

MONITORING REPORT OF SIAM CEMENT BIOMASS PROJECT



Document Prepared By South Pole Carbon Asset Management Ltd.

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

This grouped project is a combination of five GHG reduction projects in the same sectoral scope and methodology. All project activities in this group involve partial replacement of fossil fuels by alternative fuels or less carbon intensive fuels such as biomass residue in cement manufacture. As per UNFCCC guideline for the CDM project, the proposed projects can be categorized as large-scale project on sectoral scope No.4 “Manufacturing Industries”.

Each project site is illustrated as follows:

- The Siam Cement (Ta Luang) Co., Ltd (Ta Luang).
- The Siam Cement (Ta Luang) Co., Ltd (Khao Wong).
- The Siam Cement (Kaeng Khoi) Co., Ltd.
- The Siam Cement (Thung Song) Co., Ltd.
- The Siam Cement (Lampang) Co., Ltd.

They are the cement manufactures holding by SCG Cement Co., Ltd. under Siam Cement Group. The address for each site and installation capacity is shown in the table below:

Table 1 : The detail of project participants

Name of participants	Name of the cement plant	Production capacity (tons/day)	Site location
The Siam Cement (Kaeng Khoi) Co.,Ltd.	The Siam Cement (Kaeng Khoi)	19,000	Kaeng Khoi , Saraburi
The Siam Cement (Ta Luang) Co.,Ltd.	The Siam Cement (Ta Luang)	8,000	Ta Luang , Saraburi
The Siam Cement (Ta Luang) Co.,Ltd.	The Siam Cement (Khao Wong)	10,500	Khao Wong , Saraburi
The Siam Cement (Lampang) Co.,Ltd.	The Siam Cement (Lampang)	5,500	Chaehome , Lampang
The Siam Cement (Thung Song) Co.,Ltd.	The Siam Cement (Thung Song)	16,000	Thungsong , Nakorn Sri Thammarat

All cement plants have invested into infrastructure including storage and handling system for alternative fuels and biomass residue.

By means of this monitoring report GHG reductions achieved by the project activities of this proposed grouped project are being verified and certified as per requirements of the Voluntary Carbon Standard (VCS) under monitoring methodology approved by UNFCCC; the ACM0003 version 07.2.

This is the 5th and the last verification of this project for the 1st crediting period. Details of previous monitoring periods are listed below. All monitoring and verification reports are available on the VCS registry.

- 1st monitoring period : 01/04/06 to 30/09/09 , verification report issued date 11/06/10;
- 2nd monitoring period : 01/10/09 to 28/02/11 , verification report issued date 14/12/11;
- 3rd monitoring period : 01/03/11 to 31/12/12 , verification report issued date 23/07/13;
- 4th monitoring period : 01/01/13 to 31/12/13 , verification report issued date 23/09/14.

Further background information on all project activities in the group can be found in the VCS Project Description (PD) and associated documents which are available on the VCS website: http://vcsprojectdatabase.org/#/project_details/403

The total GHG emission reductions generated in this monitoring period from this group of project activities are 567,310 tCO₂e.

1.2 Sectoral Scope and Project Type

The project is a grouped project with a combination of five GHG reduction projects located in five different cement manufacturing units which are listed in paragraph 1.1. All project activities in this group involve partial replacement of fossil fuels by alternative fuels or less carbon intensive fuels in cement manufacturer. As per UNFCCC guideline for the CDM project, the proposed projects can be categorized as large-scale project on sectoral scope No.4 “Manufacturing Industries”

In accordance with the Voluntary Carbon Standard Program Guidelines, clause 5.2 (Group Projects), SCG Cement Co. Ltd will be responsible for the centralized GHG information system and controlling all associated with the project and its monitoring.

The project activity is not AFOLU project.

1.3 Project Proponent

Organization name	The Siam Cement (Kaeng Khoi) Co.,Ltd.
Contact person	Somkiat Pananookooln Chanwut Limpichai
Title	Managing Director Energy Manager
Address	1 Siam Cement Road , Bangsue Bangkok , Thailand 10800
Telephone	+662 586 5684
Email	chanwutl@scg.co.th

Organization name	The Siam Cement (Ta Luang) Co.,Ltd.
Contact person	Sira Srisukri Chanwut Limpichai
Title	Managing Director Energy Manager
Address	1 Siam Cement Road , Bangsue Bangkok , Thailand 10800
Telephone	+662 586 5684
Email	chanwutl@scg.co.th

Organization name	The Siam Cement (Lampang) Co.,Ltd.
Contact person	Sunit Kessuwan Chanwut Limpichai
Title	Managing Director Energy Manager
Address	1 Siam Cement Road , Bangsue Bangkok , Thailand 10800
Telephone	+662 586 5684
Email	chanwutl@scg.co.th

Organization name	The Siam Cement (Thung Song) Co.,Ltd.
Contact person	Nantapong Chantrakul Chanwut Limpichai
Title	Managing Director Energy Manager
Address	1 Siam Cement Road , Bangsue Bangkok , Thailand 10800
Telephone	+662 586 5684
Email	chanwutl@scg.co.th

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd.
Role in the project	Carbon credit consultant
Contact person	Ingo Puhl
Title	Mr.
Address	Technoparkstrasse 1 , Zurich , Switzerland 8005
Telephone	+66 2 678 8979
Email	i.puhl@southpole.com

1.5 Project Start Date

Table 2 : The start date of projects

Project site	Start Date
The Siam Cement (Kaeng Khoi)	04-10-02
The Siam Cement (Ta Luang)	15-10-02
The Siam Cement (Khao Wong)	30-09-04
The Siam Cement (Lampang)	30-04-04
The Siam Cement (Thung Song)	19-01-03

1.6 Project Crediting Period

The crediting period of this project activity is ten years, starting from 01 April 2006 to 31 March 2016.

1.7 Project Location

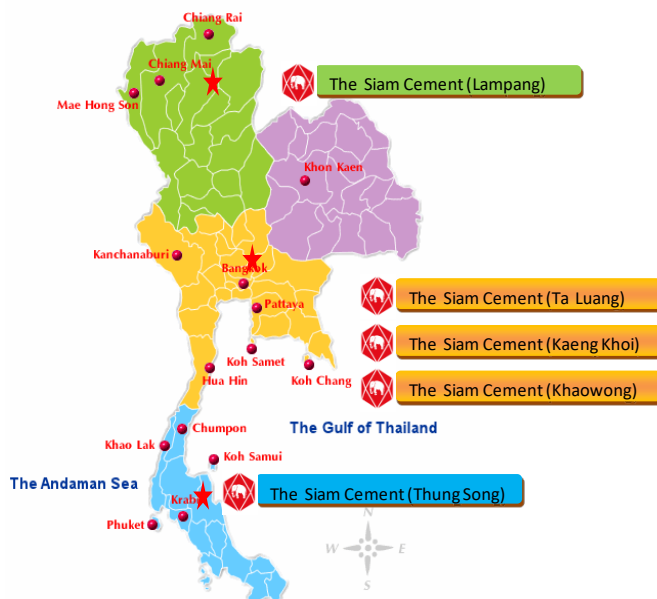
Details of the project locations, both physical address and geographical location, are presented in Table 3 and Table 4.

Table 3 : The address of projects

Project site	Address
The Siam Cement (Kaeng Khoi)	33/1 Moo3, Tambon Ban Pa, Kaeng Khoi District, Saraburi, 18110, Thailand
The Siam Cement (Ta Luang)	1 Moo 9, Tambon Ban Krao, Ban Mor District, Saraburi, 18270, Thailand
The Siam Cement (Khao Wong)	28 Moo 9, Tambon Khaowong, Phraputtabat District Saraburi 18120, Thailand
The Siam Cement (Lampang)	279 Moo 5, Tambon Bansa, Chaehom District, Lampang ,52120, Thailand
The Siam Cement (Thung Song)	52 Moo 6, Tambon Teewang, Thung Song District, Nakon Si Thammarat, 80110, Thailand

Table 4 : The geographic coordinate of project locations

Project site	Latitude	Longitude
The Siam Cement (Kaeng Khoi)	14°36'33.59"N	100°59'46.88"E
The Siam Cement (Ta Luang)	14°34'10.00"N	100°45'56.10"E
The Siam Cement (Khao Wong)	14°45'08.56"N	100°47'15.21"E
The Siam Cement (Lampang)	18°33'22.66"N	99°34'23.08"E
The Siam Cement (Thung Song)	8° 6' 1.20" N	99° 41' 2.50" E


Figure 1 : The project locations in Thailand

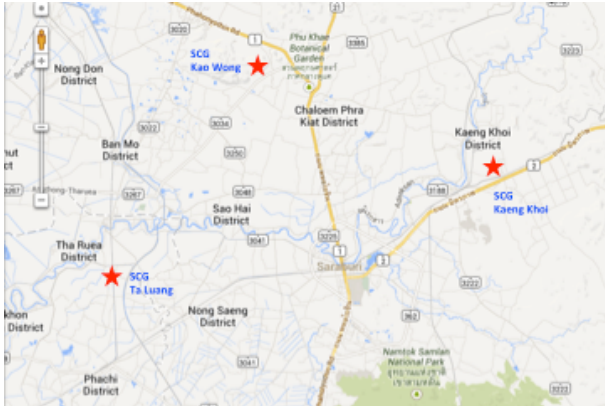


Figure 2 : Project locations in Saraburi Province



Figure 3 : Project location in Lampang Province



Figure 4 : Project location in Nakorn Sri Thammarat Province

1.8 Title and Reference of Methodology

These project activities shall be carried out for the cement manufacturing industry, which can be categorized within the sectoral scope and methodology shown below.

Sectoral scope : No.04 “*Manufacturing Industries*”
Methodology : ACM0003 Version 07.2

1.9 Other Programs

Not Applicable

1.10 Sustainable Development

The Siam Cement Group (SCG) has very strong portfolio in Sustainable Development. SCG conducts its business with sustainability throughout the entire supply chain. The examples of on-going projects regarding the sustainability development are presented below.

- In area of empowerment and enhancing quality of life of the community and society, SCG has scaled up the successful implementation of SCG Conserving Water for Tomorrow project add the Innovative Technology for Remediation of Saline Land project by setting up two Community Learning Centers to showcase good practice ad lesson learnt. Titled ‘Satanee Plook Khid Pun Sukh’ (instilling thinking and sharing happiness station), these community-based Learning Centers located in Nakornratchasima and Lampang provinces serve as on-site learning facilities for those interested in community empowerment on sustainable livelihoods.
- SCG foundation¹ ‘Power of Wisdom’ which SCG has cooperated with other partners namely ‘Man Pattana Foundation’ , to develop and offer a curriculum to train community leaders , opinion leaders , military officers and farmers , with a view to modernizing their paradigm with emphasis on logical thinking , problem-solving skill and self-sufficiency.
- In recognition of its commitment to sustainable business practice , SCG maintains its top ranking position in the Construction Materials Industry of Dow Jones Sustainability Indices for the 1st consecutive year. SCG strives to improve its transparency in disclosing information further, by committing to using global accepted sustainability reporting guidelines , the 4th generation of the Global Reporting Initiative (GRI-G4)

The information of Sustainability Performance data , SCG ECO Value and Sustainability Report , which will be updated on annually basis , is available for public under the ‘Sustainability Development’ session on its website².

