

SIAM CEMENT BIOMASS PROJECT



Document Prepared By South Pole Carbon Asset Management Ltd.

Project Title	Siam Cement Biomass Project
Version	03.1
Date of Issue	26-October-2011
Project ID	403
Monitoring Period	01-October-2009 to 28-February-2011 (Both days included)
Prepared By	Nattaya Lonawan
Contact	n.lonawan@southpolecarbon.com

Table of Contents

1	Project Details	3
1.1	Summary Description of Project	3
1.2	Sectoral Scope and Project Type.....	4
1.3	Project Proponent.....	4
1.4	Other Entities Involved in the Project	6
1.5	Project Start Date.....	6
1.6	Project Crediting Period.....	6
1.7	Project Location	7
1.8	Title and Reference of Methodology	9
2	Implementation Status.....	9
2.1	Implementation Status of the Project Activity	9
2.2	Deviations from the monitoring Plan for this monitoring period	10
2.3	Grouped Project.....	11
3	Data and Parameters.....	11
3.1	Data and Parameters Available at Validation	11
3.2	Data and Parameters Monitored	13
3.3	Description of the Monitoring Plan	22
4	Quantification of GHG Emission Reductions and Removals.....	23
4.1	Baseline Emissions	23
4.2	Project Emissions.....	28
4.3	Leakage	32
4.4	Summary of GHG Emission Reductions and Removals	35
5	Additional Information	36
5.1	Summary of monitored data	36
5.2	Summary of monitoring equipment	38
5.3	Other information used in emission calculation	41

1 PROJECT DETAILS

1.1 Summary Description of 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. 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)	10,000	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	Thung Song Nakon Si 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 reduction 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 07.3.

The 1st verification report for monitoring period 1st April 2006 to 30th September 2009 is issued on 5th June 2010.

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: <https://vcsprojectdatabase1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=403>

1.2 Sectoral Scope and Project Type

The project is 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 centralize GHG information system and controlling all associated with the project and its monitoring.

1.3 Project Proponent

Role	Project owner
Organization:	The Siam Cement (Kaeng Khoi) Co., Ltd.
Address:	1 Siam Cement Rd., Bangsue
City:	Bangkok
Country:	Thailand
Post zip	10800
Telephone:	+662 586 5684
FAX:	+662 586 3098
Represented by:	Somkiat Pananookooln Kriengkrai Suksankraisorn
Title:	Managing Director/Senior Engineer
Salutation:	Mr.

Role	Project owner
Organization:	The Siam Cement (Ta Luang) Co., Ltd.
Address:	1 Siam Cement Rd., Bangsue
City:	Bangkok
Country:	Thailand
Post zip	10800
Telephone:	+662 586 5684
FAX:	+662 586 3098
Represented by:	Sira Srisukri Kriengkrai Suksankraisorn

Title:	Managing Director/Senior Engineer
Salutation:	Mr.

Role	Project owner
Organization:	The Siam Cement (Lampang) Co., Ltd.
Address:	1 Siam Cement Rd., Bangsue
City:	Bangkok
Country:	Thailand
Post zip	10800
Telephone:	+662 586 5684
FAX:	+662 586 3098
Represented by:	Sanit Kessuwan Kriengkrai Suksankraisorn
Title:	Managing Director/Senior Engineer
Salutation:	Mr.

Role	Project owner
Organization:	The Siam Cement (Thung Song) Co., Ltd.
Address:	1 Siam Cement Rd., Bangsue
City:	Bangkok
Country:	Thailand
Post zip	10800
Telephone:	+662 586 5684
FAX:	+662 586 3098
Represented by:	Nantapong Chantrakul Kriengkrai Suksankraisorn
Title:	Managing Director/Senior Engineer
Salutation:	Mr.

Role	Carbon consultant
Organization:	South Pole Carbon Asset Management Ltd.
Street/P.O.Box:	Technoparkstrasse 1
City:	Zurich
Postfix/ZIP:	8005
Country:	Switzerland
E-Mail:	i.puhl@southpolecarbon.com
URL:	www.southpolecarbon.com
Represented by:	Ingo Puhl
Title:	Managing Partner
Salutation:	Mr.
Mobile:	+ 66 86 778 2869
Direct tel:	+ 66 2 678 8979

1.4 Other Entities Involved in the Project

1.5 Project Start Date

Table 2 : Project start date

Project site	Start date
The Siam Cement (Kaeng Khoi)	04/10/2002
The Siam Cement (Ta Luang)	15/10/2002
The Siam Cement (Khao Wong)	30/09/2004
The Siam Cement (Lampang)	30/04/2004
The Siam Cement (Thong Song)	19/01/2003

1.6 Project Crediting Period

Crediting period start date: 1 April 2006

The duration of the projects is estimated to be 20 years. After the initial crediting period of 10 years, subsequent renewals of the crediting time might be considered according to the status of the project activity and baseline revision at the time.

Table 3 : The estimated emission reductions for the current verification period

Year	Ta Lung	Kao Wong	Kaeng Khoi	Thong Song	Lampang
2006 (1st April-31 December)	30,046	141,094	209,028	112,426	27,296
2007	35,851	208,945	270,514	130,844	54,418
2008	32,948	175,019	239,771	121,635	40,857
2009	32,948	175,019	239,771	121,635	40,857
2010	32,948	175,019	239,771	121,635	40,857
2011	32,948	175,019	239,771	121,635	40,857
2012	32,948	175,019	239,771	121,635	40,857
2013	32,948	175,019	239,771	121,635	40,857
2014	32,948	175,019	239,771	121,635	40,857
2015	32,948	175,019	239,771	121,635	40,857
Total emission reduction (tCO ₂ e)	329,483	1,750,192	2,397,710	1,216,349	408,570
Total number of crediting year	10	10	10	10	10
Annual average over the crediting period of emission reduction (tCO ₂ e)	32,948	175,019	239,771	121,635	40,857

1.7 Project Location

Details of the project locations, both physical address and geographical location, are presented in table 4 and 5.

Table 4 : Physical address of project sites

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 5 : 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

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

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The grouped projects are applied with the technologies developed by the Engineering Department of SCG Cement Co., Ltd. The biomass processing and preparation is different at each site depended on type of main biomass residue used at the site.

The detail of biomass residue feeding process in each plant is described below:

Project site	Major biomass type	Main process equipment	Additional equipment
The Siam Cement (Kaeng Khoi)	Rice husk	- Hopper - Vibrating screen - Conveyor belt	Pre-treatment and wood chipper is installed for bark.
The Siam Cement (Ta Luang)	Rice husk	- Hopper - Vibrating screen - Conveyor belt with covers	The feeding system is improved from existing design to increase biomass feeding capacity.
The Siam Cement (Khao Wong)	Rice husk	- Hopper - Vibrating screen - Conveyor belt with covers - Bucket elevator	Bag filter cyclone for dust collecting system.
The Siam Cement (Lampang)	Rice husk	- Silo - Bucket elevator - Conveyor belt - Hopper	Dust collector
The Siam Cement (Thung Song)	Saw dust , rice husk , palm shell and wood slab	- Hybrid dryer - Wood chip hopper - Bucket elevator	The feeding system is improved from existing design.

