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

CONTENTS

SECTION A. General description of project activity

A.1. Title of the project activity:

Project title : Lopburi Solar Power Plant Project
Document version : 2.1
Date of completion : 02/09/2011

A.2. Description of the project activity:

The Lopburi Solar Power Plant Project developed by Natural Energy Development Co., Ltd. (hereinafter referred to as "NED") involves the installation and operation of a greenfield grid-connected solar photovoltaic (PV) power plant in Lopburi province of Thailand. This activity hereinafter is referred to as "the Project" or "project activity".

The purpose of this project activity is to utilize the sunlight as energy source for carbon-neutral electricity generation. NED plans to erect the thin-film PV panels at the project plant with the total installed capacity of 73.16MW-DC Gross (or approximately 55MW-AC Net equivalent). According to the project plan, the net quantity of electricity generation will be sold to the national power grid – Electricity Generating Authority of Thailand (EGAT)[1], via Provincial Electricity Authority (PEA) transmission lines under a 5-year automatically renewable Power Purchase Agreement (PPA) in the Small Power Producer (SPP) Program[2]. With this, EGAT will purchase all the electricity output of the plant up to 55MW-AC, which is the upper limit set in the PPA. This is considered as one of the largest solar PV power plants in the world and the first large-scale solar PV power plant in Thailand, as further discussed in Section B.5.

In the absence of the project activity, EGAT would have continued to import fossil fuel-dominated electricity from other power plants connected to the grid electricity system. This represents not only the scenario existing prior to the project implementation, but also the baseline scenario. In view of this, the Project will therefore be responsible for reduction of carbon dioxide (CO_2) emissions through the displacement of fossil fuel-dominated electricity generation by the power plants connected to the grid electricity system.

In accordance with the project implementation schedule, the Project is to be implemented in seven stages over the first operational year. Commissioning of the first stage is expected to start in November 1, 2011 and full operation is to commerce in May 1, 2012. Upon full operation, the Project is expected to export approximately 105,512MWh of net electricity to the grid per annum, which corresponds to approximately 63,096 tonnes of CO_2 equivalent greenhouse gases (GHGs) emission reductions per year.

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[1] EGAT, which was established on May 1, 1969, is the state enterprise under the Ministry of Energy. In addition to build, own and operate several types and sizes of power plants across the country, EGAT also purchases electric power from private power companies and neighbouring countries. One of the EGAT's missions is to generate, acquire and transmit electric energy to the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA), other electric energy consumers and neighbouring countries.

[2] A Small Power Producer (SPP) can be any private entity, government or state-owned enterprise that generates electricity either (a) from non-conventional sources such as wind, solar and mini-hydro energy or fuels such as waste, residues or biomass, or (b) from conventional sources provided they also produce steam through cogeneration.

Contribution to Sustainable Development

Consistent with the sustainable development criteria set by the Ministry of Natural Resources and Environment (MNRE) of Thailand, the proposed project activity will make a substantial contribution in ways outlined below:-

1) Natural resources and environment

The project activity will replace carbon emission intensive fossil fuels with carbon-neutral solar energy for electricity generation and thereby reduce the GHG emissions. In addition, the Project will diversify the sources of electricity generation and decrease the use of finite fossil fuels, contributing to the local development.

The Project conforms to the governmental policy of Thailand and will contribute to its national sustainable development using solar resource for renewable energy generation. To promote the generation of green power, the Thai Government has stipulated a policy, called SPP Program, to encourage small power producer which generates power with renewable resources to sell part or all of its output to EGAT. The Project is compliant to the Thai governmental policy and participates in the SPP Program.

2) Economic development

The benefits due to the implementation of the Project extends to economic sustainability, as the use of sustainable and renewable solar resource will reduce expensive fossil fuel imports and negative impact on the foreign exchange. Besides, it will also eliminate the risks of fluctuating coal and/or oil prices, via which it will enable more economic and reliable energy production. Furthermore, the project activity will cater to the growing power demand that is forecast in Thailand. Most importantly, the Project will be the first to demonstrate the capacity of large-scale solar projects to meet power needs in Thailand. After a large-scale private sector solar farm is shown to be feasible, other private sector investors can replicate the model in the country.

3) Social development

In terms of social contributions, the project activity will create various short-term and long-term employment opportunities to the local community from the design and installation phase through to the operation and maintenance phase of the new power plant. In addition, the local population will also benefit directly from the Project which produces reliable green energy.

4) Technology transfer

The Project, which will adopt an innovative PV module and inverter manufactured by Sharp Corporation in Japan, involves technology transfer from a developed country. Considering that this is one of the world's largest PV power plants and the first large-scale PV power plant in Thailand, transfer of know-how and training relating to the design, operating and maintenance procedures for NED local staffs are essential and will be provided by the manufacturer to ensure proper operation and maintenance. Also, a visit to Sharp's manufacturing factory for PV module and inverter in Japan has been organized.

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)	**Natural Energy Development Co., Ltd.** (Private entity)	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

See contact information at Annex 1 of this PDD

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.:

Lopburi province.

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

Wang Phloeng sub-district, Khok Samrong district.

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

Lopburi is one of the provinces in the central region of Thailand. It covers an area of 6,199 square kilometres and is located approximately 154 kilometres north of Bangkok. Lopburi's boundary reaches Phetchabun and Nakhon Sawan to the North, Sing Buri, Ang Thong, Ayutthaya and Saraburi to the South, Chaiyaphum and Nakhon Ratchasima to the East, and Khorat Plateau to the West. The proposed project activity lies in the Khok Samrong district of Lopburi province, situated on the geographic coordinates at longitude 100°53'32.2" East and latitude 15°03'01.7" North (100.8922778 and 15.0504722 in decimal format respectively).

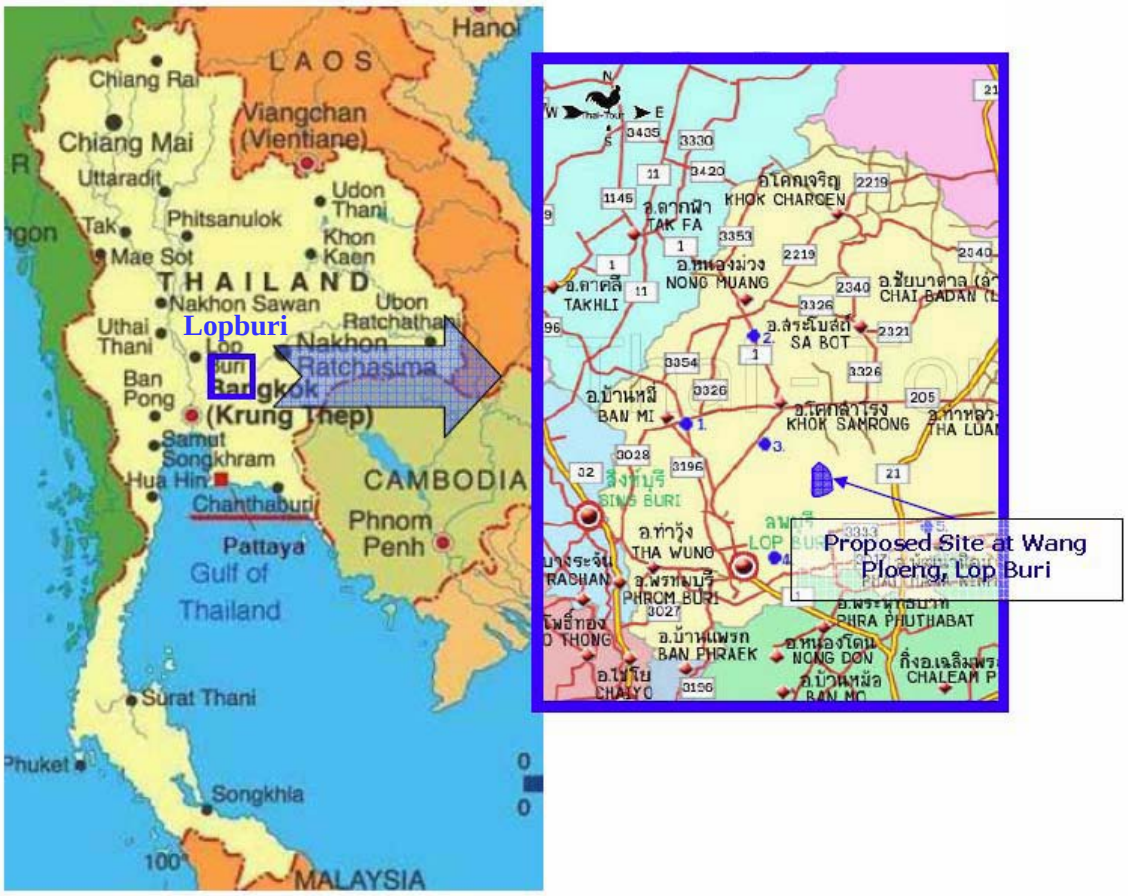


Figure 1: The location map of the project activity

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

Sectoral Scope 1: Energy industries (renewable sources).

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

Photovoltaics, which will be employed by the proposed project activity, is a method for generating electrical power by using solar cells to convert energy from the sunlight into electricity.

NED plans to use 128W and/or 135W thin-film silicon PV modules for converting sunlight into electrical power. The modules will be mounted in rows and electrically connected with underground cables. The electrical output from the PV arrays will be fed via cables to a bank of inverters that convert the direct current (DC) generated by the PV arrays into alternating current (AC) and control the entire system. The generated electrical AC power will be passed through the 22kV/115kV step-up transformer and then

exported via the 115kV transmission line to the delivery point at the Chaibadan 2 power substation[3], stipulated in the PPA.

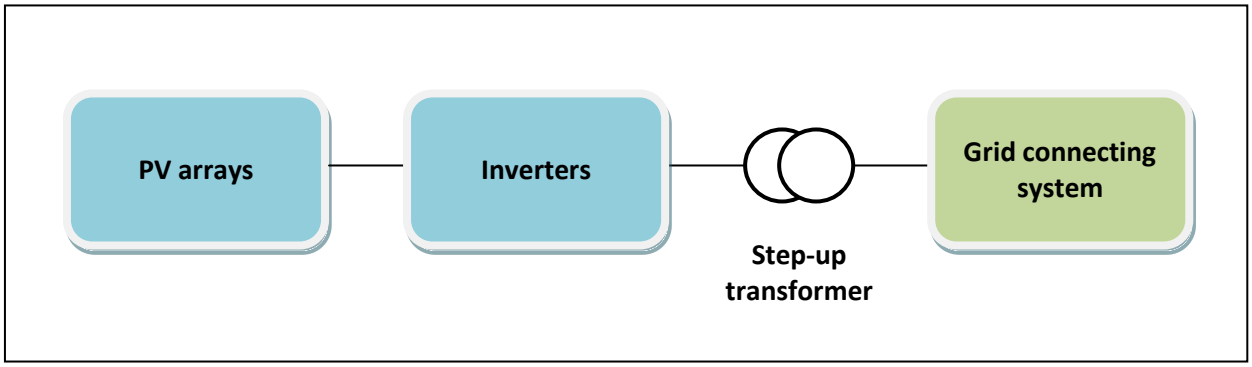


Figure 2: A simplified power generation and transmission system

The key technical specifications of the major equipments are summarized in the tables below.

Table 1: Technical specifications of the PV module

Item	Type of solar module[a)]	
	Sharp NA-F135(G6) Sharp NS-F135(G6)	Sharp NA-F128(G6) Sharp NS-F128(G6)
Cell type	Thin-film silicon (Amorphous Si / microcrystalline Si tandem structure)	Thin-film silicon (Amorphous Si / microcrystalline Si tandem structure)
Maximum power (Pmax)	135W	128W
Open-circuit voltage (Voc)	61.3V	59.8V
Short-circuit current (Isc)	3.41A	3.45A
Maximum power voltage (Vmpp)	47V	45.4V
Maximum power current (Impp)	2.88A	2.82A
Expected lifetime	25years	25years

a) Depending on the availability of the solar module and other technical aspects at the time of installation, one or more than one type(s) of solar module will be used at the project plant. It is noted that the main difference between NA- and NS- type is the back cover material of the module.

