# CLEAN DEVELOPMENT MECHANISM
# PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
**Version 03 - in effect as of: 28 July 2006**

## CONTENTS



**Annexes**

## SECTION A. General description of project activity

### A.1. Title of the project activity:

| | |
|---|---|
| Title | Solar Farm at Phitsanulok, Thailand |
| Version | 05 |
| Date | 02/11/2012 |

### A.2. Description of the project activity:

Solar Farm at Phitsanulok, Thailand (hereafter called the "project activity") is developed by Energy Absolute Public Co., Ltd. It is proposed to construct a solar photovoltaic power plant at Phompiram district, Phitsanulok province in lower northern Thailand. The average annual solar radiation of Phompiram district is 5.04 $kWh/m^2/day$[1].The total installed capacity of the solar PV power plant is about 101.25 MWp. The PV power plant is expected to generate an average of 131,729 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 78,543 t $CO_2$e per year during the 1st crediting period.

<u>The purpose of the project activity</u>

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.

<u>Scenario prior to the project activity</u>

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.

<u>Base line scenario</u>

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

<u>Scenario after the project activity</u>

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).

[1]NASA- National Aeronautical and Space Administration U.S.A.
http://eosweb.larc.nasa.gov/sse/RETScreen/

**Contribution to sustainable development in Thailand**

In Thailand, sustainable development requires the effective integration of four key elements[2], namely, the environmental, social, technological and economical dimensions of development. By having positive impacts on these four dimensions, the project activity will facilitate multi-dimensional sustainable developmental 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 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 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 for the local public.

**A.3. Project participants:**

| Name of Party involved (*) ((host) indicates a host Party) | Private and/or public entity(ies) project participants (*) (as applicable) | Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Thailand (host) | 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 | | |

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

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.4. Technical description of the project activity:

### A.4.1. Location of the project activity:

#### A.4.1.1. Host Party(ies):

Thailand

#### A.4.1.2. Region/State/Province etc.:

Phitsanulok province

#### A.4.1.3. City/Town/Community etc.:

Phompiram district

#### A.4.1.4. Details of physical location, including information allowing the unique identification of this project activity (maximum one page):

The project activity is located at Phompiram district, Phitsanulok Province, in the lower northern side of Thailand. The project is located at (+17.0795 N, +100.1044 E), (+17.0831 N, +100.1317 E), (+17.0649 N, +100.1105 E) and (+17.0658 N, +100.1203 E). The central point of the project activity is located at +17.0735 N, + 100.1144 E. The total area for this project activity is approximately 2,000 rai[3].

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

[3] 1 rai is equal to 1,600 square meters, http://en.wikipedia.org/wiki/Rai_(unit)

