Project design document form for CDM project activities

(Version 08.0)

Complete this form in accordance with the Attachment "Instructions for filling out the project design document form for CDM project activities" at the end of this form.

PROJECT DESIGN DOCUMENT (PDD)	
Title of the project activity	Nam Mang 1 Hydropower Project
Version number of the PDD	03.0
Completion date of the PDD	10/08/2017
Project participant(s)	Nam Mang 1 Power Co., Ltd.
Host Party	Lao PDR
Applied methodology(ies) and, where applicable, applied standardized baseline(s)	ACM0002 (Version 17.0, EB 89) Grid-connected electricity generation from renewable sources.
Sectoral scope(s) linked to the applied methodology(ies)	Sectoral Scope 1: Energy Industries
Estimated amount of annual average GHG emission reductions	125,775 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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Nam Mang 1 Hydropower Project is located in Bolikhamsai Province, the central of Laos. The project site is about 12 km far from Bolikhamsai Thabok town and about 105 km far from Vientiane Capital. The project is Developed by Nam Mang 1 Power Co., Ltd. Nam Mang 1 Hydropower Project is a mixed hydroelectric station and the junction structures mainly consist of head face rock-fill dam, spillway, diversion system, generation system, etc. The nominal installed capacity of the project is 64 MW (the actual installed capacity is 63.99MW with three 21.33MW unites), with annual power supply 224.8 GWh. After the completion of the Project, its electric power will be delivered to the regional grid consisting of Thailand power grid and the Lao power grid. The proposed project will mainly take charge in the power generation for residential and industrial consumption.

Lao PDR possesses abundant hydro resources. The proposed project is to generate clean electricity with the abundant resources and displace part of the electricity usage from the regional grid consisting of Thailand power grid and the Lao power grid, in which fossil fuel fired power plants are the dominated power sources. Thus the proposed project can reduce the CO_2 emissions in this area. About 125,775 tCO_2e will be reduced by this project annually.

As a renewable energy project, the project will produce positive environmental and economic benefits and contribute to the local sustainable development in following aspects:

- During the construction period, plenty of job opportunities were provided to local residents, and the newcomers surged in the area will bring local people lots of employment opportunities thus bring more revenue for the local residents;
- The infrastructures were greatly improved. The implementation of water supply program, transportation and electricity system enhancement will bring substantial benefits to local villagers;
- Reduce the local use of firewood displacing by electricity, reduce the damage to the local vegetation;
- Power supplied to the regional grid consisting of Thailand Power Grid and the Lao Power Grid, will provide clean & cheap electricity power in this region, promote the sustainable development in this region and slowing down the increasing trend of GHG emissions.

A.2. Location of project activity

A.2.1. Host Party

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Lao PDR

A.2.2. Region/State/Province etc.

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Bolikhamsai Province

A.2.3. City/Town/Community etc.

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Thabok town

A.2.4. Physical/Geographical location

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Nam Mang 1 Hydropower Project is located in Bolikhamsai Province, the central of Laos. The project site is about 12 km far from Bolikhamsai Thabok town and about 105 km far from Vientiane Capital. The approximate coordinates of the project site are: (N18.4328°, E103.1653°).

Figure A.1 Show the location of the project:

Figure A.1. Location of the project

A.3. Technologies and/or measures

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After completion of the project, the newly built plant will provide clean electric power to the regional grid consisting of Thailand Power Grid and the Lao Power Grid. The scenario prior to the start of implementation of the project activity is provision of the equivalent amount of electricity generated by the power plants connected with the regional grid, which is dominated by thermal power plants, thus leads to mass of GHG emissions. The baseline scenario is the same as the scenario prior to the start of implementation of the project activity.

Nam Mang 1 Hydropower Project is a mixed hydroelectric station and the junction structures mainly consist of head face rock-fill dam, spillway, diversion system, generation system, etc.

The power generated by the project will be supplied to transformer substation and linked with EDL system to the regional grid consisting of Thailand Power Grid and the Lao Power Grid. According to the FSR, the annual net electricity supply will be 224.8 GWh, with PLF 40.10%[1]. The actual installed capacity of the project is 63.99MW; the area of reservoir at full water level is 320,000m^2. Therefore, the power density (*PD*) = 63,990,000/320,000 = 199.97W/m^2 which is greater than 10 W/m^2.

The table below summarizes the main technical features of the project.

Table A.1 Main parameters of the project[2]

Parameter		Unit	Value
Turbine	Type	HLA858a-LJ-182	
	Rated Power	kW	22100
	Number	-	3
	Design flow	m^3/s	27.1
	Rated water head	m	90
	Rated speed	r/min	428.6
	Runaway speed	r/min	819
	Designed lifetime	Years	40
	Manufacture	DEC Dongfeng Electric Machinery Co., Ltd.	
Generator	Type	SF21.33-14/3640	
	Rated capacity	kW	21330
	Number	-	3
	Rated Voltage	V	11000
	Rated Current	A	1399.4
	Rated Frequency	Hz	50
	Rated power factor	-	0.8
	Designed lifetime	Years	40
	Manufacturer	DEC Dongfeng Electric Machinery Co., Ltd.	

A.4. Parties and project participants

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Party involved (host) indicates host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Lao PDR (host)	Nam Mang 1 Power Co., Ltd. (Project owner)	**No**

A.5. Public funding of project activity

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The project does not receive any public funding from Parties included in Annex I of the UNFCCC. The project does not use ODA directly or indirectly.

[1] PLF=224800/63.99/8760=40.10%

[2] The parameters of turbine and generator are derived from "Technical Protocol of Turbine and Generator" and Nameplate

SECTION B. Application of selected approved baseline and monitoring methodology and standardized baseline

B.1. Reference of methodology and standardized baseline

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Approved consolidated baseline and monitoring methodology ACM0002 (Version 17.0, EB 89): Grid-connected electricity generation from renewable sources.

This methodology draws upon the following tools:
Tool for the demonstration and assessment of additionality (Version 7.0.0, EB 70), and
Tool to calculate the emission factor for an electricity system (Version 5.0, EB 87)
Common Practice (Version 3.1, EB 84)

Please click following link for more information about the methodology and tool:
http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

B.2. Applicability of methodology and standardized baseline

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The baseline and monitoring methodology ACM0002 is applicable to the proposed project, because the project meets the applicability criteria stated in the methodology:

Applicability	Applicable? Yes/No	comment
This methodology applies to project activities that include retrofitting, rehabilitation (or refurbishment), replacement or capacity addition of an existing power plant or construction and operation of a Greenfield power plant.	Yes	The project is to install a new hydro power plant and hence comply with the above applicability criterion.
This methodology is applicable to grid-connected renewable energy power generation project activities that: (a) Install a Greenfield power plant; (b) Involve a capacity addition to (an) existing plant(s); (c) Involve a retrofit of (an) existing operating plants/units; (d) Involve a rehabilitation of (an) existing plant(s)/unit(s); or **(e)** Involve a replacement of (an) existing plant(s)/unit(s).	Yes	The project is to install a Greenfield hydro power plant and power generation will be imported to grid.
The methodology is applicable under the following conditions: (a) The project activity may include renewable energy power plant/unit of one of the following types: hydro power plant/unit with or without reservoir, wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit; (b) In the case of capacity additions,	Yes	a) The project result in a new reservoir and the power density of 199.97[3] W/m^2 is greater than the requirement of 4 W/m^2. b) As a Greenfield hydro plant, the project does not include capacity additions, retrofits, rehabilitations or replacements. Thus, The project matches with the above applicability criterion.

[3] The power density is calculated by dividing the submersed area by the installed capacity. The actual installed capacity of the project is 63.99MW; the area of reservoir at full water level is 320,000m^2. Therefore, the power density (*PD*) = 63,990,000/320,000 = 199.97W/m^2.

retrofits, rehabilitations or replacements (except for wind, solar, wave or tidal power capacity addition projects the existing plant/unit started commercial operation prior to the start of a minimum historical reference period of five years, used for the calculation of baseline emissions and defined in the baseline emission section, and no capacity expansion, retrofit, or rehabilitation of the plant/unit has been undertaken between the start of this minimum historical reference period and the implementation of the project activity.		
In case of hydro power plants, one of the following conditions shall apply: (a) The project activity is implemented in existing single or multiple reservoirs, with no change in the volume of any of the reservoirs; or (b) The project activity is implemented in existing single or multiple reservoirs, where the volume of the reservoir(s) is increased and the power density calculated using equation (3), is greater than 4 W/m2; or (c) The project activity results in new single or multiple reservoirs and the power density, calculated using equation (3), is greater than 4 W/m^2; or (d) The project activity is an integrated hydro power project involving multiple reservoirs, where the power density for any of the reservoirs, calculated using equation (3), is lower than or equal to 4 W/m2, all of the following conditions shall apply: i) The power density calculated using the total installed capacity of the integrated project, as per equation (4), is greater than 4 W/m^2; ii) Water flow between reservoirs is not used by any other hydropower unit which is not a part of the project activity; iii) Installed capacity of the power plant(s) with power density lower than or equal to 4 W/m2 shall be: a. Lower than or equal to 15 MW; and b. Less than 10 per cent of the total installed capacity of integrated hydro power project.	Yes	The project is Condition (c) “ with single reservoir and power density is greater than 4 W/m^2.
In the case of integrated hydro power projects, project proponent shall: (a) Demonstrate that water flow from upstream power plants/units spill	Not relevant	The project is not a integrated hydro power projects.

directly to the downstream reservoir and that collectively constitute to the generation capacity of the integrated hydro power project; or (b) Provide an analysis of the water balance covering the water fed to power units, with all possible combinations of reservoirs and without the construction of reservoirs. The purpose of water balance is to demonstrate the requirement of specific combination of reservoirs constructed under CDM project activity for the optimization of power output. This demonstration has to be carried out in the specific scenario of water availability in different seasons to optimize the water flow at the inlet of power units. Therefore this water balance will take into account seasonal flows from river, tributaries (if any), and rainfall for minimum five years prior to implementation of CDM project activity.		
The methodology is not applicable to: (a) Project activities that involve switching from fossil fuels to renewable energy sources at the site of the project activity, since in this case the baseline may be the continued use of fossil fuels at the site; (b) Biomass fired power plants/units.	Not relevant	The project does not include fossil fuel switching and biomass unit.
In the case of retrofits, rehabilitations, replacements, or capacity additions, this methodology is only applicable if the most plausible baseline scenario, as a result of the identification of baseline scenario, is "the continuation of the current situation, that is to use the power generation equipment that was already in use prior to the implementation of the project activity and undertaking business as usual maintenance".	Not relevant	The project does not include retrofits, rehabilitations, replacements, or capacity additions.