Table 2: Technical specifications of the solar inverter

Item	Solar inverter
Model	Sharp JH-250KE
Type	Grid-tied 3-phase 3-wire solar inverter
Rated output power	250kW
Rated output voltage	AC440V
Rated output current	AC328A
Rated input voltage (DC)	DC600V
Efficiency	≥95%

[3] This is a power substation of the Provincial Electricity Authority (PEA), which is connected to the project plant as per the PPA between NED and EGAT.

In addition the above basic equipments, the power plant will install a supervisory control and data acquisition (SCADA) system to control and monitor the output of the rows of panels. In this way, any system faults can be detected and power output irregularities can be identified to a particular array and rectified.

The main and backup electricity meters will be installed at the Chaibadan 2 Power Station or the project plant for measurement of the sold electrical power. For details of the electricity meters, please refer to Section B.7.

Plant load factor

Consistent with option 3(b) provided in EB48 Annex 11 *"Guidelines for the reporting and validation of plant load factors"*, the plant load factor, which is applied for the *ex-ante* CER calculation, was determined by a third party contracted by NED.

As per the contracted technology supplier (Sharp Corporation), the plant load factor was determined as 17.15%[4]. This means that the Project will be able to generate 109,911MWh gross electricity per year upon full operation. Taking into account the annual auxiliary power of 4,399MWh consumed by the project plant that was estimated by the EPC contractor (a consortium of Sharp Corporation, Italian-Thai Development Public Company Limited, and Italthai Engineering Co., Ltd.), the quantity of net electricity to be exported to the grid will amount to 105,512MWh per year, as illustrated below.

$$Net\ electricity\ export = \left(73.16 MW_{gross} \times 8{,}760\ {}^{h}/_{yr} \times 17.15\%\right) - 4{,}399\ {}^{MWh}/_{yr} \quad = 105{,}512\ {}^{MWh}/_{yr}$$

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

The chosen crediting period for the Project is 7 years, with renewal at most 2 times. In the first crediting period (01/11/2011 – 31/10/2018), the total estimated amount of emission reductions is expected to be 425,608 tCO_2e.

Years	Estimation of annual emission reductions in tonnes of CO_2e
01/11/2011 – 31/10/2012	47,032
01/11/2012 – 31/10/2013	63,096
01/11/2013 – 31/10/2014	63,096
01/11/2014 – 31/10/2015	63,096
01/11/2015 – 31/10/2016	63,096
01/11/2016 – 31/10/2017	63,096
01/11/2017 – 31/10/2018	63,096
Total estimated reductions (tonnes of CO_2e)	**425,608**
Total number of crediting years	**7**
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**60,801**

[4] The thorough estimation is provided to DOE for validation. This plant load factor has taken into account the inverter efficiency for conversion of DC power to AC power.

A.4.5. Public funding of the project activity:

The Project does not receive any public funding from Parties included in 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 approved baseline and monitoring methodology applied to the project activity is:

- ACM0002 *"Consolidated baseline methodology for grid-connected electricity generation from renewable sources (Version 12.1.0)"*

Methodology and tools referenced in ACM0002 include:

- *"Tool for the demonstration and assessment of additionality (Version 05.2)"*
- *"Combined tool to identify the baseline scenario and demonstrate additionality (Version 02.2)"*
- *"Tool to calculate the emission factor for an electricity system (Version 02)"*
- *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (Version 02)"*

B.2. Justification of the choice of the methodology and why it is applicable to the project activity:

ACM0002 is applicable to grid-connected renewable power generation project activities, including solar power project. Among the applicable activities in the methodology, the proposed project activity belongs to the category of "Greenfield plant" that involves the installation of a new power plant at a site where no renewable power plant was operated prior to the implementation of the project activity. The proposed project activity fulfils all applicability criteria stipulated in the methodology and its referenced tools as summarized below.

Table 3: The applicability and inapplicability conditions of ACM0002 and its referenced tools

	Condition	Project case
Applicability condition of ACM0002		
1	*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** The proposed project activity involves the installation and operation of a solar power plant that is connected to the local grid.
2	*In the case of capacity additions, retrofits or replacements (except for wind, solar, wave or tidal power capacity addition projects which use Option 2: on page 10 to calculate the parameter $EG_{PJ,y}$): 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 expansion or retrofit of the plant has been undertaken between the start of this minimum historical reference period*	**Not applicable** There is no existing power plant at the project site, as the proposed project activity is a Greenfield power plant.

	and the implementation of the project activity.	
3	*In case of hydro power plants, one of the following conditions must apply:* • *The project activity is implemented in an existing reservoir, with no change in the volume of reservoir; or* • *The project activity is implemented in an existing reservoir, where the volume of reservoir is increased and the power density of the project activity, as per definitions given in the Project Emissions section, is greater than 4 W/m^2; or* • *The project activity results in new reservoirs and the power density of the power plant, as per definitions given in the Project Emissions section, is greater than 4 W/m^2.*	**Not applicable** This is a solar power plant.
Inapplicability condition of ACM0002		
4	*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.*	**Not applicable** This is a Greenfield power plant and does not involve switching from fossil fuels to renewable energy sources at the project site prior to the project implementation.
5	*Biomass fired power plants.*	**Not applicable** This is a solar power plant.
6	*Hydro power plants that result in new reservoirs or in the increase in existing reservoirs where the power density of the power plant is less than 4 W/m^2.*	**Not applicable** This is a solar power plant.
Applicability condition of "Tool to calculate the emission factor for an electricity system"		
7	*The geographic and system boundaries for the relevant electricity grid can be clearly identified and information on the characteristics of the grid is available.*	**Applicable** The geographic and system boundaries of the project connected electricity grid (the national grid of Thailand) can be clearly identified. Official information on the characteristics of the grid is also available. Details are provided in Annex 3.
Applicability condition of "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"		
8	*This tool applies to calculate the project and/or leakage CO_2 emissions from the combustion of fossil fuels. It can be used in cases where CO_2 emissions from fossil fuel combustion are calculated based on the quantity of fuel combusted and its properties.*	**Not applicable** The proposed project activity will import electricity from the EGAT/PEA grid for its auxiliary consumption, whenever necessary. It will not use any fossil fuels at the project plant.

In conclusion, ACM0002 is considered as the appropriate methodology for this Project.

B.3. Description of the sources and gases included in the project boundary:

The spatial extent of the project boundary for the proposed project activity encompasses the proposed project power plant and all power plants connected physically to the electricity system that the proposed project power plant is connected to, as illustrated in the diagram below.

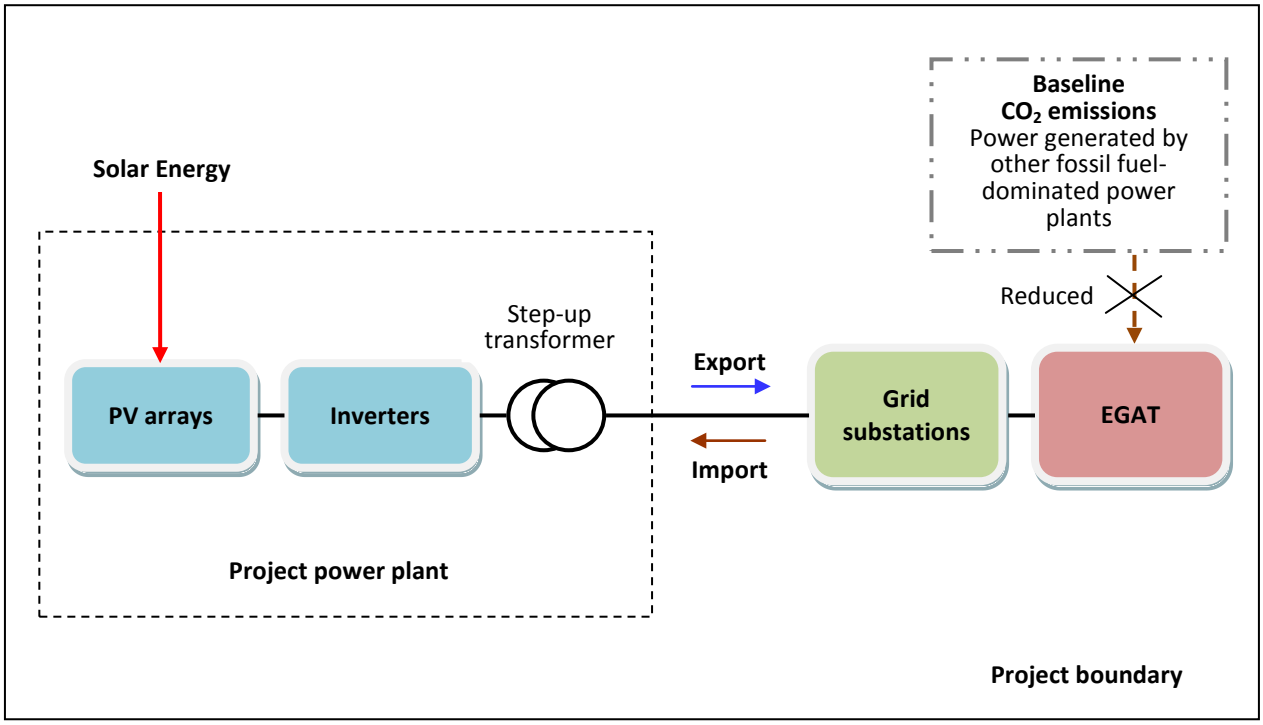


Figure 3: A simplified flow diagram in the project boundary[5]

For the sake of determining the emission reductions of the Project, the greenhouse gases and emission sources included in or excluded from the project boundary are summarized in the table below.

Table 4: Overview on emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	CO2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity.	CO_2	**Yes**	Main emission source.
		CH_4	No	Minor emission source. Excluded for simplification.
		N_2O	No	Minor emission source. Excluded for simplification.
Project activity	CO2 emissions from combustion of fossil fuels for electricity generation in solar thermal power plants.	CO_2	No	The proposed project activity involves the installation of a new photovoltaic power plant and does not consume fossil fuels. Therefore, these emissions should not be considered.
		CH_4	No	
		N_2O	No	

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

As per the guidance in ACM0002, if the project activity is the installation of a new grid-connected renewable power plant/unit, the baseline scenario is the following:

[5] For each monitoring variable and its monitoring equipment, please refer to Section B.7.

"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'."

Considering the fact that the proposed Project is a new grid-connected renewable solar power plant, the aforementioned baseline scenario applies to this project activity. Details of the grid system connected with the Project are provided in Section B.6.1. and 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):

1. PRIOR CONSIDERATION OF THE CDM AND ONGOING ACTIONS

In accordance with EB49 Annex 22 *"Guidelines on the demonstration and assessment of prior consideration of the CDM (Version 03)"*, the project participant of a proposed project activity with a start date on or after 2 August 2008 must inform a Host Party DNA and the UNFCCC secretariat in writing of the commencement of the project activity and of their intention to seek CDM status. Taking into account that the starting date of the project activity is on 19 May 2010, which was the date on which the land purchase agreement was executed, a written notification has been submitted to the DNA and the UNFCCC with the precise geographical location and project's brief description provided in accordance with the guidelines.

The following table summarizes the project timeline and all relevant evidence submitted to DOE for validation.