¹ <http://www.scgfoundation.org/>

² http://www.scg.com/en/05sustainability_development/

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The project has been implemented as per the initial project design mentioned in the registered VCS PD. The main processes and equipment for biomass feeding system are not modified or changed from original design. The biomass processing and preparation is different at each site depending on the type of main biomass residue used at the site.

- The installation of fluidized bed gasifier at Lampang site and solid waste pre-treatment plant at Kaeng Khoi site, occurred in the previous monitoring periods were considered as project design change. No emission reductions have been claimed from these two sites. Both project sites have been excluded from emission reduction calculations since the implementation of the new units, the same approach from the previous verifications is also applicable for this monitoring period.
- At Ta Luang and Khao Wong site, as a result of expensive biomass (rice husk) price due to very high demand in market from the promoting of biomass power plants in Thailand, as well as the difficulty in biomass supply sourcing. The decision to stop using of biomass in cement production was announced in 2015. Therefore, these two sites are excluded from emission reduction calculations, from 2015 onwards.

2.2 Deviations

2.2.1 Methodology Deviations

Deviation 1

Description of deviation

The $P_{\text{clinker},y}$ is not monitored by the weight feeder.

Deviated approach

The daily clinker production is calculated from the amount of raw meal and clinker factor. The summary of daily clinker production in a month is adjusted by the stock checking data at the end of month and reported in the Work Journal.

Justification of deviated approach

Since the amount of clinker production cannot be directly measured because of its high temperature. The amount the raw meal which is directly measured by weight feeder and the clinker factor is used for calculating the clinker production.

- The amount of raw meal is continuously monitored by the weight feeder and the data is recorded on daily basis.
- The clinker factor is from the result of LOI (Lost of Ignition) , % ash , % dust loss and moisture content from internal laboratory.³

³ The work instruction ; W-P-W1-001 is provided as the example of procedure to calculate the clinker production (page 21).

- The amount clinker produced in the stock checking report is from the truck scale and the available stock of clinker in the cement factory.
- The calculated amount of clinker produced is cross-checked and adjusted with the stock checking information on monthly basis to ensure the accuracy of the figures presented in the Work Journal.

This approach can improve the accuracy and reliability of monitoring data measured from monitoring devices. It was also applied for previous verifications and does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario.

Deviation 2

Description of deviation

The quantity of biomass residue type k is the additional monitored parameter in this monitoring period.

Deviated approach

The biomass residue type k is the parameter, which needs to be monitored according to ACM0003 version 07.2. This parameter is monitored based on public available data for available biomass to apply leakage estimation as per the methodological approach.

Justification of deviated approach

This parameter is applicable if approach L₂ is used to estimate the leakage emissions. It is additional monitored parameter from the registered PD which required to be monitored as per methodology. This additional monitored parameter can increase the precision of emission reduction calculation. This approach was also applied for previous verifications and does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario.

Deviation 3

Description of deviation

The quantity of electricity consumed by project is the additional monitored parameter in this monitoring period.

Deviated approach

The EC_{PJ,y} is the parameter which needs to be monitored according to ACM0003 version 07.2.

Justification of deviated approach

This parameter is used for calculating the CO₂ emissions from on-site electricity consumption by "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" It is additional monitored parameter from the registered PD which required to be monitored as per methodology. This additional monitored parameter can increase the precision of emission reduction calculation. This approach was also applied for previous verifications and does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario.

Deviation 4Description of deviation

The quantity of alternative fuel type k for biomass handling, $FC_{i,j,y}$ is the additional monitored parameter in this monitoring period. However, the monitoring method is not in line with the *Tool to calculate project or leakage CO₂ emission from fossil fuel combustion*.

Deviated approach

As per the tool, the diesel oil usage for internal biomass handling must be continuously monitored by using mass or volume meter. Since the internal biomass transfer activity is response by contractor. The project owner cannot directly monitor this parameter. The contractor will report the diesel oil consumption to the project owner, at least on yearly basis. The purchasing invoice can be used for cross-checking the consumption reported by contractor.

Justification of deviated approach

As per FAR 01 from the 3rd verification, the monitoring plan of this parameter is not in line with the tool so this FAR has been opened for the 4th verification. Although the monitoring description is not followed the tool. However, the purchasing invoice can be used for cross-checking as per QA/QC description determined in the tool. Hence, this approach can give the accurate data for emission reduction calculation. In additionally, it does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario.

Deviation 5Description of deviation

The average truck load of the trucks used during the year y, TL_y is the not monitored parameter in this monitoring period.

Deviated approach

As per the methodology, this parameter is continuously monitored from transportation data logs. Since this data is not collected at project sites. The maximum truck load allowed by Transportation regulation of Thailand is used for emission reduction calculation.

Justification of deviated approach

Since the 15 tonnes is the maximum allowance so the actual data must be always less than 15 tonnes. It is in line with conservativeness principle since it gives the higher project emissions.

2.2.2 Project Description Deviations

Deviation 1

Description of deviation

The two sites at Kaeng Khoi and Lampang are excluded from the whole monitoring period. And two sites in Saraburi province, Ta Luang and Khao Wong are excluded from 2015 onwards.

- There was the design change in Lampang site. The fluidized bed gasifier has been installed for utilization of low grade lignite. This gasification process is not included in the baseline scenario and the low grade lignite was not utilized before the installation of this gasifier. Hence, the emission reduction achieved from Lampang site is neglected in this monitoring period.
- The solid waste pre-treatment plant has been installed at Kaeng Khoi site by SCI Eco Services Company. The objective of this project is for increasing the amount of solid waste to be fired at cement kiln. This project has been commissioned at the end of year 2010 and fully operated in 2011. This additional unit is considered as design change. Since in the registered PD, only biomass is used as the alternative fuels at this site. This solid waste unit is not identified in the registered PD. Hence, the emission reduction achieved from Kaeng Khoi site is neglected in this monitoring period.
- In Saraburi province, which is one of the largest rice husk supply source in Thailand, the price of rice husk has been rapidly increased from the promoting of the biomass power plant in this region. Most of rice mills start to install their own power plant. While the price of fossil fuels has been decreased. The decision to stop using the rice husk as well as other biomass residues is effective in 2015 for 2 cement factories under Siam Cement (Ta Luang) Co.,Ltd.. The emission reductions achieved from Ta Luang and Khao Wong in this verification are from monitoring period in 2014.

This approach to exclude some project sites was also applied for previous verifications which is conservative choice and does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario.

2.3 Grouped Project

There is no new instance in this grouped project activities during this monitoring period.

2.4 Safeguards

2.4.1 No Net Harm

Not Applicable.

2.4.2 Local Stakeholder Consultation

Stakeholder consultation was carried out by the project owner at all sites which was reported in the EIA report. The consultation included an explanation of the project activity to the participants.

Place and date of meeting

Stakeholder consultation was held at each site on the date shown below. Participants were able to examine the location where the proposed project will be taken place.

Project site	Stakeholders consultation date
The Siam Cement (Kaeng Khoi)	22/11/1999
The Siam Cement (Ta Luang)	01/11/1999
The Siam Cement (Khao Wong)	23/12/1999
The Siam Cement (Lampang)	27/09/2001
The Siam Cement (Thung Song)	22/02/2002

Meeting participants

The participants in these meeting included local residents, local government officers, local shopkeepers and other members of the community.

Language

Documentation and meeting were conducted in Thai (local language).

Meeting procedures

- Purpose of consultation
- Description of the project and its environmental impacts
- General feedback

Summary of the comments received

After the meeting, participants were afforded the opportunity to ask questions regarding the project activity. The overall response to the project was encouraging and positive to local environment and social-economic conditions i.e. the stakeholders appreciate the wastewater and biomass treatment in a more efficient way in which irritable odour can be avoided while creating new jobs. In all, no adverse reactions, comments, or clarifications were received during the Stakeholder Consultation process. The project participants did not recognize any need to make changes to the project design or monitoring plans.

Current practice

Siam Cement Group (SCG) has implemented the Stakeholder Engagement by announcing the stakeholder practice policy in 2014 , to set up a clear practice guideline for each stakeholder group⁴.

⁴ http://www.scg.com/en/05sustainability_development/stakeholder-engagement.html

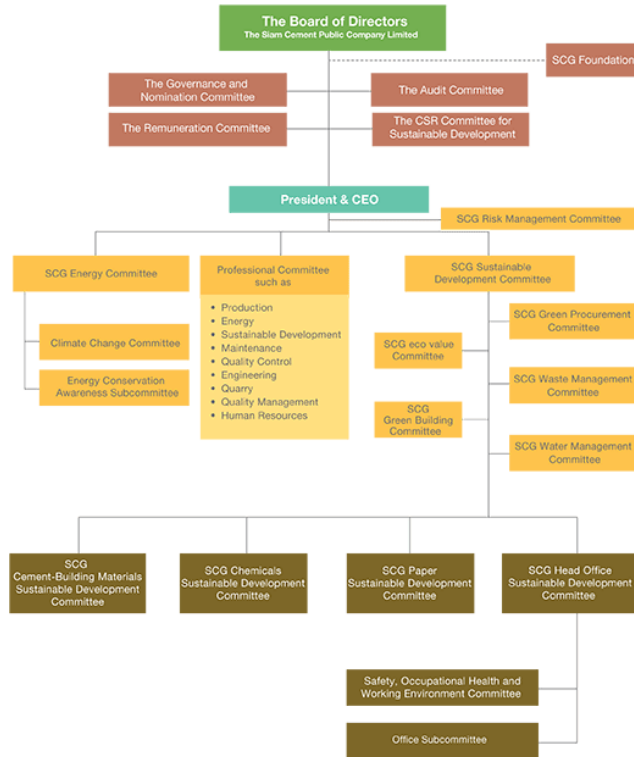


Figure 5: Sustainability management structure including CSR



Figure 6: Stakeholder Engagement Overview

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	$FC_{i,x}$, $FC_{i,x-1}$, and $FC_{i,x-2}$
Data unit	ton
Description	Quantity of fossil fuel of type i used in the project plant in year x, x-1 and x-2 where x is the year prior to the start of the project activity and i are the fossil fuel types used in the project plant in the three years prior to the start of the project activity.
Source of data	Three years data from fuel consumption work journal at the project site.
Value applied:	Presented in Table 16 and Table 17
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	$FC_{BL,F3,i,y}$
Data unit	ton
Description	Quantity of fossil fuel type i that would in the absence of the project activity be used in the project plant according to the selected baseline scenario F3 in year y.
Source of data	Fuel consumption work journal at the project site
Value applied:	Presented in Table 16 and Table 17
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of the data	Calculation of baseline emissions
Comments	Only applicable if F3 has been determined as the most likely baseline scenario.

Data / Parameter	$P_{\text{clinker},x}$, $P_{\text{clinker},x-1}$, and $P_{\text{clinker},x-2}$
Data unit	ton
Description	Production of clinker in year x, x-1 and x-2 where x is the year prior to the start of the project activity.
Source of data	Three years data from production data logs at the project site.
Value applied:	Presented in Table 16 and Table 17
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	NCV_i
Data unit	GJ/ton
Description	Net calorific value of fossil fuel types i where i is the fossil types used in the project plant in the three years prior to the start of the project activity.
Source of data	Since the values provided by the fuel supplier in invoices is not available, then the value measured by the project participants is taken.
Value applied:	Presented in Table 16 and Table 17
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	$EF_{\text{CO}_2, \text{FF}, i}$
Data unit	tCO ₂ /GJ
Description	Weighted average CO ₂ emission factor for fossil fuel type i where i are the fossil types used in the project plant in the last three years prior to the start of the project activity.
Source of data	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in the table 1.4 of Chapter 1 of Vol.