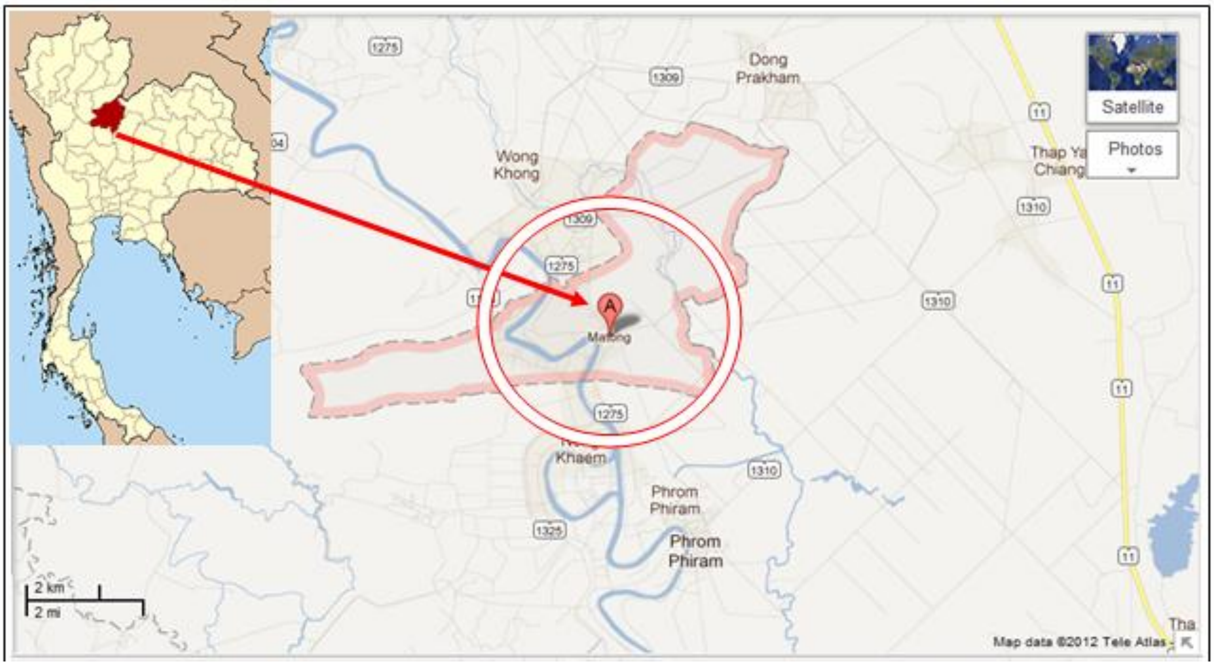


**Figure 1: Location of Phitsanulok province in Thailand**

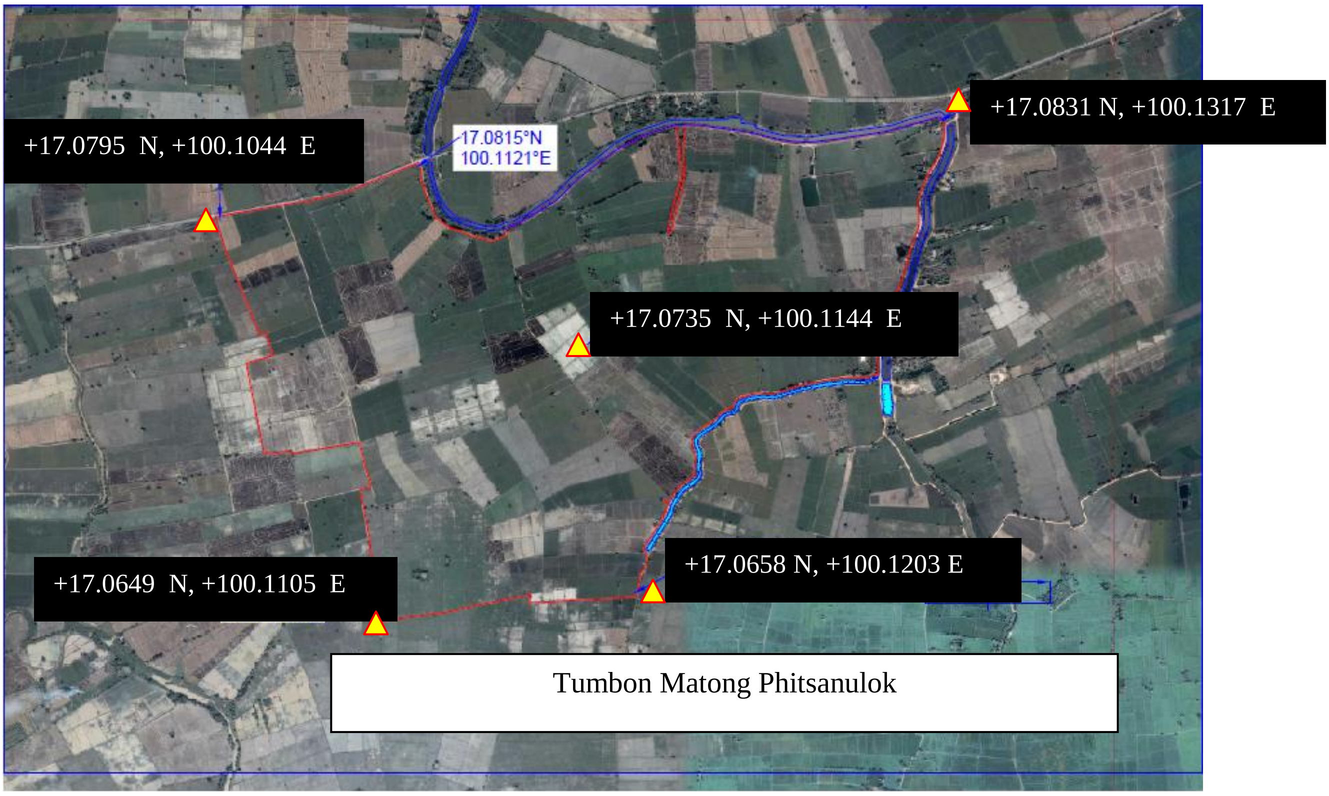


**Figure 2: Aerial photograph of the project location**

**A.4.2. Category(ies) of project activity:**

The category applicable to the project activity is:

Sectoral scope: (1) “Energy industries (renewable/non-renewable sources)”

**A.4.3. Technology to be employed by the project activity:**

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 from 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 plants incorporate 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:

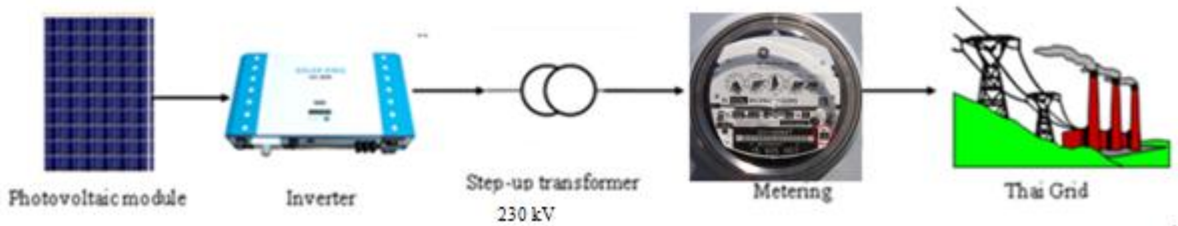


**Figure 3: Simple schematic diagram of solar PV power plant**

<u>Photovoltaic module</u>

A photovoltaic module or photovoltaic panel is a packaged, 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 101.25 MWp solar photovoltaic power plant project tentatively will comprise of the following units:

- 11,012,500 units of photovoltaic modules
- 360 units of inverters
- 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)** | **Silicon cell type** |
|---|---|---|---|---|
| Sunwell | WD-A-CC087A | 1,012,500 | 100 | Amorphous Silicon |

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

| **Manufacturer** | **Model** | **Quantity** | **AC nominal output (kW)** | **Max. efficiency / Euro efficiency (%)** |
|---|---|---|---|---|
| Power One | PVI-250-TL-CN | 360 | 250 | 98.5/98.2 |

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

| **Manufacturer** | **Capacity** | **Quantity** | **Output / Input** |
|---|---|---|---|
| QTC | 315 kVA | 360 | 230 kV / 0.32 kV |

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.4.4. Estimated amount of emission reductions over the chosen crediting period:**

The 1st renewable crediting period of the project activity is 7 years (01/12/2015 to 30/11/2022). The total and yearly estimated emission reductions during the crediting period are presented in the following table:

| **Years** | **Annual estimation of emission reductions in t $CO_2$e** |
|---|---|
| 01/12/2015 – 30/11/2016 | 82,645 |
| 01/12/2016 – 30/11/2017 | 80,594 |
| 01/12/2017 – 30/11/2018 | 79,055 |
| 01/12/2018 – 30/11/2019 | 78,030 |
| 01/12/2019 – 30/11/2020 | 77,175 |
| 01/12/2020 – 30/11/2021 | 76,492 |
| 01/12/2021 – 30/11/2022 | 75,808 |
| **Total estimated reductions** (tonnes of $CO_2$e) | **549,799** |
| **Total number of crediting years** | **7** |
| **Annual average over the crediting period of estimated reductions** (t $CO_2$e) | **78,543** |

