CLEAN DEVELOPMENT MECHANISM
SMALL-SCALE PROGRAM ACTIVITY DESIGN DOCUMENT FORM (CDM-SSC-CPA-DD)
Version 01

CONTENTS

Annexes

NOTE:

(i) This form is for submission of CPAs that apply a small scale approved methodology using the provision of the proposed small scale CDM PoA.

(ii) The coordinating/managing entity shall prepare a CDM Small Scale Programme Activity Design Document (CDM-SSC-CPA-DD)[1,2] that is specified to the proposed PoA by using the provisions stated in the SSC PoA DD. At the time of requesting registration the SSC PoA DD must be accompanied by a CDM-SSC CPA-DD form that has been specified for the proposed SSC PoA, as well as by one completed CDM-SSC CPA-DD (using a real case). After the first CPA, every CPA that is added over time to the SSC PoA must submit a completed CDM-SSC CPA-DD.

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[1] The latest version of the template form CDM-CPA-DD is available on the UNFCCC CDM web site in the reference/document section.

[2] At the time of requesting validation/registration, the coordinating managing entity is required to submit a completed CDM-POA-DD, the PoA specific CDM-CPA-DD, as well as one of such CDM-CPA-DD completed (using a real case).

SECTION A. General description of small scale CDM programme activity (CPA)

A.1. Title of the small-scale CPA:

Thailand energy efficiency improvement for street lightings in central region (sub region 1: Pathum Thani province)

Version number: 02
Date: 18/06/2012

A.2. Description of the small-scale CPA:

The CPA involves the installation of Light Emitting Diode (LED) lamps.The proposed CDM programme activity (CPA) is part of the programme of activities (PoA) "Thailand energy efficiency improvement for street lightings" initiated by Provincial Electricity Authority (PEA). PEA is also the CPA implementer. PEA will select a LED supplier to supply, install, maintain and replace project lamps through a performance based service contract.

As per the current operating scenario of streetlights in roads and highways, the existing lamps are owned and managed by the Department of Highways (DOH), Department of Rural Road (DORR), Ministry of Transport and Department of Local Administration (DOLA), under Ministry of Interior. However, the electricity for these street lighting systems is provided by Provincial Electricity Authority (PEA) free of charge. However, PEA has the obligation to pay its electricity supplier, Electricity Generating Authority of Thailand (EGAT).

Although, PEA has no obligation to implement this programme, it has seriously considered options to reduce the financial losses due to non-revenue electricity supply to public service such as DOH, DORR and DOLA lighting systems. PEA has designed this programme to respond to the need for reducing energy consumption in street lighting while providing the same or better service.

PEA plans to undertake energy efficiency activity by replacing 1,672 existing 250 W High Pressure Sodium (HPS) units[3] by 110 W[4] energy efficient LED units in Pathum Thani province. The electricity consumption of the HPS units includes electricity consumption of lamps and ballasts. The total electricity consumption of 250 W HPS units would be around 295 W[5] including ballasts. The LED lights consume around 63%[6] less electricity than that of HPS units there by reducing the greenhouse gas emissions due to fossil fuel dominated grid electricity production. The average annual emission reductions expected from this CPA are 725 t CO_2e.

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[3] The total HPS unit typically consumes 315 W including ballast.

[4] This value will vary depending upon the actual equipment specification

[5] Although the actual power consumption of the HPS lamps is around 315 W including ballast, as per paragraph 12 (a) of AMS II L, version 01, EB 60, the power consumption is conservatively assumed to be 295 W as per name plate details of the baseline fixtures.

[6] Although the actual savings (315 W – 110 W) would be around 65%, for CDM purpose, electricity savings is taken around 63% (295 W – 110 W) which is based on the nameplate details of HPS lamps and its ballast.

The LED lights to be installed will have a minimum lifespan of 50,000 hours[7] and high power factor of 0.95. The main technical features of the LED lights to be procured are presented in the below table according to the terms of reference (TOR) issued by PEA.

Description	Value
Lifetime (L70) @Ta 35 deg.C	≥ 50,000 hour
System Efficacy (Lumen/W)	≥ 90 Lumen/W
Input Voltage	230 V +/- 10% and 50 Hz
Max power per bulb	≤ 110 watt
Lumen Maintenance at 6,000 hour as at temperature Case (Ts) 85°C and at the max current of LED	≥ 90%
Driver Power factor @ max load	≥ 0.95
Driver Efficiency @ max load	≥ 85%
Driver Total Harmonic Distortion (%)	≤ 15%
Safety standard	IEC 60598 or equivalent
Warranty of product performance (lux) as per national standard and TOR	8 years

Lighting performance quality of project luminaries will be in compliance with the national standard for lighting levels for roadway lighting classes as prescribed by DOH. While the standard sets 13 lux for the different roads under the CPA, the TOR requires a minimum of 15 lux to be achieved after replacement of HPS lamps.

The project implementation schedule is as follows:

Order	Detail	Mouths of year 2012												Mouths of year 2013											
		Quarter 1			Quarter 2			Quarter 3			Quarter 4			Quarter 1			Quarter 2			Quarter 3			Quarter 4		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Approve of the project.																								
2	Preparation of specifications , TOR and Public Hearing				■	■																			
3	TOR authorization						■																		
4	Preparation of tender documents and tender procurement						■	■	■																
5	Preparation of agreements									■	■														
6	Installation and testing										■	■	■	■	■	■	■								
7	Commissioning																■	■							
8	Monitoring and assessment						♦			♦			♦			♦		♦							
9	Public relations					♦												♦							
10	Training																		♦						

Note : ♦ is operating times symbol.
■ is operating period symbol.

Event	Planned date(s)
Date of Board approval to implement the project	03/03/2012
Date of Bidding process	16/06/2012
Date of contract signing	16/10/2012
Operation commissioning date of LED	16/05/2013

CDM consideration by SSC-CPA

[7] Minimum level specified in the Terms of Reference (TOR) to be used for LED supplier selection.

The project is being developed by PEA. The project involves installation of energy efficient lamps in roads and highways. Hence by its very design, CDM has been considered right from the project inception stage.

In addition to that, the CPA will contribute to the sustainable development whose indicators are given below:

Economic indicators

- The CPA will reduce country's dependency on imported fossil fuels leading to savings in foreign exchange and improvement of energy security.
- The CPA will reduce the electricity expenses for PEA that has to be paid to Electricity Generation Authority of Thailand (EGAT) for the electricity used for powering the street lights.

Social indicators

- The implementation of this CPA will generate employments at the time of installation, periodic maintenance and repair services.
- It is also expected to improve the quality of living by offering better lighting to the population.

Natural resources and environment indicators

- Since the PoA's objective is to reduce the consumption of electricity generated from fossil fuel dominated grid, the energy savings resulting from this CPA will lead to the reduction of GHG emissions..
- There will be no impact on the air, water and soil. The project will have no impact on noise pollution as well.

Development and/or technology transfer indicators

- This CPA will bring new technology to Thailand for the first time in the form of LED lighting for street lighting applications. This could lead to the development of LED manufacturing and service sector in Thailand.
- The success of the CPA will promote best practice in street lighting technology and management by using efficient lighting equipment. Training and education of the employees will create awareness on the efficient use of electricity and the positive effect of proper energy management on the environment.

Based on the above indicators, the project participants consider that the project activity will deeply contribute to the sustainable development and offer great advantage to the local community as well as the nation.

Therefore, it is clear, that the proposed project is a voluntary action by the Managing Entity to promote sustainable electricity utilization in the country.

A.3. Entity/individual responsible for the small-scale CPA:

The coordinating or managing entity of the SSC-PoA will be PEA. CDM programme participation is only recorded at the PoA level.The contact details are as listed in Annex 1.

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)	Provincial Electricity Authority (PEA)	No
Spain	International Bank for Reconstruction and Development (IBRD) as the Trustee of the Carbon Partnership Facility)	Yes

The CPA implementer is PEA.

A.4. Technical description of the small-scale CPA:

The project activity will promote energy efficiency through replacement of 1,672 HPS units with 1,672 LED units in central region of Thailand (Pathum Thani Province).

The project activity will consist of replacing the existing 250 W HPS units by 110 W energy efficient LED units. The electricity consumption of the HPS units includes electricity consumption of lamps and ballasts (295 W)[10].

A.4.1. Identification of the small-scale CPA:

A.4.1.1. Host Party:

The host party for this CPA is Thailand.

A.4.1.2. Geographic reference or other means of identification allowing the unique identification of the small-scale CPA (maximum one page):

The project boundary is the physical, geographical location of all project luminaries installed. The CPA will be implemented within the geographical boundary of Thailand. The CPA will be located in the highways of Pathum Thani province of the Central Thailand, mainly on the following roads:

Rd.346 km.14 Tai Doi (14.0223°N, 100.5380°E)
Rd.3111 km.1 (14.0289°N, 100.5255°E)
Rd. 3111 km 0 (14.0204°N, 100.5255°E)
Rd. 307 km 10 (14.0190°N, 100.5254°E)
Rd. 307 km 4 (13.9593°N, 100.5132°E)
Rd. 3214 km 6 (14.0651°N, 100.6266°E)
Rd. 346 km 8 Patum tech. (14.0153°N, 100.5494°E)
Rd 346 km 7 St. Calos (14.0047°N, 100.5550°E)
Rd.346 km 2 Wat Prem (13.9851°N, 100.5961°E)
RD 3214 km 15 (14.0670°N, 100.7097°E)

The following figure shows the location of the CPA.

[10] Although the actual power consumption of the HPS lamps is around 315 W including ballast, as per paragraph 12 (a) of AMS II L, version 01, EB 60, the power consumption is conservatively assumed to be 295 W as per name plate details

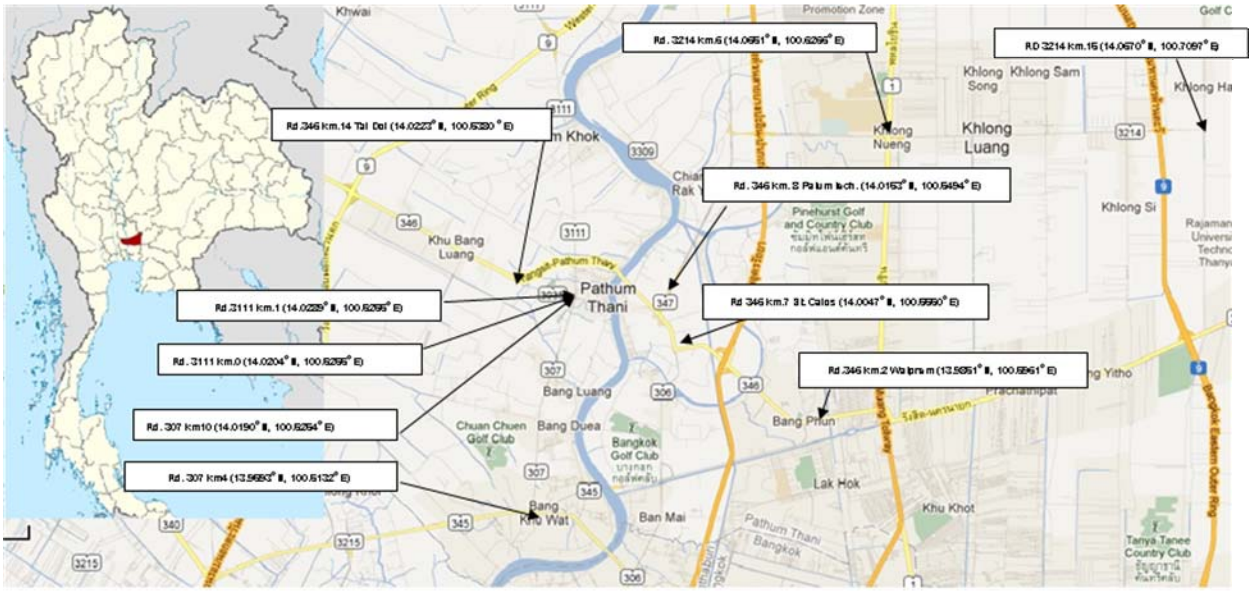

Figure 1: Location of the CPA in Thailand

A.4.2. Duration of the small-scale CPA:

A.4.2.1. Starting date of the small-scale CPA:

The starting date of a CDM programme activity is the earliest date at which either the implementation or construction or real action of a programme activity begins. The starting date for this CPA is taken as the date of contract signature with the supplier for LED procurement. . Accordingly, it is expected that starting date of this CPA would be 16/10/2012 (as given in section A.2)

A.4.2.2. Expected operational lifetime of the small-scale CPA:

The rated life of the LED units is around 50,000 hours. Considering daily operating hours of 13 hours for the street lamps, the project operational lifetime is above 10 years.

A.4.3. Choice of the crediting period and related information:

Fixed Crediting period

A.4.3.1. Starting date of the crediting period:

16/05/2013 or the date when the CPA is included in the registered PoA, whichever is later.

A.4.3.2. Length of the crediting period, first crediting period if the choice is renewable CP:

10 years 0 month

The length of crediting period will be 10 years provided that the duration of crediting period of any CPA shall be limited to the end date of the PoA regardless of when the CPA was added.

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

The estimated average annual emission reductions are 725t CO_2e. Over the chosen crediting period of 10 years, the total emission reductions are therefore expected to amount to 7,249 t CO_2e

Year	Annual estimation of emission reductions in tonnes of CO_2
16/05/2013 to 15/04/2014	725
16/05/2014 to 15/04/2015	725
16/05/2015 to 15/04/2016	725
16/05/2016 to 15/04/2017	725
16/05/2017 to 15/04/2018	725
16/05/2018 to 15/04/2019	725
16/05/2019 to 15/04/2020	725
16/05/2020 to 15/04/2021	725
16/05/2021 to 15/04/2022	725
16/05/2022 to 15/04/2023	725
Total emission reductions (tonnes of CO_2 e)	7,249
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2 e)	725

A.4.5. Public funding of the CPA:

No public funding from Annex 1 countries will be used for the proposed CDM Programme Activities (CPA).

A.4.6. Information to confirm that the proposed small-scale CPA is not a de-bundled component

Paragraph 10 of “Guidelines on assessment of de-bundling for SSC Project Activities”, version 03, EB 54 Annex 13, stipulates the following:

“If each of the *independent subsystems/measures (e.g., biogas digester, solar home system) included in the CPA of a PoA is no larger than 1% of the small-scale threshold defined by the methodology applied, then that CPA of PoA is exempted from performing de-bundling check i.e., considering as not being a de-bundled component of a large scale activity*”.

The maximum wattage rating of an LED fitting is 110 W. The wattage of the HPS fixtures (lamp + ballast) is around 295 W. Maximum annual energy saving potential from a measure is calculated by taking 13 hours usage per day.

Maximum annual energy saving potential = 13 x 365 x (295 - 110) = 0.0008778 GWh.