Table 5: Project timeline related to EB49 Annex 22

Item	Date [DD/MM/YYYY]	Key event	Evidence/Remarks
1	30/06/2009	NED's invitation to a CDM advisory proposal submission for the Project	Email correspondences between NED and Carbon Partners Asiatica ("Asiatica"). CDM advisory proposal to NED by Asiatica. **[Prior consideration of the CDM]**
2	17/08/2009	Receipt of the first version of the Engineering, Procurement and Construction (EPC) proposal from the EPC contractor	The first version EPC proposal.
3	26/10/2009	Consideration of implementing the Project as a CDM project activity	The resolution of Board of Directors No.8/2009. **[Prior consideration of the CDM]**
4	11/01/2010	Execution of the Agreement for CDM Consulting Services between NED and Asiatica	The Agreement for Consulting Services with Asiatica. **[Prior consideration of the CDM]**
5	20/01/2010 and 25/01/2010	Submission of Prior Consideration of the CDM Form to the UNFCCC Secretariat on 20/01/2010 and the Thai DNA on	The Prior Consideration of the CDM Form. The record of this notification is made available at the UNFCCC

		25/01/2010	website[6]. **[Prior consideration of the CDM]**
6	09/04/2010	Receipt of the final version of the EPC proposal from the EPC contractor	The final version EPC proposal.
7	22/04/2010	NED Board resolution to approve to enter into contract with the EPC contractor – a consortium of Sharp Corporation (SCJ), Italian-Thai Development Public Co., Ltd. (ITD), and Italthai Engineering Co., Ltd. (ITE)	The director's certificate.
8	**19/05/2010**	Execution of Land Purchase Agreement	The Land Purchase Agreement. **[Project start date]**
9	21/06/2010	Execution of Head Construction Contract between NED and EPC contractor (SCJ, ITD and ITE)	The contract with the EPC contractor for design, build, test and commission of the project plant.
10	04/08/2010	Start of construction works of the project plant	The Notice of Proceed.
11	02/02/2011	Application for the letter of approval from the host country DNA (Thailand Greenhouse Gas Management Organization (TGO))	The record of acknowledgment receipt by TGO. **[Real and continuing action taken]**
12	01/11/2011	Commercial operation of the project plant	This is an anticipated operation start date of Stage 1.

2. ADDITIONALITY DEMONSTRATION

The additionality of the project activity is assessed and demonstrated using step-wise approach delineated in the latest version of the *"Tool for the demonstration and assessment of additionality"* (hereinafter referred to as "Additionality Tool"). These steps include:

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

Sub-step 1a – Define alternatives to the project activity

The realistic and credible alternatives available to the project participants that provide outputs or services comparable with the proposed project activity are summarized as follows.

Alternative A: The proposed project activity not undertaken as a CDM project activity	
Included?	**Yes**
Justification/ Explanation	While the proposed project activity without CDM faces barriers identified in Step 3 below, implementation of such a project is deemed feasible and in compliance with mandatory laws and regulations of Thailand. For the sake of conducting a complete analysis, this option is considered as a plausible alternative and will be analysed

[6] Source: http://cdm.unfccc.int/Projects/PriorCDM/notifications/index_html.

	thoroughly by the ensuing steps of the additionality assessment.
Alternative B: Construction of a fossil fuel-fired power plant with equivalent amount of installed capacity or annual electricity output	
Included?	No
Justification/ Explanation	NED was founded in year 2008 as a power company in Thailand with its aim to develop renewable projects in the region[7]. Construction of a fossil fuel-fired power plant, which is opposite to the aim of NED's mission of generating natural/renewable energy, is not a realistic and practical alternative to NED, or other small power producers with similar investment mission.
Alternative C: Construction of a power plant using other sources of renewable energy with equivalent amount of annual electricity output	
Included?	No
Justification/ Explanation	None of the following identified renewable energy sources are realistic alternatives due to the below reasons. **(a)** ***Wind*** – Good wind areas are not widespread in Thailand and their potential is even very limited, as per the data shown in *"Thailand Alternative Energy Situation 2009"* published by DEDE[8]. Also, there is no wind power project implemented by SPP as of April 2008 according to Thailand's Ministry of Energy (MoE)[9]. **(b)** ***Hydro*** – A small portion of electricity (i.e. approximately 5% of the total national grid generation in 2008)[10] was generated by hydropower projects in Thailand, however this was produced mainly by mini-/micro- hydropower projects that are implemented by government agencies (e.g. EGAT, MoE, PEA), as in most cases obtaining various permits would be extremely difficult for the private sector (e.g. NED), as discussed in page 5 of *"Alternative energy, cogeneration and distributed generation: crucial strategy for sustainability of Thailand's energy sector"* published by MoE. According to MoE, there is no hydropower project implemented by SPP as of April 2008. **(c)** ***Biomass*** – Construction of a biomass-fired power plant with equivalent amount of annual electricity output is not a feasible option for a stand-alone power producer, due to the logistical and contractual difficulties for procuring a very large quantity of biomass. This is particularly true for NED, which does not possess any agricultural processing mills in Thailand. Taking into consideration that the biomass resource is widely dispersed in small quantities and its supply is susceptible to the weather or seasonal changes, it is impossible to secure the stability of biomass fuel supply and price throughout the project life. This, in turn, incurs both financial and logistical uncertainties. Some other barriers, such as finance-related barriers, technical barriers, information barriers and public support barriers, are also fully addressed in a

[7] More information about NED is provided at this link: https://www.ned.co.th/profile.html.

[8] Information was sourced from Table 11 of *"Thailand Alternative Energy Situation 2009"* (Page 19): http://www.dede.go.th/dede/fileadmin/upload/nov50/sep53/Thailand%20Alternative%20energy%20situation%202009.pdf.

[9] Information was sourced from Table 4 of *"Alternative energy, cogeneration and distributed generation: crucial strategy for sustainability of Thailand's energy sector"*.

[10] Information was sourced from Table 16 of *"Electric Power in Thailand 2008"*, published by DEDE, MoE.

	publication of *"Biomass and biogas energy in Thailand: Potential, opportunity and barriers"*[11]. **(d)** ***Geothermal*** – MoE indicates that the geothermal potential was evaluated based on the source of geyser (i.e. spring). From *"Thailand Alternative Energy Situation 2009"*, the geothermal energy potential is not widespread in Thailand and is rarely developed for electricity generation. According to MoE, there is no geothermal power project implemented by SPP as of April 2008. Based on the aforementioned energy situation, the identified renewable energy sources, which are likely facing technological barriers and/or unlikely to be economically competitive with other alternative energy sources (in particular the conventional energy source), are not considered plausible, and therefore this alternative can be ruled out.
Alternative D: Provision of an equivalent amount of annual power output by the grid where the Project is connected to	
Included?	**Yes**
Justification/ Explanation	This alternative is in compliance with mandatory laws and regulations in Thailand and faces no barrier, which make it a realistic and credible alternative. This also represents the continuation of the current situation.

Sub-step 1b – Consistency with mandatory laws and regulations

The following two shortlisted alternatives are in compliance with mandatory laws and regulations of Thailand, and therefore are inclusive and being analyzed in the ensuing analyzes.

Alternative A The proposed project activity not undertaken as a CDM project activity

Alternative D Provision of an equivalent amount of annual power output by the grid where the Project is connected to

STEP 2. Investment analysis

Consistent with the choices stipulated in the Additionality Tool, NED selected to substantiate the Project's additionality by means of the barrier analysis, thus the investment analysis is not applicable.

STEP 3. Barrier analysis

Sub-step 3a – Identify barriers that would prevent the implementation of the proposed CDM project activity

In order to determine whether the proposed project activity faces barriers that (a) prevent the implementation of this type of proposed project activity, and (b) do not prevent the implementation of at least one of the alternatives, relevant barriers are identified and demonstrated in accordance with the Step 3 of Additionality Tool and EB50 Annex 13 *"Guidelines for objective demonstration and assessment of barriers"*.

[11] Information was sourced from *"Biomass and biogas energy in Thailand: Potential, opportunity and barriers"*: http://www.thaiscience.info/Article%20for%20ThaiScience/Article/3/Ts-3%20biomass%20and%20biogas%20energy%20in%20thailand%20potential,%20opportunity%20and%20barriers.pdf.

Three identified barriers are 1) barriers due to prevailing practice, 2) technological barriers, and 3) investment barriers due to the lack of financing support for private investment. These barriers, which do not prevent the implementation of Alternative D, are encountered by the proposed project activity with or without undertaken as a CDM project activity, as delineated below.

1) Barriers due to prevailing practice

In accordance with EB guidelines in Additionality Tool reproduced below, national statistics from the EGAT, the DEDE and the Energy Policy and Planning Office (EPPO) of Ministry of Energy are provided to substantiate that the barriers have actually prevented the implementation of solar power projects in Thailand.

> *"Sub-step 3b:*
> *(3) In applying Sub-steps 3a and 3b, provide transparent and documented evidence, and offer conservative interpretations of this documented evidence, as to how it demonstrates the existence and significance of the identified barriers and whether alternatives are prevented by these barriers. Anecdotal evidence can be included, but alone is not sufficient proof of barriers. The type of evidence to be provided should include at least one of the following:*
> ……
> *(b) Relevant (sectoral) studies or surveys (e.g. market surveys, technology studies, etc.) undertaken by universities, research institutions, industry associations, companies, bilateral/multilateral institutions, etc.;*
> *(c) Relevant statistical data from national or international statistics; ……"*

According to the *"Electricity Report 2009"* published by EGAT, the electricity generation of national grid in 2009 was 145,300.19GWh, of which approximately 92% of the electricity was supplied from fossil fuel-based generation systems and less than 2% of the electricity was generated by renewable fuel-based generation systems using renewable fuels, such as solar, biomass residues, biogas, residual gas from production processes, etc., indicated in the table below. Therefore, it proved that renewable power generation is not a prevailing practice in Thailand.

Table 6: Quantity of electricity generated and delivered to the national grid in 2009[a)]

Generation system	Grid generation	
	(GWh)	(%)
Thermal	38,077.35	26.2
Combined-cycle	94,369.35	64.9
Gas turbine	1,143.23	0.8
Diesel engine	1.44	0.0
Hydropower	6,965.71	4.8
Renewable energy[b)]	2,140.68	1.5
Electricity import	2,602.43	1.8
Total	**145,300.19**	**100**

a) *"Electricity report 2009"*, published by EGAT.

b) This includes electricity generation from renewable fuels, such as solar, biomass residues, biogas, residual gas from production processes, etc.

Further analysis was carried out with the aim to determine whether the proposed project type using PV or other comparable technologies (i.e. solar thermal, parabolic trough and stirling engine technologies) with similar scale as the Project was already diffused in the relevant sector and region.

Based on this perspective, the analysis was focused on identifying all solar power projects in Thailand under the SPP Program, which according to the regulations allows SPPs to deliver from >10MW up to 90MW electricity for sale to EGAT.

As per the SPP data (as of December 2009 published by EPPO) that is available at the time of the investment decision made on April 2010, there was no SPP solar power project that has commenced commercial operation or has executed a PPA with EGAT. Even from the latest available SPP data as of March 24, 2010[12] (publicly available at the EPPO website on December 2010), none of SPP solar power projects are operational. The proposed project activity is the first-ever SPP solar power project that has executed a PPA with EGAT in Thailand.

Though the Thai Government has introduced a SPP Program and promotes renewable energy projects, the generation of carbon-neutral electricity from solar energy is still not a prevailing practice at the time of the investment decision or at the time of the PDD preparation. The above national statistics proved that the proposed project activity is the **first-of-its kind** in terms of the technology and scale in the country and would not have occurred as business-as-usual because the existing common practice in Thailand is the generation of electricity from conventional fossil fuel-based systems.

It is noted that this specific barrier is demonstrated not only in accordance with Sub-step 3b (item 3c) of the Additionality Tool, but also consistent with Guideline 3 of EB50 Annex 13 below.

> ***Guideline 3:*** *In order to make an objective claim for a specific barrier, the PDD confirms the existence of the barrier by using evidence sources listed in the Tool for the demonstration and assessment of additionality and the Combined tool to identify the baseline scenario and demonstrate additionality, by demonstrating, for each of the barrier, that in similar circumstances (in similar industries/sectors, in companies of similar size and ownership structure, in similar projects) the barriers actually prevented the implementation of other project(s).*
> ***Example:*** *The existence of a technological barrier for high pressure steam technology is confirmed by showing evidence that the use of this technology in the considered sector is marginal e.g. below10%.*

2) Technological barriers

The continuation of the current situation, which is the provision of an equivalent amount of annual power output by the grid where the Project is connected to (Alternative D), is likely to be the baseline scenario to the project activity. This less technologically advanced alternative to the project activity does not encounter any technological barriers, as it is the existing prevailing practice in Thailand.

