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

"10MW – scale Biomass based Power Generation"

(Implementing Entity: Obayashi Corporation, EX Research Institute Ltd.)

1. Overview of the Proposed JCM Project

Study partners	Sri Lanka Carbon Fund (Private) Limited. LTL Holdings (Private) Limited.			
Project site	Ampara District, Eastern Province, Sri Lanka			
Category of project	1. Energy Industries (Renewable - / non-renewable resources)			
Description of project	This project involves Obayashi Corporation, the principal proponent of this project, procuring *Gliricidia sepium* (hereafter referred as Gliricidia), a fast growing plant of the legume family through contract cultivation at Ampara District in the Eastern province and formation of a local community , operating an electricity generation business that utilizes woody biomass and selling electricity generated to the national transmission network hence helping replace a part of electricity supplied to the national transmission network through fossil fuel electricity generation plants , ultimately helping in the reduction of global warming gases.			
Expected project implementer	Japan	Obayashi Corporation		
	Host country	Sri Lankan Carbon Fund (Private) Limited		
Initial investment	Approx. JPY 3,940 Million		**Date of groundbreaking**	April 2016
Annual maintenance cost	Approx. JPY 677 Million		**Construction period**	24 months
Willingness to investment	Continuance of study with the assumption of investment after 2015 approved by the board		**Date of project commencement**	April 2018
Financial plan of project	Obayashi Corporation, by itself will invest 30-40% of the total project cost. Loan from the local financial bodies is planned for the remaining 60-70%. Contact has already been made with international financial bodies with presence in Sri Lanka and a positive response, albeit with a few pre conditions, have been received. Obayashi Corporation will provide the majority of the business fund while the local partners will invest about 10-30%.			
GHG emission reductions	40,052 (tCO2/y)			

2. Study Contents

(1) Project development and implementation

1) Project planning

Project implementation framework

The implementation framework of the Project is shown in the Figure 1. A Specific purpose company (SPC) will be jointly established by Obayashi Corporation (hereafter referred to as "Obayashi") and Sri Lanka Carbon Fund (Private) Ltd (hereafter referred to as "SLCF") as the operation entity of the Project. Details regarding the establishment of SPC is currently being discussed between the two companies.