"Tool to calculate the emission factor for an electricity system" (Version 5.0) was adopted to estimate the emission factor of the project.

Applicability	Applicable? Yes/No	comment
This tool may be applied to estimate the OM, BM and/or CM when calculating baseline emissions for a project activity that substitutes grid electricity, i.e. where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects).	Yes	The power generated by the project will be supplied to the regional grid consisting of Thailand Power Grid and the Lao Power Grid, and result in saving of electricity that would have been provided by the grid. Therefore, the "Tool to calculate the emission factor for an electricity system" is applicable for this project.

B.3. Project boundary

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Spatial boundary

The power generated by the project will be supplied to the Lao Power Grid, which connected with Thailand Power Grid through transmission lines. According to the "*Calculation for the emission factor for electricity generation in Lao PDR, 2010*" published by the Lao DNA, the regional grid consisting of Thailand Power Grid and the Lao Power Grid is adopted as the project boundary.

According to ACM0002 (Version 17.0), the spatial extent of the project boundary includes the project power plant and all power plants connected physically to the electricity system that the CDM project power plant is connected to.

According to "Tool to calculate the emission factor for an electricity system", the project electricity system is defined as the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (i.e. the renewable power plant location) and that can be dispatched without significant transmission constraints. A connected electricity system is defined as an electricity system that is connected by transmission lines to the project electricity system. Power plants within the connected electricity system can be dispatched without significant transmission constraints but transmission to the project electricity system has significant transmission constraint.

According to the tool mentioned above, there are no transmission constraints if any one of the following criteria is met:

i. *In case of electricity systems with spot markets for electricity: there are differences in electricity prices (without transmission and distribution costs) of less than five per cent between the two electricity systems during 60 per cent or more of the hours of the year; or*

ii. *The transmission line is operated at 90 per cent or less of its rated capacity at least during 90 per cent of the hours of the year.*

As demonstrated by the official document by Lao DNA mentioned above, for transmission lines between Thailand and Lao Power Grid, there is no spot market exists, so the criteria i. list above is not applicable. Furthermore the load of the transmission lines between Lao Power Grid and Thailand Power Grid is far below 50% of its rated capacity during all the year[4]. So, the electricity system does not have significant transmission constrain.

According to the Para 18 of the "Tool to calculate the emission factor for an electricity system": *'In addition, in cases involving international interconnection (i.e. transmission line is between different countries and the project electricity system covers national grids of interconnected countries) it should be further verified that there are no legal restrictions for international electricity exchange.'*

The grid between Lao and Thailand kept enormous power exchange, and the power comparison of Laos export, import and domestic demand are listed below:

Table B.1. Power exchange between Lao and Thailand (Unit: GWh)

	2010	2009	2008

[4] Information provided by EDL, regarding to the power load of the transmission lines between Laos and Thailand.

Lao power export to Thailand[5]	6,938.45	2,385.84	2,315.43
Domestic demand in Lao[6]	2,228.15	1,901.29	1,577.86
Lao power import from Thailand (EDL)[7]	1,042.12	1,081.19	772.8

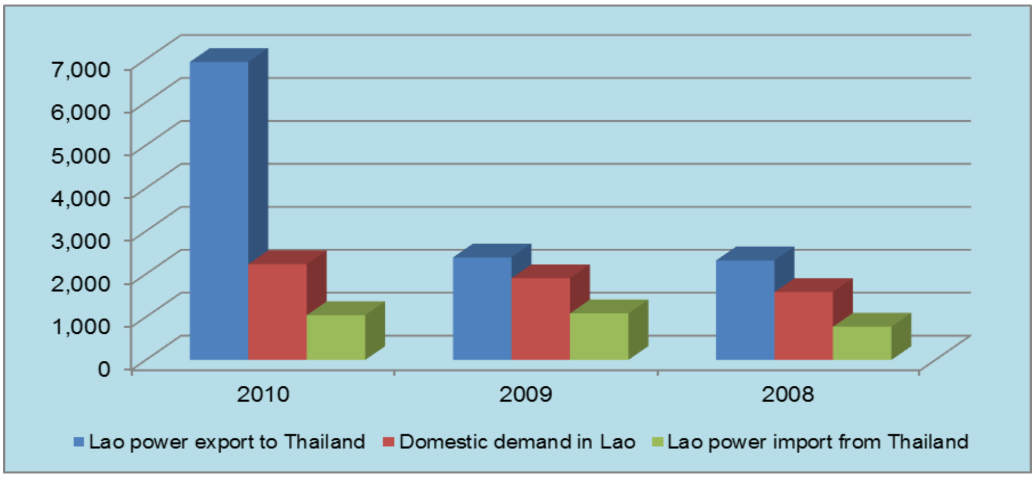

Figure B.1 Power exchange between Lao and Thailand (Unit: GWh)

The data listed above indicates the close relationship between the power system of Lao and Thailand. The Thai and Lao power system have kept intimately cooperation, and Thailand government promised that 7,000 GWh power will be imported from Lao PDR during 2010 to 2015[8]. According to the MOU signed between Lao government and Thailand government, through the interconnection between the two countries, Lao power grid could sold the surplus energy to Thailand, and the deficits of Lao demand in rush hours can be covered by imports. Based on the above information, it could be concluded that there are no legal restrictions for international electricity exchange.

Based on the reasons listed above, it is shown that the most appropriate definition of the spatial extension of the project electricity system is a regional grid consisting of Thailand Power Grid and the Lao Power Grid.

Emission sources and gases

The greenhouse gases and emission sources included in or excluded from the project boundary are shown in the table below.

Table B.2. GHG emissions in Project boundary

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity	CO_2	Yes	Main emission source
		CH_4	No	Minor emission source
		N_2O	No	Minor emission source
Project scenario	For geothermal power plants, fugitive emissions of CH_4 and CO_2 from non condensable gases contained in geothermal steam.	CO_2	No	Not applicable to hydro power Project
		CH_4	No	
		N_2O	No	

[5] EGAT Annual Report 2010, page 101 & Annual Report 2009, page 88, Electricity Generating Authority of Thailand.

[6] EDL Annual Report 2009, page 17, Electricite du Laos.

[7] EGAT Annual Report 2010, page 102 & Annual Report 2009, page 89, Electricity Generating Authority of Thailand.

[8] http://uk.reuters.com/article/idUKBKK15938520071018

	CO_2 emissions from combustion of fossil fuels for electricity generation in solar thermal power plants and geothermal power plants.	CO_2	No	Not applicable to hydro power Project
		CH_4	No	
		N_2O	No	
	For hydro power plants, emissions of CH_4 from the reservoir.	CO_2	No	Minor emission source
		CH_4	No	Minor emission source (Power density is greater than 4 W/m^2)
		N_2O	No	Minor emission source

A flow diagram of the project boundary is presented in Figure B.2 below. The flow diagram physically delineates the project boundary, includes the flow of electricity and the project electricity system (the regional grid consisting of Thailand Power Grid and the Lao Power Grid), and the GHG emissions.

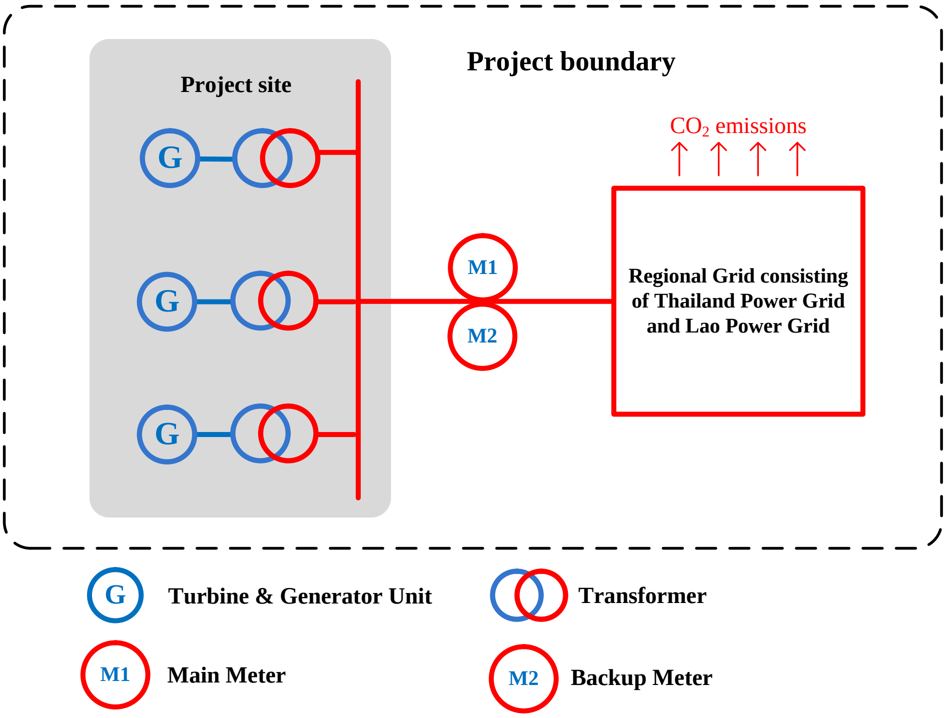

Figure B.2 Flow diagram of the project boundary

B.4. Establishment and description of baseline scenario

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According to ACM0002 (Version 17.0), if the project activity is the installation of a new grid-connected renewable power plant, the baseline scenario is the following:

"*Electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in the combined margin (CM) calculations described in the Tool to calculate the emission factor for an electricity system*."

