**PROJECT DESIGN DOCUMENT FORM
FOR CDM PROJECT ACTIVITIES (F-CDM-PDD)
Version 04.1**

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	Solar Farm at Nakhonsawan, Thailand
Version number of the PDD	0605
Completion date of the PDD	128/032/201402/11/2012
Project participant(s)	EA Solar Nakornsawan Co., Ltd.Energy Absolute Public Co., Ltd. (Public entity)
Host Party(ies)	Thailand
Sectoral scope and selected methodology(ies)	ACM0002: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (version 12.3.0, EB 66); Sectoral scope: (1) "Energy industries (renewable/non-renewable sources)"
Estimated amount of annual average GHG emission reductions	82,955 80,591 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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Solar Farm at Nakhonsawan, Thailand (hereafter called the "project activity") is developed by Energy Absolute Public Co., Ltd.[1]. It is proposed to construct a solar photovoltaic power plant at Takhli district, Nakhonsawan province in northern Thailand. The average annual solar radiation of the Takhli district is 5.18 kWh/m^2/day[2].The total installed capacity of the solar PV power plant is about ~~101.25 MWp~~ 126.126 MWp. The PV power plant is expected to generate an average of 139,446 ~~135,165~~ MWh per annum throughout its lifetime of 25 years.

The project activity will generate electricity by utilizing the available solar energy and will export it to the Thai National Grid, which is dominated by fossil fuel based power plants. By displacing the fossil fuel based electricity of the grid, the project activity contributes to the GHG emission reduction and is expected to reduce an average of 82,955 ~~80,591~~ t CO_2e per year during the 1st crediting period.

The purpose of the project activity

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

Scenario prior to the project activity

The project activity is a Greenfield activity. There were no other renewable energy power plants at the project site, prior to the implementation of the project activity. However 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.

Base line scenario

Base line scenario and the scenario prior to the project activity are one and the same.

Scenario after the project activity

Once the project activity is implemented, it will generate electricity by utilizing the available solar energy and will export to Thai national grid replacing equivalent grid electricity (which is fossil fuel dominated).

Contribution to sustainable development in Thailand

In Thailand, sustainable development requires the effective integration of four key elements[3], namely, the environmental, social, technological and economical dimensions of development. By having positive

[1] Project Participant has been changed from "Energy Absolute Public Co., Ltd." to "EA Solar Nakornsawan Co., Ltd."

[2] NASA Surface meteorology and Solar Energy data. http://eosweb.larc.nasa.gov/sse/RETScreen/

[3] Refer to the Sustainable Development Criteria of Thai DNA (Thailand Greenhouse Gas Management Organization (Public Organization)

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 activity will reduce the carbon dioxide (CO_2) emission and other fossil fuel based emissions such as NO_x, SO_x, etc. and conserve fossil fuels.
- Apart from reducing greenhouse gas emissions, the project activity will be contributing towards lowering of harmful pollutants and suspended airborne particulate matter, associated with fossil fuel based power plants

Social Indicator

- The project activity will diversify the power sources and make use of clean energy
- The project activity will support the policy of the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy (MOE) of Thailand in increasing the electricity generation by renewable energy

Technology Indicator

- The project activity will entail the import of equipments from other countries, thus paving the way for technology transfer

Economical Indicator

- The project activity will reduce the import of expensive fossil fuel, facilitating foreign exchange savings for the country with positive effect on Thailand's balance of payment
- The project activity will provide employment opportunities in operation and maintenance of the power plant to the common public.

A.2. Location of project activity

A.2.1. Host Party(ies)

>>
Thailand

A.2.2. Region/State/Province etc.

>>
Nakhonsawan province

A.2.3. City/Town/Community etc.

>>
Takhli district

A.2.4. Physical/Geographical location

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The project activity is located at Takhli district, Nakhonsawan Province, in the north side of Thailand.

The project activity is located at (+15.3767 N, +100.2855 E), (+15.3754 N, +100.3013 E), (+15.3664 N, +100.2926 E) and (+15.3607 N, +100.3117 E). The central point of the project activity is located at +15.3639 N, +100.2982 E. The total area for this project is approximately 2,000 rai[4].

Location of the power plant is shown in figure 1 and 2

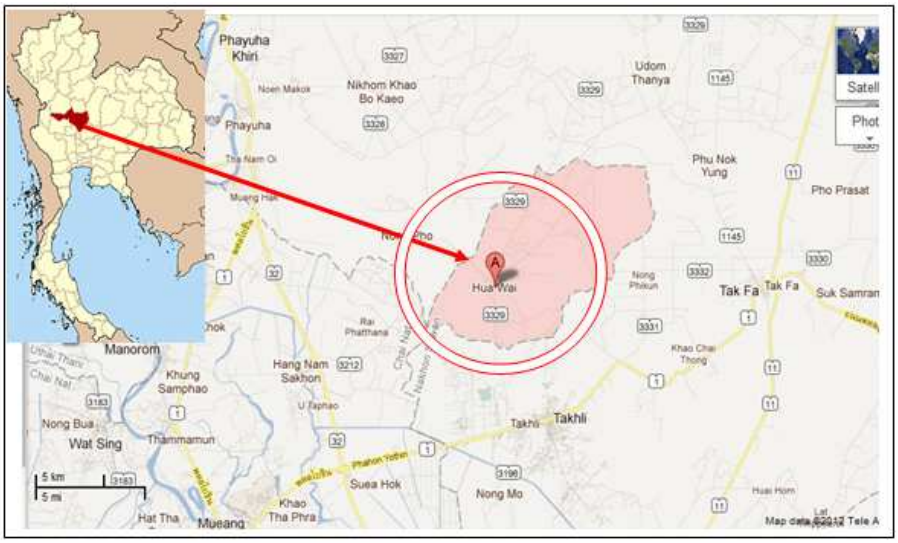

Figure 1: Location of Nakhonsawan province in Thailand

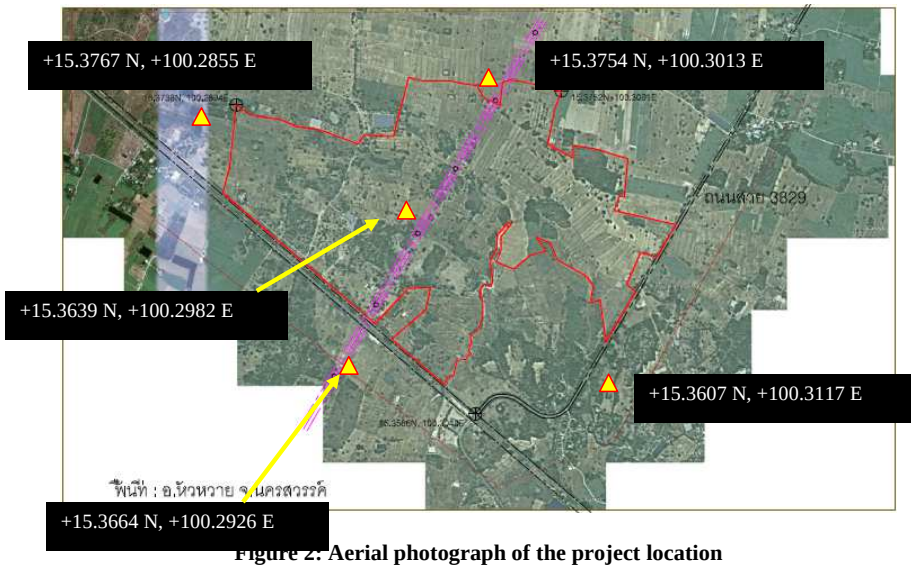

Figure 2: Aerial photograph of the project location

[4] 1 rai is equal to 1,600 square meters, http://en.wikipedia.org/wiki/Rai_(unit)

A.3. Technologies and/or measures

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The proposed project activity will use imported Solar Photovoltaic (PV) technology and thus is a case of technology transfer to Thailand. The proposed technology is environmentally safe and sound and 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. Solar photovoltaic cells are made amorphous silicon, which consists of several small silicon crystals. Like most semiconductor devices, solar photovoltaic cells include 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. Inverters or power control units are used to transform the DC produced by the solar photovoltaic cells into alternating current (AC). Only then, the electricity can be sold to the utility 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:

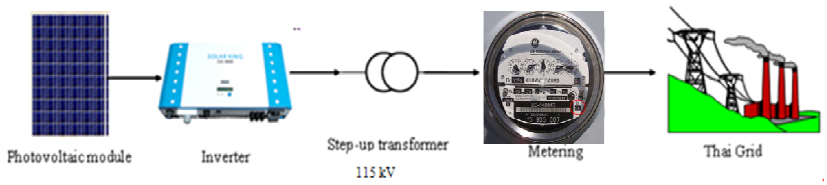

Figure 3: Simple schematic diagram of solar PV power plant

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.

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.

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.

Electricity grid

The generated electricity is supplied to the Thai grid.

The proposed 126.126 MWp~~101.25 MWp~~ solar photovoltaic power plant project tentatively will comprise of the following units:

- 508,794 ~~1,012,500~~ units of photovoltaic modules
- 180~~360~~ units of inverters
- 101~~360~~ units of transformer

The technical specification of the solar module to be used in the project activity is given in the following table:

Manufacturer	Model	Quantity	Nominal Peak Power (Wp)	Cell ~~Silicon cell~~ type
LDK	LDK-245P-20	157,300	245	Multicrystalline silicon
	LDK-250P-20	98,098	250	Multicrystalline silicon
Renesolar	JC245M-24/Bb	57,200	245	Polycrystalline
	JC250M-24/Bb	196,196	250	Polycrystalline
Total		508,794		
~~Sunwell~~	~~WD-A-CC087A~~	~~1,012,500~~	~~100~~	~~Amorphous Silicon~~

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Technical specifications of the inverter to be used in the project activity are given below:

Manufacturer	Model	Quantity	AC nominal output (kW)	Maximun / EU / CEC efficiency ~~Max. efficiency / Euro efficiency~~ (%)

Santerno~~Power One~~	TG610 1000V TE-400 OD~~PVI-250-TL-CN~~	180~~360~~	500~~250~~	98.5 / 98~~.~~ .3 / 98.0~~2~~

Technical specifications of the transformer to be used in the project activity are given below:

Manufacturer	Capacity	Quantity
Tusco Trafo	1250 kVA	90
Tusco Trafo	50 kVA	3
Tusco Trafo	100 kVA	6
Tusco Trafo	160 kVA	1
Tusco Trafo	250 kVA	1
~~QTC~~	~~315 kVA~~	~~360~~

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Facilities, systems and equipment prior to the implementation of the project activity

There were no facilities, system and equipments prior to the implementation of the project activity. The project activity is a Greenfield one.

