CDM Feasibility Study for Biomass-based Power Generation Project in Cambodia, with Development of Standardised Baseline of Off-Grid Electricity Generation

By Japan NUS Co., Ltd.

FS Partner(s)	Hyogo University Sasaki office Mekong Carbon Co., Ltd. National Authority of Preah Vihear
Location of Project Activity	Cambodia, Preah Vihear Province
Category of Project Activity	Biomass Utilisation
Targeted GHG	Carbon dioxide
CDM/JI	CDM
Description of Project Activity	This project is to introduce biomass power generation plant with total capacity of 50 MW in Preah Vihear Province of Cambodia. Biomass fuel consists of herbaceous biomass collected by plantation of napier grass and woody biomass from selective logging for forest management. There is no approved CDM methodology that can be applied to the project which supplies electricity to off-grid area by collecting biomass fuel from plantation. In addition, there are quite a few off-grid areas in Cambodia. Therefore, standardised baseline was developed so that other biomass power project in off-grid area can apply.
Methodology to be applied	New methodology
Baseline Scenario	Standardised baseline was developed along with UNFCCC policy as well as through discussion process with Cambodia DNA. Sector was set as electricity generation in Cambodian territory that has no connection to grid systems. Since large part of the local electricity provider is operating with less than 200 kW, it is concluded as reasonable that baseline scenario is electricity generation by ICE (Internal Combustion Engine) from diesel oil fuel with 200 kW capacity. Baseline emission factor was set as 0.81 tCO_2/MWh.
Monitoring Plan	Monitoring of the project shall follow new methodology applying proposed standardised baseline. Monitoring items are set based on AM0042 and new methodology developing under methodology panel of UNFCCC.
Estimation of GHG Emission Reductions	120,998 t-CO2/year
Duration of Project Activity/ Crediting Period	Considering development plan of Preah Vihear area and the longevity of hardware, duration of projecct activity is selected 25 years. Crediting period will be 21 years in

	total (seven years and two renewals).
Environmental Impact Analysis	Law on Environmental Protection and Natural Resources Management regulates electricity power project with more than 5 MW to conduct environmental impact assessment.
Demonstration of Additionality	Demonstration of additionality shall be compliance with proposed standardised baseline. Since Cambodia is designated as LDC, projects with less than 5 MW can be applied "Guidelines for demonstrating additionality of microscale project activities" for exemption of demonstration of additionality. Projects with more than 5 MW need additionality demonstration. For the proposed standardised baseline, in order to contribute to reduce transaction costs of project participants, which is one of the aim of standardised baseline, positive list was applied.
Project Feasibility	This project intends to start construction of the first 320 kW facility in 2013 and install first 10MW facility in 2015. To implement the large scale project, there are several problems to solve.
"Co-benefits" (i.e. Improvement of Local Environmental Problems)	This project can decrease sulfur oxides and soot dust from diesel generator.
Contribution to Sustainable Development in Host Country	Plantation and collection of biomass will be conducted by local people that will create employment. Increase of employment contributes to sustainable development. Introduce of biomass power plant can reduce pollution of atmosphere that also contributes to sustainable development.

1. Members of this study:

- University of Hyogo Sasaki office: Field survey on biomass
- Mekong Carbon Co., Ltd. (Cambodia): Support of field survey on biomasss and isolated electricity generator
- National Authority of Preah Vihear: Project management as governmental agency

2. Outline of the project:

（1） Project description

This project is to introduce biomass power generation plant with total capacity of 50 MW in Preah Vihear Province of Cambodia. Biomass fuel consists of herbaceous biomass called napier grass created by plantation and woody biomass from selective logging for forest management. Electricity consumer will be Eco-village residents, museums and hotels to be developed for sightseeing of Preah Vihear temple, a world heritage site. Since the project site is currently off-grid area, it is necessary to establish grid distribution.

