MOEJ/GEC JCM Feasibility Study (FS) 2014
Summary of the Final Report

"Biomass Utilization in Cement Kiln"
(Implementing Entity: Taiheiyo Engineering Corporation)

1. Overview of the Proposed JCM Project

Study partners	Osumi Corporation: MRV related survey, preparation of proposed methodology Hello Laos: (Lao PDR) Interpreter during site survey, arrangement of meeting, accommodation and transportation.		
Project site	Lao PDR		
Category of project	Waste, biomass		
Description of project	By utilizing agricultural biomass, abundant in Lao PDR as an alternative fuel to cement manufacturing process, large amount of CO2 emission reduction can be achieved, as well as saving coal resources.		
Expected project implementer	Japan	Taiheiyo Engineering Corporation	
	Host country	Lao Cement Co., Ltd.	
Initial investment	200 mil. Japanese yen	**Date of groundbreaking**	Middle of 2016 FY
Annual maintenance cost	60 mil. Japanese yen	**Construction period**	6 months
Willingness to investment	Yes	**Date of project commencement**	End of 2016 FY
Financial plan of project	Through the review and re-calculation of initial cost, due to price increase and change of adopted equipment, initial investment cost has increased. For initial cost, Equipment Support from Japanese side and own fund from Laotian side is expected. Annual maintenance cost is estimated as 3% of initial cost. It will be shouldered by project owner. Certain support within the project scheme should be considered for MRV expense for third party entity.		
GHG emission reductions	21,281 (tCO2/year) Emission reduction of 21,600 (tCO2/year) stated on the project proposal is in the case of installing 2t/h of biomass utilization equipment, simple calculation was made that all biomass was utilized in place of fossil fuel.		

	21,333 (tCO2/year) stated in intermediate report was by using data collected from site survey, considering CO2 emission from electricity consumption of biomass feeding system and biomass transportation. This time, by considering the comment from intermediate review, re-calculation was carried out using fuel and electricity consumption which were more conservative than BaU. There is no big difference from calculating basis.

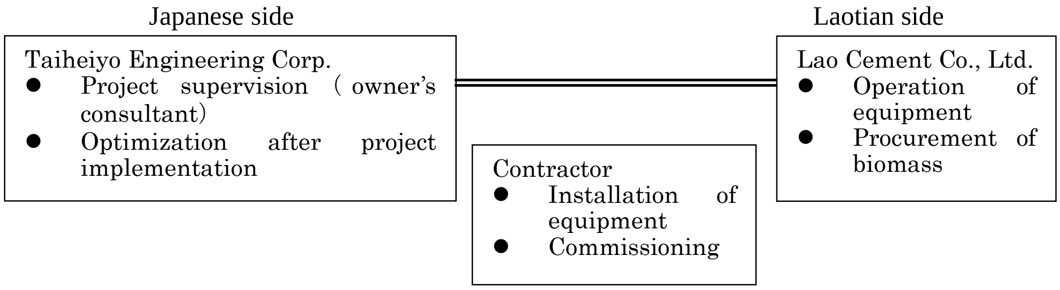
2. Study Contents

(1) Project development and implementation

1) Project planning

Project formation（Project plan and running plan）

Owner of this project is Lao Cement Co., Ltd., while Taiheiyo Engineering is expected to act as main contractor.



Project owner's management system and achievement

Lao Cement Co., Ltd. (Vang Vieng II plant) was built by Chinese fund as one of the economic corporation between China and Laos, being supported by the both government.

It produces and sells Portland Cement with the investment of Yunnan International Techno-Economical company in Chinese side and Agriculture Industry Development Enterprise Imp - Exp & General Services (DAI) in Laotian side.

Vang Vieng II Cement plant sells 200.000 - 300.000 tons of bulk cement and 50kg bagged cement annually since 2002.Its quality is conformed of ASTM C-150, ISO 9001:2008 as well as Chinese standard GB 175-1999 (ISO 679

○Evaluation of profitability of the project

(Including adequacy of investment cost, sales income and profit, project IRR and payback period)

Breakdown of initial investment cost is shown on the table below.

(1,000 Japanese yen)

	Civil and building	Machinery	E&I	Total
Manpower cost		4,845	1,479	6,324
Equipment cost		73,000	22,000	95,000
Installation cost	Total 68,776,	20,000	6,000	26,000
Design Cost		3,000	900	3,900
Total Cost		100,845	30,379	200,000

Comparing with the price stated on proposal and intermediate report, big investment coat increase was anticipated because of the adoption of another type feeder and measuring system.