**A.4.5. Public funding of the project activity:**

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

## SECTION B. Application of a baseline and monitoring methodology

### B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

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. Justification of the choice of the methodology and why it is applicable to the project activity:

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 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). | Applicable.<br>The project activity involves the installation of 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<br>Project activity involves installation of a new 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.<br>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:<br>At least one of the following conditions must apply:<br>• The project activity is implemented in an existing single or multiple reservoirs, with no change in the volume of any of the reservoir or<br>• 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 | Not applicable.<br>The project activity does not involve hydro power plant and hence this criterion is not applicable. |

| Applicability criteria | Justification |
|---|---|
| activity; or<br>• 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 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:<br>• The power density calculated for the entire project activity is greater than 4 $W/m^2$<br>• 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<br>• The water flow between the multiple reservoirs is not used by any other hydropower unit which is not a part of the project activity<br>• 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<br>• 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.<br>The project activity does not involve hydro power plant and hence this criterion is not applicable. |
| The methodology is not applicable to the following:<br>• 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<br>• Biomass fired power plants | Not applicable.<br>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 |
|---|---|
| • 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 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.<br>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:

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

| | |
|---|---|
| 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.<br>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 Annex 3. |

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

| | |
|---|---|
| This tool provides for a step-wise approach to demonstrate and assess additionality. These steps include:<br>• Demonstration whether the proposed project activity is the first-of-its-kind<br>• Identification of alternatives to the project activity<br>• 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 | Applicable.<br>Additionality of the project activity has been proved by this tool. Alternatives have been identified and an investment analysis along with sensitivity analysis has been carried out. In addition common practice analysis is used to further justify the project activity's additionality. |

| | |
|---|---|
| • Barriers analysis and<br>• Common practice analysis. | |
| 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 approved methodologies using the additionality tool. | Not applicable.<br>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.<br>The proposed project activity refers to 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. Description of the sources and gases included in the project boundary:**

According to the the baseline 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 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):

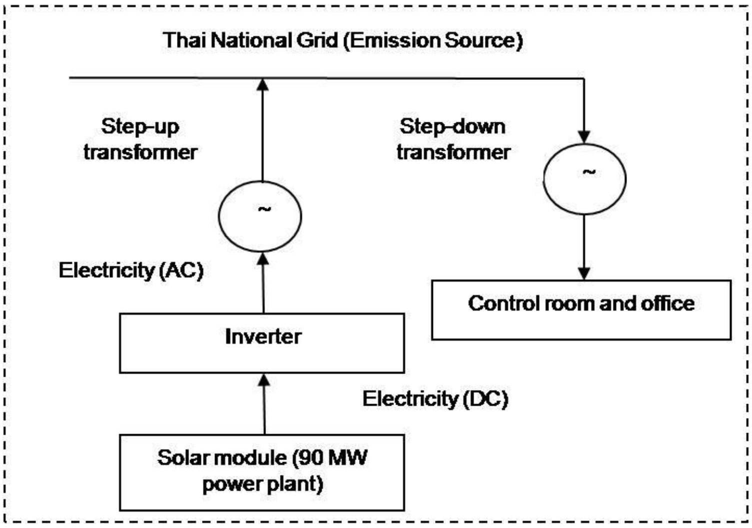


**Figure 4: Project boundary**

The following table shows the sources of gases that are included in the project boundary:

| | Source | Gas | Included? | Justification / Explanation |
|---|---|---|---|---|
| Baseline activity | $CO_2$ 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 |
| Project activity | 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 |
| | $CO_2$ 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 |

| Source | | Gas | Included? | Justification / Explanation |
|---|---|---|---|---|
| | | $N_2O$ | No | Not applicable |

**B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:**

According to 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 to the grid displacing 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 detailed of CEF calculation is given in Annex 3.

**B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):**

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 CPA, the project start date is the earliest date at which either the implementation or construction or real action of a CDM project activity or CPA begins". The starting date of the project activity is determined as 10/06/2011 which is the date 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 10/06/2011.The project participant informed Thai DNA on 17/08/2011 and UNFCCC secretariat on 21/08/2011. Both the communications 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 activity.

**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 | 10/06/2011 | | 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 | | 15/02/2012 | 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[4] |

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.

[4] http://cdm.unfccc.int/Projects/Validation/DB/QPP82AT7HQOBH2YBLVKS69IGDZLDSI/view.html

"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 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 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".*

As already explained, according to the baseline methodology, ACM0002, (version 12.3.0, EB 66), baseline is grid electricity. Since the alternative to the project activity, is the supply of electricity from grid, according to the above guidance, investment comparison analysis is not suitable and only benchmark analysis is considered appropriate.

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.

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

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[5].

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[6] | 52.26% | Relevant industry ROE |
| $W_e$: Fraction of Equity[7] | 47.74% | Relevant industry ROE |
| $K_d$: Cost of Debt[8] | 6.84% | Average of Thai commercial bank MLR at the time of decision making |
| $K_e$: Cost of Equity[9] | 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

[5] 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. However due to the fluctuation in ROE for the industry during 2006-2010, the ROE was vary from 9.64% to 26.40%. Therefore the average historical data for the previous 5 years, 2006 - 2010, was used in order to eliminate this fluctuation. For example, the ROE increased from 18.22% in the year 2010 to 18.79% and 22.10% for the years 2011 and 2012, respectively.

[6] 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

[7] 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

[8] 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

[9] 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. http://www.set.or.th/en/market/market_statistics.html

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 comes to around 13.05%.

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

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[10] | Million THB | 9,628.8 |
| Expected lifetime | Years | 25 |
| Electricity tariff rate [11] | THB/kWh | 9.6789 |
| Turn key O & M cost[12] | Million THB /year | 32.95 |
| Management cost[13] | Million THB/year | 3.9 |
| Plant load factor (PLF)[14] | % | 16.71 |
| Insurance[15] | % of EPC | 0.25 |
| Total electricity generation[16] (during 25 years) | MWh | 3,293,223 |

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

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

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

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

[14] 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 = 131,729 /788,400 = 16.71%..

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

| Parameter | Unit | Value |
|---|---|---|
| Project IRR (pre-tax) | % | 8.97 |

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 the 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).