Facilities, systems and equipment in the baseline scenario

Same as above

Technology transfer

The project activity will import the Solar Photovoltaic (PV) technology from abroad. In order to make sure that operator can operate this system properly, all of the related staff will be trained by the supplier before operation of the PV power plants.

A.4. Parties and project participants

Party involved (host) indicates a 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)
*Thailand (host)	* EA Solar Nakornsawan Co., Ltd.~~Energy Absolute Public Co., Ltd. (Public entity)~~	No

(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required

A.5. Public funding of project activity

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

SECTION B. Application of selected approved baseline and monitoring methodology

B.1. Reference of methodology

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The proposed project activity is in compliance with the criteria of the following methodology for large scale project activities:

i. ACM0002: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (version 12.3.0, EB 66);

This methodology also refers to the latest approved versions of the following tools:

i. "Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70)
ii. "Combined tool to identify the baseline scenario and demonstrate additionality"(version 05.0.0, EB 70)
iii. "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"(version 02, EB 41)
iv. "Tool to calculate the emission factor for an electricity system"(version 02.2.1, EB 63)

According to the methodology ACM0002 (version 12.3.0, EB 66), "Combined tool to identify the baseline scenario and demonstrate additionality" (version 05.0.0, EB 70), should be used for identification of the baseline scenario only if the project activity is the retrofit or replacement of existing grid-connected renewable power plant/unit(s) at the project site. But, since the project activity is Greenfield in nature, this tool is not used.

According to the methodology ACM0002 (version 12.3.0, EB 66),only for geothermal and solar thermal projects, which use fossil fuels for electricity generation, CO_2 emissions from the combustion of fossil fuels shall be accounted for as project emissions ($PE_{FF,y}$). It shall be calculated as per the latest version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". Since the project activity does not involve any of these technologies, this tool is not used.

Hence the above two, the project activity refers only to the following tools:

i. "Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70)
ii. "Tool to calculate the emission factor for an electricity system" (version 02.2.1, EB 63)

B.2. Applicability of methodology

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The project activity is in line with approved methodology ACM0002 (version 12.3.0, EB 66).Specific features and applicability of the methodology are discussed below:

Applicability criteria	Justification
This methodology is applicable to grid-connected renewable power generation project activities that (a) install a new power plant at a site where no	Applicable. The project activity involves the installation of

Applicability criteria	Justification
renewable power plant was operated prior to the implementation of the project activity (Greenfield plant); (b) involve a capacity addition; (c) involve a retrofit of (an) existing plant(s); or (d) involve a replacement of (an) existing plant(s).	new grid connected solar PV power plant.
The project activity is the installation, capacity addition, retrofit or replacement of a power plant/unit of one of the following types: hydro power plant/unit (either with a run-of-river reservoir or an accumulation reservoir), wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit.	Applicable. Project activity involves installation of a new 126.126 MWp ~~101.25 MWp~~ solar PV power plant.
In the case of capacity additions, retrofits or replacements (except for capacity addition projects for which the electricity generation of the existing power plant(s) or unit(s) is not affected):the existing plant 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 or retrofit of the plant has been undertaken between the start of this minimum historical reference period and the implementation of the project activity;	Not applicable. The project activity is a greenfield power plant. It does not involve any retrofit or replacement activities. Hence this criterion is not applicable.
In case of hydro power plants: At least one of the following conditions must apply: • The project activity is implemented in an existing single or multiple reservoirs, with no change in the volume of any of the reservoir or • The project activity is implemented in an existing single or multiple reservoirs, where the volume of any of reservoirs is increased and the power density of each reservoir the project activity, as per the definitions given in the Project Emissions section, is greater than 4 W/m^2 after the implementation of the project activity; or • The project activity results in new single or multiple reservoirs and the power density of each reservoir the power plant, as per the definitions given in the Project Emissions	Not applicable. The project activity does not involve hydro power plant and hence this criterion is not applicable.

Applicability criteria	Justification
section, is greater than 4 W/m^2 after the implementation of the project activity.	
In case of hydro power plants using multiple reservoirs where the power density of any of the reservoirs is lower than 4 W/m^2 after the implementation of the project activity all of the following conditions must apply: • The power density calculated for the entire project activity is greater than 4 W/m^2 • All reservoirs and hydro power plants are located at the same river and where are designed together to function as an integrated project that collectively constitutes the generation capacity of the combined power plant • The water flow between the multiple reservoirs is not used by any other hydropower unit which is not a part of the project activity • The total installed capacity of the power units, which are driven using water from the reservoirs with a power density lower than 4 W/m^2, is lower than 15 MW • The total installed capacity of the power units, which are driven using water from reservoirs with a power density lower than 4 W/m^2, is less than 10% of the total installed capacity of the project activity from multiple reservoirs	Not applicable. The project activity does not involve hydro power plant and hence this criterion is not applicable.
The methodology is not applicable to the following: • 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 • Biomass fired power plants • A hydro power plant that results in the creation of a new single reservoirs or in the increase in an existing single reservoirs where the power	Not applicable. The project activity does not involve any fuel switching from fossil fuel to renewable energy. Also it does not involve biomass fired power plant and hydro power plant. Hence this criterion is not applicable.

Applicability criteria	Justification
density of the reservoir is less than4 W/m^2	
In the case of retrofits, 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, i.e. 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 applicable. Since this project activity does not involve any retrofit/ replacement/ capacity addition, this criterion need not be proved

From the above justification, it can be clearly seen, that the proposed project activity is applicable under the baseline methodology ACM0002 (version 12.3.0, EB 66).

Applicability of the tools mentioned in the methodology is discussed below:

Tool to calculate the emission factor for an electricity system (version 02.2.1, EB 63):

The geographic and system boundaries for the relevant electricity grid can be clearly identified and information on the characteristics of the grid is available.	Applicable. The geographic and system boundaries of the project connected electricity grid (the national grid of Thailand) can be clearly identified. Official information on the characteristics of the grid is also available. Details are provided in Appendix 4.

Tool for the demonstration and assessment of additionality, (version 07.0.0, EB 70):

This tool provides for a step-wise approach to demonstrate and assess additionality. These steps include: • Demonstration whether the proposed project activity is the first-of-its-kind • Identification of alternatives to the project activity • Investment analysis to determine that the proposed project activity is either: 1) not the most economically or financially attractive, or 2) not economically or financially feasible • Barriers analysis and • Common practice analysis.	Applicable. Additionality of the project activity has been proved by this tool. Alternatives have been identified and an investment analysis along with the sensitivity analysis has been carried out. In addition, common practice analysis is used to further justify the project activity's additionality.

The use of the "Tool for the demonstration and assessment of additionality" is not mandatory for project participants when proposing new methodologies. Project participants may propose alternative methods to demonstrate additionality for consideration by the Executive Board. They may also submit revisions to the approved methodologies using the additionality tool.	Not applicable. The project participants are not proposing new methodology and hence this criterion is not applicable.
Once the additionally tool is included in an approved methodology, its application by project participants using this methodology is mandatory.	Applicable. The proposed project activity refers to the approved methodology ACM0002 (version 12.3.0, EB 66) which mandates the use of "Tool for the demonstration and assessment of additionality". The proposed project activity uses the tool for demonstrating the project's additionality.

B.3. Project boundary
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According to the methodology ACM0002 (version 12.3.0, EB 66), the spatial extent of the project boundary includes the project power plant and all the power plants connected physically to the electricity system that the CDM project power plant is connected to.

In the case of the proposed project activity, the project boundary includes the solar PV power plant with installation capacity 126.126 MWp ~~101.25 MWp~~ (90 MW_{AC}) and the Thai National grid to which the power plant is connected.

The project boundary is illustrated in Figure 4 as follows (the arrows indicate the direction of the electricity flow):

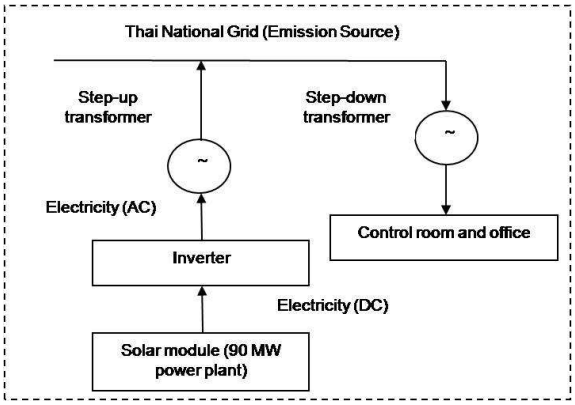

Figure 4 : Project boundary

The following table shows the sources of gases that are included in the 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 due to ACM0002, only CO_2 emissions from electricity generation is accounted for.
		CH_4	No	Excluded
		N_2O	No	Excluded
	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
		CH_4	No	Not applicable
		N_2O	No	Not applicable
Project scenario	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
		CH_4	No	Not applicable
		N_2O	No	Not applicable
	For hydro power plants, emissions of CH_4 from the reservoir	CO_2	No	Not applicable
		CH_4	No	Not applicable
		N_2O	No	Not applicable

B.4. Establishment and description of baseline scenario

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According to the methodology ACM0002, (version 12.3.0, EB 66), if the project activity is the installation of a new grid-connected renewable power plant/unit, 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".

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

Grid emission factor (GEF) of the baseline scenario is calculated using "Tool to calculate the emission factor for an electricity system", (version 02.2.1 EB 63). The details of GEF calculation is given in Appendix 4.

B.5. Demonstration of additionality
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The additionality of the project activity is demonstrated and assessed using the "Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70).

In accordance with the definition stated in CDM glossary, (version 07.0, EB 70), "In the context of a CDM project activity or PoA CPA, the starting date is the the earliest date at which either the implementation or construction or real action of a CDM project activity or PoA CPA begins". The starting date of the project activity is determined as 22/06/2011 which is the date on which the project participant purchased the land for the project activity.

According to paragraph 2 of "Guidelines on the demonstration and assessment of prior consideration of the CDM" (version 04, EB 62), 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 date. As indicated earlier the project start date is identified as 22/06/2011.The project participant informed Thai DNA on 17/08/2011 and UNFCCC secretariat on 21/08/2011.Both the communication are within 6 months of the project start date.