The project activity is the installation of a new grid-connected renewable power plant/unit, and is not a modification/retrofit of an existing plant/unit, therefore, the baseline scenario is provision of the equivalent amount of electricity generated by the power plants connected with the regional grid consisting of Thailand Power Grid and the Lao Power Grid, and the addition of new generation sources, as reflected in the combined margin (CM) calculations described in the "Tool to calculate the emission factor for an electricity system" (Version 5.0).

B.5. Demonstration of additionality

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Prior consideration of CDM

To overcome financial weakness, and unfavourable conditions that the project encounters, the project owner decided to seek CDM assistance in end of 2011 after the project Feasibility Study Report has been completed by independent design institute.

In Oct.2013, the prior consideration form was accepted by EB which strengthen the confidence of the project entity and buyer to develop the project.

According to the definition of the "starting date of a CDM project activity" provided in paragraph 67 of EB41 meeting report, the starting date of the Project is determined as 15/10/2013. The prior consideration form was submitted before the project starting date, the CDM was seriously considered in the decision to implement the project activity.

The timeline of the CDM consideration and continue action of the project entity as follow:

Table B.3. Timeline of the key events

Time	Event
1st Sep. 2010	Stakeholder meeting
Mar. 2011	FSR finished by design institute, CER revenue has been taken into account
Apr. 2011	EIA report was finished
May 04th 2011	Got the FSR Approval
Feb. 01st 2012	EIA was approved by GOL
Feb. 12th 2013	Investment decision was made by the chairman of the board and the incentive of CDM is acknowledged as a key element of the project's profitability
Oct. 10th 2013	Prior consideration form accepted by EB
Oct. 15th 2013	**EPC signed (Start date)**
Dec. 12th 2013	Got construction approval issued by Ministry of Planning and Investment
Aug. 15th 2014	A CERs buyer sent a Letter of Interest for the project
Nov. 18th 2014	Desk Due Diligence Conducted
May 03rd 2015	Another CERs buyer sent a Letter of Intent for the project
Apr. 25th 2016	Signed CDM Service Agreement with CDM Service Entity
Oct. 1st 2016~Oct. 30th 2016	PDD Started Global Stakeholder Consultation (GSC)
Apr. 1st 2017	Project start operation

Additionality

According to the "Tool for the demonstration and assessment of additionality" (Version 7.0.0) approved by EB, the additionality of the project is demonstrated and assessed through the following steps.

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

Sub-step 1a. Define alternatives to the project activity:

Plausible and credible alternatives available to the project that provide outputs or services comparable to the proposed CDM project activity include:

Alternative a): The project activity not undertaken as a CDM project activity;
Alternative b): Construction of a thermal power plant with equivalent installed capacity or annual electricity generation;
Alternative c): Construction of a power plant using other sources of renewable energy with equivalent amount of annual electricity generation;
Alternative d): Provision of an equivalent amount of annual power output by the grid into which the project is connected.

Alternative a) is in compliance with all applicable legal and regulatory requirements. But according to the investment analysis in step 2, this scenario is less attractive with low IRR and is not realistic without CDM financing.

Alternative b) is not a realistic alternative. According to the Power System Development Plan for Lao PDR, there isn't an existing thermal power plant with the similar or larger power generation capacity with Nam Mang 1 Hydropower Project in Lao yet, furthermore, at the proposed project site, there isn't any coal mine developed, the only way to obtain enough material is transport coal from other regions, and thus will significantly increase the cost in such a mountainous region.

Alternative c), other kinds of renewable energy technologies, such as wind, solar PV, geothermal, and biomass are possible grid-connected sources. However, according to the *Country Paper Rural Energy Development and Utilization*[9], these projects face varies barriers in awareness, finance, law and institution and technologies, etc. The other kinds of renewable energy technologies in Lao are not mature currently and lack of financial attractive to construct power plants with the similar power generation capacity with Nam Mang 1 Hydropower Project.

Alternative d) is in compliance with all applicable legal and regulatory requirements.

Outcome of Sub-step 1a: demonstrates that the identified realistic and credible alternative scenarios to the project activity are Alternatives a), d).

Sub-step 1b. Consistency with mandatory laws and regulations:

All the alternatives identified above are in compliance with applicable rules and regulations in Lao PDR.

Outcome of Step 1b: demonstrates that the identified realistic and credible alternative scenarios to the project activity are Alternatives a), d).

Step 2. Investment analysis

The purpose of this step is to determine whether the project activity is economically or financially less attractive than other alternatives without the revenue from the sale of certified emission reductions (CERs). The investment analysis was conducted in the following steps:

Sub-step 2a. Determine appropriate analysis method

The "*Tool for the Demonstration and Assessment of Additionality (Version 7.0.0)"* proposal three analysis methods which are:

(Option I) Simple cost analysis;
(Option II) Investment comparison analysis;

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[9] Prepared by Renewable Energy Technology Center, Technology Research Institute of Lao PDR,

(Option III) Benchmark analysis;

Since the project will earn revenues not only from the CERs sales but also from electricity sales, the simple cost analysis method is not appropriate. Investment comparison analysis method is only applicable to projects whose alternatives are similar investment projects. The Alternative d) of the project is supply electricity by the regional grid rather than newly invested projects. Therefore, Option II is not appropriate. The project will use benchmark analysis method (Option III) based on the consideration that benchmark IRR of the power sector is available.

Sub-step 2b. Option III. Apply benchmark Analysis

According to the "*Tool for the Demonstration and Assessment of Additionality (Version 7.0.0)"*, there are five options for discount rates and benchmarks determine:

a) Government bond rates, increased by a suitable risk premium to reflect private investment and/or the project type, as substantiated by an independent (financial) expert or documented by official publicly available financial data;

b) Estimates of the cost of financing and required return on capital (e.g. commercial lending rates and guarantees required for the country and the type of project activity concerned), based on bankers' views and private equity investors/funds' required return on comparable projects;

c) A company internal benchmark (weighted average capital cost of the company), only in the particular case where the project activity can be implemented by the project participant, the specific financial/economic situation of the company undertaking the project activity can be considered. The project developers shall demonstrate that this benchmark has been consistently used in the past i.e. that project activities under similar conditions developed by the same company used the same benchmark;

d) Government/official approved benchmark where such benchmarks are used for investment decisions;

e) Any other indicators, if the project participants can demonstrate that the above Options are not applicable and their indicator is appropriately justified.

For this project, option a) was applied. The project adopted US dollar as the currency accounted and invested in Lao PDR, thus the benchmark is combined by the maturity rate of the 3-month US Treasury bill and the risk premium on lending of Laos which could respectively reflect the risk-free return of the currency adopted and the risk premium of the host country.

The average value of the 3-Month US Treasury Constant Maturity Rate[10] at the recent 20 years before the start date 2.94% will be introduced to represents the risk free rate (nominal rate, consistent with the calculation of cash flow) for the following reasons:

i. There is no systematic government bond issue structure in Lao PDR;

ii. The project was accounted in U.S. dollar, and the 3-month U.S. Treasury rate is a widely accepted risk-free rate[11];

iii. The average value in the recent 20 years before the starting date was applied since the long term average value reduces the short term uncertainty and violation of the market.

Regarding the value of national risk premium. The data "Risk premium on lending (prime rate minus Treasury bill rate; %)" provided by World Bank[12] was applied. Risk premium on lending is the interest rate charged by banks on loans to prime private sector customers minus the "risk free" Treasury bill interest rate at which short-term government securities are issued or traded in the market. The data

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10 Website of the Federal Reserve Bank of St. Louis http://research.stlouisfed.org/fred2/series/DGS3MO?cid=47

11 http://www.investopedia.com/terms/r/risk-freerate.asp#axzz1V9mGhc6k

12 http://data.worldbank.org/indicator/FR.INR.RISK

is proper to illustrate the "suitable risk premium to reflect private investment" in the host country stated in the *"Tool for the Demonstration and Assessment of Additionality (Version 7.0.0)"*. Too reduce the short term uncertainty, the average risk premium of Lao PDR in the latest 5 years 12.68% was adopted (the risk premium of Lao PDR from 2006 to 2010 are 11.70, 10.10, 11.70, 15.30 and 14.60 respectively).

So, the benchmark adopted equals the maturity rate of the 3-month US Treasury bill plus the Risk premium on lending in Lao PDR, the value is 15.62% (post-tax).

Sub-step 2c. Calculation and comparison of financial indicators

1) Basic parameters for calculation of financial indicators

Based on the Feasibility Study Report (FSR) accomplished by the third party, the main assumptions for the investment analysis are shown in Table below.