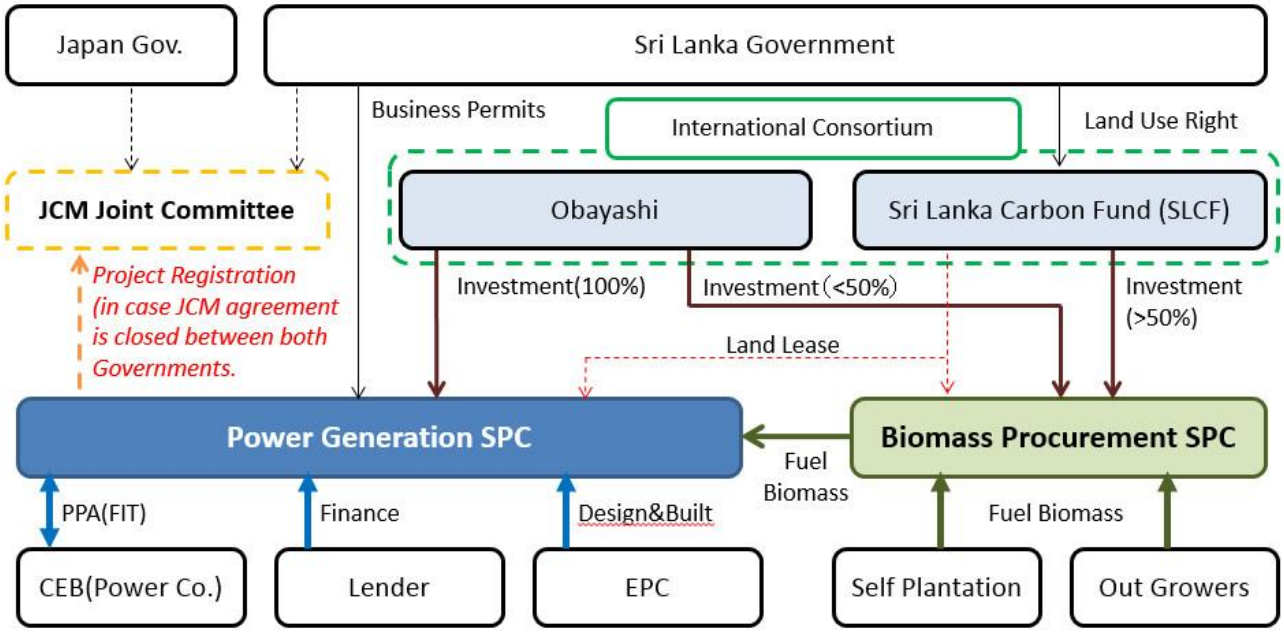

Figure 1. Project implementation framework

Installation plan of the plant

In the project, small scale power generation plant utilizing woody biomass will be developed. The facilities to be installed for the project includes components related to power generation plant as well as those necessary for biomass procurement and pretreatment. The table below shows the main facilities, equipment and units to be installed in the project along with its procurement and installation plan.

Table 1. Outline of the installation plan

Items	Details	Expected cost (approx)
Building and civil work	Preparation work, buildings, foundation for equipment and exterior etc.	400 million yen
Power plant installation	Boiler, turbine, generator, water treatment facility etc.	2,100 million yen
Overhead	Construction supervision work, engineering work, test operation cost etc.	780 million yen
Total amount	Excluding VAT and other taxes	3,280 million yen

Operation plan

A 24 hours/day and 292 or more days/year operation is planned. In addition to the local operation staff to be employed by the SPC, supervisor will be sent from Obayashi to maintain the operation. Where necessary, operation may be outsourced to a company in Sri Lanka or in neighboring countries that has operation and maintenance experience. Biomass fuel will be procured from the SPC to be established specially for the

purpose of biomass procurement (as shown in Figure 1.) and other sources. Consumables will be procured from local suppliers. Maintenance will be done in-house and if in-house is not feasible then will be out-sourced as per the recommendation of the equipment /plant manufacturer. The estimated operation and maintenance cost[1] based on the assumptions stated above is shown in Table.2.

Table 1. Operation and maintenance cost

Items	Details	Expected cost (approx)
Manpower cost	Personnel cost from Obayashi included	80 million yen
Biomass fuel procurement	Chipping and drying process included	500 million yen
Other operation and maintenance	Office, regular maintenance, consumables, inspection, insurance etc.	100 million yen
Total amount	Excluding VAT and other taxes	680 million yen

Company profile and experience of the project implementation company

Obayashi will be the project implementation company of the power generation project to be registered under the JCM scheme. Company profile and project experience of the company is shown in Table 3.

Table 2. Profile of Obayashi Corporation

Company name	:	Obayashi Corporation
Location	:	Minato-ku, Tokyo, Japan
Establishment	:	January 1892
Registered capital	:	57,752 million yen
Business	:	Engineering and contracting of construction works, and other construction-related businesses (domestic and overseas) Real estate (domestic and overseas) Power generation and supply of electricity and heat Greenhouse gases emission trading related business Production, processing and sale of agricultural products
Sales	:	2012 1.36 trillion yen (consolidated), 1.49 trillion yen (non-consolidated) 2013 1.44 trillion yen (consolidated) ,1.137 trillion yen (non-consolidated)
Profit		2012 31.1 billion yen (consolidated), 22.0 billion yen (non-consolidated) 2013 35.1billion yen (consolidated), 14.2 billion yen (non-consolidated)
Employees	:	8,329 (As of March 2014)
Experiences in renewable energy projects	:	July 2012 Established subsidiary company for renewable energy business Solar power generation facility for 58MW capacity in 17 locations (as of August 2014) Several feasibility studies on experimental project for off-shore wind power system

Evaluation of financial viability

Revenue expected from the project will be the sales of generated electric power to the Ceylon Electricity Board. The purchase price of electric power from biomass based power generation as of 2014 is as shown in Table 4.

[1] Assuming operation by SPC. Excluding overhaul cost.