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

Table 2: Prior consideration of CDM

Event	Project implementation activity	CDM application activity	Evidence
Equipment proposal from supplier	03/01/2011		Proposal from supplier
Board decision to undertake the project as CDM project activity	18/03/2011		Meeting minutes
Contract with CDM consultant		22/04/2011	Contract
Land Purchase	22/06/2011		Land purchase agreement
Submission of LOI to Thai DNA		17/08/2011	Submission letter
Submission of notification to UNFCCC		21/08/2011	Email
Thai DNA confirmation on the receipt of LOI		02/09/2011	Letter
UNFCCC confirmation on notification		04/10/2011	Email
Stakeholders consultation		08/02/2012	Meeting minutes
Submission project to TGO for requesting LOA		16/03/2012	Submission letter
Global Stakeholder process		14/04/2012 to 13/05/2012	UNFCCC website[5]
Company's registration for EA Solar Nakornsawan Co., Ltd.	24/08/2012		Affidavit
Signed substation construction agreement between Energy Absolute Public Co., Ltd and SIEMENS., Ltd	19/09/2012		Signed agreement

[5] http://cdm.unfccc.int/Projects/Validation/DB/UUM40DAKOJZTIMI0XEX64XCQKYHVRN/view.html

Event	Project implementation activity	CDM application activity	Evidence
Project registered with CDM EB		11/12/2012	UNFCCC website
Power Purchase Agreement (PPA) novation from Energy Absolute Public Co., Ltd. to EA Solar Nakornsawan Co., Ltd. with PEA	23/01/2013		Signed Novation PPA
Signed Engineering Procurement and Construction (EPC) Contract between EA Solar Nakornsawan Co., Ltd.with supplier	30/04/2013		Signed EPC contract
Substation construction agreement novation from Energy Absolute Public Co., Ltd. to EA Solar Nakornsawan Co., Ltd. with SIEMENS., Ltd	13/06/2013		Signed Novation agreement
Land purchase agreement between Energy Absolute Public Co., Ltd. to EA Solar Nakornsawan Co., Ltd.	03/07/2013		Signed agreement

In summary, the above chronology of events clearly demonstrates that the incentive from the CDM was seriously considered in the decision to undertake the project as a CDM project activity.

"Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70), provides a step-wise approach to demonstrate the additionality. These steps include:

0. Demonstration whether the proposed project activity is the first-of its-kind;
1. Identification of alternatives to the project activity;
2. Investment analysis;
3. Barriers analysis; and
4. Common practice analysis

Step 0: Demonstration whether the proposed project activity is the first-of its-kind

Since this step is optional, it is skipped.

It is considered that the proposed project activity is not a first-of-its kind project activity.

Step 1: Identification of alternatives to the project activity consistent with mandatory laws and regulations

The project activity is the installation of new grid-connected renewable energy power plant/unit. According to methodology ACM0002 (version 12.3.0, EB 66), if the project activity is the installation of a new grid-connected renewable energy power plant/unit, the baseline scenario is identified as 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".

This eliminates the requirement on the identification of the alternatives to the project activity.

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

Since the baseline scenario has been chosen based on the guidance given in the methodology, this step is not required and hence skipped.

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

Since the baseline scenario has been chosen based on the guidance given in the methodology, this step is not required and hence skipped.

Step 2: Investment analysis

Sub-step 2a: Determine appropriate analysis method

"Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70), provides three analysis methods: "Simple cost analysis" (option I), "Investment comparison analysis" (option II), and "Benchmark analysis" (option III).

Since the project activity includes income revenue from sale of electricity other than CER revenue, simple cost analysis is not possible.
Paragraph 19 of "Guidelines on the Assessment of Investment Analysis" (version 05, EB 62), states the following,

"If the proposed baseline scenario leaves the project participant no other choice than to make an investment to supply the same (or substitute) products or services, a benchmark analysis is not appropriate and an investment comparison analysis shall be used. If the alternative to the project activity is the supply of electricity from a grid this is not to be considered an investment and a benchmark approach is considered appropriate".

Since the baseline situation of project activity does not require additional investment and the project activity is the supply of electricity to a grid, investment comparison analysis is not suitable and only benchmark analysis is considered appropriate, in line with paragraph 19 of "Guidelines on the Assessment of Investment Analysis" (version 05, EB 62).

Sub-step 2b: Option III- Apply benchmarking analysis

Paragraph 12, 13 and 18 of "Guidelines on the Assessment of Investment Analysis", (version 05, EB 62), states the following

"In cases where a benchmark approach is used the applied benchmark shall be appropriate to the type of IRR calculated. Local commercial lending rates or weighted average costs of capital (WACC) are appropriate benchmarks for a project IRR. Required/expected returns on equity are appropriate benchmarks for equity IRR. Benchmarks supplied by relevant national authorities are also appropriate if the DOE can validate that they are applicable to the project activity and the type of IRR calculation presented."

"In the cases of projects which could be developed by an entity other than the project participant, the benchmark should be based on parameters that are standard in the market. The DOE's validation of the benchmark shall also include its opinion on whether a company-specific benchmark or a benchmark based on parameters that are standard in the market is suitable in the context of the underlying project activity."

"If the benchmark is based on parameters that are standard in the market, then the typical debt/equity finance structure observed in the sector of the country should be used. If such information is not readily available, 50% debt and 50% equity financing may be assumed as a default."

With reference to the above three guidance, since the project proponent wishes to use the project IRR for benchmark analysis, weighted average cost of capital (WACC) is taken as the appropriate benchmark. And the benchmark has been calculated based on the parameters that are standard in the market.

The following formula is the, the most commonly recognized formula for WACC calculation.

$$WACC = [(1 - Tax) * W_d * K_d] + [W_e * K_e]$$

Where,

Tax = Corporate Tax
W_d = Fraction of Debt
K_d = Cost of Debt
W_e = Fraction of Equity
K_e = Cost of Equity or Expected Return on Equity

As the project proponent board decided to implement this project activity on 18/03/2011 input values used in the WACC calculation are based on the available standard information in the market during year 2006 – 2010[6].

The following table represents the values used for the WACC calculation and their result based on the formula.

Parameter	Value	Comment
T: Corporate tax rate	0%	Pre-tax basis
W_d: Fraction of Debt[7]	52.26%	Relevant industry ROE

[6] At the time of making the investment decision, the latest available information for Return on Equity (ROE), Fraction of Debt (Wd) and Fraction of Equity (We) was up to the end of the year 2010 only.

Parameter	Value	Comment
W_e: Fraction of Equity[8]	47.74%	Relevant industry ROE
K_d: Cost of Debt[9]	6.84%	Average of Thai commercial bank MLR at the time of make decision
K_e: Cost of Equit[10]	19.26%	Relevant industry ROE
WACC: Weighted average cost of capital (pre-tax)	12.77 %	Calculated value

The above benchmark is based on parameters that are standard in the market such as the typical debt/equity finance structure from the energy sector of Thailand. If the default value, according to paragraph 18 of "Guidelines on the Assessment of Investment Analysis" (version 05, EB 62), at 50% debt and 50% equity financing has been used, then the WACC is around 13.05%.

Therefore, conservatively, WACC (pre-tax) of 12.77% is adopted as the benchmark for this project activity.

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

Paragraph 6 of "Guidelines on the Assessment of Investment Analysis" (version 05, EB 62), states the following:

"Input values used in all investment analysis should be valid and applicable at the time of the investment decision taken by the project participant. The DOE is therefore expected to validate the timing of the investment decision and the consistency and appropriateness of the input values with this timing. The DOE should also validate that the listed input values have been consistently applied in all calculations." The following table includes the basic data used for IRR calculation for the project activity:

Parameter	Unit	Value
Total investment cost[11]	Million THB	9,491.09~~9,438.5~~

[7]Fraction of Debt is obtained from the SET's market statistics of the companies listed in energy sector of Stock Exchange of Thailand during year 2006-2010. http://www.set.or.th/en/market/market_statistics.html

[8]Fraction of Equity is obtained from the SET's market statistics of the companies listed in energy sector of Stock Exchange of Thailand during year 2006-2010. http://www.set.or.th/en/market/market_statistics.html

[9]Minimum Lending Rate (MLR), of all commercial banks registered in Thailand during year 2006-2010. is used to represent the cost of debt. This data is obtained from the Bank of Thailand. http://www.bot.or.th/english/statistics/financialmarkets/interestrate/_layouts/application/interest_rate/IN_Rate.aspx

[10]Return on Equity (ROE), of the companies listed in energy sector of Stock Exchange of Thailand during year 2006-2010. , is used to represent the cost of equity. This data is obtained from the SET's market statistics. It is calculated as net profits divided by the equities.

[11] The investment cost includes the land cost, sub-station cost, EPC contract cost. Sub-station cost and EPC costs are based on the signed contract with the ~~the proposal from~~ supplier dated 30/04/2013~~3 January 2011~~. Interest during construction, front end fee and commitment fee are ignored for conservative.

Parameter	Unit	Value
Expected lifetime	Years	25
Electricity tariff rate[12]	THB/kWh	9.6789
Turn-key O & M cost[13]	Million THB/year	32.95
Management cost[14]	Million THB/year	3.90
Plant load factor (PLF)[15]	%	17.6917.14
Insurance[16]	% of EPC	0.25
Total electricity generation[17] (during 25 years)	MWh	3,486,1413,379,117
Project IRR (pre-tax)	%	10.269.78

As per paragraph 3 of "Guidelines for the reporting and validation of Plant load factors", (version 01, EB 48), the plant load factor shall be defined according to one of the following options:

(a) The plant load factor provided to banks and/or equity financiers while applying the project activity for project financing, or to the government while applying the project activity for implementation approval
(b) The plant load factor determined by a third party contracted by the project participants (e.g. an engineering company);

The PLF has been taken from the documents submitted to Bank for loan approval. This is in line with "option 3 (a) of Guidelines for the reporting and validation of Plant load factors", (version 01, EB 48).

As the project IRR 10.269.78% is lower than that of the benchmark (12.77 %), it is concluded that the project activity is not financially attractive.

Sub-step 2d: Sensitivity Analysis

[12] Calculated the base tariff based on data from EGAT during January 2011 at 2.9278 Baht/kWh (peak), 1.1154 Baht/kWh (off peak), Ft 0.8668 Baht/kWh. (http://www.ppa.egat.co.th/Sppx/timeofUse/2554/ft0111.pdf)
Adder at 6.5 Baht/kWh on top of the electricity tariff is considered for the first 10 years according to EPPO (http://www.eppo.go.th/nepc/kpc/kpc-131.htm).
.

