their addresses in the region which would environmentally be affected by the implementation of the project.

Figure 4. Stakeholders' meeting

Main comment by stakeholders and the reply from Hyundai green power are as follows:

NO.	Comment	Reply from hyundai
1	Please control the noise made during the construction period	We will set up a plan to reduce the noise

2	I am one of the residents within 5km and know it is impossible that there is totally no pollution by the waste gas power generation plant. I just hope that the measures you promised us to minimize the pollution will be put into practice	Yes we will try our best to minimize the pollution and put them into practice.
3	We are worrying about the noise and the dangers caused by the trucks during construction. Please try to control the noise and be careful about the local residents to let them out of danger	We will set up a plan to reduce the noise and the dust caused by trucks.
4	Please submit the internal environment management standard	Yes, we will submit the internal environment management standard, which is more strict than the national standard.
5	Please change the condensing technology from warming water emission to condensing tower	We will submit the comparative study of two technologies and choose the technology of condensing tower.
6	Please do some research to reuse the waste heat from the project,	We will set up a plan to research to find any technology to improve the efficiency of the power generation, and to reuse the waste heat from the project.

A series of actions have been implemented to respond for the stakeholders' comments. The detail actions are as follow:

1. Management to control noise during construction

Noise level has been checked periodically and a noise reducing percussive-rotary drilling (PRD) has been applied during the construction.

2. Plan for minimizing pollutants

Stricter standards than the legal standards for pollutants emission were applied

List		Legal standard	Internal standard
Air	NOx(PPm)	<50	<20
Waste water	pH	5.8~8.6	6.0~8.0
	BOD(mg/L)	<80	<20

	COD(mg/L)	<90	<20
	SS(mg/L)	<80	<20
	T-N(mg/L)	<60	<60
	T-P(mg/L)	<8	<8
	N-H Extracts(mg/L)	<5	<0.5
	Temp. (℃)	<40	<40
Black water	BOD(mg/L)	<20	<20
	SS(mg/L)	<20	<20

3. Noise control and risk management due to trucking

- Applied lots of washing facilities for trucks to reduce the dust
- Added covers for trucks in order to prevent things dropped from trucks to reduce the danger.
- Added lots of speed limit signs to control the speed of trucks.

4. Warm water discharging method analysis

During the construction of Hyundai Green-Power plant No.1-4, Hyundai Green power CO. collected extensive opinions from stakeholders and administrative agencies, and selected a submerged cooling water intake/discharge method that reduced the distance and the diffusion area of mixing the surface layer and the bottom layer. In order to decrease the temperature of heated effluent, the length of drainpipe was extended to 1,570m (existing 600m).

5. Recycling methods of waste energy resource

The researches to recycle the waste energy and improve the efficiency of power generation have been underway. We will try to recycle the waste energy if we find some technology that is adaptable to us.

Local Stakeholder Consultation during the project implementation stage:

Communications with local stakeholders are being carried out at periodic intervals. In this monitoring period, the project owner carried out questionnaire surveys for the local stakeholder to collect the relevant comments and suggestions in May 11th 2017, September 5th 2017, December 14th 2018 and November 4th 2019. And there are no negative comments received for the project. In line with VCS requirements all the processes have been implemented to receive comments from local stakeholders as well as communicate with them at periodic intervals. Besides, In order to improve the living quality of local residents, the project owner invest funds every year to improve the local living conditions, such as roads improving, school repairing, scholarship providing, etc. The acts of improving local conditions and benefits during the project period are as follows:

Type	Number of projects	Cost (1000KRW)	Benefits
Improve income of local residence	1	24,570	Increase the working efficiency of farming through providing new cranes
Improve local environment	41	982,000	Increase the quality of living environment through rural road drainage channel repairing and Public community construction
Support Education	8	420,000	Increase the quality of education through school repairing and providing scholarship