As is demonstrated above 0.0008778 GWh per LED is much less than the 1% of the small-scale threshold of 0.6 GWh. Hence the SSC-CPA is not a de-bundled component of a large scale activity.

A.4.7. Confirmation that small-scale CPA is neither registered as an individual CDM project activity or is part of another Registered PoA:

The procedure established in the PoA to avoid double counting is given below.

The street lights are managed and maintained by DOH, DORR and DOLA during business as-usual scenario and will be managed and maintained by PEA through the LED supplier during the project scenario. All the street lights under this CPA are under the PEA service territory. No one has the authority to implement such projects in the street lights covered under the service territory of PEA. Moreover, it has been stipulated in the TOR for equipment procurement and in the agreement between PEA and LED supplier that PEA remains the sole entity eligible for claiming CERs for this CPA. In addition, the TOR will be signed by DOH, DORR and DOLA accepting PEA's operating and ownership rights and benefits as a result CPA & PoA.
Moreover, the boundary of the Pathum Thani CPA is clearly demarcated with roads name and location. No other CPA would be implemented in the same roads. Since PEA performs the dual role of PoA coordinating and managing entity as well as the CPA implementer, it will ensure that there will be no occurrence of double counting of CERs.

PEA has checked the CDM project database to establish whether a CDM project activity or CPA of another PoA of energy efficiency in street lighting has already been registered in the same geographic area before the start of this PoA. This search covered registered project activities, project activities requesting registration, project activities under review and project activities for which either a review or corrections have been requested.

Based on the above, PEA(CME) confirms that there have been: (i) no registered small-scale CPA of a PoA, (ii) no application to register another small-scale CPA of a PoA or (iii) no other registered CDM project activity that aim at implementing LED street lights in replacement of HPS lamps in PEA territory.

In conclusion, the CPA included in the PoA is not part of another CDM programme activity or CDM project activity.

SECTION B. Eligibility of small-scale CPA and Estimation of emissions reductions

B.1. Title and reference of the Registered PoA to which small-scale CPA is added:

Thailand energy efficiency improvement for street lightings

B.2. Justification of the why the small-scale CPA is eligible to be included in the Registered PoA :

A CPA under the PoA is required to fulfill the eligibility criteria outlined in the below table for inclusion in the PoA. The developed eligibility criteria are consistent with the "Standard for demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programme of activities", Version 01.0, EB 65.

Street lighting energy efficiency improvement in central region (sub region 1: Pathum Thani province) is eligible to be included in the PoA "Thailand energy efficiency improvement for street lightings" because it meets all established eligibility criteria as demonstrated in the below table.

#	**Eligibility criteria as per requirements of the standard**	**Eligibility criterion applied?**
a	**Geographical boundary of the CPA**	
	The CPA geographical boundary should be located within the geographic boundary of Thailand	Yes – The CPA is located within Thailand (Central Thailand) as shown in the map.
b	**Avoidance of double counting of emission reductions**	
	Each CPA-DD shall be uniquely identified and defined in an unambiguous manner by providing geographic information (GPS coordinates)	Yes – the CPA will be implemented in Pathum Thani region on clearly identified roads through name and GPS coordinates.
	The coordinating entity will ensure that all CPAs under its PoA are neither registered as an individual CDM project activity nor included in another registered PoA, and that the CPA is subscribed to the PoA	Yes – PEA is the CME and also the sole CPA implementer. CPAs are implemented in distinct roads. It is also confirmed through CDM projects database on UNFCCC website that this CPA is neither registered as an individual CDM project activity nor included in another registered PoA.
	Relevant contracts and agreements ensure the avoidance of double counting of emission reductions	Yes. In the TOR it will be clearly specified that the ownership of CERs lies solely with PEA only and not with any other party involved in the CPA. All the parties will sign the TOR accepting this. By this way, DOH, DORR & DOLA also voluntarily concedes the right of CERs to PEA only. Moreover, LED supplier has no right on CERs as specified in the TOR.
c	**Specifications of technology/measure implemented by the CPA**	
	LEDs replace only HPS lamps in street lights in the project.	Yes – According to the TOR, 250-W HPS units will be replaced by 110-W LED units.
	Only those street light circuits that are supplied with electricity produced from and connected with Thai National grid are eligible.	Yes – the CPAs involves only roads that are under PEA service areas and powered by Thainational grid.
	The LEDs should have a minimum rated lifetime of 50,000 hours	Yes – 50,000-hours is the minimum rated lifetime of LED as required by the TOR.
	LEDs used in CPAs meet the requirements of	Yes – the TOR requires the lamps to be

#	Eligibility criteria as per requirements of the standard	Eligibility criterion applied?
	appropriate lighting standard and are tested /confirmed to their specifications by an accredited laboratory.	tested and certified as per IEC standards.
	PEA charges no costs from consumers for meeting street lighting operational expenses.	Yes – Current situation regarding electricity costs of street lighting will continue and DOH, DORR & DOLA will benefit from the project, i.e., free of charge for its street lighting services
d	**Check the start date of the CPA through documentary evidence**	
	The start data of the CPA is in line with CDM glossary and demonstrates prior consideration of CDM	Yes – the start date of the CPA is projected to be the date of signature contract for equipment supply (16/10/2012). This date is after the PoA publication on CDM website for Global Consultation Process.
e	**Compliance with applicability and other requirements of the methodology applied by CPAs**	
	Each CPA is in compliance with applicability and other requirements of the baseline and monitoring methodology AMS II L, version 01.	Yes – the CPA meets all applicability conditions of AMS II L, version 01 as demonstrated in the below table.
	Individual CPA's energy savings should not exceed 60 GWh	Yes – Estimated energy saving is 1.42 GWh which less than 60 GWh
	LED luminaires selected to replace existing equipment must be new equipment and not transferred from another activity.	Yes –new LED luminaires will be procured to replace existing HPS luminaires. No old equipments will be transferred.
f	**CPAs meet the requirements pertaining to the demonstration of additionality**	
	The additionality is demonstrated as per Attachment A of Appendix	Yes – Attachment A of Appendix B is used and investment barrier is demonstrated in Section B.3.
	The investment comparison should concludes that the CDM programme activity cannot be considered as the most financially attractive	Yes – As per the investment comparison analysis, CPA project activity cannot be considered as the most financially attractive alternative.
g	**Local stakeholder consultations and environmental impact analysis**	
	The CPA must have secured all required environmental clearances as outlined in Section C.	Yes – Initial Environmental Evaluation carried out at PoA level
	The project must have undertaken a stakeholder consultation as outlined in Section D.	Yes – Stakeholder consultation is undertaken both at CPA and PoA level
h	**Affirmation of non diversion of official development assistance (ODA)**	
	A letter from from Annex I parties should affirm that funding, if any, does not result in a diversion of ODA	Yes – LOA from Annex I country confirms non diversion of ODA
i	**Target Groups**	
	Not relevant to the project	Not applicable
j	**Sampling requirements**	

#	Eligibility criteria as per requirements of the standard	Eligibility criterion applied?
	The sampling plan is designed in accordance with the "Standard for sampling and surveys for CDM project activities and programme of activities" and the confidence/precision level required by the methodology	Yes - The sampling plan is designed at 90% confidence level and 10% error margin as per AMS-II.L and the Standard for sampling and surveys for CDM project activities and programme of activities.
k	**CPA in aggregate meets the small-scale threshold**	
	Individual CPA's energy savings should not exceed 60 GWh throughout the crediting period of the CPA	Yes – Estimated energy saving is 1.42 GWh which less than 60 GWh
l	**Requirements for the debundling check are met**	
	Each SSC-CPA must satisfy de-bundling rules for PoA in accordance with the "Guidelines on assessment of de-bundling for SSC project activities"	Yes – Each LED saves 0.0008778 GWh much less than the 1% of the small-scale threshold of 0.6 GWh

The AMS-II.L version 01, methodology applies to this CPA as it complies with the prescribed requirements justified as follows:

Applicability Criteria as per AMS II.L	Justification
1. This category comprises activities that lead to efficient use of electricity through the adoption of energy efficient lamps and/or fixture combinations to replace less efficient lamps and/or fixture combinations in public- or utility-owned street lighting systems.	The CPA involves installation of energy efficient LED lamps in place of HPS lamps in the street lighting system.
2. This methodology is applicable for one-for-one replacements of baseline luminaries with project luminaries or for replacing multiple baseline luminaries with multiple project luminaries.[11] This methodology is also applicable to the projects that involve the implementation of lighting controls that reduce total operating hours or average wattage of the lighting system as well as for new construction installations.	The CPA involves one-for one replacement of 1,672 HPS lamps with 1,672 LED lamps. Hence, this methodology is applicable.
3. This methodology is only applicable if failed project equipment will continuously be replaced based on local maintenance practices, during the crediting period, by equipment of equivalent or better lighting and energy performance specification.	As part of the programme implementation arrangement, the failed LED lamps during the crediting period will be continuously replaced with new LED lamps as part of current maintenance practices with equivalent or better lighting and energy performance.

[11]For example, a project involving replacing a collection of street lighting luminaries with new street lighting luminaries when the number of project luminaries may be more or less numerous than the baseline luminaries, but the project luminaries in total consume less energy than the replaced luminaries.

The luminaries selected to replace existing equipment must be new equipment and not transferred from another activity.	The LED lamps will be new as per they will be procured (as per the TOR) and not transferred from another activity.
4. Controls covered by this methodology may include simple photocells and/or astronomical time clocks that provide basic streetlight scheduling control. Controls may also include advanced systems that allow more sophisticated strategies such as adaptive lighting (dynamically altering street lighting power (dimming or multiple levels of operation such as bi-level lighting) based on vehicle and/or pedestrian traffic sensors or schedules, time of night, ambient conditions, etc.) a practice known as adaptive lighting.	The control system involved in this CPA is photocell sensor for on/off operation of the light points. But these control systems will not be used for reducing total operating hours or average wattage of the lighting system.
5. This methodology applies to street lighting projects that provide lighting performance quality either: (a) equivalent to or better than the baseline lighting performance; or (b) equivalent to or better than the applicable street lighting standard.	The lighting performance quality is measured against the street lighting standard of the country. The Lighting Standard will be in accordance to the DOH which prescribes 13 lux level for the different types of roads involved in the CPA, but the project will target a lux level of 15 lux (as prescribed by the TOR).
6. For retrofit projects, lighting performance quality of project luminaries shall be shown to comply with this methodology through the use of one of the following methods: i. <u>Equivalence to existing baseline luminaries</u>: The project participant shall prove that project luminaries provide equivalent or improved total useful illumination (lx), compared to the baseline luminaries being replaced, at each representative location. Either by: (i) Measurements and calculations; or (ii) Computer modelling of average luminance from baseline and project luminaries at representative locations that shall be determined in accordance with CIE standard 140:2000; ii. <u>Compliance with applicable street lighting standard</u>: If a national or local lighting standard is available that prescribes lighting levels for roadway lighting classes, such shall be used to evaluate the project luminary compliance at each representative location. A standard	The CPA is a retrofit project, which replaces HPS lamps with LED lamps to improve the street lighting performance. The lighting performance quality of the project luminaries is in compliance with applicable national street lighting standard of the DOH which prescribes lux level for different types of roads. The measurement of illumination will be carried out according to the method described in Annex 4. As per the TOR, site acceptance test shall be carried out for illumination by LED supplier.

field of calculation shall be defined to field measure or computer model luminance of this methodology. Project luminaries must meet or exceed the luminance levels prescribed in the standard, as well as the uniformity and glare criteria as applicable; If no national or local standard exists, the project participant shall use an approved international standard such as CIE's Lighting of Roads for Motor and Pedestrian Traffic (CIE 115:2010), which provides a structured model for selection of the appropriate roadway lighting class and gives recommended maintained lighting levels. Alternately, if appropriate, project participant may use the luminance standards given in CIE's Technical Report: Road Transport Lighting for Developing Countries (CIE 180:2007). The luminance, uniformity and glare requirements of both of these standards.	
7. In the case of a Greenfield (new construction) project, the existing baseline technology is assumed to be the prevailing street lighting technology used in the region for equivalent roadway types and lighting classes.	The project activity is not a Greenfield project. Hence, this criterion is not applicable.
8. The aggregate electricity savings by a single project activity may not exceed the equivalent of 60 GWh per year.	The aggregate savings by the CPA is around 1.42 GWh/year which far below 60 GWh per year.

B.3. Assessment and demonstration of additionality of the small-scale CPA , as per eligibility criteria listed in the Registered PoA:

Alternatives to the project activity

Alternative 1: Installation of LEDs without being registered as a CDM project activity

The project activity could occur without being registered as a PoA through government support. In such a case, the PEA will implement the project only if the government funds are available.

Alternative 2: Step dimming in the existing HPS units

This involves installation of step dimming device in the existing HPS units. The installation of dimming device will reduce the light output during non-peak hours. This will result in energy saving of about 25%[12] by decreasing the baseline output during the off-peak time.

Alternative 3: Dimming with electronic ballast

This is another type of dimming mechanism involving installation of electronic ballast with dimming, in which, the energy saving will be about 28% by reducing the baseline output during the off-peak time.

Alternative 4: Continued use of HPS units without replacing with LED units

This implies continuing the operation of HPS lamps, which is the most common practice in Thailand. Currently, more than 90% of the street lights are HPS lamps only. The cost of HPS lamps is significantly cheaper than LED lamps. As of now, the LED technology is not in use for street lights in Thailand. Moreover, there is no mandatory requirement for PEA to develop energy efficiency projects in Thailand. Hence, there is an option to continue with HPS lamps without any additional investment. But it would have lead to higher GHG emissions due to high energy consumption of HPS lamps when compared to that of LED lamps.

Alternative 5: Dimming with transformers

This method uses transformer to reduce the voltage of the circuit. It maintains the shape of electricity wave and has zero impact on the electricity released to the circuit. Mainly, it is suitable with gas-discharge bulbs, including the high pressure lights, which are used with metal ballast. This system consists of voltage control unit, analogue or digital control unit and programmable clock to control electricity voltage at the source. The energy saving is about 30-40 %, depending upon the category of bulbs.

Alternative 6: Dimming with power electronics

This method uses electronic device to chop part of voltage wave, resulting in a set of suitable waves to electrify the lights. More the wave is chopped, the more the energy saved. Such device is lighter, smaller and more efficient in dimming when compared to the transformer. However, it causes high harmonic. Also, when implemented, capacitors have to be removed, bringing about low power factor. It is able to bring down electricity power from 100% to 65% for HPS lights, metal halides, mercury and fluorescents.

DOH requires that the energy-saving equipment has to control each lamp individually and independently. This condition rules out the alternatives 5 and 6[13]. Hence, alternatives 5 and 6 are not considered as plausible alternatives.

In the absence of any mandatory regulation, there is no obligation for PEA to invest. Hence, the most appropriate baseline for the project activity will be the continuation of the existing practice of HPS units

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[12] As compared to 315 W baseline HPS lamps. Only for emission reduction calculation purpose, 295 W is taken for baseline HPS lamps.