	2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventory are taken for calculation																																							
Value applied:	<table><tr><th>Fuel Type</th><th>Unit</th><th>Lower</th><th>Upper</th></tr><tr><td colspan="4">Fossil</td></tr><tr><td>Coal</td><td>tCO₂/TJ</td><td>92.80</td><td>100.00</td></tr><tr><td>Coke</td><td>tCO₂/TJ</td><td>82.90</td><td>115.00</td></tr><tr><td>Heavy fuel</td><td>tCO₂/TJ</td><td>75.50</td><td>78.80</td></tr><tr><td>Diesel oil</td><td>tCO₂/TJ</td><td>72.60</td><td>74.80</td></tr><tr><td>Lignite</td><td>tCO₂/TJ</td><td>90.90</td><td>115.00</td></tr><tr><td>Anthracite</td><td>tCO₂/TJ</td><td>94.60</td><td>101.00</td></tr><tr><td>Biodiesel</td><td>tCO₂/TJ</td><td>59.80</td><td>84.30</td></tr></table>				Fuel Type	Unit	Lower	Upper	Fossil				Coal	tCO ₂ /TJ	92.80	100.00	Coke	tCO ₂ /TJ	82.90	115.00	Heavy fuel	tCO ₂ /TJ	75.50	78.80	Diesel oil	tCO ₂ /TJ	72.60	74.80	Lignite	tCO ₂ /TJ	90.90	115.00	Anthracite	tCO ₂ /TJ	94.60	101.00	Biodiesel	tCO ₂ /TJ	59.80	84.30
Fuel Type	Unit	Lower	Upper																																					
Fossil																																								
Coal	tCO ₂ /TJ	92.80	100.00																																					
Coke	tCO ₂ /TJ	82.90	115.00																																					
Heavy fuel	tCO ₂ /TJ	75.50	78.80																																					
Diesel oil	tCO ₂ /TJ	72.60	74.80																																					
Lignite	tCO ₂ /TJ	90.90	115.00																																					
Anthracite	tCO ₂ /TJ	94.60	101.00																																					
Biodiesel	tCO ₂ /TJ	59.80	84.30																																					
Justification of choice of data or description of measurement methods and procedures applied	-																																							
Purpose of the data	Calculation of baseline emissions																																							
Comments	-																																							

3.2 Data and Parameters Monitored

Data / Parameter	FC _{PJ,k,y} and FC _{PJ,i,y}
Data unit	ton
Description	Quantity of alternative fuel or less carbon intensive fossil fuel type k (FC _{PJ,k,y}) and fossil fuel of type i (FC _{PJ,i,y}) used in the project plant in year y.
Source of data	Work Journal : WJ
Description of measurement methods and procedures to be applied	- The quantity of solid fossil fuel and biomass fuel is continuously monitored by weight scale equipment. The data from all inline measuring equipment is connected to Distributed Control System (DCS) at the control room. The data recording from DCS is carried out by cell operator on daily basis. - The fuel oil volume is continuously monitored by flow meter. The cell operators record the totalized flow at the flow meter before and after the operation of fuel oil supply pump. The daily monitored data is checked and adjusted with stock checking report at the end of month. The final figures are summarized in Work Journal (WJ) by engineer.
Frequency of monitoring/recording	Continuous monitoring with daily recording and adjusting with stock checking report at the end of month.

Value monitored:	Presented in Table 13 and Table 14 and Table 15
Monitoring equipment	Presented in Table 18 and Table 19 and Table 20
QA/QC procedures to be applied	- The monitoring equipment is calibrated according to calibration plan and/or shutdown plan of kiln. - The documentation and calibration is controlled and managed in accordance with ISO9001 requirements.
Purpose of the data	Calculation of baseline emissions
Calculation method	The amount of fuels for trial projects ⁵ which is not the normal operational used is not included in the ER calculation.
Comments	The information of monitoring equipment is provided in the calibration sheet of ER calculation spread sheet.

Data / Parameter	EF _{CO2,k,y}																																				
Data unit	tCO ₂ /GJ																																				
Description	Weighted average CO ₂ emission factor for biomass residue of type k (EF _{CO2,k,y}) and for fossil fuel of type i (EF _{CO2,FF,i}) in year y.																																				
Source of data	IPCC default values at the upper/lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories. For alternative fuels , the source of emission factor is from the CO₂ Accounting and Reporting Standard for the Cement Industry⁶ , provided by World Business Council for Sustainable Development.																																				
Description of measurement methods and procedures to be applied	-																																				
Frequency of monitoring/recording	-																																				
Value monitored:	<table><tr><th>Fuel Type</th><th>Unit</th><th>Lower</th><th>Upper</th></tr><tr><td colspan="4">Fossil</td></tr><tr><td>Coal</td><td>tCO₂/TJ</td><td>92.80</td><td>100.00</td></tr><tr><td>Coke</td><td>tCO₂/TJ</td><td>82.90</td><td>115.00</td></tr><tr><td>Heavy fuel</td><td>tCO₂/TJ</td><td>75.50</td><td>78.80</td></tr><tr><td>Diesel oil</td><td>tCO₂/TJ</td><td>72.60</td><td>74.80</td></tr><tr><td>Lignite</td><td>tCO₂/TJ</td><td>90.90</td><td>115.00</td></tr><tr><td>Anthracite</td><td>tCO₂/TJ</td><td>94.60</td><td>101.00</td></tr><tr><td>Biodiesel</td><td>tCO₂/TJ</td><td>59.80</td><td>84.30</td></tr></table>	Fuel Type	Unit	Lower	Upper	Fossil				Coal	tCO ₂ /TJ	92.80	100.00	Coke	tCO ₂ /TJ	82.90	115.00	Heavy fuel	tCO ₂ /TJ	75.50	78.80	Diesel oil	tCO ₂ /TJ	72.60	74.80	Lignite	tCO ₂ /TJ	90.90	115.00	Anthracite	tCO ₂ /TJ	94.60	101.00	Biodiesel	tCO ₂ /TJ	59.80	84.30
Fuel Type	Unit	Lower	Upper																																		
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Biodiesel	tCO ₂ /TJ	59.80	84.30																																		

⁵ The amount for these types of fuels is shown in the WJ but the heating value test is not carried out since the heat generated has no significant to the performance of combustion process.

⁶ <http://wbcsdcement.org/index.php/key-issues/climate-protection/co2-accounting-and-reporting>

	Alternative fossil fuel	Unit	Upper
	waste oil	tCO ₂ /TJ	74
	tyres	tCO ₂ /TJ	85
	plastics	tCO ₂ /TJ	75
	solvents	tCO ₂ /TJ	74
	impregnated saw dust	tCO ₂ /TJ	75
	mixed industrial waste	tCO ₂ /TJ	83
	other fossil based wastes	tCO ₂ /TJ	80
Monitoring equipment	-		
QA/QC procedures to be applied	Any future revision of the IPCC and WBCSD Guidelines will be taken into account.		
Purpose of the data	Calculation of project emissions		
Calculation method	-		
Comments	EF _{CO2,k,y} is zero for the biomass residues referred to page 29/40 ACM0003 version 07.2.		

Data / Parameter	NCV _{k,y} and NCV _{i,y}
Data unit	GJ/ton
Description	Weighted average net calorific value of the alternative or less carbon intensive fuel type k (NCV _{k,y}) and fossil fuel types i (NCV _{i,y}) in year y
Source of data	- The NCV analysis results from internal laboratory. - The NCV for HFO is from the test reports provided by supplier. - The National's default values , if the results from laboratory is not available.
Description of measurement methods and procedures to be applied	The fuel sample is analyzed by internal laboratory. The results are saved in QIS (Quality Information System) by lab analyst.
Frequency of monitoring/recording	This parameter will be measured daily or every batch / delivery depends on type of fuel. The monthly weighted-average figure from QIS is used in emission reduction calculation.
Value monitored:	Presented in Table 13 and Table 14 and Table 15
Monitoring equipment	-
QA/QC procedures to be applied	- The NCV is measured according to the national or international approved standards and procedures through a qualified laboratory. - The laboratory equipment is calibrated as per manufacturer's recommendation. - The documentation and calibration is controlled and managed in accordance with ISO9001 requirements

Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	- In case the NCV data is not available, it means there is not fuel delivered in that month. The NCV data from previous month will be used. - The NCV of fuel oil applied for all sites is from the annual maximum test results from provided by suppliers. The same maximum value is used for all sites.

Data / Parameter	AVD _y
Data unit	km
Description	Average round trip distance (from and to) between the alternative fuel supply sites and the site of the project plant during the year y.
Source of data	The maximum round trip distance suggested in methodology ACM0003 version 07.2.
Description of measurement methods and procedures to be applied	400 km is considered as the maximum round trip distance and is used for calculation.
Frequency of monitoring/recording	-
Value monitored:	400
Monitoring equipment	-
QA/QC procedures to be applied	Any future revision of the methodologies will be taken into account.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	EF _{km,CO₂,y}
Data unit	tCO ₂ /km
Description	CO ₂ emission factor for the trucks represented per km of the distance travelled. .
Source of data	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, Table 1-32 (for US heavy duty diesel vehicles, uncontrolled)
Description of measurement methods and procedures to be applied	The value from IPCC is applied for the most conservative approach.

Frequency of monitoring/recording	-
Value monitored:	0.001097
Monitoring equipment	-
QA/QC procedures to be applied	Any future revision of the methodologies will be taken into account.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$AF_{T,k,y}$
Data unit	ton
Description	Quantity of biomass residue type k that has been transported to the project site during the year y.
Source of data	Work Journal : WJ
Description of measurement methods and procedures to be applied	Using weight scale to measure and monthly adjusted according to stock change.
Frequency of monitoring/recording	Continuous monitoring with daily recording
Value monitored:	Presented in Table 13 and Table 14 and Table 15
Monitoring equipment	Presented in Table 18 and Table 19 and Table 20
QA/QC procedures to be applied	- The monitoring equipment is calibrated according to calibration plan and/or shutdown plan of kiln. - The documentation and calibration is controlled and managed in accordance with ISO9001 requirements
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	TL_y
Data unit	Ton
Description	Average truck load of the trucks used during the year y.
Source of data	Transportation regulation of Thailand
Description of measurement methods and procedures to be applied	For a conservative calculation, the default value 15 tons/trip is used, since the on-site data is not available.
Frequency of monitoring/recording	Every verification period.
Value monitored:	15

Monitoring equipment	-
QA/QC procedures to be applied	Any future revision of the regulation will be taken into account.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	Refer to methodology deviation 5.