Since the project IRR (8.97 %) of a project 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

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 spreadsheets."*

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

- 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:

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

| Variables | Project IRR @ 25 years | | Breakeven point[17] |
|---|---|---|---|
| | **Increasing variable by 10%** | **Decreasing variable by 10%** | |
| Total investment cost | - | 10.85% | Decrease 18% |
| Electricity price | 9.72% | - | Increase 54 % |
| Electricity generation | 10.76% | - | Increase 21% |

Total investment cost

The project IRR (pre-tax) increases only when the investment cost decreases. The investment 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. The recent 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.

Electricity price:

With the increase in electricity price, the project IRR also increases. If the electricity price is increased by 54%, 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[18] (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 54%.

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.

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

[18] 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.

Only if the electricity generation increases by around 21%, 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 around 21 % 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.

With the CDM revenue accounted, the project IRR could be improved to 9.70%. 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 activity'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 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[19]:

**Table: List of solar PV power plants (technology) having comparable capacities**

| 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[20] | Registered[21] |

[19] http://www.eppo.go.th/power/data/index.html

[20] Commissioning of the first stage is expected to start in November 1, 2011and full operation is to commence in May 1, 2012

[21] http://cdm.unfccc.int/Projects/DB/LRQA%20Ltd1312465274.35/view

| Company Name | Location | Export to Grid (MW) | Fuel | COD date | CDM status |
|---|---|---|---|---|---|
| Bangchak Petroleum Public Company Limited | Ayutthaya province | 38.00 | Solar PV | 01/05/2011 | Under Validation. Received LoA from DNA |
| Energy Absolute Public Co., Ltd. | Nakon sawan province | 90.00 | Solar PV | 01/12/2013 | Under validation[22]. Received LoA from DNA |
| Energy Absolute Public Co., Ltd. | Lampang province | 90.00 | Solar PV | 01/12/2014 | Under validation[23]. Received LoA from DNA |
| Energy Absolute Public Co., Ltd. | Pitsanulok province[24] | 90.00 | Solar PV | 01/112/2015 | 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 Co.,Ltd. | Lopburi province | 35.00 | Solar PV | 01/11/2013 - 01/06/2014 | |
| Bangchak Petroleum Public Company Limited | Chaiyaphum province | 50.00 | Solar PV | 01/12/2012 | |

It is clear from the above list that, only one solar PV plant of comparable capacity (55 MW plant in Lopburi province) has reached commercial operation stage. This clearly depicts the low penetration of solar PV technology in Thailand's electricity market as of now.

[22] http://cdm.unfccc.int/Projects/Validation/DB/UUM40DAKOJZTIMI0XEX64XCQKYHVRN/view.html
[23] http://cdm.unfccc.int/Projects/Validation/DB/42GV3HPJ109RE26CZ9GOYFA77O89GK/view.html
[24] Current project activity

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;*

*(e) 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 use 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 MWAC to 135 MWAC) of the installation capacity of the proposed project activity (90 MWAC) 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 | Registered[25] |
| Energy Absolute Public Co., Ltd. | Nakon Sawan province | 90.00 | Solar PV | 01/12/2013 | Under validation[26]. Received LoA from DNA |
| Energy Absolute Public Co., Ltd. | Lampang province | 90.00 | Solar PV | 01/12/2014 | Under validation[27]. 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 |

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 10/06/2011 and the PDD was published for global stakeholder consultation on 14/04/2012, the earlier date among them is the project start date on 10/06/2011. Therefore, there is no PV power plant in Thailand where has commercial operation date before the project start date.

[25] http://cdm.unfccc.int/Projects/DB/LRQA%20Ltd1312465274.35/view
[26] http://cdm.unfccc.int/Projects/Validation/DB/UUM40DAKOJZTIMI0XEX64XCQKYHVRN/view.html
[27] http://cdm.unfccc.int/Projects/Validation/DB/42GV3HPJ109RE26CZ9GOYFA77O89GK/view.html

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:**

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 of the methodology ACM0002 (version 12.3.0, EB 66)
(b) retrofits and replacements of an existing renewable energy power plant, formula 8 of the methodology ACM0002 (version 12.3.0, EB 66)
(c) capacity additions to an existing renewable energy power plant, formula 10 of the 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 of the "Tool to calculate the emission factor for an electricity system" (t $CO_2$/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 Annex 3. 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 $CO_2$e)
$BE_y$ = Baseline emissions in year *y* (t $CO_2$)
$PE_y$ = Project emissions in year *y* (t $CO_2$e)

**B.6.2. Data and parameters that are available at validation:**

| **Data / Parameter:** | **$FC_{i,y}$** |
|---|---|
| Data unit: | Mass or volume unit |
| Description: | Amount of fossil fuel type i consumed in the project electricity system in year y |
| Source of data used: | "Electricity Statistic Annual Report 2010", published by EGAT |
| Value applied: | Refer Annex 3 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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). |
| Any comment: | - |

| **Data / Parameter:** | **$NCV_{i,y}$** |
|---|---|
| Data unit: | GJ/mass or volume unit |
| Description: | Net calorific value (energy content) of fossil fuel type *i* in year *y* |
| Source of data used: | "Electric Power in Thailand 2010", published by the Department of Alternative Energy Development and Efficiency, Ministry of Energy |
| Value applied: | Refer Annex 3 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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) |
| Any comment: | - |

| **Data / Parameter:** | **$EF_{CO2,i,y}$** |
|---|---|
| Data unit: | t $CO_2$/GJ |
| Description: | $CO_2$ emission factor of fossil fuel type *i* in year *y* |
| Source of data used: | 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 applied: | Refer Annex 3 |
| Justification of the | Data choice and calculation method as per the latest version of the |

| | |
|---|---|
| choice of data or description of measurement methods and procedures actually applied : | methodological tool “Tool to calculate the emission factor for an electricity system”(version 02.2.1, EB 63) |
| Any comment: | - |