In comparison with the conventional fossil fuel-based generation system, solar PV-based generation system is considered as an innovative and advanced technology in Thailand. The most distinctive technology items of a grid-connected solar power plant are the solar modules and the inverters. The modules will harvest the solar energy and convert it into DC power, whereas the inverters will be designed to work under the variable power output conditions of the modules, to convert the DC power into AC power that will be then connected to a transformer in order to deliver useful AC power to be connected to the national grid. As described in Section A.4.3., this Project may use four different types of Sharp thin-film silicon tandem structure modules (NA-F128(G6), NS-F128(G6), NA-F138(G6) and NS-F138(G6)) and central inverter model JH-250KE, which are all recently

[12] Data source: http://www.eppo.go.th/power/data/index.html.

developed and not available in Thailand[13]. Therefore, the technological risk introduced by this state-of-the-art technology to be employed by the Project cannot simply be ignored.

In addition to the aforementioned technological risk, a lack of skilled management to oversee the innovative large-scale PV-based power plant and properly trained labour to operate and maintain the technology, which leads to an unacceptably high risk of equipment disrepair, malfunctioning or other underperformance, is also deemed as one of the technological barriers. This is of particular concern for a project to be developed in a developing country like Thailand. According to the relevant survey related to the world's largest PV power plants undertaken by PV Resources[14], the top twelve PV power plants, which are recently developed and/or commissioned, are all located in developed countries and with the installed capacity ranged from 40MW-DC to 97MW-DC, as shown in the table below.

Table 7: World's largest PV power plants

Name of PV power plant	Location	Power capacity (MW-DC)	Year of construction completion
Sarnia PV power plant	Canada	97	2009-2010
Montalto di Castro PV power plant	Italy	84.2	2009-2010
Solarpark Finsterwalde I, II, III	Germany	80.7	2009-2010
Rovigo PV power plant	Italy	70	2010
Parque Fotovoltaico Olmedilla de Alarcon	Spain	60	2008
Solarpark Strasßkirchen	Germany	54	2009
Solar park Lieberose	Germany	53	2009
Parque Fotovoltaico Puertollano	Spain	50	2008
Copper Mountain Solar Facility	USA	48	2010
Moura photovoltaic power plant	Portugal	46	2008
Cellino San Marco PV power plant	Germany	43	2010
Solarpark Waldpolenz	Germany	40	2007-2008

It justified that a lack of skilled personnel in managing and operating a PV-based power plant, which was demonstrated in line with Sub-step 3b (item 3b) of the Additionality Tool reproduced above, is a real and existent barrier in Thailand.

To further substantiate the credibility of these technological barriers, the below Guideline 1 of EB50 Annex 13 was also applied:

> *"Guideline 1: While demonstrating barriers related to the lack of access to capital, technologies and skilled labour, the project proponents shall provide information on the nature of the companies and entities involved in the financing and implementation of the project. More specifically:*

[13] It is noteworthy that there are two reasons why NED has gone the thin film solar route other than other with other solar technologies available. They are: (a) thin film is better suited to the geographical location in Thailand due to the temperature range; and (b) the bottom line efficiency / capacity comparison based on unit price made thin film more economical for NED even though there are more panels compared to crystalline solar panels.

[14] Data source of large-scale photovoltaic power plants: http://www.pvresources.com/en/top50pv.php (accessed on 23/02/2011).

- *While demonstrating barriers related to technologies and skilled labour, information should include nature of company, organization and its ownership, and previous experience with similar project (that is under consideration for CDM) in other locations."*

NED was founded in year 2008 as a power company in Thailand with its aim to develop renewable projects in the region. The company operation is to generate and distribute electricity to Thailand electricity generating and distributing units under Thailand regulations for purchasing power for very small power producer and small power producer (VSPP and SPP). Currently, NED focuses its power project development on two energy sources, solar and wind power, which are clean and non-polluting types of energy resources. The proposed project activity is the first-ever solar power plant that is being developed by the project participant. NED is an equally joint venture of the following three companies, each holding 33.33% share:

a) ***CLP Thailand Renewables Ltd.*** – A wholly owned subsidiary of CLP Holdings Limited ("CLP"). Founded in 1901 in Hong Kong, the CLP Group is one of the leading power companies in Asia-Pacific. Over the past two decades, CLP has expanded its footprint from Hong Kong into mainland China, Australia, India, Thailand and Taiwan, and has the total generating capacity of over 17,000MW, of which well over 90% of the total generating capacity of its portfolio is fossil fuel- and nuclear-based plants. CLP has in recent years expanded into renewable energy generation, developing projects such as:
   - Yunnan Dali Yang_er 49.8MW hydropower project (CDM reference 1388);
   - Datang Jilin Shuangliao wind farm project (CDM reference 0869);
   - Shandong Changdao 27.2MW wind power project (CDM reference 1090);
   - Shandong Weihai 69MW wind power project (CDM reference 1128);
   - Guohua Binzhou Zhanhua 49.5MW wind farm project (Phase 1) (CDM reference 2438);
   - Jilin Shuangliao 2nd phase wind power project (CDM reference 2685);
   - CLP Huanyu (Shandong) biomass heat and power generation project (under validation);
   - Qian'an Wangxin Caizi Town windfarm project phase I (under validation); etc.

   Notwithstanding its global experience in power generation industry and its diversified and climate-friendly generation portfolio, CLP lacks development and operation experience in the solar power sector and the proposed project activity is the first-ever solar power plant for CLP[15].

b) ***Diamond Generating Asia Limited ("DGA")*** – A wholly owned subsidiary of Mitsubishi Corporation ("MC"). MC is Japan's largest general trading company and has long been engaged in business with customers around the world in virtually every industry, including energy, metals, machinery, chemicals, food and general merchandise. DGA is recently formed in May 2009 to mainly develop the power business in MC in the Southeast Asia region and Taiwan. Though MC has been engaged in business with customers in different industries, their experience is not relevant.

c) ***Electricity Generating Public Company Limited ("EGCO")*** – EGCO is the first independent power producer in Thailand. It was incorporated on May 12, 1992 by EGAT, which marked the commencement of the Thai government's privatization initiatives to allow broader private sector investment in the power sector. EGCO was transformed into a public company on

[15] Information was sourced from CLP website: https://www.clpgroup.com/ouroperations/assetsandservices/powergeneraton/Pages/powergeneration.aspx.

March 23, 1994 and is a holding company with investment in power generation and supply. Though EGCO owns and develops generating units, which cover diversified fuels such as natural gas, coal, diesel oil, hydropower and biomass, similar to CLP, EGCO also lacks development and operation experiences in solar power sector and the proposed project activity is also the first-ever solar power plant to EGCO[16].

This obviously leads to another problem, which is project development. As discussed above, large-scale solar PV is new to Thailand and therefore all project participants (not only NED but law firm to draft a contract, government to approve the project, technical advisor to do the feasibility study, lender to approve the loan, etc.) face an inherent barrier and a steep learning curve, which would be near to impossible to overcome for a SPP with less formidable members. Being positioned with strong power-sector owners, NED however could leverage the robust power sector experience of its shareholders. The approach NED has taken towards EPC contract negotiation is an example of using traditional power-sector experience to effectively control the risks associated with large-scale solar PV plant development, over-and-above the typical standards of the solar PV industry internationally. For management of solar-specific technology and design issues as well as operation of a solar PV plant, however, general power sector experience is not necessarily sufficient.

3) Investment barriers

Among the three identified barriers, investment barriers due to the lack of financing support for private investment are the most insurmountable barriers. The risks associated with introducing new thin-film PV technology on a large-scale together with the inherent uncertainty in the intermittent solar energy source were two of the major concerns to the financial lenders when assessing the financial loans of the Project. Having no track record of operation of such project plant, NED indeed faced uphill obstacles not only in convincing the host country government to approve the Project using this type of new technology, but also in acquiring financing supports from the lenders.

According to NED's financial plan, the Project will raise its project capital by means of equity from the shareholders and bank loan from the financial lenders, with the equity to debt ratio of 30% to 70%. NED applied the loans from the Asian Development Bank (ADB) alongside other local financial institutions including Kasikorn Bank PCL, Bangkok Bank PCL and Siam Commercial Bank PCL, with specifying its intention to develop the Project as a CDM project activity. Throughout the negotiations between the lenders and NED, it is realized by the NED that all the financial lenders took explicitly the CDM registration into account and looked at the CDM revenue as an upside to the project return during the loan approval process. Without the benefit of the CDM, it is unlikely that NED will acquire sufficient financing support for the project implementation. This is particularly the case for the crucial lender of the Project – ADB, which is supported by ADB's internal but publicly available report namely *"Proposed loan and administration of grant for solar power project"* dated March 2010. This is indeed a report and recommendation of the President of ADB to the Board of Directors for ADB's loan approval. As delineated in the report, ADB will provide its financing support to the proposed CDM project activity in the following manners:

a) A proposed loan will be for up to the lower of 70 million US dollars equivalent in baht and 25% of project costs. In the event that ADB cannot effectively fund baht loans, or NED elects to arrange financing under an ADB partial credit guarantee, the proposed direct loan may be

[16] Information was sourced from EGCO website: http://www.egco.co.th/en/corperate_profile_busin_group.asp.

replaced by a partial credit guarantee issued by ADB to eligible lenders up to the lower of 70 million US dollars equivalent in baht and 25% of project costs.

b) The grant component of investments, amounting to 2 million US dollars, will be financed on a grant basis by the Clean Energy Fund under the Clean Energy Financing Partnership Facility, comprising three clean energy funds whose aim is to help improve energy security in developing member country and decrease the rate of climate change. The grant funds will be administrated by ADB and cover a portion of the contingency financing in the event that the Project has to draw down contingency funds. The grant funds for contingency financing significantly reduce the risk of introducing PV technology on large-scale.

c) The pre-financed certified emission reductions from ADB's Future Carbon Fund will be offered to the Project. This fund can provide up-front financing by purchasing a portion of the post-2012 carbon credits that will be generated from January 1, 2013 to December 31, 2020.

To support the implementation of this project activity, ADB's Carbon Market Initiative team, who administers the current CDM support program of ADB, has been working on the CDM component with NED, in parallel with the ADB loan discussions. NED must admit to ADB's justification given in the report that:

- ADB assistance will play a crucial role in helping the Project to obtain appropriate long-term financing, which is a necessary condition for the viability of a solar project. Due to the recent credit crunch, bank liquidity is limited, and local banks can rarely provide loans for more than 10-12 years. However, tenors required for solar power generation projects are significantly longer. ADB's long-term local currency loan or, in the alternative, guarantee give NED the tenors it needs in order to fund a power generation plant that has high upfront investment costs, but no ongoing fuel cost.

- Without the availability of ADB's loan, pre-financed CERs from the Future Carbon Fund and the proposed grant component of investments by the Clean Energy Fund, it is unlikely that the Project would meet NED's minimum hurdle rates to implement the Project.

- ADB's facility encourages the commitment of local commercial banks, which have less experience in clean energy projects. Therefore, ADB's participation in the debt financing will help facilitating local and/or international bank participation.

