Project design document form

(Version 10.1)

Complete this form in accordance with the instructions attached at the end of this form.

BASIC INFORMATION	
Title of the project activity	5MW Thap Sakae Photovoltaic Solar Cell Power Plant Project, Thailand
Scale of the project activity	☐ Large-scale ☒ Small-scale
Version number of the PDD	08
Completion date of the PDD	28/11/2017
Project participants	Electricity Generating Authority of Thailand
Host Party	Thailand
Applied methodologies and standardized baselines	AMS-I.D – "Grid connected renewable electricity generation" (Version 18, Sectoral scope 01, EB 81)
Sectoral scopes linked to the applied methodologies	Sectoral scope 01: Energy industries (renewable sources / non-renewable resources)
Estimated amount of annual average GHG emission reductions	3,618 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>> "5MW Thap Sakae Photovoltaic Solar Cell Power Plant Project, Thailand" (hereafter called the "project") is developed by Electricity Generating Authority of Thailand (hereafter called the "EGAT"). The project activity is a construction and operation of a new solar photovoltaic (PV) power plant at Prachuap Khiri Khan Province in Thailand. The total capacity of the power plant is 5 $MW_{(AC)}$. The electricity from the project activity is expected to supply 7,560 MWh per annum[1] to the nation grid. The scenario existing prior to the project activity implementation is only an abandon coconut plantation area where is no any other power plants existed (this is a Greenfield project)

The purpose of this project is to generate clean electricity by utilizing solar energy and to reduce the green house gas (GHG) emissions by displacing equivalent amount of electricity from carbon intensive the national grid. The project activity involves generation of electricity by utilizing the available solar energy and exporting it to the Thai National Grid. By displacing the fossil fuel based grid electricity, the project activity contributes to the GHG emission reduction and is expected to reduce an average of 3,618 tCO_2e per year or total GHG emission reduction for entire 10-year crediting period is 36,180 tCO_2e.

The baseline scenario is that the electricity delivered to the grid by the project activity would have otherwise been generated by the operation of other grid-connected power plants included fossil based power plants.

The purpose of the project activity

The purpose of the proposed project activity is to abate the GHG emissions by generating clean electricity through solar PV technology. The project supports the Thailand Government policy of promoting the development of renewable energy technology. It also contributes to the decreased dependence on fossil fuel based thermal power plants.

Contribution to sustainable development in Thailand

In Thailand, sustainable development requires the effective integration of four key elements[2] namely, the environmental, social, technological and economical indicators. By providing positive impacts on these four dimensions, the project activity will facilitate multi-dimensional sustainable development benefits to the local communities as well as to the nation. The details are furnished below:

Environmental Indicator

- The project does not contribute to the GHG emissions such as CO_2, NO_x, SO_x, etc. and harmful pollutants and suspended airborne particulate matter associated with fossil fuel based power plants
- The project activity does not involve any equipment with moving component and hence it is free of noise pollution.
- The project activity does not involve any waste generation and hence there will be no discarded waste and related waste management, as in biomass or biogas projects.
- The project activity does not contaminate the soil and water.
- The project activity contributes towards conserving fossil fuels

Social Indicator

[1] The average electricity generation for 25 years

[2] Refer to support document "sustainable development criteria.pdf"

- The project activity supports the policy of the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy (MOE) of Thailand in increasing the electricity generation using renewable energy.
- The project activity diversifies the power sources and makes use of the clean energy.
- The project activity improves the public infrastructure in Thailand by adding electricity to the grid.

Technology Indicator

- The project activity entails the import of equipments from other countries, thus paving way for transfer of technology.
- The project activity leads to capacity building for the local personnel.

Economical Indicator

- The project activity increases the utilisation of renewable energy in Thailand.
- The project activity reduces the import of expensive fossil fuel, thereby facilitating foreign exchange savings for the country with positive effect on Thailand's balance of payment.

The project activity also provides employment opportunities in operation and maintenance of the power plant.

A.2. Location of project activity

>> The project site is situated in Thap Sakae District, Prachuap Khiri Khan Province in Thailand. The total site area available for this project is approximately 250 rai. The co-ordinates of each corner of the project site are (11°28'31.52"N Latitude, 99°35'41.62"E Longitude), (11°28'21.90"N Latitude, 99°35'39.33"E Longitude), (11°28'10.62"N Latitude, 99°36'0.87"E Longitude) and (11°28'29.92"N Latitude, 99°36'1.69"E Longitude). The central point of the project activity is located at 11°28'21.60"N Latitude 99°35'52.54"E Longitude.

Figure 1: Map of Thap Sakae district in Prachuap Khiri Khan province, Thailand

Figure 2: Aerial photograph of the project location in Thap Sakae district, Prachuap Khiri Khan Province.

A.3. Technologies/measures

>> Technology of the project activity

The project activity applies Solar Photovoltaic (PV) technology imported from oversea and thus is a case of technology transfer to Thailand. The proposed technology is sound and environmentally safe because it does not produce any GHGs during its operation.

Solar photovoltaic systems convert sunlight into electricity. Solar photovoltaic cells employ special materials called semiconductors that produce electricity when exposed to sunlight. Like most of the semiconductor devices, solar photovoltaic cells include also a positive layer (at the bottom) and a negative layer (on the top) that create an electrical field inside the cell. When a photon of light strikes a semiconductor, it releases electrons. The free electrons flow through the solar cell's bottom layer to a connecting wire as direct current (DC).

In addition to modules, several components such as inverters, transformers, etc. are needed to complete a solar photovoltaic power plant. These power plants incorporate inverters or power control units to transform the DC produced by the solar photovoltaic cells into alternating current (AC). Only then, the electricity can be sold to the national grid. Complete systems usually include safety disconnects, fuses and a grounding circuit as well.

The schematic diagram of the grid connected solar PV power plant is given in the following figure:

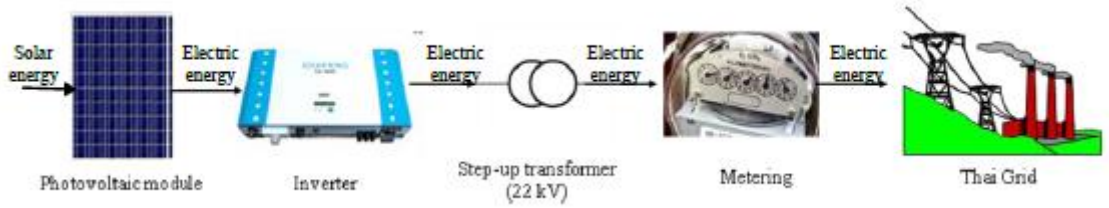

Figure 3: Schematic diagram of solar PV power plant

Photovoltaic module

A photovoltaic module or photovoltaic panel is a packaged, interconnected assembly of photovoltaic cells. Solar panels use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The structural (load carrying) member of a module can either be the top layer or the bottom layer. The conducting wires that take the current off the panels may contain silver, copper or other conductive (but generally non- magnetic) transition metals. The project applies 4 PV technologies as below;

Table 1: PV module specification

No.	Photovoltaic module type	Quantity ($MW_{(AC)}$)	Quantity (Cell)	Nominal peak (Wp)	Module Efficiency (%)	Applicable Standard
1	Crystalline Silicon: c-Si	1	5,016	250	15.3	IEC61646 IEC61730
2	Amorphous Silicon: a-Si	2	40,000	65	$\geq$ 8.22	IEC61646 IEC61730
3	Copper Indium (Gallium) Di-Selenide: Cl(G)S	1	10,880	115	$\geq$ 12.2	IEC61646 IEC61730 UL1703
4	Micro Crystalline Amorphous Silicon: µc/a-Si	1	9,792	130	12	IEC61646 IEC61730

Inverter

An inverter is an electrical device that converts direct current (DC) into alternating current (AC). The converted AC can be obtained at any required voltage and frequency by using appropriate transformers, switching and control circuits.

Table 2: Inverter specification

Inverter Capacity	Quantity	Efficiency (%)	Applicable Standard
630 kW Inverter	10	100% rate inverter load = 98.39%	EN50178 IEC62109-1 IEC62109-2

Step-up transformer

Step-up transformers are devices which increase the voltage of the incoming current. These are typically used before interconnecting with the grid.

Table 3: Transformer specification

No.	Transformer Capacity	Quantity	Output/Input	Efficiency (%)
1	1,250 KVA	5	22 KV/315 V	98.58

2	200 KVA	1	22 KV/400 V	98.56

Electricity grid

The monitoring equipment consists of 2 electricity meters which are an export meter and import meter. The export meter shall be installed after step-up transformer to monitor the amount of supplied electricity to the grid while the import meter shall be installed before a main breaker to monitor the amount of project electricity consumed from the grid.

The technical lifetime of the project activity is 25 years with 18 % of plant load factor.

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Thailand (host)	Electricity Generating Authority of Thailand (Public entity)	No

A.5. Public funding of project activity

>> The project involves no public funding from Parties that are Annex I signatories to the Kyoto Protocol

A.6. History of project activity

>> The project activity is to construct and operate a new solar photovoltaic power plant on the abandon coconut plantation where is no any other power plants existed. Therefore, this project is neither registered as a CDM project activity nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA). And the project activity is not a project activity that has been deregistered.

A.7. Debundling

>> In accordance with the para 2 of the guidelines on assessment of debundling for SSC project activities, Version 03.0, EB54 Annex 13, a proposed small-scale project activity shall be deemed to be a debundled component of a large project activity, if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

- with the same project participants;
- in the same project category and technology/measure;
- registered within the previous 2 years; and
- whose project boundary is within 1 km of the project boundary of the proposed small-scale activity at the closest point.

It is confirmed that neither the proposed project complies with any of the above listed statements, nor has the project participants any other ongoing or future activity related to this project in anyway and hence the project is not a de-bundled activity of a larger project.