[13] According to DOH's letter no. 0635/1576(2)/3269 dated 12th May 2009 and DORR's letter no. 0701.1/4744 dated 9th June 2009

for street lighting application. Continuation of current circumstance, will lead to DOH and DORR maintaining and installing HPS lamps and fixtures with similar efficiency. Double bulbs and single bulbs will continue to have 250 W HPS lamps. These inefficient lamps will lead to increased electricity consumption from the grid which would in turn, result in increased GHG emission.

Additionality

As per the decision 17/CP.7 Para 43, a CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the CPA. The proposed CPA reduces the anthropogenic emissions of GHG by sources below those that would have occurred in the absence of the registered SSC-CPA.

PEA wishes to prove the additionality of the CPA using the "Standard for demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programme of activities", Attachment A of the Appendix B and the "*Non-binding best practice examples to demonstrate additionality for SSC project activities" Version 01, EB 35.* According to Attachment A of the Appendix B, the project participants shall provide an explanation to show that the project activity would not have occurred anyway due to at least one of the following barriers:

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

Among the multiple barriers identified in the implementation of the project activity, the investment barrier is used to demonstrate the financial non-viability of the project activity in a conservative manner. The project activity involves high investment cost. The returns generated from the project activity are low and hence the CDM revenue is considered essential for improving the returns generated from the project.

Investment barrier

The investment barrier has been demonstrated in accordance with the "Non-binding best practice examples to demonstrate additionality for SSC project activities" provided by CDM EB in its 35th Meeting (Annex 34), which states under investment barrier, *"Best practice examples include but are not limited to, the application of investment comparison analysis using a relevant financial indicator, application of a benchmark analysis or a simple cost analysis (where CDM is the only revenue stream such as end-use energy efficiency)"*

Similarly paragraph 19 of "Guidelines on the assessment of investment analysis" *version 05, EB 62,* states that *"In cases where the alternative requires investment anyhow and baseline emissions are based* *on that alternative, the only means of determining that the project activity is less financially attractive than at least one alternative is to conduct an investment comparison analysis".*

Hence, the investment comparison analysis has been carried out with the most plausible alternatives for the project activity (replacement of conventional HPS street lights with high quality LED lights in Pathum Thani province). The Internal Rate of Return (IRR) of the investments is chosen as the relevant financial indicator for comparing the options.

The alternative to the project activity includes the following:

Alternative 1: LED replacement (w/o CDM)

Alternative 2: Step dimming

Alternative 3: Dimming with electronic ballast

Alternative 4: Business-as-usual scenario

Alternative 5: Dimming with transformers

Alternative 6: Dimming with power electronic devices.

Alternative 5 and 6 are restricted by the conditions laid by DOH[14] . Therefore are not considered as plausible alternatives. These alternatives are therefore not included for the investment comparison analysis.

The following table summarizes the main assumptions used in the investment comparison.

	Alternative 1 - LED replacement (w/o CDM)	Alternative 2 - Step dimming	Alternative 3 - Dimming with electronic ballast	Alternative 4 – Business-as-usual	Sources of data
Number of lamps	1,672	1,672	1,672	1,672	Actual Counting for the CPA
Savings Potential[15]	65%	25%	28%	n/a	Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps

[14] According to the letter no 0635/1576(2)/3269 date 12 May 2009

[15] Net energy savings is compared to the actual energy consumption of the baseline HPS lamps which is 315 W (PEA study). For emission reduction calculation, however only 295 W is considered as per the AMS II L, version 01, EB 60. However for IRR calculation, 315 W is considered which is a conservative value for IRR calculation (if 295 W is considered, it would result in lesser energy savings which leads to lower IRR).

	Alternative 1 - LED replacement (w/o CDM)	Alternative 2 - Step dimming	Alternative 3 - Dimming with electronic ballast	Alternative 4 – Business-as-usual	Sources of data
					and High Intensity Discharge (HID) Street Lights (Chapter 8. Economic and Financial Feasibility Study of Project)
Number of operating hours	13	13	13	13	Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps and High Intensity Discharge (HID) Street Lights. [16]
Project life (years)	10	10	10	10	Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps and High Intensity Discharge (HID) Street Lights (P. No. 97 in Executive summary - Part 1)
Investment Cost (THB)	32,854,800	5,016,000	4,848,800	n/a	Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps and High Intensity Discharge (HID) Street Lights (P. No. 315 in Executive

[16] This is also supported by the study conducted KMUTT

	Alternative 1 - LED replacement (w/o CDM)	Alternative 2 - Step dimming	Alternative 3 - Dimming with electronic ballast	Alternative 4 – Business-as-usual	Sources of data
					summary – Part 2)[17]
Replacement Cost every 5 years (THB)	0	3,000,000	3,000,000	n/a	
Electricity Tariff (THB/kWh)	2.4696	2.4696	2.4696	2.4696	Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps and High Intensity Discharge (HID) Street Lights (P. No. 149 in Executive summary – Part 1)
Value of energy saved (THB)	4,011,650	1,542,942	1,729,095	n/a	Calculated
Salvage value[18] (THB)	3,285,480	0	0	n/a	
Financing (debt/equity percentage)	0%/100%	0%/100%	0%/100%	n/a	

Based on the above, the investment comparison analysis is done for all plausible alternative scenarios. The alternatives and their investment details are given in the following table:

Alternatives	Estimated Energy Saving	Total Investment Cost (THB)	Return from Project activity
			IRR (%)
Alternative 1: LED replacement (w/o CDM)	65%	32,854,800	6.29
Alternative 2: Step dimming	25%	5,016,000	29.79

[17] This is supported by the quote from supplier (Philips) for different alternatives.

[18] 5% is used for conservativeness though according the Royal Decree, the equipment has no accounting value after 5 years

Alternatives	Estimated Energy Saving	Total Investment Cost (THB)	Return from Project activity
			IRR (%)
Alternative 3: Dimming with electronic ballast	28%	4,848,800	35.29
Alternative 4: Business-as-usual scenario	n/a	n/a	n/a

Result of financial analysis

The IRR for installation of LEDs without being registered as CDM project activity is very low (negative) when compared to that of the other alternatives. This alternative will not have high returns and hence this option is not considered as an attractive and feasible option when compared to the other alternatives.

The *alternative 2,* installation of step dimming technology in the existing lights, is having very high IRR when compared to that of LED installation options because of its comparatively lower investment cost.
The *alternative 3,* installation of dimming by means of installing electronic ballast in the existing street lights, is also having a higher IRR when compared to other options.
The *alternative 4* is the business-as-usual scenario, i.e., the continuation of the current practice. This scenario does not require any additional investment. There is no mandatory requirement for the CME to develop energy efficiency projects in Thailand. Hence, there is an option to continue with HPS lamps without any additional investment. But it would have lead to higher GHG emissions due to high energy consumption of HPS lamps when compared to that of LED lamps. Hence, this alternative is considered as baseline scenario.

As per investment comparison analysis, "*If one of the other alternatives has the best indicator (e.g., highest IRR), then the CDM project activity cannot be considered as the most financially attractive*".

As a result of investment comparison analysis above, there are two alternative options, i.e., *alternative 2 and alternative 3,* which are having higher IRR and alternative 4 does not require any investment when compared to that of the proposed project activity.

Based on the above discussion, the proposed CDM CPA is not the most financially attractive alternative. Hence, the project owner (PEA) considers CDM benefits as the most decisive factor for overcoming the extra cost to sustain the project. Therefore, the project activity is additional.

B.4. Description of the sources and gases included in the project boundary and proof that the small-scale CPA is located within the geographical boundary of the registered PoA.

The project boundary is the physical and geographical location of each measure installed. The energy efficient devices reduce the need for electricity. The electricity is supplied by the grid which is pre-dominantly fossil fuel based. Therefore, the GHG emissions (CO_2) from grid-connected power plants are reduced indirectly. Other sources/gases are deemed negligible.

	Source	Gas	Included?	Justification/Explanation
Baseline	Power plants serving the electricity grid	CO_2	Included	Main Emission Source.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
Project Activity	Power plants serving the electricity grid	CO_2	Included	Main Emission Source.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.

B.5. Emission reductions:

B.5.1. Data and parameters that are available at validation:

Data / Parameter:	$\mathbf{FC_{i,y}}$
Data unit:	Mass or volume unit
Description:	Amount of fossil fuel type i consumed in the project electricity system in year y
Source of data used:	"Electricity Statistic Annual Report 2010", published by EGAT
Value applied:	Refer Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 02.2.1, EB 63
Any comment:	-

Data / Parameter:	$\mathbf{NCV_{i,y}}$
Data unit:	GJ/mass or volume unit
Description:	Net calorific value (energy content) of fossil fuel type *i* in year *y*
Source of data used:	"Electric Power in Thailand 2010", published by the Department of Alternative Energy Development and Efficiency, Ministry of Energy
Value applied:	Refer Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 02.2.1, EB 63
Any comment:	-

Data / Parameter:	$\mathbf{EF_{CO2,i,y}}$
Data unit:	t CO_2/GJ

Description:	CO_2 emission factor of fossil fuel type *i* in year *y*
Source of data used:	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the *"2006 IPCC Guidelines on National GHG Inventories"*
Value applied:	Refer Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 02.2.1, EB 63
Any comment:	-

Data / Parameter:	**EG_y**
Data unit:	MWh
Description:	Net quantity of electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must run power plants/units, in year *y*
Source of data used:	"Electricity Statistic Annual Report 2008-2010", published by EGAT
Value applied:	Refer Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 02.2.1, EB 63
Any comment:	-

Data / Parameter:	**$FC_{i,m,y}$**
Data unit:	Mass or volume unit
Description:	Amount of fossil fuel type i consumed by the power plant/unit m in year y
Source of data used:	"Electricity Statistic Annual Report 2010", published by EGAT
Value applied:	Refer Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 02.2.1, EB 63
Any comment:	-

Data / Parameter:	**$EG_{m,y}$**
Data unit:	MWh
Description:	Net quantity of electricity delivered to the grid by power plant / unit *m* serving the system, not including low-cost / must run units, in year *y*
Source of data used:	"Electricity Statistic Annual Report 2010", published by EGAT

Value applied:	Refer Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data choice and calculation method as per the latest version of the methodological tool "Tool to calculate the emission factor for an electricity system", version 02.2.1, EB 63
Any comment:	-

Data / Parameter:	$EF_{CO2,ELEC,y}$[19] (=EF $_{CO2,grid,,y}$[20]=EF$_{grid,CM,y}$[21])
Data unit:	t CO_2/MWh
Data unit:	t CO_2/MWh
Description:	CO_2 emission factor of the grid
Source of data used:	Calculated
Value applied:	0.5113
Justification of the choice of data or description of measurement methods and procedures actually applied :	The Grid Emission Factor of Thai National Grid is calculated using the latest version 02.2.1 of "Tool to calculate the emission factor for an electricity system", EB 63
Any comment:	This value is used for the entire crediting period.

Data / Parameter:	**$EF_{grid,OM,y}$**
Data unit:	t CO_2/MWh
Description:	Simple Operating Margin
Source of data used:	Calculated
Value applied:	0.5994
Justification of the choice of data or description of measurement methods and procedures actually applied :	The Grid Emission Factor of Thai National Grid is calculated using the latest version 02.2.1 of "Tool to calculate the emission factor for an electricity system", EB 63.
Any comment:	This value is used for the entire crediting period.

Data / Parameter:	**$EF_{grid,BM,y}$**
Data unit:	t CO_2/MWh
Description:	Build Margin

[19] As mentioned in approved methodology AMS II L, "Demand-side activities for efficient outdoor and street lighting technologies" version 1

[20] As mentioned in approved methodology AMS I D, "Grid connected renewable electricity generation", version 17

[21] As mentioned in approved methodological tool, "Tool to calculate the emission factor for an electricity system", version 02.2.1

Source of data used:	Calculated
Value applied:	0.4231
Justification of the choice of data or description of measurement methods and procedures actually applied :	The Grid Emission Factor of Thai National Grid is calculated using the latest version 02.2.1 of "Tool to calculate the emission factor for an electricity system", EB 63.
Any comment:	This value is used for the entire crediting period.

Data / Parameter:	$Q_{i,BL}$
Data unit:	Number
Description:	Quantity of baseline (*BL*) luminaries of type *i* replaced under the project activity
Source of data used:	SSC-CPA implementer
Value applied:	1,672
Justification of the choice of data or description of measurement methods and procedures actually applied :	Data on number of baseline HPS units to be replaced with LED units is provided by PEA and will be confirmed during implementation.
Any comment:	The data will be checked during replacement of HPS units with LED units and the value lowest among the two data will be used for number of HPS units replaced. At the time of the exchange/installation, a record will be kept of the number of replaced equipment. This information will be stored in the project database.

Data / Parameter:	$O_{i,BL}$
Data unit:	Hours
Description:	Annual operating hours for the baseline luminaries in year *y*
Source of data used:	PEA Records
Value applied:	4,745
Justification of the choice of data or description of measurement methods and procedures actually applied :	This value is based on continuous measurement of daily average usage hours of luminaires for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90% confidence interval and 10% maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days. For ex-ante calculation purpose, annual operating hours of 13 hours per day is taken "Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps and High Intensity Discharge (HID) Street Lights".[22]

[22] This evidence is also supported by the information provided by KMUTT.

	For ex-ante calculation purpose, annual operating hours from PEA study for each CPA will be used. As per PEA records, the daily operating hours are 13 hours, or 4,745 hours for 365 days in a year.
Any comment:	Will vary each year.

Data / Parameter:	$P_{i,BL}$
Data unit:	kW
Description:	Rated power of the baseline luminaries of the group of *i* lighting devices.
Source of data used:	Equipment specification
Value applied:	0.295
Justification of the choice of data or description of measurement methods and procedures actually applied :	The name plate/rated power of the equipment are used to calculate baseline energy consumption. Failure rates during the crediting period to be determined ex post from maintenance records that indicate the actual fraction of system-wide equipment of type i that fail annually.
Any comment:	The technical specification given by the manufacturer for the HPS lamps is 295 W, which included both lamp (250 W)and ballast (45 W). For *ex ante* calculations, failure rate in year *y* is assumed to equal to $O_{i,y}$ divided by the rated average life for project equipment type.