All of the above clearly demonstrated that the financing of the Project was assured only due to the benefit of the CDM. Without this financing support, the proposed project activity will not be implemented. These insurmountable investment barriers are substantiated in line with the Guideline 6 of EB50 Annex 13, reproduced as follows:

> ***"Guideline 6:*** *In case the PPs make the claim for investment barriers, they should demonstrate in the PDD that the financing of the project was assured only due to the benefit of the CDM. Therefore, it should be demonstrated that the loan approval (or other significant financing decision(s)) by the lender takes explicitly the CDM registration into account.*
> ***Example 1:*** *For the cases where the investment is done by a company which also purchases the CERs and the loan agreement mentions that, there is an objective demonstration that the CDM facilitated the lending.*

Example 2: *For the cases where it can be objectively demonstrated that a significant part of the project investment is provided upfront by a company as a pre-payment for expected CERs, there is an objective demonstration that the CDM actually enabled the financing of the project.*
Rationale: *Loan agreements are an objective means to demonstrate the barrier."*

Sub-step 3b – Show that the identified barriers would not prevent the implementation of at least one of the alternatives

It is evident in Sub-step 3a above, the identified barriers do not affect the alternative to the project activity, which is provision of an equivalent amount of annual power output by the grid where the Project is connected to (Alternative D). The alternative to the Project is essentially the continuation of current situation and the technological and investment barriers involved in the proposed project activity will not affect or prevent the continued implementation of current practice.

Based on the foregoing assessments, Alternative D is considered as the realistic baseline scenario to the project activity.

STEP 4. Common practice analysis

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

According to the Additionality Tool, *"unless the proposed project type has demonstrated to be first-of-its kind, the above generic additionality tests shall be complemented with an analysis of the extent to which the proposed project type has already diffused in the relevant sector and region"*.

Given that the proposed project activity is demonstrated as the **first-of-its kind** in terms of technology and scale in Thailand based on the EPPO's official data as delineated in Sub-step 3a above, it is concluded that the project activity is not widely observed and commonly carried out in the region and therefore the common practice analysis, as a credibility check to complement the barrier analysis, is not required.

Sub-step 4b – Discuss any similar options that are occurring

As per Sub-step 4a, there are no similar options that are occurring in Thailand.

3. CONCLUSION

The above analyzes demonstrate that the proposed project activity meets not only the additional criteria, but also the criteria for the prior consideration and ongoing actions, and therefore it is additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

1. BASELINE EMISSIONS

The baseline emissions associated with electricity generation from power plants connected to the grid are calculated by the equation below:

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

where:

BE_y	*Baseline emissions in year y (tCO_2e/yr)*
$EG_{PJ,y}$	*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/yr)*
$EF_{grid,CM,y}$	*Combined margin CO2 emission factor for grid connected power generation in year y calculated using the latest version of the "Tool to calculate the emission factor for an electricity system" (tCO_2/MWh)*

(a) Determination of net quantity of electricity generation ($EG_{PJ,y}$)

Considering that the proposed project activity is a Greenfield renewable energy power plant where no renewable power plant was operated prior to the project implementation, then:

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

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

(b) Determination of grid emission factor ($EF_{grid,CM,y}$)

The $EF_{grid,CM,y}$ is calculated as a combined margin (CM), following the 7 steps stipulated in *"Tool to calculation the emission factor for an electricity system"*, as delineated in Annex 3. Table 8 summarizes the baseline emission factors of Thailand's national electricity system in 2009.

Table 8: Baseline emission factors of Thailand's national electricity system in 2009

Emission factor	Data	Unit	Data source
Operating margin (OM)	0.6147	tCO_2/MWh	*"The study of emission factor for an electricity system in Thailand 2009"* published by TGO on September 3, 2010
Build margin (BM)	0.5477	tCO_2/MWh	
Combined margin (CM)	0.5980	tCO_2/MWh	

2. PROJECT EMISSIONS

In accordance with ACM0002, a solar PV power generation project activity, which utilizes solely renewable solar fuel and does not consume fossil fuels for power generation, will not incur project emissions. Hence,

$$PE_{FF,y} = 0\ tCO_2e$$

3. LEAKAGE

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, transport). Taking into consideration that these emission sources are neglected in ACM0002, no leakage emissions are considered. Hence,

$$LE_y = 0\ tCO_2e$$

4. EMISSION REDUCTIONS

Emission reductions due to the project implementation are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y$$

where:

ER_y	*Emission reductions in year y (tCO_2e/yr)*
BE_y	*Baseline emissions in year y (tCO_2e/yr)*
PE_y	*Project emissions in year y (tCO_2e/yr)*
LE_y	*Leakage emissions in year y (tCO_2e/yr)*

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 report 2007-2009"* published by EGAT
Value applied:	Refer to Table A5 of 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 methodological tool *"Tool to calculate the emission factor for an electricity system (Version 02)"*.
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 2008"*, published by the Department of Alternative Energy Development and Efficiency, Ministry of Energy
Value applied:	Refer to Table A2 of Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice as per the methodological tool *"Tool to calculate the emission factor for an electricity system (Version 02)"*.
Any comment:	-

Data / Parameter:	**$EF_{CO2,i,y}$**
Data unit:	tCO_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 to Table A2 of Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice as per the methodological tool *"Tool to calculate the emission factor for an electricity system (Version 02)"*.
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 report 2007-2009"* published by EGAT
Value applied:	Refer to Table A4 of Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice as per the methodological tool *"Tool to calculate the emission factor for an electricity system (Version 02)"*.
Any comment:	-

Data / Parameter:	**$FC_{i,m,y}$**
Data unit:	Mass or volume unit
Description:	Amount of fossil fuel type *i* consumed by power plant/unit *m* in year *y*
Source of data used:	*"Electricity report 2009"* published by EGAT
Value applied:	Refer to Table A9 of 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 methodological tool *"Tool to calculate the emission factor for an electricity system (Version 02)"*.
Any comment:	-

Data / Parameter:	**$EG_{m,y}$**
Data unit:	MWh/yr
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 report 2009"* published by EGAT
Value applied:	Refer to Table A9 of Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice as per the methodological tool *"Tool to calculate the emission factor for an electricity system (Version 02)"*.
Any comment:	-

B.6.3. Ex-ante calculation of emission reductions:

1. BASELINE EMISSIONS

With reference to the project implementation schedule below, the Project is to be implemented in seven stages over the first operational year. Commissioning of the first stage is expected to start in November 1, 2011 and full operation is to commerce in May 1, 2012.

Stage	Expected commissioning date[a)] (DD/MM/YYYY)
1	01/11/2011
2	01/12/2011
3	01/01/2012
4	01/02/2012
5	01/03/2012
6	01/04/2012
7 (full operation)	01/05/2012

a) Should the commissioning date of Stage 1 delay, the commissioning date of the subsequent stages shall be delay accordingly.

With this, the Project is expected to export approximately 78,649 MWh and 105,512 MWh[17] of net electricity to the grid at year 1 and each of the following years after the commercial operation respectively.

$$\boldsymbol{BE_y = EG_{facility,y} \times EF_{grid,CM,y}}$$

Parameter	Symbol	Value	Source / Note
Quantity of net electricity generation supplied by the project plant/unit to the grid in year *y*	$EG_{facility,y}$	Year 1: 78,649 MWh/yr Year 2 and onwards: 105,512 MWh/yr	Please refer to the CER calculation spreadsheet, which is submitted together with the PDD, for details.
Combined margin CO2 emission factor for grid connected power generation in year *y*	$EF_{grid,CM,y}$	0.5980 tCO_2/MWh	*"The study of emission factor for an electricity system in Thailand 2009"*
Baseline emissions	BE_y	Year 1: **47,032 tCO_2e/yr** Year 2 and onwards: **63,096 tCO_2e/yr**	Calculated.

2. PROJECT EMISSIONS

As explained in Section B.6.1., no project emissions are involved in this Project. Hence,

$$\boldsymbol{PE_{FF,y} = 0\ tCO_2e}$$

3. LEAKAGE

[17] Net electricity generation and export to the grid is the difference between the gross electricity generation and the auxiliary power consumption by the project activity (i.e. (73.16MW_{gross} x 8,760h/yr x 17.15%) – 4,399MWh/yr = 105,512MWh/yr, where 17.15% is the plant load factor estimated by the third party). For details, please also refer to Section A.4.3..

As explained in Section B.6.1., no leakage emissions are considered in this Project. Hence,

$$LE_y = 0\ tCO_2e$$

4. EMISSION REDUCTIONS

$$ER_y = BE_y - PE_y - LE_y$$

Parameter	Symbol	Value	Source / Note
Baseline emissions in year *y*	BE_y	Year 1: 47,032 tCO_2e/yr Year 2 and onwards: 63,096 tCO_2e/yr	Calculated results of Section B.6.3.1.
Project emissions in year *y*	PE_y	0 tCO_2e/yr	As per ACM0002.
Leakage emissions in year *y*	LE_y	0 tCO_2e/yr	As per ACM0002.
Emission reductions	ER_y	Year 1: **47,032 tCO_2e/yr** Year 2 and onwards: **63,096 tCO_2e/yr**	Calculated.

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

Year	Estimation of baseline emissions	Estimation of project activity emissions	Estimation of leakage	Estimation of overall emission reductions
	(tCO_2e)	(tCO_2e)	(tCO_2e)	(tCO_2e)
	A	B	C	D=A-B-C
01/11/2011 – 31/10/2012	47,032	0	0	47,032
01/11/2012 – 31/10/2013	63,096	0	0	63,096
01/11/2013 – 31/10/2014	63,096	0	0	63,096
01/11/2014 – 31/10/2015	63,096	0	0	63,096
01/11/2015 – 31/10/2016	63,096	0	0	63,096
01/11/2016 – 31/10/2017	63,096	0	0	63,096
01/11/2017 – 31/10/2018	63,096	0	0	63,096
Total	**425,608**	**0**	**0**	**425,608**

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

B.7.1 Data and parameters monitored:

Data and parameter to be monitored based on ACM0002:

Data / Parameter:	**$EG_{facility,y}$**
Data unit:	MWh

Description:	Quantity of net electricity generation supplied by the project plant/unit to the grid in year *y*
Source of data to be used:	Calculated based on the monitored data
Value of data applied for the purpose of calculating expected emission reductions in section B.5.	Year 1: 78,649 Year 2 and onwards: 105,512
Description of measurement methods and procedures to be applied:	This parameter will be determined through calculating the difference between the electricity supplied to and drawn from the grid (EGAT/PEA) by the Project, which are measured continuously and recorded at least monthly, as follows: $EG_{facility,y} = EG_{export,y} - \Sigma EC_{import,i,y}$ where $EG_{export,y}$ Electricity exported to the grid in year *y* (MWh) $EC_{import,i,y}$ Electricity imported from the grid via substation *i* in year *y* (MWh)
QA/QC procedures to be applied:	The calculated result will be cross-checked by the CDM Manager, where appropriate.
Any comment:	-

Data / Parameter:	**$EG_{export,y}$**
Data unit:	MWh
Description:	Electricity exported to the grid in year *y*
Source of data to be used:	On-site measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.5.	Year 1: 83,048 Year 2 and onwards: 109,911
Description of measurement methods and procedures to be applied:	Measurement procedures This parameter will be continuously monitored by electricity meter(s) with stipulated accuracy class as per local grid's (EGAT/PEA) requirements. Measurement frequency Continuously. Data is to be recorded at least monthly.
QA/QC procedures to be applied:	The electricity meter(s) will be calibrated in accordance with the national/international standards and recalibrated at appropriate intervals according to the local grid's (EGAT/PEA) requirements, national/international standards, or manufacturer specifications. The consistency of metered electricity export should be cross-checked with invoices / receipts from electricity sales.
Any comment:	-

Data / Parameter:	$EC_{import,i,y}$
Data unit:	MWh
Description:	Electricity imported from the grid via substation *i* in year *y*
Source of data to be used:	On-site measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.5.	Year 1: 4,399 Year 2 and onwards: 4,399
Description of measurement methods and procedures to be applied:	Measurement procedures This parameter will be continuously monitored by electricity meter(s) with stipulated accuracy class as per local grid's (EGAT/PEA) requirements. Measurement frequency Continuously. Data is to be recorded at least monthly.
QA/QC procedures to be applied:	The electricity meter(s) will be calibrated in accordance with the national/international standards and recalibrated at appropriate intervals according to the local grid's (EGAT/PEA) requirements, national/international standards, or manufacturer specifications. The consistency of metered electricity import should be cross-checked with invoices / receipts from electricity purchases.
Any comment:	-

B.7.2. Description of the monitoring plan:

1. CDM MONITORING TEAM

NED understands that having a good monitoring team to execute a well-defined monitoring plan is extremely important for the project activity. From this perspective, NED planned a tentative operational and management system that will be implemented upon the project commissioning. The responsibility of data collecting, archiving, analyzing and reviewing falls on different members of the CDM monitoring team. This team is composed of a General Manager, a CDM Project Manager, a CDM Coordinator, and a group of Operators and Technicians, as shown in the diagram below.