Data / Parameter	FC _{i,j,y}
Data unit	Liters/year
Description	Quantity of alternative fuel type k for biomass handling
Source of data	- TS Specific consumption figure which used for ex-ante estimation in the registered PD. The reference information is provided in Table 21. - KW , TL The fuel consumption used for internal biomass handling is reported by contractor.
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	At least once a year
Value monitored:	Presented in Table 13 and Table 14 and Table 15
Monitoring equipment	-
QA/QC procedures to be applied	The purchasing invoice can be used for cross-checking.
Purpose of the data	-
Calculation method	-
Comments	This is the additional monitored parameter from the registered PD as per methodology deviation 4.

Data / Parameter	EF _{grid,y}
Data unit	tCO ₂ /MWh
Description	CO ₂ emission factor for grid electricity during the year y
Source of data	Summary report : The study of emission factor for electricity generation of Thailand in year 2014 , published by Thailand Greenhouse Gas Management Organization. ⁷

⁷<http://ghgreduction.tgo.or.th/tver-method/tver-calculation-data.html>

Description of measurement methods and procedures to be applied	Use the most update public data available
Frequency of monitoring/recording	Update in every verification period.
Value monitored:	0.5897
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	This emission factor in this report is calculated by Methodological Tool (Version 4.0) "Tool to calculate the emission factor for an electricity system"

Data / Parameter	$TDL_{j,y}$
Data unit	-
Description	Average technical transmission and distribution losses for providing electricity to source j.
Source of data	World Bank indicator 'Electric power transmission and distribution loss (%of output)' for Thailand ⁸
Description of measurement methods and procedures to be applied	The latest data available on the reference source
Frequency of monitoring/recording	Every verification period
Value monitored:	6.073% - in 2014
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$P_{clinker,y}$
Data unit	ton
Description	Production of clinker in year y
Source of data	Work Journal : WJ as per description provided in deviation 1

⁸ <https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?locations=TH&page=6>

Description of measurement methods and procedures to be applied	The quantity of clinker produced is calculated from amount of raw material with clinker factor and adjusting with stock checking report at the end of month. The final figures are summarized in WJ.
Frequency of monitoring/recording	The amount of raw material is continuously monitored. Daily recording and adjusting with stock checking report at the end of month.
Value monitored:	Presented in Table 13 and Table 14 and Table 15
Monitoring equipment	Presented in Table 18 and Table 19 and Table 20
QA/QC procedures to be applied	- The monitoring equipment is calibrated according to calibration plan and/or shutdown plan of kiln. - The documentation and calibration is controlled and managed in accordance with ISO9001 requirements
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	EF _{CO2,BL,y}
Data unit	tCO ₂ /GJ
Description	Carbon dioxide emissions factor for the fossil fuels displaced by the use of biomass residue in the project plant.
Source of data	The annual weighted average value is calculated as determined in "Procedure for the selection of the most plausible baseline scenario"
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Every verification period.
Value monitored:	Presented in Table 5 and Table 6 and Table 7
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of baseline emissions
Calculation method	$EF_{BL,CO2,y} = \frac{\sum_i FC_{BL,F3,i,y} * NCV_{i,y} * EF_{CO2,i,y}}{\sum_i FC_{BL,F3,i,y} * NCV_i}$
Comments	The calculation method is described in Baseline emission calculation step 2 of the registered PD.

Data / Parameter	$FC_{BL,i,y}$
Data unit	ton
Description	Quantity of fossil fuel type i displaced in the project plant as a result of the project activity in year y.
Source of data	The quantities and types of fossil fuels i that are displaced as a result of the project activity ($FC_{BL,i,y}$) should be determined consistent with the guidance above on the determination of the baseline CO ₂ emission factor ($EF_{CO_2,BL,y}$)
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Every verification period
Value monitored:	Presented in Table 13 and Table 14 and Table 15
Monitoring equipment	Presented in Table 18 and Table 19 and Table 20
QA/QC procedures to be applied	-
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	Biomass residue type K
Data unit	-
Description	Quantity of biomass residue type k that are utilized (eg. for energy generation or as feedstock) in the defined geographical region.
Source of data	Thailand Alternative Energy Situation Report 2014 , 2015 and 2016 , from Department of Alternative Energy Development and Efficiency (DEDE)
Description of measurement methods and procedures to be applied	Use the latest update data from official sources.
Frequency of monitoring/recording	Every verification period
Value monitored:	Presented in Table 11 and Table 12
Monitoring equipment	
QA/QC procedures to be applied	-
Purpose of the data	Calculation of leakage emissions
Calculation method	-
Comments	The reference is provided in methodology deviation 2.

Data / Parameter	EC _{PJ,y}
Data unit	kWh
Description	Quantity of electricity consumed by project electricity consumption source j in year (MWh/year)
Source of data	- For TL and TS the installed rated capacity of biomass related equipment is used to determine electricity consumption. - The energy meter at Khao Wong site is used to measure electricity consumption.
Description of measurement methods and procedures to be applied	- The power consumption is calculated from the total kW and the number of operating hours within monitoring period (applicable for TL and TS) - At Khao Wong site, the power meter continuously monitors the electricity consumption. The record is taken by operator on monthly basis.
Frequency of monitoring/recording	Continuous monitoring with monthly recording
Value monitored:	Presented in Table 8 and Table 9 and Table 10
Monitoring equipment	Multifunction power meters , presented in Table 20
QA/QC procedures to be applied	- The installed power capacity is updated when the changing in process equipment (applicable for TL and TS). - At Khao Wong site, the electricity meter is calibrated at least once a year.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	- Please refer to the information in methodology deviation 3. - The maximum error is applied for monitored electricity consumption at KW, as a result of calibration delay.

3.3 Monitoring Plan

A monitoring plan has been developed to ensure that accurate and relevant measurements and observations are made to document cement production metrics , energy usage and equipment operation, including possible sources of emissions and leakage. This plan reflects good monitoring practice appropriate to this type of project activity and meets the requirements of the methodologies involved.

The Cell operators are responsible for recording the data from DCS (Distributed Control System) into daily log sheet and input in daily report file. The daily report file is checked by the Cell Head and engineer respectively. At the end of month, the engineer will prepare the Work Journal (WJ) by using the data from daily report and adjusting by the data from stock checking report.

Data in electronic format from each site will be centralised at SCG's Engineering Department and then submitted to consultant for emission calculations.

The data backup at each site and SCG's Engineering Department is periodically carried out as per the data management procedure of ISO9001. The data submitted to consultant is saved on consultant's server and backed up at least once a month.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

The project reduces CO₂ emissions by using alternative fuels and/or less carbon intensive fossil fuels in the pre-calcliner and the kiln for the production of clinker in cement manufacturing. CH₄ emissions from preventing disposal or uncontrolled burning of biomass residues are included in this emission.

$$BE_y = BE_{FF,y} + BE_{CH4,biomass,y}$$

Where :

BE_y	=	Baseline emissions in year y (tCO ₂)
$BE_{FF,y}$	=	Baseline emission from fossil fuels displaced by alternative fuels or less carbon intensive fossil fuels in year y (tCO ₂)
$BE_{CH4,biomass,y}$	=	Baseline methane emissions avoided during the year y from preventive disposal or uncontrolled burning of biomass residues (tCO ₂ e)

Baseline emissions are determined in the following step:

Step 1. Estimate the project specific “fuel penalty”

This project specific fuel penalty (FP_y) should be determined as follows:

$$FP_y = P_{clinker,y} * (SEC_{clinker,PJ,y} - SEC_{clinker,BL})$$

Where :

FP_y	=	Fuel penalty in year y (GJ)
$P_{clinker,y}$	=	Production of clinker in year y (ton)
$SEC_{clinker,PJ,y}$	=	Specific energy consumption of the project plant in year y (GJ/t clinker)
$SEC_{clinker,BL}$	=	Specific energy consumption of the project plant in the absence of The project activity (GJ/t clinker)

The specific energy consumption in the project is calculated based on the quantity of all fuels used in the project plant and the quantity of clinker produced in year, as follows:

$$SEC_{clinker,PJ,y} = \frac{\sum_i (FC_{PJ,i,y} * NCV_{i,y}) + \sum_k (FC_{PJ,k,y} * NCV_{k,y})}{P_{clinker,y}}$$

Where :

$SEC_{clinker,PJ,y}$	=	Specific energy consumption of the project plant in year y (GJ/t clinker)
$FC_{PJ,i,y}$	=	Quantity of fossil fuel type i fired in the project plant in year y (ton)
$NCV_{i,y}$	=	Net calorific value of the fossil fuel type i in year y (GJ/ton)
$FC_{PJ,k,y}$	=	Quantity of alternative fuel or less carbon intensive fossil fuel type k used in the project plant in year y (ton)
$NCV_{k,y}$	=	Net calorific value of the alternative or less carbon intensive fuel type k used in the project plant in year y (ton)
$P_{clinker,y}$	=	Production of clinker in year y (ton)
k	=	Alternative fuel types and less carbon intensive fossil fuel type used in the project plant in year y
i	=	Fossil fuel types used in the project plant in year y that are not less carbon intensive fossil fuel type

$$SEC_{clinker,BL} = MIN \left(\frac{HG_x}{P_{clinker,x}} ; \frac{HG_{x-1}}{P_{clinker,x-1}} ; \frac{HG_{x-2}}{P_{clinker,x-2}} \right)$$

With :

$$HG_x = \sum_i FC_{i,x} * NCV_i$$

Where :

$SEC_{clinker,BL}$	=	Specific energy consumption of the project plant in the absence of the Project activity (GJ/t clinker)
HG_x	=	Heat generated from fuel combustion in the project plant in year x (GJ)
$FC_{i,x}$	=	Quantity of fossil fuel type i used in the project plant in year x (tons)
NCV_i	=	Net calorific value of the fossil fuel type i (GJ/ton)
$P_{clinker,x}$	=	Production of clinker in year x (tons)
x	=	Year prior to the start of the project activity
i	=	Fossil fuel types used in the project plant in the last 3 years prior to the start of the project activity

Step 2. Calculate baseline emission from the fossil displaced by the alternative or less carbon intensive fuel(s)

Baseline emissions from displacement of fossil fuels are calculated as follows:

$$BF_{FF,y} = \left[\sum_k (FC_{PJ,k,y} * NCV_{k,y}) - FP_y \right] * EF_{CO2,BL,y}$$

Where :

$BF_{FF,y}$	=	Baseline emission from fossil fuels displaced by alternative fuels or less carbon intensive fuels in year y (tCO ₂)
$FC_{PJ,k,y}$	=	Quantity of alternative fuels or less carbon intensive fossil fuel type k used in the project plant in year y (tons)
$NCV_{k,y}$	=	Net calorific value of the alternative or less carbon intensive fuel type k in year y (GJ/ton)
FP_y	=	Fuel penalty in year y (GJ)
$EF_{CO2,BL,y}$	=	Carbon dioxide emissions factor for the fossil fuels displaced by the use of alternative fuels or less carbon intensive fossil fuels in the project plant in year y (tCO ₂ /GJ)
k	=	Alternative fuel types and less carbon intensive fossil fuel types used in the project plant in year y

Since F3 has been determined as the most likely baseline scenario, the weighted average annual CO₂ emission factor for the fossil fuel(s) that would have been consumed according to fuel mix determined in "Procedure for the selection of the most plausible baseline scenario" as follows:

$$EF_{BL,CO2,y} = \frac{(\sum_i FC_{BL,F3,i,y} * NCV_{i,y} * EF_{CO2,i,y})}{(\sum_i FC_{BL,F3,i,y} * NCV_i)}$$

Where :

$EF_{BL,CO2,i,y}$	=	Carbon dioxide emissions factor for the fossil fuels displaced by the Used of alternative fuels or less carbon intensive fossil fuels in the project plant in year y (tCO ₂ /GJ)
$FC_{BL,F3,i,y}$	=	Quantity of fossil fuel type i that would in the absence of the project activity be used in the project plant according to the selected baseline scenario F3 in year y (ton)
$NCV_{i,y}$	=	Net calorific value of the fossil fuel type i in year y (tCO ₂ /GJ)
$EF_{CO2,i,y}$	=	Carbon dioxide emission factor fuel type i in year y (tCO ₂ /GJ)
i	=	Fossil fuel types that are less carbon intensive fossil fuel types and that would in the absence of the project activity be used in the project plant

Step 3. Calculate baseline emissions from decay, dumping or burning of biomass residues.