- Annual profit

For project profitability, profit is calculated from income (in this project, saved anthracite cost) and expected running costs as shown the chart below.

Calculation of annual profit

(1,000 Japanese Yen/year)

	income	Running cost
Income (saved anthracite cost)	90,650	
1. Maintenance cost of biomass utilization equipment		6,000
2. Electricity consumption of biomass utilization equipment		2,145
3. Manpower cost		1,152
4. Fuel cost of transporting trucks		1,192
Total cost		10,489
Profit	80,161	

Further study for additional cost not listed above should be conducted.

- Payback Period

Simple payback period is calculated as follow;

200,000 / 80,160 ≒2.5years

- Calculation of IRR

Using above figures, IRR is calculated. The result is shown below;

year		IRR
Initial investment	**-200,000**	
1	80,161	-
2	80,161	-14%
3	80,161	10%
4	80,161	22%
5	80,161	29%
6	80,161	33%
7	80,161	35%
8	80,161	37%
9	80,161	38%
10	80,161	39%

As shown on above chart, IRR will turn positive from third year and goes up year by year up to 30%. This shows that the profitability of the project is high. However, procurement of biomass as plan is essential condition.

○Financial plan for initial investment, O&M and MRV

The following scheme is being considered.

- For initial investment, application to Equipment Support scheme of MOEJ is anticipated.
- Project owner will invest for local fabrication part and civil work.

It is also considered to reduce investment from the project owner. Because investment cost has increased from proposal.

For O&M expense, no public support is planned because the cost expected will be within the range of normal maintenance cost.

For MRV, necessary data is accurate transaction records of raw materials, fuel, energy and products, no special measurement is needed.

Necessary cost for MRV is initial capacity building. For capacity building, application to public fund is expected.

Especially for the initial stage of MRV, audit to judge the adequacy of implementation and additional capacity building to confirm sufficient number of skilled personnel are expected to be necessary. Also for those purpose, application to public fund is expected.

○Risk analysis

-Expected risk

The biggest anticipated risk is regarding biomass collection.

Currently, biomass (rice husks) is not utilized systematically. However, when utilization increases, procuring enough amount of biomass may be more difficult.

-Effect to the project profitability

This will directly affect the project effect, leads less emission reduction and less profitability. Further study to avoid this situation is necessary.

-Countermeasures

Business model for biomass procurement should be of 'win-win' model. For biomass producer, more advantages other than elimination of biomass dumping site should be sought.

○Possibility of Project implementation considering the above risks

Technically, it was proved that biomass can be utilized in Laotian cement kiln through the burning test.
The burning test carried out during this study was to burn 0.75 ton of bagged rice husks per hour for temporary chute for three hours. During that study, no problem was found for burning of rice husks. Burning efficiency of 98% was recorded, without adverse effect to the cement manufacturing process and product quality.
It was a good opportunity for Laotian Government staff and Lao Cement top management for witnessing the effect of fossil fuel consumption reduction.

For smooth implementation of this project, procurement of sufficient biomass is most important because procured biomass amount directly affect to the profitability of the project.

If a business model which benefits all of the three,--rice husk producer(rice mills) , user of rice husk user (cement plant) and rice husk transporter (transportation organization)—can be established, this project goes much closer to implementation.

2) Permits and License for the project development and implementation

In this project, biomass measuring / feeding system will be retrofitted to existing clinker manufacturing plant.
Part of fossil fuel (anthracite) is substituted by agricultural biomass whose component is known.
Project plant has already equipped with ESP or electro static precipitator. Therefore, there will be almost no adverse effect to environment.
For necessary approval / license including environmental impact assessment, further study should be in cooperation with Laotian side.
After evaluating the result of biomass burning test, meeting with MONRE and MOIT should be held to confirm any approval / license is necessary or not.
If necessary, the content and application procedure of necessary approval / license should be confirmed.

3) Advantage of Japanese technology

In Japanese cement manufacturing process, cost reduction and greenhouse gas emission reduction has been achieved by utilizing various waste materials as alternative raw material or alternative fuel.
Since property of each waste material varies, it is essential to select and install pre-treatment equipment, transportation equipment which fits property of the waste.
To minimize adverse effect to cement manufacturing process and quality fluctuation from waste materials utilization, installation of measuring equipment is essential.