2.3 AFOLU-Specific Safeguards

N/A

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

During this monitoring period, the project was operated normally, generators shut down 98 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. The information of shut down has been provided to DOE. Key technical specifications of main equipments are as follows:

Equipment	Number	Specification	Value
Generator	4	Model	SGEN6-100A-2P
		Quantity	1
		Rated Power	116.54MW
		Rated Voltage	13.8kV
		Rated Current	5736A
		Rated Speed	3600rpm
Turbine	4	Model(HP/IP)	SST-700/SST-900
		Quantity	1/1
		Rated Power(MW)	100(26.7%/73.3%)
		Rated Water Head(kg/cm^2)	127/33
		Rated Flux(ton/h)	287

		Rated Speed(RPM)	7116/3600
Boiler	4	Model	N/A
		BMCR	340ton/h
		Main steam temperature,℃	541
		Combustion mode	Front Firing
		Main steam pressure,kg/cm2	131
LDG booster fan	1	Volume flow	19.3 m^3/s
		Fan rotational speed	1190 rpm
		Total pressure rise	8698 Pa
		Motor Manufacture	Hyosung Corp
		Motor type	HSEP
		Motor power	240kw
		voltage	6600V
COG booster fan	2	Volume flow	16.6 m^3/s
		Fan rotational speed	1,790 rpm
		Total pressure rise	12018 Pa
		Motor Manufacture	Hyosung Corp
		Motor type	HSEP
		Motor power	450kw
		voltage	6600V

3.2 Deviations

3.2.1 Methodology Deviations

There is no deviation about methodology.

3.2.2 Project Description Deviations

According to the monitoring plan in the VCS PD, the quantity of electricity consumed by the project electricity consumption ($EC_{PJ,y}$),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>

FAN for COG

450kW X2 sets X 24hr X 365 days = 7,884,000 kWh/yr

Fan for LDG

240kW X 1 set X 24hrs X 365days = 2,102,400 kWh/yr

The amount of electricity consumption of booster fan is 9,986,400 kWh for a year (27.36MW per day). The monitoring period covers 997days. Therefore, total amount of the electricity consumption of booster fan is 27,277.92 MWh for the 4th monitoring period. Detail calculation can refer to 4.2 Data and Parameters Monitored.

As a result, the deviation of proposed project will not impacts the applicability of the methodology, additionality, or the appropriateness of the baseline scenario. The GHG emission has been calculated by conservative approach. The deviation approach was also applied for the previous monitoring periods and accepted by Verra.

3.3 Grouped Projects

This is not a grouped project activity.

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data / Parameter	$EF_{grid,OM,y}$
Data unit	tCO_2/MWh
Description	Operating Margin emission factor
Source of data	Refer to the registered PD
Value applied	0.7224
Justification of choice of data or description of measurement methods and procedures applied	The data calculation was done according to "Tool to calculate the emission factor for an electricity system".
Purpose of Data	Calculation of baseline emissions Calculation of project emissions
Comments	The value numbers were calculated around the time of the submission of the PD and would not change during the accreditation period.

Data / Parameter	$EF_{grid,BM,y}$
Data unit	tCO_2/MWh
Description	Build Margin emission factor

Source of data	Refer to the registered PD
Value applied	0.6059
Justification of choice of data or description of measurement methods and procedures applied	The data calculation was done according to "Tool to calculate the emission factor for an electricity system".
Purpose of Data	Calculation of baseline emissions Calculation of project emissions
Comments	The value numbers were calculated around the time of the submission of the PD and would not change during the accreditation period.

Data / Parameter	EF_y
Data unit	tCO_2/MWh
Description	Carbon emission factor of Korea National power grid
Source of data	"Refer to the registered PD"
Value applied	0.6641
Justification of choice of data or description of measurement methods and procedures applied	The data calculation was done according to "Tool to calculate the emission factor for an electricity system".
Purpose of Data	Calculation of baseline emissions Calculation of project emissions
Comments	The value numbers were calculated around the time of the submission of the PD and would not change during the accreditation period.