Table 3. Purchase price of electric power from biomass based power generation

Year	Flux rate (LKR/kWh)		Fixed rate (LKR/kWh)		
	Operation cost	Fuel cost	1st period (1-8 years)	2nd period. (9-15years)	3rd period (16-20years)
1-15 years	1.52	12.25	9.67	3.72	-
16 year onward	1.90	-	-	-	2.11
Price adjustment rate	+5.16%	+3.44%	-	-	-

Based on the initial investment and operation cost (for the first year) shown in Table 5, financial viability is estimated as shown in Table 5.

Table 5. Financial viability (summary)

Items	Value	Note
Initial investment	LKR 4,331 million	
Sales	LKR 1,800 million	Average in project period
Operation and maintenance cost	LKR 1,069 million	Average in project period
IRR (20 years)	19.0%	
Investment recovery period	5 years	

2) Permits and License for the project development and implementation

Project Owner will be requested to apply and obtain permit and license from competent authorities for renewable energy, such as Sri Lanka Sustainable Energy Authority (SLSEA) and Public Utility Committee of Sri Lanka, which is the sole authority to regulate and manage public utilities in Sri Lanka. In addition, project owner will be requested to obtain approval on environmental assessment from Central Environmental Authority (CEA) and conclude a standard power purchase agreement with Ceylon Electricity Board (CEB).

Table 4. Permits & Licenses required for business operation

	Permit & License	Duration	Remarks
1	Provisional Approval (P/A) issued by SLSEA	3months	Application Fee; LKR100,000.- as initial application fee covering power plant capacity not exceeding 1MW. Additional LKR50,000.-/MW will be charged for every 1MW in excess of 1st 1MW. Validity for Permit is 6 months and extendable for another 6 months
2	Letter of Intention issued by CEB	Included in 1 above	
3	Environmental Protection License issued by CEA		Project Owner is requested to prepare and submit a report in accordance with Environmental Protection Order or Terms of Reference for Environmental Impact Assessment to be issued by CEA
4	Power Generation License by PUCSL		
5	Energy Permit (E/P) issued by SLSEA		Valid for 20 years. Maximum extension of 2 years as construction period is allowed. Project owner shall obtain E/P within 6 month after the date of P/A issue is required.
6	Standard Power Purchase (SPP) Agreement with CEB		Project owner shall conclude a SPP within 1 month of acquisition of Energy Permit

It is common for the local parities to submit Provisional Applications. Obayashi is currently considering the adequate body that will act as a principal to apply for permits and licenses described in Table 7, including the option of setting up a local subsidiary. Applications will be filed as soon as the principal body is determined.

3) Advantage of Japanese technology

Facilities and equipment to be employed at the power plant include incinerator, boiler, steam turbine, generator, condenser, deaerator, pre-air heater, economizer, electrostatic precipitator etc. Among these facilities and equipment mentioned, it has been confirmed during last year`s study that for incinerators and boilers, Japanese technology does not hold a superiority. However, among turbines for electricity generation and for electric generators themselves, only the turbines of Shin Nihon Machinery (SNM) had a turbine efficiency of 25% or over at the extraction condition designated by EPC and hence this value was set as the benchmark in the JCM methodology. In this year`s study, as the amount of electricity generation of 11.5 MW (including internal electricity consumption) is about twice that of last year`s project (5.7MW) and the EPC to be used in this project will design a new system, a comparison of efficiency of steam turbine and generators (STG) between Japanese products and products that have a higher possibility of being used in Sri Lanka was carried out. The result is show below.

Besides SNM, TRIVENI (India), MAXWATT (India) and SIEMENS (Germany) are the 3 manufacturers whose products are in the market. Among these companies, no response was received from TRIVENI to our inquiry. Although our request for cooperation was accepted by SIEMENS, product specs and pricing information was not made available at the time of preparation of this report. Hence, comparison is done with MAXWATT for which specifications and pricing information is available.