SECTION B. Application of selected methodologies and standardized baselines

B.1. Reference to methodologies and standardized baselines

>> AMS-I.D – "Grid connected renewable electricity generation" (Version 18, Sectoral scope 01, EB 81)

- "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (Version 02.0)
- "Tool to calculate the emission factor for an electricity system" (Version 04.0)

B.2. Applicability of methodologies and standardized baselines

>> The following tables present the applicability criteria of the project activity to the methodology (AMS-I.D, Version 18) and the relation of the project case to the applicability criterion.

Table 5: Applicability criterion and justification

Applicability Criteria	Justification
1. This methodology comprises renewable energy generation units, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable biomass supplying electricity to a national or a regional grid.	According to EPC contract and General design plot plan, the project activity is an 5 $MW_{(AC)}$ solar PV based power generation project that generates and supply renewable electricity to the Thai national grid. The project activity contains renewable energy generation unit (solar photovoltaic power generation system) that supply electricity to Thai national grid.
2. Illustration of respective situations under which each of the methodology (i.e. "AMS-I.D.: Grid connected renewable electricity generation", "AMS-I.F.: Renewable electricity generation for captive use and mini-grid" and "AMS-I.A.: Electricity generation by the user) applies is included in the appendix.	According to Single line diagram, the project activity supplied electricity to a national/regional grid. Therefore, the project is under AMS-I.D, Version 18.
3. This methodology is applicable to project activities that (a) install a Greenfield plant; (b) Involve a capacity addition in (an) existing plant(s); (c) involve a retrofit of (an) existing plant(s); (d) Involve a rehabilitation of (an) existing plant(s)/unit(s); or (e) Involve a replacement of (an) existing plant(s).	According to EPC contract and General design plot plan, the project involves installation of new solar power plant at the site where there is no renewable energy power plant operating prior to the implementation of the project activity. Also, the project activity is a green field project activity. The project activity is not a capacity addition, retrofit and replacement activity.
4. Hydro power plants with reservoirs that satisfy at least one of the following conditions are eligible to apply this methodology: (a) The project activity is implemented in an existing reservoir with no change in the volume of reservoir; (b) The project activity is implemented in an existing reservoir, where the	EPC contract and General design plot plan, the project activity involves the installation of Solar PV power plant and does not involve any hydro power plants. Hence, this criterion is not applicable.

Applicability Criteria	Justification
volume of reservoir is increased and the power density of the project activity, as per definitions given in the project emissions section, is greater than 4 W/m^2; (c) The project activity results in new reservoirs and the power density of the power plant, as per definitions given in the project emissions section, is greater than 4 W/m^2.	
5. If the new unit has both renewable and non-renewable components (e.g., a wind/diesel unit), the eligibility limit of 15 MW for a small-scale CDM project activity applies only to the renewable component. If the new unit co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.	EPC contract and General design plot plan, project activity is only 5 $MW_{(AC)}$ solar PV based renewable electricity generation project. It does not include any non renewable unit and co-firing system.
6. Combined heat and power (co-generation) systems are not eligible under this category.	EPC contract and General design plot plan, the project activity does not involve combined heat and power generation.
7. In the case of project activities that involve the addition of renewable energy generation units at an existing renewable power generation facility, the added capacity of the units added by the project should be lower than 15 MW and should be physically distinct from the existing units.	EPC contract and General design plot plan, the project activity involves new installation of renewable energy generation units and does not involve extension of any existing facility Hence, this criterion is not applicable.
8. In the case of retrofit, rehabilitation or replacement, to qualify as a small-scale project, the total output of the retrofitted, rehabilitated or replacement power plant/unit shall not exceed the limit of 15 MW.	EPC contract and General design plot plan, the project activity involves new installation of renewable energy generation units and does not involve retrofit or replacement of existing facilities. Hence, this criterion is not applicable.
9. In the case of landfill gas, waste gas, wastewater treatment and agro-industries projects, recovered methane emissions are eligible under a relevant Type III category. If the recovered methane is used for electricity generation for supply to a grid then the baseline for the electricity component shall be in accordance with procedure prescribed under this methodology. If the recovered methane is used for heat generation or cogeneration other applicable Type-I methodologies such as "AMS-I.C.: Thermal energy production with or without electricity" shall	EPC contract and General design plot plan, the project activity involves new installation of Solar PV renewable energy generation units and does not involve to the landfill gas, waste gas, wastewater treatment and agro-industries projects, recovered methane emissions. Hence, this criterion is not applicable.

Applicability Criteria	Justification
be explored.	
10. In case biomass is sourced from dedicated plantations, the applicability criteria in the tool "Project emissions from cultivation of biomass" shall apply.	EPC contract and General design plot plan, the project activity involves new installation of Solar PV renewable energy generation units and does not involve to the biomass power generation. Hence, this criterion is not applicable.

The project activity which involves the installation of 5 $MW_{(AC)}$ Solar PV power plant would not have any change in the capacity of the project during its crediting period. Since the project generates and exports renewable electricity to the grid system and the capacity of the project activity is well below the qualifying limit of 15 MWp, the choice of project Type and category is justified.

B.3. Project boundary, sources and greenhouse gases (GHGs)

>> As per AMS-I.D, Version 18, the spatial extent of the project boundary includes the project power plant and all power plants connected physically to the electricity system that the project is connected to. Therefore, the project boundary encompasses the physical and geographical site of the PV solar system, its auxiliary and Thai national grid. Emission sources and gases included in the project boundary for the purpose of calculating emission reductions are as follows:

	Source	GHG	Included?	Justification/Explanation
Baseline	Thai national grid	CO_2	Included	According to AMS-I.D, Version18, only CO_2 emissions from net electricity supplied to the Thai national grid should be accounted for.
		CH_4	Excluded	According to AMS-I.D, Version18
		N_2O	Excluded	According to AMS-I.D, Version18
Project activity	Source 1	CO_2	Excluded	According to AMS-I.D, Version18
		CH_4	Excluded	According to AMS-I.D, Version18
		N_2O	Excluded	According to AMS-I.D, Version18

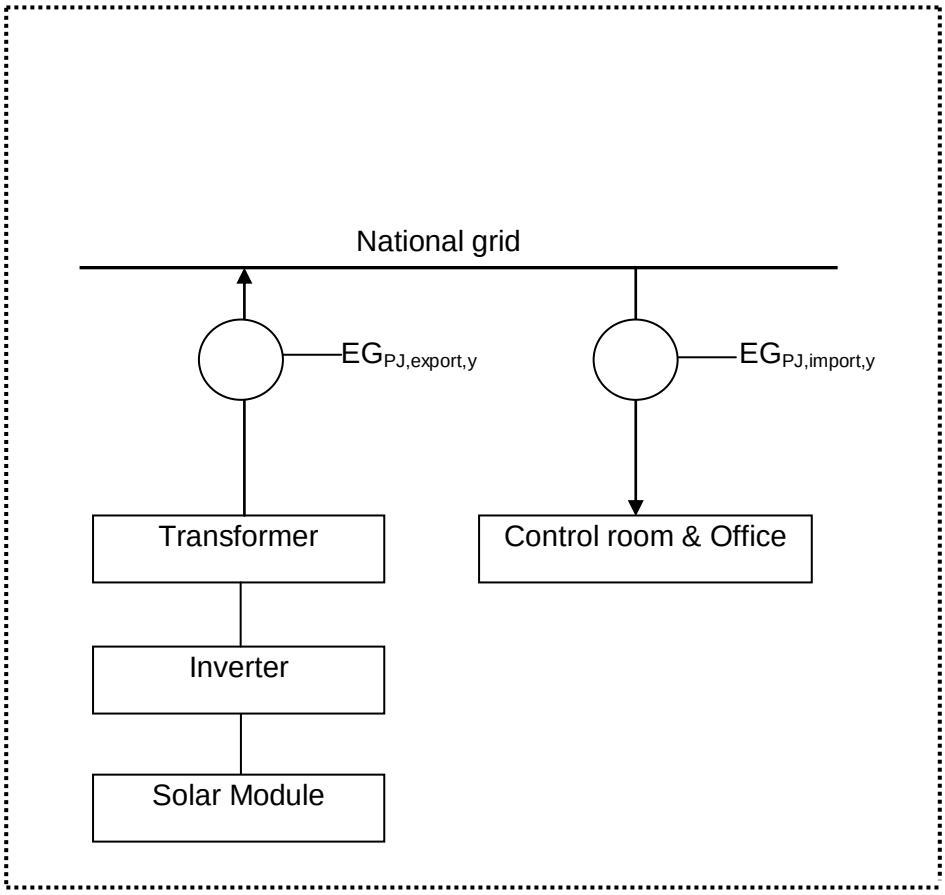

Figure 4: Project boundary

B.4. Establishment and description of baseline scenario

>> The project activity is the installation of a new grid connected renewable energy based power plant. According to paragraph 19 of AMS-I.D, Version 18, it prescribes the baseline scenario as "The baseline scenario is that the electricity delivered to the grid by the project activity would have otherwise been generated by the operation of other grid-connected power plants included fossil based power plants."

In accordance with the methodology, the baseline scenario for the project activity is the generation of net electricity by the power plants connected to Thai national grid. At present, the grid electricity in Thailand heavily depends upon conventional thermal power generation, using natural gas, petroleum, coal, etc. The generated electricity from the project activity is exported in order to displace some portion of the electricity generation in the national grid system.

There are national policies from Ministry of Industry since 2010 to increase power generation from renewable energy[3] by provided adder to the renewable power plant that feed electricity to the national grid. This policy can be considered as E- policy, however, this policy not be taken into account in establishing the baseline scenario.

According to the methodology AMS-I.D, Version 18, the baseline emissions are the product of electricity energy baseline expressed in MWh of electricity produced by the renewable generating unit multiplied by the emission factor.

[3] http://www.eppo.go.th/power/powerN/PICP/File/(20).pdf

The emission factor can be calculated in a transparent and conservative manner as follows:

(a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the 'Tool to calculate the Emission Factor for an electricity system'.

(b) The weighted average emissions (in tCO_{2e}/MWh) of the current generation mix. The data of the year in which project generation occurs must be used.

Option (a) has been considered to calculate the grid emission factor as per the "Tool to calculate the emission factor for an electricity system", Version 04.0.0, as data is available from an official source. In this project activity, Grid emission factor has been calculated and **fixed ex-ante.** The operating margin has been taken as a weighted average of the recent 3 year available data (2012 – 2014).