1) Cost and efficiency comparison with competing product /technology (to be introduced if JCM is not applied)

Expected primitive utilization of waste material is of manual feeding or of simple feeding point (manhole) and simple transportation system.

In these systems, feeding rate is not known. So, efficiency is much lower than proposed weighing system developed in Japan.

Also, bigger adverse effect to cement manufacturing process is expected, it prevents smooth operation of the process

However, the cost of installation is much lower because of simplicity. It may cost less than half of Japanese system.

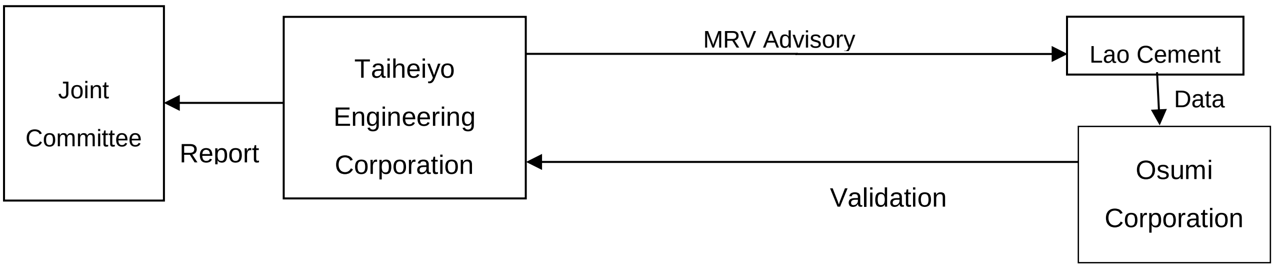
2) Current market situation in host country(Market share of competing product /technology)

In host country, there is no information for systemized waste material utilization. Therefore, competing product /technology have not introduced yet.

4) MRV structure

1) MRV structure

Regarding MRV implementation structure, Taiheiyo Engineering Corporation plays the main role with the support of Osumi Corporation, as shown below figure.



2) MRV training (Capacity building)

The following training shall be conducted.

- Selection of equipment necessary for monitoring
- Capacity building for measuring and monitoring record keeping through on the job training

5) Environmental integrity and Sustainable development in host country

1) Confirmation of environmental integrity

Proposed Japanese waste utilization (including agricultural biomass) technology to be introduced in this project does not affect environment such as air pollution.

Considering this advantage, it is possible to implement dissemination and incentive program for Japanese waste utilization (including agricultural biomass) technology.
It may include financial support like JCM equipment support or application of ODA fund.

With above program, Host country can achieve Environmental integrity and energy conservation, while Japanese equipment manufacture can achieve technology export of waste utilization (including agricultural biomass) technology and more business opportunity.
When crediting system is established, both countries can obtain credit.

2) Contribution to Sustainable development in host country

For the economic development of the host country, infrastructure development to meet economic development is essential. For host country, cement is one of the few building materials which can be manufactured only by domestic resources.
However, domestic fossil fuel is not abundant to meet increasing cement demand. This will affect the continuous development of host country.
Introduction of Japanese waste utilization technology which can achieve not only reduction of fossil fuel consumption, but also greenhouse gas emission reduction greatly contributes the low carbon and sustainable development of host country.

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

Planned schedule and possible obstacles to be overcome are as follow;

1) Estimated project implementation schedule

2014 Feasibility Study (FS) -- This report—
Explanation to concerned Laotian Government organization and Lao Cement,
Outline design of biomass utilization equipment
Trail burning
Consideration of biomass collection system

2015 Project study（PS）
Lao Cement’s decision for investment
Detailed design of biomass utilization equipment

Confirmation of business scheme

Deeper consideration of biomass collection system and test-run

2016 Project implementation using equipment support

Installation of equipment and running

Commencement of MRV, capacity building

2) Possible obstacles to be overcome and countermeasures

i) Lao Cement's decision for investment

At the beginning of this study, explanation including equipment support scheme was made to Lao Cement Top management. Understanding and consent were already given from them.
However, they are looking at the profitability of the project to decide their investment.
More explanation with burning test data is necessary to push their decision.

ii) Establishment of biomass collection system

Further study to confirm enough amount of biomass like confirmation of available rice mills, consideration of collecting system is necessary.
Establishing of biomass collecting business model along with its test run is also necessary.