[Findings]

Table 5. Technical Comparison Sheet among potential STG suppliers

Description	Unit	SNM	MAXWATT
Power Generation Capacity (kW)	kW	11,500	11,500
Inlet Steam Pressure	Ata	67	67
Inlet Steam Temperature	℃	490	485
Inlet Enthalpy	kcal/kg	810.1	807.7
Inlet Steam Flow Rate	t/h	48.00	51.60
Inlet Energy	kW	45,106	48,332
Amount of Steam to be consumed	kg/ kWh	4.17	4.49
Power Generation Efficiency	%	**25.5**	23.8
Cost (FOB)[2]	JPY(JPY000)	265,000	192,000
Unit Cost per MW	JPY/ MW	2,304 万円	1,670 万円

As a result of the feasibility study and as shown in Table 8 above, it was confirmed that the product of Shin Nihon Machinery (SNM) is slightly superior to those manufactured by potential competitors with the possibility of being used in Sri Lanka. In Sri Lanka, as the usage of large scale biomass using industrial facilities is increasing in recent years, discussion regarding efficiency of biomass use is becoming commonplace. Therefore, it is expected that demand for efficient usage of resources through the introduction of highly efficient facilities will increase further.

[2] Exchange Rate of USD1 = JPY120 applied

4) MRV structure

Monitoring parameters and monitoring method

Parameters for calculation of GHG emission reductions include pre-set default values and those acquired through monitoring. Table 9 shows the details of parameters to be monitored. Monitoring will be conducted using monitoring equipment that satisfies the degree of precision required by the JCM scheme and calibration will be conducted periodically.

Table 9. Outline of monitoring parameters

	Monitored parameters	Parameter	Monitoring option	Monitoring frequency
1	Amount of electricity supplied to grid	$EG_{PJ,p}$	Option C (measurement)	Continuous, once per day
2	Amount of biomass used	$Q_{bio,p}$	Option C (measurement)	Per batch
3	Amount of electricity purchased from grid	$EC_{PJ,p}$	Option C (bill statement)	Bill statement issued from CEB, once every month
4	Amount of electricity supplied from stand-alone power generation	$EC_{PJ,cap,p}$	Option C (measurement)	Continuous, once every day when using stand-alone generation

Monitoring and reporting system

Monitoring will be carried out under the MRV system as shown in Figure 2. Engineering unit in charge of operation will conduct measurement and record in the monitoring format. The monitoring record will be approved by the manager of engineering unit and transferred to the administration unit. Administration unit will digitize the record into electric data and cross-check the information with other relevant documents in accounting and procurement units to ensure the accuracy of the information. After these procedures, the recorded values are transferred to spreadsheet attached to PDD and will be submitted to the board which is the responsible body for the project.

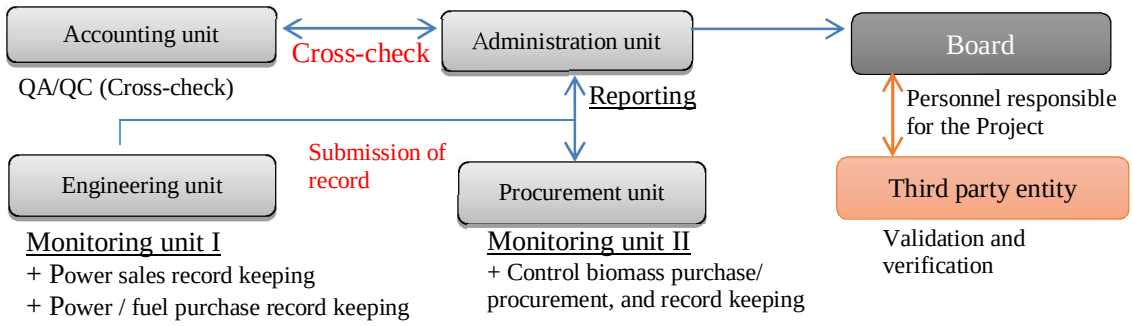

Figure 2. Monitoring and reporting system

Verification

Validation and verification of the approved report will be consigned to the third party entity that is registered in the host country. Although there are no registered third party entities in Sri Lanka as of February2015, it is expected that qualified entities including Japanese entities will register once the JCM agreement is signed. The best suited entity will be selected from the registered entities.

Support for MRV system establishment

In January 2014, a seminar for supporting MRV system establishment was held in Colombo (as shown in the photograph) with Mr. Yamamoto (Senior Technical Manager) from JQA acting as the instructor. The participants included project implementation bodies (Obayashi Corp and SLCF) and Director General and staffs from Sri Lanka Standard Institution, the candidate entity of local third party entity in Sri Lanka. The followings are the contents of the seminar.