Table 7: Emission factor

Parameter	Value
Operating margin CO_2 emission factor	0.5383
Build margin CO_2 emission factor	0.2996
Combined margin CO_2 emission factor	0.4786

The detailed calculation of emission factor is given in Appendix 4.

B.5. Demonstration of additionality

>> **Prior consideration of CDM**

In accordance with the definition stated in CDM glossary, version 6, "The starting date of a CDM project activity is the earliest date at which either the implementation or construction or real action of a project activity begins". Therefore, the starting date of the project is defined as 08/05/2014, which is the signing date of the Engineering Procurement and Construction contract.

According to paragraph 4 of "Guidelines on the demonstration and assessment of prior consideration of the CDM", version 04, for project activities with a starting date on or after 2 August 2008, the project participant must inform the Host Party Designated National Authority (DNA) and the UNFCCC secretariat in writing of the commencement of the project activity and of their intention to seek CDM status within 6 months of the project activity start date.

Since the starting date of the project is defined as 08/05/2014, the project participant submitted the prior consideration form to Thai DNA on 25/04/2013, it complies with the requirement of Guidelines on the demonstration and assessment of prior consideration of the CDM, version 04, because both notifications were submitted before the starting date of the project. This clearly shows that the project participant has considered that the CDM benefits were considered necessary in the decision to undertake the project as a CDM project activity.

Relevant detailed timeline is summarized in the following table to prove that the CDM was seriously considered in decision-making of the project.

Table 8: Project chronological activity

Event	Project implementation activity	CDM application activity	Evidence
EGAT conducted the feasibility study	10/2011		The feasibility study
Board of EGAT approved to implement the project	24/02/2012		MoM for the project
UNFCCC notification		24/04/2013	Prior Consideration of the CDM
EGAT submitted a Letter of Intent (LoI) to Thai DNA		25/04/2013	Letter of Intent
EGAT conducted the public consultation	21/05/2013		Initial Environment Evaluation and Sustainable Development report
Thai cabinet approved the project		19/07/2013	Approval letter from Thai cabinet
EGAT signed the Engineering Procurement and Construction contract (EPC)	08/05/2014		EPC
EGAT submitted the project documents to Thai DNA for requesting Letter of Approval (LoA)		14/08/2014	Submission letter
DOE started onsite validation		11/03/2015	Validation plan
EGAT plan for started commercial export electricity to Thai national grid (COD)		03/06/2015	Progress report (09/2014)

Additionality

According to para 1 of Guidelines on the demonstration of additionality of small-scale project activities, version09, PP shall provide an explanation to show that the project activity would not have occurred anyway due to at least one of the following barriers:

(a) **Investment barrier**: a financially more viable alternative to the project activity would have led to higher emissions.
(b) **Technological barrier**: a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions.
(c) **Barrier due to prevailing practice**: prevailing practice or existing regulatory or policy requirements would have led to the implementation of a technology with higher emissions.
(d) **Other barriers**: without the project activity, for another specific reason identified by the project participant, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources or capacity to absorb new technologies, emissions would have been higher.

According to para 2 (a) of Guidelines on the demonstration of additionality of small-scale project activities, version 09, documentation of barriers, as per paragraph 1 above, is not required for the positive list of technologies and project activity types that are defined as automatically additional for project sizes up to and including the small-scale CDM thresholds (e.g. installed capacity up to 15 MW). The positive list comprises of the following grid-connected and off-grid renewable electricity generation technologies:

(i) Solar technologies (photovoltaic and solar thermal electricity generation);
(ii) Off-shore wind technologies;

(iii) Marine technologies (wave, tidal);
(iv) Building-integrated wind turbines or household rooftop wind turbines of a size up to 100 kW;

Since this project activity involves the implementation of 5 $MW_{(AC)}$ of grid-connected solar photovoltaic power plant, it is in line with requirement of the category (i) in para 2 (a) of Guidelines on the demonstration of additionality of small-scale project activities, version 09. Therefore this project activity is automatically defined as **additional** without further documentation of barriers.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

>> The emissions associated with fossil based electricity, which will be replaced by the current project activity, are calculated as per the following formula as given in AMS-I.D, Version 18.

Baseline emission:

According to para 22 AMS-I.D, Version 18. baseline emissions include only CO_2 emissions from electricity generation in 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:

$$BE_y = EG_{PJ,y} * EF_{grid,y}$$

Where,

BE_y	Baseline Emissions in year *y* (t CO_2)
$EG_{PJ,y}$	Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year *y* (MWh)
$EF_{grid,y}$	CO_2 emission factor of the grid in year y (t CO_2/MWh)

The project activity is the installation of green field Solar PV power plant, hence, according to para 26,

$EG_{PJ,y}$ (MWh) = $EG_{PJ,facility,y}$ (MWh)

Where,

$EG_{PJ,facility,y}$	Quantity of net electricity generation supplied by the project plant/unit to the grid in year *y* (MWh)
$EG_{PJ,export,y}$	The quantity of electricity supplied by the project plant/unit to the grid (MWh)
$EG_{PJ,import,y}$	The quantity of electricity delivered to the project plant/unit from the grid (MWh)

In ex-post calculation, the electricity imported from the grid ($EG_{PJ,import,y}$) will be monitored and applied for baseline emission calculation. However, for ex-ante calculation, the electricity imported from the grid ($EG_{PJ,import,y}$) is assumed to be zero.

The emission factor can be calculated in a transparent and conservative manner as follows:

(a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the "Tool to calculate the Emission Factor for an electricity system".

or

(b) The weighted average emissions (in tCO_{2e}/MWh) of the current generation mix. The data of the year in which project generation occurs must be used.

Option (a) has been considered to calculate the grid emission factor as per the "Tool to calculate the emission factor for an electricity system", Version 04.0, as data is available from an official source. In this project activity, Grid emission factor has been calculated and **fixed ex-ante.** The operating margin has been taken as a weighted average of the recent 3 year available data (2012 – 2014).

The steps used are as follows:
STEP 1. Identify the relevant electricity systems;
STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional);
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.

The detailed calculation of grid emission factor is given in Appendix 4:

Project emission:

In accordance with AMS-I.D, Version18, no project emissions are considered because there is no on-site fossil fuel consumption during project activity and the project activity is not the operation of geothermal power plants and not hydro power plants.

Leakage emission:

As per AMS-I.D, Version18, para 42, General guidance on leakage in biomass project activities shall be followed to quantify leakages pertaining to the use of biomass residues. This project will not involve any use of biomass residues. Hence, the leakage emission due to use of biomass residues is not considered.

Emission reduction:

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

ER_y	Emission reductions in year *y* (t CO_2/y)
BE_y	Baseline Emissions in year *y* (t CO_2/y)
PE_y	Project emissions in year *y* (t CO_2/y)
LE_y	Leakage emissions in year *y* (t CO_2/y)

B.6.2. Data and parameters fixed ex ante

Data/Parameter	$FC_{i,y}$
Data unit	Mass or volume unit
Description	Amount of fossil fuel type i consumed in the project electricity system in year y
Source of data	Energy Policy&Planning Office (EPPO), Ministry of Energy.
Value(s) applied	Refer to Appendix 4
Choice of data or measurement methods and procedures	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 04.0
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$NCV_{i,y}$
Data unit	GJ/mass or volume unit
Description	Net calorific value (energy content) of fossil fuel type i in year y
Source of data	Thailand energy efficiency situation 2013/ Department of Alternative Energy Development and Efficiency, Ministry of Energy
Value(s) applied	Refer Appendix 4
Choice of data or measurement methods and procedures	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 04.0
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$EF_{CO2,i,y}$
Data unit	t CO_2/GJ
Description	CO_2 emission factor of fossil fuel type i in year y
Source of data	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the "2006 IPCC Guidelines on National GHG Inventories"
Value(s) applied	Refer Appendix 4
Choice of data or measurement methods and procedures	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 04.0
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	EG_y
Data unit	MWh
Description	Net quantity of electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must run power plants/units, in year y
Source of data	Energy Policy&Planning Office (EPPO), Ministry of Energy.
Value(s) applied	Refer Appendix 4
Choice of data or measurement methods and procedures	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 04.0
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$FC_{i,m,y}$
Data unit	Mass or volume unit
Description	Amount of fossil fuel type i consumed by the power plant/unit m in year y
Source of data	Electricity Generating Authority of Thailand (EGAT)
Value(s) applied	Refer Appendix 4
Choice of data or measurement methods and procedures	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 04.0
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$EG_{m,y}$
Data unit	MWh
Description	Net quantity of electricity delivered to the grid by power plant / unit m serving the system, not including low-cost / must run units, in year y
Source of data	Electricity Generating Authority of Thailand (EGAT)
Value(s) applied	Refer Appendix 4
Choice of data or measurement methods and procedures	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 04.0
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$EF_{grid,y}$
Data unit	t CO_2/MWh
Description	CO_2 emission factor of the grid
Source of data	Calculated
Value(s) applied	0.4786
Choice of data or measurement methods and procedures	The Grid Emission Factor of Thai National Grid is calculated using the latest version 04.0 of "Tool to calculate the emission factor for an electricity system".
Purpose of data	Calculation of baseline emissions
Additional comment	This value is used for the entire crediting period.

Data/Parameter	$EF_{grid,OM,y}$
Data unit	t CO_2/MWh
Description	Simple Operating Margin
Source of data	Calculated
Value(s) applied	0.5383
Choice of data or measurement methods and procedures	The Grid Emission Factor of Thai National Grid is calculated using the latest version 04.0 of "Tool to calculate the emission factor for an electricity system".
Purpose of data	Calculation of baseline emissions
Additional comment	This value is used for the entire crediting period.

Data/Parameter	$EF_{grid,BM,y}$
Data unit	t CO_2/MWh
Description	Build Margin
Source of data	Calculated
Value(s) applied	0.2996
Choice of data or measurement methods and procedures	The Grid Emission Factor of Thai National Grid is calculated using the latest version 04.0 of "Tool to calculate the emission factor for an electricity system"
Purpose of data	Calculation of baseline emissions
Additional comment	This value is used for the entire crediting period.