[13] According to the quotation from supplier date 3 January 2011

[14] Management cost which includes the labour cost of different types of power plant staffs at site is an internal estimate of the project participant

[15] Plant Load Factor (PLF) = Annual average output of solar photovoltaic power plant (for 25 years) / annual maximum output of solar photovoltaic power plant (90*24*365); Therefore, PLF = 139,446 135,165 /788,400 = 17.6917.14%.

[16] According to the quotation from supplier date 3 January 2011

[17] This figure is based on the guarantee figure from supplier

In order to demonstrate the investment barriers to the proposed project activity, a sensitivity analysis is also carried out for the relevant variables. The sensitivity analysis of the project activity has been conducted to show whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions.

According to paragraph 20 of the "Guidelines on the Assessment of Investment Analysis", (version 05, EB 62),

"Only variables, including the initial investment cost, that constitute more than 20% of either total project costs or total project revenues should be subjected to reasonable variation (all parameters varied need not necessarily be subjected to both negative and positive variations of the same magnitude), and the results of this variation should be presented in the PDD and be reproducible in the associated spread sheets."

In accordance to the above guidance, the following financial parameters were taken as factors for sensitive analysis:

- Total investment cost
- Electricity tariff rate (base price only as adder will be fixed for the whole 10 years)
- Electricity generation

In the sensitivity analysis, variations of ±10% have been considered in the critical assumptions. A summary of the results of sensitivity analysis is provided in the following table:

Variables	Project IRR @ 25 years		Breakeven point[18]
	Increasing variable by 10%	Decreasing variable by 10%	
Total investment cost	-	12.2611.75%	Decrease 12.314%
Electricity price	11.3810.55%	-	Increase 4129.0%
Electricity generation	12.4911.65%	-	Increase 11.516%

Total investment cost

As tThe project IRR (pre-tax) increases only when the investment cost decreases. The investment in the investment analysis is the actual cost which project owner has signed with supplier. Therefore this cost has been fixed. cost includes land, cost of supply, cost of services etc. The cost of supply involves the cost of all equipments & machineries including structural and supplies for civil works. The contract with the equipment supplier is based on turnkey equipment supply. The investment cost for the project activity on turnkey basis, includes the cost of service required for design, engineering, erection, construction, installation, testing, commissioning and remedy of defects in connection and related to the project activity. The total EPC cost of supply and services is considered as per the proposal received from the supplier. Only the actual cost components to be incurred in accomplishing the project activity are considered under project cost. Although a decrease of 10%, which is impossible, in the investment cost makes the project IRR still lowerhigher than the benchmark, it is impossible to decrease the project cost by 10%. The recent

[18]The breakeven point is the magnitude for sensitivity of the variable parameters that will make IRR equal to the benchmark.

~~catastrophic flood has increased the material cost considerably. Also the demand for labour has risen enormously leading to increased labour cost. In addition, recently, Thai government has implemented a labour law which has fixed minimum wages for labour. All these have contributed to increased investment cost. Hence the possibility of decreasing the project cost is absent.~~ In this context, it may be stated that even if the project cost is reduced by 10%, the project would remain additional.

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Electricity price:

With the increase in electricity price, the project IRR also increases. If the electricity price is increased by 29.0%~~41%~~, the project IRR (pre-tax) reaches the benchmark. According to the unit price of electricity published by EGAT since January 2009 till June 2011, the highest electricity unit price was 3.2611 Baht/kWh[19] (May 2011) which is only 2.59% higher than the estimated electricity price, of 3.1789 Baht/kWh used in the project IRR calculation. Hence, it is very unlikely and impossible for the electricity price to increase by 29.0%~~41%~~.

Electricity Generation:

The electricity generation is mainly based on four parameters, installed capacity, solar radiation, overall efficiency of the system and annual degradation. Installed capacity of the power plant is a fixed one. The other 3 parameters are based on the guaranteed figure from supplier and the available public information. Only if the electricity generation increases by 11.5%, ~~around 16%,~~ the project IRR meets the benchmark IRR. The solar radiation for the project site is a taken from credible source (NASA) and is also the value used by the supplier for guaranteed electricity generation. Therefore, increasing the electricity generation by 11.5% ~~around 16%~~ is not possible. A 10% positive change does not help much and project IRR remains below the benchmark rate.

Outcome of step 2:

Thus, the investment analysis shows that the project activity is not a financially attractive option and the sensitivity analysis shows that it is unlikely to be financially attractive compared to the benchmark under reasonable variations in the assumptions.

When the CDM revenue is accounted, the project IRR is slightly improved to 10.53%.Therefore; the project proponent has considered the CDM revenue and decided to pursue the development of the project activity with the help of CDM.

Step 3: Barrier analysis

Consistent with the choices given in the "Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70), the project proponent decided to prove the project's additionality by means of the investment analysis, thus the barrier analysis is skipped.

Step 4: Common practice

The Thailand grid heavily depends upon the thermal power generation, such as petroleum, coal and mostly natural gas for its energy source. The electricity generation by photovoltaic power plant is classified as a part of the "others" group which is 1.5% and 1.8% of total power generation for year 2008 and 2009, respectively. It is evident that the prevailing practice of electricity generation in Thailand is

[19] The electricity unit cost consists of 2 parts: (1) base price which has remained constant at 2.3121 Baht/kWh since January 2009 to June 2011 and (2) Ft which has varied from 0.8668 – 0.9490 Baht/kWh. The unit electricity price between January 2009 and June 2011 has varied between 3.1789 – 3.2611 Baht/kWh.

generated by fossil fuel while the renewable energy technology including solar PV technology is a new technology penetrating into Thailand's electricity market.

The list of solar PV power plants (technology) having comparable capacities are as follows[20]:

Company Name	Location	Export to Grid (MW)	Fuel	COD date	CDM status
Natural Energy Development Co., Ltd.	Lopburi province	55.00	Solar PV	01/11/2011 [21]	Registered[22]
Bangchak Petroleum Public Company Limited	Ayutthaya province	38.00	Solar PV	-	Under Validation. Received LoA from DNA
Energy Absolute Public Co., Ltd.	Nakonsawan province[23]	90.00	Solar PV	01/12/2013	Received LoA from DNA
Energy Absolute Public Co., Ltd.	Lampang province	90.00	Solar PV	01/2/2014	Under Validation[24]. Received LoA from DNA
Energy Absolute Public Co., Ltd.	Pitsanulok province	90.00	Solar PV	01/12/2015	Under Validation[25]. Received LoA from DNA
SPP Six Co., Ltd.	Lopburi province	41.00	Solar PV	01/12/2012	
Serm Sarng Palungngarn Co.,Ltd.	Lopburi province	40.00	Solar PV	01/10/2013	
Demco Public Company Limited	Ubonratchathani province	30.00	Solar PV	31/05/2012	
CLP Power (Thailand) Co.,Ltd.	Lopburi province	50.00	Solar PV	01/11/2013	
Natural Energy Development	Lopburi province	35.00	Solar	01/11/2013 -	

[20] http://www.eppo.go.th/power/data/index.html
[21] Commissioning of the first stage is expected to start in November 1, 2011and full operation is to commerce in May 1, 2012
[22] http://cdm.unfccc.int/Projects/DB/LRQA%20Ltd1312465274.35/view
[23] Current project activity
[24] http://cdm.unfccc.int/Projects/Validation/DB/42GV3HPJ109RE26CZ9GOYFA77O89GK/view.html
[25] http://cdm.unfccc.int/Projects/Validation/DB/QPP82AT7HQOBH2YBLVKS69IGDZLDSI/view.html

Company Name	Location	Export to Grid (MW)	Fuel	COD date	CDM status
Co.,Ltd.			PV	01/06/2014	
Bangchak Petroleum Public Company Limited	Chaiyaphum province	50.00	Solar PV	01/12/2012	

According to paragraph 13 (b) (definition section) of "Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70), **measure** (for emission reduction activities) is a broad class of greenhouse gas emission reduction activities possessing common features. Four types of measures are currently covered in the framework:

(i) Fuel and feedstock switch (example: switch from naphtha to natural gas for energy generation, or switch from limestone to gypsum in cement clinker production);
(ii) Switch of technology with or without change of energy source (including energy efficiency improvement as well as use of renewable energies)(example: energy efficiency improvements, power generation based on renewable energy);
(iii) Methane destruction (example: landfill gas flaring);
(iv) *Methane formation avoidance (example: use of biomass that would have been left to decay in a solid waste disposal site resulting in the formation and emission of methane, for energy generation)*

From the above measures, measure (ii) is applicable to this project activity. Hence sub-step 4(a) of the "Tool for the demonstration and assessment of additionality" (version 07.0.0, EB 70), is applied.

Sub-step 4a: The proposed CDM project activity(ies) applies measure(s) that are listed in the definitions section above

If the proposed project activity applies the measure that are listed in the definition, then, according to the additionality tool, "Guidelines on Common Practice", version 02.0, EB 69 shall be used for carrying out common practice analysis.

Paragraph 3 and 4 of "Guidelines on Common Practice", version 02.0, EB 69, suggests the following:

Output *is goods/services produced by the project activity including, among other things, heat, steam, electricity, methane, and biogas unless otherwise specified in the applied methodology.*

Different technologies *are technologies that deliver the same output and differ by at least one of the following (as appropriate in the context of the measure applied in the proposed clean development mechanism (CDM) project activity and applicable geographical area):*

(a) Energy source/fuel (example: energy generation by different energy sources such as wind and hydro and different types of fuels such as biomass and natural gas);
(b) Feed stock (example: production of fuel ethanol from different feed stocks such as sugar cane and starch, production of cement with varying percentage of alternative fuels or less carbon-intensive fuels);

(c) Size of installation (power capacity)/energy savings:

i. Micro (as defined in paragraph 24 of decision 2/CMP.5 and paragraph 39 of decision 3/CMP.6);
ii. Small (as defined in paragraph 28 of decision 1/CMP.2);
iii. Large.

(d) Investment climate on the date of the investment decision, inter alia:
i. Access to technology;
ii. Subsidies or other financial flows;
iii. Promotional policies;
iv. Legal regulations;

1. Other features, inter alia:
i. Nature of the investment (example: unit cost of capacity or output is considered different if the costs differ by at least 20 %).

Stepwise approach for common practice

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

The applicable range of +/-50% of the design output or capacity of the proposed project activity (90 MW_{AC}) is from 45 MW to 135 MW.

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

Step 2 (a): The projects are located in the applicable geographical area

- Since the project activity is located at Thailand, PV power plant projects in the same geographical area (Thailand) is shown in the below table fulfilling this requirement.