There is no approved CDM methodology that can be applied to the project which supplies electricity to off-grid area by collecting biomass fuel from plantation. In addition, there are quite a few off-grid areas in Cambodia. Therefore, standardised baseline was developed which can be applied to biomass power project in off-grid area. The development of standardised baseline was processed through discussion with Cambodia DNA, survey of electricity situation of local area, and reference of UNFCCC guidelines. The standardised baseline was reached the emission of CO_2 from diesel generator of 200 kW.

Operator of the electricity plant will be a private company, Green Earth Co., Ltd. National Authority of Preah Vihear (NAPV) will also be involved in management of local residents for collecting biomass and plantation.

This project will be developed along with the development plan of Preah Vihear. Several problems remain to be solved for establishing 50 MW class electricity plant. Start of construction is aimed in 2013.

（2）Methodology application

New methodology is developed

3. Study content

（1）Subjects of the study:

- Baseline and monitoring methodology: develop standardised baseline which can be applied to Cambodia and develop new methodology.
- Setting of baseline scenario and project boundary: developing standardised baseline as well as new methodology which can apply the developed standardized baseline. Project boundary will be decided.
- Monitoring plan: study monitoring items of the project
- Greenhouse gas emissions reduction: estimate greenhouse gas emissions reduction complying with project plan and standardised baseline.
- Duration of the project activity and crediting period: investigate of project activity duration and crediting period.
- Environmental impacts and other indirect influence: study cases which need environmental impact assessment.
- Stakeholders’comments: collect comments from residents around the project site about biomass electricity project.
- Financial plan: investigate finance scheme of the project.
- Analysis of business potential: evaluate economical feasibility of the project.
- Demonstration of additionality: investigate additionality along with developing

standardised baseline
- Cobenefit: evaluate co-benefits by implementation of the project.
- Contribution to sustainable development: investigate contribution to sustainable development by implementation of the project.

(2) Contents of the study

Field survey was conducted four times. Schedule and content of the field survey is described in table 1.

Table 1 Content of the field survey

	Survey period	Survey content (visiting place)
First	15 / Augst ~ 20 / August	・Discussion with DNA ・Visiting site and discussion between stakeholders ・Survey of electricity situation
Second	12 / October ~ 13 / Octber	・Discussion development of standardised baseline (DNA) ・Discussion electricity development plan (NAPV)
Third	27 / November ~ 28 / November	・Survey on biomass (Preah Vihear) ・Discussion electricity supply area (NAPV) ・Discussion off-grid electricity survey (Mekong carbon)
Fourth	22 / December ~ 23 / December	・Discussion electricity development plan (NAPV) ・Submission of standardised baseline (DNA)

Summary of the study content is described below.

- Baseline and monitoring methodology: investigated energy consumption rate of off-grid electricity by studying policy papers and survey of local area and then developed standardised bseline of biomass power project in off-grid area. In addition, new methodology was developed.
- Setting of baseline scenario and project boundary: researched electricity situation of Cambodia in order to develop standardised baseline. Project boundary was set through discussion with NAPV.
- Monitoring plan: developed monitoring methodology and monitoring plan based on information such as facility specification and data.
- Greenhouse gas emissions reduction: estimated electricity production and calculated CO_2 emissions reduction.
- Duration of the project activity and crediting period: set project activity duration and crediting period.
- Environmental impacts and other indirect influence: studied regulations about environmental impact assessment in Cambodia.
- Stakeholders'comments: collected comments about the project from local residents.
- Financial plan: conducted discussion financial plan between biomass electricity operator and NAPV.
- Analysis of business potential: analyzed economical feasibility with and without CDM project.
- Demonstration of additionality: investigated about demonstration of additionality based on standardised baseline.
- Co-benefit: evaluated co-benefits of the project based on "Manual for Quantitative Evaluation of the

Co-Benefits Approach to Climate Change Projects".

- Contribution to sustainable development: investigated items that can contribute to sustainable development through the project.