| **Data / Parameter:** | **$EG_y$** |
|---|---|
| Data unit: | MWh |
| Description: | Net quantity of electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must run power plants/units, in year *y* |
| Source of data used: | “Electricity Statistic Annual Report 2008-2010”, published by EGAT |
| Value applied: | Refer Annex 3 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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) |
| Any comment: | - |

| **Data / Parameter:** | **$FC_{i,m,y}$** |
|---|---|
| Data unit: | Mass or volume unit |
| Description: | Amount of fossil fuel type i consumed by the power plant/unit m in year y |
| Source of data used: | “Electricity Statistic Annual Report 2010”, published by EGAT |
| Value applied: | Refer Annex 3 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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) |
| Any comment: | - |

| **Data / Parameter:** | **$EG_{m,y}$** |
|---|---|
| Data unit: | MWh |
| Description: | Net quantity of electricity delivered to the grid by power plant / unit *m* serving the system, not including low-cost / must run units, in year *y* |
| Source of data used: | “Electricity Statistic Annual Report 2010”, published by EGAT |
| Value applied: | Refer Annex 3 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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) |

| | |
|---|---|
| Any comment: | - |

| | |
|---|---|
| **Data / Parameter:** | **$EF_{grid,CM,y}$** |
| Data unit: | t $CO_2$/MWh |
| Description: | $CO_2$ emission factor of the grid |
| Source of data used: | Calculated |
| Value applied: | 0.5554 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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) |
| Any comment: | This value is used for the entire crediting period. |

| | |
|---|---|
| **Data / Parameter:** | **$EF_{grid,OM,y}$** |
| Data unit: | t $CO_2$/MWh |
| Description: | Simple Operating Margin |
| Source of data used: | Calculated |
| Value applied: | 0.5996 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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) |
| Any comment: | This value is used for the entire crediting period. |

| | |
|---|---|
| **Data / Parameter:** | **$EF_{grid,BM,y}$** |
| Data unit: | t $CO_2$/MWh |
| Description: | Buid Margin |
| Source of data used: | Calculated |
| Value applied: | 0.4231 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | 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) |
| Any 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:

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

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,% (= 80.63%) |
| $R_{actual}$ | = | Solar irradiation, kWh/m $^2$ /day (= 5.04 kWh/m$^2$-d or 5.04 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 Annex 3:

| Year | Energy output warranty (MWh) |
|---|---|
| 1 | 148,802 |
| 2 | 145,109 |
| 3 | 142,340 |
| 4 | 140,493 |
| 5 | 138,955 |
| 6 | 137,724 |
| 7 | 136,493 |

Baseline emission due to avoided grid electricity (t $CO_2$e)

| **Year** | **$BE_y$** | **=** | **$EG_{PJ,y}$ (MWh/yr)** | ***** | **$EF_{grid,CM,y}$ (t $CO_2$/MWh)** |
|---|---|---|---|---|---|
| 01/12/2015 – 30/11/2016 | 82,645 | = | 148,802 | * | 0.5554 |
| 01/12/2016 – 30/11/2017 | 80,594 | = | 145,109 | * | 0.5554 |
| 01/12/2017 – 30/11/2018 | 79,055 | = | 142,340 | * | 0.5554 |
| 01/12/2018 – 30/11/2019 | 78,030 | = | 140,493 | * | 0.5554 |
| 01/12/2019 – 30/11/2020 | 77,175 | = | 138,955 | * | 0.5554 |
| 01/12/2020 – 30/11/2021 | 76,492 | = | 137,724 | * | 0.5554 |

| Year | $BE_y$ | = | $EG_{PJ,y}$ (MWh/yr) | * | $EF_{grid,CM,y}$ (t $CO_2$/MWh) |
|---|---|---|---|---|---|
| 01/12/2021 – 30/11/2022 | 75,808 | = | 136,493 | * | 0.5554 |

Project emission due to project activities (t $CO_2$e):

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 $CO_2$e/yr) | = | $BE_y$ (t $CO_2$e/yr) | - | $PE_y$ (t $CO_2$e/yr) |
|---|---|---|---|---|---|
| 01/12/2015 – 30/11/2016 | 82,645 | = | 82,645 | - | 0 |
| 01/12/2016 – 30/11/2017 | 80,594 | = | 80,594 | - | 0 |
| 01/12/2017 – 30/11/2018 | 79,055 | = | 79,055 | - | 0 |
| 01/12/2018 – 30/11/2019 | 78,030 | = | 78,030 | - | 0 |
| 01/12/2019 – 30/11/2020 | 77,175 | = | 77,175 | - | 0 |
| 01/12/2020 – 30/11/2021 | 76,492 | = | 76,492 | - | 0 |
| 01/12/2021 – 30/11/2022 | 75,808 | = | 75,808 | - | 0 |

**B.6.4 Summary of the ex-ante estimation of emission reductions:**

| Year | Estimation of project activity emissions (t $CO_2$ e) | Estimation of baseline emissions (t $CO_2$ e) | Estimation of leakage (t $CO_2$ e) | Estimation of overall emission reductions (t $CO_2$ e) |
|---|---|---|---|---|
| 01/12/2015 – 30/11/2016 | 0 | 82,645 | 0 | 82,645 |
| 01/12/2016 – 30/11/2017 | 0 | 80,594 | 0 | 80,594 |

| Year | Estimation of project activity emissions (t $CO_2$ e) | Estimation of baseline emissions (t $CO_2$ e) | Estimation of leakage (t $CO_2$ e) | Estimation of overall emission reductions (t $CO_2$ e) |
|---|---|---|---|---|
| 01/12/2017 – 30/11/2018 | 0 | 79,055 | 0 | 79,055 |
| 01/12/2018 – 30/11/2019 | 0 | 78,030 | 0 | 78,030 |
| 01/12/2019 – 30/11/2020 | 0 | 77,175 | 0 | 77,175 |
| 01/12/2020 – 30/11/2021 | 0 | 76,492 | 0 | 76,492 |
| 01/12/2021 – 30/11/2022 | 0 | 75,808 | 0 | 75,808 |
| **Total** (t $CO_2$ e) | **0** | **549,799** | **0** | **549,799** |