Table B.4. Basic parameters of the project

Basic parameters	Unit	Value	Source
Installed capacity	MW	64	FSR
Static investment Cost	10^3 USD	98,949.1	FSR
Fluid Capital	10^3 USD	200	FSR
Electricity Tariff	USD/kWh	0.0571 (increase by 1.5% in the former 9 years and then keep steady)	FSR
Average O&M cost	10^3 USD	1,535.9	Calculated based on FSR
Annual net power supplied	GWh	224.8	FSR
Project lifetime (excluding construction period)	year	40	FSR
Construction period	year	3	FSR

The analysis shows that without the revenue of CERs, the IRR of the project will be 9.43% much lower than the benchmark 15.62%. The project is not financial attractive. Considering the CDM revenues, the IRR of the project will be 14.05%. Thus the CDM revenues will help project overcome the investment barriers.

Sub-step 2d. Sensitivity analysis

The sensitivity analysis shows whether the conclusion regarding financial attractiveness is robust to reasonable variations in the critical assumptions. For the project, the most important parameters impacting the project IRR are:

- Static investment
- Annual O&M cost
- Electricity tariff (including VAT)
- Power supplied to the grid

In case of the ±10% variation range of the four parameters, the fluctuations of the IRR (without CER revenue) are showing below:

Table B.5. Sensitive analysis of the project

Variation range / IRR / Parameters	-10%	-5%	0%	+5%	+10%

Static investment	10.67%	10.03%	9.43%	8.88%	8.37%
Annual O&M cost	9.57%	9.50%	9.43%	9.36%	9.29%
Electricity tariff	8.23%	8.84%	9.43%	10.01%	10.59%
Power supplied to the grid	8.23%	8.84%	9.43%	10.01%	10.59%

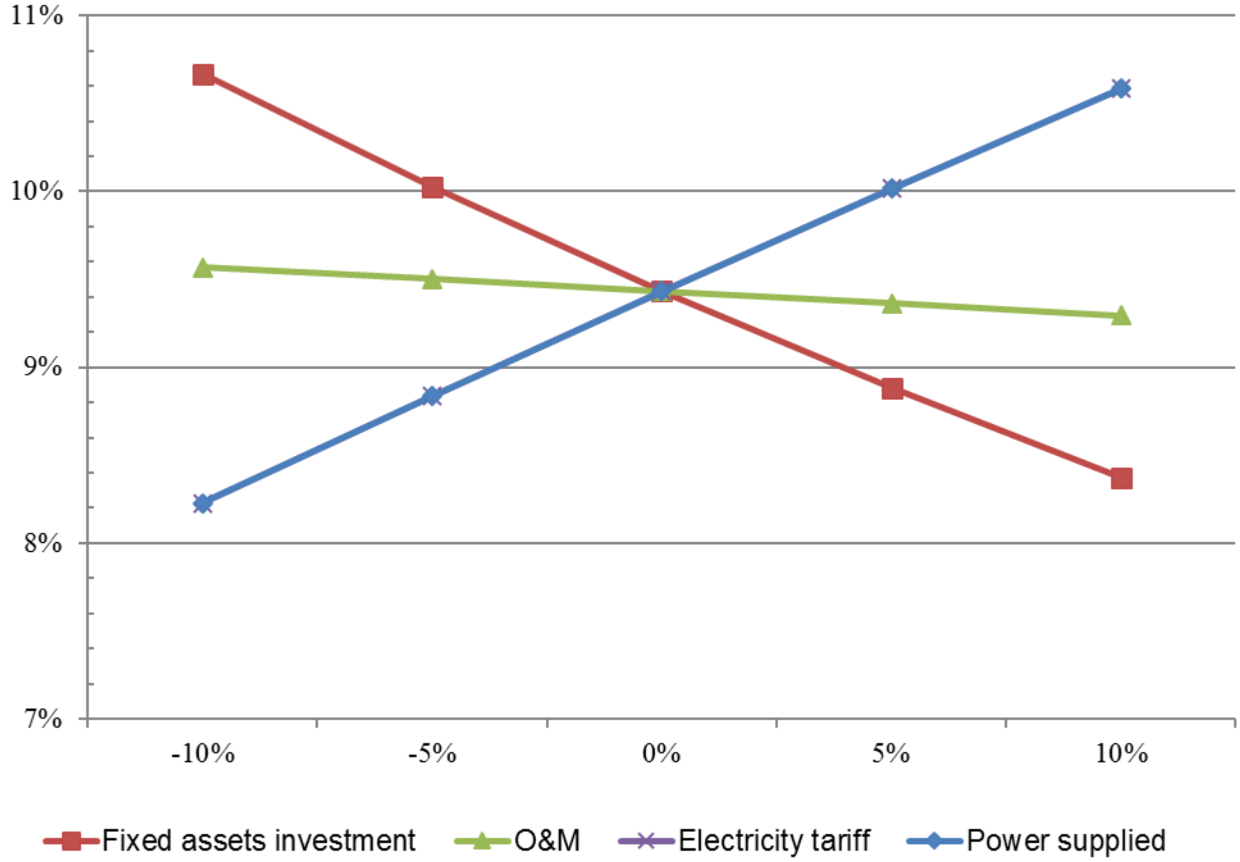


Figure B.3. Sensitive analysis

Based on the relationship shown above, we can find out that the project IRR that will decline accompany with the rise of the Static investment and the annual O&M cost; and the IRR will rise accompany with the rise of the electricity tariff and the electricity supply. We can conclude from the above analysis that, even if ±10% variation range of the four parameters, the IRR of the project still can't surpass the benchmark. However, the revenue from the CERs will greatly improve the financial feasibility of the project.

In conclusion, without the consideration of the revenue from CERs, the conclusion of the project activities lacks of commercial attraction is evidenced, so the specific project is in shortage of commercial attraction.

Based on the above analysis, the project IRR could reach the benchmark 15.62% if one of the following conditions can be achieved:

Table B.6. Conditions make the IRR reach the benchmark

Parameters	Overall
Static investment	-37.58%
Annual O&M cost	-489%
Electricity tariff	58.20%
Power supplied to the grid	58.20%

However, none of these conditions can be achieved due to the following reasons:

1) Regarding the static investment

The parameters adopted from the FSR that finalized by the third party with abundant experiences in hydropower projects. The static investment estimated in the FSR is in line with local standards on engineering, procurement and construction. Comparing with the actual signed EPC contracts, the static investment estimated in FSR has already carried out, the EPC price is 77,080,000 USD, which is 77.90% of the static investment estimated in the FSR, thus it is unlikely to decrease the investment as much as 37.58%.

2) Regarding the annual O&M cost

O&M is not a sensitive parameter. In this project, even if the O&M decreased to zero, the IRR is still lower than the benchmark. Actually, according to the O&M Agreement between project owner and the operator, the O&M cost pay for the operator is almost the same compare with the value estimated in the FSR.

3) Regarding the electricity tariff

The Tariff adopted in the analysis is sourced from the FSR that finalized by the third party, and the electricity tariff increased by 1.5% on an annual basis in the first decade during the operation period and then keep steady. The Power value of the Power Purchase Agreement signed between the Project Owner and the power grid company showed that the on-grid price is 5.71 US cents/kWh (same as the FSR value) in the first year and then increases by 1.5% in the next following 9 years, consistent with the FSR. Therefore, the electricity tariff will unlikely to increase 58.20% during the contract period.

4) Regarding the power supplied

The power supply is determined by the FSR author according to a relative long-term local hydrological data. There may exist fluctuations and uncertainty among the practical situation in each operational year regarding to the precipitation and runoff of the river, but the space of fluctuation would be limited, it is unlikely to deviate from the long-term hydrological data as much as 58.20% annually.

In conclusion, without the consideration of the revenue from CERs, the conclusion of the project activities lacks of commercial attraction is evidenced, so the specific project is in shortage of commercial attraction.

Step 3 Barrier analyses

This step is not adopted.

Step 4 Common practice analyses

Sub-step 4a. Analyze other activities similar to the project activity

As per *Tool for the Demonstration and Assessment of Additionality*, projects are considered similar if they are in the same country/region and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory frame-work, investment climate, access to technology, access to financing, etc. According to the *Common Practice (version 03.1),* common practice analysis is presented through the following 4 steps.

Step 1: Calculate applicable output range as +/-50% of the design output or capacity of the proposed project activity.

The installed capacity of Nam Mang 1 Hydropower Project is 63.99 MW, the projects with capacity ±50% of the project (32.00~95.99MW) are considered as similar size.

Step 2: Identify similar projects (both CDM and non-CDM) which fulfil all of the following conditions:

(a) The projects are located in the applicable geographical area;
(b) The projects apply the same measure as the proposed project activity;
(c) The projects use the same energy source/fuel and feedstock as the proposed project activity, if a technology switch measure is implemented by the proposed project activity;
(d) The plants in which the projects are implemented produce goods or services with comparable quality, properties and applications areas (e.g. clinker) as the proposed project plant;
(e) The capacity or output of the projects is within the applicable capacity or output range calculated in Step 1;
(f) The projects started commercial operation before the project design document (CDM-PDD) is published for global stakeholder consultation or before the start date of proposed project activity, whichever is earlier for the proposed project activity.

Considering the above criteria, hydropower projects located in Lao PDR with installed capacity of 32~96MW, which started commercial operation before the starting date of the project are selected for further analysis are selected. According to EDL Annual Report 2008 and Electric Power Plants in Laos (as of March 2009)[13], there are 1 project was observed.

Table B.7. Similar hydropower projects comparison

Project name	Capacity MW	Commissioning year	Ownership	CDM application
Se Xet 1	45	1990	EDL	No

Step 3: Within the projects identified in Step 2, identify those that are neither registered CDM project activities, project activities submitted for registration, nor project activities undergoing validation. Note their number N_{all}.

Refer to the projects listed above, the parameter N_{all} is 1.

Step 4: Within plants identified in Step 2, identify those that apply technologies different that the technology applied in the proposed project activity. Note their number N_{diff}.