B.6.3. Ex ante calculation of emission reductions

>> The calculation follows the procedure as per AMS-I.D, Version 18, and the calculation is as follows:

Baseline Emissions:

The baseline emission calculated from the electricity generation in the project scenario and calculated as follows:

$$BE_y = EG_{PJ,y} * EF_{grid,y}$$

As per para26 of AMS. I.D version18.0
The project activity is the installation of a Greenfield power plant, then

$$EG_{PJ,y} = EG_{PJ,facility,y}$$

The net electricity supplied to the grid ($EG_{PJ,facility,y}$) is calculated as per the following formula.

$EG_{PJ,facility,y}$ (MWh)	=	$EG_{PJ,export,y}$ (MWh)	-	$EG_{PJ,import,y}$ (MWh)

In ex-ante calculation,

$EG_{PJ,export,y}$ (MWh) is 7,560 MWh per year which is estimated by project participant

$EG_{PJ,import,y}$ (MWh) is assumed to be zero.

Therefore,

$EG_{PJ,facility,y}$ (MWh)	=	7,560	-	0
$EG_{PJ,y}$	=	7,560		

In ex-ante calculation, $EG_{PJ,export,y}$ is determined by project participant as follows:

Table 9: Energy output

Year	Energy output (MWh)
1	7,560
2	7,560
3	7,560
4	7,560
5	7,560
6	7,560
7	7,560
8	7,560
9	7,560
10	7,560

Since the grid emission factor for Thai national grid is 0.4786 t CO_2/MWh as shown in Appendix 4 for the detailed calculation, the baseline emissions are summarised as below Table.

Table 10: Baseline emission

Year	BE_y	=	$EG_{PJ,facility,y}$	x	$EF_{grid,y}$
1	3,618	=	7,560	x	0.4786
2	3,618	=	7,560	x	0.4786
3	3,618	=	7,560	x	0.4786
4	3,618	=	7,560	x	0.4786
5	3,618	=	7,560	x	0.4786
6	3,618	=	7,560	x	0.4786
7	3,618	=	7,560	x	0.4786
8	3,618	=	7,560	x	0.4786
9	3,618	=	7,560	x	0.4786
10	3,618	=	7,560	x	0.4786

Project Emissions:

Since the project activity and also there is no on-site fossil fuel consumption during project activity, the project emission due to this project is considered as zero.

PE_y = 0

Leakage Emissions:

As per AMS-I.D, Version18, para 42, General guidance on leakage in biomass project activities shall be followed to quantify leakages pertaining to the use of biomass residues. This project will not involve any use of biomass residues. Hence, the leakage emission associated with this project activity is considered as zero.

LE_y = 0

Emission Reductions:

The emission reductions of the project activity are determined as:

$$ER_y = BE_y - PE_y - LE_y$$

For each year,

ER_y = BE_y - PE_y - LE_y
= 3,618 - 0 - 0
= 3,618

Table 11: Emission reductions

Year	ER_y	=	BE_y	-	PE_y	-	LE_y
1	3,618	=	3,618	-	0	-	0
2	3,618	=	3,618	-	0	-	0
3	3,618	=	3,618	-	0	-	0
4	3,618	=	3,618	-	0	-	0
5	3,618	=	3,618	-	0	-	0
6	3,618	=	3,618	-	0	-	0
7	3,618	=	3,618	-	0	-	0
8	3,618	=	3,618	-	0	-	0
9	3,618	=	3,618	-	0	-	0
10	3,618	=	3,618	-	0	-	0

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)
Year 1	3,618	0	0	3,618
Year 2	3,618	0	0	3,618
Year 3	3,618	0	0	3,618
Year 4	3,618	0	0	3,618
Year 5	3,618	0	0	3,618
Year 6	3,618	0	0	3,618
Year 7	3,618	0	0	3,618
Year 8	3,618	0	0	3,618
Year 9	3,618	0	0	3,618
Year 10	3,618	0	0	3,618
Total	36,180	0	0	36,180
Total number of crediting years	10			
Annual average over the crediting period	3,618	0	0	3,618

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data/Parameter	**$EG_{PJ,facility,y}$**
Data unit	MWh
Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y
Source of data	Electricity meters (from **$EG_{PJ,export}$** and **$EG_{PJ,import}$**)
Value(s) applied	7,560
Measurement methods and procedures	Calculated as difference between (a) the quantity of electricity supplied by the project plant/unit to the grid (**$EG_{PJ,export}$**); and (b) the quantity of electricity the project plant/unit from the grid (**$EG_{PJ,import}$**). The plant officer is responsible for this calculation.
Monitoring frequency	Continuous monitoring, hourly measurement and at least monthly recording.
QA/QC procedures	Quantity of net electricity supplied to the grid shall be crosschecked with records for sold or purchased electricity (e.g. invoices/receipts issued by PEA).
Purpose of data	Calculation of baseline emissions
Additional comment	The net electricity supplied to the grid is the difference between the measured quantities of the export electricity and the import electricity. $EG_{PJ,facility,y} = EG_{PJ,export,y} - EG_{PJ,import,y}$

Data/Parameter	**$EG_{PJ,export,y}$**
Data unit	MWh
Description	The quantity of electricity supplied by the project plant/unit to the grid
Source of data	Electricity meter
Value(s) applied	7,560
Measurement methods and procedures	Monitored continuously by the electricity meter. The amount of export electricity is recorded based on monthly basis by plant officer.
Monitoring frequency	Measured continuously by using on-site electricity meter with accuracy class 0.2s. The amount of export electricity is recorded on monthly basis.
QA/QC procedures	Meter will be calibrated periodically as per national standard by accredited person or institution or EGAT. Data measured will be crosschecked by power delivery report issued by EGAT monthly.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	**$EG_{PJ,import,y}$**
Data unit	MWh
Description	The quantity of electricity delivered to the project plant/unit from the grid
Source of data	Electricity meter
Value(s) applied	0 (ex-ante)
Measurement methods and procedures	Monitored continuously by the electricity meter. The amount of import electricity is recorded on monthly basis by plant officer.
Monitoring frequency	Measured continuously by using on-site electricity meter with accuracy class 0.2s. The amount of import electricity is recorded based on monthly.
QA/QC procedures	Meter will be calibrated periodically as per national standard by accredited person or institution or EGAT. Data measured will be crosschecked by electricity invoice from PEA monthly.
Purpose of data	Calculation of baseline emissions
Additional comment	-

All the above monitored data will be stored for at least two years after the end of crediting period or the last issuance of CERs for this project activity, whichever occurs later.

B.7.2. Sampling plan

>> The data and parameter are not determined by sampling approach.

B.7.3. Other elements of monitoring plan

>> **Composition of CDM monitoring team**

EGAT is well aware of the importance of having a good operational and management team in order to execute a well-defined monitoring plan for the project activity. So, it has an operational and management structure created exclusively for monitoring the relevant plant parameters. The responsibilities of data monitoring, archiving and analyzing will be managed by members of the monitoring team.
The CDM monitoring team comprises of the following members:

- Plant manager
- Project consultant or Technical support team
- Operation team

The responsibilities of each of the CDM monitoring team member are as follows:

Plant manager:
- Supervision all the monitoring activities

Project consultant or Technical support team:
- Checking the data and taking measures for ensuring precision of the meters.
- Ensuring monthly reading and monthly testing on a regular basis.
- Ensuring that the erroneous measurements are detected and reported by any employee involved in the implementation of monitoring plan

Operation team:
- Reading, recording, handling, reporting and archiving relevant data.
- Maintaining a daily log for issues related to power generation

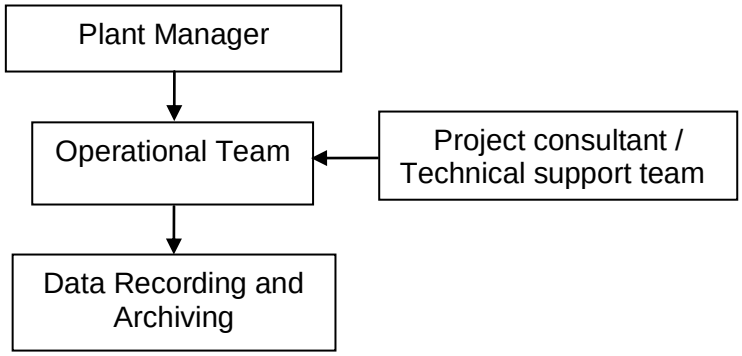

Figure 5: Planned operational and management structure for monitoring

Under the supervision of the Plant Manager, the monitoring and archiving are carried out by the operational team. All the data is recorded according to the data archiving procedures and stored electronically in a systematic and transparent manner. The Plant Manager will review the archived

data. This data will be verified again by an external independent Designated Operational Entity (DOE) annually.

Data logging, presentation and storing

EGAT will monitor the quantity of electricity exported to the grid and imported to the project activity using the electricity meters installed in the solar power plant, which undertaken by EGAT. Both electricity meters will measure the amount of electricity continuously and record electronically. The plant operator also manually record amount of the electricity import and export meter to the grid from meters in the log book monthly. The monitoring reports will be checked and discussed periodically.

'Daily operation and maintenance log books' will be kept at site and maintained by responsible operators. They will be able to provide detailed on-the-spot information about the operation of the plant. Any distinguishing event will be reported and recorded as special log. Data measured will be crosschecked by monthly power delivery reports and electricity invoices.

All monitored data will be stored for at least two years after the end of crediting period or the last issuance of CERs for this project activity, whichever occurs later.