The main processes and equipments is not modified or changed from which are determined in registered PD.

The main fuels used in the clink production process, before the implemented use of the biomass residue system, was fossil fuels such as fuel oil, coal, lignite, petroleum coke and anthracite.

Since implementing the project activity, some biomass residue has partially substituted fossil fuel in the grouped project. Rice husk is a main biomass residue used in all sites. However, some sites, such as Kaeng Khoi and Thung Song consume other kinds of biomass residue such as wood chip, palm shell, and bark.

The quantity of each type of fuel will be varied by season, climate situation, available resources, quality, cost, etc. While the specific energy consumption of cement production is also varied from the fluctuation of clinker production quantity and the performance of cement production process.

2.2 Deviations from the monitoring plan for this monitoring period

Deviation	Deviated approach for monitoring period	Justification for deviation
1 The quantity of fossil fuel oil is not directly measured.	The monitored value from fuel oil flow meter is converted into tons by using the density value.	The standard formulae, D (density) equals mass divided by volume. Hence the mass in ton is from density in kg/m^3 multiplied with volume in m^3 . http://www.thecalculatorsite.com/conversions/substances/oil.php
2 The quantity of biomass residue type k is the additional monitored parameter in this monitoring period.	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 publically available data for available biomass to apply leakage estimation as per the methodological approach.	This parameter is applicable if approach L_2 is used to estimate the leakage emissions.
3 The quantity of electricity consumed by project is the additional monitored parameter in this monitoring period.	The $EC_{PJ,y}$ is the parameter which needs to be monitored according to ACM0003 version 07.2.	This parameter is used for calculating the CO_2 emissions from on-site electricity consumption by "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
4 The heating value of fossil fuel oil, $NCV_{i,y}$ is not recorded in operation report and log sheet on daily basis.	The annual maximum value from result of analysis is applied. Sources of data applied are as listed below.	Since the maximum heating value of fuel oil will give the higher project emissions. This results in lower emission reduction achieved, which is the conservative approach.

	• KW, KK, TL, TS : SCG internal lab • LP : COA from supplier	
--	---	--

2.3 Grouped Project

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

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data Unit / 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:	As presented in Table 27
Purpose of the data:	Used for project emission calculation
Any comment:	-

Data Unit / 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:	As presented in Table 27
Purpose of the data:	Used for baseline emission calculation
Any comment:	Only applicable if F3 has been determined as the

	most likely baseline scenario.
--	--------------------------------

Data Unit / 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:	As presented in Table 29
Purpose of the data:	Used for baseline emission calculation
Any comment:	-

Data Unit / 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:	As presented in Table 28
Purpose of the data:	Used for baseline emission calculation
Any comment:	-

Data Unit / 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:	Fuel Type (t CO ₂ /TJ)		
		Lower	Upper
	Fossil		
	Coal	92.80	100.00
	Coke	82.90	115.00
	Heavy fuel	75.50	78.80
	Diesel oil	72.60	74.80
	Natural gas		
	Lignite	90.90	115.00
	Anthracite	94.60	101.00
	Biomass		
	Wood	0.01	0.10
Agricultural waste	0.01	0.10	
Purpose of the data:	Used for baseline emission calculation		
Any comment:	-		

3.2 Data and Parameters Monitored

Data Unit / 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:	Measured by weighting equipment and fuel oil flow meter
Description of measurement methods and procedures to be applied:	- The quantity of solid-state fossil fuel and biomass fuel is continuously monitored by weighing equipment. The counter from measuring equipment is recorded from DCS by operator. - The fuel oil volume is continuously monitored by flow meter in volume units, m³. The density of fuel oil is used for conversion of m³ into ton. The conversion description is clarified in deviation 1.

Frequency of monitoring/recording:	Continuous monitoring with daily recording
Value monitored:	Presented in Table 19 and Error! Reference source not found.
Monitoring equipment:	Presented in tables of section 5.2
QA/QC procedures to be applied:	- The monitoring equipment is calibrated according to calibration plan and/or shutdown plan of kiln. - All data is managed according to ISO 9001.
Calculation method:	-
Any comment:	-

Data Unit / 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.																																									
Description of measurement methods and procedures to be applied:	-																																									
Frequency of monitoring/recording:	-																																									
Value monitored:	<table><tr><th>Fuel Type</th><th colspan="2">(t CO₂/TJ)</th></tr><tr><th></th><th>Lower</th><th>Upper</th></tr><tr><td>Fossil</td><td></td><td></td></tr><tr><td>Coal</td><td>92.80</td><td>100.00</td></tr><tr><td>Coke</td><td>82.90</td><td>115.00</td></tr><tr><td>Heavy fuel</td><td>75.50</td><td>78.80</td></tr><tr><td>Diesel oil</td><td>72.60</td><td>74.80</td></tr><tr><td>Natural gas</td><td></td><td></td></tr><tr><td>Lignite</td><td>90.90</td><td>115.00</td></tr><tr><td>Anthracite</td><td>94.60</td><td>101.00</td></tr><tr><td>Biomass</td><td></td><td></td></tr><tr><td>Wood</td><td>0.01</td><td>0.10</td></tr><tr><td>Agricultural waste</td><td>0.01</td><td>0.10</td></tr></table>			Fuel Type	(t CO ₂ /TJ)			Lower	Upper	Fossil			Coal	92.80	100.00	Coke	82.90	115.00	Heavy fuel	75.50	78.80	Diesel oil	72.60	74.80	Natural gas			Lignite	90.90	115.00	Anthracite	94.60	101.00	Biomass			Wood	0.01	0.10	Agricultural waste	0.01	0.10
Fuel Type	(t CO ₂ /TJ)																																									
	Lower	Upper																																								
Fossil																																										
Coal	92.80	100.00																																								
Coke	82.90	115.00																																								
Heavy fuel	75.50	78.80																																								
Diesel oil	72.60	74.80																																								
Natural gas																																										
Lignite	90.90	115.00																																								
Anthracite	94.60	101.00																																								
Biomass																																										
Wood	0.01	0.10																																								
Agricultural waste	0.01	0.10																																								
Monitoring equipment:	-																																									
QA/QC procedures to be applied:	Any future revision of the IPCC Guidelines will be taken into account.																																									

Calculation method:	-
Any comment:	EF _{CO₂,k,y} is zero for the biomass residues referred to page 29/40 ACM0003 version 07.2.

Data Unit / 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 laboratory (both internal and external) or the certificate of analysis (COA) from fuel supplier.
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. Then the operator will input the figure into the daily report.
Frequency of monitoring/recording:	This parameter will be measured daily or every batch / delivery depends on type of fuel. The annual weighted-average figure is calculated and used in emission reduction calculation.
Value monitored:	Presented in Table 19 and Table 20
Monitoring equipment:	Presented in tables of section 5.2
QA/QC procedures to be applied:	• NCV will be 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 result of analysis is controlled as per ISO9001 requirements.
Calculation method:	-
Any comment:	The monitoring of NCV of fuel oil and other alternative fuels are described in deviation 4.