4. Result of the study towards CDM project implementation

(1) Baseline and monitoring methodology

It is necessary for the project to be registered as CDM project that development of standardised baseline as well as new methodology. New methodology was developed with referred to AM0042 "Grid-connected electricity generation using biomass from newly developed dedicated plantations" and new methodology under developed in methodology panel of UNFCCC "Renewable energy power generation in isolated grids".

The following items are set as applicability of the new methodology.

- Project activities is installation of a greenfield renewable energy power plant and/or the establishment of an isolated grid and/or additions of renewable energy capacity;
- Biomass used by the project facility is not stored for more than one year;
- The dedicated plantation must be newly established as part of the project activity for the purpose of supplying biomass exclusively to the project;
- The biomass from the plantation is not chemically processed (e.g. esterification to produce biodiesel, production of alcohols from biomass, etc) prior to combustion in the project plant but it may be processed mechanically or be dried;
- The site preparation does not cause longer-term net emissions from soil carbon. Carbon stocks in soil organic matter, litter and deadwood can be expected to decrease more due to soil erosion and human intervention or increase less in the absence of the project activity;
- The land area of the dedicated plantation will be planted by direct planting and/or seeding;
- After harvest, regeneration will occur either by direct planting or natural sprouting;
- Grazing will not occur within the plantation;
- No irrigation is undertaken for the biomass plantations;
- The land area where the dedicated plantation will be established is, prior to project implementation, severely degraded and in absence of the project activity would have not been used for any other agricultural or forestry activity;
- Most plausible baseline scenarios meet the proposed standardised baseline "Standardised baseline for off-grid biomass electricity generation in Cambodia".

Baseline scenario and demonstration of additionality shall be in compliance with proposed standardised baseline.

(2) Setting of baseline scenario and project boundary:

Standardised baseline was developed along with UNFCCC policy as well as through discussion process with Cambodia DNA. The content and the result are described below.

① Level of aggregation

Host country is limited to Cambodia.

Sector was set as electricity generation in Cambodian territory that has no connection to grid systems defined by Electricity Authority of Cambodia (EAC): The Phnom Penh Grid System, The Banteay Meanchey Grid System, The Kampong Cham Grid System, The Vietnam MV Grid System, and The Thai MV Grid System.

Applicable technology was set as electricity generation using either of the following specified biomass: woody biomass, grass, and mix of woody biomass and grass.

② Additionality demonstration

Considering Cambodia is LDC (least developed countries), additionality demonstration is separated by project scale (up to 5 MW / more than 5 MW).

③ Baseline identification

It is identified that over 700 rural electricity enterprises play a dominant role in the private sector by generating electricity through diesel-powered generators in rural areas of Cambodia. According to EAC, electricity provider with capacity of less than 200 kW shares 70% in Cambodia.

Since large part of the local electricity provider is operating with less than 200 kW, it is concluded as reasonable that baseline scenario is electricity generation by ICE (Internal Combustion Engine) from diesel oil fuel with 200 kW capacity.

④ Baseline emission factor setting

Baseline emission factor was set as 0.81 tCO_2/MWh. The specific value is derived by the steps below.

$$BE_y = EG_{BI,y} \times EF_{CO2,BL,y}$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2/yr)
$EG_{BI,y}$	=	Quantity of net electricity generated as a result of the implementation of the CDM project activity in year y (MWh/yr)
$EF_{CO2,BL,y}$	=	Baseline CO_2 emission factor in year y (tCO_2/MWh)

In order to obtain an accurate estimation for $EF_{CO2,BL,y}$, it is divided into several factors so as to take advantage of the available well-established data.

$$EF_{CO2,BL,y} = FC_{BL,y} \times DST_{DO} \times E\_INT_{DO} \times C\_INT_{DO} \times CF$$