Data / Parameter:	$AFR_{i,BL}$
Data unit:	Fraction
Description:	Annual Failure Rate of luminaires calculated as a fraction of *Q*
Source of data used:	Equipment specification
Value applied:	0.0949
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value for failure rate during the baseline (BL) is assumed to be the same as determined for each year of the crediting period y and may vary from year to year. Failure rates during the crediting period to be determined *ex-post* from maintenance records that indicate the actual fraction of system-wide equipment of type *i* that fail annually.
Any comment:	For *ex-ante* calculations, failure rate in year *y* is estimated as per AMS-II.L, i.e., operating hours (4,745 hours) divided by the project lamp lifespan (50,000 hours), gives a value of this $AFR_{i,BL}$ = 4,745/50,000 = 0.0949

Data / Parameter:	$OF_{i,BL}$
Data unit:	Fraction
Description:	Average time, in hours, elapsed between failure of luminaires type *i* and their replacement, divided by $O_{i,y}$, annual operating hours
Source of data used:	Equipment specification/PEA records
Value applied:	1

Justification of the choice of data or description of measurement methods and procedures actually applied :	This shall be determined by documented maintenance practice and records of maintenance turn-around time from failure to replacement.
Any comment:	The outage factor value during the baseline (*BL)* is assumed to be the same as determined for each year of the crediting period (*y*) and may vary from year to year. For *ex ante* calculations, failure rate in year *y* is assumed to equal to $O_{i,y}$ divided by the rated average life for project equipment type *i*

Data / Parameter:	$Q_{i,P}$
Data unit:	Number
Description:	Quantity of project (*P*) luminaries of type *i* distributed and installed under the project activity.
Source of data used:	SSC-CPA implementer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1,672
Description of measurement methods and procedures to be applied:	At the time of the exchange/installation, a record will be kept on the number of replaced equipment. This information will be stored in the project database.
QA/QC procedures to be applied:	The actual number of installed fittings will be compared with the number of fittings removed. Any discrepancy will be documented. The installed number of equipment will be documented and verifiable by DOE at random. Project luminaries replaced as part of a regular maintenance or warranty program can be counted as operating.
Any comment:	Once all of the project luminaries are distributed or installed, $Q_{i,P}$ is normally a constant value independent from *y* unless size of operating luminaries inventory decreases during crediting period, in which case only operating project luminaries will be credited.

Data / Parameter:	$O_{i,y}$
Data unit:	Hours
Description:	.Annual operating hours for the project luminaries in year *y*
Source of data to be used:	Measurement
Value of data applied for the purpose of calculating expected emission reductions in	4,745

section B.5	
Description of measurement methods and procedures to be applied:	Working hours are on the basis of the change in streetlights turning ON time and OFF time depending on the sunrise and sunset times through the year. This value is based on continuous measurement of daily average usage hours of luminaires for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90% confidence interval and 10% maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days.
QA/QC procedures to be applied:	For ex-ante calculation purpose, annual operating hours of 13 hours per day is taken "Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps and High Intensity Discharge (HID) Street Lights".[23] During ex-post monitoring, this data will be collected through sampling techniques using the above measurement method. -
Any comment:	All data will be stored in the project database for at least two years after the crediting period or the last issuance of CERs for this programme, whichever occurs later.

Data / Parameter:	$P_{i,P,y}$
Data unit:	kW
Description:	Rated power of the project luminaries of the group of *i* lighting devices
Source of data used:	Equipment specification/lamps nameplate data
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.110
Description of measurement methods and procedures to be applied:	Nameplate rated power of project lamps or manufacturer specifications will be recorded and documented
QA/QC procedures to be applied:	The data will be recorded during installation of project lamps. Procurement orders and manufacturer specification will be documented.
Any comment:	-

Data / Parameter:	$OF_{i,,y}$
Data unit:	-
Description:	Average time, in hours, elapsed between failure of luminaires type *i* and their replacement, divided by *Oi,y*, annual operating hours
Source of data used:	PEA maintenance records
Value of data applied for the purpose of	1 (ex-ante value)

[23] This evidence is also supported by the information provided by KMUTT.

calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	The value is determined ex-post based on documented maintenance practice and records of maintenance turn-around time from failure to replacement.
QA/QC procedures to be applied:	The maintenance staff will be trained to record and maintain all data about failure and replacement.
Any comment:	The outage factor value during the baseline (*BL)* is assumed to be the same as determined for each year of the crediting period (*y*) and may vary from year to year.

Data / Parameter:	$AFR_{i,y}$
Data unit:	-
Description:	Annual Failure Rate of luminaires calculated as a fraction of *Q*
Source of data used:	Maintenance records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.0.0949 (for ex-ante calculation, actual value will be recorded ex-post).
Description of measurement methods and procedures to be applied:	Failure rates during the crediting period to be determined *ex post* from maintenance records that indicate the actual fraction of system-wide equipment of type *i* that fail annually
QA/QC procedures to be applied:	The maintenance staff will be trained to record and document the operating conditions of lamps.
Any comment:	The value for failure rate during the baseline (*BL)* is assumed to be the same as determined for each year of the crediting period *y* and may vary from year to year. For *ex ante* calculations, failure rate in year *y* could be assumed to equal to $O_{i,y}$ divided by the rated average life for project equipment type *i*

Data / Parameter:	TD_y
Data unit:	%
Description:	Average annual technical grid losses (transmission and distribution) during year *y*.
Source of data used:	Annual Report, Electric Power in Thailand, 2010 (P. No. 32)
Value applied:	6.3%
Justification of the choice of data or description of measurement methods and procedures actually	According to "Tool to calculate baseline, project and/or leakage emissions from According to AMS-II.L, the average annual technical grid losses shall be determined using recent, accurate and reliable data available for the host country. This value can be determined from recent data published either by a national utility or an official governmental body. Reliability of the data used

applied :	(e.g. appropriateness, accuracy/uncertainty, especially exclusion of non technical grid losses) shall be established and documented by the project participant. A default value of 10% shall be used for average annual technical grid losses, if no recent data are available or the data cannot be regarded accurate and reliable. The project activity uses the latest accurate, reliable government data. The source of data is "Annual statistics from Thailand Department of Alternative Energy Development and Efficiency"
Any comment:	-

B.5.2. Ex-ante calculation of emission reductions:

The CPA used the small scale approved methodologies AMS-II.L, Version 01, which defines the project type and category as below:

Type II : Energy efficiency improvements projects
Category L : Demand-side activities for efficient outdoor and street lighting technologies
Sectoral scope : 03

Name of the approved baseline and monitoring methodology:

AMS II.L – "*Demand-side activities for efficient outdoor and street lighting technologies*" (Version 01, Sectoral scope 03, EB 60)

This project also refers to the methodological tool "Tool to calculate the Emission Factor for an electricity system (Version 02.2.1, EB 63)".

The total emission reductions of the CPA are calculated on the basis of the equations and parameters presented and explained in section E.6.1 of the PoA DD and B.5.2 of CPA. The calculation follows the procedure as per AMS II.L, version 01, which is as follows:

Emission reduction

Emissions reduction is the net electricity savings (*NES*) times an emission factor (*EF*) calculated in accordance with provisions under AMS-I.D.

$$ER_y = NES_y * EF_{CO2,ELEC,y}$$

Where:

$EF_{CO2,ELEC,y}$	Emission factor in year *y* calculated in accordance with the provisions in AMS-I.D (t CO_2/MWh)
ER_y	Emission reductions in year *y* (t CO_2e)
NES_y	Net electricity saved in year y (kWh)

Where

$$NES_y = \sum_{i=1}^{n} ES_{i,y} * \frac{1}{(1-TD_y)}$$

Where:

$$ES_{i,y} = \left(Q_{i,BL} * P_{i,BL} * O_{i,BL} * (1 - SOF_{i,BL})\right) - \left(Q_{i,P} * P_{i,P,y} * O_{i,y} * (1 - SOF_{i,y})\right)$$

$$SOF_{i,BL} = AFR_{i,BL} * OF_{i,BL}$$
$$SOF_{i,y} = AFR_{i,y} * OF_{i,y}$$

NES_y	Net electricity saved in year *y* (kWh)
$ES_{i,y}$	Estimated annual electricity savings for equipment of type *i*, for the relevant type of project equipment in year *y* (kWh)
y	Crediting year counter
i	Counter for luminaries type
n	Number of luminaries
TD_y	Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the luminaries are installed, expressed as a fraction.
Q_i ($Q_{i,BL}$ and $Q_{i,P}$)	Quantity of baseline (*BL*) or project (*P*) luminaries of type *i* distributed and installed under the project activity (units).
$P_{i,BL}$	Rated power of the baseline luminaries of the group of *i* lighting devices (kW)
$P_{i,P,y}$	Rated power of the project luminaries of the group of *i* lighting devices (kW)
O_i ($O_{i,BL}$ and $O_{i,y}$)	Annual operating hours for the baseline and project luminaries in year *y*. May differ from *BL* to *P*. This value is based on continuous measurement of daily average usage hours of luminaries for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90% confidence interval and 10% maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days.
$SOF_{i\ i}$ ($SOF_{i,BL}$ and $SOF_{i,y}$)	System Outage Factor (*SOF*) for equipment type *i* in year *y*. *SOF* is calculated as the product of the equipment Outage Factor and the equipment Annual Failure Rate. The value for *BL* is assumed to be the same as monitored for *P* and may vary from year to year
OF_i ($OF_{i,BL}$ and $OF_{i,y}$)	Outage Factor is the average time, in hours, elapsed between failure of luminaries type *i* and their replacement, divided by $O_{i,y}$, annual operating hours.
AFR_i ($AFR_{i,BL}$ and $AFR_{i,y}$)	Annual Failure Rate of luminaries calculated as a fraction of *Q*. The value for failure rate during the baseline (*BL)* is assumed to be the same as determined for each year of the crediting period *y* and may vary from year to year.

Electricity savings:

$$ES_{i,y} = \left(Q_{i,BL} * P_{i,BL} * O_{i,BL} * (1 - SOF_{i,BL})\right) - \left(Q_{i,P} * P_{i,P,y} * O_{i,y} * (1 - SOF_{i,y})\right)$$

For ex-ante calculation, the outage factor is included in the operating hours itself. Hence, $OF_{i,BL}$ = 1.

The lamp failure rate estimated as per AMS-II.L, i.e. operating hours (4,745 hours) divided by the project lamp lifespan (50,000 hours), gives a value of this $AFR_{i,BL}$ = 4,745/50,000 = 0.0990.
The System outage factor, $SOF_{i,BL}$ = 1*0.0.0949 = 0.0949

Besides, the baseline and project outage factor are assumed to be the same.

Hence, the electricity saving becomes,

$$ES_{i,y} = \left(1{,}672 \times 0.295 \times 4{,}745 \times (1 - 0.0949)\right) - \left(1{,}672 \times 0.110 \times 4{,}745 \times (1 - 0.0.949)\right)$$

$$ES_{i,y} = 1{,}328{,}436 \quad kWh / year$$

Net electricity savings:

$$NES_y = \sum_{i=1}^{n} ES_{i,y} * \frac{1}{(1 - TD_y)}$$

$$NES_y = 1{,}328{,}436 * \frac{1}{(1 - 0.063)} = 1{,}417{,}755 \text{ kWh/year}$$

Emission reduction:

Emissions reduction is the net electricity savings (*NES*) times an emission factor (*EF*) calculated in accordance with provisions under AMS-I.D.

$$ER_y = NES_y * EF_{CO2,ELEC,y}$$

Emission factor is calculated in a transparent and conservative manner as follows:

A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the "Tool to calculate the Emission Factor for an electricity system" as described in Annex 3. The value of grid emission factor is calculated on ex-ante and remains fixed for the crediting period of CPA.

$$ER_y = 1{,}418 \times 0.5113 = 725 \; t \; CO_2e / year$$

With the input values used for this CPA, the estimated annual emission reduction is 725t CO_2e.

B.5.3. Summary of the ex-ante estimation of emission reductions:

Year	Annual estimation of emission reductions in tonnes of CO_2
16/05/2013 to 15/04/2014	725
16/05/2014 to 15/04/2015	725
16/05/2015 to 15/04/2016	725
16/05/2016 to 15/04/2017	725
16/05/2017 to 15/04/2018	725
16/05/2018 to 15/04/2019	725
16/05/2019 to 15/04/2020	725
16/05/2020 to 15/04/2021	725
16/05/2021 to 15/04/2022	725
16/05/2022 to 15/04/2023	725
Total emission reductions (tonnes of CO_2 e)	7,249
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2 e)	725

B.6. Application of the monitoring methodology and description of the monitoring plan:

B.6.1. Description of the monitoring plan:

The monitoring plan of the CPA "street lighting energy efficiency improvement in central region (sub region 1: Pathum Thani province) is consistent with the methodology AMS II.L "*Demand-side activities for efficient outdoor and street lighting technologies*" version 01.

Institutional Arrangement for Monitoring and Evaluation

A monthly monitoring report will be prepared by PEA personnel (CDM management unit within Office of Energy Efficiency Management (OE^2M) staff) by filling in monitoring data record forms. These reports will be used for annual verification report preparation. The monitoring of operating hours for the project luminaries and failure rate will be recoded via automatic meter reading (AMR) and data from AMR will be transfer to OE^2M directly as illustrated in the following figure:

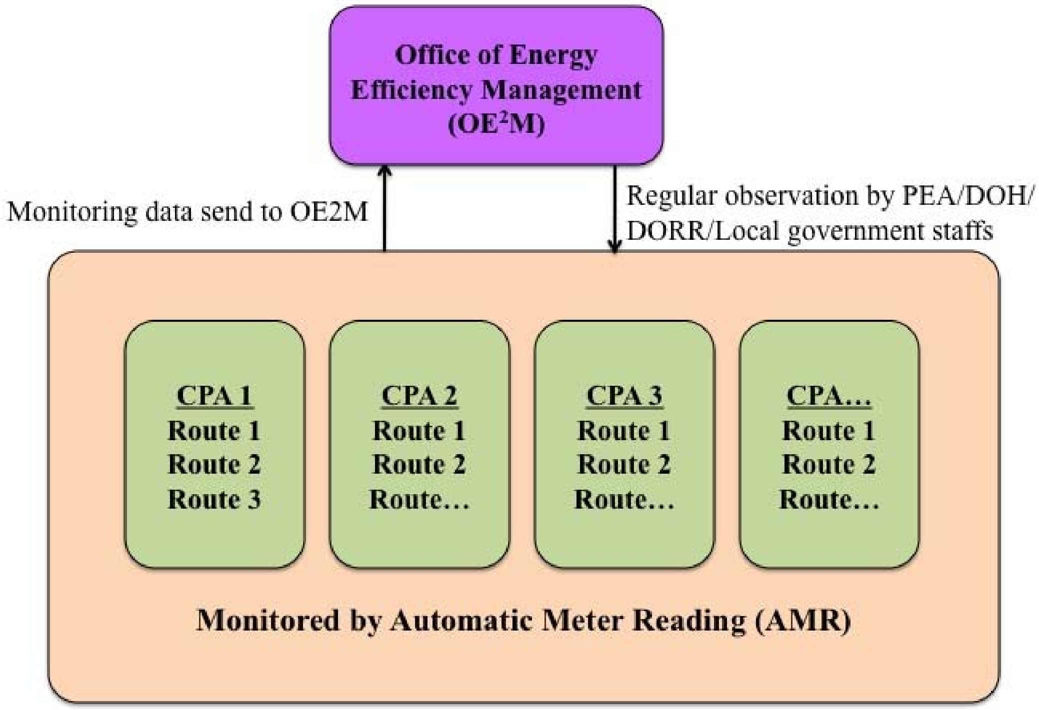

Figure 2: CPA luminaries monitoring

In addition, other parties such as DOH, DORR, DOLA and general public will carry out regular survey on the road standard as well as operation of street lighting. They can also report black out on the road through PEA call centre. The monitoring expenses will be covered by PEA or its LED supplier. OE^2M and PEA will be responsible for recording maintenance turn-around time from failure to replacement (Outage factor). PEA will ensure that all sites conduct the monitoring activities. PEA is also responsible for training and building the capacity of on-site personnel in order to properly conduct M&E.