As mentioned in the Table B.7, Se Xet 1 projects was implemented in 1990. The Asian Economic Crisis and problems among key international power sector investors exposed many weaknesses in project financing models in use throughout the region. These facts indicate the significant financial barrier in Lao PDR non-state funds section. The decision making and financing progress of the Se Xet 1 project is before Asian Economic Crisis, its regulatory frame-work, investment climate and access to financing are rather different from the Nam Mang 1 Hydropower Project.

In conclusion, the projects listed in the Table B.7 applied different technology compare with Nam Nam Mang 1 Hydropower Project according to the criteria provided by the *Guidelines On Common Practice*, the parameter N_{diff} is 1.

Step 5: calculate factor $F=1-N_{diff}/N_{all}$ representing the share of similar projects (penetration rate of the measure/technology) using a measure/technology similar to the measure/technology used in the proposed project activity that deliver the same output or capacity as the proposed project activity.

[13] Published by EDL http://edllaos.com/download/Electric_Power_Plants_in_Laos_as_of_March_2009.pdf

Based on the above analysis, the parameter F representing the share of plants using technology similar to the technology used in the project activity in all plants that deliver the same output or capacity as the project activity, which is calculated by $1\text{-}N_{diff}/N_{all}=0$. Since F is less than 0.2, it can be concluded that the project is not a common practice and the project is additional.

In conclusion, all the steps above are satisfied, the proposed CDM project is not the baseline scenario, and the proposed project activity is additional.

B.6. Emission reductions

B.6.1. Explanation of methodological choices

>>

The Methodology ACM0002 (version 17.0) is applied in the context of the project in the following four steps:

- **Step 1, calculate the project emissions;**
- **Step 2, calculate the baseline emissions;**
- **Step 3, calculate the project leakage;**
- **Step 4, calculate the emission reductions.**

Calculate the project emissions

According to Methodology, the project emissions shall be calculated by the following equation:

$$PE_y = PE_{FF,y} + PE_{GP,y} + PE_{HP,y} \quad \text{(Equation B.1)}$$

Where:

PE_y	Project emissions in year *y* (tCO_2e/y);
$PE_{FF,y}$	Project emissions from fossil fuel consumption in year *y* (tCO_2/y);
$PE_{GP,y}$	Project emissions from the operation of geothermal power plants due to the release of non-condensable gases in year *y* (tCO_2e/y);
$PE_{HP,y}$	Project emissions from water reservoirs of hydro power plants in year *y* (tCO_2e/y);

For this project, does not involve the fossil fuel consumption and geothermal power, so $PE_{FF,y}=0$, $PE_{GP,y}=0$. For hydro power project activities that result in new reservoirs and hydro power project activities that result in the increase of existing reservoirs, project proponents shall account for project emissions, estimated as follows:

a) If the power density (*PD*) of power plant is greater than 4 W/m^2 and less than or equal to 10 W/m^2:

$$PE_{HP,y} = \frac{EF_{Res} \cdot TEG_y}{1000} \quad \text{(Equation B.2)}$$

Where:

$PE_{HP,y}$	Project emissions from water reservoirs (tCO_2e/y);
EF_{Res}	Default emission factor for emissions from reservoirs, and the default value as per EB 23 is 90 kg CO_2e /MWh;
TEG_y	Total electricity produced by the project activity, including the electricity supplied to the grid and the electricity supplied to internal loads, in year *y* (MWh);

b) If the power density (*PD*) of the power plant is greater than 10 W/m^2

$$PE_{HP,y}=0 \quad \text{(Equation B.3)}$$

The PD of the project activity is calculated as follows:

$$PD=\frac{Cap_{PJ}-Cap_{BL}}{A_{PJ}-A_{BL}}$$ (Equation B.4)

Where:

PD	Power density of the project activity (W/m^2);
Cap_{PJ}	Installed capacity of the hydro power plant after the implementation of the project activity (W);
Cap_{BL}	Installed capacity of the hydro power plant before the implementation of the project activity (W). For new hydro power plants, this value is zero;
A_{PJ}	Area of the reservoir measured in the surface of the water, after the implementation of the project activity, when the reservoir is full (m^2);
A_{BL}	Area of the reservoir measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m^2). For new reservoirs, this value is zero;

According to the FSR, the PD is greater than 10W/m^2, thus $PE_{HP,y}$= 0. Then PE_y= 0 tCO_2.

Calculate the baseline emissions

Baseline emissions include only CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity. The methodology assumes that all project electricity generation above baseline levels would have been generated by existing grid-connected power plants and the addition of new grid-connected power plants. The baseline emissions are to be calculated as follows:

$$BE_y=EG_{PJ,y}\times EF_{grid,CM,y}$$ (Equation B.5)

Where:

BE_y	=	Baseline Emissions in year *y* (tCO_2/yr);
$EG_{PJ,y}$	=	Quantity of net electricity supplied to the grid as a result of the implementation of the CDM project activity in year *y* (MWh/yr);
$EF_{grid,CM,y}$	=	Combined margin CO_2 emission factor for grid connected power generation in year *y*;

According to Methodology, if the project activity is the installation of a new grid-connected renewable power plant/unit at a site where no renewable power plant was operated prior to the implementation of the project activity, then:

$$EG_{PJ,y}=EG_{facility,y}$$ (Equation B.6)

Calculate the Combined margin CO_2 emission factor

The emission coefficient (measured in tCO_2e/MWh) should be calculated in a transparent and conservative manner according to the procedures prescribed in the "*Tool to calculate the emission factor for an electricity system*" (Version 05.0).

The data used for calculation are from an official source (where available) and publicly available. The calculation processes are as follows:

STEP 1: Identify the relevant electricity system.

STEP 2: Choose whether to include off-grid power plants in the project electricity system.

STEP 3: Select a method to determine the operating margin (OM).

STEP 4: Calculate the operating margin emission factor according to the selected method.

STEP 5: Calculate the build margin (BM) emission factor;

STEP 6: Calculate the combined margin (CM) emissions factor.

STEP 1: Identify the relevant electricity system

The DNA of Lao has published a delineation[14] of the project electricity system and connected electricity systems, therefore these delineations are applied. The Project will supply power to Lao Power Grid, which according to the delineation published by Lao DNA, is a part of the regional power grid consisted by Lao and Thailand power grid. Therefore, the relevant electricity system is the regional power grid including Lao Power Grid and Thailand Power Grid. And the **connected electricity system** is Malaysia, China and Vietnam Power Grid[15].

For the purpose of determining the operating margin emission factor, 0 tCO_2/MWh was applied as the emission factor(s) for net electricity imports from a connected electricity system.

STEP 2: Choose whether to include off-grid power plants in the project electricity system (optional)

According to "*Tool to calculate the emission factor for an electricity system*" (Version 05.0), there are two options to calculate the operating margin and build margin emission factor:
Option I: Only grid power plants are included in the calculation.
Option II: Both grid power plants and off-grid power plants are included in the calculation.

Option I is chosen for operating margin and build margin emission factor calculation.

STEP 3: Select a method to determine the operating margin (OM)

According to "*Tool to calculate the emission factor for an electricity system*" (Version 05.0), there are four methods for calculating the $EF_{grid, OM, y}$:
(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch Data Analysis OM, or
(d) Average OM

The method (d) average OM is selected.

$EF_{grid,OM-ave,y}$ is calculated using ex ante option: a 3-year generation-weighted average in 2010, 2009, 2008, without requirement to monitor and recalculate the emissions factor during the crediting period.

STEP 4: Calculate the operating margin emission factor according to the selected method

The average OM emission factor is calculated as the average emission rate of all power plants serving the grid, using the methodological guidance as described under Step 4 in the "Tool to calculate the emission factor for an electricity system" for the simple OM, but also including the low-cost / must-run power plants in all equations.

According to *Tool to calculate the emission factor for an electricity system*, there are two options based on different data for calculating average OM:
Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit; or
Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

14 See Calculation for the emission factor for electricity generation in Lao PDR, 2010, Lao DNA

15 According to Electrical Power in Thailand 2008, 2009, 2010, Thailand DEDE, the Thailand import power from Lao PDR and Malaysia. Lao is considered as part of the project electricity system, and Malaysia is considered as the connected electricity system. Vietnam and China are also considered as connected electricity system for the power supply to Lao according to the Annual Repot 2012 by the Lao Power Grid Electric du Lao (EDL).

The necessary data for Option A is not available, so Option B can be used.

Under this option, the average OM emission factor is calculated based on the net electricity supplied to the grid by all power plants serving the system, including low-cost/must-run power plants/units, and based on the fuel type(s) and total fuel consumption of the project electricity system, as follows:

$$EF_{grid,OM-ave,y} = \frac{\sum_i (FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y})}{EG_y}$$ (Equation B.7)

Where:

$EF_{grid,OM-ave,y}$	Average operating margin CO_2 emission factor in year *y* (tCO_2/MWh);
$FC_{i,y}$	Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit);
$NCV_{i,y}$	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit);
$EF_{CO2,i,y}$	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ);
EG_y	Net electricity generated and delivered to the grid by all power sources serving the system, including low-cost/must-run power plants/units, in year *y* (MWh);
i	All fossil fuel types combusted in power sources in project electricity system in year *y*;
y	The data available in the most recent 3 years;

According to the *Tool to calculate the emission factor for an electricity system*, electricity imports from the connected electricity systems $EG_{import,y}$ are included in the EG_y.

The detailed calculating procedures please refer to Appendix 4 of the PDD.

Step 5. Calculate the build margin (BM) emission factor

To calculate the build margin (BM) emission factor, the data for determine the sample group of power units *m* about the most recently units in the electricity system is needed. However, as an international project system, it's difficult to obtain the information for all the units in both Lao and Thailand (power generation data, commissioning date, and the fuel consumption). The data requirements for the application for calculate the build margin (BM) emission factor cannot be met.