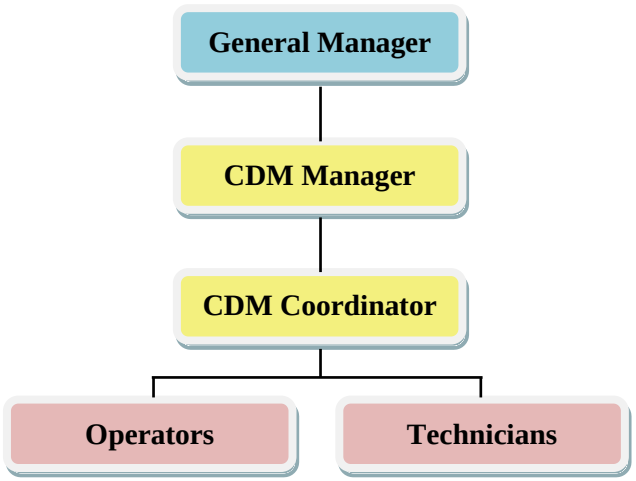


Figure 4: The CDM monitoring team

The roles and responsibilities of each team member are as follows:

A. General Manager

He/she is responsible for overall supervision of the whole project plant, including the CDM monitoring and verification activities as well as internal review of the monitoring records and the CDM monitoring reports.

B. CDM Project Manager

He/she is in charge of issues related to the CDM, including:

- Supervise the CDM monitoring team
- Review the monitoring data and monthly records
- Liaise with the Production Manager
- Liaise with the Finance Manager
- Liaise with the CDM Advisor and the Verification DOE
- Track the CDM development of the Project

C. CDM Coordinator

He/she is responsible to:

- Check the monitored data on-site and collect measured data regularly
- Archive collected data electronically and prepare the monitoring records monthly
- Cross-check the monitoring records with the sales and/or purchases invoices, if available
- Collect and archive the instrument calibration reports
- Report to the CDM Manager regularly

D. Operators

They are responsible to:

- Monitor the operation of monitoring instruments and meters
- Record the monitored data
- Report to the Production Manager and the CDM Manager when the abnormal operation observes

E. Technicians

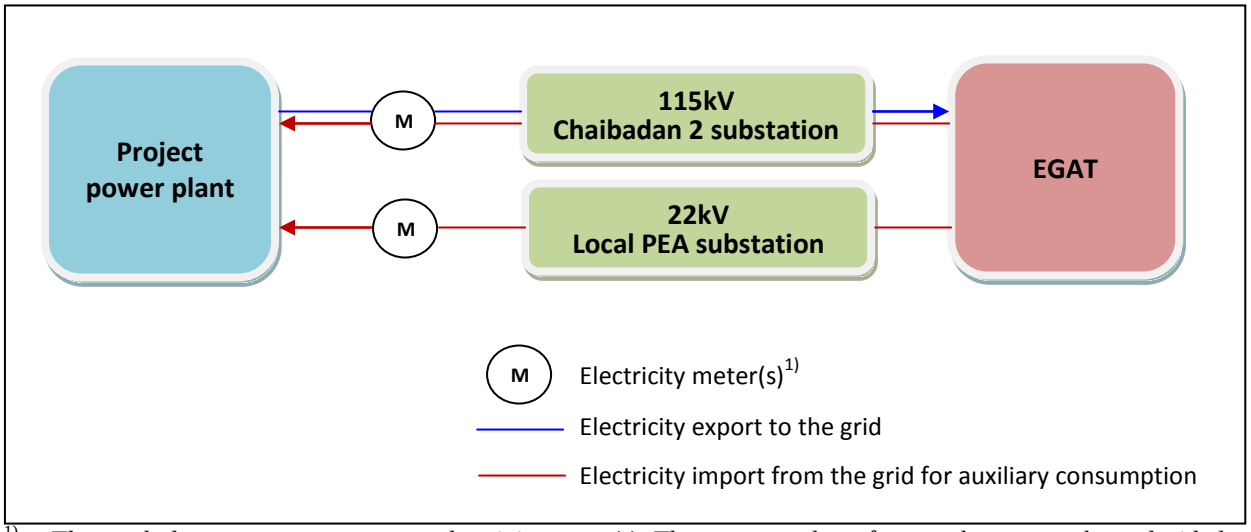
They are responsible for:

- Facilities, instruments and meters maintenance
- Ensuring smooth operation of each instrument and meter

In order to ensure that the monitoring activity will take place in accordance with the set monitoring plan and the applied monitoring methodology, the relevant staffs will receive training on measurement methods to be applied for each parameter as well as data monitoring and recording requirements before the project implementation. In the following years within the crediting period, on-the-job training will also be provided whenever necessary.

2. MONITORING INSTRUMENTS

In accordance with ACM0002 the project activity applies, the net electricity supplied by the Project to the grid ($EC_{facility,y}$) is calculated as the difference between the electricity exported to the grid ($EG_{export,y}$) and the electricity imported from the grid via substation *i* ($EC_{import,i,y}$) due to the on-site auxiliary consumption by the project activity.



1) The symbol represents one or more electricity meter(s). The exact number of meters has not yet been decided at the time of PDD preparation.

Figure 5: A simplified monitoring plan of the Project

In order to determine the net electricity supplied by the Project, the quantities of electricity exported to and imported from the grid will be measured using electricity meters. As per Figure 5, a main meter with accuracy class of 0.2S (the maximum error is ±0.2%) will be installed at the Chaibadan 2 power substation or the project plant [18] to monitor the electricity exported ($EG_{export,y}$) to and imported ($EC_{import,Chaibadan,y}$) from the grid via the main 115kV transmission line continuously. In addition, a backup

[18] NED has been in renegotiation with the grids about the location of the main and backup electricity meters at the time of validation. It is noted that these meters will be installed at the location that is mutually agreed by the involved parties and would not compromise the monitoring plan.

meter with the same accuracy level will be installed beside the main electricity meter for double checking in case of inaccuracy or malfunction of the main electricity meter. Individual electricity meter(s) with precision of 0.5S (the maximum error is ±0.5%) will also be installed at the project plant or other designated location as per grid's directive to monitor the auxiliary power imported from the backup 22kV transmission line connected to the local PEA substation ($EC_{import,PEA,y}$) whenever necessary. All electricity meters shall be calibrated regularly in accordance with the local grid's requirements, national/international standards, or manufacturer specifications where appropriate. It is noted that the number of electricity meters could possibly change but that it would not compromise the monitoring plan.

3. DATA MONITORING AND MANAGEMENT SYSTEM

The parameter stipulated in Section B.7.1 shall be monitored as per the set monitoring frequency in the monitoring plan and logged at a predetermined time either manually and/or electronically by the plant Operators. The CDM Coordinator will usually collect the measured data and archive the collected data electronically monthly, unless otherwise stated in Section B.7.1. The archived results will then be analyzed and cross-checked against the sales and/or purchases invoices, if available, by the CDM Coordinator together with the CDM Manager. As part of the internal quality control and assurance process, the monthly records will be submitted to the top management for internal review. The overall CDM monitoring activity will be overseen by the General Manager of the project plant.

For the sake of verification, a CDM Monitoring Report, which contains estimated delivered emission reductions, status of plant operation and maintenance, instrument calibration certificates, etc., will be prepared by the CDM Coordinator and the CDM Manager regularly. This essential report will then be reviewed by the General Manager before submitting to a DOE for emission reduction verification.

In compliance with the methodology, all data collected as part of monitoring shall be archived electronically and be kept at least 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in Section B.7.1. All meters and instruments shall be calibrated regularly as per relevant industry standards.

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):

The baseline study was completed on 02/09/2011 by:

Carbon Partners Asiatica
Suite 1402, World Commerce Centre,
11 Canton Road, Tsim Sha Tsui,
Kowloon, Hong Kong
(Tel: +852-31010131 / Fax: +852-36221360)
www.cp-asiatica.com

CDM Advisors
Ms. Coty Tsui (coty.tsui@cp-asiatica.com)
Ms. Kyoko Tochikawa (kyoko.tochikawa@cp-asiatica.com)

Carbon Partners Asiatica is the CDM advisor to the Project and is 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:

19/05/2010

(The starting date of the project activity refers to the date of initial real action taken, when the land purchase agreement was executed. The serious consideration of CDM prior to the project start is supported by (a) the Agreement of Consulting Services with Asiatica and (b) the Prior Consideration of the CDM Form submitted to the UNFCCC Secretariat and the Thai DNA on 20 January 2010 and 25 January 2010 respectively.)

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

25 years 0 month.

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

The project activity will use a renewable crediting period.

C.2.1. Renewable crediting period:

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

01/11/2011 or immediately from the date of project registration, whichever is the latest.

C.2.1.2. Length of the first crediting period:

7 years 0 month.

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:

According to the National Environmental Quality Act of Thailand, NED is NOT required to submit an Environmental Impact Assessment (EIA) report of the proposed project activity to the Office of National Resources and Environmental Policy and Planning (ONEP) for national approval[19].

However, in compliance with the host country DNA regulation, which stipulates that an EIA or an Initial Environmental Evaluation (IEE) shall be conducted for all CDM projects regardless of the severity of the environmental impact, EIA has been conducted for the Project by an accredited entity, Greener Consultant Co., Ltd. and completed in December 2009.

The EIA assesses all environmental aspects of the Project from construction phase through to operation phase. The overall results of the EIA were favourable and it is demonstrated that no negative impacts were identified. For the sake of avoidance or mitigation of any potential impacts on our environment, a series of environmental impact prevention and mitigation measures are suggested to be implemented during each phase.

Table 9: Potential pollution sources at construction and operation periods and its mitigation measures

Potential pollution source	Environmental impact prevention and mitigation measures	
	Construction period	Operation period
Air pollution	- Construction activities will generate dust. Measures to be adopted to minimize dust generation include (a) frequently spraying the dusty areas by water, and (b) use of engines/machines with regular maintenance and at good condition.	- No air pollution source is expected.
Wastewater	- 20m^3/day of domestic wastewater will be generated by labours. There are toilets, which bury septic tank to treat wastewater before discharging it into holding pond. Treated water will be sprayed on the dusty areas.	- 1.6m^3/day of domestic wastewater will be treated by septic tank. - 48m^3/day contaminated rain runoff and 0.06m^3/day wastewater from machines/engines cleaning will be discharged into an oil separator tank.
Noise pollution	- Noise and vibration will be generated during construction by heavy construction machinery. Though these impacts are short-term, mitigation measures will be taken to protect the labours and nearby residents. These	- No noise pollution source is expected from the power production process.

[19] Data are sourced from the following link: http://www.onep.go.th/eia/index.php?option=com_content&view=article&id=67:2010-10-04-22-39-53&catid=4:2010-09-16-04-32-17&Itemid=10.

	include (a) avoidance of construction activities between 7:00pm and 7:00am, and (b) provision of protection equipments, such as ear-muffs, masks and helmets, to the workers.	
Solid waste	- 1.3m^3/day of solid waste will be generated by labours. All solid waste will be temporarily stored in the rubbish bags or containers at the site and is to be collected and treated by the licensed company.	- Solar cells are expected to be expired in 25 years. - 32kg/day of solid waste will be generated by employees. - 4.8m^3/day of oil will be separated from the oil separator tank. - All of the wastes above are to be collected and treated by the licensed company.