Monitoring Plan

The monitoring plan of CPA is consistent with the methodology AMS II.L "*Demand-side activities for efficient outdoor and street lighting technologies*" version 01.

Monitoring objective and organization:

The purpose of the monitoring plan is to describe the criteria for maintaining the energy efficient devices/equipment and to report on the failure of any equipment in the system, in addition to maintaining the project's sustainability.

PEA will be responsible for the overall monitoring process by ensuring proper implementation of the monitoring plan, meter calibration, data management. The LED supplier will attend to the maintenance as per the communication from PEA. PEA will only be responsible for operating and monitoring aspects. The main objective of the monitoring would be to establish the amount of electricity saving resulting from the installation of LED units in place of HPS units and determine the emission reductions.

The data will be archived electronically and be stored for 2 years after the end of the crediting period of the CPA. PEA personnel will be trained adequately for this task.

PEA will ensure that monitoring plan as required by the simplified baseline and monitoring methodology for small scale CDM project activity AMS-II.L, version 01 will be implemented.

Monitoring Plan

Monitoring Data

As per paragraph 16 (a) of methodology AMS II L, version 01, EB 60, the following parameters are monitored for the 1st monitoring survey carried out within the first year after installation of all project luminaires:

- Outage factor (OF_i)
- Annual failure rate (AFR_i)
- Average annual operating hours (O_i)
- Rated power of the project luminaires (P_i)
- Number of project luminaries placed in service and operating under the project activity ($Q_{P,i}$)[25]

The ex-post monitoring will be carried out for the adjustment of net electricity savings.

As per paragraph 16 (b) of methodology AMS II L, version 01, EB 60, subsequent monitoring surveys will be carried at least every alternate year after the first year of the crediting period (i.e. 1, 3, 5, 7 and 9) to determine *ex post* OF_i, AFR_i, O_i, and $P_{i,P}$ for use in *ex post* emission reduction calculations until such time as CERs are no longer being requested.

In addition to the above data, as per paragraph 17 of methodology AMS II.L, version 01, EB 60, during project activity implementation, the following data will be recorded:

- Number of LED lamps distributed and installed under the project activity, identified by the type of luminaries, operating schedule and adaptive controls strategy, if any, and the date of installation;
- The number, power and operating schedules of the HPS lamps
- Information on baseline and project lighting controls.

The emission reductions are calculated *ex ante* and will be adjusted *ex post* following the monitoring surveys.

Ex-post monitoring surveys are required to be conducted to adjust the net electricity savings considering the actual lamp failure data. On the basis of *ex-post* monitoring surveys, the net electricity savings are adjusted considering the annual failure data. If the *ex-post* failure rates (AFR_i) are higher or lower than the *ex-ante* estimate, subsequent emission reduction claims shall be based on linear failure rate curve reconstructed for the remaining period of the crediting period.

[25] While project luminaires replaced as part of a regular maintenance or warranty program will be counted as operating, project luminaires cannot be replaced as part of the PoA monitoring survey process and counted as operating

Measurement of monitoring parameters

Number of LED units installed ($Q_{P,i}$)

The number of the LED lamps installed will also be monitored based on the luminary distribution data maintained by the CPA implementer. The number of LED units installed is compared with the number of HPS units removed and scrapped. Any discrepancies will be documented. The rated power of baseline lamps (including ballast) and project lamps will be recorded and documented.

Operating hours of LED units (O_i)

As per paragraph 16 (c) of methodology AMS II L, version 01, EB 60, for each *ex post* monitoring survey, the project monitoring plan shall include continuous monitoring of equipment run-time for at least 90 continuous days to determine average daily operating hours for extrapolation to annual operating hours (O_i).

Hence, the operating hours is based on continuous measurement of daily average usage hours of luminaries for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90% confidence interval and 10% maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days. The method used to extrapolate the 90 days of data to annual values will be documented.

The following table describes the sampling method and size of sample required to establish the operating hours.

Parameters to be measured	Sampling method	No. of samples
Average annual operating hours	Simple random sampling	26 switch points

Further details are given in Annex 4.

Annual failure rate of LED equipment (AFR_i)

Annual failure rate is calculated as a fraction of number of installed LED lamps. This will be monitored *ex-post* from maintenance records that indicate the actual fraction of system-wide equipment of type *i* that fail annually.

Outage factor of LED equipment (OF_i)

Outage factor is the average time elapsed between failure of LED lamps and their replacement, divided by the annual operating hours ($O_{i,y}$).

The outage factor value and the annual failure rate during the baseline (BL) is assumed to be the same as determined for each year of the crediting period (y) and may vary from year to year. Outage factor and annual failure rates during the crediting period will be determined ex-post from maintenance records that indicate the actual fraction of LED lights i that failed annually.

This will be determined by documented maintenance practice and records of maintenance turn-around time from failure to replacement.

All parameters will be monitored as per the methodology. Accumulative measurements will be entered into an electronic database at the end of each month. Any problems occurring with the monitoring equipment will be entered into the database. Every year monitoring report will be produced containing the monthly monitoring data files and details of any equipment faults and/or loss of data. The report will be submitted to the project participants for review and acceptance.

Rated power (P_i)

Rated power of the lamps is taken from the name plate details. Nameplate rated power of project lamps or manufacturer specifications will be recorded and documented.

All parameters will be monitored as per the methodology. Accumulative measurements will be entered into an electronic database at the end of each month. Any problems occurring with the monitoring equipment will be entered into the database. Every year monitoring report will be produced containing the monthly monitoring data files and details of any equipment faults and/or loss of data. The report will be submitted to the project participants for review and acceptance.

In addition to the above data, as per paragraph 17 (a) of AMS II L, version 01, EB 60, during project activity implementation, the following data will be recorded:

(i) Number of project luminaries distributed and installed under the project activity, identified by the type of luminaires, operating schedule and adaptive controls strategy, if any, and the date of installation;
(ii) The number, power, and operating schedules of the replaced devices;
(iii) Information on baseline and project lighting controls. Indicate:
    - Use of photocell and type if so;
    - Use of time-clock and type if so;
    - Dimming or multi-level operation, and type if so;
    - Sensor controls – traffic volume, light sensors, etc. and type if so;
    - Networked controls with central scheduling, monitoring, and/or reporting features.

<u>Monitoring periods</u>

Data will be collected for each monitoring period and will be used to calculate emission reductions for that portion of the crediting period. The first monitoring will be carried out at the first year after implementation and at least every other year after the first year, with random ex-post surveys conducted as explained in Annex 4.

While it is assumed that the installation of LEDs will occur on the same day when the respective HPS are exchanged with LEDs, the start date of monitoring period for each CPA will be no less than 7 days after installation completion or receipt of installation completion report by PEA from the CPA Implementer, whichever is later.

Quality assurance and quality control

QA & QC procedures for recording, maintaining and archiving data shall be implemented as a part of this PoA. PEA will implement QA & QC measures to calibrate and guarantee the accuracy of metering and safety of the project operation.

The following measures will be taken related to the monitoring equipment, its installation and operation:

- All meters used for monitoring will be of recognised standards.
- All monitoring equipment will be located in secure locations, free from the possibility of accidental damage.
- Any damage to monitoring equipment will be documented. The equipment will be repaired or replaced. In case monitoring equipments are damaged and no reliable readings can be recorded, the project entity will use the lowest historical values to calculate energy savings and emission reductions.
- Routine maintenance and calibration of all monitoring equipment will be performed in accordance with the manufacturer's specification for ensuring that the data remains accurate.

To ensure the quality of the recorded data, all personnel will be trained in accordance with this monitoring plan.

The following quality assurance measures will be taken related to the storage of the monitored data:

- A paper/manual backup of the monthly electronic data file will be stored in a secure location on-site.
- The monthly data files will be included as a part of the annual monitoring report and an electronic backup of the report will be taken.

<u>Determination of grid emission factor</u>

The grid emission factor for electricity displaced from the grid is sourced from Thailand DNA published data and is be fixed ex-ante for the whole crediting period of the CPA.

<u>Database management</u>

Data to be collected for each CPA:

- Title of the CPA
- CPA number
- Location of the CPA
- Clear project boundary
- Number of HPS lamps replaced
- Rated power of the HPS units (lamps+ballast)
- Number of LED lamps installed
- Rated power of the LED lamps
- Date of installation of LED lamps

- Number of LED lamps failed and replaced
- Date of replacement of fused LED lamps
- Outage hours (turn-around time from failure to replacement)
- Annual operating hours

Along with supplier, the local office staff will collect the above information only for the street lights included under that particular CPA boundary. The number of HPS lamps in the CPA are collected and cross checked with the number of LED devices installed. The number of HPS lamps replaced will be equal to the number of LED lamps installed. All the required details will be collected by the staff at local offices of the corresponding CPAs.

Hard copy and electronic data base creation, storage and management:

The following activities and procedures will apply for creating and maintaining electronic data base:

- The above hard copy data collected by project in-charge personnel will then be transferred into an electronic data base by the project supervisor of PEA. The hard copy format for data collection will be developed during CPA implementation stage.

The final database including the data of all CPAs will be maintained by the Project Manager of PEA.
As a coordinating entity, the PEA will be responsible for the management of records and data associated with each CPA. They will maintain the overall programme database for these records. The Project Manager will manage the overall programme database and maintain the records of all CPAs under this programme.

PEA in addition to being the Managing Entity will be the CPA implementer for each CPA. The operational and management structure for monitoring the project is given in the above figure.

Hence, the data collected by the CPA in charge personnel will be cross checked by the project supervisor and then by the Project Manager. This will ensure that the proper record keeping system is in place.

Paper and electronic records will be kept during the entire crediting period of each CPA (10 years) and two years after the crediting period.

Roles & responsibilities (during monitoring)

The institutional arrangement is as shown in the following figure:

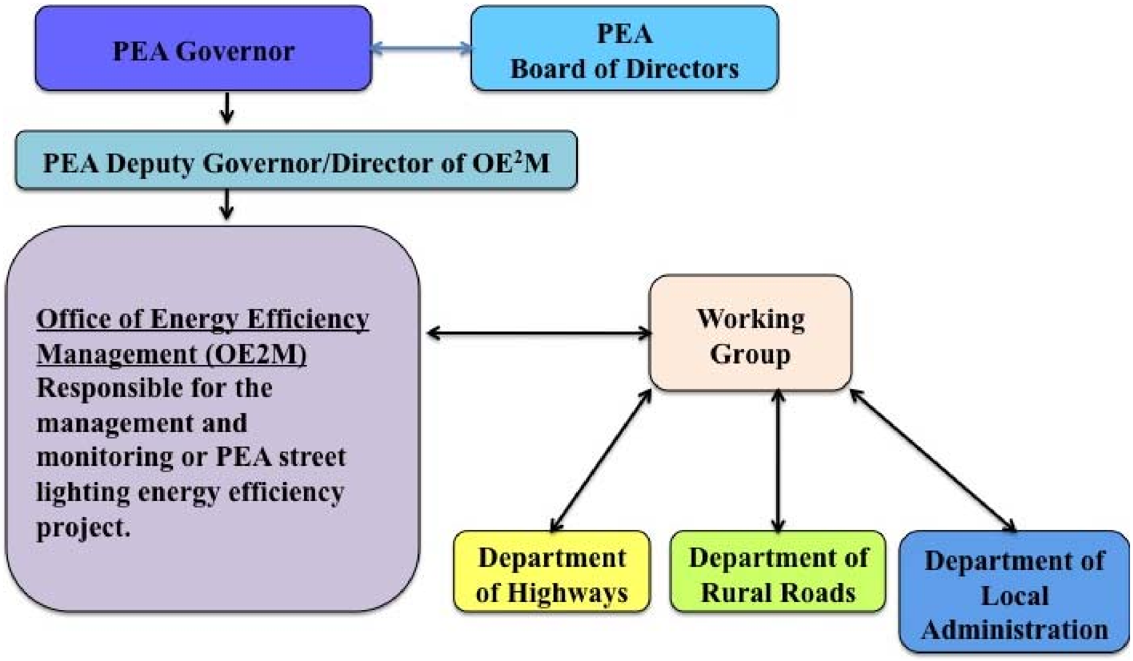

Figure 3: CFO Institutional Arrangements

The role and responsibility of each party involved is described below:

1) **Provincial Electricity Authority (PEA)** will (a) serve as the Project leader with overall responsibility for Project preparation and implementation; (b) provide technical advice and guidance to personnel involved in the project during the course of Project preparation and implementation; and (c) supervise the project as well as prepare the initial verification report.. PEA has set up the Office of Energy Efficiency Management (OE^2M) within PEA to be responsible for the implementation and monitoring of the project. PEA deputy governor will be the director of this office, and there will be two manager assistants, one of which will be responsible for the project. PEA will also be responsible for selection of LED supplier through competitive bidding process. The institutional arrangement within PEA is illustrated in the following figure:

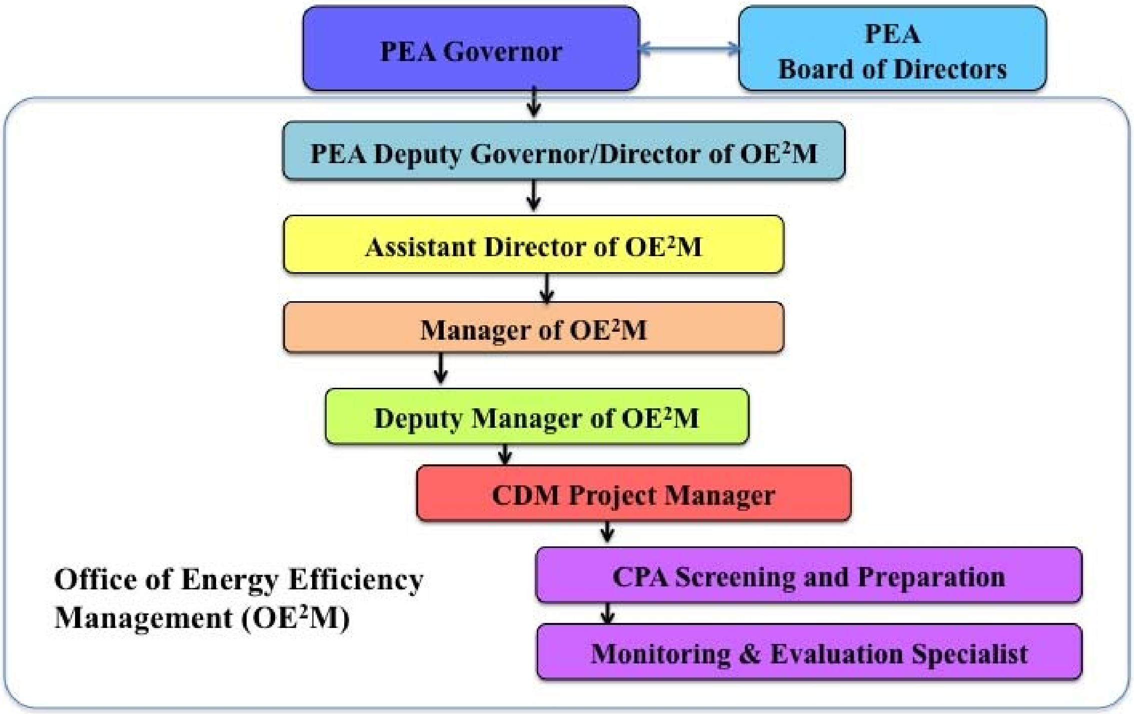

Figure 4: Institutional Arrangements of PEA

2) **Department of highways (DOH)** responsible for site selection and monitoring of highways in accordance with road safety standard;
3) **Department of Rural Roads (DORR)** responsible for site selection and monitoring of rural roads in accordance with road safety standard; and
4) **Department of Local Administration (DOLA)** responsible for site selection and monitoring of road condition within the responsibility area of the local government.DOH, DORR, DOLA and general public will also carry out regular survey on the road standard as well as operation of street lighting. They can also report black out on the road through PEA call centre. OE^2M and PEA will be responsible for recording maintenance turn-around time from failure to replacement (Outage factor). PEA will ensure that all sites conduct the monitoring activities. PEA is also responsible for training and building the capacity of on-site personnel in order to properly conduct M&E. The reporting of black outs are illustrated in the following figure:

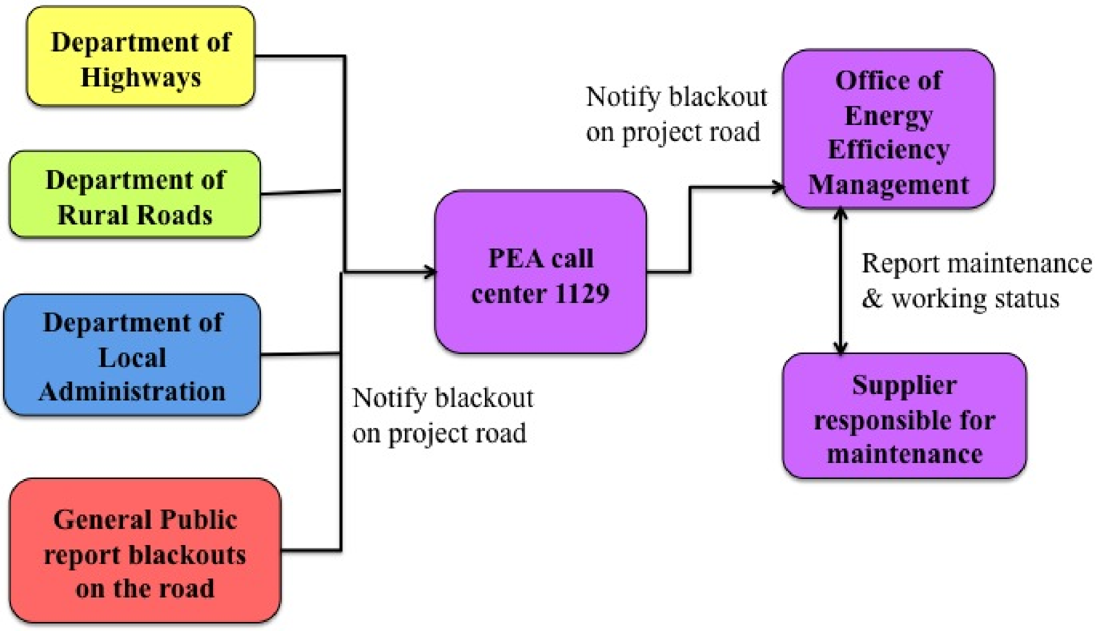

Figure 5: Black out report

Entity name	Individual/position	Roles and responsibilities during monitoring
CME	• Deputy Governor, PEA • Project Manager of PoA	• Conduct local stakeholder consultations. • Develop the project, plan for and source the finance to implement each CPA of the programme. • Develop data recording formats and provide them to the CPA implementer in each region. • Manage a centralised database system and maintain the data of all CPA. • Carry out quality control and quality assurance of data and CPA operation. • Plan CPA activities in each region. • Review and confirm CDM documentation/access to CDM data base. • Sell Emission Reductions (ERs). • Determine the use of funds from emission reductions.
CPA Manager/Supervisor (PEA local office)	• Local office staff	• Organize the LED awareness raising campaign in their respective regions. • Supervise the implementation of CPA activities in each of the regions under this PoA • Monitor LED units along with LED supplier.

Entity name	Individual/position	Roles and responsibilities during monitoring
		• Keep records of all maintenance activities (number of fused lamps, dates of notice and replacement, outage hours, etc.) • Generate primary data for CPA database and report to PEA CPA project manager/supervisor • Capture hard copy data as per the data recording format and convert it into electronic data. • Manage database for CPA in line with CDM requirements under the supervision of the CME. • Assure quality assurance and quality control of CPA data (cross-checking, field visit, accuracy, completeness, corrective actions, etc.) • Report CPA data and monitoring information to the CME.
LED Supplier	• LED supplier/contractor	• Supply LED fittings as per the terms of reference and contracts • Removal old baseline lamps and installation of project lamps • Collect and return working HPS units to DoH and DORR • Warranty of lifespan of supplied LED lamps • Do the maintenance activities as per instruction from PEA personnel in-charge for CPA.
DOH/DORR/DOLA	• Local staffs	• Reporting blackouts
Local public	• General public	• Reporting blackouts

The parameters to be monitored are:

Data / Parameter:	$Q_{i,P}$
Data unit:	Number
Description:	Quantity of project (*P*) luminaries of type *i* distributed and installed under the project activity.
Source of data used:	SSC-CPA implementer
Value of data applied for the purpose of	1,672

calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	At the time of the exchange/installation, a record will be kept on the number of replaced equipment. This information will be stored in the project database.
QA/QC procedures to be applied:	The actual number of installed fittings will be compared with the number of fittings removed. Any discrepancy will be documented. The installed number of equipment will be documented and verifiable by DOE at random. Project luminaries replaced as part of a regular maintenance or warranty program can be counted as operating.
Any comment:	Once all of the project luminaries are distributed or installed, $Q_{i,P}$ is normally a constant value independent from *y* unless size of operating luminaries inventory decreases during crediting period, in which case only operating project luminaries will be credited.

Data / Parameter:	$O_{i,y}$
Data unit:	Hours
Description:	.Annual operating hours for the project luminaries in year *y*
Source of data to be used:	Measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.5	4,745
Description of measurement methods and procedures to be applied:	Working hours are on the basis of the change in streetlights turning ON time and OFF time depending on the sunrise and sunset times through the year. This value is based on continuous measurement of daily average usage hours of luminaires for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90% confidence interval and 10% maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days.
QA/QC procedures to be applied:	For ex-ante calculation purpose, annual operating hours of 13 hours per day is taken “Feasibility Study for PEA Installation of Energy-Saving Equipment for High Mast Lamps and High Intensity Discharge (HID) Street Lights”.[27] During ex-post monitoring, this data will be collected through sampling techniques using the above measurement method. -
Any comment:	All data will be stored in the project database for at least two years after the crediting period or the last issuance of CERs for this programme, whichever

[27] This evidence is also supported by the information provided by KMUTT.

	occurs later.

Data / Parameter:	$P_{i,P,y}$
Data unit:	kW
Description:	Rated power of the project luminaries of the group of *i* lighting devices
Source of data used:	Equipment specification/lamps nameplate data
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.110
Description of measurement methods and procedures to be applied:	Nameplate rated power of project lamps or manufacturer specifications will be recorded and documented
QA/QC procedures to be applied:	The data will be recorded during installation of project lamps. Procurement orders and manufacturer specification will be documented.
Any comment:	-

Data / Parameter:	$OF_{i,,y}$
Data unit:	-
Description:	Average time, in hours, elapsed between failure of luminaires type *i* and their replacement, divided by *Oi,y*, annual operating hours
Source of data used:	PEA maintenance records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1 (ex-ante value)
Description of measurement methods and procedures to be applied:	The value is determined ex-post based on documented maintenance practice and records of maintenance turn-around time from failure to replacement.
QA/QC procedures to be applied:	The maintenance staff will be trained to record and maintain all data about failure and replacement.
Any comment:	The outage factor value during the baseline (*BL)* is assumed to be the same as determined for each year of the crediting period (*y*) and may vary from year to year.

Data / Parameter:	$AFR_{i,y}$
Data unit:	-
Description:	Annual Failure Rate of luminaires calculated as a fraction of *Q*
Source of data used:	Maintenance records
Value of data applied for the purpose of calculating expected	0.0.0949 (for ex-ante calculation, actual value will be recorded ex-post).

emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Failure rates during the crediting period to be determined *ex post* from maintenance records that indicate the actual fraction of system-wide equipment of type *i* that fail annually
QA/QC procedures to be applied:	The maintenance staff will be trained to record and document the operating conditions of lamps.
Any comment:	The value for failure rate during the baseline (*BL)* is assumed to be the same as determined for each year of the crediting period *y* and may vary from year to year. For *ex ante* calculations, failure rate in year *y* could be assumed to equal to $O_{i,y}$ divided by the rated average life for project equipment type *i*

C.1. Please indicate the level at which environmental analysis as per requirements of the CDM modalities and procedures is undertaken. Justify the choice of level at which the environmental analysis is undertaken:

The environmental analysis is undertaken at the PoA level as the project (LED bulbs) nature is the same irrespective of the individual CPA location. Hence sections C.2. and C.3 of this form are left blank

C.2. Documentation on the analysis of the environmental impacts, including transboundary impacts:

Not applicable.

C.3. Please state whether an environmental impact assessment is required for a typical CPA, included in the programme of activities (PoA), in accordance with the host Party laws/regulations:

Not applicable.

SECTION D. Stakeholders' comments

D.1. Please indicate the level at which local stakeholder comments are invited. Justify the choice:

Stakeholder consultations were carried out both at PoA and CPA level.

D.2. Brief description how comments by local stakeholders have been invited and compiled:

The objective of the local stakeholder consultation was to inform the stakeholders about the project as well as the potential impact that might occur as a result of the project implementation. A set of questionnaire was also distributed during the stakeholder consultation.

The stakeholders attended the consultation were a group of well represented stakeholders from various groups of road user and organization responsible for road safety in the local area. There were a total of 21 participants from PEA local officers (11), local government representatives (2), Department of Highway representatives (3), local bus operator (1), academic institution representative (1) and the World Bank representatives (3). The stakeholders eagerly participated in discussion.

An opening remark was given by Mr. Niwat Chayakul, LED team leader on the objectives and expectation of the consultation, as well as the objective of PEA Street Lighting Energy Efficiency Project. 3 presentations were made in total.

1) Climate change and CDM, 2) Street Lighting standard & LED and 3) Pilot Project

The World Bank consultant gave the first presentation on the overall causes of climate change, its potential impact, importance and urgency of greenhouse gas mitigation and Clean Development Mechanism (CDM). The highlight of the presentation was the explanation on the concept of CDM Programme of Activities (POA), which will be adopted for the PEA Street Lighting Energy Efficiency Project.

The second presentation was given PEA's street lighting engineer. The presentation covered visual impact, luminance requirement for road safety, criteria for road luminance design and options to improve street lighting energy efficiency. The presentation highlighted the benefits of switching from High Pressure Sodium (HPS) lamps to LED, including the ability of LED to give instant lighting after switch on, absence of ultraviolet or infrared radiation and increased operating lifetime (50,000 hr) as compared to the HPS lighting systems. The presenter also showed pictures and video of pilot sites in other countries that has adopted LED street lighting to the audience.

LED deputy team leader then gave a presentation on the street lighting energy efficiency project. The presentation provided information on the location of proposed pilot project in 4 regions of Thailand; Chiang Mai province in the North, Patum Thani province in the central region, Nakorn Ratchasima in the North East and Phuket in the South. He presented that the total number of street lighting unit that will be changed in the pilot project will be around 16,000 lighting units. He also informed the public, that the overall program will eventually change around 450,000 HPS lighting units to LED. He informed the audience that the location for the first phase of the pilot project is in Patum Thani, (4 routes) with approximately 1,600 lighting units. The first phase of the pilot project will be able to save at least 1.9 million units of electricity and save about 5 million THB per year. He informed the public, that the specifications for LED units will ensure that the luminance provided will meet road safety standard and help reduce greenhouse gas emission.**D.3. Summary of the comments received:**

There were two questions asked during the consultation.

Q1. Whether other parties such as local resident could participate in the project or not?

Answer: At present the current POA covers only street lighting. But in future PEA may include a program to replace lighting units in residential home. PEA's priority is to introduce nationwide energy efficiency programme. At present PEA is carrying out a pilot project with Thammasart University and Chiang Mai

University, where PEA invests in the implementation of LED and the amount of net energy saved will be charged to the universities until the total investment is returned.

Q2. Whether the colour of LED light (white light compared to yellow lights provided by HPS units) would have visual impact under foggy condition or not?

According to the tests on street lighting for road safety, the visibility during foggy condition depends on luminance uniformity and brightness rather than the colour of the lights. Therefore, the colour of LED lights would not have any impact on the visibility during foggy condition.
The questionnaires was distributed to the stakeholders attended the consultation to ensure that the objectives of the consultation were met. The return rate of the questionnaire was 100%, while the analysis of questionnaire results, showed that the stakeholders had better understanding of the climate change impact, and impact and benefits of LED street lighting project. All stakeholders agreed to the implementation of PEA Street Lighting Energy Efficiency Project. The stakeholders also agreed that the consultation provided opportunities to ask questions and discuss project detail.

The stakeholder's consultation provided opportunities for stakeholder in the local area to learn about the potential impact of climate change, needs to mitigate greenhouse gas mitigation, and LED replacement to improve street lighting energy efficiency. After the presentations, questions and answers session and discussion, the stakeholders agreed to implementation of PEA Street Lighting Energy Efficiency Project.

D.4. Report on how due account was taken of any comments received:

No negative comments were received. Hence, no action is needed.