As the Simplified CM is adopted in the step 6, the weighting of build margin emissions factor is 0.

STEP 6: Calculate the combined margin (CM) emissions factor

The calculation of the combined margin (CM) emission factor ($EF_{grid,CM,y}$) is based on one of the following methods:

(a) Weighted average CM; or
(b) Simplified CM.

According to *Tool to calculate the emission factor for an electricity system*, the simplified CM can be used if:

(a) The project activity is located in: (i) a Least Developed Country (LDC); or in (ii) a country with less than 10 registered CDM projects at the starting date of validation; or (iii) a Small Island Developing States (SIDS); and
(b) The data requirements for the application of Step 5 above cannot be met.

Lao is a Least Developed Country, therefore the criteria (a) is met; and also as mentioned in step 5, the data requirements for the application for calculate the build margin (BM) emission factor is not available, therefore the criteria (b) is also met.

The Simplified CM method is calculated as follow:

$$EF_{grid,CM,y} = w_{OM} \times EF_{grid,OM,y} + w_{BM} \times EF_{grid,BM,y}$$ (Equation B.8)

Where:

$EF_{grid,CM,y}$	Combined margin CO_2 emission factor in year *y* (tCO_2/MWh);
$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year *y* (tCO_2/MWh);
$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year *y* (tCO_2/MWh);
w_{OM}	Weighting of operating margin emission factor (%);
w_{BM}	Weighting of build margin emission factor (%).

Where, w_{BM}= 0, w_{OM}= 1.

Thus $EF_{CO2, grid, y}$ =$EF_{grid, CM, y}$ =0.5595 tCO_2/MWh.

Calculate the project leakage

No leakage emissions are considered.

Calculate the emission reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y$$ (Equation B.9)

Where:

ER_y	Emission reduction in year *y* (t CO_2e/y);
BE_y	Baseline emission in year *y* (t CO_2e/y);
PE_y	Project emission in year *y* (t CO_2e/y).

B.6.2. Data and parameters fixed ex ante

Data / Parameter	$FC_{i,y}$
Unit	mass or volume unit of the fuel *i*
Description	Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit)
Source of data	*Calculation for the emission factor for electricity generation in Lao PDR, 2010*
Value(s) applied	Refer to Appendix 4 for details.
Choice of data or Measurement methods and procedures	Data used are from Thailand DNA.
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	$NCV_{i,y}$
Unit	kJ/kg or kJ/m^3
Description	The net calorific value (energy content) per mass or volume unit of fuel *i* in year *y.*
Source of data	*Electric Power in Thailand 2010*
Value(s) applied	Refer to Appendix 4 for details.

Choice of data or Measurement methods and procedures	Data used are from Thailand authorities, DEDE.
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	$EF_{CO2,i,y}$
Unit	tCO_2/TJ
Description	The CO_2 emission factor per unit of fuel i in year y
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Chapter 1 Table 1.4
Value(s) applied	Refer to Appendix 4 for details.
Choice of data or Measurement methods and procedures	No specific local value available, the value form IPCC 2006, Guidelines for National Greenhouse Gas Inventories was adopted.
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	EG_y
Unit	GWh
Description	Net electricity generated and delivered to the grid by all power sources serving the system, including low-cost/must-run power plants/units, in year y.
Source of data	Calculation for the emission factor for electricity generation in Lao PDR, 2010
Value(s) applied	See Annex 3 for details.
Choice of data or Measurement methods and procedures	Data used are from Thailand DNA, TGO.
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	$EG_{import,y}$
Unit	MWh
Description	The electricity(MWh) imported from Malaysia, China and Vietnam Power Grid in year y.
Source of data	Electricity report by EGAT (2010, 2009, 2008) EDL Annual Report 2012
Value(s) applied	Refer to Appendix 4 for details.
Choice of data or Measurement methods and procedures	Data used are from Thailand authorities, EGAT.
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	A_{BL}
Unit	m^2
Description	Area of the reservoir measured in the surface of the water, before the implementation of the project activity, when the reservoir is full

Source of data	Project site
Value(s) applied	0
Choice of data or Measurement methods and procedures	For new reservoirs, this value is zero.
Purpose of data	Project Emission Calculation
Additional comment	-

Data / Parameter	CAP_{BL}
Unit	MW
Description	Installed capacity of the hydro power plant before the implementation of the project activity.
Source of data	Project site
Value(s) applied	0
Choice of data or Measurement methods and procedures	For new hydro power plants, this value is zero
Purpose of data	Project Emission Calculation
Additional comment	-

B.6.3. Ex ante calculation of emission reductions

>>

Project emission

PE_y**=0**

Baseline emission

According to section B.6.1, in first crediting period, the baseline emission factor of the project:

$EF_{grid,CM,y} = w_{OM} \times EF_{grid,OM,y} + w_{BM} \times EF_{grid,BM,y}$ =0.5595 tCO_2e/MWh.

The baseline emission of the project:

$BE_y = EG_{PJ,y} \times EF_{grid,CM,y}$ = 224,800×0.5595= 125,775 tCO_2e

Project leakage

No leakage emissions are considered.

Emission reductions

$ER_y = BE_y - PE_y$ =125,775 - 0=125,775CO_2e

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
01/10/2017-31/12/2017	31,702[16]	0	0	31,702
01/01/2018-31/12/2018	125,775	0	0	125,775
01/01/2019-31/12/2019	125,775	0	0	125,775
01/01/2020-31/12/2020	125,775	0	0	125,775
01/01/2021-31/12/2021	125,775	0	0	125,775
01/01/2022-31/12/2022	125,775	0	0	125,775
01/01/2023-31/12/2022	125,775	0	0	125,775
01/01/2024-30/09/2024	94,073	0	0	94,073
Total	880,425	0	0	880,425
Total number of crediting years	7			
Annual average over the crediting period	125,775	0	0	125,775

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data / Parameter	$EG_{facility,y}$
Unit	MWh
Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y
Source of data	Calculated value
Value(s) applied	$EG_{facility,y} = EG_{output,y} - EG_{input,y}$
Measurement methods and procedures	-
Monitoring frequency	-
QA/QC procedures	-
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	$EG_{output,y}$
Unit	MWh
Description	Electricity supplied by the project to the grid in year y
Source of data	Measured by meters
Value(s) applied	224,800
Measurement methods and procedures	Continuous measurement and monthly recording

[16] The period of first year covers 01/10/2017~31/12/2017, thus the baseline emission (prorated on the basis of the actual number of days(92 days, from 01/10/2017~31/12/2017) is 125,775×92/365 = 31,702 tCO_2e.

Monitoring frequency	Continuously
QA/QC procedures	According to the recommendation by the manufacturer or the regulations of the grid company, meters will be calibrated periodically. Data measured by meters will be cross-checked with the record document confirmed by EDL
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	$EG_{input,y}$
Unit	MWh
Description	The electricity used by the project and input from the grid in year y
Source of data	Measured by meters
Value(s) applied	0 MWh for ex-ante calculation
Measurement methods and procedures	Continuous measurement and monthly recording
Monitoring frequency	Continuously
QA/QC procedures	According to the recommendation by the manufacturer or the regulations by the grid company, meters will be calibrated periodically. Data measured by meters will be cross-checked with the record document confirmed by EDL.
Purpose of data	Baseline Emission Calculation
Additional comment	-

Data / Parameter	CAP_{PJ}
Unit	W
Description	Installed capacity of hydropower plant after the implementation of the project activity
Source of data	Project site
Value(s) applied	63,990,000
Measurement methods and procedures	Checking nameplate of the installed capacity at the beginning of each crediting period
Monitoring frequency	Once at the beginning of each crediting period
QA/QC procedures	--
Purpose of data	Project Emission Calculation
Additional comment	-

Data / Parameter	A_{PJ}
Unit	m^2
Description	Area of the reservoir measured in the surface of water, after the implementation of the project activity, when the reservoir is full.
Source of data	Project site
Value(s) applied	320,000
Measurement methods and procedures	The water level of the reservoir will be daily recorded in the operation period. The highest one of reservoir level records of a calendar year will be used to determine the water surface area of the reservoir of that year by the project owner. Base on the elevation chart of the reservoir, water level records correspond to specific area of the reservoir. With computer-aid design program, the area determined by the record can be calculated, thus the data A_{PJ} is achieved.

Monitoring frequency	Once at the beginning of each crediting period
QA/QC procedures	-
Purpose of data	Project Emission Calculation
Additional comment	-

B.7.2. Sampling plan

>>
The data and parameters monitored in section B.7.1 above are not determined by a sampling approach.

B.7.3. Other elements of monitoring plan

>>
The purpose of the monitoring plan is to ensure that the monitoring and calculation of emission reductions of the project within the crediting period is complete, consistent, clear and accurate. The plan will be implemented by the project owner with the support of the grid corporation.

