**CLEAN DEVELOPMENT MECHANISM**
**PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD)**
**Version 03 - in effect as of: 22 December 2006**

**CONTENTS**



**Annexes**

**Revision history of this document**

| Version Number | Date | Description and reason of revision |
|---|---|---|
| 01 | 21 January 2003 | Initial adoption |
| 02 | 8 July 2005 | • The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document.<br>• As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>. |
| 03 | 22 December 2006 | • The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM. |

## SECTION A. General description of small-scale project activity

### A.1 Title of the small-scale project activity:

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Biopower project at Charoensuk Starch Co. Ltd, Thailand

Version history:

| Version Number | Date | Comment |
|---|---|---|
| Version 1 | 30/05/2010 | Version submitted for GSP |
| Version 2 | 30/09/2010 | Version submitted to DOE following Draft Validation Report |
| Version 3 | 25/07/2011 | Version submitted to DOE following comments during requesting for registration |

### A.2. Description of the small-scale project activity:

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The proposed project activity shall be implemented by NP Biopower Co.,Ltd. (hereafter referred to as NP), a company which was established in 2007 to generate energy by treating wastewater from Charoensuk Starch (2005) Company Limited (hereafter referred to as CS), which was established in 2005 and commenced operations in 2006. The company currently produces on average 123 tonnes of native starch per day[1].

The current practice is the treatment of the wastewater from the starch plant through 8 cascading anaerobic open lagoons[2] without methane capture. The depth of these ponds is 5.0 m. The average ambient temperature in the region is 27.12°C[3]. These conditions result in an anaerobic environment in the ponds, which lead to methane generation from the degradation of organic content (characterized by chemical oxygen demand or COD) in the wastewater. This methane is released into the atmosphere. The treated wastewater is utilized as fertilizer in plantations in nearby area and/or evaporated into the atmosphere. This practice is in compliance with relevant environmental regulation of Thailand.

The proposed project activity involves the installation of a new stage of wastewater treatment, using Modified Anaerobic Baffled Reactor (MABR) technology to treat the wastewater generated from the starch plant. The installation will be sequential to the existing open lagoon system in order to capture and use methane. The new treatment will help to reduce emissions of methane to the atmosphere. Methane is a greenhouse gas that is generated and emitted from the operation of the open anaerobic lagoon system which is the prevailing practice of wastewater treatment in the starch factory.

The captured biogas will be used as fuel in a radiant tube burner system to replace heavy fuel oil (HFO) consumption for starch drying purposes. Hence, the project activities utilize 100% of the biogas produced. In case of surplus biogas, project owner will install an electricity gas engine system. An open flare will be also installed for use in any emergency situation.

[1] Data from Charoensuk's production record year 2007-2009

[2] The total number of open lagoon is 11 ponds, of which 8 ponds are considered in the baseline and other 3 remaining ponds are used as back up ponds.

[3] Data from www.tmd.go.th year 2008,

The biogas generation and utilization is illustrated in illustrated below:

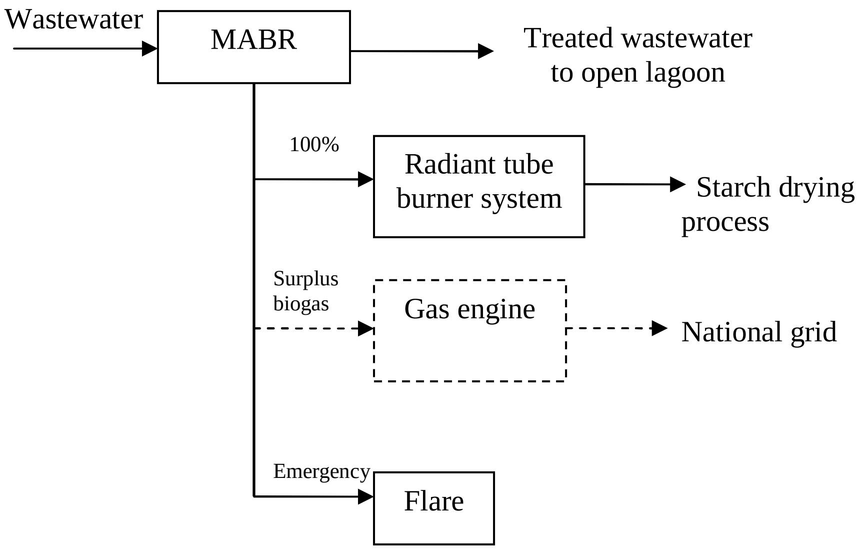


**Figure 1. Biogas generation and utilization diagram**

The implementation of the proposed project activity is well in line with the policies and strategies promoted by the Thai Government.[4] National policies and strategies foresee targets for the introduction of renewable energy technologies in various sectors as an instrument for reducing the country's dependency on imports of fossil fuels. The proposed project will directly support these goals as renewable energy technology will be introduced and fossil fuels will be reduced directly by the substitution of HFO. In addition, the project will contribute to other factors that directly support a sustainable development for Thailand. In the following the expected impacts are described in relation to three dimensions.

**Environmental benefits**

- Mitigation of uncontrolled GHG emissions from the current lagoon system,
- Improvement of water quality in these lagoons,
- Reduction of the unpleasant odor caused by the treatment of organic wastewater in open lagoons,
- Reduction of GHG emissions from the use of fossil fuels.

**Economic benefits**

- Utilization of the biogas as a new indigenous fuel source in Thailand and hence a reduction in the import of fossil fuels from overseas,
- Earnings of foreign exchange from sale of CERs to Annex I country,
- New business field (energy generation and sales) within the agro-industry sector,
- Reduction of the fuel costs within factory.

**Social benefits**

- Participation of several local stakeholders thorough consultation meeting to explain the project, respond to questions and provide project owner's feedback on environment and social impacts,

[4] http://www.ldd.go.th/Thai-html/05022007/PDF/PDF01/E-Plan10.pdf, 22 April 2010

- Creation of employment opportunities for local skilled workers during construction and operation,
- Provision of staff training to improve their technical skills.

**A.3. Project participants:**

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**Table 1; List of project participants**

| Name of party involved(*) ((host) indicates a host Party) | Private and/or public entity(ies) project participants(*) (as applicable) | Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| **Thailand (host)** | NP Biopower Co., Ltd. | No |
| **Germany** | EnBW Energie Baden-Württemberg AG | No |

**A.4. Technical description of the small-scale project activity:**

**A.4.1. Location of the small-scale project activity:**

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

>>

Kingdom of Thailand

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

>>

Kamphaeng Phet Province

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

>>

Tambol Phetchompoo, Amphor Kosumpeenakhon

**A.4.1.4. Details of physical location, including information allowing the unique identification of this small-scale project activity :**

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The project activity is located as shown below in the map:
188 Moo 7 Phraholyothin Road, Tambol Phetchompoo, Amphor Kosumpeenakhon,
Kamphaeng Phet Province, 62000,
Thailand

The wastewater treatment plant is located at latitude16°37’21.43"N Latitude and 99°24’37.97"E longitude. The source of generating wastewater is located at latitude16°38’35.69"N Latitude and 99°24’45.10"E longitude.

The starch factory is located approximately 380 km Northeast from Bangkok.


**Figure 2: Location map of project site**[5]

[5] http://www.moohin.com/thailand-map/thailandmap.jpg (9 November 2009)