Data Unit / 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.
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	$EF_{km,CO_2,y}$
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.
Calculation method:	-
Any comment:	-

Data Unit / 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:	On-site measurements
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:	As presented in Table 20
Monitoring equipment:	As presented in tables of section 5.2
QA/QC procedures to be applied:	The monitoring equipment is calibrated according to calibration plan and/or shutdown plan of kiln. All data is managed according to ISO 9001.
Calculation method:	-
Any comment:	The amount of biomass residue is a same as the biomass residue consumption during the year, since no other activities in the project consume biomass residue.

Data Unit / 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 tonnes/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.
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	FC _{diesel,biomass_handling,y}
Data unit:	Liters/ton biomass

Description:	Quantity of alternative fuel type k for biomass handling
Source of data:	To be conservative, the maximum number of fossil fuel used in biomass handling systems is applied.
Description of measurement methods and procedures to be applied:	-
Frequency of monitoring/recording:	Every verification period.
Value monitored:	0.4955
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	The value applied is from the specific fuel consumption by the biomass handling equipment at Thung Song site. Reference information is described in section 5.3.

Data Unit / Parameter:	EF _{grid,y}
Data unit:	tCO ₂ /MWh
Description:	CO ₂ emission factor for grid electricity during the year y
Source of data:	Thailand Greenhouse Gas Management Organization, using Annex 14 Methodological Tool (Version 02) "Tool to calculate the emission factor for an electricity system" ¹
Description of measurement methods and procedures to be applied:	Update in every verification period.
Frequency of monitoring/recording:	Every verification period.
Value monitored:	0.5812
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	-

¹ http://www.tgo.or.th/download/publication/GEFReport_EN.pdf

Data Unit / Parameter:	$TDL_{j,y}$
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to source j.
Source of data:	Scenario A "Electricity consumption from the grid" is applicable in this case.
Description of measurement methods and procedures to be applied:	The latest version of the tool.
Frequency of monitoring/recording:	Every verification period.
Value monitored:	20%
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	Then default value of 20% is chosen for a conservative calculation.

Data Unit / Parameter:	$P_{\text{clinker},y}$																											
Data unit:	Ton																											
Description:	Production of clinker in year y																											
Source of data:	Daily log file																											
Description of measurement methods and procedures to be applied:	The quantity of clinker produced is calculated from amount of raw material.																											
Frequency of monitoring/recording:	The amount of raw material is recorded continuously and reported daily.																											
Value monitored:	<table><tr><th>Year</th><th>2009</th><th>2010</th><th>2011</th></tr><tr><td>TL</td><td>471,804</td><td>2,614,240</td><td>437,834</td></tr><tr><td>KW</td><td>822,758</td><td>3,328,836</td><td>517,666</td></tr><tr><td>KK</td><td>1,539,992</td><td>6,149,138</td><td>1,142,934</td></tr><tr><td>TS</td><td>1,057,025</td><td>4,259,472</td><td>850,452</td></tr><tr><td>LP</td><td>278,538</td><td>1,466,104</td><td>309,477</td></tr></table>				Year	2009	2010	2011	TL	471,804	2,614,240	437,834	KW	822,758	3,328,836	517,666	KK	1,539,992	6,149,138	1,142,934	TS	1,057,025	4,259,472	850,452	LP	278,538	1,466,104	309,477
Year	2009	2010	2011																									
TL	471,804	2,614,240	437,834																									
KW	822,758	3,328,836	517,666																									
KK	1,539,992	6,149,138	1,142,934																									
TS	1,057,025	4,259,472	850,452																									
LP	278,538	1,466,104	309,477																									
Monitoring equipment:	Presented in tables of section 5.2																											
QA/QC procedures to be applied:	The monitoring equipment is calibrated according to calibration plan and/or shutdown plan of kiln.																											

	All data is managed under ISO 9001.
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	$EF_{CO_2,BL,y}$		
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:	Project site	$EF_{CO_2,BL,y}$	
	TL	0.0891	
	KW	0.0870	
	KK	0.0891	
	TS	0.0888	
	LP	0.0908	
Monitoring equipment:	-		
QA/QC procedures to be applied:	-		
Calculation method:	$EF_{BL,CO_2,y} = \frac{\sum_i FC_{BL,F3,i,y} \times NCV_{i,y} \times EF_{CO_2,i,y}}{\sum_i FC_{BL,F3,i,y} \times NCV_i}$		
Any comment:	The calculation method is described in Baseline emission calculation step 2.		

Data Unit / 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 _{CO2,BL,y})
Description of measurement methods and procedures to be applied:	-
Frequency of monitoring/recording:	Every verification period
Value monitored:	As presented in Table 27
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	-

Data Unit / 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:	The Biomass Potential Report http://www.thaienergydata.in.th/
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:	As presented in Table 15, Table 16 and Table 17
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	Please refer to deviation 2

Data Unit / Parameter:	Biomass residue type K
Data unit:	-
Description:	Quantity of available biomass residues of type k in the region
Source of data:	The Biomass Potential Report http://www.thaienergydata.in.th/
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:	As presented in 15 , Table 16 and Table 17
Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	-
Any comment:	Please refer to deviation 2

Data Unit / 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:	- The installed rated capacity of biomass equipments - The electricity meter of biomass operation unit (for Khao Wong site)
Description of measurement methods and procedures to be applied:	- The power consumption is calculated from the total kW and the number of days within monitoring period. - 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:	As presented in Table 11
Monitoring equipment:	Multifunction power meter : E Power ECM 700
QA/QC procedures to be applied:	- The installed power capacity is updated when the changing in process equipment. - The electricity meter is calibrated according to the manufacturer's recommendation.
Calculation method:	-
Any comment:	Since the electricity meter is not calibrated. The maximum error of 0.5% is applied for conservativeness approach as per EB 52 Annex 60. Please refer to description in deviation 3.

3.3 Description of the 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 operator are responsible for collection of the monitoring data and input in daily log file. The file will be approved by the Cell Head and the Engineer respectively. All the data files should be stored in electronic format with data backup performed at least once a week. The backup data should be placed in another location to avoid the loss of data in case of fire.

Data from each site will be centralised at SCG's Engineering Department and then submitted to consultant. The emission calculations and emission monitoring reports will be issued by the consultant following the methodology.