1. Monitoring organization

The monitoring process will be carried out and responsibility by the project owner. A monitoring panel will be established by the plant managers to be in charge of monitoring the data and information relating to the calculation of emission reductions with the cooperation of the Technical and Financial Department. A CDM manager will be assigned full charge the monitoring works. The operation and management structure is shown below:

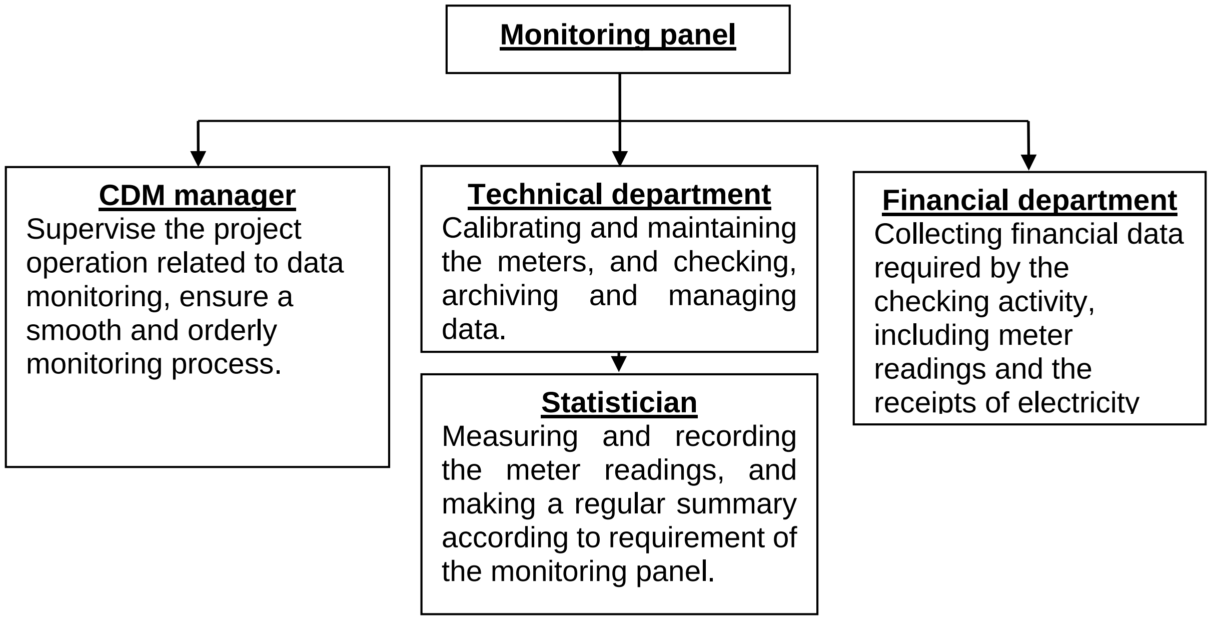
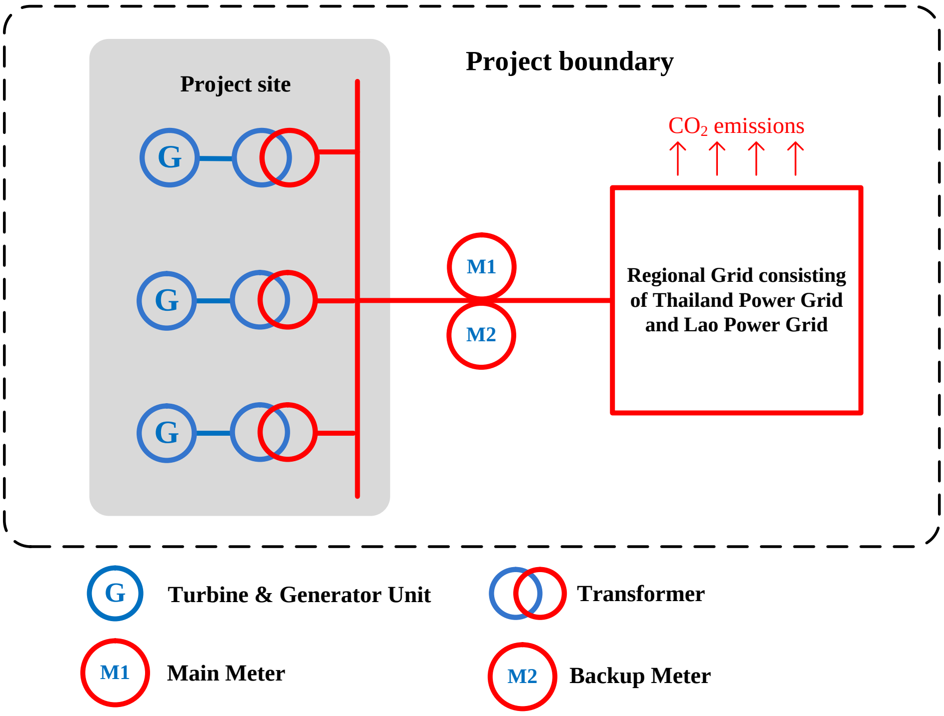


Figure B.4. Organization structure of the monitoring activity

2. Monitoring apparatus and installation

The power generated by the three 21.33MW generators will be supplied to Ban Thabok Substation through 115kV transmission line and then distributed in Lao Power Grid which is connected with Thailand Power Grid. The power supplied to and input from Lao Power Grid were measured by 2 sets of meters (M1, M2) installed on 115kV line. M1 is main meter while M2 served as backup meter. The accuracy of the meters is no less than 0.5S. The monitoring diagram is as following:



The meters will be installed in accordance with relevant national or international standard. Before the operation of the project, the metering equipments will be clarified and examined by the project owner and the power grid company according to the above regulation.

3. Data collection

The specific steps for data collection and reporting are listed below:

a) During the crediting period, both the grid company and the project owner will record the values displayed by the main meter.
b) Simultaneously to step a), the project owner will both record the values displayed by the backup meters.
c) The meters will be calibrated according to the relevant regulation and request of EDL.
d) The main meter's readings will be cross-checked with record document confirmed by EDL.
e) The project owner and the grid company will record both output and input power readings from the main meter. These data will be used to calculate the amount of net electricity delivered to the grid.
f) The project owner will be responsible of providing copies of record document confirmed by EDL to the DOE for verification.

If the reading of the main meter in a certain month is inaccurate and beyond the allowable error or the meter doesn't work normally, the grid-connected power generation shall be determined by following measures:

a) Read the data of the backup meters.
b) If the backup meter's data is not so accurate as to be accepted, or the practice is not standardized, the project owner and the grid corporation should jointly make a reasonable and conservative estimation method which can be supported by sufficient evidence and proved to be reasonable and conservative when verified by DOE.
c) If the project owner and the grid corporation don't agree on an estimated method, arbitration will be conducted according the procedures set by the agreement to work out an estimation method.

4. Calibration

Calibration of Meters & Metering should be implemented according to relevant standards and rules accepted by the grid company EDL. After the examination, the meters should be sealed. The lift of the seals requires the presence of both the project owner and the grid company. One party must not lift the seals or fiddle with the meters without the presence of the other party.

All the meters installed shall be tested by a qualified metering verification institution commissioned jointly by the project owner and the grid company within 10 days after:

1) Detection of a difference larger than the allowable error in the readings of both meters;
2) The repair of all or part of meter caused by the failure of one or more parts to operated in accordance with the specifications.

5. Data management system

Physical document such as the plant electrical wiring diagram will be gathered with this monitoring plan in a single place. In order to facilitate auditors' access to project documents, the project materials and monitoring results will be indexed. All paper-based information will be stored by the technical department of the project owner and all the material will have a copy for backup. All data, including calibration records, will be kept until 2 years after the end of the total crediting period.

6. Monitoring Report

During the crediting period, at the end of each year, the monitoring officer shall produce a monitoring report covering the past monitoring period. The report shall be transmitted to the General Manager who will check the data and issue a final monitoring report in the name of the projects participants. Once the final report is issued, it will be submitted to the DOE for verification.

B.8. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

>>
Date of completion of application of methodology and standardized baseline:
10/08/2017

Responsible persons/ entities:
Mr. Lu Yaodong
Yaodong.lu@karbon.com.cn
Beijing Karbon Energy Consulting Co., Ltd.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

>>
15/10/2013;

C.1.2. Expected operational lifetime of project activity

>>
40 years

C.2. Crediting period of project activity

C.2.1. Type of crediting period

>>

Renewable crediting period

C.2.2. Start date of crediting period

>>
01/10/2017 or registration date, which is later

C.2.3. Length of crediting period

7 years

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>
The Environmental Impact Assessment Report for Nam Mang 1 Hydropower Project was compiled by the Hydrochina Kunming Engineering Corporation which is qualified for EIA consultancy services and is independent from the project owner. According to this EIA report, environmental impacts caused by the project and the corresponding measures adopted by the project owner for mitigation are as following:

Water Quality

Production wastewater mainly derives from the excavation and pouring of the dam, sand and stone processing system and concrete mixing system. Modern construction technology is generally provided with wastewater treat system and the wastewater is discharged after being treated through sedimentation and reaching up to the discharge standard, which has fewer impacts on rivers. In the early impoundment stage of the reservoir, algae on the surface of the reservoir may multiply enormously, for the residual organisms at the bottom will degrade and such inorganic substances as nitrogen, phosphor and kalium in the soil will enters the water, resulting in a higher concentration of nutrient elements in the water.

Atmospheric /air impact Assessment and noise

During the construction of the power station, a lot of dust and fly ashes and some noises will be produced by the excavation and blasting of earth and stone, the operation of construction machinery and transport vehicles will produce harmful gases such as SO2 and NO2. The construction area is located in the remote mountain canon, far away from residential areas, thus the air pollution and noise pollution will have little influence on surrounding areas but have certain influence on construction personnel.

Terrestrial ecological impact

The reservoir inundation and the land occupation of the construction will have impacts on regional forests and vegetation. The plants distributed below the submerged line of the reservoir will disappear. At the same time, the hydro project construction, road construction and construction activities, etc will also damage regional vegetation, which will decrease vegetation area and quantities of plant resources in construction area. But these activities don't lead to the disappearing of biological diversity and the great impact on regional biological diversity. The construction of the Project will have no great impact on terrestrial animal in this area. Influenced by the construction of the Project, the animal habitat in this area will be reduced by reservoir inundation and land occupation of the construction, yet adult animals generally have strong activity ability and large activity territory and they will migrant toward the areas around the reservoir and outside construction area, during the construction and the reservoir impounding.