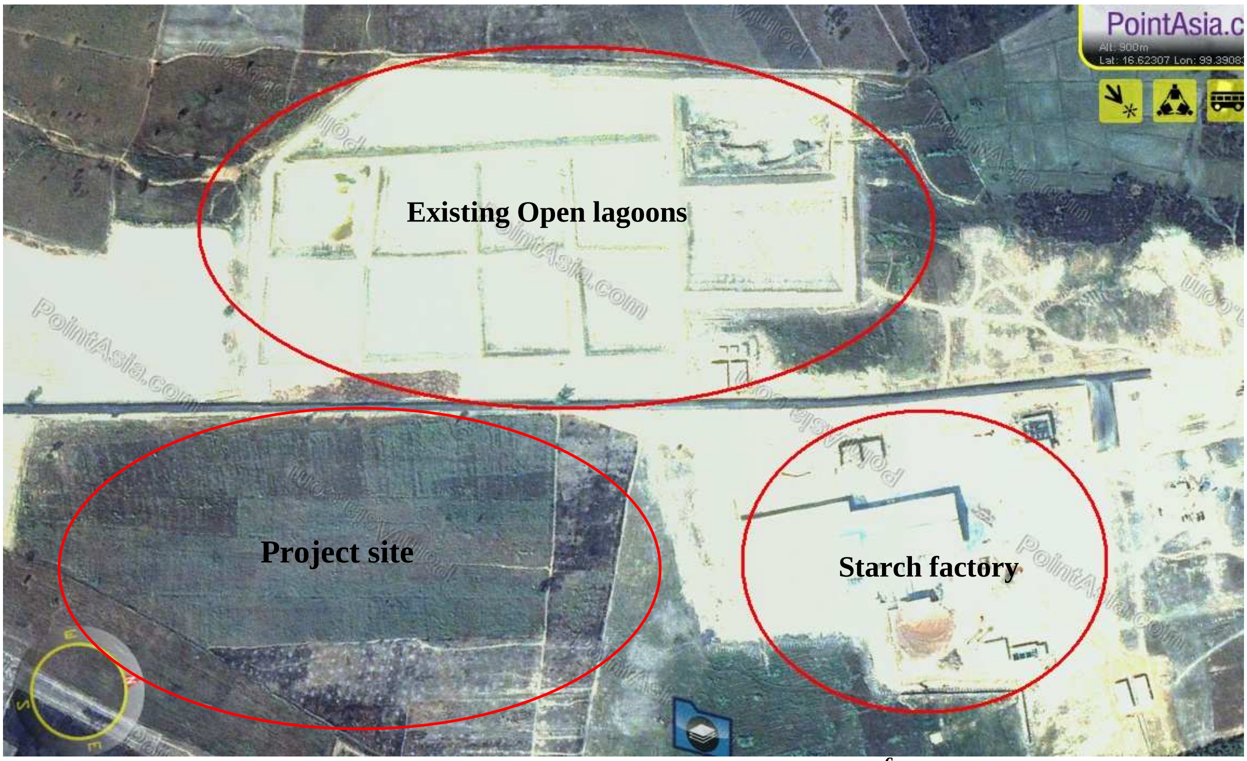


**Figure 3. aerial photograph of project site**[6]

**A.4.2. Type and category(ies) and technology/measure of the small-scale project activity:**

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**1. Type of project categories of the small-scale project activity**

In accordance with Appendix B of the simplified modalities and procedures for small-scale CDM project activities, the proposed project falls under the following types and categories:

AMS III.H
Scope 13 : Waste handling and disposal
Type III : Other project activities
Category H : Methane recovery in wastewater treatment

AMS I.C
Scope 1 : Energy industries (renewable/ non-renewable source)
Type I : Renewable project
Category C : Thermal energy production with or without electricity

AMS I.D
Scope 1 : Energy industries (renewable/ non-renewable source)
Type I : Renewable project
Category D : Grid connected renewable electricity generation

[6] www.pointasia.com (9 November 2009)

**Technology of the small-scale project activity**

The wastewater will be treated in a Modified Anaerobic Baffled Reactor (MABR) reactor supplied by Premier Energy Co., Ltd. The treatment process guarantees a removal of 85% of the COD in the wastewater[7].