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-calciner and the kiln for the production of clinker in cement manufacture. CH₄ emissions from preventing disposal or uncontrolled burning of biomass residues are included in this emission.

$$BE_y = BE_{FF,y} + BE_{CH_4,biomass,y}$$

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)
$BE_{CH_4,biomass,y}$	=	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:

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

Where :

FP_y	=	Fuel penalty in year y (GJ)
$P_{clinker,y}$	=	Production of clinker in year y (tons)
$SEC_{clinker,PJ,y}$	=	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:

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

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 (tons)
 $NCV_{i,y}$ = 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 (tons)
 $NCV_{k,y}$ = Net calorific value of the alternative or less carbon intensive fuel type k used in the project plant in year y (tons)
 $P_{clinker,y}$ = Production of clinker in year y (tons)
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 types

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

With :

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

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

Table 6 : Summary of fuel penalty : BE calculation step 1

Project site		Ta Luang			Khao Wong			Kaeng Khoi		
Year		2009	2010	2011	2009	2010	2011	2009	2010	2011
$FC_{PJ,i,y} \times NCV_{i,y}$	GJ	1,586,176	8,812,640	1,462,009	2,188,755	9,743,380	1,423,467	4,568,641	18,581,670	3,270,554
$FC_{PJ,k,y} \times NCV_{k,y}$	GJ	92,061	225,526	88,469	368,749	556,510	169,019	228,796	1,349,852	349,618
$P_{clinker,y}$	tonne	471,804	2,614,240	437,834	822,758	3,328,836	517,666	1,539,992	6,149,138	1,142,934
$SCE_{clinker,PJ,y}$	GJ/ton	3.56	3.46	3.54	3.11	3.09	3.08	3.12	3.24	3.17
$SCE_{clinker,BL}$	GJ/ton	3.41	3.41	3.41	3.04	3.04	3.04	3.08	3.08	3.08
F_{py} (calculation)	GJ	70,933	132,183	58,900	57,317	184,262	19,409	50,581	977,483	97,204
F_{py} (conservative)	GJ	70,933.25	132,183	58,900	57,317	184,262	19,409	50,581	977,483	97,204
Project site		Thung Song			Lampang					
Year		2009	2010	2011	2009	2010	2011			
$FC_{PJ,i,y} \times NCV_{i,y}$	GJ	2,779,791	10,138,360	2,406,529	713,132	4,062,115	810,431			
$FC_{PJ,k,y} \times NCV_{k,y}$	GJ	455,466	2,192,709	119,879	117,982	561,863	69,651			
$P_{clinker,y}$	tonne	1,057,025	4,259,472	850,452	278,538	1,466,104	309,477			
$SCE_{clinker,PJ,y}$	GJ/ton	3.06	2.89	2.97	2.98	3.15	2.84			
$SCE_{clinker,BL}$	GJ/ton	3.12	3.12	3.12	3.01	3.01	3.01			
F_{py} (calculation)	GJ	(63,520)	(961,946)	(127,694)	(6,501)	215,131	(50,573)			
F_{py} (conservative)	GJ	-	-	-	-	215,131	-			

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:

$$BF_{FF,y} = \left[\sum_k (FC_{PJ,k,y} \times NCV_{k,y}) - F_{P,y} \right] \times EF_{CO_2,BL,y}$$

Where :

- $BF_{FF,y}$ = Baseline emission from fossil fuels displaced by alternative fuels or less carbon intensive fuels in year y (tCO₂)
- $FC_{PJ,k,y}$ = 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)
- $F_{P,y}$ = Fuel penalty in year y (GJ)
- $EF_{CO_2,BL,y}$ = 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 (tCO₂/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:

$$EF_{BL,CO_2,y} = \frac{\sum_i FC_{BL,F3,i,y} \times NCV_{i,y} \times EF_{CO_2,i,y}}{\sum_i FC_{BL,F3,i,y} \times NCV_i}$$

Where :

- $EF_{BL,CO_2,i,y}$ = 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 (tCO₂/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 (tons)
- $NCV_{i,y}$ = Net calorific value of the fossil fuel type i in year y (tCO₂/GJ)
- $EF_{CO_2,i,y}$ = Carbon dioxide emission factor fuel type i in year y (tCO₂/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

Table 7 : Summary of baseline emissions from the displacement of fossil fuel

Project Site		Ta Laung			Khao Wong			Kaeng Khoi		
Year		2009	2010	2011	2009	2010	2011	2009	2010	2011
$\sum FC_{PL,k,y} \times NCV_{k,y}$	GJ	92,061	225,526	88,469	368,749	556,510	169,019	228,796	1,349,852	349,618
FP_y	GJ	70,933	132,183	58,900	57,317	184,262	19,409	50,581	977,483	97,204
$EF_{BL,CO_2,y}$ (option A)	tCO ₂ /GJ	0.0891	0.0891	0.0891	0.0870	0.0870	0.0870	0.0891	0.0891	0.0891
$EF_{BL,CO_2,y}$ (option B)	tCO ₂ /GJ	0.0917	0.0919	0.0917	0.0921	0.0917	0.0917	0.0926	0.0926	0.0927
$EF_{BL,CO_2,y}$ (option C)	tCO ₂ /GJ	0.0891	0.0891	0.0891	0.0870	0.0870	0.0870	0.0891	0.0891	0.0891
$BE_{FF,y}$	tCO ₂	1,884	8,321	2,636	27,099	32,391	13,018	15,888	33,196	22,502
Project Site		Thung Song			Lampang					
Year		2009	2010	2011	2009	2010	2011			
$\sum FC_{PL,k,y} \times NCV_{k,y}$	GJ	455,466	2,192,709	119,879	117,982	561,863	69,651			
FP_y	GJ	-	-	-	-	215,131	-			
$EF_{BL,CO_2,y}$ (option A)	tCO ₂ /GJ	0.0888	0.0888	0.0888	0.0908	0.0908	0.0908			
$EF_{BL,CO_2,y}$ (option B)	tCO ₂ /GJ	0.0926	0.0913	0.0927	0.0908	0.0908	0.0909			
$EF_{BL,CO_2,y}$ (option C)	tCO ₂ /GJ	0.0888	0.0888	0.0888	0.0908	0.0908	0.0908			
$BE_{FF,y}$	tCO ₂	40,441	194,692	10,644	10,708	31,468	6,321			

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:

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

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)
$EF_{burning, CH_4, k, y}$	=	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, page 17, 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 8 : Summary of baseline emission from burning of biomass residue

Project site		Ta Luang			Khao Wong			Kaeng Khoi		
Year		2009	2010	2011	2009	2010	2011	2009	2010	2011
$FC_{PJ, k, y} \times EF$	tCH ₄	0.64	1.48	6.22	2.52	3.25	1.11	0.81	5.70	1.76
GWP_{CH_4}	tCO ₂ e/tCH ₄	21	21	21	21	21	21	21	21	21
$BE_{CH_4, B1/B3, y}$	tCO ₂ e	13.52	31.17	130.53	52.96	68.31	23.41	17.05	119.62	36.88
Project site		Thung Song			Lampang					
Year		2009	2010	2011	2009	2010	2011			
$FC_{PJ, k, y} \times EF$	tCH ₄	3.32	13.89	8.75	0.86	4.10	5.05			
GWP_{CH_4}	tCO ₂ e/tCH ₄	21	21	21	21	21	21			
$BE_{CH_4, B1/B3, y}$	tCO ₂ e	69.82	291.65	183.77	17.99	86.08	106.01			