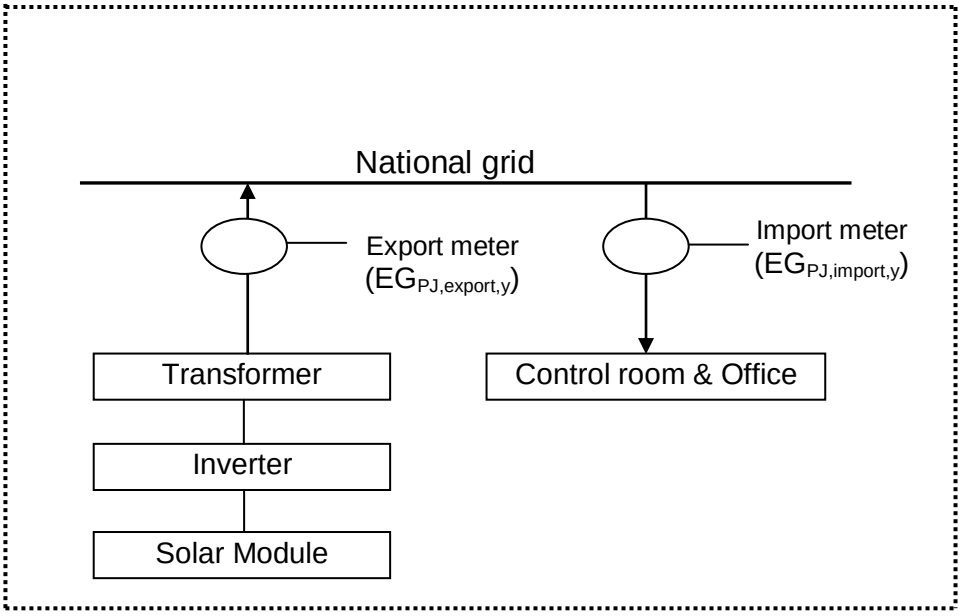

Figure 6: Monitoring diagram

Quality assurance and quality control

The meters installed in the solar power plant to monitor imported and exported electricity in the project activity are undertaken by EGAT and will take responsibility in calibration and overall maintenance on a regular basis at least once in 3 years throughout the crediting period in accordance with the national/international standards. In case of EGAT cannot calibration the electricity meter in accordance with the national/international standards (at least once in 3 years) due to any reason, the meters will calibrated by an accredited person or institution. EGAT will take responsibility in recording and archiving the data by appointing consultants and/or technical support team. EGAT will also provide sufficient number of staff for data collection and monitoring and necessary training in order to improve the efficiency of their work. In case that the

responsibility for monitoring is transferred to another person, it needs to be approved by the power plant manager.

Operation and Maintenance

EGAT would check the healthiness of the meters by checking indicator lamps or by taking readings as frequently as possible. If meters are found to be defective, it would be tested and calibrated immediately. The defective meters will be replaced immediately by a new meter. Operation team would take corrective active if meters are found not working. In case that the meters are malfunction, the operator will repair the meter soonest and then will fix or replace with a new meter after getting notification.

Emergency procedure

In case of emergency that the monitoring equipment has a problem, the operator will repair the meter soonest and then will fix or replace with a new meter after getting notification. During emergency situation, monitoring data from backup meter will be used for calculation of emission reduction. In case loss of monitoring data from both main and backup meter at the same time, the emission reduction will not be claimed during this period

Training

All the relative staff will be trained before operation of the PV power plants by PP's representative. The training consists of CDM knowledge, operational regulations, quality control (QC), data monitoring requirements and data management regulations, etc.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

>> 08/05/2014 (signing date of the Engineering Procurement and Construction contract)

C.2. Expected operational lifetime of project activity

>> 25 years 0 months

C.3. Crediting period of project activity

C.3.1. Type of crediting period

>> Fixed crediting period

C.3.2. Start date of crediting period

>> 01/08/2016

C.3.3. Duration of crediting period

>> 10 years and 0 months

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>> According to the announcement by Ministry of Natural resource and Environment dated 16 June 2009, the EIA report is required only for the thermal based electricity generation projects whose capacity is more than 10 MW[4]. Therefore solar project is not required to conduct EIA. However, according to the Thai DNA's regulation, all CDM projects need to conduct at least the Initial Environmental Evaluation (IEE) Report. Therefore IEE report has been submitted to the Thai DNA for LoA application.

In general, the photovoltaic power plant project causes limited and insignificantly environmental impacts comparing to that of a fossil fuel power plant. However, the major impacts from the project are listed below:

Atmospheric impacts

The electricity generated using the photovoltaic will be supplied to the Thai national grid. This will result in significant reduction of emissions considering that currently the electricity supply of the country is substantially contributed by fossil fuel.

Soil impacts

The project activity does not have any negative impact on soil of the surrounding area.

Land impacts

The project activity does not have any negative impact to the land because the project site is an empty land prior to implement the project.

Water impacts

The water usage in the project activity is only for staff consumption and there is no discharge of waste water and the project does not have any negative impact on the surrounding water resources.

Noise impacts

The project activity does not have noise impacts which will affect the surrounding community. The noise level of the project activity will meet the Thai regulation.

Light reflection impact

Due to the light reflection from the solar module is very less and there is a buffer area surrounding the project site. Therefore, there is no light reflection impact to the community nearby.

As mentioned above the project activity has no major impacts to the surrounding area/community or environment

[4] According to project type no. 18 of the announcement by Ministry of Natural resource and Environment dated 16 June 2009

D.2. Environmental impact assessment

>> According to the announcement by Ministry of Natural resource and Environment dated 16 June 2009, the EIA report is required only for the thermal based electricity generation projects whose capacity is more than 10 MW[5].

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

>> The Public Consultation Meeting was voluntary organized by EGAT on 21st May 2013 at Conference hall of Thap Sakae District Office, Nahukwang Subdistrict, Thap Sakae District, Prachuap Khiri Khan Province, Thailand after inviting earlier all the stakeholders to participate. The invitation letters were sent to representatives of the government, local officials, academic institutions, members from the local community living in the project area and others. There were 715 participants including local government officers, leaders and villagers living near the project site.

In the meeting, detailed information about the project activity and CDM were presented by CDM consultant (Advance Energy Plus Co., Ltd.). The event provided a forum for all stakeholders to ask questions about the impact of the project, and share opinions.

E.2. Summary of comments received

>> The public consultation also provided an opportunity to the participants to raise questions and/or comments which were not specifically related to the context of the project. These questions and/or comments were mostly related to general information regarding the community benefit from the project activity and summarized below:

Issue raise: *Is there any wastewater from the cleaning process of PV module? Is there storage pond in the project site?*

PP response: As the cleaning process is to clean the dust on the PV module, therefore the clean water without hazardous chemical substance will be used for cleaning process. The water from cleaning process will permeate to underground without negative effect to underground water.
The water for cleaning process will be from underground water inside the project site.

Issue raise: *The project site will be located near the mayor of Nahukwang Administrative Subdistrict Organization's house which will less useful for Solar PV education centre. So can it be relocated to the area near Suan Laung?*

PP response: The project site is needed to close to the Provincial Electricity Authority's grid connection point, therefore the present selected location is the most suitable.

Issue raise: *After implementation the project, can the raining water be consumed?*

PP response: The project activity does not affect to the quality of raining water, so if prior implementation the project, the raining water can be consumed then after implementation the project it can be consumed as it be.

[5] According to project type no. 18 of the announcement by Ministry of Natural resource and Environment dated 16 June 2009

Issue raise: *What is the tariff rate for the electricity from the project and how much area that the electricity can cover?*

PP response: The tariff rate is not determined by EGAT. The electricity generated from 5 MW PV plant is very less so it can cover area not over Thap Sakae District.

E.3. Consideration of comments received

>> At the beginning of the meeting, the project developers explained the complete details of the project to the participants. The key environmental benefits from the project activity (reduced air pollution, no negative impact on soil, reduced water usage and no noise issue) were also explained, which the participants understood well. Hence, there was no serious comment on the environmental impacts or safety aspects.

None of the participants had a negative view about the project.

SECTION F. Approval and authorization

>> Letter of approval from each party involved in the project activity is not available at the time of submitting the PDD to DOE.

Appendix 1. Contact information of project participants

Organization name	Electricity Generating Authority of Thailand
Country	Thailand
Address	53 Moo2, Charan Sanitwong Road, Bangkruai, Nonthaburi, Thailand 11130
Telephone	+662 436 1140
Fax	+662 436 1190
E-mail	-
Website	-
Contact person	Mrs. Waraporn Kunawanakit

Appendix 2. Affirmation regarding public funding

The proposed project do not available any public funding from Annex I countries.

Appendix 3. Applicability of methodologies and standardized baselines

Referring to Section B.2 of PDD, the applicability criterions are met for the project activity.

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

Calculation of the Emission Factor for an electricity system

The Emission Factor can be calculated by using **Annex 15 Methodological Tool (version 04.0.0) " Tool to calculate the emission factor for an electricity system"** which has been approved by the CDM Executive Board on October 04, 2013 (EB 75). Parameters of this method are listed below.

Parameter	SI Unit	Description
$EF_{grid,CM,y}$	t CO_2/MWh	Combined margin CO_2 emission factor for the project electricity system in year *y*
$EF_{grid,BM,y}$	t CO_2/MWh	Build margin CO_2 emission factor for the project electricity system in year *y*
$EF_{grid,OM,y}$	t CO_2/MWh	Operating margin CO_2 emission factor for the project electricity system in year *y*

The calculated Emission Factor can be used for the calculation of emission reductions of CDM projects that produce electricity and export to the national grid.

The emission factor for an electricity system can be determined by applies the following six steps:

STEP 1: Identify the relevant electricity systems

For determining the electricity emission factors, a project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without significant transmission constraints

Thailand Greenhouse Gas Management Organization, TGO who is the Thai DNA has published a delineation of the connected electricity system on December 30, 2011.

Delineation of connected electricity system:

In Thailand, the electricity transmission line system is considered as a single grid system due to the transmission lines are networked all of the country area. Electricity Generating Authority of Thailand (EGAT) regulate electricity generation and main transmission system, meanwhile Metropolitan

Electricity Authority (MEA) is responsible for electricity distribution system in Bangkok and vicinity area, and Provincial Electricity Authority (PEA) is responsible for electricity distribution system in the rest of country.