- Introduction to JCM scheme: JCM under UNFCCC, negotiation process, concepts
- JCM project: flow of JCM projects, required documents, concept of "net emission reduction"
- MRV concept and contents of MRV: JCM project cycle (validation>monitoring>reporting>verification)
- International standard for measurement and calibration: CIPM MRA [3] and application in Sri Lanka, "calibration" concept in JCGM, calibration of measurement equipment, validity period of calibration
- QA/QC

The participants stated that the seminar provided a meaningful opportunity to understand the JCM scheme and MRV system under JCM.

5) Environmental integrity and Sustainable development in host country

The need for environmental impact assessment was discussed with CEA and other relevant persons several times. As a result, it became clear that for renewable energy power generation projects, decision on the need to conduct an EIA would not be clear before submission and receipt of Provisional Approvall to SLSEA. This is because the decision would depend on various conditions of the project like business type, scale and locations which differ from project to project and the need to carry out EIA will be judged based on these conditions. Hence, an IEE issued by CEA for a project that has similarities to this project was obtained. In that IEE, the following information was required to be disclosed by the project proponent.

- Project location (fuel procurement and storage, combustion system, power generation and transmission system, ash treatment, waste water treatment, exhaust gas treatment, noise and vibration control, other facilities, and construction plan)
- Current environmental condition of the project location (physical conditions, water resource, climate condition, topography, ecosystem, socio-economic impact)
- Measures to mitigate environmental impact
- Monitoring plan
- Summary

Among similar businesses, at Buttala electricity generation plant operated by SLCF, an Environmental written directive was issued. The EIA was exempted on the condition that the requirements indicated on the directive were followed. From the above it can be inferred that even if it is not indicated in the guide for electricity generation facilities using renewal energy, as is also seen in Japan, a screening on whether EIA/IEE is required in carried out by the CEA. It seems plausible to assume that the decision flow involves a process whereby if it is decided that EIA is not required, then the Environmental written directive is issued whereas if it is decided that EIA is required, then a decision is made by the scoping committee. Further, through this study, meteorological information and information on environmental standards of Sri Lanka have been collected.

[3] International Committee for Weights & Measrues / Matual Recognition Arrangement

This project involves replacing a part of national electricity produced by fossil fuel with biomass produced electricity. In addition to reduction of air pollution and GHG reduction, the project, through the procurement of biomass, contributes to the development of the local society and helps to attain sustainable development in various areas.

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

Future plans

Obayashi, in parallel to this F/S, is conducting various activities for the realization of the business. However, many challenges and risk that need to be tackled still remain and hence there is a need to continue the study. If it is decided to move to the commercialization stage, it is necessary to start on the detailed design and formulation of framework for the business. There are plans to apply for JCB funding after which start of operations is aimed to start from the spring of 2018.

Challenges

How smoothly can negotiations with the local population during the phase of biomass procurement like land procurement and formation of community with the peasants can be carried out is a big challenge towards the implementation of the project. Further, what sort of preventive measures can be taken to counter country risk and economic climate risk is a very important factor. This factor is influenced by response of government and financial bodies of the Japanese side and hence in future negotiations, support from these bodies is anticipated.

(2) JCM methodology development

1) Eligibility criteria

Table 10 shows the eligibility criteria defined under the JCM Methodology and purpose of setting the criteria.

Table6. Eligibility Criteria

No	Purpose	Criteria
Criterion 1	Defining project type (Scale/Fuel type), Securing Additionality	The project only uses wood biomass fuel and exports electricity to the national grid and replaces the grid electricity as a feed-in-tariff project.
Criterion 2	Necessity of not considering existing facilities	The facilities in the project are newly installed.
Criterion 3	1)~3) Securing sustainability of biomass fuel 4)Defining eligible biomass fuel for default values	The biomass resources used in the project satisfies all the following conditions: a) The biomass resources that the Sri Lanka Central Environmental Authority has approved to use for the project in accordance with the national guideline "Guideline for Biomass Assessment in Sri Lanka" set by the Sri Lanka Sustainable Energy Authority. b) In the case where the project plans to have biomass resources procurement from newly established dedicated plantations, it is necessary to demonstrate that the biomass resources used in the project are only from scrub lands and/or unutilized land areas, c) The land for the plantation is not categorized as forest, nature reserve or peat land (organic soil). However, if special permission is given by the relevant authorities in charge of forest and nature reserves to collect and move the biomass, then the biomass from these land categories can be used as