In this case only scenario B3 is the applicable baseline. Then the calculation for methane baseline emissions will be as follows:

$$BE_{CH_4,B1/B3,y} = GWP_{CH_4} * \sum_k FC_{PJ,k,y} * NCV_{k,y} * EF_{burning,CH_4,k,y}$$

Where :

$BE_{CH_4,B1/B3,y}$	=	Baseline methane emissions avoided during the year y from aerobic decay and/or uncontrolled burning of biomass residues (tCO ₂ e)
GWP_{CH_4}	=	Global warming potential of methane valid for the commitment period (tCO ₂ e/tCH ₄)
$FC_{PJ,k,y}$	=	Quantity of alternative fuel or less carbon intensive fossil fuel type k in year y (ton)
$NCV_{k,y}$	=	Net calorific value of the alternative or less carbon intensive fossil fuel type k in year y (GJ/ton)
$EF_{burningCH_4,k,y}$	=	CH ₄ emissions factor for uncontrolled burning of the biomass residue type k during the year y (tCH ₄ /GJ)
k	=	Types of biomass residues used as alternative fuel in the project plant in year y for which the identified baseline scenario is B1 or B3 and for which leakage effects could be ruled out with one of the approaches L ₁ , L ₂ or L ₃ described in the leakage section

As per recommendation in methodology , 0.0027 tCH₄ per ton of biomass should be used as default value for the project. To provide conservative estimates of emission reductions, a conservativeness factor must be applied to the CH₄ emission factor. The level of the conservativeness factor depends on the uncertainty range of the estimate for the CH₄ emission factor. The Table 2 in methodology, page 18, is shown the conservativeness factor and for this case, the uncertainty can be deemed to be greater than 100%, resulting in a conservativeness factor of 0.73. Thus an emission factor of 0.001971 tCH₄/t biomass should be used.

Table 5 : Summary of BE calculation of Ta Laung Site

BE Step 1		2014
$FC_{PJ,i,y} \times NCV_{i,y}$	GJ	8,794,139
$FC_{PJ,k,y} \times NCV_{k,y}$	GJ	643,911
$SEC_{clinker,PJ,y}$	GJ/t clinker	3.52
$SEC_{clinker,BL,y}$	GJ/t clinker	3.41
FP_y	GJ	296,238
$FP_y (conservative)$	GJ	296,238

BE Step 2		2014
$\sum FC_{PJ,k,y} \times NCV_{k,y}$	GJ	643,911
FP_y	GJ	296,238
$EF_{CO2,BL,y} (option A)$	tCO2/GJ	0.0891
$EF_{CO2,BL,y} (option B)$	tCO2/GJ	0.0849
$EF_{CO2,BL,y} (option C)$	tCO2/GJ	0.0891
$BE_{FF,y}$	tCO2	29,526

BE Step 3		2014
$\sum FC_{PJ,k,y}$	ton	47,576
$EF_{burning,CH4,k,y}$	tCH4e/t	0.001971
GWP_{CH4}	tCO2e/tCH4	25
$BE_{CH4,B1/B3,y}$	tCO2	2,344

Table 6 : Summary of BE calculation of Thung Song site

BE Step 1		2014	2015	1-Jan-16 to 31-Mar-16
$FC_{PJ,i,y} \times NCV_{i,y}$	GJ	11,214,959	11,742,600	3,328,383
$FC_{PJ,k,y} \times NCV_{k,y}$	GJ	3,560,958	3,666,272	1,211,260
$SEC_{clinker,PJ,y}$	GJ/t clinker	3.34	3.32	3.33
$SEC_{clinker,BL,y}$	GJ/t clinker	3.12	3.12	3.12
FP_y	GJ	980,338	903,834	291,095
$FP_y (conservative)$	GJ	980,338	903,834	291,095

BE Step 2		2014	2015	1-Jan-16 to 31-Mar-16
$\sum FC_{PJ,k,y} \times NCV_{k,y}$	GJ	3,560,958	3,666,272	1,211,260
FP_y	GJ	980,338	903,834	291,095
$EF_{CO2,BL,y} (option A)$	tCO2/GJ	0.0888	0.0888	0.0888
$EF_{CO2,BL,y} (option B)$	tCO2/GJ	0.0925	0.0926	0.0927
$EF_{CO2,BL,y} (option C)$	tCO2/GJ	0.0888	0.0888	0.0888
$BE_{FF,y}$	tCO2	229,135	245,279	81,702

BE Step 3		2014	2015	1-Jan-16 to 31-Mar-16
$\sum FC_{PJ,k,y}$	ton	228,255	248,322	84,588
$EF_{burning,CH4,k,y}$	tCH4e/t	0.001971	0.001971	0.001971
GWP_{CH4}	tCO2e/tCH4	25	25	25
$BE_{CH4,B1/B3,y}$	tCO2	11,247	12,236	4,168

Table 7 : Summary of BE calculation at Khao Wong site

BE Step 1		2014
$FC_{PJ,i,y} \times NCV_{i,y}$	GJ	9,411,592
$FC_{PJ,k,y} \times NCV_{k,y}$	GJ	1,414,710
$SEC_{clinker,PJ,y}$	GJ/t clinker	3.22
$SEC_{clinker,BL,y}$	GJ/t clinker	3.04
FP_y	GJ	614,289
FP_y (conservative)	GJ	614,289

BE Step 2		2014
$\sum FC_{PJ,k,y} \times NCV_{k,y}$	GJ	1,414,710
FP_y	GJ	614,289
$EF_{CO2,BL,y}$ (option A)	tCO ₂ /GJ	0.0875
$EF_{CO2,BL,y}$ (option B)	tCO ₂ /GJ	0.0923
$EF_{CO2,BL,y}$ (option C)	tCO ₂ /GJ	0.0875
$BE_{FF,y}$	tCO ₂	70,006

BE Step 3		2014
$\sum FC_{PJ,k,y}$	ton	84,649
$EF_{burning,CH4,k,y}$	tCH ₄ e/t	0.001971
GWP_{CH4}	tCO ₂ e/tCH ₄	25
$BE_{CH4,B1/B3,y}$	tCO ₂	4,171

4.2 Project Emissions

Quantify project emissions and/or removals. Project emissions include project emission from the use of alternative fuels and/or less carbon intensive fossil fuel ($PE_{k,y}$), project emissions from additional electricity and/or fossil fuel consumption as a result of the project activity ($PE_{EC,y}$ and $PE_{FC,y}$), project emission from combustion of fossil fuels for transportation of alternative fuels to the project plant ($PE_{T,y}$). In this grouped project activities the project emission from the cultivation of renewable biomass at the dedicated plantation is not included.

$$PE_y = PE_{k,y} + PE_{FC,y} + PE_{EC,y} + PE_{T,y}$$

Where :

PE_y	=	Project emissions during the year y (tCO ₂ e)
$PE_{k,y}$	=	Project emissions from the combustion of alternative fuels and/or less carbon intensive fossil fuels in the project plant in year y (tCO ₂)
$PE_{FC,y}$	=	Project emissions from the additional fossil fuel combustion as a result of project activity in year y (tCO ₂)
$PE_{EC,y}$	=	Project emissions from the additional electricity consumption as a result of project activity in year y (tCO ₂)
$PE_{T,y}$	=	CO ₂ emissions during the year y due to transport of alternative fuels to the project plant (tCO ₂)

Project emissions are calculated in the following steps:

Step 1. Calculate project emission from the use of alternative fuels and/or less carbon intensive fossil fuels

Project emission from the use of alternative fuels and/or less carbon intensive fossil fuels in the project plant are calculated as follows:

Where :

$$PE_{k,y} = \sum_k FC_{PJ,k,y} * NCV_{k,y} * EF_{CO2,k,y}$$

$PE_{k,y}$	=	Project emissions from the combustion of alternative fuels and/or Less carbon intensive fossil fuels in the project plant in year y (tCO ₂)
$FC_{PJ,k,y}$	=	Quantity of alternative fuel or less carbon intensive fossil fuel type k in year y (ton)
$NCV_{k,y}$	=	Net calorific value of the alternative or less carbon intensive fossil fuel type k in year y (GJ/ton)
$EF_{CO2,k,y}$	=	Carbon dioxide emissions factor of alternative fuels or less carbon intensive fossil fuels type k in year y (tCO ₂ /GJ)
k	=	Alternative fuel types and less carbon intensive fossil fuel used in the project plant in year y

Step 2. Calculate project emissions from additional electricity and/or fossil fuel consumption as a result of the project activity

The use of alternative fuels or less carbon intensive fossil fuels may result in additional fossil fuel and/or electricity consumption at the project site which included

- Mechanical treatment of the fuels; and
- On-site transportation of the fuels.

CO₂ emission from on-site electricity consumption ($PE_{EC,y}$) will be calculated using the latest approved version of the "Tool to calculate baseline, project and/or leakage emissions form electricity consumption". Then the project emission from electricity consumption is calculated as follows:

$$PE_{EC,y} = \sum EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y})$$

Where :

$PE_{EC,y}$	=	Project emissions from the additional electricity consumption as a result of project activity in year y (tCO ₂ /y)
$EC_{PJ,j,y}$	=	Quantity of electricity consumed by project electricity consumption source j in year (MWh/year)
$EF_{EL,j,y}$	=	Emission factor for electricity generation for source j in year (tCO ₂ /MWh)
$TDL_{j,y}$	=	Average technical transmission and distribution losses for providing electricity to source j in year

The quantity of electricity consumed by project activity will be calculated from the machine specification multiplied by operating time, since the consumption of electricity by project activity is not available. Moreover emission factor for electricity generation is taken from the calculation by Thailand Greenhouse Gas Management Organization⁹

The average technical transmission and distribution losses use recommended values of from World Bank¹⁰.

CO₂ emission from on-site combustion of fossil is calculated using the "Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion" version 04.4 approved by the CDM Executive Board (CDM EB) and validity from 2nd of August 2008.