Table 9 : Summary of Baseline emission calculation

Year	Ta Luang	Khao Wong	Kaeng Khoi	Thung Song	Lampang
	BE _y	BE _y	BE _y	BE _y	BE _y
2009	1,897	27,152	15,905	40,511	10,726
2010	8,352	32,459	33,316	194,984	31,554
2011	2,767	13,042	22,539	10,828	6,427

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 :

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

$PE_{k,y}$	=	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)
$EF_{CO_2,k,y}$	=	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

Table 10 : Summary of project emission from the use of alternative fuels and/or less carbon intensive fossil fuels

Project site		Ta Luang			Khao Wong			Kaeng Khoi		
Year		2009	2010	2011	2009	2010	2011	2009	2010	2011
$FC_{PJ,K,y} \times EF$	tCH ₄	0.67	3.84	0.57	4.02	19.19	2.82	20.35	98.53	18.86
GWP_{CH_4}	tCO ₂ e/tCH ₄	21	21	21	21	21	21	21	21	21
$PE_{k,y}$	tCO ₂ e	14.09	80.61	12.07	84.47	402.92	59.26	427.27	2,069.17	396.14
Project site		Thung Song			Lampang					
Year		2009	2010	2011	2009	2010	2011			
$FC_{PJ,K,y} \times EF$	tCH ₄	-	-	-	0.11	0.06	0.09			
GWP_{CH_4}	tCO ₂ e/tCH ₄	21	21	21	21	21	21			
$PE_{k,y}$	tCO ₂ e	-	-	-	2.33	1.34	1.80			

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 from electricity consumption". Then the project emission from electricity consumption is calculated as follows:

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

Where :

$PE_{EC,y}$	=	Project emissions from the additional electricity consumption as a result of project activity in year y (tCO ₂ /y)
-------------	---	---

- $EC_{PJ,y}$ = 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 (tCO₂/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 Organization²

The average technical transmission and distribution losses use conservative default values of 20%, according to “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”

Table 11 : The project emissions from additional electricity consumption

Parameters	Unit	Ta Luang			Khao Wong			Kaeng Khoi		
		2009	2010	2011	2009	2010	2011	2009	2010	2011
Electricity consumption, EC	kWh	342,240	1,357,800	219,480	141,425	387,078	300,775	6,273,414	24,889,087	4,023,168
EF	tCO ₂ /MWh	0.5812	0.5812	0.5812	0.5812	0.5812	0.5812	0.5812	0.5812	0.5812
TDL	%	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
PE	tCO ₂	239	947	153	99	270	210	4,375	17,359	2,806
Parameters	Unit	Thung Song			Lampang					
		2009	2010	2011	2009	2010	2011			
Electricity consumption, EC	kWh	1,485,359	5,941,437	990,240	220,800	876,000	141,600			
EF	tCO ₂ /MWh	0.5812	0.5812	0.5812	0.5812	0.5812	0.5812			
TDL	%	0.200	0.200	0.200	0.200	0.200	0.200			
PE	tCO ₂	1,036	4,144	691	154	611	99			

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 02 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;

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

Where :

- $PE_{FC,j,y}$ = CO₂ emissions from fossil fuel combustion in process j during year y (tCO₂/y)
 $FC_{i,j,y}$ = Quantity of fuel type i combusted in process j during the year y (mass or volume unit / year)

² http://www.tgo.or.th/download/publication/GEFReport_EN.pdf

$COEF_{i,y}$ = CO2 emission coefficient of fuel type i in year y
(tCO₂/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;

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO_2,i,y}$$

Where :

$COEF_{i,y}$ = CO2 emission coefficient of fuel type i in year y
(tCO₂/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)
 $EF_{CO_2,i,y}$ = the weighted average CO₂ emission factor of fuel type i in year y
(tCO₂/GJ)
i = the fuel types combusted in process j during the year y

Table 12 : The project emissions from on-site transportation

Parameters	Unit	Ta Luang			Khao Wong			Kaeng Khoi		
		2009	2010	2011	2009	2010	2011	2009	2010	2011
Average amount of fossil fuel for biomass handling; FC	litre/year	4,021	9,598	3,054	17,643	21,985	10,555	5,417	39,942	11,768
NCV for diesel	MJ/litre	36.42	36.42	36.42	36.42	36.42	36.42	36.42	36.42	36.42
EF _{CO2}	tCO ₂ /TJ	74.80	74.80	74.80	74.80	74.80	74.80	74.80	74.80	74.80
PE	tCO ₂	11	26	8	48	60	29	15	109	32
Parameters	Unit	Thung Song			Lampang					
		2009	2010	2011	2009	2010	2011			
Average amount of fossil fuel for biomass handling; FC	litre/year	23,831	95,221	8,296	5,614	26,861	3,287			
NCV for diesel	MJ/litre	36.42	36.42	36.42	36.42	36.42	36.42			
EF _{CO2}	tCO ₂ /TJ	74.80	74.80	74.80	74.80	74.80	74.80			
PE	tCO ₂	65	259	23	15	73	9			

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:

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

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 liter) 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 13 : Project emissions from combustion of fossil fuels for transportation of alternative fuels to project plant.

Parameters	Unit	Ta Luang			Khao Wong			Kaeng Khoi		
		2009	2010	2011	2009	2010	2011	2009	2010	2011
Quantity of biomass residue; AF	tonnes	8,115	19,371	6,163	35,607	44,370	21,301	10,933	80,610	23,749
Average truck load; TL	tonnes/trip	15	15	15	15	15	15	15	15	15
Average round trip; AVD	km	400	400	400	400	400	400	400	400	400
EF	tCO ₂ /km	0.001097	0.001097	0.001097	0.001097	0.001097	0.001097	0.001097	0.001097	0.001097
PE	tCO ₂	237	567	180	1,042	1,298	623	320	2,358	695

Parameters	Unit	Thung Song			Lampang		
		2009	2010	2011	2009	2010	2011
Quantity of biomass residue; AF	tonnes	48,096	192,171	16,743	11,330	54,210	6,634
Average truck load; TL	tonnes/trip	15	15	15	15	15	15
Average round trip; AVD	km	400	400	400	400	400	400
EF	tCO ₂ /km	0.001097	0.001097	0.001097	0.001097	0.001097	0.001097
PE	tCO ₂	1,407	5,622	490	331	1,586	194

Table 14 : Summary of Project emission calculation

Year	Ta Luang	Khao Wong	Kaeng Khoi	Thung Song	Lampang
	PE _y	PE _y	PE _y	PE _y	PE _y
2009	501	1,273	5,137	2,508	503
2010	1,544	2,031	21,895	10,025	2,271
2011	342	921	3,929	1,203	304

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.