Data / Parameter	$COEF_{j,y}$
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

Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	-
Comments	-

Data / 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%
Justification of choice of data or description of measurement methods and procedures applied	Use as default values of 20% for project or leakage electricity consumption sources according to “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	NCV_i
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 attachment EF_{grid} calculation
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	-

4.2 Data and Parameters Monitored

Data / Parameter	$EG_{j,y}$
Data unit	MWh
Description	Quantity of electricity supplied to the grid by the project activity during the year *y*.
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 recorded every day and aggregated monthly
Value monitored	6,318,716.92
Monitoring equipment	Main meter M1 (old) Type : 3P4W110V5A Accuracy class : 0.2s Serial number : PT-0808A177-01 Main meter M1 (new,replaced on 29/10/2019) Type : ZMD402Q Accuracy class : 0.2s Serial number : 53934439 Main meter M2(old) Type : 3P4W110V5A Accuracy class : 0.2s Serial number : PT-08082A717-01 Main meter M2 (new,replaced on 29/10/2019) Type : ZMD402Q Accuracy class : 0.2s Serial number : 53934442 Main meter M3(old) Type : 3P4W110V5A

	Accuracy class : 0.2s Serial number : PT-0808A176-01 Main meter M3 (new,replaced on 29/10/2019) Type : ZMD402Q Accuracy class : 0.2s Serial number : 53934443 Main meter M4(old) Type : 3P4W110V5A Accuracy class : 0.2s Serial number : PT-0808A178-01 Main meter M4 (new,replaced on 29/10/2019) Type : ZMD402Q Accuracy class : 0.2s Serial number : 53934444 Backup meter M5 for M1 Type : 3P4W110V5A Accuracy class : 0.5s Serial number : 51001401 Backup meter M6 for M2 Type : 3P4W110V5A Accuracy class : 0.5s Serial number : 51001399 Backup meter M7 for M3 Type : 3P4W110V5A Accuracy class : 0.5s Serial number : 51001400 Backup meter M8 for M4 Type : 3P4W110V5A Accuracy class : 0.5s Serial number : 51001398
QA/QC procedures to be applied	The amount of power generation is crosschecked with the Electricity Transation Notes (ETNs). The meters are calibrated at average of every 3.5 years(with error testing at the 4th year and calibrating at

	<table><tr><td rowspan="2">Meter</td><td colspan="2">Calibration</td><td rowspan="2">Calibration Entity</td></tr><tr><td>Date of calibration</td><td>Valid until</td></tr><tr><td rowspan="2">M1(old)</td><td>24/03/2015</td><td>23/03/2019</td><td rowspan="20">Korea Testing Certification(KTC)</td></tr><tr><td>10/12/2018</td><td>09/12/2022</td></tr><tr><td>M1(new)</td><td>17/10/2019</td><td>16/10/2023</td></tr><tr><td rowspan="2">M2(old)</td><td>03/07/2015</td><td>02/07/2019</td></tr><tr><td>30/07/2019</td><td>29/07/2022</td></tr><tr><td>M2(new)</td><td>17/10/2019</td><td>16/10/2023</td></tr><tr><td rowspan="2">M3(old)</td><td>26/08/2015</td><td>25/08/2019</td></tr><tr><td>30/07/2019</td><td>29/07/2022</td></tr><tr><td>M3(new)</td><td>17/10/2019</td><td>16/10/2023</td></tr><tr><td rowspan="2">M4(old)</td><td>24/08/2015</td><td>23/08/2019</td></tr><tr><td>30/07/2019</td><td>29/07/2022</td></tr><tr><td>M4(new)</td><td>17/10/2019</td><td>16/10/2023</td></tr><tr><td rowspan="2">M5</td><td>24/03/2015</td><td>23/03/2019</td></tr><tr><td>10/12/2018</td><td>09/12/2022</td></tr><tr><td rowspan="2">M6</td><td>03/07/2015</td><td>02/07/2019</td></tr><tr><td>16/07/2019</td><td>15/07/2022</td></tr><tr><td rowspan="2">M7</td><td>26/08/2015</td><td>25/08/2019</td></tr><tr><td>16/07/2019</td><td>15/07/2022</td></tr><tr><td rowspan="2">M8</td><td>24/08/2015</td><td>23/08/2019</td></tr><tr><td>16/07/2019</td><td>15/07/2022</td></tr></table> the 7th year). The latest dates of calibration for the meters are as follows:
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	$EC_{PJ,y}$
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	27,277.92
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	-
Purpose of the data	Calculation of project emissions
Calculation method	FAN for COG 450kW X2set X 24hr X 365 days = 7,884,000 kWh/yr Fan for LDG 240kW X 24hrs X 365days = 2,102,400 kWh/yr Total $EC_{PJ,y}$=(7,884,000+2,102,400)/365X(184+365+365+83)/1000=27,277.92MWh
Comments	-