Step 2 (b): The projects apply the same measure as the proposed project activity

- The proposed project activity comes under measure *(b) "Switch of technology with or without change of energy source including energy efficiency improvement as well as use of renewable energies (example: energy efficiency improvements, power generation based on renewable energy)"* because solar energy is a type of renewable energy.

- The identified projects as shown in the below table also come under solar PV technology. This fulfils this requirement because measure of the proposed project activity plant and the projects in the below apply the same measure.

Step 2 (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

- Since the proposed project activity uses solar energy as energy source, PV power plant projects as identified in the below table fulfils this requirement due to the use of same energy source.

Step 2 (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

- The output of proposed project activity, electricity, is supplied to Thai national grid. The PV power plant projects as identified in below table fulfils this requirement as their output, electricity is also supplied to the grid. .

Step 2 (e): The capacity or output of the projects is within the applicable capacity or output range calculated in Step 1

- The PV power plant project as shown in below table have installation capacity in range of +/- 50% (45 MW_{AC} to 135 MW_{AC}) of the installation capacity of the proposed project activity (90 MW_{AC}) and fulfils this requirement.

Considering the above conditions from 2 (a) to 2 (e), from the "*Table: List of solar PV power plants (technology) having comparable capacities", l*ist of similar plants within the range is deduced and is given below:

Company Name	Location	Export to Grid (MW)	Fuel	COD date	CDM Status
Natural Energy Development Co., Ltd.	Lopburi province	55.00	Solar PV	01/11/2011 [26]	Registered[27]
Energy Absolute Public Co., Ltd.	Phitsanulok province	90.00	Solar PV	01/12/2015	Under Validation[28]. Received LoA from DNA
Energy Absolute Public Co., Ltd.	Lampang province	90.00	Solar PV	01/12/2014	Under Validation[29]. Received LoA from DNA
CLP Power (Thailand) Co.,Ltd.	Lopburi province	50.00	Solar PV	01/11/2013	N/A
Bangchak Petroleum Public Company Limited	Chaiyaphum province	50.00	Solar PV	01/12/2012	N/A

[26] Commissioning of the first stage is expected to start in November 01, 2011 and full operation is to commerce in May 01, 2012
[27] http://cdm.unfccc.int/Projects/DB/LRQA%20Ltd1312465274.35/view
[28] http://cdm.unfccc.int/Projects/Validation/DB/QPP82AT7HQOBH2YBLVKS69IGDZLDSI/view.html
[29] http://cdm.unfccc.int/Projects/Validation/DB/42GV3HPJ109RE26CZ9GOYFA77O89GK/view.html

Step 2 (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.

- Since the proposed project activity start date was 22/06/2011 and the PDD was published for global stakeholder consultation on 14/04/2012, the earlier date among them is the project start date on 22/06/2011. Therefore, there is no PV power plant in Thailand where has commercial operation date before the project start date.

Step 3: Within plants 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}.

Therefore, $N_{all} = 0$.

Step 4: Within similar projects identified in Step 3, identify those that apply technologies that are different to the technology applied in the proposed project activity. Note their number N_{diff}

$N_{diff} = 0$.

Step 5: Calculate factor $F=1-N_{diff}/N_{all}$

F = 1 – 0/0
F = 1

As per the paragraph 10 of "Guidelines on Common Practice", version 02.0, EB 69,

The proposed project activity is a "common practice" within a sector in the applicable geographical area if the factor F is greater than 0.2 and N_{all}-N_{diff} is greater than 3.

Calculation of N_{all}-N_{diff}

N_{all}-N_{diff} = 0 and this is less than 3.

Here, as N_{all}-N_{diff} is less than 3, it can be concluded that the proposed project activity is **NOT a 'common practice'**.

Sub-step 4b: The proposed CDM project activity(ies) does not apply any of the measures that are listed in the definitions section above

Not applicable.

Outcome of Step 4:

If similar activities were widely observed and commonly carried out, it calls into question the claim that the proposed project activity is financially unattractive. However, as described in the previous step, the proposed project activity technology (solar PV) is not commonly practiced.

It is clear from the above steps that similar activity is not commonly carried out. Hence the proposed project activity is considered to be additional.

B.6. Emission reductions

B.6.1. Explanation of methodological choices

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Equations provided by methodology ACM0002, (version 12.3.0, EB 66), are used to calculate project emissions, baseline emissions, leakage and emission reductions.

Baseline emission (BE_y)

Baseline emissions include only CO_2 emissions from electricity generation in grid connected fossil fuel fired power plants that are displaced due to the project activity. 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 therefore are calculated as follows:

$$BE_y = EG_{PJ,y} \cdot EF_{grid,CM,y}$$

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)

$EF_{grid,CM,y}$ = Combined margin CO_2 emission factor for grid connected power generation in year *y*

The calculation of $EG_{pj,y}$ is different for

(a) greenfield renewable energy power plants, formula 7 in methodology ACM0002 (version 12.3.0, EB 66)
(b) retrofits and replacements of an existing renewable energy power plant, formula 8 in methodology ACM0002 (version 12.3.0, EB 66)
(c) capacity additions to an existing renewable energy power plant, formula 10 in methodology ACM0002 (version 12.3.0, EB 66)

Since the project activity is Greenfield renewable energy power plant, $EG_{PJ,y}$ is calculated using the following formula

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

Where:

$EG_{PJ,y}$ = 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)

$EG_{facility,y}$ = Quantity of net electricity generation supplied by the project plant/unit to the grid in year *y* (MWh)

Combined margin CO_2 emission factor for grid connected power generation in year *y* ($EF_{grid,CM,y}$) is calculated using the latest version the "Tool to calculate the emission factor for an electricity system" (t CO_2e/MWh) (version 02.2.1, EB 63).

The following procedure was adopted for estimating the grid electricity emission factor:

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 calculation method and the detailed calculation of Thai grid emission factor is given in Appendix4. In this project activity, Grid emission factor has been calculated and fixed ex-ante.

Parameter	Units	Value
Operating margin	t CO_2/MWh	0.5996
Built margin	t CO_2/MWh	0.4231
Combined margin	t CO_2/MWh	0.5554

Project emissions (PE_y)

For most renewable power generation project activities, $PE_y = 0$. However, some project activities may involve project emissions that can be significant. These emissions shall be accounted for as project emissions by using the following equation:

$$PE_y = PE_{FF,y} + PE_{GP,y} + PE_{HP,y}$$

Where:
PE_y = Project emissions in year *y* (t CO_2e)
$PE_{FF,y}$ = Project emissions from fossil fuel consumption in year *y* (t CO_2)
$PE_{GP,y}$ = Project emissions from the operation of geothermal power plants due to the release of non-condensable gases in year *y* (t CO_2e)
$PE_{HP,y}$ = Project emissions from water reservoirs of hydro power plants in year *y* (t CO_2e)

According to the methodology ACM0002 (version 12.3.0, EB 66), only for geothermal and solar thermal projects, which use fossil fuels for electricity generation, CO_2 emissions from the combustion of fossil fuels shall be accounted for as project emissions ($PE_{FF,y}$). It shall be calculated as per the latest version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". Since the project activity does not involve any of these technologies, this tool is not used and hence the project emission from the project activity due to fossil fuel combustion is taken as zero.

$PE_y = 0$

Leakage

No leakage emissions are considered. The main emissions potentially giving rise to leakage in the context of electric sector projects are emissions arising due to activities such as power plant construction and upstream emissions from fossil fuel use (e.g. extraction, processing and transport). These emissions sources are neglected.

Emission reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \quad \textbf{(1)}$$

Where:

ER_y = Emission reductions in year *y* (t CO_2e)
BE_y = Baseline emissions in year *y* (t CO_2)
PE_y = Project emissions in year *y* (t CO_2e)

B.6.2. Data and parameters fixed ex ante

Data / Parameter	**$FC_{i,y}$**
Unit	Mass or volume unit
Description	Amount of fossil fuel type i consumed in the project electricity system in year y
Source of data	"Electricity Statistic Annual Report 2010", published by 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 02.2.1, EB 63)
Purpose of data	
Additional comment	-

Data / Parameter	**$NCV_{i,y}$**
Unit	GJ/mass or volume unit
Description	Net calorific value (energy content) of fossil fuel type *i* in year *y*
Source of data	"Electric Power in Thailand 2010", published by the 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 02.2.1, EB 63)
Purpose of data	
Additional comment	-

Data / Parameter	$EF_{CO2,i,y}$
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 02.2.1, EB 63).
Purpose of data	-
Additional comment	

Data / Parameter	EG_y
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	"Electricity Statistic Annual Report 2008-2010", published by 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 02.2.1, EB 63)
Purpose of data	
Additional comment	-

Data / Parameter	$FC_{i,m,y}$
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 Statistic Annual Report 2010", published by 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 02.2.1, EB 63).
Purpose of data	
Additional comment	-

Data / Parameter	$EG_{m,y}$
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 Statistic Annual Report 2010", published by 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 02.2.1, EB 63).
Purpose of data	
Additional comment	-

Data / Parameter	$EF_{grid,CM,y}$
Unit	t CO_2/MWh
Description	CO_2 emission factor of the grid
Source of data	Calculated
Value(s) applied	0.5554
Choice of data or Measurement methods and procedures	The Grid Emission Factor of Thai National Grid is calculated using the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system" (version 02.2.1, EB 63).
Purpose of data	
Additional comment	This value is used for the entire crediting period.

Data / Parameter	$EF_{grid,OM,y}$
Unit	t CO_2/MWh
Description	Simple Operating Margin
Source of data	Calculated
Value(s) applied	0.5996
Choice of data or Measurement methods and procedures	The Grid Emission Factor of Thai National Grid is calculated using the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system" (version 02.2.1, EB 63).
Purpose of data	
Additional comment	This value is used for the entire crediting period.

Data / Parameter	**$EF_{grid,BM,y}$**
Unit	t CO_2/MWh
Description	Buid Margin
Source of data	Calculated
Value(s) applied	0.4231
Choice of data or Measurement methods and procedures	The Grid Emission Factor of Thai National Grid is calculated using the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system" (version 02.2.1, EB 63).
Purpose of data	
Additional comment	This value is used for the entire crediting period.