Table 15: Rice husk Potential for Saraburi area (Kaeng Koi , Ta Luang and Khao Wong site)

Year 2008	Rice husk Potential		
	ktoe	GJ	Ton
Bangkok	16.82	710,544	49,343
Nonthaburi	19.92	841,500	58,438
Samutprakarn	5.21	220,091	15,284
Samutsakorn	1.96	82,798	5,750
Nakornpathom	61.28	2,588,712	179,772
Saraburi	39.44	1,666,103	115,702
Lopburi	85.72	3,621,156	251,469
Singhburi	64.98	2,745,015	190,626
Chainat	135.25	5,713,501	396,771
Uthaithani	45.43	1,919,145	133,274
Suphanburi	204.83	8,652,839	600,892
Angthong	65.13	2,751,352	191,066
Kanchanaburi	33.51	1,415,596	98,305
Ratchaburi	43.11	1,821,139	126,468
Phetchburi	37.44	1,581,615	109,834
Ayutthaya	122.57	5,177,847	359,573
Nakornnayok	28.5	1,203,954	83,608
Prajeenburi	39.88	1,684,691	116,992
Srakaew	27.58	1,165,090	80,909
Samutsongkram	0.26	10,983	763
Chacherngsao	79.21	3,346,147	232,371
Chantaburi	1.8	76,039	5,281
Rayong	1.94	81,953	5,691
Chonburi	6.64	280,500	19,479
SUM	1,168	49,358,312	3,427,661

Table 16 : Rice husk Potential for Lampang site

Year 2008	Rice husk Potential		
	ktoe	GJ	Ton
Chiang Rai	91.19	3,852,230	267,516
Lampang	29.64	1,252,112	86,952
Chiang Mai	37.9	1,601,048	111,184
Tak	13.26	560,155	38,900
Phayao	13.26	560,155	38,900
Sukhothai	74.74	3,157,317	219,258
Phrae	16.88	713,079	49,519
Uttaradit	52.61	2,222,457	154,337
Phitsanuloke	127.54	5,387,800	374,153
Phichit	150.05	6,338,712	440,188
Maehongsorn	6.48	273,741	19,010
Lampoon	10.32	435,958	30,275
Nan	0	-	-
SUM	1,951	82,434,519	5,724,619

Table 17 : Rice husk Potential for Thung Song site

Year 2008	Rice husk Potential		
	ktoe	GJ	Ton
Ranong	0	5,914	411
Saratthani	1	49,848	3,462
Phang Nga	0	14,363	997
Phuket	0	1,267	88
Krabi	1	35,485	2,464
Trang	2	70,970	4,928
Nakorn Sri Thammarat	32	1,362,791	94,638
Patthalung	22	927,678	64,422
Songkhla	25	1,053,988	73,194
Satun	3	144,474	10,033
Pattani	9	374,282	25,992
SUM	2,499	105,564,799	7,330,889

The Rice Husk potential data presented in Table 15, Table 16 and Table 17, demonstrates the availability of rice husk, which is not utilized in each area³. It is presented in unit ktoe or kilo ton oil equivalent. The calorific values of 42.244 GJ/toe and 14.4 MJ/kg respectively for oil and paddy husk are used for unit conversion.⁴

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, Hence the leakage emissions from project activities are considered zero as per approach L₂.

³ <http://www.thaienergydata.in.th/>

⁴ http://www.dede.go.th/dede/fileadmin/upload/nov50/nov52/ener_2551.pdf

4.4 Summary of GHG Emission Reductions and Removals

The total emission reduction achieved by this project activities within this monitoring period is 352,443 tCO₂e

Table 18 : Summary of Emission reduction achieved for this crediting period

Site / Year	2009	2010	2011	Total
Ta Luang	1,396	6,809	2,424	10,629
Khao Wong	25,879	30,428	12,121	68,428
Kaeng Khoi	10,768	11,421	18,610	40,799
Thung Song	38,003	184,959	9,625	232,587
Lampang	0	0	0	0
Total	76,046	233,617	42,780	352,443

5 ADDITIONAL INFORMATION

5.1 Summary of monitored data

Table 19 : The monitored quantity and NCV value of fossil fuel oil

Fuel Type		Ta Luang			Khao Wong			Kaeng Khoi		
Fossil		2009	2010	2011	2009	2010	2011	2009	2010	2011
Fuel Oil	Ton	171	1,755	347	218	2,107	235	1,486	4,066	482
Coal	Ton	32,417	220,398	33,531	63,982	170,278	25,997	245,236	950,736	174,340
Lignite	Ton	41,208	190,668	35,406	40,001	263,446	36,591			
Anthrasite	Ton					4,465	1,409			
Bituminus	Ton					23,701	3,675			
Net Calorific Value*		2009	2010	2011	2009	2010	2011	2009	2010	2011
Fuel Oil	GJ/ton	42.90	43.29	43.29	41.01	39.53	39.75	42.85	43.14	43.27
Coal	GJ/ton	22.88	23.22	23.07	22.05	23.21	23.54	18.37	19.36	18.64
Lignite	GJ/ton	20.32	18.98	19.02	19.22	19.31	18.84			
Anthrasite	GJ/ton					22.03	22.17			
Bituminus	GJ/ton				21.21	22.01	22.17			
Fuel Type		Thung Song			Lampang					
Fossil		2009	2010	2011	2009	2010	2011			
Fuel Oil	Ton	871	20,176	283	57	551	28			
Coal	Ton	116,290	415,914	102,896						
Lignite	Ton				43,761	242,115	47,574			
Anthrasite	Ton									
Bituminus	Ton									
Net Calorific Value*		2009	2010	2011	2009	2010	2011			
Fuel Oil	GJ/ton	45.92	43.21	42.90	42.92	42.92	42.64			
Coal	GJ/ton	23.56	22.28	23.27						
Lignite	GJ/ton				16.24	16.68	17.01			
Anthrasite	GJ/ton									
Bituminus	GJ/ton									

Table 20 : The monitored quantity and NCV value of Biomass and other alternative fuel

Fuel Type		Ta Luang			Khao Wong			Kaeng Khoi		
Alternative fuel		2009	2010	2011	2009	2010	2011	2009	2010	2011
Rice Husk	Ton									
Saw dust	Ton									
Biomass		8,115	19,371	6,163	35,607	44,370	21,301	10,933	80,610	23,749
Mixed solid waste	Ton	341	1,300	236	1,309	5,007	751	7,420	25,865	6,238
Waste oil	Ton					541	32			
Charcoal	Ton									
Heating Value		2009	2010	2011	2009	2010	2011	2009	2010	2011
Rice Husk	GJ/ton									
Saw dust	GJ/ton									
Biomass	GJ/ton	10.87	10.50	13.82	9.70	10.04	7.17	10.17	9.68	10.13
Mixed solid waste	GJ/ton	11.38	17.07	14.07	17.76	17.81	20.01	15.85	22.02	17.48
Waste oil	GJ/ton					40.20	40.19			
Charcoal	GJ/ton									
Fuel Type		Thung Song			Lampang					
Alternative fuel		2009	2010	2011	2009	2010	2011			
Rice Husk	Ton				8,911	44,338	4,739			
Saw dust	Ton				2,419	9,872	1,895			
Biomass		48,096	192,171	16,743						
Mixed solid waste	Ton				132	76	102			
Waste oil	Ton									
Charcoal	Ton		10,042							
Heating Value		2009	2010	2011	2009	2010	2011			
Rice Husk	GJ/ton				10.35	10.62	10.51			
Saw dust	GJ/ton				10.38	9.18	10.21			
Biomass	GJ/ton	9.47	9.90	7.16						
Mixed solid waste	GJ/ton				4.86	4.85	4.86			
Waste oil	GJ/ton									
Charcoal	GJ/ton		28.90							