Ideas for collecting cost responsibility of each party should be prepared. Advice and consultation from Lao Cement and concerned Laotian Government Organizations should be taken into account.

(2) JCM methodology development

1) Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

	Content	Reason to be set as criterion and appropriateness
Criterion 1	The coal alternative fuel must be a biomass residue the agriculture system etc.	In host country, majority of alternative fuel to coal is biomass residue, especially agricultural biomass. Domestic consumption should be considered.
Criterion 2	Should not be influenced on others in case the biomass residue (rice husk) has been used more	Currently, there is no systematic rice husk utilization; most of the rice husk goes to

	for other thing.	decay. So, utilization of rice husk will not affect or cause burden to current small scale usage and agricultural system.
Criterion 3	Should not be forced for agriculture to an additional load to etc. in the result of using the biomass residue.	
Criterion 4	The rice husk feeding system must have robustness and steady controls, causes no adverse effect to the quality of manufactured clinker.	For alternative fuel utilization including biomass, stable operation and no adverse effect to cement manufacturing process is essential.
Criterion 5	Having sufficient performance for environment protection ➢ To satisfy environmental regulatory standard and similar standard. ➢ Dust collector shall be installed.	It is not allowed to affect environment with utilization of biomass. Since proposed equipment in this project is equipped with dust collector which fulfills regulatory environment standard, no adverse effect is expected.

2) Calculation of GHG emissions (including reference and project emissions)

i) Calculation of reference emissions

Calculation of reference emissions are as follows;

$RE_y = RE_{coal,y} + RE_{elec,y}$ ･･････････････････････eq-1

Where,

RE_y	Emission from reference activity without project activity	t-CO_2/ y
$RE_{coal,y}$	Emission from reference activity from consumption of coal for cement manufacturing without project activity	t-CO_2/ y
$RE_{elec,y}$	Emission from reference activity from consumption of electricity for cement manufacturing without project activity	t-CO_2/ y

Subscript indexes expressed in parameters means the following;

$_{Coal}$: Coal for kiln

$_{elec}$: Electricity

$$RE_{coal,y} = \sum_{i=1}^{12} FC_{RE,y,i} * EF_{coal,CO2,y} * f_{scale,y}$$

$$= \sum_{i=1}^{12} (ClinGN_{PJ,y,i} * SFC(C)_{RE,y,i}) * EF_{coal,CO2,y} * f_{scale,y} \quad \cdots\cdots\text{eq-2}$$

$SFC(C)_{RE,y,i} = \mathbf{FC}_{RE,y,i} / ClinGN_{PJ,y,i}$ ･････････････････eq-3

$CementGN_{PJ,y,i} = ClinGN_{PJ,y,i} + M(Gyp)_{PJ,y,i}$

$M(Gyp)_{PJ,y,i} = ClinGN_{PJ,y,i} * M(Gyp)rate_{RE}$

$ClinGN_{PJ,y,i} = M(Lim)_{PJ,y,i} + M(Iron)_{PJ,y,i} - Loss,_{PJ,y,i}$

$M(Iron)_{PJ,y,i} = ClinGN_{PJ,y,i} * M(Iron)rate_{RE}$

- The mixed rate of Gypsum to Clinker is being decided.
- The mixed rate of iron ore to the limestone is being decided.
- The consumption quantity measurement of the limestone, the iron ore and the gypsam is enforced from the viewpoint of PDCA. Therefore, a result of measurement isn't used for the calculation of the CO_2 emissions.

$$REelec,y = \sum_{i=1}^{12} EC_{RE,y,i} * EFelec,_{CO2,y} * f_{elec,y}$$

$$= \sum_{i=1}^{12} (ClinkerGN_{PJ,y,i} * SFC(E)_{RE,y,i}) * EFelec,_{CO2,y} * f_{elec,y} \text{ ････････eq-4}$$

$$SFC(E)_{RE,y,i} = \sum_{i=1}^{12} \mathbf{EC}_{RE,y,i} / \sum_{i=1}^{12} ClinkerGN_{PJ,y,i} \text{ ･･･････････････eq-5}$$