In the process of starch production, Charoensuk Starch (2005) Co., Ltd discharges on average 1,808 $m^3$ of wastewater per day for 249 days in a year. The wastewater is treated in an anaerobic open lagoon system. The anaerobic conditions results in release of methane ($CH_4$) into the atmosphere. The treated wastewater is used as irrigation water at the plantation. Since the wastewater is not discharged into any water bodies. The current practice is in line with the existing environmental regulations. To reduce the emissions, the project will install MABR technology for the treatment of the wastewater in a closed environment and the biogas will be captured and used for energy purposes. The MABR is basically a covered anaerobic pond, which contains the organic rich effluent water from the starch factory. The absence of oxygen in the covered pond optimizes the contact with anaerobic bacteria to convert the organic matter into biogas. The wastewater is pumped from the bottom and circled in the system to digest the organic matter then the treated wastewater will be from the system. The hydraulic retention time (HRT) of MABR system is longer than the conventional covered anaerobic pond.

The MABR is covered by High Density Polyethylene (HDPE). HDPE is an essentially impermeable, resilient plastic which has high durability in sunlight and provides a system to evacuate accumulated rainwater. HDPE covers are used to provide a gas seal to prevent methane from escaping to the atmosphere.

MABR biogas digester system is shown in figure 4.

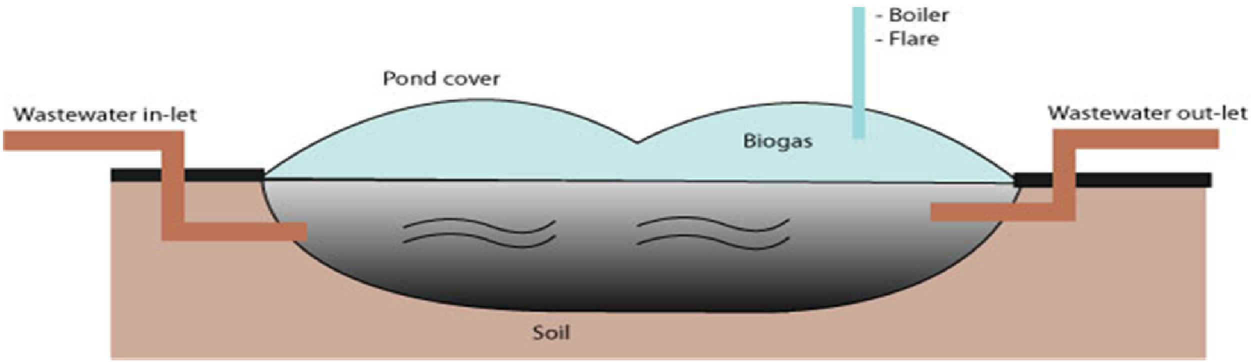



**Figure 4: MABR digester system**

The biogas generated from MABR will contain around 55-60% methane. The biogas is then collected in pipes, cleaned and stripped of hydrogen sulphide and is fed to utilizing in the Charoensuk starch factory for the starch drying process. In the starch drying process, the biogas substitutes HFO at new radiant tube burner from BKE Combustion Controls Co., Ltd.

In case of surplus biogas, the remaining of the biogas will be used as fuel in a power generator with installed capacity around 1 MW.

[7] Proposal from Premier Energy (Biogas Technology Provider)

**A.4.3 Estimated amount of emission reductions over the chosen crediting period:**

>>
Table 2: Ex-ante estimation of emission reductions

| **Years** | **Estimation of annual emission reductions in tonnes of $CO_2$e** |
|---|---|
| 1 | 21,213 |
| 2 | 21,213 |
| 3 | 21,213 |
| 4 | 21,213 |
| 5 | 21,213 |
| 6 | 21,213 |
| 7 | 21,213 |
| 8 | 21,213 |
| 9 | 21,213 |
| 10 | 21,213 |
| **Total estimates reductions (tonnes of $CO_2$e)** | **212,132** |
| **Total number of crediting years** | **10** |
| **Annual average of the estimated reductions over the crediting period (t $CO_2$e)** | **21,213** |

**A.4.4. Public funding of the small-scale project activity:**

>>
The project involves no ODA or public funding from Parties that are Annex I signatories of the Kyoto Protocol.