Annex 1

CONTACT INFORMATION ON ENTITY/INDIVIDUAL RESPONSIBLE FOR THE SMALL-SCALE CPA

Organization:	PEA
Street/P.O.Box:	200 Ngamwongwan Rd.
Building:	
City:	Bangkok
State/Region:	
Postfix/ZIP:	10900
Country:	Thailand
Telephone:	+662 590 9531
FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	Deputy Governor
Salutation:	Mr.
Last Name:	Lowattanatakul
Middle Name:	
First Name:	Numchai
Department:	
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	

Organization:	IBRD
Street/P.O.Box:	1818 H St. NW
Building:	
City:	Washington
State/Region:	DC
Postfix/ZIP:	20433
Country:	USA
Telephone:	+1 (202) 473-3616
FAX:	+1 (202) 522-7432
E-Mail:	
URL:	
Represented by:	
Title:	Manager
Salutation:	Ms.
Last Name:	Chassard
Middle Name:	
First Name:	Joëlle

Department:	Carbon Finance Unit
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	jchassard@worldbank.org

Organization:	Kingdom of Spain - Ministry of Economy and Finance
Street/P.O.Box:	Po de La Castellana,
Building:	162
City:	Madrid
State/Region:	
Postcode/ZIP:	28046
Country:	Spain
Telephone:	+34 91 583 58 55
FAX:	
E-Mail:	
URL:	
Represented by:	Mr. Gonzalo GARCIA ANDRES
Title:	General Director International Finance
Salutation:	Mr.
Last name:	GARCIA ANDRES
Middle name:	
First name:	Gonzalo
Department:	International Finance Department
Mobile:	
Direct FAX:	+34 91 583 58 55
Direct tel:	
Personal e-mail:	gga@meh.es

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding.

Annex 3

BASELINE INFORMATION

For the project activity, the baseline scenario involves equivalent electricity generation from the grid which entails GHG emissions at the grid end. The Emission Factor can be calculated by using Annex 19 Methodological Tool (version 02.2.1) " Tool to calculate the emission factor for an electricity system". Parameters of this method are listed below.

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

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

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

STEP 1: Identify the relevant electricity systems

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

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

Delineation of connected electricity system

In Thailand, the electricity transmission line system is considered as a single grid system due to the transmission lines are networked all of the country area. Electricity Generating Authority of Thailand (EGAT) regulate electricity generation and main transmission system, meanwhile Metropolitan Electricity Authority (MEA) is responsible for electricity distribution system in Bangkok and vicinity area, and Provincial Electricity Authority (PEA) is responsible for electricity distribution system in the rest of country.

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

Only grid connected power plants are included in the calculation, as per Option I of the "Tool to calculate the emission factor for an electricity system" version 02.2.1

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

Method to determine the operating margin (OM)

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

1) Simple OM
2) Simple adjusted OM
3) Dispatch data analysis OM
4) Average OM

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

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

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

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

From the above table, it is clear that the LC/MR resources constitute an average of 6.32 % of total generation which is less than 50%. This satisfies the criteria for simple OM method. On this basis, Option (a), the Simple OM has been selected. Hence, according to the data available, the simple OM method (Ex ante Option) is the most appropriate method for Thailand.

This method requires the latest 3 years data including quantity of electricity generated, fuel types used and fuel consumption of each fuel type. This study used data obtained in the year 2008-2010.

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

STEP 4: Calculate the operating margin emission factor according to the selected method The Simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (t CO_2/MWh) of all generating power plants serving the system, excluding of low-cost/must-run power plants/units.

The Simple OM may be calculated:

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

Option B: the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system

Option A is selected for OM calculation since the data required for option A, i.e., the net electricity and a CO_2 emission factor of each power unit is available.

Where option A is used, the simple OM emission factor is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

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

where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year y (t CO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{El,m,y}$	=	CO_2 emission factor of power unit m in year y (t CO_2/MWh)
m	=	All power units serving the grid in year y except low-cost / must-run power units
y	=	The relevant year as per the data vintage chosen in Step 3

Determination of $EF_{EL,m,y}$

To estimate the emission factor of each power unit m ($EF_{EL,m,y}$), option A1 is applied, since data on fuel consumption and net electricity generation is available. Following formula is used to calculate Simple OM.

$$EF_{EL,m,y} = \frac{\sum_{i} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum EG_{m,y}}$$

Where:

$EF_{EL,m,y}$	=	CO_2 emission factor of power unit m in year y
$FC_{i,m,y}$	=	Amount of fuel type i consumed by power plant/unit m in year y.
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type i in year y
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type i in year y
$EG_{m,y}$	=	Net electricity generated and delivered to the grid by power plant/unit m in year y
m	=	All power plants/units serving the grid in year y except low-cost/must-run power units.

i	=	All fossil fuel types combusted in power unit m in year y
y	=	The relevant year as per the data vintage chosen in Step 3

The determination of the operating margin emission factor should follow ***ex-ante*** option, which requires 3 year generation–weighted average of the most recent data available at the time of PDD submission.

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

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

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

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

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year *y* (t CO_2/MWh)
$FC_{i,y}$	=	Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit)
$NCV_{i,y}$	=	Net Calorific value (energy content) of fossil fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,I,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (t CO_2/GJ)
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must run power plants/units, in year *y* (MWh)
i	=	All fossil fuel types combusted in power sources in the project electricity system in year *y*
y	=	The relevant year as per the data vintage chosen

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

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

Fuel type[28]	**Unit**	**Net calorific value[29] (MJ/Unit)**	**CO_2 emission[30] (t CO_2/TJ)**	**CO_2 emission (kg CO_2/Unit)**

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

Fuel type[28]	Unit	Net calorific value[29] (MJ/Unit)	CO_2 emission[30] (t CO_2/TJ)	CO_2 emission (kg CO_2/Unit)
Natural gas	Scf.	1.02	54.30	0.0554
Lignite	ton	10,470.00	90.90	951.7230
Bituminous	ton	26.370.00	89.50	2,360.1150
Bunker	litre	39.77	75.50	3.0026
Diesel	litre	36.42	72.60	2.6441

The quantity of electricity was generated and transmitted to the national grid can be obtained from the Electricity Statistic Annual Report 2008 – 2010 that provided by EGAT. The quantity of electricity generation data is categorized by electricity generation system, group of power producer (EGAT, IPP and SPP) and type of power plant (LC/MR and Non LC/MR) as shown in Table 2. The data of type and quantity of fossil fuel consumption in electricity generation are categorized by type of power producer (EGAT, IPP and SPP) as shown in Table 3.

VSPP are renewable power plants based on biogas, biomass, hydropower, wind power and solar power with installed capacity equal or less than 10 MW and are considered as LC/MR power plant. However, VSPP power plants are non-firm and can supply only a small quantity of electricity to the national grid compared to other power plants. In year 2010, the quantity of electricity sold to the PEA was 1,155.10 GWh[31] (0.72% of the total electricity was generated in 2010).

This study does not include quantity of electricity generated and supplied by VSPP in the calculation. The total quantity of electricity transmitted to the national grid (only Non LC/MR) in the years 2008 – 2010 was 424,913.67 GWh.

Table 2: Quantity of electricity generated and transmitted to the national grid[32]

Generation system	Grid generation (GWh)				
	EGAT	IPP	SPP	Total	%
2010					
Summary	78,517.70	67,775.98	13,897.27	160,190.96	100.00
Non LC/MR	73,185.41	67,775.98	11,642.33	152,603.73	95.26
LC/MR[33]	5,332.30	-	2,254.94	7,587.23	4.74
Thermal	27,289.03	15,408.42	2,162.89	44,860.34	
Combined - cycle	38,338.71	52,367.56	8,655.76	99,362.04	
Gas turbine	276.30	-	823.67	1,099.97	
Diesel engine	3.98	-	-	3.98	
Hydropower	5,325.20	-	23.64	5,348.84	
Renewable energy	7.10	-	2,231.30	2,238.40	

[29] Electric Power in Thailand 2010/ Department of Alternative Energy Development and Efficiency, Ministry of Energy
[30] IPCC default values at the lower limit as provide in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
[31] Provincial Electricity Authority
[32] Electricity Statistic Annual Report 2008 – 2010, Electricity Generating Authority of Thailand
[33] LC/MR power plants include hydropower and renewable energy (including biomass, solar and geothermal power)

Generation system	Grid generation (GWh)				
	EGAT	IPP	SPP	Total	%
Electricity import	7,277.39	-	-	7,277.39	
2009					
Summary	66,488.10	64,840.72	13,971.37	145,300.19	100.00
Non LC/MR	59,541.66	64,840.72	11,811.42	136,193.80	93.73
LC/MR[34]	6,946.44	-	2,159.95	9,106.39	6.27
Thermal	23,463.69	12,388.03	2,225.63	38,077.39	
Combined - cycle	33,164.46	52,452.69	8,752.19	94,369.35	
Gas turbine	309.63	-	833.60	1,143.23	
Diesel engine	1.44	-	-	1.44	
Hydropower	6,941.74	-	23.97	6,965.71	
Renewable energy	4.70	-	2,135.98	2,140.68	
Electricity import	2,602.43	-	-	2,602.43	
2008					
Summary	63,719.02	67,420.14	14,092.83	145,232.00	100.00
Non LC/MR	56,791.19	67,420.14	11,904.81	136,116.14	93.73
LC/MR	6,927.83	-	2,188.03	9,115.86	6.27
Thermal	26,778.89	14,398.34	1,996.83	43,174.06	
Combined cycle	26,7449.20	53,021.80	9,029.90	88,500.90	
Gas turbine	659.33	-	878.07	1,537.41	
Diesel engine	2.30	-	-	2.30	
Hydropower	6,926.02	-	28.77	6,954.79	
Renewable energy	1.81	-	2,159.26	2,161.07	
Electricity import	2,901.47	-	-	2,901.47	

Table 3: Amount of fossil fuel consumed by power plants[35]

Fuel type	Unit	Fuel consumption			
		EGAT	IPP	SPP	Total
2010					
Natural gas	scf.	430,662,249,446	491,131,955,423	151,290,468,150	1,073,084,673,019
Lignite	ton	16,043,174	-	-	16,043,174
Bituminous	ton	-	3,646,898	1,855,262	5,502,160
Bunker	litre	140,084,467	87,347,782	5,797,497	233,229,746
Diesel	litre	11,865,427	10,853,795	1,307,336	24,026,558
2009					
Natural gas	scf.	369,146,214,392	459,228,417,361	140,550,086,056	968,924,717,809
Lignite	ton	15,818,265	-	-	15,818,265
Bituminous	ton	-	3,645,721	1,840,527	5,486,248
Bunker	litre	111,039,065	38,180,874	8,797,506	158,017,445

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

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

Fuel type	Unit	Fuel consumption			
		EGAT	IPP	SPP	Total
Diesel	litre	12,140,891	-	1,685,046	13,825,937
2008					
Natural gas	scf.	340,739,529,461	490,866,999,785	145,410,364,035	977,016,893,281
Lignite	ton	16,407,465	-	-	16,407,465
Bituminous	ton	-	3,711,791	1,866,776	5,578,567
Bunker	litre	247,441,682	93,212,260	9,555,452	350,209,394
Diesel	litre	6,792,039	43,698,832	1,451,087	51,941,958

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

The OM emission factor calculated by the equation (1) and following Simple OM method option B (ex ante option) is shown in Table 5. The OM emission factor is 0.5994 tCO_2 /MWh.

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

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

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

Year	CO_2 emission (t CO_2)	Grid consumption (GWh)	OM Emission Factor (t CO_2/MWh)
2010	88,452,088	152,603.73	0.5796
2009	82,178,673	136,193.80	0.6034
2008	84,083,369	136,116.14	0.6177
Summary	254,714,130	424,913.67	0.5994

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

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

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

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

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

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

The group of power units that supply electricity to the grid most recently (sorted by the Commercial Operation Date (COD) which is the date when the power unit starts to supply electricity to the grid) and their annual quantity of electricity generation comprise larger than or equal to 20% of total annual electricity generation (in year 2010) are shown in Table 6. And fuel consumption of these power units are shown in Table 7.

Table 6: Electricity Generation by most recently built power plants[36]

Power unit	Grid generation (GWh)	COD

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

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

Table 7: Fuel consumptions of the most recently built power plants as listed in Table[37]

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

The build Margin Emission Factor calculated by using equation below;

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

Where,

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

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

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

m = Power units included in the build margin

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

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

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

Table 8: Calculation of Build Margin Emission Factor

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

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

Method to determine the Combined Margin (CM)

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

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

Where,

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

Table 9: Weighting of operating and build margin emissions factor for general CDM projects

CDM project type	W_{OM}	W_{BM}
General project	0.50	0.50

As the project activity is involves a general project, W_{OM} = 0.50 and W_{BM} = 0.50 is selected. The Combined Margin Factors of General CDM project is calculated by using equation 2 is 0.5113 as given in Table 10.