5.2 Summary of monitoring equipment

Table 21 : Monitoring equipment information of Kaeng Khoi site

Project site	Meter name	Type	Tag no.	Accuracy	Cal History
KK3	WF-Solid fuel WF main burner	Pfister	22FE02	2%	05-Jul-09 20-Oct-09 20-Mar-10
KK3	WF-Solid fuel WF calciner	Pfister	22WF01W1	0.50%	05-Jul-09 20-Oct-09 20-Mar-10
KK3	WF-Waste		08WF03	2%	05-Jul-09 20-Oct-09 15-Mar-10
KK4	WF-Solid fuel main burner	Pfister	22FE51	2%	27-Apr-09 10-Jul-09 10-Mar-10
KK4	WF-Solid fuel calciner	Pfister	22WF53W1	0.50%	27-Apr-09 10-Jul-09 10-Mar-10
KK4	WF-Biomass		08FC77	2%	27-Apr-09 10-Jul-09 01-Mar-10
KK5	Weight feeder	Pfister	W5V72	1%	10-Jun-09 20-Jan-10
KK5	Weight feeder	Clorioris	W5V82	1%	12-Jun-09 21-Jan-10
KK6	Weight feeder	Pfister	W6V72	1%	06-May-09 12-Nov-09 07-Apr-10
KK6	Weight feeder	Pfister	W6V82	1%	15-Dec-09 07-Apr-10
KK6	WF- Biomass		W6V139	2%	28-Apr-09 24-Nov-09 22-Apr-10
KK	Truck scale S/N 4258304-OZR	Mettler Toledo Model 8350	NO.7	2%	02-Sep-09 02-Mar-10
KK	Truck scale 4283910-4ZS	Mettler Toledo Model 8350	NO.8	2%	05-Oct-09 03-Mar-10

Table 22 : Monitoring equipment information of Khao Wong site

Project site	Meter name	Type	Tag no.	Accuracy	Cal History
KW	Feeder lignite	Pfister	1566-1	-	25-Oct-09 03-Aug-10
KW	Feeder lignite	Pfister	1566-2	-	25-Oct-09 03-Aug-10
KW	Feeder lignite	Pfister	1566-3	-	25-Oct-09 03-Aug-10
KW	Biomass belt weigher	Bel weight	904H-1	3%	13-Jan-09 31-Jan-10
KW	Biomass belt weigher	Bel weight	904H-2	3%	15-Jan-09 31-Jan-10
KW	Truck scale 4290782-4QT	Mettler Toledo Model 8350	X2503	2%	23-Jun-08 03-Sep-10

KW	Truck scale 4268350-4RS	Mettler Toledo Model 8350	X2504	2%	23-Jun-08 03-Sep-10
KW	Truck scale 4290789-4QT	Mettler Toledo Model 8350	X2505	2%	23-Jun-08 07-Apr-09
KW	Truck scale 4289112-4PT	Mettler Toledo Model 8350	X2506	2%	23-Jun-08 10-mar-09
KW	Truck scale 4286655-4NT	Mettler Toledo Model 8350	X2507	2%	23-Jun-08 07-Apr-09
KW	Truck scale 0040351-6EH	Mettler Toledo Model 8350	X2508	2%	23-Jun-08 02-Jun-09

Table 23 : Monitoring equipment information of Lampang site

Project site	Meter name	Type	Tag no.	Accuracy	Cal History
LP	WF-Biomass		793_21	-	01-Apr-09 13-Jul-09 01-Sep-09 04-Jan-10 24-Apr-10 26-Aug-10
LP	WF-Biomass		793_31	-	01-Apr-09 13-Jul-09 01-Sep-09 04-Jan-10 24-Apr-10 26-Aug-10
LP	WF-Solid fuel	Pfister	791.1	-	14-Jul-09 24-Oct-09 06-Jan-10 25-Apr-10
LP	WF-Solid fuel	Pfister	792.1	-	14-Jul-09 24-Oct-09 06-Jan-10 25-Apr-10
LP	WF-Solid fuel	Pfister	793.1	-	14-Jul-09 24-Oct-09 06-Jan-10 25-Apr-10
LP	Truck scale – clinker 4377789-4SW	Mettler Toledo Model 8350	HWB1	2%	05-Jul-09
LP	Truck scale – clinker 4380183-4TW	Mettler Toledo Model 8350	HWB2	2%	05-Jul-09
LP	Truck scale – clinker 4385568-4VW	Mettler Toledo Model 8350	LWB1	2%	19-Jan-09
LP	Truck scale – clinker 4367058-4NW	Mettler Toledo Model 8350	LWB2	2%	19-Jan-09
LP	Truck scale – raw mat 4377791-4SW	Mettler Toledo Model 8350	RWB1	2%	19-Jan-09
LP	Truck scale – raw mat 4377790-4SW	Mettler Toledo Model 8350	RWB2	2%	19-Jan-09