**A.4.5. Confirmation that the small-scale project activity is not a debundled component of a large scale project activity:**

Annex 13 of EB 54 report, Guidelines on assessment of debundling for SSC project activities, (Version 03), specify de-bundling in a small scale CDM project as follows:

A proposed small-scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

- With the same project participants;

- In the same project category and technology/measure; and
- Registered within the previous 2 years; and
- Whose project boundary is within 1 km of the project boundary of the proposed smallscale
- Activity at the closest point.

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

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

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

>>
The proposed project activity is in compliance with the criteria of the following methodologies for small scale project activities and methodological tools:

(i) AMS III.H for Methane Recovery in Wastewater Treatment, Version 14, Scope 13 with reference to EB 53, 2010.
(ii) AMS I.C small scale methodology for Thermal energy for the user with or without electricity, Version 17, Scope 1 with reference to EB 54, 2010.
(iii) AMS I.D for Grid connected renewable electricity generation, Version 16, Scope 1 with reference to EB 54, 2010.
(iv) Tool to determine project emissions from flaring gases containing methane, EB 28 annex 13.
(v) Tool to calculate the emission factor for an electricity system, Version 2, EB 50 annex 14.
(vi) Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion, Version 2, EB 41 annex 11.
(vii) Tool to calculate baseline, project and/or leakage emissions from electricity consumption Version 1, EB 39 annex 7.

### B.2 Justification of the choice of the project category:

>>
The following tables present applicable applicability criteria for each methodology and the relation of the project case to each applicability criteria is described.

The applicability criteria for the methodology AMS III.H, are shown in table 3:

Table 3: The applicability criteria for the methodology AMS III.H

| | Applicability condition | Project case |
|---|---|---|
| 1 | This methodology comprises measures that recover biogas from biogenic organic matter in wastewaters by means of one of the following options:<br>**(vi)** Introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or without sludge | The project activity involves the installation of a sequential stage of wastewater treatment with methane recovery (MABR) and combustion of the generated biogas. The existing open lagoon system has no methane recovery. |

| | Applicability condition | Project case |
|---|---|---|
| | treatment, to an existing anaerobic wastewater treatment system without biogas recovery (e.g. introduction of treatment in an anaerobic reactor with biogas recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery). | |
| 2 | The recovered methane from the above measures may also be utilized for the following applications instead of combustion/flaring:<br>(a) Thermal or electrical energy generation directly; or<br>(b) Thermal or electrical energy generation after bottling of upgraded biogas;<br>(c) Thermal or electrical energy generation after upgraded and distribution:<br>(i) Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints;<br>(ii) Upgrading and transportation of biogas via a dedicated pipes network to a group of end users;<br>(d) Hydrogen production | The project activity utilizes recovered methane for (a) thermal generation. |
| 3 | If the recovered methane is used for project activity covered under paragraph 2 (a) heat and or electrical energy generation, that component of the project activity can use a corresponding category under type I. | The recovered methane is used for heat and electricity energy generation. The approved baseline and monitoring methodologies AMS I.C and AMS I.D are used for heat generation component and electricity energy generation of the project activity respectively. |
| 4 | Measures are limited to those that result in emission reductions of less than or equal to 60 kt $CO_2$ equivalent annually. | Ex-ante emission reductions due to the wastewater treatment were estimated at 18 kt $CO_2$e annually. The result is lower than the 60 kt $CO_2$e threshold. |
| 5 | Under this methodology anaerobic lagoons are considered ponds deeper than 2 meters, without aeration, Ambient temperature above 15°C, at least during part of the year, on a monthly average basis, and with a volumetric loading rate of Chemical Oxygen Demand above 0.1 kg COD.m-3.day-1. The minimum interval between two consecutives sludge removal events shall be 30 days. | The depth of all lagoons is 5.0 meters. Ambient temperature is 27.12 $^{o}$C. The sludge removal period is more than 3 years. The COD volumetric loading is 0.14 kg COD.$m^{-3}$.$day^{-1}$. |

The applicability criteria for the methodology, AMS I.C, are shown in table 4:

Table 4: The applicability criteria for the methodology AMS I.C

| | Applicability condition | Project case |
|---|---|---|
| 1 | This category comprises renewable energy technologies that supply users with thermal energy that displaces fossil fuel use. These units include technologies such as solar thermal water heaters and dryers, solar cookers, energy derived from renewable biomass and other technologies that provide thermal energy that displaces fossil fuel. | The project utilizes biogas collected from the wastewater treatment system for heat generation and substitutes HFO currently being used to generate thermal energy to meet the plant's heat demand. |
| 2 | The total installed/rated thermal energy generation capacity of the project equipment is equal to or less than 45 $MW_{thermal}$ | Thermal generation capacity is 3.0 $MW_{thermal}$ [8] and is thus under the 45 $MW_{thermal}$ threshold. |
| 3 | For co-fired systems, the total installed thermal energy generation capacity of the project equipment, when using both fossil and renewable fuel shall not exceed 45 $MW_{thermal}$ | The biogas heater is installed as part of the project activity. Furthermore the thermal generation capacity is 3.0 $MW_{thermal}$ threshold. |

The applicability criteria for the methodology AMS I.D are shown in table 5:

Table 5: The applicability criteria for the methodology AMS I.D

| | Applicability condition | Project case |
|---|---|---|
| 1 | This category comprises renewable energy generation units, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable that supply electricity to a national or a regional grid. | The project uses biogas recovered from the wastewater treatment system to generate electricity for export to the national grid. |
| 2 | This methodology is applicable to project activities that (a) install a new power plant at a site where there was no renewable energy power plant operating prior to the implementation of the project activity (Greenfield plant); (b) involve a capacity addition; (c) involve a retrofit of (an) existing plant(s); or (d) involve a replacement of (an) existing plant(s). | The project involves the installation of new gas engine at site where there was no renewable energy power plant operating prior to the implementation of the project activity. |
| 3 | If the new unit has both renewable and non-renewable components (e.g., a wind/diesel unit), the eligibility limit of 15 MW for a small-scale CDM project activity applies only to the renewable component. If the unit added co-fires fossil fuel[1], the capacity of the entire unit shall not exceed the limit of 15 MW. | If there are surplus biogas, gas engine with capacity of approx. 1 MW will be installed by the project activity. The project is within the 15 MW threshold. Even if all biogas would be used as fuel for the gas engine the project would be within the 15 MW threshold. |