It is noted that the Project will fully comply with the following Thai environmental regulations published at the website of the Pollution Control Department (PCD) under MNRE[20]:

- Air quality standards
- Noise and vibration standards
- Water quality standards

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 above EIA study indicates that no significant negative environmental impacts were identified from the Project. With implementation of the aforementioned prevention and mitigation measures, the Project will make a positive contribution to the environment via production of the renewable energy as well as mitigation of GHG emissions. The full documentation of the EIA report will make available to the DOE for validation.

SECTION E. Stakeholders' comments

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

The stakeholder consultation was conducted to facilitate communication channel to inform the local stakeholders and the affect communities about the proposed project activity and solicit inputs and comments from them directly. To achieve this, invitation letters have been sent to the Sub-district Administrative Organization of the two identified sub-districts (i.e. Wang Phloeng and Khao Laem) before the public hearings. Different groups of the affected people or stakeholders, including residents and community leaders in the identified area, representative of government agencies, representative of local administrative organizations, and representative of educational institutions, participated in the stakeholder consultation. Comments were invited and complied through (a) public hearing and (b) household socio-economic survey during the course of EIA preparation.

[20] The Thai environmental regulations can be accessed from this link: http://www.pcd.go.th/info_serv/en_regulation.html.

1. Public hearing

Two public hearings were carried out at each of the identified sub-district within a radius of 5km around the proposed project plant. The first hearing included a session of project activity description, a brief explanation on how this project activity will mitigate climate change and contribute to social, economic and environmental development of host country, an overview of benefits to local community, followed by a question and answer session. The second hearing aimed at presenting and explaining the results of the environmental quality and impact study, and its environmental impact prevention and mitigation measures to the local community.

Table 10: Details of the public hearings

Date (DD/MM/YYYY)	Venue	Number of participant
The first public hearing		
31/08/2009	Wang Phloeng sub-district of Khok Samrong district	71
16/09/2009	Khao Laem sub-district of Chai Badan district	114
The second public hearing		
02/10/2009	Wang Phloeng sub-district of Khok Samrong district	66
21/10/2009	Khao Laem sub-district of Chai Badan district	188

a) First public hearing at Wang Phloeng

b) First public hearing at Khao Laem

c) Second public hearing at Wang Phloeng

d) Second public hearing at Khao Laem

2. Household socio-economic survey

The survey covered 347 local residents in 21 villages of the Wang Phloeng and Khao Laem sub-districts was held during September 26-30, 2009. Samples of the local community, including project beneficiaries and affected persons, were randomly selected. In addition, comments from 66 local government officials and community leaders were also sought.

E.2.	Summary of the comments received:

No formal comments have been received from local stakeholders to date, except that some stakeholders raised various questions pertaining to the Project and requested for further explanation on both the negative and positive concerns during the public hearings. These concerns were specified in the following areas:

1. **Impact on the local environment**
   - Air quality
   - Water quality
   - Noise levels

   Response: NED explained that all of these concerned impacts have been considered in the EIA. The EIA concludes that the effects on the air quality, water quality and noise levels due to the Project implementation are expected to be low. To avoid any potential impacts caused to the local environment, the Project will implement appropriate environmental impact prevention and mitigation measures and be fully compliant with the national/local environmental laws and regulations.

2. **Potential benefits to the local community**
   - Employment opportunities
   - Clean and steady power supply to the local residents
   - Mitigation of global warming

   Response: NED expressed that the project activity will create various short-term and long-term employment opportunities to the local community from the construction and installation phase through to the operation and maintenance phase of the new power plant. It is expected that approximately 500 labors will be hired during the construction period and 40 employees will be employed at the operation phase. In addition to this, NED convinced that the project activity will be able to provide clean power supply to the local residents and at the same time contribute to the global warming mitigation.

3. **Potential adverse effects on the local community**
   - Sunlight reflection and safety problems
   - Effects on agriculture due to sunlight reflection

   Response: NED explained that a solar power plant, which installed many solar cells with old technology could reflect sunlight to pilot. However, the proposed project activity will adopt modern and advanced solar technology that has anti-reflection film. Therefore, the impact on pilot vision is low. This was supported by a research of a Victorville 2 hybrid power project in Victorville, California, USA, which studied the effect of solar cell reflection to pilot vision. The result showed that solar cells did not reflect the sunlight to pilots, as they saw solar cells as water surface. Given the adoption of the advanced solar technology, the effects on agriculture due to sunlight reflection are also expected to be low.

All questions were duly answered and no subsequent concerns or comments were raised. At the end of the hearings, most of the participants expressed their satisfaction on employment opportunities, clean power supply, climate change migration and also national sustainable development, which will be achieved

through implementation of this CDM Project. The results of the survey also showed that most of the participants supported the implementation of the project activity. The full documentation of the stakeholder consultation will make available to the DOE for validation.

E.3. Report on how due account was taken of any comments received:

There were no negative comments received from the local stakeholders, thus no further action was taken.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Natural Energy Development Co., Ltd.
Street/P.O.Box:	999/9 Rama 1 Road, Patumwan
Building:	45/F The Offices at Central World
City:	Bangkok
State/Region:	-
Postcode/ZIP:	10330
Country:	Thailand
Telephone:	+662-6249211
FAX:	+662-6249299
E-Mail:	somboon@ned.co.th
URL:	www.ned.co.th
Represented by:	-
Title:	Associate Engineer
Salutation:	Mr.
Last name:	Lertsuwannaroj
Middle name:	-
First name:	Somboon
Department:	-
Mobile:	-
Direct FAX:	+662-6249299
Direct tel:	+662-6249286
Personal e-mail:	somboon@ned.co.th

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

The Project does not involve public funding from Annex 1 countries.

Annex 3

BASELINE INFORMATION

Calculation of the baseline emission factor ($EF_{grid,CM,y}$)

The CO_2 emissions factor for the grid system is sourced from "*The study of emission factor for an electricity system in Thailand 2009*"[21] (hereinafter referred to as the "Study"), published by Thailand Greenhouse Gas Management Organization (TGO) on August 26, 2010. TGO is a public organization under the Ministry of Natural Resources and Environment (MNRE) and is being the Designated National Authority for CDM (DNA-CDM) in Thailand. According to this documentation, this grid emission factor was determined based on the data given in the "*Electricity Report 2007 – 2009"* and along with the procedure stipulated in latest methodological tool "*Tool to calculate the emission factor for an electricity system (version 02)"* (hereinafter referred to as the "EF Tool")

This methodological EF Tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the operating margin (OM), the build margin (BM) as well as the combined margin (CM), as follows:

Step 1: Identify the relevant electricity systems

Consistent with the requirements stipulated in the EF Tool, the delineations of the project electricity system and connected electricity systems that were published by the host country DNA, TGO, are applied. Following the Thai DNA delineation, the relevant electric power system of the project activity is Thailand's national grid. It is because the electricity transmission system of Thailand is considered as a single system since the transmission lines are networked throughout the country and owned by the Electricity Generating Authority of Thailand (EGAT). EGAT is the authority that controls electricity generation and distribution in Thailand, whereas the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) are the authorities that supply the electricity to the users in Bangkok and provinces, respectively.

The quantity of electricity generated and delivered to the national grid can be obtained from the *"Electricity Report 2007 – 2009"* published by EGAT. Data are categorized by electricity generation system, type of power plant and quantity of electricity generated by LC/MR and Non LC/MR power plants. Type of power plant includes the power plant of the EGAT, Independent Power Producers (IPPs), Small Power Producers (SPPs) and imported electricity from neighboring countries.

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

Project participant chosen Option I as provided in Step 2 of the EF Tool, where, only grid power plants are included in the calculation. It is because in Thailand the generated electricity that is transferred to the national grid is the only available data. Thus, it is impossible to obtain off-grid electricity generation data.

[21] Data source: http://www.tgo.or.th/download/publication/GEFReport_EN.pdf.

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

The EF Tool offers four methods for the calculation of operating margin emission factor ($EF_{grid,OM,y}$), which include:
(a) Simple OM;
(b) Simple adjusted OM;
(c) Dispatch data analysis OM; or
(d) Average OM.

Out of the four methods, the simple OM method (Option a) is used, as low-cost/must-run (LC/MR) resources of the national grid was determined to be 5.92% of the total grid generation in average of the five most recent years, which constitute less than threshold limit of 50%, as shown in Table A1: below.

Table A1: National grid generation in Thailand from 2005 to 2009

Generation System	Grid Generation (GWh)				Percentage
	EGAT	IPP	SPP	Total	
(2009)					
Total	66,488.10	64,840.72	13,971.37	145,300.19	-
- Non LC/MR	59,541.66	64,840.72	11,811.42	136,193.80	-
- LC/MR[22]	6,946.44	0	2,159.95	9,106.39	6.27%
(2008)					
Total	63,719.02	67,420.14	14,092.83	145,232.00	-
- Non LC/MR	56,791.19	67,420.14	11,904.81	136,116.14	-
- LC/MR	6,927.83	0	2,188.03	9,115.86	6.28%
(2007)					
Total	67,704.95	62,233.44	14,426.00	144,364.39	-
- Non LC/MR	59,765.33	62,233.44	11,982.99	133,981.76	-
- LC/MR	7,939.62	0	2,443.02	10,382.64	7.19%
(2006)[23]					
Total	72,991.85	55,360.64	13,652.19	142,004.68	-
- Non LC/MR	65,039.23	55,360.64	13,607.40	134,007.27	-
- LC/MR	7,952.62	0	44.79	7,997.41	5.63%
(2005)[24]					
Total	69,265.79	51,989.60	13,571.59	134,826.98	-
- Non LC/MR	63,592.35	51,989.60	13,554.16	129,136.11	-
- LC/MR	5,673.44	0	17.43	5,690.87	4.22%
				Average 5 year of LC/MR	**5.92%**

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

[23] Grid generation data of 2005 and 2006 is received from Department of Power Control System, EGAT.

Between the *Ex-ante* and *Ex-post* options of the data vintages, the *Ex-ante* option of a 3-year generation – weighted average is chosen for the project activity. The simple OM emission factor is calculated based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emission factor during the crediting period.

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 (tCO_2/MWh) of all generating power plants serving the system, not including LC/MR power plants/units. Option B, which is based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system, provided in Step 4 of the EF Tool was chosen with the following reasons:

(a) The necessary data for Option A is not available (Net electricity generation and a CO_2 emission factor of each power plant unit);
(b) Only nuclear and renewable power generation are considered as LC/MR power sources and quantity of electricity supplied to the grid by these sources is known; and
(c) Off-grid power plants are not included in the calculation, as per reason provided in Step 2 that off-grid data in Thailand is not available.

Therefore, the simple OM emission factor ($EF_{grid,OMsimple,y}$) is calculated based on the net electricity supplied to the grid by all power plants serving the system, excluding LC/MR power plants/units and including electricity imports, and based on the fuel type(s) and total fuel consumption of the project electricity system, as follows:

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

Where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FC_{i,y}$	=	Amount of fossil fuel type *i* consumed in the project electricity system in year y (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including LC/MR 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 in Step 3

The values of CO_2 emission from combustion of fossil fuel (per unit of fossil fuel) are shown in Table A2. Net Calorific Value (NCV) is obtained from data provided by the Department of Alternative Energy Department and Efficiency (DEDE), Ministry of Energy. The CO_2 Emission Factor of fossil fuel follows IPCC default values as specified in the "*2006 IPCC Guidelines for National Greenhouse Gas Inventories*".

Table A2: Net Calorific Values ($NCV_{i,y}$) and CO_2 emission per unit of each type of fossil fuel ($EF_{CO2,i,y}$)

Fuel type[24]	Unit	Net Calorific Value[25]	CO_2 Emission Factor[26]	CO_2 Emission
		(MJ/Unit)	(tCO_2/TJ)	($kgCO_2$/Unit)
Natural Gas	scf.	1.02	54.30	0.055
Lignite	ton	10,470.00	90.90	951.723
Bituminous	ton	26,370.00	89.50	2,360.115
Bunker	liter	39.77	75.50	3.003
Diesel	liter	36.42	72.60	2.644

Table A3: Comparison of the name of fuel type sourced from different reports

The Study[27]	DEDE[28] (Thailand)	IPCC[29]
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

The quantity of electricity generated and delivered to the national grid can be obtained from the *"Electricity Report 2007 – 2009"*, as shown in Table A4. Data are categorized by electricity generation system, type of power plant and quantity of electricity generated by non LC/MR power plants. Type of power plant includes the power plant of the EGAT, IPPs and SPPs. Quantity and type of fossil fuel consumed in electricity generation are also obtained from the *"Electricity Report 2007 – 2009"*, as shown in Table A5.