		biomass fuel in the project as a special case. (e.g., biomass generated during the removal of invasive exotic species from nature reserves) d) Processed biomass resources such as pellets, briquettes and bio-cokes are not used in the project.
Criterion 4	Positive listing of applicable technology (Benchmark setting)	Power generation efficiency in the specification of the power generation facility is 25% or more. The power generation efficiency can be defined as the amount of electricity generated by the facility divided by the input energy to the turbine.
Criterion 5	Securing high efficiency of the facility	Periodical check at least once a year is planned.

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

a) Establishment of Reference Emissions

Reference emission is calculated on the basis of the official grid emission factor that is published by the Sri Lankan Government multiplied by the amount of electricity to be generated and exported to the national grid by the project. In the methodology, the latest grid emission factor published by the Sri Lankan Government will be applied.

b) Calculation of Reference Emissions

Reference emissions are calculated by Equation1 as shown below:

$RE_p = EG_{PJ,p} \times EF_{grid}$ ..... [Equation1]

$= 70{,}080 \times 0.7092$

$= \underline{49{,}701\ (tCO2/y)}$

RE_p : Reference emission [tCO2/p]

$EG_{PJ,p}$: Project quantity of electricity generation and supply to the grid in the project in period p [MWh/p]

EF_{grid} : Emission factor for grid electricity [tCO2/MWh]

Table 11 shows the data necessary for calculation of reference emissions.

Table 7.Preconditions of Reference Emissions Calculation

Item	Figure	Remarks
Electricity generating capacity	11.5 MW	
Onsite electricity consumption	1.5 MW	
Electricity supply capacity to the grid	10.0 MW	
Plant operation rate	80%	
Amount of electricity generation	80,592 MWh/year	
Amount of onsite electricity consumption	10,512 MWh/year	Electricity will basically be supplied from biomass power plant.
Amount of electricity to be supplied to the grid annually ($EG_{PJ,p}$)	70,080 MWh/year	Assuming “period p＝1 year” Net electricity sales to the grid（”Amount of electricity generation” minus ”Amount of onsite electricity consumption”）
CO2 emission factor of grid electricity (EF_{grid})	0.7092 tCO2/MWh	Grid emission factor

c) Calculation of Project emissions

Project emission is calculated by using emission related to biomass cultivation, transportation and pre-treatment, emission related to electricity consumption by the project and emission from the burning of fossil fuel used as supplemental fuel. Equation 2 is used to calculate the project emission. Amon the parameters specified in equation 2, the underlined parameters are subject to monitoring whereas the non-underlined ones are pre set values.

$$PE_p = \{APE_{cul} + APE_{pret} + APE_{trans}\} \times \underline{Q_{bio,p}} + \underline{EC_{PJ,grid,p}} \times EF_{PJ,grid} + \underline{EC_{PJ,cap,p}} \times EF_{PJ,cap} \quad \text{[Equation2]}$$

$$= \{0.0252 + 0.0220 + 0.0245\} \times 134{,}569 + 0 \times 0.7092 + 0 \times 0.8$$

$$= \underline{9{,}609\ (tCO2/y)}$$

PE_p :Project Emission in period p [tCO2/p]

APE_{cul} :Unit project CO2 emissions from biomass procurement in period p [tCO2/t]

APE_{pret} :Unit project CO2 emissions from fossil fuel and electricity consumption at the pretreatment facility [tCO2/t]

APE_{trans} :Unit project CO2 emissions from transportation of biomass resources [tCO2/t]

$Q_{bio,p}$:Quantity of biomass fuel procured after the project starts (wet base)[t/p]

$EC_{PJ,grid,p}$:Amount of electricity imported from grid and consumed in the project in period p [MWh/p]

$EF_{PJ,grid}$:Emission factor for grid connected electricity [tCO2/MWh]

$EC_{PJ,cap,p}$:Amount of off grid electricity consumed by the generator in the project period p [MWh/p]