B.6.3. Ex ante calculation of emission reductions

>>

Quantity of net electricity generation supplied by the project plant/unit to the grid

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

For ex ante calculation, $EG_{facility,y}$ is taken as the guaranteed electricity figures by project's technology supplier which is estimated as follows:

$$EG_{facility,y} = [C_{name} \times (1 - \%Degrad e_n) \times TF \times SF \times R_{actual} \times AF \times 365\ days] - PL$$

Where:

C_{name}	=	Full name plate capacity, kWp (= 101,250 kWp)
%Degrade	=	Degradation factor, % (= 0.8% of average value through 25 years of project lifetime and 3% in the first year)
n	=	Year
TF	=	Tilt factor of the tilt angle 15° fixed system (= 1.0297)
SF	=	System derating factor, % (= 80.49%)
R_{actual}	=	Solar irradiation, kWh/m^2 /day (= 5.18 kWh/m^2-d or 5.18 h/day)
AF	=	Plan availability factor, % (= 99.50%)
PL	=	Parasitic Load, kWh/year (= 450,000 kWh /y)

Therefore, $EG_{facility,y}$ in ex ante for the first crediting period are summarised in the following table. The guaranteed electricity figures for entire project lifetime are given in Appendix 4:

Year	Energy output warranty (MWh)
1	152,666~~152,682~~
2	151,564~~148,893~~
3	150,463~~146,051~~
4	149,361~~144,157~~
5	148,259~~142,578~~

Year	Energy output warranty (MWh)
6	147,158~~141,315~~
7	146,056~~140,052~~

Baseline emission due to avoided grid electricity (t CO_2e)

Year	BE_y	=	$EG_{PJ,y}$ (MWh/yr)	*	$EF_{grid,CM,y}$ (t CO_2/MWh)
01/12/2013 – 30/11/2014	84,791~~84,799~~	=	152,666~~152,682~~	*	0.5554
01/12/2014 – 30/11/2015	84,179~~82,695~~	=	151,564~~148,893~~	*	0.5554
01/12/2015 – 30/11/2016	83,567~~81,117~~	=	150,463~~146,051~~	*	0.5554
01/12/2016 – 30/11/2017	82,955~~80,065~~	=	149,361~~144,157~~	*	0.5554
01/12/2017 – 30/11/2018	82,343~~79,188~~	=	148,259~~142,578~~	*	0.5554
01/12/2018 – 30/11/2019	81,731~~78,486~~	=	147,158~~141,315~~	*	0.5554
01/12/2019 – 30/11/2020	81,119~~77,785~~	=	146,056~~140,052~~	*	0.5554

Project emission due to project activities (t CO_2e)

The project emission for the project activity is zero.

Estimating the leakage:

The leakage for the project activity is zero

Estimating the emission reduction:

Year	ER_y (t CO_2e/yr)	=	BE_y (t CO_2e/yr)	-	PE_y (t CO_2e/yr)
01/12/2013 – 30/11/2014	84,791~~84,799~~	=	84,791~~84,799~~	-	0
01/12/2014 – 30/11/2015	84,179~~82,695~~	=	84,179~~82,695~~	-	0

Year	ER_y (t CO_2e/yr)	=	BE_y (t CO_2e/yr)	-	PE_y (t CO_2e/yr)
01/12/2015 – 30/11/2016	83,56781,117	=	83,56781,117	-	0
01/12/2016 – 30/11/2017	82,95580,065	=	82,95580,065	-	0
01/12/2017 – 30/11/2018	82,34379,188	=	82,34379,188	-	0
01/12/2018 – 30/11/2019	81,73178,486	=	81,73178,486	-	0
01/12/2019 – 30/11/2020	81,11977,785	=	81,11977,785	-	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)
01/12/2013 – 30/11/2014	84,79184,799	0	0	84,79184,799
01/12/2014 – 30/11/2015	84,17982,695	0	0	84,17982,695
01/12/2015 – 30/11/2016	83,56781,117	0	0	83,56781,117
01/12/2016 – 30/11/2017	82,95580,065	0	0	82,95580,065
01/12/2017 – 30/11/2018	82,34379,188	0	0	82,34379,188
01/12/2018 – 30/11/2019	81,73178,486	0	0	81,73178,486
01/12/2019 – 30/11/2020	81,11977,785	0	0	81,11977,785
Total	**580,686564,136**	**0**	**0**	**580,686564,136**
Total number of crediting years	7			
Annual average over the crediting period	**82,95580,591**	**0**	**0**	**82,95580,591**

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 to the grid in year *y*
Source of data	Export & Import data will be sourced from the electricity meters. The net (Export – Import) electricity would be calculated based on Export & Import data.
Value(s) applied	152,681 (1st year of crediting period)
Measurement methods and procedures	$EG_{facility,y} = EG_{export,y} - EG_{import,y}$ $EG_{export,y}$ and $EG_{import,y}$ will be measured continuously and will be recorded daily. The recorded data will be reported on a monthly basis.
Monitoring frequency	
QA/QC procedures	The value will be cross checked with the records for sold electricity.
Purpose of data	
Additional comment	All data will be stored electronically for the duration of the project activity plus two additional years.

Data / Parameter	$EG_{export,y}$
Unit	MWh
Description	Quantity of electricity supplied by the project to the grid in year *y*
Source of data	Data measured and recorded from the electricity meters installed at the power station
Value(s) applied	152,681 (1st year of crediting period)
Measurement methods and procedures	Continuously measured by installed on-site electricity meter(s) with at least 2% accuracy and will be recorded daily. The recorded data will be reported on a monthly basis.
Monitoring frequency	
QA/QC procedures	Meter will be installed at the power plant substation to monitor the electricity exported to the grid. The meter will be properly calibrated according to the national standard but at least once in a year. Back up meter of same accuracy class will be installed. It will be used in case of any malfunctioning of the main electricity meter. The measurement results will be cross checked with invoices for the sold electricity to the grid.
Purpose of data	
Additional comment	All data will be stored electronically for the duration of the project activity plus two additional years.

Data / Parameter	$EG_{import,y}$
Unit	MWh
Description	Quantity of import electricity by the project activity from the grid in year y
Source of data	Data measured and recorded from the electricity meters installed at the power Station
Value(s) applied	0 (ex-ante)
Measurement methods and procedures	Continuously measured by 3 installed on-site electricity meters~~(s)~~ with at least 2% accuracy and will be recorded daily. The recorded data will be reported on a monthly basis. $EG_{import,y} = EG_{import,y,1} + EG_{import,y,2} + EG_{import,y,3}$
Monitoring frequency	
QA/QC procedures	The meters will be installed at the power plant substation to monitor the electricity imported from the grid. The meters will be properly calibrated according to the national standard but at least once in a year. ~~. Back up meter of same accuracy class will be installed. It will be used in case of any malfunctioning of the main electricity meter.~~ The measurement results will be cross checked with the electricity sales receipts from the national grid.
Purpose of data	
Additional comment	All data will be stored electronically for the duration of the project activity plus two additional years.

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B.7.2. Sampling plan

>>

N/A

B.7.3. Other elements of monitoring plan

>>

In accordance with the methodology ACM0002 (version 12.3.0), data collected as part of monitoring will be archived electronically and be kept at least for 2 years after the end of the last crediting period. In addition, all measurements will be conducted with calibrated measurement equipment according to relevant industry standards.

In accordance with the requirements of the methodology, monitoring will be undertaken by the designated on-site engineer(s) and/or other authorised individuals, using the latest state-of-the-art monitoring equipment.

Composition of CDM team for monitoring

The CDM team will comprise of the following members:

- Plant manager
- Data handling and reporting manager
- QA & QC manager
- Shift in-charge

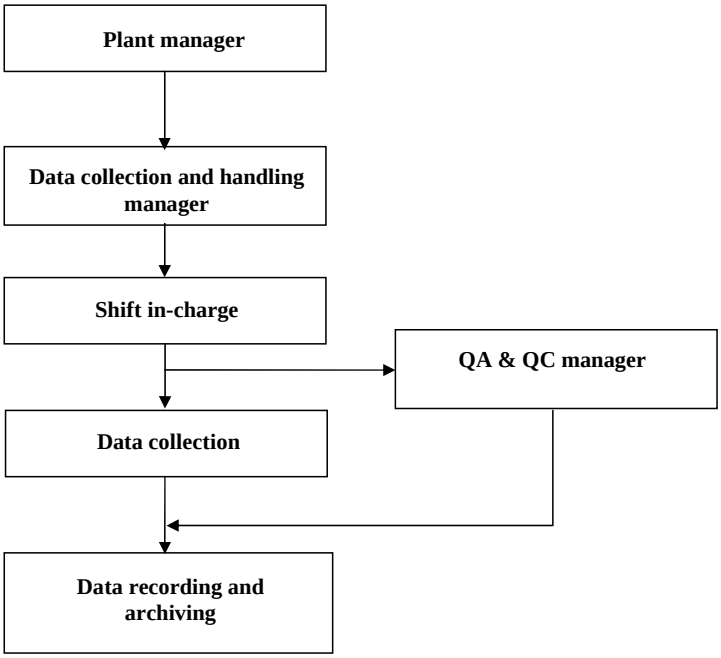

Figure 5: Operation and management structure for monitoring

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

Plant manager:

- Supervision all the monitoring activities

Data handling and reporting manager:

- Reading, recording, handling, reporting and archiving relevant data.
- Ensuring monthly reading and monthly testing on a regular basis.