Table A4: Quantity of electricity generated and delivered to the national grid[30] (excluding LC/MR power plants/units), EG_y

Generation System	Electricity Generated and Delivered to the Grid (EG_y, GWh)			
	EGAT	IPP	SPP	Total
(2009)				
Total non LC/MR	**59,541.66**	**64,840.72**	**11,811.42**	**136,193.80**
Thermal	23,463.69	12,388.03	2,225.63	38,077.35

[24] See Table A3: Comparison of the name of fuel type sourced from different report

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

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

[27] The Study of emission factor for an electricity system in Thailand 2009

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

[29] 2006 IPCC Guideline for National Greenhouse Gas Inventories

[30] Electricity report 2007 – 2009/ Electricity Generating Authority of Thailand (EGAT)

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
Electricity Import	2,602.43	-	-	2,602.43
(2008)				
Total non LC/MR	**56,791.19**	**67,420.14**	**11,904.81**	**136,116.14**
Thermal	26,778.89	14,398.34	1,996.83	43,174.06
Combined-Cycle	26,449.20	53,021.80	9,029.90	88,500.90
Gas Turbine	659.33	-	878.07	1,537.41
Diesel Engine	2.30	-	-	2.30
Electricity Import	2,901.47	-	-	2,901.47
(2007)				
Total non LC/MR	**59,765.33**	**62,233.44**	**11,982.99**	**133,981.76**
Thermal	30,265.00	17,453.59	2,168.76	49,887.35
Combined-Cycle	24,124.09	44,779.85	8,935.60	77,839.54
Gas Turbine	884.20	-	878.63	1,762.83
Diesel Engine	1.17	-	-	1.17
Electricity Import	4,490.87	-	-	4,490.87

Table A5: Amount of fossil fuel consumed by power plants[31] (excluding LC/MR power plants/units), $FC_{i,y}$

Fuel Type	Unit	Fuel Consumption			
		EGAT	IPP	SPP	Total
(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	liter	111,039,065	38,180,874	8,797,506	158,017,445
Diesel	liter	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	liter	247,441,682	93,212,260	9,555,452	350,209,394
Diesel	liter	6,792,039	43,698,832	1,451,087	51,941,958
(2007)					
Natural Gas	scf.	342,335,310,261	454,590,745,280	145,512,075,117	942,438,130,658
Lignite	ton	16,060,766	-	-	16,060,766
Bituminous	ton	-	3,692,979	1,889,868	5,582,847

[31] Electricity report 2007 – 2009/ Electricity Generating Authority of Thailand (EGAT)

Bunker	liter	785,979,152	144,198,973	6,042,880	936,221,005
Diesel	liter	7,381,996	2,688,851	1,266,337	11,337,184

Table A6 summarizes the calculated CO_2 emissions from electricity generation in the years 2007 – 2009 categorized by fuel types. The total emissions during the 3-year period were 249,762,588 tCO_2. The results in Table A6 show that the 3-year weighted average simple OM emission factor is 0.6147 tCO_2/MWh.

Table A6: Determination of the simple OM emission factor, $EF_{grid,OMsimple,y}$

Fuel type	Fuel Consumption ($FC_{i,y}$)		NCV of fossil fuels, $NCV_{i,y}$ (MJ/Unit)	CO_2 Emission Factor of Fossil Fuel, $EF_{CO2i,y}$ (tCO_2/TJ)	Electricity Generated and Delivered to Grid, EG_y (MWh)	CO_2 Emissions (tCO_2)	OM Emission Factor (tCO_2/MWh)
	Unit	Volume/mass					
(2009)							
Total					**136,193,800**	**82,178,673**	
Natural Gas	scf.	968,924,717,809	1.02	54.3		53,664,864	
Lignite	ton	15,818,265	10,470	90.9		15,054,607	**0.6034**
Bituminous	ton	5,486,248	26,370	89.5	136,193,800	12,948,176	
Bunker	liter	158,017,445	39.8	75.5		474,469	
Diesel	liter	13,825,937	36.4	72.6		36,557	
(2008)							
Total					**136,116,140**	**84,083,369**	
Natural Gas	scf.	977,016,893,281	1.02	54.3		54,113,058	
Lignite	ton	16,407,465	10,470	90.9		15,615,362	**0.6177**
Bituminous	ton	5,578,567	26,370	89.5	136,116,140	13,166,060	
Bunker	liter	350,209,394	39.8	75.5		1,051,551	
Diesel	liter	51,941,958	36.4	72.6		137,339	
(2007)							
Total					**133,981,760**	**83,500,546**	
Natural Gas	scf.	942,438,130,658	1.02	54.3		52,197,878	
Lignite	ton	16,060,766	10,470	90.9		15,285,400	**0.6232**
Bituminous	ton	5,582,847	26,370	89.5	133,981,760	13,176,161	
Bunker	liter	936,221,005	39.8	75.5		2,811,130	
Diesel	liter	11,337,184	36.4	72.6		29,977	
Average simple OM Emission Factor, $EF_{grid,OMsimple,y}$, during 2007 - 2009							**0.6147**

Step 5: Identify the group of power units to be included in the build margin

The build margin is calculated as the generation-weighted average emission factor of a sample group of power plants. The sample group of power units *m* used to calculate the build margin consists of either:

(a) The set of five power units that have been built most recently; or

(b) The set of power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

From these two options, the sample group that comprises the larger annual generation is to be chosen. In the case of the Thailand's national grid, the annual electricity generation estimated under Option (a) equals to 28,305,630 MWh, whereas that under Option (b) equals to 38,323,760MWh, which is equivalent to 26.38% of the total national grid generation in 2009 (145,300,180 MWh). Therefore, Option (b) is chosen.

Table A7: Annual electricity generation of the set of five power units in Option (a)

Power Unit	Commissioning Date	Grid Generation (MWh)[32]
1. Bangpakong Power Plant (Unit 05)	16-Sep-09	1,918,110
2. South Bangkok Power Plant (Unit 03)	1-Mar-09	4,745,320
3. Chana Power Plant (Unit 01)	15-Jul-08	4,150,260
4. Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	1-Jul-08	8,153,260
5. Gulf Power Generation Co., Ltd. (Unit 1&2)	1-Mar-08	9,338,680
Total annual electricity generation from five most recently built power plants	-	**28,305,630**

Table A8: Annual electricity generation of the set of power units in Option (b)

Power Unit	Commissioning Date	Grid Generation (MWh)[33]	Accumulated MWh	Accumulated % as of total grid generation in 2009
1. Bangpakong Power Plant (Unit 05)	16-Sep-09	1,918,110	1,918,110	1.32%
2. South Bangkok Power Plant (Unit 03)	1-Mar-09	4,745,320	6,663,430	4.59%
3. Chana Power Plant (Unit 01)	15-Jul-08	4,150,260	10,813,690	7.44%
4. Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	1-Jul-08	8,153,260	18,966,950	13.05%
5. Gulf Power Generation Co., Ltd. (Unit 1&2)	1-Mar-08	9,338,680	28,305,630	19.48%
6. BLCP Power Co., Ltd. (Unit 1&2)	1-Feb-07	10,018,130	**38,323,760**	**26.38%**[34]

Between the *Ex-ante* and *Ex-post* options of the data vintages, the *Ex-ante* option is chosen for the project activity. For the first crediting period, the BM emission factor is calculated *ex-ante* based on the most recent information available on units already built for sample group *m* at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the BM emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the BM

[32] Electricity Report 2009/Electricity Generating Authority of Thailand

[33] Electricity Report 2009/ Electricity Generating Authority of Thailand

[34] As per footnote 7 of the EF Tool, *"if 20% on part capacity of a unit, that unit is fully included in the calculation"*, therefore, electricity generation from BLCP Co., Ltd (Unit 1&2) was included in the calculation.

emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

Step 6: Calculate the build margin emission factor

The build margin emission factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year y for which power generation data is available. As represented in Step 5, six power plants listed in Table A8: comprise 26.38% of total national grid generation system in 2009, which has the larger generation than the group of power plants listed in Table A7:. Therefore, the group of power plants in Option (b) of Step 5 is chosen and used for build margin emission factor calculation, shown below:

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

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year *y* (tCO_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* (tCO_2/MWh)
m	=	Power units included in the build margin
y	=	Most recent historical year for which power generation data is available

The CO_2 emission factor of each power unit *m* ($EF_{EL,m,y}$) is determined as per the guidance in Option A1 of Step 4 provided in the EF Tool as follows:

$$EF_{EL,m,y} = \frac{\sum_i (FC_{i,m,y} \; x \; NCV_{i,y} \; x \; EF_{CO2,i,y})}{EG_{m,y}}$$

Where:

$FC_{i,m,y}$	=	Amount of fossil fuel type *i* consumed by power unit *m* in year *y* (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
i	=	All fossil fuel types combusted in power unit *m* in year *y*

Thus, the build margin CO_2 emission factor ($EF_{grid,BM,y}$) is then calculated by the following equation:

$$EF_{grid,BM,y} = \frac{\sum_i (FC_{i,m,y} \; x \; NCV_{i,y} \; x \; EF_{CO2,i,y})}{EG_{m,y}}$$

Table A9: Build margin emission factor ($EF_{grid,BM,y}$) in 2009

Fuel type	Fuel Consumption,[35] $FC_{i,m,y}$		NCV of fossil fuels, $NCV_{i,y}$ (MJ/Unit)	CO_2 Emission Factor of Fossil Fuel, $EF_{CO2i,y}$ (tCO_2/TJ)	Electricity Generated and Delivered to Grid, $EG_{m,v}$ (MWh)	CO_2 Emissions (tCO_2)
	Unit	Volume/ mass				
Natural Gas	scf.	223,467,679,056	1.02	54.3	38,323,760	12,376,981
Bituminous	ton	3,645,721	26,370	89.5		8,604,321
Diesel	liter	3,929,038	36.4	72.6		10,389
				Total	38,323,760	20,991,690
BM Emission Factor, $EF_{grid,BM,y}$ (tCO_2/MWh)					**0.5477**	

Based on the above calculation, the resultant build margin (BM) emission factor is 0.5477 tCO_2/MWh.

Step 7: Calculate the combined margin emission factor

The combined margin emission factor ($EF_{grid,CM,y}$) is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \, x \, W_{OM} + EF_{grid,BM,y} \, x \, W_{BM}$$

Where:

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

As per the EF Tool, the weightings of OM and BM emission factors for a solar power project are 0.75 and 0.25 respectively for the first crediting period and for subsequent crediting periods. Table A10: demonstrates that the resultant combined margin (CM) CO_2 emission factor of Thailand's national grid is 0.5980 tCO_2/MWh, for a solar power project.

Table A10: Baseline emission factor of Thailand's national grid in 2009

Parameters	Solar power project
OM emission factor, $EF_{grid,OM,y}$ (tCO_2/MWh)	0.6147
Weighting of OM, W_{OM} (tCO_2/MWh)	0.75
BM emission factor, $EF_{grid,BM,y}$ (tCO_2/MWh)	0.5477
Weighting of BM, W_{BM} (tCO_2/MWh)	0.25
CM emission factor, $EF_{grid,CM,y}$ (tCO_2/MWh)	**0.5980**

[35] Fuel consumptions of the most recently built power plants as listed in Table 8 are sourced from Electricity Report 2009/ Electricity Generating Authority of Thailand.

Annex 4

MONITORING INFORMATION

Please refer to Section B.7. for details.

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