According to the tool, CO₂ emission from fossil fuel combustion in on-site transportation is calculated based on the quantity of fuels combusted and the CO₂ emission coefficient of those fuels, as follows;

$$PE_{FC,j,y} = \sum FC_{i,j,y} * COEF_{i,y}$$

Where :

PE _{FC,j,y}	=	CO ₂ emissions from fossil fuel combustion in process j during year y (tCO ₂ /y)
FC _{i,j,y}	=	Quantity of fuel type i combusted in process j during the year y (mass or volume unit / year)
COEF _{i,y}	=	CO ₂ emission coefficient of fuel type i in year y (tCO ₂ /mass or volume unit)
i	=	the fuel types combusted in process j during the year y

The CO₂ emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO₂ emission factor of the fuel type, as follows;

$$COEF_{i,y} = NCV_{i,y} * EF_{CO2,i,y}$$

Where :

COEF _{i,y}	=	CO ₂ emission coefficient of fuel type i in year y (tCO ₂ /mass or volume unit)
NCV _{i,y}	=	the weighted average net calorific value of the fuel type i in year y (GJ / mass or volume unit)
EF _{CO2,i,y}	=	the weighted average CO ₂ emission factor of fuel type i in year y (tCO ₂ /GJ)
i	=	the fuel types combusted in process j during the year y

⁹http://ghgreduction.tgo.or.th/transfer/index.php?option=com_jdownloads&task=download.send&id=55&catid=12&m=0&Itemid=180

¹⁰ <https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?locations=TH&page=6>

Step 3. Project emissions from combustion of fossil fuels for transportation of alternative fuels to the project plant

As per methodology, the option 1 approach is chosen to calculate the emissions from combustion of fossil fuels for transportation of alternative fuels to the project plant which is based on the basis of distance and the number of trips (or the average truck load) as follows:

$$PE_{T,y} = \frac{\sum_k AF_{T,k,y}}{TL_y} * AVD_y * EF_{km,CO_2,y}$$

Where :

$PE_{T,y}$	=	CO ₂ emissions during the year y due to transport of alternative fuels to the project plant (tCO ₂)
N_y	=	Number of truck trips during the year y
$EF_{km,CO_2,y}$	=	Average CO ₂ emission factor for form trucks measured during the year y (tCO ₂ /km)
$AF_{T,k,y}$	=	Quantity of alternative fuel type k that has been transported to the project site during the year y (mass or volume units)
TL_y	=	Average truck load for trucks used (tons or litre) during the year y
k	=	Types of alternative fuels used in the project plant and that have been transported to the project plant in year y

Table 8 : Summary of PE calculation at Ta Luang site

PE Step 1		2014
PE _{k,y}		1,466

PE Step 2		2014
2.1 Electricity		
Installed capacity	kW	155
EC _{Pj,y}	MWh	1,226.00
EF _{grid,y}	tCO ₂ /MWh	0.5897
TDL _{L,y}	%	6.073%
PE _{EC,y}	tCO ₂ e	767
2.2 On-site transportation		
Biomass residues	ton-dry	47,576
FC _{i,j,y}	litres/month	4,742
	litres/year	56,904
NCV _{i,y}	MJ/litre	36.42
EF _{CO₂,i,y}	tCO ₂ /TJ	74.8
PE _{FC,y}	tCO ₂ e	155.02
PE _y	tCO ₂ e	922

PE Step 3		2014
AF _{T,k,y}	ton/y	47,576
AVD _y	km	400
EF _{km,CO₂,y}	tCO ₂ /km	0.001097
TL _y	tonnes/trip	15
PE _{T,y}		1,392

Table 9 : Summary of PE calculation at Thung Song site

PE Step 1		2014	2015	1-Jan-16 to 31-Mar-16
PE _{k,y}		25,367	36,547	20,145

PE Step 2		2014	2015	1-Jan-16 to 31-Mar-16
2.1 Electricity				
EC _{Pj,y}	MWh	5,941	5,941	1,485
EF _{grid,y}	tCO ₂ /MWh	0.5897	0.5897	0.5897
TDL _{L,y}	%	6.073%	6.073%	6.073%
PE _{EC,y}	tCO ₂ e	3,716	3,716	929
2.2 On-site transportation				
Biomass residues	ton-dry	228,255	248,322	84,588
FC _{i,j,y}	litres/ton	0.4955	0.4955	0.4955
	litres/year	113,100	123,044	41,913
NCV _{i,y}	MJ/litre	36.42	36.42	36.42
EF _{CO₂,i,y}	tCO ₂ /TJ	74.8	74.8	74.8
PE _{FC,y}	tCO ₂ e	308.11	335.20	114.18
PE _y	tCO ₂ e	4,024.55	4,051.64	1,043.29

PE Step 3		2014	2015	1-Jan-16 to 31-Mar-16
AF _{T,k,y}	ton/y	228,255	248,322	84,588
AVD _y	km	400	400	400
EF _{km,CO₂,y}	tCO ₂ /km	0.001097	0.001097	0.001097
TL _y	tonnes/trip	15	15	15
PE _{T,y}		6,677	7,264	2,474

Table 10 : Summary of PE calculation at Khao Wong site

PE Step 1		2014
$PE_{k,y}$		8,286

PE Step 2		2014
2.1 Electricity		
$EC_{p,j,y}$	MWh	452
$EF_{grid,y}$	tCO ₂ /MWh	0.5897
$TDL_{i,j,y}$	%	6.073%
$PE_{EC,y}$	tCO ₂ e	283
2.2 On-site transportation		
Biomass residues	ton-dry	84,649
$FC_{i,j,y}$	litres/year	41,752
$NCV_{i,y}$	MJ/litre	36.42
$EF_{CO2,i,y}$	tCO ₂ /TJ	74.8
$PE_{FC,y}$	tCO ₂ e	113.74
PE_y	tCO ₂ e	396.48

PE Step 3		2014
$AF_{T,k,y}$	ton/y	84,649
AVD_y	km	400
$EF_{km,CO2,y}$	tCO ₂ /km	0.001097
TL_y	tonnes/trip	15
$PE_{T,y}$		2,476

4.3 Leakage

The main source of leakage for this group project activity is an increase in emission from fossil fuel combustion due to the diversion of rice husk from other uses to the project plant as a result of the project activity. The L₂ option in methodology ACM0003 version 07.2 is used to demonstrate that the rice husk used in the group project does not increase fossil fuel consumption elsewhere. It is required to demonstrate that there is an abundant surplus of the rice husk in the region of the project activity, which is not utilized.

The biomass potential data from Thailand Alternative Energy Situation Report¹¹ 2014 , 2015 and 2016, demonstrates the availability of biomass which is not utilized and deducted by forecasted consumption in each area. The rice husk information is chosen for consideration, except Thung Song site. At this site the of biomass usage is varied by the availability of biomass residues. In this monitoring period, the main consumption is from coconut dust and coconut dust then the availability is considered from this kind of biomass.

The data is presented in unit ktoe or kilo ton oil equivalent. The calorific values of 42.244 GJ/toe is applied for conversion from ktoe to GJ. And the energy content of 14.4 , 10.88 and 16.41 MJ/kg respectively for paddy husk , saw dust and coconut dust are used for conversion into tonne.

¹¹ http://www.dede.go.th/ewt_news.php?nid=42079

Table 11 : The rice husk availability data of Ta Luang and Khao Wong sites in 2014

Year 2014	Rice Husk Potential - TL , KW		
	ktoe	GJ	Ton
Saraburi	30.38	1,283,373	89,123
Lopburi	43.77	1,849,020	128,404
Singhburi	30.55	1,290,554	89,622
Chainat	72.1	3,045,792	211,513
Suphanburi	125.15	5,286,837	367,141
Angthong	32.52	1,373,775	95,401
Ayutthaya	85.6	3,616,086	251,117
Nonthaburi	12.2	515,377	35,790
Bangkok	11.96	505,238	35,086
Nakornnayok	30.44	1,285,907	89,299
Praeeenburi	22.12	934,437	64,891
Chacherngsao	62.35	2,633,913	182,911
Srakaew	20.43	863,045	59,934
Chanthaburi	0.7	29,571	2,054
Rayong	0.87	36,752	2,552
Chonburi	5.16	217,979	15,137
Samutprakarn	3.68	155,458	10,796
Samutsakorn	1.39	58,719	4,078
Nakornpathom	46.62	1,969,415	136,765
Kanchanaburi	33.36	1,409,260	97,865
Ratchaburi	32.79	1,385,181	96,193
Samutsongkram	0.47	19,855	1,379
Phetchburi	32.64	1,378,844	95,753
Uthaithani	41.45	1,751,014	121,598
Total	317.18	13,398,952	930,483

Total consumption in 2014 91,440 ton/year
% usage by Project activities 10%
Availability 90%

Table 12 : The saw dust availability data of Thung Song site during 2014 - 2016¹²

Year 2014	Biomass Residue Potential - TS saw dust		
	ktoe	GJ	Ton
Chumphon	1.29	54,495	5,009
Ranong	0.44	18,587	1,708
Suratthani	5.1	215,444	19,802
Phang Nga	1.49	62,944	5,785
Phuket	0.17	7,181	660
Krabi	1.32	55,762	5,125
Trang	2.99	126,310	11,609
Nakorn Sri Thammarat	3.85	162,639	14,948
Patthalung	1.5	63,366	5,824
Songkhla	4.3	181,649	16,696
Satun	0.75	31,683	2,912
Pattani	0.64	27,036	2,485
Yala	2.49	105,188	9,668
Narathiwat	1.81	76,462	7,028
Total	28.14	1,188,746	109,260

Total consumption in 2014 53,520 ton/year
 % usage by Project activities 49%
 Availability 51%

Year 2014	Biomass Residue Potential - TS coconut dust		
	ktoe	GJ	Ton
Chumphon	42.57	1,798,327	109,587
Ranong	0.59	24,924	1,519
Suratthani	26.56	1,122,001	68,373
Phang Nga	1.67	70,547	4,299
Phuket	1.67	70,547	4,299
Krabi	1.6	67,590	4,119
Trang	1.38	58,297	3,553
Nakorn Sri Thammarat	18.13	765,884	46,672
Patthalung	0.9	38,020	2,317
Songkhla	1.54	65,056	3,964
Satun	0.4	16,898	1,030
Pattani	10.86	458,770	27,957
Yala	1.3	54,917	3,347
Narathiwat	7.47	315,563	19,230
Total	117	4,927,340	300,264

Total consumption in 2014 34,670 ton/year
 % usage by Project activities 12%
 Availability 88%

Year 2015	Biomass Residue Potential - TS saw dust		
	ktoe	GJ	Ton
Chumphon	1.16	49,003	4,503.96
Ranong	0.43	18,165	1,670
Suratthani	6.12	258,533	23,762
Phang Nga	1.22	51,538	4,737
Phuket	0.15	6,337	582
Krabi	1.39	58,719	5,397
Trang	2.66	112,369	10,328
Nakorn Sri Thammarat	3.74	157,993	14,521
Patthalung	1.46	61,676	5,669
Songkhla	4.27	180,382	16,579
Satun	0.74	31,261	2,873
Pattani	0.62	26,191	2,407
Yala	2.42	102,230	9,396
Narathiwat	1.71	72,237	6,639
Total	28.09	1,186,634	109,066

Total consumption in 2015 70,703 ton/year
 % usage by Project activities 65%
 Availability 35%

Year 2015	Biomass Residue Potential - TS coconut dust		
	ktoe	GJ	Ton
Chumphon	41.22	1,741,298	106,112
Ranong	0.55	23,234	1,416
Suratthani	22.25	939,929	57,278
Phang Nga	1.43	60,409	3,681
Phuket	1.37	57,874	3,527
Krabi	1.6	67,590	4,119
Trang	1.03	43,511	2,652
Nakorn Sri Thammarat	15.33	647,601	39,464
Patthalung	0.91	38,442	2,343
Songkhla	1.45	61,254	3,733
Satun	0.4	16,898	1,030
Pattani	9.64	407,232	24,816
Yala	0.85	35,907	2,188
Narathiwat	6.21	262,335	15,986
Total	104	4,403,515	268,343