## B.7. Application of the monitoring methodology and description of the monitoring plan:

### B.7.1 Data and parameters monitored:

| **Data / Parameter:** | $EG_{facility,y}$ |
|---|---|
| Data unit: | MWh |
| Description: | Quantity of net electricity generation supplied by the project plant to the grid in year *y* |
| Source of data to be used: | Export & Import data will be sourced from the electricity meters. The net (Export – Import) electricity would be calculated based on Export & Import data. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 148,802 (1st year of crediting period) |
| Description of measurement methods and procedures to be applied: | $EG_{facility,y} = EG_{export,y} - EG_{import,y}$<br><br>$EG_{export,y}$ and $EG_{import,y}$ will be measured continuously and will be recorded hourly. The recorded data will be reported on a monthly basis. |
| QA/QC procedures to be applied: | The value will be cross checked with the records for sold electricity and bills from the national grid for electricity usage. |
| Any comment: | All data will be stored electronically for the duration of the project activity plus two additional years. |

| **Data / Parameter:** | $EG_{export,y}$ |
|---|---|

| | |
|---|---|
| Data unit: | MWh |
| Description: | Quantity of electricity supplied by the project to the grid in year *y* |
| Source of data to be used: | Data measured and recorded from the electricity meters installed at the power station |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 148,802 (1st year of crediting period) |
| Description of measurement methods and procedures to be applied: | 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. |
| QA/QC procedures to be applied: | 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. |
| Any comment: | All data will be stored electronically for the duration of the project activity plus two additional years. |

| | |
|---|---|
| Data / Parameter: | $EG_{import,y}$ |
| Data unit: | MWh |
| Description: | Quantity of import electricity by the project activity from the grid in year y |
| Source of data to be used: | Data measured and recorded from the electricity meter installed at the power Station |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 0 (ex-ante) |
| Description of measurement methods and procedures to be applied: | 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. |
| QA/QC procedures to be applied: | Meter will be installed at the power plant substation to monitor the electricity imported from 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 the bills from the national grid for electricity usage. |
| Any comment: | All data will be stored electronically for the duration of the project activity plus two additional years. |

### B.7.2. Description of the 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

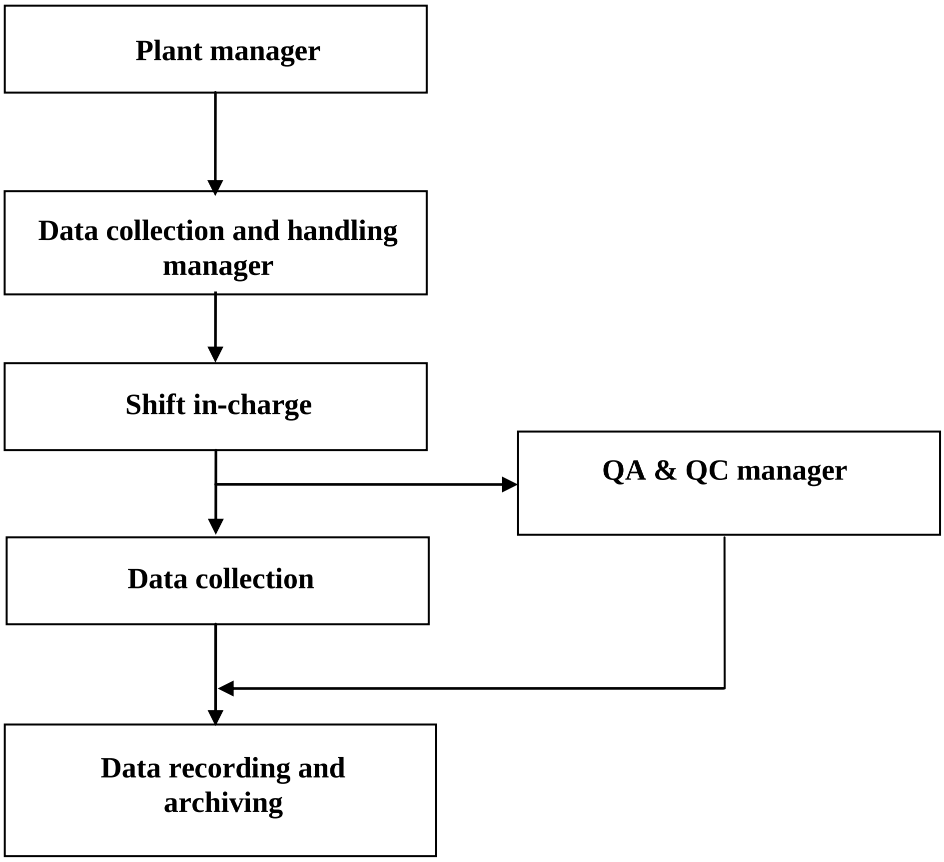


**Figure 5: Operation and management structure for monitoring**

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:

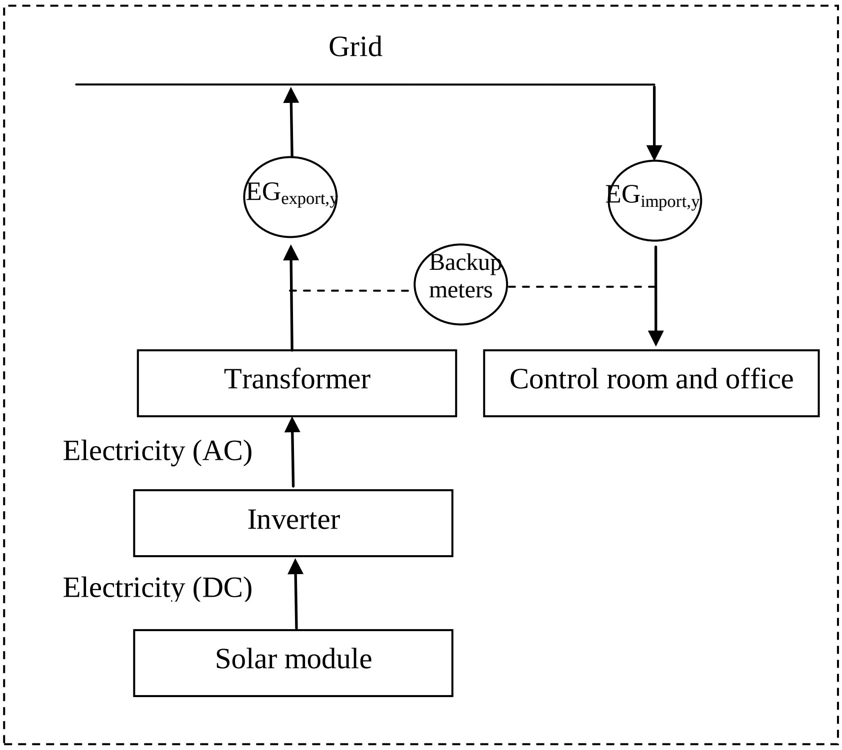


**Figure 6: Monitoring Meter Flow Diagram**

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 (national grid).