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

Only grid connected power plants are included in the calculation, as per Option I of the "Tool to calculate the emission factor for an electricity system" version 04.0.0

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

Method to determine the operating margin (OM)

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

1) Simple OM

2) Simple adjusted OM

3) Dispatch data analysis OM

4) Average OM

The simple OM method (Option a) can only be used if low-cost/must-run resources (LC/MR) constitute less than 50% of total grid generation in:

1) Average of the five most recent years, OR
2) Based on long-term averages for hydroelectricity production.

The following table summarizes the grid generation with LC/MR and non LC/MR units for the past 5 years in Thailand.

Year	2014	2013	2012	2011	2010	Average 5 years
Total	180,945.04	177,398.56	176,973.23	162,343.14	163,668.46	
Non LC/MR	171,788.90	168,559.51	165,841.26	152,078.41	156,055.94	
LC/MR	9,156.14	8,839.05	11,131.97	10,264.73	7,612.52	
%LC/MR	**5.06**	**4.98**	**6.29**	**6.32**	**4.65**	**5.46**

From the above table, it is clear that the LC/MR resources constitute an average of 5.46 % of total generation which is less than 50%. This satisfies the criteria for simple OM method. On this basis, Option (a), the Simple OM has been selected. Hence, according to the data available, the simple OM method (Ex ante Option) is the most appropriate method for Thailand.

This method requires the latest 3 years data including quantity of electricity generated; fuel types used and fuel consumption of each fuel type. This study used data obtained in the year 2012-2014 due to the following reasons:

1. In Thailand, the generated electricity that is transferred to the national grid is the only available data. Thus, it is not possible to obtain off-grid electricity generation data.
2. The low-cost/must-run (LC/MR) power plants include hydropower and renewable power plants. The quantity of electricity that was generated by LC/MR, constitute less than 50% of the total grid generation in average of the 5 most recent years (in the years 2010 – 2014).Therefore, LC/MR data are not included in the OM calculation.

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

The Simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (t CO_2/MWh) of all generating power plants serving the system, excluding of low-cost/must-run power plants/units.

The Simple OM may be calculated:

Option A: the net electricity generation and a CO_2 emission factor of each power unit; or

Option B: 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

Option B is selected to calculate OM emission factor due to the following reasons:

a) The necessary data for option A is not available such as data of net electricity generation of each power plant/unit serving the system;
b) Only nuclear and renewable power generation are considered as low-cost/must-run power sources and the quantity of electricity supplied to the grid by these sources is known; and
c) Off-grid power plants are not included in the calculation (Option I has been chosen in Step 2).

The Operating Margin emission factor is calculated by using Simple OM Option B as the following equation:

$$EF_{grid,OMsimple,y} = \frac{\sum_i FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_y} \quad (1)$$

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year y (t CO_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 (t CO_2/GJ)
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must run power plants/units, in year y (MWh)
i	=	All fossil fuel types combusted in power sources in the project electricity system in year y
y	=	The relevant year as per the data vintage chosen

The Net Calorific Value (NCV) is obtained from data that provided by Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. The CO_2 emission factor of fossil fuel follows IPCC default values in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. The values of CO_2 emission from combustion of fossil fuel (per unit of fossil fuel) are shown in Table 1.

Table 1. Net Calorific Value and CO_2 emission per unit of each type of fossil fuel

Fuel type[6]	*Unit*	*Net calorific value*[7] *(MJ/Unit)*	*CO_2 emission*[8] *(t CO_2/TJ)*	*CO_2 emission (kg CO_2/Unit)*
Natural gas	*Scf.*	*1.02*	*54.30*	*0.0554*
Lignite	*ton*	*10,470.00*	*90.90*	*951.7230*
Bituminous	*ton*	*26,370.00*	*89.50*	*2,360.1150*
Bunker	*litre*	*39.77*	*75.50*	*3.0026*
Diesel	*litre*	*36.42*	*72.60*	*2.6441*

The quantity of electricity was generated and transmitted to the national grid can be obtained from Energy Policy&Planning Ofice (EPPO) under Ministry of Energy (http://www.eppo.go.th/info/index-statistics.html). The quantity of electricity generation data is categorized by fuel type for electricity generation system and type of power plant (LC/MR and Non LC/MR) as shown in Table 2. The data of type and quantity of fossil fuel consumption in electricity generation are categorized by type of power producer (EGAT, IPP and SPP) as shown in Table 3.

VSPP are renewable power plants based on biogas, biomass, hydropower, wind power and solar power with installed capacity equal or less than 10 MW and are considered as LC/MR power plant. However, VSPP power plants are non-firm and can supply only a small quantity of electricity to the national grid compared to other power plants.

This study does not include quantity of electricity generated and supplied by VSPP in the calculation. The total quantity of electricity transmitted to the national grid (only Non LC/MR) in the years 2012 – 2014 was 506,189.67 GWh.

Table 2: Quantity of electricity was generated and transmitted to the national grid[9]

Year	**2014**	**2013**	**2012**
Hydro Electricity	5,163.57	5,412.08	8,431.22
Fuel Oil	1,574.15	1,238.45	1,299.96
Coal&Lignite	37,571.90	35,352.24	34,517.54
Natural Gas	120,314.17	119,217.89	119,433.57
Diesel	68.97	179.14	62.76
Import	12,259.71	12,571.79	10,527.43
Others	3,992.57	3,426.97	2,700.75
Total	180,945.04	177,398.56	176,973.23
Non LC/MR	171,788.90	168,559.51	165,841.26
LC/MR	9,156.14	8,839.05	11,131.97

[6] See Table: Comparison of name of fuel type

[7] Thailand energy efficiency situation 2013/ Department of Alternative Energy Development and Efficiency, Ministry of Energy

[8] IPCC default values at the lower limit as provide in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

[9] Table 5.2-2: Power Generation classified by fuel type (http://www.eppo.go.th/info/5electricity_stat.htm)

Table 3: Amount of fossil fuel consumed by power plants[10]

Fuel type	Unit	Fuel consumption			
		EGAT	IPP	SPP	Total
2014					
Natural gas	scf.	446,760,000,000	310,980,000,000	247,835,000,000	1,005,575,000,000
Lignite	ton	17,020,430	0	0	17,020,430
Bituminous	ton	0	6,144,030	2,331,890	8,475,920
Bunker	litre	378,890,000	0	0	378,890,000
Diesel	litre	20,830,000	0	0	20,830,000
2013					
Natural gas	scf.	448,585,000,000	318,645,000,000	216,445,000,000	983,675,000,000
Lignite	ton	16,884,950	0	0	16,884,950
Bituminous	ton	0	5,561,210	2,234,080	7,795,290
Bunker	litre	316,710,000	0	0	316,710,000
Diesel	litre	60,350,000	0	0	60,350,000
2012					
Natural gas	scf.	485,450,000,000	336,530,000,000	152,935,000,000	974,915,000,000
Lignite	ton	16,754,280	0	0	16,754,280
Bituminous	ton	0	5,362,170	2,417,070	7,779,240
Bunker	litre	319,340,000	0	0	319,340,000
Diesel	litre	19,060,000	0	0	19,060,000

Table 4 shows the calculated CO_2 emission from electricity generation in the years 2012 - 2014 categorized by type of fossil fuel. The total emissions during the 3-years period were 272,461,572 tCO_2.

The OM emission factor calculated by the equation (1) and following Simple OM method option B (ex ante option) is shown in Table 5. The OM emission factor is 0.5383 t CO_2 /MWh.

[10] Table 3.2-2: Consumption of Natural Gas by sector (http://www.eppo.go.th/info/3ng_stat.htm)

Table 4.1-2: Consumption of Coal and Lignite Classified by Sector (Thousand Tons) (http://www.eppo.go.th/info/4coal_lignite_stat.htm)

Table 5.4-1: EGAT Fuel Consumption in Power Generation (http://www.eppo.go.th/info/5electricity_stat.htm)

Table 4: CO_2 emission from electricity generation in the year 2010-2014

Fuel type	Fuel consumption		CO_2 emission (kg CO_2/Unit)	CO_2 emission (tCO_2)
	Unit	Volume		
2014				
Total				93,090,402
Natural Gas	scf.	1,005,575,000,000	0.0554	55,694,777
Lignite	ton	17,020,430	951.7230	16,198,735
Bituminous	ton	8,475,920	2,360.1150	20,004,146
Bunker	litre	378,890,000	3.0026	1,137,668
Diesel	litre	20,830,000	2.6441	55,076
2013				
Total				90,059,935
Natural Gas	scf.	983,675,000,000	0.0554	54,481,824
Lignite	ton	16,884,950	951.7230	16,069,795
Bituminous	ton	7,795,290	2,360.1150	18,397,781
Bunker	litre	316,710,000	3.0026	950,965
Diesel	litre	60,350,000	2.6441	159,571
2012				
Total				89,311,235
Natural Gas	scf.	974,915,000,000	0.0554	53,996,642
Lignite	ton	16,754,280	951.7230	15,945,434
Bituminous	ton	7,779,240	2,360.1150	18,359,901
Bunker	litre	319,340,000	3.0026	958,861
Diesel	litre	19,060,000	2.6441	50,396

Table 5: Operating Margin Emissions Factor (Ex-ante option)

Year	CO_2 emission (t CO_2)	Grid consumption (GWh)	OM Emission Factor (t CO_2/MWh)
2014	93,090,402	171,788.90	0.5419
2013	90,059,935	168,559.51	0.5343
2012	89,311,235	165,841.26	0.5385
Summary	**272,461,572**	**506,189.67**	**0.5383**

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

In terms of the two eligible options for data vintage, option 1) is chosen, in which, the BM is calculated ex-ante for the first crediting period based on the most recent available data. In case of renewal of the crediting period, this data would be updated. In case of a second renewal of the crediting period, the BM calculated for the second period would be used. This option does not require monitoring the emission factor during the crediting period.

The build margin is calculated as the generation-weighted average emission factor of a sample of power plants. Capacity additions from retrofits of power plants are not included.