Table 10: Calculated Combined Margin Emission Factor

CDM project type	Emission Factor ($t\ CO_2/MWh$)		
	$EF_{grid,OM}$	$EF_{grid,BM}$	$EF_{grid,CM}$
General project	0.5996	0.4231	0.5113

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

Report[38]	DEDE[39] (Thailand)	IPCC[40]

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

Report[38]	DEDE[39] (Thailand)	IPCC[40]
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

ENERGY CONTENT OF FUEL (NET CALORIFIC VALUE)

S. No.	Type (Unit) Commercial Energy	K Cal/unit	toe/10^6 unit	MJ/unit	10^3 BTU/unit
1.	Crude Oil (litre)	8,680	860.00	36.33	34.44
2.	Condensate (litre)	7,900	782.72	33.07	31.35
3.	Natural Gas				
	3.1 Wet (scf)	248	24.57	1.04	0.98
	3.2 Dry (scf)	244	24.18	1.02	0.97
4.	Petroleum products				
	4.1 LPG (litre)	6,360	630.14	26.62	25.24
	4.2 Gasoline (litre)	7,520	745.07	31.48	29.84
	4.3 Jet Fuel (litre)	8,250	817.40	34.53	32.74
	4.4 Kerosene (litre)	8,250	817.40	34.53	32.74
	4.5 Diesel (litre)	8,700	861.98	36.42	34.52
	4.6 Fuel Oil (litre)	9,500	941.24	39.77	37.70
	4.7 Bitumen (litre)	9,840	974.93	41.19	39.05
	4.8 Petroleum Coke (kg)	8,400	832.26	35.16	33.33
5.	Electricity (kWh)	860	85.21	3.60	3.41
6.	Hydroelectricty (kWh)	2,236	221.54	9.36	8.87
7.	Geothermal (kWh)	9,500	941.24	39.77	37.70
8.	Coal import (kg)	6,300	624.19	26.37	25.00
9.	Coke (kg)	6,600	653.92	27.63	26.19
10.	Anthracite (kg)	7,500	743.09	31.40	29.76
11.	Ethane (kg)	11,203	1,110.05	46.89	44.45
12.	Propane (kg)	11,256	1,115.34	47.11	44.67
13.	Lignite				
	13.1 Li (kg)	4,400	435.94	18.42	17.46
	13.2 Krabi (kg)	2,600	257.60	10.88	10.32
	13.3 Mao Moh (kg)	2,500	247.70	10.47	9.92
	13.4 Chae Khon (kg)	3,610	357.67	15.11	14.32
	New & Renewable Energy				
1.	Fuel Wood (kg)	3,820	378.48	15.99	15.16

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

[40] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

S. No.	Type (Unit) Commercial Energy	K Cal/unit	toe/10^6 unit	MJ/unit	10^3 BTU/unit
2.	Charcoal (kg)	6,900	683.64	28.88	27.38
3.	Paddy Husk (kg)	3,440	340.83	14.40	13.65
4.	Bagasse (kg)	1,800	178.34	7.53	7.14
5.	Garbage (kg)	1,160	114.93	4.86	4.60
6.	Saw Dust (kg)	2,600	257.60	10.88	10.32
7.	Agricultural Waste (kg)	3,030	300.21	12.68	12.02
8.	Biogas (m^3)	5,000	495.39	20.93	19.84

TABLE 1.4: DEFAULT CO_2 EMISSION FACTORS FOR COMBUSTION[41]

Fuel type English description		Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[42]		
				Default Value[43]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Crude oil		20.0	1	73 300	71 100	75 500
Orimulsion		21.0	1	77 000	69 300	85 400
Natural Gas		17.5	1	64 200	58 300	70 400
Gasoline	Motor gasoline	18.9	1	69 300	67 500	73 000
	Aviation gasoline	19.1	1	70 000	67 500	73 000
	Jet gasoline	19.1	1	70 000	67 500	73 000
Jet kerosene		19.5	1	71 500	69 700	74 400
Other kerosene		19.6	1	71 900	70 800	73 000
Shale oil		20.0	1	73 300	67 800	79 200
Gas / Diesel oil		20.2	1	74 100	72 600	74 800
Residual fuel oil		21.1	1	77 400	75 500	78 800

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

[42] TJ = 1000 GJ

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

Fuel type English description		Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[42]		
				Default Value[43]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Liquefied petroleum gases		17.2	1	63 100	61 600	65 600
Ethane		16.8	1	61 600	56 500	68 600
Naphtha		20.0	1	73 300	69 300	76 300
Bitumen		22.0	1	80 700	73 000	89 900
Lubricants		20.0	1	73 300	71 900	75 200
Petroleum coke		26.6	1	97 500	82 900	115 000
Refinery Feedstock		20.0	1	73 300	68 900	76 600
Other Oil	Refinery gas	15.7	1	57 600	48 200	69 000
	Paraffin waxes	20.0	1	73 300	72 200	74 400
	White spirit & SBP	20.0	1	73 300	72 200	74 400
Other petroleum products		20.0	1	73 300	72 200	74 400
Anthracite		26.8	1	98 300	94 600	101 000
Coking coal		25.8	1	94 600	87 300	101 000
Other Bituminous coal		25.8	1	94 600	89 500	99 700
Sub-Bituminous coal		26.2	1	96 100	92 800	100 000
Lignite		27.6	1	101 000	90 900	115 000
Oil shale and tar sands		29.1	1	107 000	90 200	125 000
Brown coal briquettes		26.6	1	97 500	87 300	109 000
Patent fuel		26.6	1	97 500	87 300	109 000
Coke	Coke oven coke and lignite coke	29.2	1	107 000	95 700	119 000
	Gas coke	29.2	1	107 000	95 700	119 000
Coal tar		22.0	1	80 700	68 200	95 300
Derives Gases	Gas works gas	12.1	1	44 400	37 300	54 100
	Coke oven gas	12.1	1	44 400	37 300	54 100
	Blast furnace gas [44]	70.8	1	260 000	219 000	308 000
	Oxygen steel furnace gas [5]	49.6	1	182 000	145 000	202 000
Natural Gas		15.3	1	56 100	54 300	58 300
Municipal Wastes (non-biomass fraction)		25.0	1	91 700	73 300	121 000
Industrial wastes		39.0	1	143 000	110 000	183 000

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

Fuel type English description		Default carbon content (Kg/GJ)	Default carbon oxidation factor	Effective CO_2 emission factor (Kg/TJ)[42]		
				Default Value[43]	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Waste oil		20.0	1	73 300	72 200	74 400
Peat		28.9	1	106 000	100 000	108 000
Solid bio-fuels	Wood/wood waste	30.5	1	112 000	95 000	132 000
	Sulphite lyes (black liquor)[45]	26.0	1	95 300	80 700	110 000
	Other primary solid biomass	27.3	1	100 000	84 700	117 000
	charcoal	30.5	1	112 000	95 000	132 000
Liquid bio-fuels	Biogasoline	19.3	1	70 800	59 800	84 300
	Biodiesels	19.3	1	70 800	59 800	84 300
	Other liquid biofuels	21.7	1	79 600	67 100	95 300
Gas biomass	Landfill gas	14.9	1	54 600	46 200	66 000
	Sludge gas	14.9	1	54 600	46 200	66 000
	Other biogas	14.9	1	54 600	46 200	66 000
Other non-fossil fuels	Municipal wastes (biomass fraction)	27.3	1	100 000	84 700	117 000

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

Annex 4

MONITORING INFORMATION

Sampling Plan

As per the Standard for Sampling and Surveys for CDM Project activities and Programme of Activities Ver. 2.0 (EB65, Annex 2), the sampling plan should contain information relating to: (a) sampling design; (b) data to be collected; and (c) implementation plan.

(a) Sample Design

Objectives and Reliability Requirements
The sampling objective is determining the values of operating hours for a representative number of devices. The average value derived will be used to estimate energy savings, thus the emission reductions. As required by AMS-II.L, the sampling aims at installing a number of runtime meters for more reliable estimate of annual operating hours. This value is based on continuous measurement of daily average usage hours of luminaries for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90% confidence interval and 10% maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days.

Target Population
The targeted population is all switching points within the project boundary. The switching points are normally the metering points for the street lights. It is estimated that there are 40 lamps per photocell sensor (switching point). Hence, the total number of switching points is found to be 42 for 1,672 lamps. The parameter to be established is the annual operating hours of the street lights. The primary objective of the measurements is to obtain a reliable estimate of the average annual hours of operation.

The sample frame will be developed for the switching points within the project boundary. The switching points are normally the metering points for the street lights. The sample size is determined for 90% confidence level with 10% precision

Sampling Method
A simple random sampling method will be used. Each element of the sample will be drawn randomly from the total population of switching points involved in the project activity. Runtime meters are installed at the sample of randomly selected switching points to measure the operating hours for a minimum of 90 days. The measurement survey will be carried out every year.

Sample Size.
The sample size is calculated to meet a 90% confidence interval and a 10% error margin. The determination of the sample size is based on the formula used by PEA.

$$n_0 = \frac{z^2 * cv^2}{e^2}$$

Where:

n_o Initial estimate of the required sample size, before sampling begins
cv Coefficient of variance, defined as the standard deviation of the measurement divided by the average measurement value. a variability of 50% is chosen as an initial estimate.
e Desired level of precision. 10% precision is used as per AMS-II.L.
z Standard normal distribution value and for the desired confidence level. For a 90% confidence level, z is 1.64

For small population such as 42 switching points, the sample size is recalculated using the following formula:

$$n = \frac{n_0 N}{n_0 + N}$$

$$n_0 = \frac{1.64^2 * 0.5^2}{0.1^2} = 67$$

For 42 switching points, the minimum sample size is calculated as follows:

$$n = \frac{n_0 N}{n_0 + N} = \frac{67 \times 42}{67 + 42} = 26$$

Parameters to be measured	Sampling method	No. of samples
Average annual operating hours	Simple random sampling	26 Switching points

Sampling frame
The sampling frame is the total number of switching points involved in the CPA. The sample will be selected randomly from the list of switching points.

(b) Data:

Field Measurements:
AMS-II.L. requires continuous measurement of daily average usage hours of luminaries for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90% confidence interval and 10% maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days.

The sampling aims at installing a number of runtime meters at switching points for more reliable estimate of annual operating hours. Annual; survey will be conducted to determine the annual operating hours.

Quality Assurance/Quality Control
The technicians are trained on data logging. Any biased data is immediately identified. The measurement is then repeated until the reason for abnormal figures are found and corrected. As part of the QA/QC,

PEA is responsible for the calibration of run-time meters. The results of the calibration will be included in the monitoring report.
If there are any anomalies in the readings of the runtime meters, they will be recalibrated and the measurement reinitiated. For the period in which anomalies were noted, lowest value recorded in the past, ex-ante and metered will be used to calculate energy savings and emission reductions.

Analysis:
The average value of all meter readings is used to calculate the electricity consumption and savings achieved by the project activity. The annual operating hours will also be used to calculate the baseline energy and baseline emissions. Seasonal variations will be captured by adjustment of the measured data.

(c) Implementation

The sample is calculated by the Project Supervisor. The project is managed in the field by CPA in-charge personnel including LED supplier and PEA local office staff who will be trained to collect and process data and project implementation.

Annex 5

METHOD FOR MEASURING AND CALCULATING AVERAGE ILLUMINANCE

Evaluating roadway illuminance, a measure of the amount of luminous flux, falling per unit area – lumens/m^2, or lux (lx), is a simple comparative basis for roadway lighting systems (McKinlay. Dec. 2006) used in this methodology, though luminance evaluations are common and are also acceptable.[47] Total Useful Illuminance is defined here as the average maintained illuminance on the target task plane (i.e., roadway surface), from the baseline and project luminaries. *Maintained* illuminance takes into account the depreciation in luminous flux over time, which varies from one light source to another, and is defined as illuminance delivered when a product has reached the end of its maintenance cycle. Appropriate depreciation factors should be applied to modelled or measured illuminance values, based on the light source used.

As the roadway uses dimensions and lighting systems layout which vary from location to location, it is not practical to measure or model lighting performance for an entire street lighting system. It shall be sufficient for this methodology's lighting performance requirements to show the compliance at representative locations within the project boundaries. Representative locations are the sample locations selected during project design for each roadway and intersection lighting class (defined in Annex III) found within the project boundaries, including multiple locations within a lighting class, where any significant variation in streetlight pole spacing and mounting height and street dimensions occur. Representative locations are used only for comparing baseline and to measure lighting performance and are not intended to constitute the sampling plan for *ex-post* monitoring of project equipment power and operating hours. Lighting performance and compliance shall be established at the commencement of project activities by competent lighting design professionals.

Quantifying illuminance can either be done through computer modelling of illuminance or actual field measurements. Measurement and calculation of average illuminance from baseline and project luminaries at representative locations shall be determined in accordance with standard practices, such as CIE 140:2000, summarized in Annex II. CIE 140:2000 provides the basis for determining fields of calculation, the location of measurement or simulation points for lighting calculations and calculation methods for average illuminance values, as well as uniformity and glare values across the field of calculation.

Illuminance comparisons must be made for fields of calculation within each representative location addressed by project activities, based on roadway and intersection lighting class as well as variations in mounting height, distance between luminaries, and roadway dimensions, as described in paragraph 3.

Illuminance equivalence shall be determined following the guidance provided here for illuminance measurements and modelling, based on CIE 140:2000, which provides detailed guidance on the layout of

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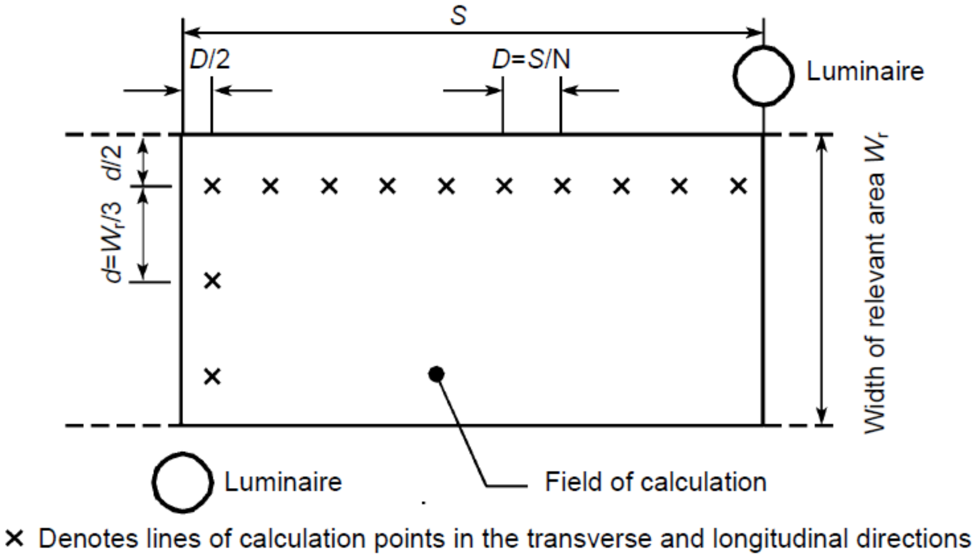
[47]Luminance, a measure of the intensity of reflected light per unit area of an illuminated surface, in candela (cd)/m^2, is another common metric for evaluating street lighting performance. Luminance can be measured in the field or calculated as well and is another acceptable metric for compliance with applicable street lighting standards or comparison of baseline and measure technology performance. See Annex III.

fields of calculation for measuring or simulating illuminance points in a given area. Please refer to CIE 140:2000 for details.

(1) The field of calculation should be typical of the area of the road or intersection which is of interest to the driver and pedestrian, and may include the footways, cycle ways and verges. As shown in the figure below, adapted from CIE 140:2000. it should be bounded by the edges of the roadway and by transverse lines through two consecutive luminaries;



CIE 140:2000 Illustration of illuminance field of calculation

(2) For staggered installations, consecutive luminaries will be on opposite sides of the road;

(3) The calculation points should be evenly spaced in the field of calculation (see figure above) and their number should be chosen as follows:

- In the longitudinal direction, the spacing in the longitudinal direction should be determined from the equation:

$$D = S / N$$

Where:

D Space between points in the longitudinal direction (m)

S Space between luminaries (m)

N Number of calculation points in the longitudinal direction with the following values:

- S ≤ 30 m, N = 10;
- S > 30 m, N = the smallest integer giving D ≤ 3 m

The first row of calculation points is spaced at a distance D/2 beyond the first luminary (m).

- In the transverse direction:

$$d = W_r / 3$$

Where:

d Space between points in the transverse direction (m)

W_r The width of the roadway or intersection (m)

The spacing of points from the edges of the relevant area is *D*/2 in the longitudinal direction, and *d*/2 in the transverse direction, as indicated in the figure above.

(4) Number of luminaries included in calculation:

Luminaries which are situated within five times the mounting height from the calculation point should be included in the calculation.

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