**Calibration frequency of meters**

The meters of the project activity are calibrated according to the national standard at least once in a year by a 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 there is any 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.

**B.8. Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies):**

| | |
|---|---|
| Organization | Advance Energy Plus Co., Ltd. |
| Contact person | Mr. Anat Prapasawad |
| Telephone no. | +662 645 3347 |
| Email address | anat_p@aep.co.th |
| Date of completion | 02/11/2012 |

Advance Energy Plus Co., Ltd. (AEP) is the CDM advisor to the project activity (not a project participant).

## SECTION C. Duration of the project activity / crediting period

### C.1. Duration of the project activity:

#### C.1.1. Starting date of the project activity:

10/06/2011(i.e. signed land purchase date)

#### C.1.2. Expected operational lifetime of the project activity:

25 years 0 months

### C.2. Choice of the crediting period and related information:

#### C.2.1. Renewable crediting period:

##### C.2.1.1. Starting date of the first crediting period:

01/12/2015 or when registered with the UNFCCC whichever is later

##### C.2.1.2. Length of the first crediting period:

7 years 0 months crediting period

#### C.2.2. Fixed crediting period:

##### C.2.2.1. Starting date:

Not applicable

##### C.2.2.2. Length:

Not applicable

## SECTION D. Environmental impacts

### D.1. Documentation on the analysis of the environmental impacts, including transboundary 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[28]. However, an Initial Environmental Evaluation (IEE) Report of this CDM project 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**

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. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

The environmental impacts are not significant.

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

## SECTION E. Stakeholders' comments

### E.1. Brief description how comments by local stakeholders have been invited and compiled:

Energy Absolute Public Co., Ltd. has organized the public consultation meeting 2 times. The first meeting was on 9th February, 2012 at the meeting room of Tumbon Prompiram Administrative Organization in Pitsanulok province. The participants were invited by telephonic conversation and there were 56 participants including villagers living near the solar power plant site .The objective of this meeting was to create awareness about the project activity and to have a more detailed public consultation.

The second public consultation meeting was on 15th February 2012 at the meeting room of Ban Hang Lai School in Pitsanulok 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 relevant others along with the earlier participants. Totally, there were 278 participants including local officials, Tambol Administration Organization and villagers living near the solar power plant. The details of the stakeholder meetings participants are given below:

| Organization | Number of participants 9 Feb 2012 | Number of participants 15 Feb 2012 |
|---|---|---|
| Local government officer | 0 | 8 |
| Tambol Administration Organization | 0 | 9 |
| Village Chief | 0 | 21 |
| Villagers | 56 | 240 |
| Total | 56 | 278 |

In the meeting, detailed information about the project activity 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 the 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 specific, project-related comments and questions from the participants are summarized below:

1. *Question:* Is there any plan for community management as the project activity is expected to make changes in such as road lane expansion, local life-style and other aspects?

   *Answer:* All the changes made under the project activity will help improving the community. However further discussion will be initiated to accomplish the goal of community development.

2. *Question:* Will the project activity increase more UV radiation?

*Answer:* UV radiation comes from naturally from the sun, the project /solar cell does not emit any UV radiation. There will be no negative impact on human and other lives.

*3. Question:* Why the project activity life is just 30 years?

*Answer: The average life time of solar cell is about 25 years. Although it will work even after 30 years, the efficiency will be reduced and hence it is advisable to replace.*

*4. Question*: Can farmers use the road of the project activity?

*Answer:* Yes, they can. The project activity does not affect any of the public facilities.

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

**E.3. Report on how due account was taken of any 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.

## Annex 1

### CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

| | |
|---|---|
| Organization: | Energy Absolute Public Co., Ltd. |
| Street/P.O. Box: | Viphavadee-Rangsit road |
| Building: | 888 I Tower, 15th floor |
| City: | Chatuchak |
| State/Region: | Bangkok |
| Postfix/ZIP: | 10900 |
| Country: | Thailand |
| Telephone: | +662 554 9238-42 |
| FAX: | +662 554 9243 |
| E-Mail: | somphote@energyabsolute.co.th |
| URL: | |
| Represented by: | |
| 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 |

**<u>Annex 2</u>**

**INFORMATION REGARDING PUBLIC FUNDING**

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

# Annex 3

## 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.

<u>Delineation of connected electricity system</u>

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**[29] | **Unit** | **Net calorific value**[30] **(MJ/Unit)** | **$CO_2$ emission**[31] **(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 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[32] (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.

---

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

[30] Electric Power in Thailand 2010/ Department of Alternative Energy Development and Efficiency, Ministry of Energy

[31] 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

[32] Provincial Electricity Authority

Table 2: Quantity of electricity was generated and transmitted to the national grid[33]

| 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[34] | 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[35] | 6,946.44 | - | 2,159.95 | 9,106.39 | 6.27 |
| 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 | |

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

| Generation system | Grid generation (GWh) | | | | |
|---|---|---|---|---|---|
| | EGAT | IPP | SPP | Total | % |
| 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 | |

**Table 3: Amount of fossil fuel consumed by power plants**[36]

| 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 |

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

| Fuel type | Unit | Fuel consumption | | | |
|---|---|---|---|---|---|
| | | EGAT | IPP | SPP | Total |
| 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 $tCO_2$.