Data / 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

<table>
<tr><td>Value monitored</td><td>1,872,433</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>Tag No.</th><th>Model</th><th>Uncertainty</th><th>Remark</th></tr>
<tr><td>10513239（old）</td><td>G4000</td><td>±0.5%</td><td>Has been replaced by new meters listed below in 2017.11.15</td></tr>
<tr><td>10513238 (old)</td><td>G4000</td><td>±0.62%</td><td>Has been replaced by new meters listed below in 2017.11.15</td></tr>
<tr><td>10524545-2017 (new)</td><td>SM-RI-X</td><td>±0.5%</td><td>New installed in 2017.11.15</td></tr>
<tr><td>10524546-2017 (new)</td><td>SM-RI-X</td><td>±0.5%</td><td>New installed in 2017.11.15</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>The meters would be calibrated by LNG supplier when the meter is at abnormal condition. Consumption recordings crosschecked with invoices.</td></tr>
<tr><td>Purpose of the data</td><td>Calculation of project emissions</td></tr>
<tr><td>Calculation method</td><td>-</td></tr>
<tr><td>Comments</td><td>-</td></tr>
</table>

Data / 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[8]
Description of measurement methods and procedures to be	IPCC default values at the upper limit of the uncertainty at a 95% according to "Tool to calculate

[8] The NCV_i is used only in calculating project emission caused by LNG consumption. And in the calculation for EF_{OM} and EF_{BM}, the specific NCV of LNG for each power plant was adopted.

applied	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	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	In project PDD, the source of NCV_i was KOREA GAS CORPORATION, but the project owner did not record the value of NCV_i during the monitoring period, so for conservative approach, according to "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"IPCC default values at the upper limit of the uncertainty at a 95% was considered.

Data / Parameter	$EF_{CO2,i,y}$
Data unit	kgCO2/TJ
Description	CO2 emissions factor for LNG.
Source of data	*IPCC 2006*
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	58,300
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	The value will be upgraded when the value in IPCC

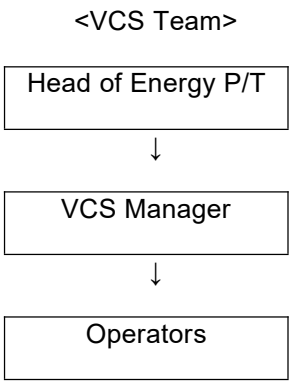
	changed.

Data / Parameter	Energy balance of Hyundai Steel Mill
Data unit	-
Description	Energy balance of Hyundai Steel Mill
Source of data	Energy balance provided by project owner
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	-
Value monitored	See APPENDIX 1
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	See APPENDIX 1
Calculation method	-
Comments	-

4.3 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 an 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 ER calculation. - Calculation of annual GHG emissions reduction and documentation of monitoring report, and report to Head of Energy P/T.
Operator	Operation of facilities and logging. - 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.