Total consumption in 2015 41,130 ton/year
 % usage by Project activities 15%
 Availability 85%

Year 2016	Biomass Residue Potential - TS saw dust		
	ktoe	GJ	Ton
Chumphon	1.13	47,736	4,387.47
Ranong	0.41	17,320	1,591.92
Suratthani	5.95	251,352	23,102
Phang Nga	1.21	51,115	4,698
Phuket	0.15	6,337	582
Krabi	1.35	57,029	5,242
Trang	2.62	110,679	10,173
Nakorn Sri Thammarat	3.64	153,768	14,133
Patthalung	1.4	59,142	5,436
Songkhla	4.21	177,847	16,346
Satun	0.74	31,261	2,873
Pattani	0.61	25,769	2,368
Yala	2.43	102,653	9,435
Narathiwat	1.69	71,392	6,562
Total	27.54	1,163,400	106,930

Total consumption in 2016 82,330 ton/year
 % usage by Project activities 77%
 Availability 23%

Year 2016	Biomass Residue Potential - TS coconut dust		
	ktoe	GJ	Ton
Chumphon	39.09	1,651,318	100,629
Ranong	0.52	21,967	1,339
Suratthani	21.11	891,771	54,343
Phang Nga	1.36	57,452	3,501
Phuket	1.3	54,917	3,347
Krabi	1.51	63,788	3,887
Trang	0.97	40,977	2,497
Nakorn Sri Thammarat	14.55	614,650	37,456
Patthalung	0.87	36,752	2,240
Songkhla	1.38	58,297	3,553
Satun	0.38	16,053	978
Pattani	9.15	386,533	23,555
Yala	0.81	34,218	2,085
Narathiwat	5.89	248,817	15,163
Total	99	4,177,509	254,571

Total consumption in 2016 29,186 ton/year
 % usage by Project activities 11%
 Availability 89%

¹² The saw dust and coconut dust consumption in 2016 of TS for the biomass availability assessment, is included with the consumption from April to December which is not considered in this monitoring period.

The quantity of available biomass in all areas, 200 kilometres of boundary from project sites, is more than 25% than the quantity of biomass that would be utilized by project activities.

Only the availability of saw dust in 2016 for Thung Song site is slightly lower than 25%. However, the overall biomass availability (for 2 major types of biomass) is much more higher than 25% in the region of this project site. Additionally, this project site has flexibility to switch between various types of biomass, according to the availability of biomass sources. Hence the leakage emissions from project activities are considered as zero as per approach L₂.

4.4 Net GHG Emission Reductions and Removals

The total emission reduction achieved by these project activities within this monitoring period is presented in table below.

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)
Year 2014	346,430	50,978	0	295,452
Year 2015	257,515	47,864	0	209,651
Year 2016	85,870	23,663	0	62,207
Total	689,815	122,505	0	567,310

Justification for the increasing of emission reductions in this monitoring period

The emission reductions claimed from Thung Song site are higher than the PD estimated value because of the amount of biomass residues used in cement production is higher than ex-ante estimation. Since there are plenty of biomass availability, as well as variety of biomass types in this region, to be used as fuel sources for cement production at Thung Song site.

APPENDIX 1 : ADDITIONAL INFORMATION

1. Summary of monitoring data

Table 13 : Monitored data of Ta Luang site

TL	2014		
	Amount	LHV	Heat
Type of fuel	ton-AF	GJ/ton	GJ
<i>Clinker</i>	<i>2,683,465</i>		
<i>Running Hrs.</i>	<i>7,910</i>		
HFO+used oil	1,671	40.40	67,505
CKB			
Lignite-Maeteep	34,202	17.19	587,925
Hical 40	1,480	11.94	17,661
Petcoke			
Lignite-MT	39,054	19.02	742,612
Coal-High Heat	103,090	26.10	2,690,234
Bituminous dust	136,190	24.27	3,305,308
Coal-Low Heat	52,870	24.67	1,304,507
Coal-Spot Lot	4,587	20.94	96,049
Coal Noble			
Total	373,144	23.62	8,811,800
Husk	47,576	13.16	626,251
Total	47,576	13.16	626,251

Table 14 : Monitored data of Thung Song site

TS	2014		2015		1-Jan-16 to 31-Mar-16		
	Amount	Heat	Amount	Heat	Amount	Heat	FC*NCV*EF
Type of fuel	ton-AF	GJ	ton-AF	GJ	ton-AF	GJ	tCO2
Clinker	4,420,508		4,647,840		1,361,360		
Running Hrs.	6,794		6,922		2,099		
HFO	3,654	147,641	2,830	114,343	212	8,568	647
Coal	138,230	3,445,481	197	5,004	-	-	-
Coal HH	176,999	4,414,285	174,546	4,506,849	51,911	1,332,230	123,631
Coal MH	122,455	3,032,731	270,305	6,990,798	75,164	1,954,202	181,350
Bituminous dust	7,071	174,820	2,745	70,150	-	-	-
Coal Low Grade	-	-	2,326	55,457	1,400	33,383	2,988
Total	448,409	11,214,959	452,949	11,742,600	128,687	3,328,383	308,616
Rubber tire	10,431	294,618	14,760	425,471	5,251	157,476	13,385
Used oil	82	3,321	-	-	-	-	-
RDF	176	935	165	4,604	203	4,050	336
RDF ECO	-	-	-	-	2,908	77,391	6,423
Total	10,689	298,874	14,925	430,075	8,362	238,917	20,145
Palm shell	5,368	76,957	110	1,739	-	-	-
50-wood cip	-	-	-	-	5,487	68,264	-
Saw dust	53,520	791,349	70,703	948,440	31,610	348,474	-
73-wood chip	-	-	-	-	14,549	144,302	-
Wood chip	35,700	392,306	25,126	278,559	-	-	-
Rice husk	16,731	219,947	3,815	49,717	13	123	-
Coconut dust	34,670	680,517	41,130	647,858	11,604	174,078	-
Charcoal	49	640	826	16,357	29	383	-
Bark	40,817	542,605	35,945	414,971	7,494	81,982	-
Dust wood	-	-	-	-	532	7,104	-
Crushed bark	-	-	57,705	701,051	13,269	147,632	-
Stump	1	16	-	-	-	-	-
Recycle wood chip	41,400	557,747	12,963	177,505	-	-	-
Total	228,255	3,262,084	248,322	3,236,197	84,588	972,343	

Table 15 : Monitored data of Khao Wong site

KW	2014		
	Amount	LHV	Heat
Type of fuel	ton-AF	GJ/ton	GJ
Clinker	3,360,554		
Running Hrs.	-		
Coal	311,909	24.25	7,563,214
Coal + Anthracite			
(ultra)HFO CKB	2,499	39.63	99,044
Shale Hi-Cal	7,830	11.39	89,203
Lignite	86,477	19.20	1,660,130
Other FC based	1,202	21.90	26,328
Total	409,917	23.02	9,437,920
RDF + R40B	1,319	14.02	18,486
Mixed waste	3,004	18.63	55,967
waste oil			
Total	4,323	17.22	74,454
Agricultural waste			
Saw dust	40,785	16.56	675,413
Rice husk	43,864	14.56	638,514
Total	84,649	15.52	1,313,928

2. Summary of baseline (historical) data

Table 16 : Historical data of Ta Laung , Khao Wong and Kaeng Khoi sites

Fuel Type		TL				KW				KK			
Fossil		2000	2001	2002	Total	2000	2001	2002	Total	2000	2001	2002	Total
Fuel Oil	ton-dry	885	825	4,866	6,576	3,705	4,188	2,261	10,154	3,877	3,320	5,678	12,875
Coal	ton-dry	16,923	5,944	31,708	54,575	27,218	3,166	19,574	49,958	137,006	1,948	43,007	181,961
Lignite	ton-dry	46,845	92,730	251,340	390,915	189,534	140,995	270,215	600,744	468,388	647,769	533,107	1,649,264
Pet-Coke	ton-dry	4,643	1,771	59,457	65,871	129,514	143,749	106,027	379,290	56,917	104,250	157,989	319,156
Anthracite	ton-dry	-	-	-	-	2,835	48,758	8,477	60,070	-	14,077	4,545	18,622
Heating Value		2000	2001	2002	Average	2000	2001	2002	Average	2000	2001	2002	Average
Fuel Oil	GJ/ton	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39
Coal	GJ/ton	24.30	25.41	25.09	24.88	24.95	26.70	28.47	26.44	25.74	25.74	25.74	25.74
Lignite	GJ/ton	18.21	18.12	17.16	17.51	21.42	20.79	20.26	20.75	17.99	17.99	17.99	17.99
Pet-Coke	GJ/ton	30.13	30.46	32.63	32.40	32.96	32.25	33.76	32.91	32.46	32.44	32.44	32.44
Anthracite	GJ/ton	0.00	0.00	0.00	0.00	29.25	27.80	27.86	27.88	0.00	27.21	27.21	27.21
HG = FC x NCV	GJ	2000	2001	2002	Total	2000	2001	2002	Average	2000	2001	2002	Average
Fuel Oil	GJ	35,758	33,326	196,562	149,663	169,174	91,314			156,611	134,111	229,362	
Coal	GJ	411,229	151,037	795,550	679,164	84,540	557,242			3,527,069	50,149	1,107,168	
Lignite	GJ	852,967	1,680,437	4,312,638	4,060,567	2,930,958	5,474,624			8,425,008	11,651,578	9,589,125	
Pet-Coke	GJ	139,876	53,941	1,940,124	4,268,854	4,635,753	3,579,497			1,847,457	3,382,026	5,125,400	
Anthracite	GJ	-	-	-	-	82,929	1,355,435	236,153		-	383,021	123,665	
Pclinker	ton	410,188	557,145	2,126,642	1,031,325	3,041,073	3,017,068	3,254,406	3,104,182	4,527,703	4,912,623	5,045,459	4,828,595
HG/Pclinker	GJ/ton	3.51	3.44	3.41		3.04	3.04	3.05		3.08	3.18	3.21	
FC x NCV x EF		2000	2001	2002	Total	2000	2001	2002	Total	2000	2001	2002	Total
Fuel Oil	GJ	2,700	2,516	14,840	11,300	12,773	6,894			11,824	10,125	17,317	
Coal	GJ	38,162	14,016	73,827	63,026	7,845	51,712			327,312	4,654	102,745	
Lignite	GJ	77,535	152,752	392,019	369,106	266,424	497,643			765,833	1,059,128	871,651	
Pet-Coke	GJ	11,596	4,472	160,836	353,888	384,304	296,740			153,154	280,370	424,896	
Anthracite	GJ	-	-	-	-	7,845	128,224	22,340		-	36,234	11,699	
EFBL _{CO2,y}	tCO2/GJ	0.0903	0.0906	0.0885	0.0891	0.0871	0.0871	0.0881	0.0875	0.0901	0.0891	0.0883	0.0891