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[37]

| 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[38]

| 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 | - |

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

| Fuel type | Fuel consumption | | $CO_2$ emission (kg $CO_2$/Unit) | $CO_2$ emission (t $CO_2$) |
|---|---|---|---|---|
| | Unit | Volume | | |
| Diesel | litre | 1,179,772 | 2.6441 | 3,119 |

The build Margin Emission Factor calculated by using equation below;

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

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[39] | DEDE[40] (Thailand) | IPCC[41] |
|---|---|---|
| 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 |

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

[40] Electric Power in Thailand 2008/ Department of Alternative Energy Development and Efficiency, Ministry of Energy

[41] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

**ENERGY CONTENT OF FUEL (NET CALORIFIC VALUE)**

| S. No. | Type (Unit)<br>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 |

| S. No. | Type (Unit)<br>Commercial Energy | K Cal/unit | toe/$10^6$ unit | MJ/unit | $10^3$ BTU/unit |
|---|---|---|---|---|---|
| 12. | Propane (kg) | 11,256 | 1,115.34 | 47.11 | 44.67 |
| 13. | Lignite | | | | |
| | 13.1 Li (kg) | 4,400 | 435.94 | 18.42 | 17.46 |
| | 13.2 Krabi (kg) | 2,600 | 257.60 | 10.88 | 10.32 |
| | 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[42]**

| Fuel type English description | | Default carbon content (Kg/GJ) | Default carbon oxidation factor | Effective $CO_2$ emission factor (Kg/TJ)[43] | | |
|---|---|---|---|---|---|---|
| | | | | Default Value[44] | 95% confidence interval | |
| | | A | B | C=A*B*44/12*1000 | Lower | Upper |
| Crude oil | | 20.0 | 1 | 73 300 | 71 100 | 75 500 |
| Orimulsion | | 21.0 | 1 | 77 000 | 69 300 | 85 400 |
| Natural Gas | | 17.5 | 1 | 64 200 | 58 300 | 70 400 |
| Gasoline | Motor gasoline | 18.9 | 1 | 69 300 | 67 500 | 73 000 |
| | Aviation gasoline | 19.1 | 1 | 70 000 | 67 500 | 73 000 |
| | Jet gasoline | 19.1 | 1 | 70 000 | 67 500 | 73 000 |
| Jet kerosene | | 19.5 | 1 | 71 500 | 69 700 | 74 400 |
| Other kerosene | | 19.6 | 1 | 71 900 | 70 800 | 73 000 |
| Shale oil | | 20.0 | 1 | 73 300 | 67 800 | 79 200 |
| Gas / Diesel oil | | 20.2 | 1 | 74 100 | 72 600 | 74 800 |
| Residual fuel oil | | 21.1 | 1 | 77 400 | 75 500 | 78 800 |
| Liquefied petroleum gases | | 17.2 | 1 | 63 100 | 61 600 | 65 600 |
| Ethane | | 16.8 | 1 | 61 600 | 56 500 | 68 600 |
| Naphtha | | 20.0 | 1 | 73 300 | 69 300 | 76 300 |
| Bitumen | | 22.0 | 1 | 80 700 | 73 000 | 89 900 |
| Lubricants | | 20.0 | 1 | 73 300 | 71 900 | 75 200 |

42 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

43 TJ = 1000 GJ

44 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)[43] | | |
|---|---|---|---|---|---|---|
| | | | | Default Value[44] | 95% confidence interval | |
| | | A | B | C=A*B*44/12*1000 | Lower | Upper |
| 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 |
| 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 |

| Fuel type English description | | Default carbon content (Kg/GJ) | Default carbon oxidation factor | Effective $CO_2$ emission factor (Kg/TJ)[43] | | |
|---|---|---|---|---|---|---|
| | | | | Default Value[44] | 95% confidence interval | |
| | | A | B | C=A*B*44/12*1000 | Lower | Upper |
| | Blast furnace gas [45] | 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 |
| Solid bio-fuels | Sulphite lyes (black liquor)[46] | 26.0 | 1 | 95 300 | 80 700 | 110 000 |
| Solid bio-fuels | Other primary solid biomass | 27.3 | 1 | 100 000 | 84 700 | 117 000 |
| Solid bio-fuels | charcoal | 30.5 | 1 | 112 000 | 95 000 | 132 000 |
| Liquid bio-fuels | Biogasoline | 19.3 | 1 | 70 800 | 59 800 | 84 300 |
| Liquid bio-fuels | Biodiesels | 19.3 | 1 | 70 800 | 59 800 | 84 300 |
| Liquid bio-fuels | Other liquid | 21.7 | 1 | 79 600 | 67 100 | 95 300 |

[45] 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

[46] 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.

| Fuel type English description | | Default carbon content (Kg/GJ) | Default carbon oxidation factor | Effective $CO_2$ emission factor (Kg/TJ)[43] | | |
|---|---|---|---|---|---|---|
| | | | | Default Value[44] | 95% confidence interval | |
| | | A | B | C=A*B*44/12*1000 | Lower | Upper |
| | biofuels | | | | | |
| 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 |

**b) Guaranteed electricity generation from technology provider (MWh)**

| Year | Guaranteed electricity output (MWh) |
|---|---|
| 1 | 148,802 |
| 2 | 145,109 |
| 3 | 142,340 |
| 4 | 140,493 |
| 5 | 138,955 |
| 6 | 137,724 |
| 7 | 136,493 |
| 8 | 135,262 |
| 9 | 134,185 |
| 10 | 133,108 |
| 11 | 132,030 |
| 12 | 131,107 |
| 13 | 130,184 |
| 14 | 129,261 |
| 15 | 128,492 |
| 16 | 127,722 |
| 17 | 126,953 |
| 18 | 126,337 |
| 19 | 125,722 |
| 20 | 125,106 |
| 21 | 124,491 |
| 22 | 124,029 |
| 23 | 123,568 |
| 24 | 123,106 |
| 25 | 122,645 |

## Annex 4

## MONITORING INFORMATION

Please refer section B.7.2

- - - - -