$FC_{BL,y}$	=	0.3 (L/kWh) Diesel consumption per unit of electricity generation (Sustainable Rural Electrification Plans for Cambodia: National level plans)
DST_{DO}	=	0.847 (kg/L) Specific gravigy of diesel (EIA Documentation for Emissions of GHG in the USA 2006)
E_INT_{DO}	=	0.043 (GJ/kg) Net calorific value of diesel (2006 IPCC Guidelines for National Greenhouse Gas Inventories)
C_INT_{DO}	=	20.2 (kg/GJ) Carbon emission factor (2006 IPCC Guidelines for National Greenhouse Gas Inventories)
CF	=	44/12 Ratio of molecular weight CO_2 (44) to the molecular weight Carbon 12

Therefore,

$$\begin{aligned} EF_{CO2,BL,y} &= FC_{BL,y} \times DST_{DO} \times E\_INT_{DO} \times C\_INT_{DO} \times CF \\ &= 0.3(L/kWh) \times 0.847(kg/L) \times 0.043(GJ/kg) \times 20.2(kg/GJ) \times 44/12 \\ &= 0.81 tCO2/MWh \end{aligned}$$

(3) Monitoring plan:

Monitoring of the project shall follow new methodology applying proposed standardised baseline. Monitoring items are set as below table 2 based on AM0042 and new methodology developing under methodology panel of UNFCCC.

Table 2 Monitoring parameters and their monitoring plan

Parameter	Description	Frequency	Measurement method
$EG_{PJ, y}$	Electricity delivered to grid	Continuous	Amount of electricity generation and sales are measured with electricity meters
$EC_{PJ, y}$	On-site electricity consumption attribute to the project activity	Continuous	Electricity meters are installed and electricity consumption is measured
$BF_{PJ, y}$	Quantity of biomass residue transported to the project site	Continuous	Measured with truck scale installed at the entrance and exit of the site
NCV_i	Net calorific value of biomass residues	Semiannually	Measured at on-site laboratory regularly as well as reputed laboratory once for half year
N_y	Number of trucks transported	Every time	Number of trucks transported to deliver biomass are recorded
AVD_y	Average return trip distance between biomass collection station and the project site	Every time	Distance between each biomass collection station and the ptoject site are measured
$EF_{km, CO2, y}$	Emission factor of CO_2 per 1 km of transport by truck	Every year	CO_2 emission factor of transportation by truck used in project site are confirmed
FC_y	Fuel consumption per unit of electricity generation applied in standardised baseline	Every year	Value of standardised baseline which shall be revised every three year are confirmed

Monitoring manager will record and manage these monitoring parameters when project activity starts.

(4) Greenhouse gas emissions reduction:

Estimation of greenhouse gas (GHG) emissions reduction is shown in table 3.

Table 3 GHG emissions reduction

Year	GHG emissions reduction (tCO_2)
2013	2,711
2014	5,422
2015	59,538
2016	113,655
2017	167,771
2018	221,887
2019	276,004

2020	276,004
2021	276,004
2022	276,004
Ten year total	1,674,998
Ten year average	167,500
First seven year total	846,988
First seven year average	120,998

(5) Duration of the project activity and crediting period:

Considering development plan of Preah Vihear area and the longevity of hardware, duration of project activity is selected 25 years. Crediting period will be 21 years in total (seven years and two renewals).

(6) Environmental impacts and other indirect influence:

Law on Environmental Protection and Natural Resources Management regulates electricity generation project with more than 5 MW conduct environmental impact assessment. Therefore, this project will be required to assess environmental impacts from the project activity. Conceivable environmental impacts and other indirect influence are described below.

- Effluent gas from electricity generation: since biomass includes little sulfur content, it is not expected to emit sulfur from the project;
- Ash content from combustion: it will be buried or used as fertilizer;
- Energy for drying biomass: since the project introduces co-generation system for drying biomass, there is no additional energy consumption;
- Water consumption: the project requires huge amount of water in order to cool down the power plant. However, there is not enough water resource such as river or lake around the site. Construction of reservoir and establishment of cooling water circulation system will be inevitable.