$EF_{PJ,cap}$:Emission factor for captive electricity [tCO2/MWh]

Table8. Preconditions of Project Emissions Calculation

Item	Figure	Remarks
Unit project CO2 emissions from biomass procurement in period p (APE_{cul})	0.0252 tCO2/t	Default value defined in the MRV methodology, Calculated based on CDM methodological tool 16.
Unit project CO2 emissions from fossil fuel and electricity consumption at the pretreatment facility (APE_{pret})	0.0220 tCO2/t	Default value defined in the MRV methodology, Market survey targeting five manufacturers eight products.
Unit project CO2 emissions from transportation of biomass resources (APE_{trans})	0.0245 tCO2/t	Default value defined in the MRV methodology, Calculated based on UNFCCC Methodological Tool 12 and result of the interviews with the specialists in the host country.
Quantity of biomass fuel procured after the project starts ($Q_{bio,p}$)	134,569 t	Assuming "period p＝1 year", wet basis
Amount of electricity imported from grid and consumed in the project in period p ($EC_{PJ,grid,p}$)	0 MWh/year	Set to 0 during preliminary calculation as it is the startup electric power required when the biomass electricity generation plant is stopped.
Emission factor for grid connected electricity ($EF_{PJ,grid}$)	0.7092 tCO2/MWh	Default value defined in the MRV methodology, Official figure of the host country.

Item	Figure	Remarks
Amount of off grid electricity consumed by the generator in the project period p ($EC_{PJ,cap,p}$)	0 MWh/year	Set to 0 during preliminary calculation. Only used during times when the biomass electricity generation plant is stopped and when the purchase of power from the grid is not possible due to factors like power blackout
Emission factor for captive electricity ($EF_{PJ,cap}$)	0.8 tCO2/MWh	Default value defined in the MRV methodology, Default value specified in the CDM approved small scale methodology: AMS-I.A.

d) Calculation of Emission Reduction

ER_p : Emission Reduction during period p [tCO2/p]
RE_p : Reference Emission during period p [tCO2/p]
PE_p : Project Emission during period p [tCO2/p]

Table9. Emission Reduction

Item	Figure
Reference Emission	57,156 tCO2/y
Project Emission	17,104 tCO2/y
Emission Reduction	40,052 tCO2/y

3) Data and parameters fixed *ex ante*

In the methodology used in this project, the reference emission is obtained by multiplying the amount of generated electricity that replaces the grid power with CO2 emission factor of the grid power. However, due to the reasons stated below, it is hard to logically set a reference emission lower than the BaU emission and hence it was decided to conservatively calculate the project emission.

- The method of calculating CO2 emission factor of grid power has already been established by CDM and the calculated value has already been made public
- The replacement power of grid power can be accurately monitored by using electricity meter

Based on the above, default values set before the implementation of the project using this methodology relating to emission amount are shown below. For project emissions, choosing a larger number is more conservative.

Table14. Default Values and Conservative Measures

Parameter	Description	Conservative measures	Figure
APE_{cul}	Unit project CO2 emissions from biomass procurement in period p (tCO2/t)	Maximum value chosen for condition for cultivation in the host country (for fertilizers, based on interview with experts it is assumed that fertilizer is not used)	0.0252
APE_{pret}	Unit project CO2 emissions from fossil fuel and electricity consumption at the pretreatment facility (tCO2/t)	Maximum value among 8 products from 5 companies considered in the study	0.0220
APE_{trans}	Unit project CO2 emissions from transportation of biomass resources (tCO2/t)	For CO2 emission per distance transported, used conservative value chosen from the UNFCCC Methodology Tool12. For transport distance, based on expert interview of the host country, assumed a one way distance of average of 100km which is the maximum distance for the business to be viable, hence ensuring conservativeness.	0.0245
$EF_{PJ,grid}$	Emission factor for grid connected electricity (tCO2/MWh)	Not use conservative method that contributes to net emission reduction (Used the government published value for grid emission. For off-grid electricity generation, use emission factor used by CDM small scale methodology AMS-I.A).	0.7092
$EF_{PJ,cap}$	Emission factor for captive electricity (tCO2/MWh)		0.8