Soil erosion

Some construction activities during the construction of the power station will destroy forests and vegetation in the construction area, disturb the surface soil and cause water loss and soil erosion. If measures against soil erosion are not taken, such problems may be caused as nutrient loss of soil, the decreasing of soil productivity and the lowering of water quality of rivers.

Impacts on fish

After the completion of the power station, the original continuous river ecosystem will be divided into discontinuous environmental units, leading to the fragmentation of ecological landscape; heterogeneous species will form and their genes cannot exchange due to the fragmentation of fish habitat, which will reduce the genetic diversity of each species and impact, to a certain extent, the fish idioplasmic at both upstream and downstream of the dam. After the reservoir is built, compared with the natural conditions, water area, depth and water body will increase while oxygen dissolved by the water at the dam bottom will decrease, which is quite unfavorable for the native fishes requiring a highly-concentrated dissolved oxygen environment; the slowdown of the flow speed, sedimentation of silt and increasing transparency of the water will decrease the species preferring rapid current environment and increase the species preferring slow current environment.

In conclusion, environmental impacts arising from the Project are considered insignificant.

D.2. Environmental impact assessment

>>

Both the Host Party and the project participant regard that the proposed project will not bring significant negative impact to the environment. The project could be put into commencement only after the approval of the EIA by local Environmental Protection Administration.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

>>

According to the Social Impact Assessment compiled, the stakeholders of the project comprise four main groups:

- People residing in the study area who may be affected directly and indirectly by the project
- Government officials at the district, government and national level
- The broader interested community
- NGOs operating in the Lao PDR
- International NGOs, international organizations and other interest groups, including the local, regional and national media.

Widely public consultations were carried out to reduce negative impacts, enhance positive community effects and make sure all the stakeholders involve in the decision-making and implement of the project. Series of Public Consultation workshop and information discloses. There have been officially consultation meeting at provincial level, district level as well as villages level during the field survey and Dialogue has been established with interested groups and stakeholders who are directly or indirectly involved in the Nan Mang 1 Hydropower Project and who have expressed a wish to participate in the project’s public consultation program.

After the above mentioned activities, a CDM stakeholder meeting was held by the project owner, made a further investigation, make sure the local and indigenous communities participated in the decision-making process.

To ensure that locals were consulted in an open and transparent way, a survey was conducted via questionnaire distributed and collected by the project owner. The stakeholder meeting was hold on 1st September 2010, 50 questionnaires were distributed and 50 questionnaires were returned.

The profile of the participants of survey is as follows:

Table E.1. Basic information of the survey participants

Item	Category	Number	Percentage
Age	Below 30	11	22%
	30~40	14	28%
	40~50	18	36%
	Above 50	7	14%
Gender	Male	26	52%
	Female	24	48%
Education	Elementary school	19	38%
	Junior high school	18	36%
	Senior high school	9	18%
	College and above	4	8%

The contents and results of this questionnaire survey were as follows:

1) Do you agree with the construction of the project;
2) What is the influence on local economic development for the project implement;
3) What is the influence on local residents' livelihood for the project implement;
4) Will the project improve the local employment;
5) What are the influences on the local environment you concern about;
6) In general, what's your opinion on the project environment effects.

E.2. Summary of comments received

>>

The summary of the questionnaires are as follows:

1) 82% of the respondents agree with the construction of the project, 18% of them don't care with the project, and 0% of the respondents disagree with the construction of the project.
2) There are 74% of the respondents consider the implement of the project have positive influence on local economic development, and 26% of the respondents consider the implement of the project have no influence on local economic development, and 0% of the respondents consider the implement of the project have negative influence on local economic development.
3) There are 62% of the respondents consider the implement of the project can improve the live quality of local residents, 38% of the respondents consider the implement of the project have no influence on local residents' livelihood, and 0% of the respondents consider the implement of the project will reduce local residents' livelihood.
4) There are 78% of the respondents consider the implement of the project could improve local employment, 0% of the respondents consider the implement of the project will reduce local employment opportunities, 22% of the respondents consider the implement of the project have no influence on local employment.

5) When asked about the impacts on the local environment, 32% of the respondents worry about the dust produced during the project construction, 22% of the respondents worry about the effect of noise, 10% of the respondents worry about the soil and water conservation problem, 26% of the respondents worry about the effect of solid wastes, and 10% of the respondents worry about the effect to the ecological environment;
6) 14% of the respondents consider the construction of the project will improve local environment condition, 18% of the respondents consider the construction of the project have no influence to local environment, 68% of the respondents consider the construction of the project may bring some problems, but the problems can be mitigated or controlled after environmental protection measures adopted, 0% of the respondents consider the construction of the project will reduce local environment condition.

E.3. Report on consideration of comments received

>>
From the questionnaires, it can be known that all stakeholders are in favor of the project activity. Local residents deem that the project activity will bring impact on environment, but in a slight way. Points on the impacts the stakeholders concern (Water, noise, atmospheric /air, soil and terrestrial ecological environment), the project owner will adopt relevant measures listed in Section D.1. No additional account is required to be taken of the comments received.

SECTION F. Approval and authorization

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The Letter of approval from the DNA of Lao PDR has been issued on 24th July, 2017.

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Appendix 1. Contact information of project participants and responsible persons/ entities

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Nam Mang 1 Power Co., Ltd.
Street/P.O. Box	No. 3224
Building	House No. 0789, Unit 18, Small Road No.13
City	Thaphalanxay Village, Sisattanak District
State/Region	Vientiane Capital
Postcode	01000
Country	LAO PDR
Telephone	+8562023274648
Fax	
E-mail	
Website	
Contact person	Ji Chengmeng
Title	Manager
Salutation	Mr.
Last name	Ji
Middle name	
First name	Chengmeng
Department	
Mobile	+8562023274648
Direct fax	
Direct tel.	
Personal e-mail	

Appendix 2. Affirmation regarding public funding

No public funding from parties included in UNFCCC Annex I is available to the project activity.

Appendix 3. Applicability of methodology and standardized baseline

Please refer to the Section B.1 of the PDD.

Appendix 4. Further background information on ex ante calculation of emission reductions

Table 1 Net electricity generated and delivered to the grid by all power sources serving the system (GWh)

Year	2010	2009	2008
Power generation by EdL owned power plants	1,552.73	1,655.91	1,777.57
Power generation by IPP located in Laos	7,329.69	2,135.32	1,938.01
Power generation in Thailand	152,913.56	142,697.75	142,330.52
Sum up	**161,795.98**	**146,488.98**	**146,046.10**

Sources from:
EDL Annual Report 2012, 2010, 2009, Electricite Du Laos;
Electric Power in Thailand 2010, 2009, 2008, Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand;
Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand.

Table 2 Power import from the connected system (GWh)

Year	2010	2009	2008
Malaysia	160.31	92.68	470.67
Vietnam	31.81	25.39	22.59
China	77.02	21.58	17.78
Sum up	**269.14**	**139.65**	**511.04**

Sources from:
Electricity Statistic Annual Report 2010, 2009, 2008, Electricity Generating Authority of Thailand.
EDL Annual Report 2012, Electricite Du Laos. .

Table 3 Quantity of GHG emission by all power sources serving the system

Fuel Type	Fuel Consumption		Fuel Specific EF	Net Calorific Value	GHG emission
	$FC_{i,y}$		$EF_{CO2,m,i,y}$	$NCV_{i,y}$	$FC_{i,y}$ x $EF_{CO2,m,i,y}$ x $NCV_{i,y}$/1000000
	Unit	FC/Unit	tCO_2/TJ	MJ/Unit	tCO_2
2010					
Natural Gas	scf.	1,073,084,673,019	54.3	1.02	59,433,868
Lignite	ton	16,043,174	90.9	10470	15,268,658
Bituminous	ton	5,502,160	89.5	26370	12,985,730
Bunker	liter	233,229,746	75.5	39.77	700,304
Diesel	liter	24,026,558	72.6	36.42	63,528
2009					
Natural Gas	scf.	968,924,717,809	54.3	1.02	53,664,864
Lignite	ton	15,818,265	90.9	10470	15,054,607
Bituminous	ton	5,486,248	89.5	26370	12,948,176
Bunker	liter	158,017,445	75.5	39.77	474,469
Diesel	liter	13,825,937	72.6	36.42	36,557
2008					

Fuel Type	Fuel Consumption		Fuel Specific EF	Net Calorific Value	GHG emission
	$FC_{i,y}$		$EF_{CO2,m,i,y}$	$NCV_{i,y}$	$FC_{i,y}$ x $EF_{CO2,m,i,y}$ x $NCV_{i,y}$/1000000
	Unit	FC/Unit	tCO_2/TJ	MJ/Unit	tCO_2
Natural Gas	scf.	977,016,893,281	54.3	1.02	54,113,058
Lignite	ton	16,407,465	90.9	10470	15,615,362
Bituminous	ton	5,578,567	89.5	26370	13,166,060
Bunker	liter	350,209,394	75.5	39.77	1,051,551
Diesel	liter	51,941,958	72.6	36.42	137,339

Sources from:

- Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand.
- IPCC 2006, Guidelines for National Greenhouse Gas Inventories, Volume 2 Chapter 1 Table 1.4.
- Electric Power in Thailand 2010, Energy Content of Fuel, Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand.

$$EF_{grid,CM,y} = w_{OM} \times EF_{grid,OM,y} + w_{BM} \times EF_{grid,BM,y}$$
$$= 1 \times 0.5595 = 0.5595 \ tCO_2e/MWh.$$

Based on the equation and above data, the $EF_{grid,OM\text{-}ave,y}$ =0.5595 tCO_2/MWh

Appendix 5. Further background information on monitoring plan

Please refer to the Section B.7 of the PDD.

Appendix 6. Summary of post registration changes

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