The sample group of power units *m* is determined as follows:

- the set of five power units, excluding units registered as CDM project activity, that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and determine their annual electricity generation ($AEG_{5\text{-units}}$);
- the annual electricity generation of the project electricity system, excluding power units registered as CDM project activity, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total}. AEG_{total} is the annual electricity generation of the PES, excluding power units registered as CDM project activity. This set is denominated $SET_{>20\ per\ cent}$. Determine their annual electricity generation ($AEG_{>20\%}$);
- from $SET_{5\text{-units}}$ and $SET_{>20\ per\ cent}$ select the set that comprises the larger annual electricity generation and define as SET_{sample}.

Other sub-steps are irrelevant since in Thailand either set does not comprise of power units that started to supply electricity more than 10 years ago. This is illustrated with the SET_{sample} comprising of the following power units:

The set of five power units, excluding units registered as CDM project activity, that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and their annual electricity generation ($AEG_{5\text{-units}}$) shown in table 6 below;

Table 6: list of $SET_{5\text{-units}}$

No.	$SET_{5\ Units}$	$AEG_{SET\text{-}5\text{-}Units}$ (kWh)	COD date
1	Gulf JP NS Co., Ltd. (Nong Saeng Power Plant)	853,977,185	1-Dec-14
2	Ratchaburi world cogeneration Co., Ltd. (Unit 1)	105,859,207	1-Nov-14
3	Chana power plant (Unit 02)	2,820,201,043	15-Jul-14
4	Wang Noi Power Plant (Unit 04)	2,708,141,698	25-Apr-14
5	Uthaithani bio energy Co., Ltd. (Unit 1)	19,367,098	11-Apr-14
	Total	**6,507,546,231**	

The group of power units that supply electricity to the grid most recently (sorted by the Commercial Operation Date (COD) which is the date when the power unit starts to supply electricity to the grid) and their annual quantity of electricity generation comprise larger than or equal to 20% of total annual electricity generation (in year 2014) are shown in Table 7.

Table 7: Electricity Generation by most recently built power plants[11]

Power unit	Grid generation (kWh)	COD
1. Gulf JP NS Co., Ltd.	853,977,185	1-Dec-14
2. Ratchaburi world cogeneration Co., Ltd. (Unit 1)	105,859,207	1-Nov-14
3. Chana power plant (Unit 02)	2,820,201,043	15-Jul-14
4. Wang Noi Power Plant (Unit 04)	2,708,141,698	25-Apr-14
5. Uthaithani bio energy Co., Ltd. (Unit 1)	19,367,098	11-Apr-14
6. ES power Co., Ltd.	113,110,132	21-Jan-14
7. Amata B.Grimm power (Rayong) 1 Co., Ltd.	639,153,827	1-Nov-13
8. Navanakorn electric Co., Ltd.	608,729,184	31-Oct-13
9. Rojana power Co., Ltd. (Unit 2)	633,335,275	18-Oct-13
10. Kaset thai bio power Co., Ltd.	154,485,041	7-Oct-13
11. Gulf JP NS 2 Co., Ltd.	616,203,418	1-Oct-13
12. Rojana power Co., Ltd. (Unit 4)	209,720,540	26-Jul-13
13. Gulf JP CRN Co., Ltd.	643,534,326	1-Jul-13
14. Bangpain cogeneration Co., Ltd.	647,522,021	28-Jun-13

[11] Data source of power generation for BM.rar

Power unit	Grid generation (kWh)	COD
15. Amata B.Grimm power (Rayong) 1 Co., Ltd.	642,750,539	21-Jun-13
16. Gulf JP NLL Co., Ltd.	634,483,336	1-May-13
17. Gulf JP NNK Co., Ltd.	646,349,336	1-Apr-13
18. Gulf JP TLC Co., Ltd.	644,821,264	1-Mar-13
19. Gulf JP KP 2 Co., Ltd.	630,951,534	1-Feb-13
20. Mitr phol Bio-power (Kalasin) Co., Ltd.	185,637,117	18-Jan-13
21. Gulf JP KP 1 Co., Ltd.	627,803,717	5-Jan-13
22. Glow SPP 11 Co., Ltd. (Unit 2)	626,194,010	12-Dec-12
23. Amata B.Grimm power 3 Co., Ltd.	622,207,167	1-Oct-12
24. Mungcharoen Biomass Co.,Ltd	92,324,827	5-Sep-12
25. Glow energy Pcl. (Unit 3)	512,479,014	1-Jun-12
26. Dan chang bioenergy (Unit 3)	151,960,620	29-May-12
27. Department of Alternative Energy Development and Efficiency	29,672,499	21-Mar-11
28. Siam power generation Pcl. (Unit 1)	240,990,450	29-Dec-10
29. Khon Kaen sugar industry Co., Ltd. (Unit 2)	175,272,649	30-Nov-10
30. North Bangkok Power Plant (Unit 01)	4,289,376,736	15-Oct-10
31. Global power synergy Co., Ltd. (Unit 2)	195,900,607	17-Sep-10
32. Dan chang bioenergy Co., Ltd. (Unit 2)	81,693,399	13-Nov-09
33. Mitr phol biopower (Unit 2)	72,629,322	13-Nov-09
34. Bangpakong Power Plant (Unit 05)	4,901,850,288	16-Sep-09
35. South Bangkok Power Plant (Unit 03)	4,888,089,600	1-Mar-09
36. Global power synergy Co., Ltd. (Unit 1)	388,191,600	24-Jan-09
37. Chana Power Plant (Unit 01)	3,069,969,135	15-Jul-08
Summary	35,124,938,761	
Percentage as of 2014 Grid Generation (171,885.34 GWh)	20.44	

According to para 71 (c) of "Tool to calculate the emission factor for an electricity system" version 04.0, stated that "From S*ET5-units* and *SET□20 per cent* select the set of power units that comprises the larger annual electricity generation (*SETsample*)"; therefore, from annual electricity generation for $SET_{5\text{-units}}$ and $SET_{>20 \text{ per cent}}$ list in table 6 and table 7 respectively, the power units in $SET_{>20 \text{ per cent}}$ were selected as SET_{sample} for calculation of build margin.

From SET_{sample}, the fuel consumption of power units listed in SET_{sample} will be used for calculation of BM emission factor.

According to para 73 and 74 of "Tool to calculate the emission factor for an electricity system" version 04.0, the simple OM, Options A3 was applied for determination of $EF_{EL,m,y}$ of other power units. It is stated that "If for a power unit m only data on electricity generation is available, an emission factor of 0 t CO2/MWh can be assumed as a simple and conservative approach."

From list of power units in SET_{sample} ($SET_{>20 \text{ per cent}}$ in table 7), it has only fuel consumption data available for Chana power plant (Unit 02), Wang Noi Power Plant (Unit 04), North Bangkok Power Plant (Unit 01), Bangpakong Power Plant (Unit 05) and South Bangkok Power Plant (Unit 03). Therefore for conservative, only fuel consumption from these power plants will be applied for the fuel consumption of power units in $SET_{sample,}$

The fuel consumption for SET_{sample} provided in table 8 below;

Table 8: Fuel consumptions of the most recently built power plants as listed in Table[12]

Fuel type	Fuel consumption		CO_2 emission (kg CO_2/Unit)	CO_2 emission (t CO_2)
	Unit	Volume		
Total				10,522,399
Natural Gas	scf.	189,973,651,944	0.0554	10,521,881
Lignite	ton	0	951.7230	0
Bituminous	ton	0	2,360.1150	0
Bunker	litre	0	3.0026	0
Diesel	litre	196,022	2.6441	518

The build Margin Emission Factor calculated by using equation below;

$$EF_{grid,BM,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}}$$

Where,

[12] Data source of fuel consumption for BM.rar,

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (t CO_2/MWh)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)

$EF_{El,m,y}$ = CO_2 emission factor of power unit m in year y (t CO_2/MWh)

m = Power units included in the build margin

y = Most recent historical year for which power generation data is available

As shown in Table 7, the annual electricity generated by the most recently built power plants is 35,124.94 GWh (20.44% of the total electricity generated in year 2014 excluded power units registered as CDM which is 171,885.034 GWh). Fuel consumptions of the most recently built power plants as listed in Table 8 emit 10,522,399 ton CO_2. As shown in table 9, the Build Margin emission factor calculated by using equation (1), is 0.2996 tCO_2/MWh.

Table 9: Calculation of Build Margin Emission Factor

Year	CO_2 emission (t CO_2)	Grid consumption (GWh)	OM Emission Factor	
			(t CO_2/MWh)	(g CO_2/KWh)
2014	10,522,399	35,124.94	0.2996	299.60

STEP 6: Calculate the Combined Margin (CM) emissions factor

Method to determine the Combined Margin (CM)

The Combined Margin Emission Factor can be calculated by using equation 2

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times W_{OM} + EF_{grid,BM,y} \times W_{BM} \quad (2)$$

Where,

$EF_{grid,CM,y}$ = Combined margin CO_2 emission factor in year *y,* (t CO_2/MWh)

$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year *y,* (t CO_2/MWh)

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y,* (t CO_2/MWh)

W_{OM} = Weighting of operating margin emission factor

W_{BM} = Weighting of build margin emission factor

The weighting of general CDM projects is different from wind and solar power generation CDM projects as shown in Table 10.

Table 10: Weighting of operating and build margin emissions factor for Solar power generation CDM projects

CDM project type	W_{OM}	W_{BM}
Solar power generation project	0.75	0.25

As the project activity is involves a Solar power generation project, W_{OM} = 0.75 and W_{BM} = 0.25 is selected. The Combined Margin Factors of General CDM project is calculated by using equation 2 is 0.4786 as given in Table 11.