Table 17 : Historical data of Thung Song and Lampang site

Fuel Type		TS				LP			
Fossil		2000	2001	2002	Total	2000	2001	2002	Total
Fuel Oil	ton-dry	4,126	3,291	2,486	9,903	519	477	682	1,678
Coal	ton-dry	188,136	166,152	143,493	497,781	-	-	-	-
Lignite	ton-dry	50,424	208,229	225,796	484,449	105,615	105,743	191,910	403,268
Pet-Coke	ton-dry	143,272	101,586	105,029	349,888	-	-	-	-
Anthracite	ton-dry	-	-	16,879	16,879	-	-	-	-
Heating Value		2000	2001	2002	Average	2000	2001	2002	Average
Fuel Oil	GJ/ton	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39
Coal	GJ/ton	25.12	25.83	25.39	25.44	0.00	0.00	0.00	0.00
Lignite	GJ/ton	18.85	20.48	19.32	19.77	18.10	17.94	17.82	17.92
Pet-Coke	GJ/ton	33.98	32.81	32.22	32.11	0.00	0.00	0.00	0.00
Anthracite	GJ/ton			26.46	26.46	0.00	0.00	0.00	0.00
HG = FC x NCV	GJ	2000	2001	2002	Average	2000	2001	2002	Average
Fuel Oil	GJ	166,665	132,951	100,415		20,965	19,268	27,563	
Coal	GJ	4,726,725	4,292,170	3,643,295		-	-	-	
Lignite	GJ	950,726	4,263,615	4,363,495		1,912,101	1,897,156	3,418,995	
Pet-Coke	GJ	4,868,550	3,332,781	3,383,884		-	-	-	
Anthracite	GJ	-	-	446,680		-	-	-	
Pclinker	ton	3,381,254	3,797,506	3,825,211	3,667,990	642,816	603,902	1,063,054	769,924
HG/Pclinker	GJ/ton	3.17	3.17	3.12		3.01	3.17	3.24	
FC x NCV x EF		2000	2001	2002	Total	2000	2001	2002	Total
Fuel Oil	GJ	12,583	10,038	7,581		1,583	1,455	2,081	
Coal	GJ	438,640	398,313	338,098		-	-	-	
Lignite	GJ	86,421	387,563	396,642		173,810	172,451	310,787	
Pet-Coke	GJ	403,603	276,288	280,524		-	-	-	
Anthracite	GJ	-	-	42,256		-	-	-	
EFBL _{CO2,y}	tCO2/GJ	0.0879	0.0892	0.0892	0.0888	0.0907	0.0907	0.0908	0.0908

3. Information of monitoring equipment specification and calibration

Table 18 : Monitoring equipment at Ta Luang site

Project Site	Meter Name	Type	Tag No.	Accuracy	Calibration History		
					2013	2014	2015
TL6	WF-Biomass	Schenck-Multidas	W1U64F1	0.50%	21-Sep-13	17-Oct-14	6-Nov-15
TL5	WF-Biomass	Schenck-Multidas	W2U64F1	0.50%	24-Apr-13	15-Nov-14	17-Sep-15
TL5	Kiln Feed		W2A03F1	1%	27-Apr-13	21-Nov-14	17-Sep-15
TL6	Kiln Feed		W1A01F1 > W1A03F1	1%	26-Sep-13	17-Oct-14	4-Nov-15
TL6	WF-Solid fuel	Coriolis	K6A10	1%	14-May-13	16-Oct-14	13-Oct-15
TL6	WF-Solid fuel	Pfister	L7F15	0.50%	14-May-13	17-Oct-14	13-Nov-15
TL5	WF-Solid fuel	Pfister	L5F35	0.50%	23-Apr-13	25-Nov-14	20-Sep-15
TL5	WF-Solid fuel (stop)	Pfister	K1A02	0.50%	23-Apr-13	Stop	
TL5	WF-Solid fuel (stop)	Pfister	K1A03	0.50%	23-Apr-13	Stop	
TL5	WF-Solid fuel (New)	Coriolis	K1A10	0.50%		26-Nov-14	20-Sep-15
TL	Truck scale	Kubota KL-D1000S	8XBSU6009	-	27-Nov-12	5-Jun-14	
TL	Truck scale	Kubota KL-D1000S	8XBSU60015	-	27-Nov-12	5-Jun-14	
TL	Truck scale	Mettler Todelco IND.310	0038720-6CK	-	3-Jul-13		11-Feb-15
TL	Bomb Calorimeter	Isoperibol	0.15%	-	5-Nov-13	25-Apr-14 16-Oct-14	3-Apr-15

Table 19 : Monitoring equipment at Thung Song site

Project Site	Meter Name	Type	Tag No.	Accuracy	Calibration History				
					2013	2014	2015	2016	2017
TS	WF-Biomass		228_92		23-Oct-13	19-Apr-14 10-Aug-14	2-Aug-15	4-May-16	22-Jul-17
TS	WF-Biomass		228_95		23-Oct-13	19-Apr-14 10-Aug-14	2-Aug-15	4-May-16	22-Jul-17 27-Jul-17
TS	WF-Biomass		6796-03		19-Sep-13	19-Mar-14 4-Sep-14	10-Feb-15 20-Oct-15	18-Jun-16	18-Sep-17 21-Sep-17
TS	WF-Biomass		6796-06		19-Sep-13	19-Mar-14 4-Sep-14	10-Feb-15 20-Oct-15	18-Jun-16	18-Sep-17 21-Sep-17
TS	WF-Biomass		K4J32		20-Jun-13	Kiln 4 stop			
TS	WF-Solid fuel	Coriolis	791-10	1%	23-Oct-13	29-Jul-14	24-Jul-15	25-Jul-16	22-Jul-17
TS	WF-Solid fuel	Pfister	792-10	1%	23-Oct-13	29-Jul-14	24-Jul-15	22-Jul-16	22-Jul-17
TS	WF-Solid fuel	Pfister	793-10	1%	23-Oct-13	29-Jul-14	24-Jul-15	22-Jul-16	22-Jul-17
TS	WF-Solid fuel	Coriolis	6791-10	1%	10-Dec-13	29-Jul-14	24-Jul-15	25-Jul-16	22-Jul-17
TS	WF-Solid fuel	Coriolis	6792-10	1%	10-Dec-13	29-Jul-14	24-Jul-15	25-Jul-16	22-Jul-17
TS	WF-Solid fuel	Coriolis	6793-10	1%	10-Dec-13	29-Jul-14	24-Jul-15	25-Jul-16	22-Jul-17
TS	WF-Solid fuel	Coriolis	K4J20	1%	21-Jun-13	29-Jul-14	24-Jul-15	25-Jul-16	22-Jul-17
TS	WF-Solid fuel	Coriolis	K5J20	1%	21-Jun-13	29-Jul-14	24-Jul-15	25-Jul-16	22-Jul-17
TS	Truck scale	Mettler Toledo Model IND 310	BIX03 00461186FL	40 kg	13-Mar-13	11-Mar-14		24-Mar-16	
TS	Truck scale	Mettler Toledo Model IND 780	BIX04 B312160815	40 kg	27-May-13	11-Mar-14		24-Mar-16	27-Feb-17
TS	Truck scale	Mettler Toledo Model IND 560	XIX05 B211772421	40 kg	3-Apr-13	14-Jan-14		24-Mar-16	
TS	Truck scale	Mettler Toledo Model IND 780	XIX06 B308063872	40 kg	3-Apr-13	15-Jan-14		24-Mar-16	
TS	Bomb calorimeter	LECO AC-350	C-26		10-Feb-13 10-Aug-13	10-Aug-14 23-Dec-14	10-Feb-15 10-Aug-15	10-Feb-16 10-Aug-16	10-Feb-17 10-Aug-17
TS	Bomb calorimeter	LECO AC-500	C-25		10-Jan-13 10-Jul-13	10-Jan-14 10-Jul-14	10-Jan-15 10-Jul-15	10-Jan-16 10-Jul-16	10-Jan-17 10-Jul-17

Table 20 : Monitoring equipment at Khao Wong site

Project Site	Meter Name	Type	Tag No.	Accuracy	Calibration History		
					2013	2014	2015
KW	Raw Meal	Schenck	0802F101	3%		31-Jan-14	29-Jan-15
KW	Raw Meal	Schenck	0802F201	3%		31-Jan-14	29-Jan-15
KW	Feeder Lignite	Pfister	1566-1	-	22-Dec-13	1-Apr-14 28-Apr-14 23-May-14 19-Jun-14 8-Jul-14 31-Jul-14 5-Sep-14 4-Nov-14	22-Jan-15
KW	Feeder Lignite	Pfister	1566-2	-	22-Dec-13	1-Apr-14 22-Apr-14 28-Apr-14 23-May-14 13-Jun-14 5-Sep-14 4-Nov-14	7-May-15
KW	Feeder Lignite	Pfister	1566-3	-	21-Sep-13	1-Apr-14 28-Apr-14 23-May-14 16-Jun-14 7-Jul-14 31-Jul-14 25-Aug-14 5-Sep-14 4-Nov-14	22-Apr-15
KW	Biomass Belt Weigher	Belt Weight	904H-1	3%	13-Dec-13	24-Jan-14	7-Jan-15
KW	Biomass Belt Weigher	Belt Weight	904H-2	3%	11-Dec-13	22-Jan-14	6-Jan-15
KW	Truck Scale	Mettler Toledo Model IND.780	5691932-5HN	2%	23-May-12	24-Mar-14	
KW	Truck Scale	Mettler Toledo Model 8530	4286655-4NT	2%	24-Oct-13		
KW	Truck Scale	Mettler Toledo Model IND.310	0040351-6EH	2%	25-Sep-12	24-Mar-14	
KW	Truck Scale	Mettler Toledo Model IND.780	B308063871	2%	17-May-13	24-Mar-14	
KW	Truck Scale	Mettler Toledo Model IND.780	B309072021	2%	31-Jul-13		
KW	Power Meter - MCC+N1 incoming : 34)	SOCOMECDIRISAp	034611058	0.5%		28-Oct-14	2-Sep-15
KW	Power Meter (SWC-35)	E-POWER ECM 700	1008031258427	1.0%		28-Oct-14	2-Sep-15
KW	Bomb calorimeter	Isoperibol	6200110823296	0.15%	5-Nov-13	25-Apr-14 16-Oct-14	3-Apr-15

4. Other information used for emission calculation in this monitoring period

1) The specific fuel consumption for biomass handling equipment

The procedure for determining the specific fuel consumed by biomass handling equipment was conducted at Thung Song site. This trial was based on the assumption that this site has the highest biomass consumption and various types of biomass as per explanation in page 16 of the registered PD.

The test was done by measuring the biomass transferred quantity and fuel consumed by each equipment in one hour. The total specific fuel consumption is 0.4955 liters/ton of biomass. The consumption details and the process diagram are presented below.

Table 21 : Specific consumption of Biomass handling equipment

Machine	Fuel usage (Litre/hr.)	Capacity (ton/hr.)	Fuel consumption (Litre/ton)
1. Wood gripper 120 hp.	4	48.02	0.0833
2. CAT 966 220 hp.	23	168.62	0.1364
3. CAT 924 120 hp.	8	190.48	0.042
4. WA300 165 hp.	10	125.00	0.08
5. 10W Truck	5.5	35.76	0.1538