Where,

$FC_{RE,y,i}$	(On month i of year y) Energy of coal consumption for clinker manufacturing without project activity $FC_{RE,y,i} = PFC_{RE,y,i} \times NCV_{c,y,i}$	Gcal/month
$PFC_{RE,y,i}$	(On month i of year y) Consumption of coal for clinker manufacturing without project activity	t-coal/month
$NCV_{c,y,i}$	(On month i of year y) Net calorific value of coal used for Clinker manufacturing	GJ/t-coal
$f_{scale,y}$	Conservative coefficient. (In year y) The ratio of the lower limit value of a standard for the Lao People's Democratic Republic Agency for Standardization and Metrology of the track scale. (For conservative)	-
$EFcoal,_{CO2,y}$	(In year y) CO_2 emission factor for coal	t-CO_2/Gcal
$CementGN_{PJ,y,i}$	(On month i of year y) Cement production after project implementation	t-cement/month

$ClinkerGN_{PJ,y,i}$	(On month i of year y) Clinker production after project implementation	t-clinker/month
$SFC(C)_{RE,y,i}$	(On month i of year y) Unit coal consumption for clinker manufacturing without project activity	Gcal/ t- clinker
$M(Gyp)_{PJ,y,i}$	(On month i of year y) Gypsum consumption for clinker manufacturing	t-gypsum/t- clinker
$M(Gyp)rate_{RE}$	Gypsum injection rate is decided.	-
$M(Lim)_{PJ,y,i}$	(On month i of year y) Limestone consumption for clinker manufacturing	t-limestone/t-clinker
$M(Iron)_{PJ,y,i}$	(On month i of year y) Iron ore consumption for clinker manufacturing	t-iron ore/t-clinker
$M(Iron)rate_{RE}$	Iron ore injection rate is decided.	-
$Loss,_{PJ,y,i}$	(On month i of year y) Clinker production loss after project implementation	t-clinker/month
$EC_{RE,y,i}$	(On month i of year y) Electricity consumption for clinker manufacturing without project activity	MWh/month
$EFelec,_{CO2,y}$	(In year y) CO_2 emission factor for grid electricity	t-CO_2/MWh
$f_{elec,y}$	Conservative coefficient (In year y) The ratio of the lower limit value of a standard for the Lao People's Democratic Republic Agency for Standardization and Metrology of the electric power meter. (For conservative)	-
$SFC(E)_{RE,y,i}$	(On month i of year y) Unit electricity consumption for clinker manufacturing without project activity	MWh/t-clinker

Subscript indexes expressed in parameters means the following;

$_{CO2}$: CO_2

$_{PJ}$: Project

$_{RE}$: Reference

$_{scale}$: Track scale

$_{elec}$: Electric power meter

[Note]

An official approval by the standard of Truck Scale is being enforced one times every year. Acceptance standard is the following.

Instrument ：Truck scale

Capacity and error ：Max 50t±20kg,

Reference Standard ：A set of National Standard Weights Class M1

Calibration Method ：Weighing Performance Test

As for calculating the amount of the project emission, it is necessary to consider the amount of the emission of GHG from the coal transportation of the clinker manufacturing, the electric power using, and the biomass residue (rice husk) transportation. In other hand, the limestone transportation is not included for the calculating because there is no difference between the reference and the project scenario. The coal transportation is not conservatively considered as well.

The rice husk is secondarily generated as waste during year that lies growing of farm products in the amount of the emission, and it doesn't think here as an amount of the emission from the project.

As for the amount of yearly emission from farm products, it is not considered for the emission of the project because the rice husk is product secondly.

Calculation of reference emission

Actual calculation of reference emission by methodology spreadsheet is as follow;

To confirm conservativeness for calculation (not BaU,) least unit fuel consumption of recent three years was used.

CO2 emission from fossil fuel consumption	71,089t-CO2/year
CO2 emission from grid electricity consumption	19,465t-CO2/year
Total CO2emission	90,554t-CO2/year

ii) Calculations of project emissions

Calculations of project emissions are as follows.