QA & QC manager:

- Checking the data and taking measures for ensuring precision of the meters.
- Ensuring that the erroneous measurements are detected and reported by any employee involved in the implementation of monitoring plan

Shift in-charge:

- Ensuring the data collection on shift basis
- Maintaining a daily log for issues related to power generation

Data collection

The project participant will install electricity meter(s) as follows:

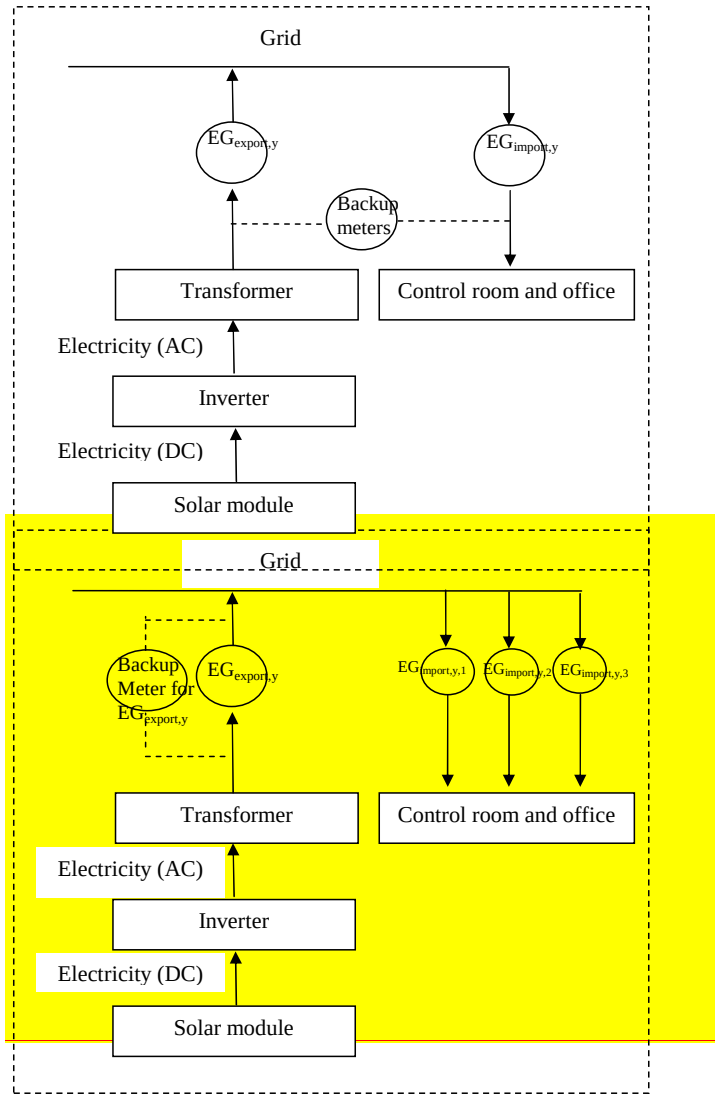

Figure 6: Monitoring Meter Flow Diagram

These meters will continuously monitor the amount of electricity supplied to the grid, store the data in regular intervals, and will allow the project participant to access the readings remotely. The measurement

results will be cross-checked with the electricity sales receipt (export) and electricity bill (import) from EGAT.

Calibration frequency of meters

The meters of the project activity are calibrated according to the national standard at least once in a year by the qualified third party entity.

Monitoring plan

The data collection will be on shift basis. Shift-in-charge will maintain a daily log for issues related to power generation. Data handling and reporting manager will ensure monthly reading and monthly testing on a regular basis.

Data management

Data management systems are used to archive the monitoring data. The meters readings, as well as the relevant information and data source(s) will be archived. Emission reductions of the project activity will be calculated based on the monitoring data. To ensure transparency and conservativeness, excel sheets which include all the relevant data and calculation processes will be provided to DOE for verification. All the relevant documents and monitoring data will be archived electronically and will be kept for at least two years after the end of the crediting period.

Training

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

Emergency preparedness

When erroneous measurement is detected by any employee involved in the implementation of monitoring plan, the erroneous measurement will be reported to the QA & QC manager at once. Staffs will be designated to deal with erroneous measurement. The back-up meter will be used for measurement when the exported main meter on malfunction or inaccuracy.

Maintenance of monitoring equipments

PP 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. Data collection and handling manager, QA&QC manager, and Shift-in-charge would take corrective actions if meters are found not working.

SECTION C. Duration and crediting period
C.1. Duration of project activity
C.1.1. Start date of project activity
>>
22/06/2011 (i.e., signed land purchase date)

C.1.2. Expected operational lifetime of project activity
>>
25 years 0 months

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
>>
01/12/2013 or when registered with the UNFCCC whichever is later

C.2.3. Length of crediting period
>>
7 years 0 months crediting period

SECTION D. Environmental impacts
D.1. Analysis of environmental impacts
>>
The EIA report is required for the thermal based electricity generation projects whose capacity is more than 10 MW. For the solar project, it is not necessary to conduct EIA[30]. However, an Initial Environmental Evaluation (IEE) Report of this CDM project activity has been submitted to the Thai DNA instead of EIA Report

In general, the photovoltaic project causes less environmental impacts when compared to that of a fossil fuel power plant. The major impacts based on national guideline are listed below:

Atmospheric impacts

The electricity generated using the photovoltaic will be supplied to the 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.

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 activity does not have any negative impact on the surrounding water resources.

Noise impacts

[30] According to the declaration letter no. 1009.7/1495 by ONEP

The proposed project activity does not involve any high level noise source. Therefore, the project activity does not have noise impacts which will affect surrounding community. The noise level of project activity will meet the Thai regulation.

D.2. Environmental impact assessment

>>

The environmental impacts are not significant.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

>>

Energy Absolute Public Co., Ltd. has organized the public consultation meeting 2 times. The first meeting was on 2nd February, 2012 at the meeting room of Tumbon Hua Wai Administrative Organization in Nakhonsawan province. The participants were invited by telephonic conversation and there were 330 participants including villagers living near the solar power plant site. The objective of the meeting was to create awareness about the project and to have a more detailed public consultation.

The second public consultation meeting was on 8th February 2012 at the meeting room of Wat Hua Wai in Nakhonsawan province, Thailand. The invitation letters were sent to the representatives of the government, local officials, NGOs, academic institutions, members from the local community living in and around the project area and other relevant people along with the earlier participants. Totally, there were 133 participants including local officials, Tambol Administration Organization and villagers living near the solar power plant. The details of the stakeholder meeting participants are given below:

Organization	Number of participants 02 Feb 2012	Number of participants 08 Feb 2012
Local government officer	17	10
Tambol Administration Organization	20	21
Village Chief	11	11
Villagers	282	91
Total	330	133

In the meeting, detailed information about the project and its benefits were presented by the project developers to the participants. The event provided a forum for all stakeholders to ask questions about the impact of the project activity and to share their opinions. The project activity was represented by owner representatives. The project owner answered the questions regarding the solar technology and impact due to project activity**.**

E.2. Summary of comments received

>>

The public consultation also provided an opportunity to the participants to raise questions which were not specifically related to the context of the project activity. These questions were mostly related to general information regarding the community benefit from the project activity.

The comments and questions from the participants are summarized below:

1. Question: Will there be any extra activity apart from the project activity in this CDM project?

Answer: A fund will be created which will be used to develop/support community nearby, its local culture and traditions and boost its economy.

2. Question: Can it generate electricity when there is no sunshine?

Answer: The project activity will not operate or generate electricity during rain and no sunshine period. Normally, the project activity generates electricity at 8.00-18.00 hours.
3. Question: Are there any other method to generate electricity?

Answer: The solar farm requires high investment. It is very hard to make any adaption at later stages. Any changes needs request for new license because as the power purchase agreement was meant for Solar Photovoltaic technology only.

4. Question: What is the plan at the end of Solar Photovoltaic Panel's life time?

Answer: When the life time of solar photovoltaic panel is over, it can still generate electricity, but low efficiency. Therefore it will be removed and will be returned to the manufacturer for recycling. Moreover, such modules can be kept as a model at schools or can be installed in remote area to generate electricity.

After the meeting, all the participants were asked for their opinion about the project development. Most of the participants agreed for this project activity.

E.3. Report on consideration of comments received
>>
At the beginning of the meeting, the project developers explained the complete details of the project activity to the participants. The key environmental benefits from the solar power plant (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 activity.

SECTION F. Approval and authorization
>>
The Letter of Approval from the host country DNA is not available at the time of submitting the PDD to the validating DOE. However, currently, the Letter of Approval from the host country DNA was received and forwarded to the validating DOE.

- - - - -

Appendix 1:

Appendix 2:

Appendix 3: Contact information of project participants

Organization name	EA Solar Nakornsawan Co., Ltd.~~Energy Absolute Public Co., Ltd.~~
Street/P.O. Box	Viphavadee-Rangsit road
Building	888 I Tower, 15th floor
City	Chatuchak
State/Region	Bangkok
Postcode	10900
Country	Thailand
Telephone	+662 554 9238-42
Fax	+662 554 9243
E-mail	somphote@energyabsolute.co.th
Website	
Contact person	
Title	Managing director
Salutation	Mr.
Last name	Ahunai
Middle name	
First name	Somphote
Department	
Mobile	
Direct fax	+662 554 9243
Direct tel.	+662 554 9238-42
Personal e-mail	somphote@energyabsolute.co.th

Appendix 4: Affirmation regarding public funding

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

Appendix 5: Applicability of selected methodology

Please refer to Section B.2

Appendix 6: Further background information on ex ante calculation of emission reductions

BASELINE INFORMATION

a) Calculation of the Emission Factor for an electricity system

The Emission Factor can be calculated by using Annex 19 Methodological Tool "Tool to calculate the emission factor for an electricity system" (version 02.2.1) which has been approved by the CDM Executive Board on September 29, 2011 (EB 63). 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*
$EF_{grid,OM,y}$	t CO_2/MWh	Operating 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*

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 30th December 2011, 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 02.2.1, EB 63)

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	2006	2007	2008	2009	2010	Average 5 years
Total	139,422	144,364	145,232	145,300	160,191	
Non LC/MR	129,461	133,982	136,116	136,194	152,604	
LC/MR	9,961	10,383	9,116	9,106	7,588	
%LC/MR	7.14	7.19	6.28	6.27	**4.74**	**6.32**

From the above table, it is clear that the LC/MR resources constitute an average of 6.32 % 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 2008-2010 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 2006 – 2010).Therefore, LC/MR data are not included in the OM calculation.

http://www.tgo.or.th/download/publication/GEFReport_EN.pdf

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:

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

$EF_{grid,OMsimple,y}$ = 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[31]	Unit	Net calorific valueF[32] (MJ/Unit)	CO_2 emission[33] (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 the Electricity Statistic Annual Report 2008 – 2010 that provided by EGAT. The quantity of electricity generation data is categorized by electricity generation system, group of power producer (EGAT, IPP and SPP) and type of power plant (LC/MR and Non LC/MR) as shown in Table 2. The data of

[31] See Table: Comparison of name of fuel type
[32] Electric Power in Thailand 2010/ Department of Alternative Energy Development and Efficiency, Ministry of Energy
[33] 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

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. In year 2010, the quantity of electricity sold to the PEA was 1,155.10 GWh[34] (0.72% of the total electricity was generated in 2010).

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 2008 – 2010 was 424,913.67 GWh.