Table 11: Calculated Combined Margin Emission Factor

CDM project type	Emission Factor (t CO_2/MWh)		
	$EF_{grid,OM}$	$EF_{grid,BM}$	$EF_{grid,CM}$
Solar power generation project	0.5383	0.2996	0.4786

Reference Table : Comparison of name of fuel type from different reports

Report[13]	DEDE[14] (Thailand)	IPCC[15]
Natural gas	Natural gas (Dry)	Natural gas
Lignite	Lignite (Mae Moh)	Lignite
Bituminous	Coal import	Other bituminous coal
Bunker	Fuel oil	Residual fuel oil
Diesel	Diesel	Diesel oil

[13] The Study of emission factor for an electricity system in Thailand 2010

[14] Electric Power in Thailand 2013/ Department of Alternative Energy Development and Efficiency, Ministry of Energy

[15] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

ENERGY CONTENT OF FUEL (NET CALORIFIC VALUE)

S. No.	Type (Unit) Commercial Energy	K Cal/unit	toe/10^6 unit	MJ/unit	10^3 BTU/unit
1.	Crude Oil (litre)	8,680	860.00	36.33	34.44
2.	Condensate (litre)	7,900	782.72	33.07	31.35
3.	Natural Gas				
	3.1 Wet (scf)	248	24.57	1.04	0.98
	3.2 Dry (scf)	244	24.18	1.02	0.97
4.	Petroleum products				
	4.1 LPG (litre)	6,360	630.14	26.62	25.24
	4.2 Gasoline (litre)	7,520	745.07	31.48	29.84
	4.3 Jet Fuel (litre)	8,250	817.40	34.53	32.74
	4.4 Kerosene (litre)	8,250	817.40	34.53	32.74
	4.5 Diesel (litre)	8,700	861.98	36.42	34.52
	4.6 Fuel Oil (litre)	9,500	941.24	39.77	37.70
	4.7 Bitumen (litre)	9,840	974.93	41.19	39.05
	4.8 Petroleum Coke (kg)	8,400	832.26	35.16	33.33
5.	Electricity (kWh)	860	85.21	3.60	3.41
6.	Hydroelectricty (kWh)	2,236	221.54	9.36	8.87
7.	Geothermal (kWh)	9,500	941.24	39.77	37.70
8.	Coal import (kg)	6,300	624.19	26.37	25.00
9.	Coke (kg)	6,600	653.92	27.63	26.19
10.	Anthracite (kg)	7,500	743.09	31.40	29.76
11.	Ethane (kg)	11,203	1,110.05	46.89	44.45
12.	Propane (kg)	11,256	1,115.34	47.11	44.67
13.	Lignite				
	13.1 Li (kg)	4,400	435.94	18.42	17.46
	13.2 Krabi (kg)	2,600	257.60	10.88	10.32

S. No.	Type (Unit) Commercial Energy	K Cal/unit	toe/10^6 unit	MJ/unit	10^3 BTU/unit
	13.3 Mao Moh (kg)	2,500	247.70	10.47	9.92
	13.4 Chae Khon (kg)	3,610	357.67	15.11	14.32
	New & Renewable Energy				
1.	Fuel Wood (kg)	3,820	378.48	15.99	15.16
2.	Charcoal (kg)	6,900	683.64	28.88	27.38
3.	Paddy Husk (kg)	3,440	340.83	14.40	13.65
4.	Bagasse (kg)	1,800	178.34	7.53	7.14
5.	Garbage (kg)	1,160	114.93	4.86	4.60
6.	Saw Dust (kg)	2,600	257.60	10.88	10.32
7.	Agricultural Waste (kg)	3,030	300.21	12.68	12.02
8.	Biogas (m^3)	5,000	495.39	20.93	19.84

TABLE 1.4: DEFAULT CO_2 EMISSION FACTORS FOR COMBUSTION[16]

Fuel type English description		Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[17]		
				Default Value[18]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Crude oil		20.0	1	73,300	71,100	75,500
Orimulsion		21.0	1	77,000	69,300	85,400
Natural Gas		17.5	1	64,200	58,300	70,400
Gasoline	Motor gasoline	18.9	1	69,300	67,500	73,000
	Aviation gasoline	19.1	1	70,000	67,500	73,000
	Jet gasoline	19.1	1	70,000	67,500	73,000
Jet kerosene		19.5	1	71,500	69,700	74,400
Other kerosene		19.6	1	71,900	70,800	73,000
Shale oil		20.0	1	73,300	67,800	79,200
Gas / Diesel oil		20.2	1	74,100	72,600	74,800
Residual fuel oil		21.1	1	77,400	75,500	78,800
Liquefied petroleum gases		17.2	1	63,100	61,600	65,600
Ethane		16.8	1	61,600	56,500	68,600
Naphtha		20.0	1	73,300	69,300	76,300
Bitumen		22.0	1	80,700	73,000	89,900
Lubricants		20.0	1	73,300	71,900	75,200
Petroleum coke		26.6	1	97,500	82,900	115,000
Refinery Feedstock		20.0	1	73,300	68,900	76,600

[16] The lower and upper limits of the 95 percent confidence intervals, assuming lognormal distributions, fitted to a dataset, based on national inventory report, IEA data and available national data. A more detailed description is given in section 1.5

[17] TJ = 1000 GJ

[18] The emission factor value for BFG includes carbon dioxide originally contained in this gas as well as that formed due to combustion of gas.

Fuel type English description		Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[17]		
				Default Value[18]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Other Oil	Refinery gas	15.7	1	57,600	48,200	69,000
	Paraffin waxes	20.0	1	73,300	72,200	74,400
	White spirit & SBP	20.0	1	73,300	72,200	74,400
Other petroleum products		20.0	1	73,300	72,200	74,400
Anthracite		26.8	1	98,300	94,600	101,000
Coking coal		25.8	1	94,600	87,300	101,000
Other Bituminous coal		25.8	1	94,600	89,500	99,700
Sub-Bituminous coal		26.2	1	96,100	92,800	100,000
Lignite		27.6	1	101,000	90,900	115,000
Oil shale and tar sands		29.1	1	107,000	90,200	125,000
Brown coal briquettes		26.6	1	97500	87,300	109,000
Patent fuel		26.6	1	97,500	87,300	109,000
Coke	Coke oven coke and lignite coke	29.2	1	107,000	95,700	119,000
	Gas coke	29.2	1	107,000	95,700	119,000
Coal tar		22.0	1	80,700	68,200	95,300
Derives Gases	Gas works gas	12.1	1	44,400	37,300	54,100
	Coke oven gas	12.1	1	44,400	37,300	54,100
	Blast furnace gas [19]	70.8	1	260,000	219,000	308,000
	Oxygen steel furnace gas [5]	49.6	1	182,000	145,000	202,000
Natural Gas		15.3	1	56,100	54,300	58,300

[19] The emission factor values for OSF includes carbon dioxide originally contained in this gas as well as that formed due to combustion of this gas

Fuel type English description		Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[17]		
				Default Value[18]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Municipal Wastes (non-biomass fraction)		25.0	1	91,700	73,300	121,000
Industrial wastes		39.0	1	143,000	110,000	183,000
Waste oil		20.0	1	73,300	72,200	74,400
Peat		28.9	1	106,000	100,000	108,000
Solid bio-fuels	Wood/wood waste	30.5	1	112,000	95,000	132,000
	Sulphite lyes (black liquor)[20]	26.0	1	95,300	80,700	110,000
	Other primary solid biomass	27.3	1	100,000	84,700	117,000
	charcoal	30.5	1	112,000	95,000	132,000
Liquid bio-fuels	Biogasoline	19.3	1	70,800	59,800	84,300
	Biodiesels	19.3	1	70,800	59,800	84,300
	Other liquid biofuels	21.7	1	79,600	67,100	95,300
Gas biomass	Landfill gas	14.9	1	54,600	46,200	66,000
	Sludge gas	14.9	1	54,600	46,200	66,000
	Other biogas	14.9	1	54,600	46,200	66,000
Other non-fossil fuels	Municipal wastes (biomass fraction)	27.3	1	100,000	84,700	117,000

[20] Include the biomass-derived CO_2 emitted from the black liquor combustion unit and the biomass-derived CO_2 emitted from the kraft mill lime kiln.

Appendix 5. Further background information on monitoring plan

Referring to section B.7 for details

Appendix 6. Summary report of comments received from local stakeholders

Not applicable at the validation stage.

Appendix 7. Summary of post-registration changes

Permanent changes to the registered monitoring plan

In the actual project implementation, there are the permanent changes to the registered monitoring plan as details below

1) The accuracy class of import electricity meter has been changed from 0.5s to 0.2s. In the actual project implementation, the import electricity meters have been operated and maintained by EGAT instead of PEA because a higher accuracy meter and meter calibration frequency can be controlled by EGAT.
2) In the actual project implementation, the import electricity meters have been operated and maintained by EGAT instead of PEA because a higher accuracy meter and meter calibration frequency can be controlled by EGAT. Therefore, the QA/QC procedure of parameter $EG_{PJ,export,y}$ has been changed to "Meter was calibrated periodically as per national standard by accredited person or institution or EGAT. Data measured will be crosschecked by power delivery report issued by EGAT monthly."
3) In the actual project implementation, the import electricity meters have been operated and maintained by EGAT instead of PEA because a higher accuracy meter and meter calibration frequency can be controlled by EGAT. Therefore, the QA/QC procedure of parameter $EG_{PJ,import,y}$ has been changed to "Meter was calibrated periodically as per national standard by accredited person or institution or EGAT. Data measured will be crosschecked by electricity invoice from PEA monthly."

Changes to project design

In the actual project implementation, there are changes to project design due to the installation of units with lower capacity the installation. The number of photovoltaic panel, Crystalline Silicon: c-Si has been changed in the actual project implementation from 5,040 to 5,016 cells.

The decreasing number of photovoltaic panel does not affect to the registered CDM project activity on the following:
(a) The applicability and application of the applied methodologies and, where applicable, the applied standardized baselines, with which the project activity has been registered;
(b) The compliance of the monitoring plan with the applied methodologies and, where applicable, the applied standardized baselines;
(c) The level of accuracy and completeness in the monitoring of the project activity compared with the requirements contained in the registered monitoring plan;
(d) The additionality of the project activity;
(e) The scale of the project activity.

Changes of the start date of crediting period

Due to the construction of project activity was completed and started to operate after the start date that indicated in the registered PDD, therefore the start date of crediting period has been changed from "01/01/2016" to "01/08/2016. Please refer to the detail of such change from the following link https://cdm.unfccc.int/Projects/DB/BVQI1443850710.86/view.