The location of monitoring equipment and monitoring points are as flows:

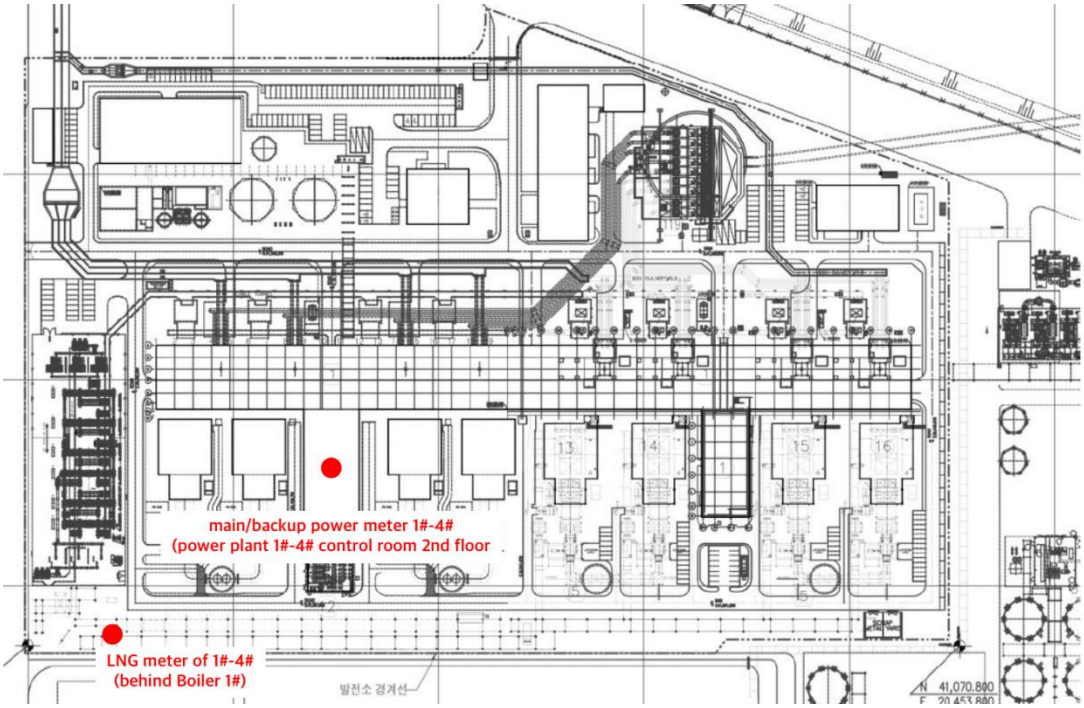


Figure 5. Location of monitoring equipments

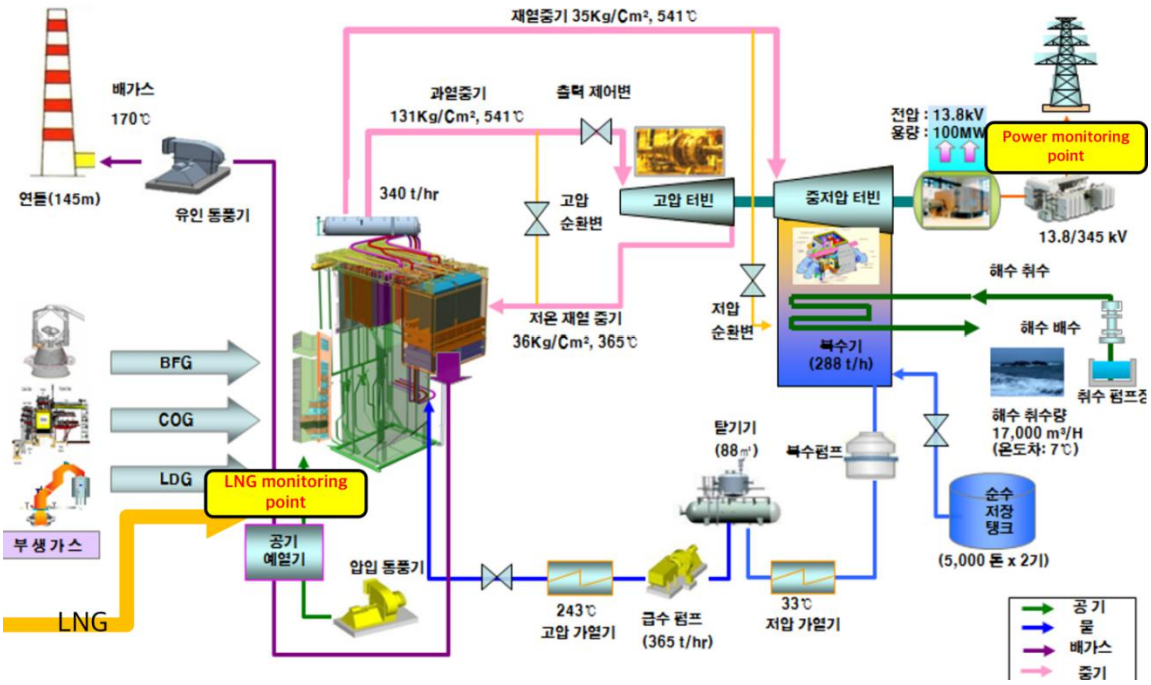


Figure 6. monitoring points

1.2 Cross checking

The amount of power generation and LNG consumption is crosschecked with the receipt, if there is any deference between monitored data and receipt, the reason of the deference 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.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 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 tCO_2.
$BE_{Ther,y}$	Baseline emissions from thermal energy (due to heat generation by elemental processes) during the year y (tCO_2).

(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* (tCO_2)
$EG_{i,j,y}$	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 CO_2 emission factor for the electricity source *i* (gr for the grid), displaced due to the project activity, during the year *y* (tCO_2/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 $EF_{elec,i,j,y}$= $EF_{y,}$. The CO_2 emission factor of the electricity EF_y was calculated following the guidance provided in the "Tool to calculate the emission factor for an electricity system".