Table 2: Quantity of electricity was generated and transmitted to the national grid[35]

Generation system	Grid generation (GWh)				
	EGAT	IPP	SPP	Total	%
2010					
Summary	78,517.70	67,775.98	13,897.27	160,190.96	100.00
Non LC/MR	73,185.41	67,775.98	11,642.33	152,603.73	95.26
LC/MR[36]	5,332.30	-	2,254.94	7,587.23	4.74
Thermal	27,289.03	15,408.42	2,162.89	44,860.34	
Combined - cycle	38,338.71	52,367.56	8,655.76	99,362.04	
Gas turbine	276.30	-	823.67	1,099.97	
Diesel engine	3.98	-	-	3.98	
Hydropower	5,325.20	-	23.64	5,348.84	
Renewable energy	7.10	-	2,231.30	2,238.40	
Electricity import	7,277.39	-	-	7,277.39	
2009					
Summary	66,488.10	64,840.72	13,971.37	145,300.19	100.00
Non LC/MR	59,541.66	64,840.72	11,811.42	136,193.80	93.73
LC/MR[37]	6,946.44	-	2,159.95	9,106.39	6.27

[34] Provincial Electricity Authority
[35] Electricity Statistic Annual Report 2008 – 2010, Electricity Generating Authority of Thailand
[36] LC/MR power plants include hydropower and renewable energy (including biomass, solar and geothermal power)

Generation system	Grid generation (GWh)				
	EGAT	IPP	SPP	Total	%
Thermal	23,463.69	12,388.03	2,225.63	38,077.39	
Combined - cycle	33,164.46	52,452.69	8,752.19	94,369.35	
Gas turbine	309.63	-	833.60	1,143.23	
Diesel engine	1.44	-	-	1.44	
Hydropower	6,941.74	-	23.97	6,965.71	
Renewable energy	4.70	-	2,135.98	2,140.68	
Electricity import	2,602.43	-	-	2,602.43	
2008					
Summary	63,719.02	67,420.14	14,092.83	145,232.00	100.00
Non LC/MR	56,791.19	67,420.14	11,904.81	136,116.14	93.73
LC/MR	6,927.83	-	2,188.03	9,115.86	6.27
Thermal	26,778.89	14,398.34	1,996.83	43,174.06	
Combined cycle	26,7449.20	53,021.80	9,029.90	88,500.90	
Gas turbine	659.33	-	878.07	1,537.41	
Diesel engine	2.30	-	-	2.30	
Hydropower	6,926.02	-	28.77	6,954.79	
Renewable energy	1.81	-	2,159.26	2,161.07	
Electricity import	2,901.47	-	-	2,901.47	

[37] LC/MR power plants include hydropower and renewable energy (including biomass, solar and geothermal power)

Table 3: Amount of fossil fuel consumed by power plants[38]

Fuel type	Unit	Fuel consumption			
		EGAT	IPP	SPP	Total
2010					
Natural gas	scf.	430,662,249,446	491,131,955,423	151,290,468,150	1,073,084,673,019
Lignite	ton	16,043,174	-	-	16,043,174
Bituminous	ton	-	3,646,898	1,855,262	5,502,160
Bunker	litre	140,084,467	87,347,782	5,797,497	233,229,746
Diesel	litre	11,865,427	10,853,795	1,307,336	24,026,558
2009					
Natural gas	scf.	369,146,214,392	459,228,417,361	140,550,086,056	968,924,717,809
Lignite	ton	15,818,265	-	-	15,818,265
Bituminous	ton	-	3,645,721	1,840,527	5,486,248
Bunker	litre	111,039,065	38,180,874	8,797,506	158,017,445
Diesel	litre	12,140,891	-	1,685,046	13,825,937
2008					
Natural gas	scf.	340,739,529,461	490,866,999,785	145,410,364,035	977,016,893,281
Lignite	ton	16,407,465	-	-	16,407,465
Bituminous	ton	-	3,711,791	1,866,776	5,578,567
Bunker	litre	247,441,682	93,212,260	9,555,452	350,209,394
Diesel	litre	6,792,039	43,698,832	1,451,087	51,941,958

Table 4 shows the calculated CO_2 emission from electricity generation in the years 2008 - 2010 categorized by type of fossil fuel. The total emissions during the 3-years period were 254,714,130 tCO_2.

[38] Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

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 0.5994 /MWh.

Table 4:. CO_2 emission from electricity generation in the year 2008-2010

Fuel type	Fuel consumption		CO_2 emission (kg CO_2/Unit)	CO_2 emission (kg CO_2)
	Unit	Volume		
2010				
Total				88,452,088
Natural Gas	scf.	1,073,084,673,019	0.0554	59,433,868
Lignite	ton	16,043,174	951.7230	15,268,658
Bituminous	ton	5,502,160	2,360.1150	12,985,730
Bunker	litre	233,229,746	3.0026	700,304
Diesel	litre	24,026,558	2.6441	63,528
2009				
Total				82,178,673
Natural Gas	scf.	968,924,717,809	0.0554	53,664,864
Lignite	ton	15,818,265	951.7230	15,054,607
Bituminous	ton	5,486,248	2,360.1150	12,948,176
Bunker	litre	158,017,445	3.0026	474,469
Diesel	litre	13,825,937	2.6441	36,557
2008				
Total				84,083,369
Natural Gas	scf.	977,016,893,281	0.0554	54,113,058
Lignite	ton	16,407,465	951.7230	15,615,362
Bituminous	ton	5,578,567	2,360.1150	13,166,060
Bunker	litre	350,209,394	3.0026	1,051,551
Diesel	litre	51,941,958	2.6441	137,339

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)
2010	88,452,088	152,603.73	0.5796
2009	82,178,673	136,193.80	0.6034
2008	84,083,369	136,116.14	0.6177
Summary	254,714,130	424,913.67	0.5994

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 set of five power units, excluding 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%. Determine their annual electricity generation ($AEG_{>20\%}$);
- from $SET_{5\text{-units}}$ and $SET_{>20\%}$ 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 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 2010) are shown in Table 6. And fuel consumption of these power units are shown in Table 7.

Table 6: Electricity Generation by most recently built power plants[39]

Power unit	Grid generation (GWh)	COD
1. North Bangkok Power Plant (Unit 01)	1,584.22	19-Nov-10
2. Bangpakong Power Plant (Unit 05)	4,643.22	16-Sep-09
3. Phu Kieaw Bio Power Project 2	79.46	15-Sep-09
4. Dan Chang Bio Power Project 2	76.75	15-Sep-09
5. South Bangkok Power Plant (Unit 03)	4,431.92	1-Mar-09
6. Chana Power Plant (Unit 01)	5,090.02	15-Jul-08
7. Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	7,124.72	1-Jul-08
8. Gulf Power Generation Co., Ltd. (Unit 1&2)	9,903.93	1-Mar-08
Summary	32,934.25	
Percentage as of 2010 Grid Generation (160,190.96 GWh)	20.56	

Table 7: Fuel consumptions of the most recently built power plants as listed in Table[40]

Fuel type	Fuel consumption		CO_2 emission (kg CO_2/Unit)	CO_2 emission (t CO_2)
	Unit	Volume		
Total				13,933,411
Natural Gas	scf.	251,512,881,819	0.0554	13,930,292
Lignite	ton	-	951.7230	-
Bituminous	ton	-	2,360.1150	-
Bunker	litre	-	3.0026	-
Diesel	litre	1,179,772	2.6441	3,119

The build Margin Emission Factor calculated by using equation below;

[39] Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand
[40] Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

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

Where,

$EF_{grid,BM,y}$ = 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 6, the annual electricity generated by the most recently built power plants is 32,934.25 GWh (20.56% of the total electricity generated in year 2010 which is 160,190.96 GWh). Fuel consumptions of the most recently built power plants as listed in Table 7 emit 13,930,292ton CO_2. As shown in table 8, the Build Margin emission factor calculated by using equation (1), is 0.4231 t CO_2 /MWh.

Table 8: Calculation of Build Margin Emission Factor

Year	CO_2 emission (t CO_2)	Grid consumption (GWh)	BM Emission Factor	
			(t CO_2/MWh)	(g CO_2/KWh)
2010	13,933,412	13,933,412	0.4231	423.10

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

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

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

Table 9: 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 solar power generation project, W_{OM} = 0.75 and W_{BM} = 0.25 is selected. The Combined Margin Factors of Solar power generation CDM project is calculated by using equation 2 is 0.5554 as given in Table 10.

Table 10: 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	0.5996	0.4231	0.5554

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

Report[41]	DEDE[42] (Thailand)	IPCC[43]
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

[41] The Study of emission factor for an electricity system in Thailand 2010
[42] Electric Power in Thailand 2008/ Department of Alternative Energy Development and Efficiency, Ministry of Energy
[43] 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				

S. No.	Type (Unit) Commercial Energy	K Cal/unit	toe/10^6 unit	MJ/unit	10^3 BTU/unit
	13.1 Li (kg)	4,400	435.94	18.42	17.46
	13.2 Krabi (kg)	2,600	257.60	10.88	10.32
	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[44]

Fuel type English description	Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[45]		
			Default Value[46]	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

[44] 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
[45] TJ = 1000 GJ
[46] 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)[45]		
				Default Value[46]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
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
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

Fuel type English description		Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[45]		
				Default Value[46]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
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	97 500	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 [47]	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
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

[47] 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)[45]		
				Default Value[46]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
	Sulphite lyes (black liquor)[48]	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

[48] 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.

b) Guaranteed electricity generation from technology provider (MWh)

Year	Guaranteed electricity output (MWh)
1	152,666~~152,682~~
2	151,564~~148,893~~
3	150,463~~146,051~~
4	149,361~~144,157~~
5	148,259~~142,578~~
6	147,158~~141,315~~
7	146,056~~140,052~~
8	144,954~~138,789~~
9	143,852~~137,684~~
10	142,751~~136,579~~
11	141,649~~135,474~~
12	140,547~~134,527~~
13	139,446~~133,580~~
14	138,344~~132,633~~
15	137,242~~131,843~~
16	136,140~~131,054~~
17	135,039~~130,264~~
18	133,937~~129,633~~
19	132,835~~129,002~~
20	131,734~~128,370~~
21	130,632~~127,739~~
22	129,530~~127,265~~
23	128,428~~126,791~~
24	127,327~~126,318~~
25	126,225~~125,844~~

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Appendix 7: Further background information on monitoring plan

Please refer Section B.7

Appendix 8: Summary of post registration changes

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History of the document

Version	Date	Nature of revision
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	EB 66 13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the project design document form for CDM project activities" (EB 66, Annex 8).
03	EB 25, Annex 15 26 July 2006	
02	EB 14, Annex 06b 14 June 2004	
01	EB 05, Paragraph 12 03 August 2002	Initial adoption.
Decision Class: Regulatory **Document Type:** Form **Business Function:** Registration		