(7) Stakeholders' comments:

Stakeholders' comments were collected by interviewing ten local residents. Six of them were farmers, two were housewives, one was police officer, and one was soldier. All of the respondents were agree with the electricity project. They expect time saving and acquiring energy by introducing grid electricity in their community. All respondents expect the project contributes to increase employment as additional benefit. Electricity price was the highest concern for them. NAPV insists electricity price of the project should be lower than market price. Electricity price will be decided considering the balance between their expectation and economical feasibility.

(8) Project implementation structure:

Figure 1 shows project implementation structure. Project owner will be Green Earth Co., Ltd., a Cambodia based company. Leopard Capital, a Cambodia based investment company, is also interested in investing in the project. NAPV will manage the project site and arrange participation of local residents. Japan NUS supports project origination and PDD writing. Part of the work will be commissioned Mekong Carbon.

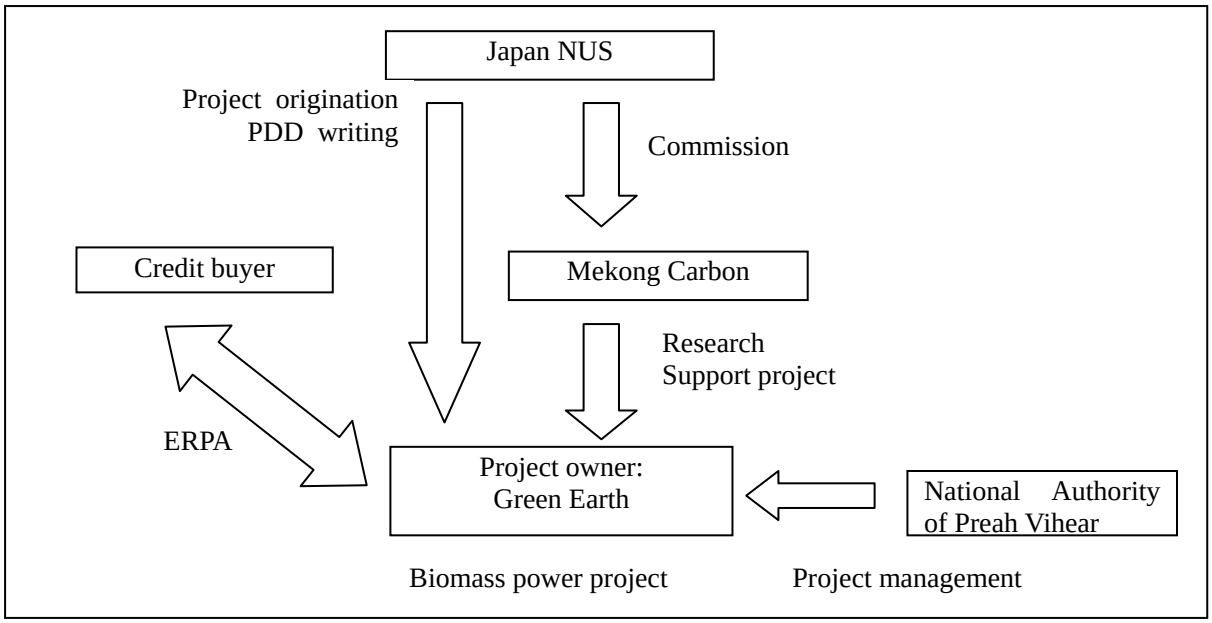

Figure 1 Project implementation structure

(9) Financial plan:

Financial plan is considered in two ways. One is combination of own money of Green Earth and loan from bank. Green Earth has intention to conduct the project solely. Another way is Leopard Capital participates in shareholders. They are interested in the project and expect the presentation of the detailed project plan. Financial plan will be discussed after project plan is fixed. ODA could be used for infrastructures such as transmission lines. NAPV will discuss with national government.

(10) Analysis of business potential:

IRR (Internal Rate of Return) of ten years will be 7%. Assuming 1 tCER is sold at 5 Euros, IRR increases to 8%. Therefore, economical feasibility with 0.3 USD/kWh is not high profitability. Although NAPV and Green Earth recognize the price with 0.3 USD/kWh will be low profitability, they are positive to implement the project due to high potential of the project site.