The result of EF_y *is 0.6641*(tCO_2/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:

$$BE_y = BE_{En,y} + BE_{flst,y}$$

$$= BE_{Elec,y} + BE_{Ther,y} + BE_{flst,y}$$

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

= 1×1×6,318,716.92MWh×0.6641 tCO_{2e}/MWh+0+0

= 4,196,260 (tCO2e)

Calculation of Baseline emission reductions by years:

year	f_{cap}	f_{wcm}	$EG_{j,y}$ (MWh)	EF_y (tCO_{2e}/MWh)	$BE_{Elec,y}$ (tCO_{2e})	$BE_{Ther,y}$ (tCO_{2e})	$BE_{flst,y}$ (tCO_{2e})	BE_y (tCO_{2e})
2017.7.1-2017.12.31	1	1	1,186,837.50	0.6641	788,179	0	0	788,179
2018	1	1	2,290,416.28	0.6641	1,521,065	0	0	1,521,065
2019	1	1	2,501,835.15	0.6641	1,661,469	0	0	1,661,469
2020.1.1-2020.3.23	1	1	339,628.00	0.6641	225,547	0	0	225,547
Total	/	/	6,318,716.92	/	4,196,260	/	/	4,196,260

Detail information for calculation of Baseline Emission calculation can be found in the excel file attachment of "4th_ER calculation sheet for Hyundai phase II monitoring".