$PE_y = PE_{coal,y} + PE_{elec,y} + PE_{Tr,y} + PE_{BC,y}$ ････････････････eq-6

Where

PEy	CO2 emission from project activity	$t\text{-}CO_2/y$
PEcoal,y	Emission from project activity from consumption of coal for cement manufacturing	$t\text{-}CO_2/y$
PEelec,y	Emission from project activity from consumption of electricity for cement manufacturing	$t\text{-}CO_2/y$
$PE_{Tr,y}$	Amount of project emission according to rice husk	$t\text{-}CO_2/y$

	transportation	
$PE_{BC,y}$	Amount of emission according to cultivation of farm products (Do not consider it.)	$t\text{-}CO_2/y$

Subscript indexes expressed in parameters means the following;

$_{Tr}$: Truck

$_{BC}$: Biomass Cultivation

$$PEcoal_{,y} = \sum_{i=1}^{12} \mathbf{FC}_{PJ,y,i} * EFcoal_{,CO2,y}$$

$$= \sum_{i=1}^{12} (ClinGN_{PJ,y,i} * SFC(C)_{PJ,y,i}) * EFcoal_{,CO2,y} \cdots\cdots\cdots\cdots eq\text{--}7$$

$$SFC(C)_{PJ,y,i} = \mathbf{FC}_{PJ,y,i} / ClinGN_{PJ,y,i} \cdots\cdots\cdots\cdots\cdots\cdots\cdots eq\text{--}8$$

Or,

$$PEcoal_{,y} = REcoal_{,y} - PER_{Husk,y}$$

$$PER_{Husk,y} = \sum_{i=1}^{12} ((M_{(Husk),y,i} * NCV_{Husk,y,i}) / NCV_{C,y,i}) * EFcoal_{,CO2,y} \cdots\cdots eq\text{--}9$$

- CO2 emission reduction from the coal substitution by the husk is calculate.

$$PEelec,y = \sum_{i=1}^{12} \mathbf{EC}_{PJ,y,i} * EFelec_{,CO2,y}$$

$$= \sum_{i=1}^{12} (ClinGN_{PJ,y,i} * SFC(E)_{PJ,y,i}) * EFelec_{,CO2,y} \cdots\cdots\cdots\cdots eq\text{--}10$$

$$SFC(E)_{PJ,y,i} = \sum_{i=1}^{12} \mathbf{EC}_{PJ,y,i} / \sum_{i=1}^{12} ClinkerGN_{PJ,y,i} \cdots\cdots\cdots\cdots\cdots eq\text{--}11$$

$$PE_{Tr,y} = \sum_{i=1}^{12} \left(\frac{M_{(Husks),y,i}}{TL_{Tr,y,i}} \times AVD_{Husks,y,i} \times EF_{tr,CO2} \right) \cdots\cdots\cdots\cdots eq\text{—}12$$

- I In general, " $AVD_{Chaff,y,i}$ " is calculated by the round trip distance. However, it can be almost disregarded levl in this project. The reason is why the rice husk is collected from the rice milles along the national road on one's way back to the cement transportation in Vientiane city.

  However, considering the maintainability, constant transportation distance is assumed (=20 km/truck).

$$PE_{BC,y} = 0 \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots eq\text{---}13$$

- It is not aimig to grow rice for the fuel using. And, the rice husk is alomost all abandoned without efficient use.

Energy of coal consumption for clinker manufacturing without project activity

Where,

$FC_{PJ,y,i}$	(On month i of year y) Expected energy of coal consumption for clinker manufacturing by project activity $FC_{PJ,y,i} = PFC_{PJ,y,i} \times NCV_{c,y,i}$	Gcal/month
$PFC_{PJ,y,i}$	(On month i of year y) Expected coal consumption for clinker manufacturing by project activity	t-coal/month
$NCV_{c,y,i}$	(On month i of year y) Net calorific value of coal used for Clinker manufacturing	GJ/t-coal
$EFcoal,_{CO2,y}$	(In year y) CO_2 emission factor for coal	t-CO_2/GJ
$ClinkerGN_{PJ,y,i}$	(On month i of year y) Clinker production after project implementation	t-clinker/month
$SFC(C)_{PJ,y,i}$	(On month i of year y) Expected unit coal consumption for clinker manufacturing after project implementation	t-coal/t-clinker
$EC_{PJ,y,i}$	(On month i of year y) Expected electricity consumption for clinker manufacturing after project implementation	MWh/month
$EFelec,_{CO2,y}$	(In year y) CO_2 emission factor for grid electricity	t-CO_2/MWh
$SFC(E)_{PJ,y,i}$	(On month i of year y) Expected unit electricity consumption for clinker manufacturing after project implementation	MWh/t-clinker
$M_{(Husks), y,i}$	(On month i of year y) The amount of one month rice husk using for the clinker manufacturing.	t-husks /month
$PER_{Husk,y,i}$	(On month i of year y) The amount of CO2 emission reduction of Rise Husk	t-CO_2/ month
$NCV_{Husk,y}$	Net calorific value of dried rice husk used for Clinker manufacturing (Default value is presumed.)	GJ/t-husk
TL Tr, y,i	(On month i of year y) Average load of transportation track for rice husk	t-husks /truck
AVD_{Husks}, y,i	(On month i of year y) Average transportation distance of additional track for the project activity such as one way distance from rice husk exhaust facilities to clinker manufacturing plant etc. (20km/track; default value)	km /truck
EFtr, CO_2	CO_2 emission factor for truck (t- CO_2/km)	tCO_2/km