Table 24 : Monitoring equipment information of Ta Laung site

Project site	Meter name	Type	Tag no.	Accuracy	Cal History
TL5	WF-Rice husk	Schenck-Multidas	W2U64F1	0.50%	08-Mar-07 28-Feb-08 03-Jun-09 13-Jun-10
TL5	WF-Solid fuel	Pfister	K1A02	0.50%	30-May-07 29-Nov-08 30-May-09 16-Mar-10
TL5	WF-Solid fuel	Pfister	K1A03	0.50%	30-May-07 29-Nov-08 30-May-09 16-Mar-10
TL5	WF-Solid fuel	Pfister	L5F35	0.50%	30-May-07 29-Nov-08 30-May-09 16-Mar-10
TL5	WF-Raw meal	Schenck-Multicont	W2A02F1		03-Nov-09
TL6	WF-Rice husk	Schenck-Multidas	W1U64F1	0.50%	10-Mar-07 22-Jun-08 28-Jul-09 19-May-10
TL6	WF-Solid fuel	Cloriolis	K6A10	0.50%	20-Sep-07 12-Nov-08 14-Mar-09 24-Jan-10
TL6	WF-Solid fuel	Pfister	L7F15	0.50%	20-Sep-07 12-Nov-08 14-Mar-09 24-Jan-10
TL6	WF-Solid fuel	Pfister	L7F25	0.50%	20-Sep-07 12-Nov-08 14-Mar-09 24-Jan-10
TL6	WF-Raw meal	Schenck-Multicont	W1A02F1	-	09-Oct-09
TL	Truck scale 8XBSU.60015	Kubota KL-D1000S	P0L07F1	-	03-Mar-09
TL	Truck scale 8XBSU.60009	Kubota KL-D1000S	P0L07F2	-	04-Mar-09
TL	Truck scale 8XBSU.60013	Kubota KL-D1000S	P5X11F2	-	04-Mar-09
TL	Truck scale 00387206CK	Mettler Toledo IND 313	L7X09F2	-	05-Oct-09
TL	Truck scale CC-09-9132-0-3	Kubota KS-C.7200E	L7X09F1	-	22-Feb-10
TL	Truck scale 8XBSU.60015	Kubota KL-D1000S	P0L07F1	-	03-Mar-09
TL	Truck scale 8XBSU.60009	Kubota KL-D1000S	P0LO7F2	-	04-Mar-09
TL	Truck scale 8XBSU.60010	Kubota KL-D1000S	P5X11F2	-	04-Mar-09
TL	Truck scale 00387206CK	Mettler Toledo IND 313	L7X09F2	-	05-Oct-09
TL	Truck scale CC-09-9132-0-3	Kubota KS-C.7200E	L7X09F1	-	22-Feb-10

Table 25 : Monitoring equipment information of Thung Song site

Project site	Meter name	Type	Tag no.	Accuracy	Cal History
TS5	WF-Solid fuel	Pfister	792_10	1%	07-Jul-10
TS5	WF-Solid fuel	Pfister	793_10	1%	07-Jul-10
TS5	WF-Biomass		228_92	1%	06-Jul-10
TS5	WF-Biomass		228_95	1%	06-Jul-10
TS	Truck scale		BIX03	40 kg	25-Jul-09 22-Oct-09 22-Jan-10
TS	Truck scale		BIX04	40 kg	25-Jul-09 22-Oct-09 22-Jan-10
TS	Truck scale		XIX05	40 kg	29-Aug-09 25-Nov-09 21-Feb-10
TS	Truck scale		XIX06	40 kg	29-Aug-09 25-Nov-09 21-Feb-10

5.3 Other information used in emission calculation

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.

The test was done by measuring the biomass transferred quantity and fuel consumed by each equipments in one hour. The total specific fuel consumption is 0.4955 liters/ton of biomass. The consumption details are presented in Table 26.

Table 26 : Specific consumption of Biomass handling equipment

Machine	Fuel Consumption (L/hr)	Capacity (t/hr)	Fuel Consumption (L/ton)
1. Wood Gripper 120 hp.	4	48.02	0.0833
2. CAT.966 220 hp. Bucket size 4.0 m3	23	168.62	0.1364
3. CAT.924 120 hp. Bucket size 2.0 m3	8	190.48	0.042
4. WA300 165 hp. Bucket size 2.0 m3	10	125.00	0.08
5. 10W Truck	5.5	35.76	0.1538

2) Information for Baseline emissions calculation

Table 27 : Quantity of fossil fuel used in the project plant 3 years before project implementation

Fuel Type		TaLung			Khao Wong			Kaeng Khoi		
Fossil		2000	2001	2002	2000	2001	2002	2000	2001	2002
Fuel Oil	Ton (dry basis)	885	825	4,866	3,705	4,188	2,261	3,877	3,320	5,678
Coal	Ton (dry basis)	16,923	5,944	31,708	27,218	3,166	19,574	137,006	1,948	43,007
Lignite	Ton (dry basis)	46,845	92,730	251,340	189,534	140,995	270,215	468,388	647,769	533,107
Pet-Coke	Ton (dry basis)	4,643	1,771	59,457	129,514	143,749	106,027	56,917	104,250	157,989
Anthracite	Ton (dry basis)	-	-	-	2,835	48,758	8,477	-	14,077	4,545
Fuel Type		Thung Song			Lampang					
Fossil		2000	2001	2002	2000	2001	2002			
Fuel Oil	Ton (dry basis)	4,126	3,291	2,486	519	477	682			
Coal	Ton (dry basis)	188,136	166,152	143,493	-	-	-			
Lignite	Ton (dry basis)	50,424	208,229	225,796	105,615	105,743	191,910			
Pet-Coke	Ton (dry basis)	143,272	101,586	105,029	-	-	-			
Anthracite	Ton (dry basis)	-	-	16,879	-	-	-			

Table 28: Heating value of fossil fuel used in the project plant 3 years before project implementation

Fuel Type		TaLung			Khao Wong			Kaeng Khoi		
Heating Value		2000	2001	2002	2000	2001	2002	2000	2001	2002
Fuel Oil	GJ/ton	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39	40.39
Coal	GJ/ton	24.31	25.41	25.09	24.95	26.70	28.47	25.74	25.74	25.74
Lignite	GJ/ton	18.21	18.12	17.16	21.42	20.79	20.26	17.99	17.99	17.99
Pet-Coke	GJ/ton	30.13	30.47	32.63	32.96	32.25	33.76	32.46	32.44	32.44
Anthracite	GJ/ton	-	-	-	29.25	27.80	27.86	-	27.21	27.21
Fuel Type		Thung Song			Lampang					
Heating Value		2000	2001	2002	2000	2001	2002			
Fuel Oil	GJ/ton	40.39	40.39	40.39	40.39	40.39	40.39			
Coal	GJ/ton	25.12	25.83	25.39	-	-	-			
Lignite	GJ/ton	18.85	20.48	19.32	18.10	17.94	17.82			
Pet-Coke	GJ/ton	33.98	32.81	32.22	-	-	-			
Anthracite	GJ/ton	-	-	26.46	-	-	-			

Table 29: The energy consumption of the project plant 3 years before project implementation

Project site	Unit	TaLung			Khao Wong			Kaeng Khoi		
Year		2000	2001	2002	2000	2001	2002	2000	2001	2002
HG = FC x NCV	GJ	1,440,040	1,918,788	7,244,873	9,241,177	9,175,860	9,938,830	13,956,145	15,600,885	16,174,720
Pclinker	ton	410,188	557,145	2,126,642	3,041,073	3,017,068	3,254,406	4,527,703	4,912,623	5,045,459
HG/Pclinker	GJ/ton	3.5107	3.4440	3.4067	3.0388	3.0413	3.0540	3.0824	3.1757	3.2058
Project site	Unit	Thung Song			Lampang					
Year		2000	2001	2002	2000	2001	2002			
HG = FC x NCV	GJ	10,712,666	12,021,515	11,937,768	1,933,066	1,916,424	3,446,558			
Pclinker	ton	3,381,254	3,797,506	3,825,211	642,816	603,902	1,063,054			
HG/Pclinker	GJ/ton	3.1683	3.1656	3.1208	3.0072	3.1734	3.2421			