5.2 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.

$$PE_y = PE_{AF,y} + PE_{EL,y} \quad (4)$$

Where:

PE_y The total project emissions during the year y

$PE_{AF,y}$ 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

$PE_{EL,y}$ Project activity 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)

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:

$$PE_{AF,j,y} = \sum_i AF_{i,j,y} \times NCV_{i,y} \times EF_{CO2,i,y} \quad (5)$$

= 1,872,433Nm^3 X 1000 / 22.4L/mol X 16g/mol / 10^9 X 50.4 TJ/Gg X 58,300kgCO_2/TJ

= 1.3375 Gg X 50.4 TJ/Gg X 58,300kgCO_2/TJ

= 3,930 tCO_2e

Where:

$AF_{i,j,y}$	LNG consumed on-site for power generation
NCV_i	Net calorific value for fuel LNG
$EF_{CO2,i,y}$	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

Calculation of $PE_{AF,y}$ by years

Year	$AF_{i,j,y}$ (Nm^3)	$AF_{i,j,y}$ (Gg)	NCV_i (TJ/Gg)	$EF_{CO2,i,y}$ (kgCO2/TJ)	$PE_{AF,y}$ (tCO_2e)
2017.7.1-2017.12.31	708,040	0.5057	50.4	58,300	1,486
2018	685,506	0.4896	50.4	58,300	1,439
2019	57,433	0.0410	50.4	58,300	121

2020.1.1-2020.3.23	421,454	0.3010	50.4	58,300	885
Total	1,872,433	1.3375	/	/	3,930

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

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

= 27,277.92 MWh X 0.6641 tCO_2/MWh X(1+0.2)

= 21,738 tCO2e

Where:

$PE_{EL,y}$	Project emissions from electricity consumption in year y (tCO_2/yr)
$EC_{PJ,j,y}$	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 (tCO_2/MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source j in year y

Calculation of $PE_{EL,y}$ by years

Year	$EC_{PJ,j,y}$ (MWh)	$EF_{EL,j,y}$ (tCO2/MWh)	$TDL_{j,y}$	$PE_{EL,y}$ (tCO_{2e})
2017.7.1-2017.12.31	5034.24	0.6641	20%	4,012

2018	9,986.40	0.6641	20%	7,958
2019	9,986.40	0.6641	20%	7,958
2020.1.1-2020.3.23	2,270.88	0.6641	20%	1,810
Total	27,277.92	0.6641	20%	21,738

Calculation of Project emission reductions:

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

$$PE_y = PE_{AF,y} + PE_{EL,y}$$

$$= \sum_i AF_{project,i,y} \times NCV_i \times EF_{CO2,i,y} + PE_{EL,y}$$

= 3,930 +21,738

= 25,668 (tCO_2e)

Calculation of Project emission reduction by years

Year	$PE_{AF,y}$ (tCO_2e)	$PE_{EL,y}$ (tCO_2e)	PE_y (tCO_2e)
2017.7.1-2017.12.31	1,486	4,012	5,498
2018	1,439	7,958	9,397
2019	121	7,958	8,079
2020.1.1-2020.3.23	885	1,810	2,694
Total	3,930	21,738	25,668

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

5.3 Leakage

In accordance with ACM 0012, no leakage is considered.

5.4 Net GHG Emission Reductions and Removals

Emission Reduction of the proposed project can be determined as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (7)$$

= 4,196,260 – 25,668 – 0

= 4,170,592 tCO_2e/yr

This monitoring period started from 01/07/2017 to 23/03/2020, with totally 997 days. Based on the annual estimated emission reductions from the registered VCS PD, the amount of emission reductions for this monitoring period would be 1,774,699 tCO_2e/ 365 days × 997 days = 4,847,602 tCO_2e. The actual emission reductions in this monitoring period (997 days) are 4,170,592 tCO_2e, which is 13.96% less than the estimated value in the revised PDD. It is because the waste gas supplier Hyundai steel supplied less waste gas than expected. According to energy balance (see APPENDIX 1), Hyundai was supposed to supply 54.3%[9] of total waste gas to the proposed project. But the real ratio of waste gas supply to the proposed project was 34.98%, 31.32%, 33.65% and 27.13% in 2017-2020. So, it is reasonable that during this monitoring period, the actual emission reduction is less than the estimated value.