(11) Demonstration of additionality:

Demonstration of additionality shall be compliance with proposed standardised baseline. Since Cambodia is designated as LDC (least developed countries), projects with less than 5 MW can be applied "Guidelines for demonstrating additionality of microscale project activities" for exemption of demonstration of additionality. Projects with more than 5 MW need additionality demonstration. For the proposed standardised baseline, in order to contribute to reduce transaction costs of project participants, which is one of the aim of standardised baseline, positive list was applied. Positive lists are listed below:

- Fuels and technologies are biomass combustion power plant;
- The "Investment Analysis" of the project as indicated in "Tool for the demonstration and assessment of additionality" concludes that the project is not economically or financially feasible, without the revenue from the sale of certified emission reductions (CERs);
- There is no national or local enforced regulation mandating use of the technologies;
- There is no national or local enforced regulation prohibiting use of the biomass as fuel.

Since this project is more than 5 MW, the project must meet all positive lists.

Regarding the investment benchmark, 15% was applied because the domestic bank loan to a company is around 15%.

（12）Feasibility of the project:

This project aims to start construction of the first 320 kW facility in 2013 and install first 10 MW facility in 2015. For the implementation of the large scale project, there are several problems to solve such as below:

- Acquiring water for cooling 10 MW facilities especially. It will require 700 ~ 800 t of water per day. There is little water resource such as river and lake in eco-village area.
- Lack of electricity demand. Although museums, hotels and restaurants are expected to be developed for sightseeing, demand of electricity is not likely to increase immediately.
- Labor force of plantation. It will be necessary for local residents to be trained for plantation. A large amount of people must participate in the project in the small village.
- Electricity price. The project assumes 0.6 USD/kWh when installing 320 kW and 0.3 USD/kWh when installing 10 MW. However, these prices are not agreed with government. It always exists the request of price down of electricity price and this project must consider social demand.

5. Result of the study about co-benefits

This project can reduce sulfur oxides and soot dust from diesel generator. Baseline scenario emits a lot of sulfur oxides and soot dust due to low efficient diesel generator. On the other hand, project scenario uses biomass fuel collected from the site for electricity generation.

By monitoring that the biomass electricity plant is working, it can conclude that it reduces soot dust.

Reduction of sulfur oxide will be depending on the data of standardised baseline. Sulfur oxides can be calculated using the following formula;

$$BE_{SO_x,y} = 1/1000 \times EG_y \times FC_{BL,y} \times DST_D \times E\_INT_D \times EF_{SO_x}$$

Where:

$BE_{SOx,y}$	=	(Ton) Baseline sulfur oxides emissions
EGy	=	43,800,000 (kWh/year) Electricity generation (10 MW 10 hr 365 d）
$FC_{BL,y}$	=	0.3 (L/kWh)　Diesel consumption per unit of electricity generation (Sustainable Rural Electrification Plans for Cambodia: National level plans)
DST_D	=	0.847 (kg/L)　Specific gravity of diesel (EIA Documentation for Emissions of GHG in the USA 2006)
E_INT_D	=	0.043 (GJ/kg)　Net calorific value of diesel (2006 IPCC Guidelines for National Greenhouse Gas Inventories)
EF_{SOx}	=	0.1247 (kg/GJ) Emission factor of sulfur oxides (EPA AP 42 3.3 Gasoline and Diesel Industrial Engines)

Emissions of sulfur oxides in baseline scenario were calculated 59.7 t / year. Since sulfur content of biomass almost equals to zero, the reduction of sulfur oxides will be 59.7 t / year.

6. Contribution to Sustainable Development in Host Country

Plantation and collection of biomass will be conducted by local people that will create employment. Increase of employment contributes to sustainable development.

Introduce of biomass power plant can reduce pollution of atmosphere that also contributes to sustainable development.