Subscript indexes expressed in parameters means the following;

$_{Husks}$: Rice husks

$_{tr,}$: Track

Calculation of project emission

Actual calculation of reference emission by methodology spreadsheet is as follow;

Estimated project emission

CO2 emission from fossil fuel consumption 49,640t-CO2/year
(Reduction from rice husk utilization 21,449t-CO2/year)
CO2 emission from grid electricity consumption 19,527t-CO2/year
(rice husk utilization equipment also consumes electricity)
CO2 emission from rice husk transportation 106t-CO2/year distance 20km,one-way
Total CO2 emission 69,273t-CO2/year

iii) Emission reduction

Reference emission—Project emission ＝Emission reduction

90,554 － 69,273 ＝ 21,281t-CO2/year

3) Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
Iron ore injection rate :M(Iron)$_{rate}$	Iron ore injection rate is decided Lao Cement Company Ltd. (Lao Cement).	Set as the default value. ✓ Lao cement record
Gypsum injection rate :M(Gyp)$_{rate}$	Gypsum injection rate is decided Lao Cement.	Set as the default value. ✓ Lao cement record
Unit heat value of coal :SFC(C)$_{RE,y,i}$	(On month i of year y) Unit coal consumption for clinker manufacturing. (t-coal/t- clinker) Unit heat value for coal is calculated by the past data of amount of clinker manufacture and the amount of coal consumption. But, setting more boldly than BaU conservative unit heat value.	Set as the default value. ✓ Lao cement record
CO2Emission factor for Coal :EFcoal,$_{CO2,y}$	(In year y) CO_2 emission factor for coal. (t-CO_2/Gcal) Default value from IEA CO_2 Emissions From Fuel Combustion Documentation for Beyond 2020 Proximate analysis of coal	Set as the default value. ✓ IEA CO_2 Emissions From Fuel Combustion Documentation for Beyond 2020 ✓ Lao cement record

Unit value of electricity :SFC(E) $_{RE,y,i}$	(On month i of year y) Unit electricity consumption for clinker manufacturing. (MWh/t- clinker) Unit value of electricity is calculated from the past amount of clinker manufacture and the amount of electric power consumption.	Set as the default value. ✓ Lao cement record
Grid electricity CO2 Emission factor :EFelec,$_{CO2,y}$	(In year y) CO_2 emission factor for grid electricity. (t-CO_2/MWh) Grid electricity CO_2 emission factor is as follow; 0.5764 t-CO_2/MWh	To be fixed ex ante before the project starts. ✓ Grid factor for Lao People's Democratic Republic
$f_{scale,y}$	(In year y) The ratio of the lower limit value of a standard for an acceptability criterion of Lao People's Democratic Republic Agency for Standardization and Methodology of the track scale. (For conservative)	Set as the default value. Lao cement record
$f_{elec,y}$	(In year y) The ratio of the lower limit value of a standard for an acceptability criterion of Lao People's Democratic Republic Agency for Standardization and Methodology of the electric power meter. (For conservative)	Set as the default value. Lao cement record
EFtr, CO_2	CO_2 emission factor for truck (t- CO_2/km)	Set as the default value. IPCC 2006
AVD $_{Husks,\ y,i}$	(On month i of year y) Transportation distance from each rice mill by track (km/truck) The rice husk is transported on one's way back of the cement transportation to Vientiane. Therefore, it conservatively set 20km per track even though the transportation distance is not generated.	Set as the default value.