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2017.7.1-2017.12.31	788,179	5,498	0	782,681
2018	1,521,065	9,397	0	1,511,668
2019	1,661,469	8,079	0	1,653,390
2020.1.1-2020.3.23	225,547	2,694	0	222,853
Total	4,196,260	25,668	-	4,170,592

[9] 54.3% =1- 45.7%

APPENDIX 1: INFORMATION 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/h)	Percentage	Amount (Gcal/h)	Percentage	Amount (Gcal/h)	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 2017.7~2017.12>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	347,978	11.15%	2,773,625	88.85%	3,121,604	100%
BFG	2,293,434	45.97%	2,695,983	54.03%	4,989,417	100%
LDG	375,929	72.87%	139,973	27.13%	515,902	100%
Total	3,017,341	34.98%	5,609,582	65.02%	8,626,923	100%

<The actual energy balance in 2018>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	804,931	12.29%	5,743,134	87.71%	6,548,065	100%
BFG	4,134,272	40.94%	5,964,687	59.06%	10,098,959	100%
LDG	629,184	55.65%	501,515	44.35%	1,130,699	100%
Total	5,568,387	31.32%	12,209,337	68.68%	17,777,723	100%

<The actual energy balance in 2019>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage

COG	896,047	13.45%	5,767,613	86.55%	6,663,660	100%
BFG	4,571,943	43.70%	5,891,216	56.30%	10,463,160	100%
LDG	693,054	58.61%	489,468	41.39%	1,182,522	100%
Total	6,161,045	33.65%	12,148,297	66.35%	18,309,342	100%

<The actual energy balance in 20201.1~2020.03.23>

Waste Gas	For Hyundai Greenpower		For alternative uses (Hyundai Steel)		Total	
	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage	Amount (Gcal)	Percentage
COG	137,464	8.74%	1,435,676	91.26%	1,573,140	100%
BFG	945,072	35.46%	1,720,405	64.54%	2,665,476	100%
LDG	129,046	56.62%	98,887	43.38%	227,933	100%
Total	1,211,581	27.13%	3,254,967	72.87%	4,466,549	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 2017 to 2020 are 65.02%, 68.68%, 66.35% and 72.87%. 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)
2017.7.1-2017.12.31	191,797.25	68,000	848.16
2017.8	199,012.55	49,975	848.16
2017.9	214,968.27	17,526	820.80
2017.10	193,985.52	44,229	848.16
2017.11	187,058.13	438,106	820.8
2017.12	200,015.78	90,204	848.16
2018.1	180,182.81	432,078	848.16
2018.2	153,712.26	121,285	766.08
2018.3	154,703.32	5,525	848.16
2018.4	157,740.65	30,576	820.80
2018.5	174,411.92	19,427	848.16
2018.6	195,208.01	12,973	820.8
2018.7	252,583.11	2,847	848.16
2018.8	208,689.88	1,286	848.16
2018.9	241,675.20	766	820.80
2018.10	233,168.90	11,214	848.16
2018.11	156,233.16	6,045	820.80
2018.12	182,107.03	41,484	848.16
2019.1	176,394.39	8,644	848.16
2019.2	169,811.27	4,726	766.08
2019.3	228,031.71	2,486	848.16
2019.4	205,996.87	7,065	820.80
2019.5	187,069.50	-	848.16
2019.6	217,594.63	-	820.80
2019.7	205,288.15	-	848.16
2019.8	217,815.42	-	848.16

2019.9	231,767.38	5,351	820.80
2019.10	254,103.97	3,061	848.16
2019.11	233,040.35	26,100	820.80
2019.12	174,921.50	-	848.16
2020.1	189,147.00	24,457	848.16
2020.2	150,481.00	275,605	793.44
2020.3.1- 2020.3.23	109,604.62	121,392	629.28
Total	6318716.92	1,872,433	27,277.92