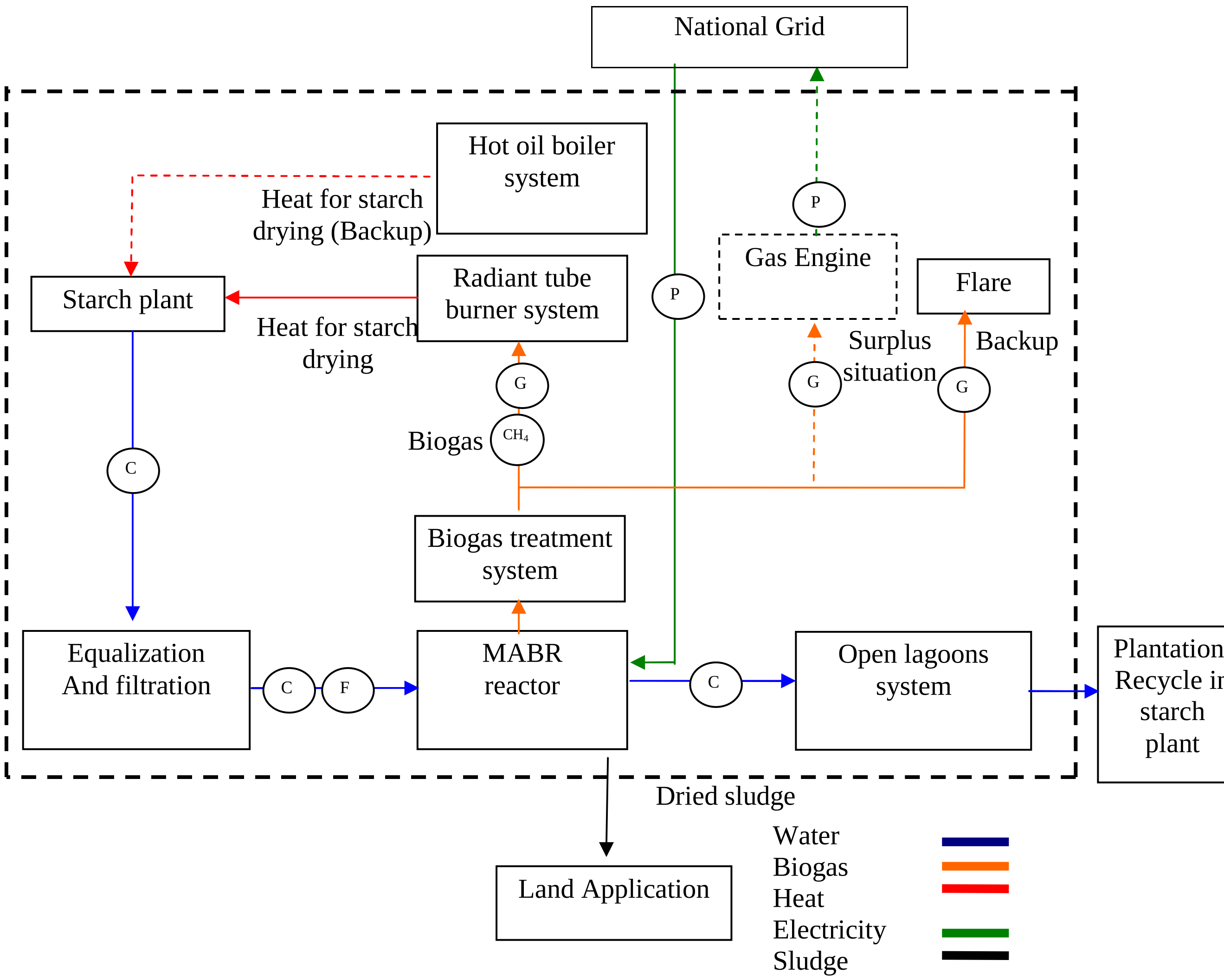
**B.3. Description of the project boundary:**

>>

The physical and geographical location of the project activity encompasses the project boundary as specified in Appendix B of the Simplified Modalities and Procedures. In the present case, the project

[8] Technical specification from supplier

boundary includes the MABR digester, biogas treatment system newly radiant tube burner system, gas engine, open lagoons, and the newly established flare next to the biogas plant. The open lagoons in the project refer to the existing lagoons. The treated wastewater in the MABR reactor will be channeled to the existing open lagoons. The project boundary is shown in the figure 5 below:




**Remark;**

F = Flow meter (waste water)

G = Gas meter (biogas)

P = Power meter (electricity)

C = COD measurement (wastewater)

$CH_4$ = Methane content sampling

**Figure 5. Project boundary line diagram**

The table 6 indicates the GHG emissions that are considered in the proposed CDM project activity.

Table 6: GHG emissions in the proposed CDM project activity;

| Source | Source | Gas | Included/Excluded | Justification/Explanation |
|---|---|---|---|---|
| Baseline | Wastewater treatment Processes | $CO_2$ | Excluded | $CO_2$ emissions from the decomposition of organic waste are not accounted for. This is conservation. |
| | | $CH_4$ | Included | Main source of emissions in the baseline from open lagoons. |
| | | $N_2O$ | Excluded | Excluded for simplification. This is conservative. |
| | Thermal Heat Generation | $CO_2$ | Included | Main emission source. Biogas captured is used to generate thermal to replace fuel oil in starch drying purposes. |
| | | $CH_4$ | Excluded | Excluded for simplification. This is conservative. |
| | | $N_2O$ | Excluded | Excluded for simplification. This is conservative. |
| | Electricity Generation | $CO_2$ | Included | Main emission source. Biogas is used to generate electricity in order to export electricity to the national grid. |
| | | $CH_4$ | Excluded | Excluded for simplification. This is conservative. |
| | | $N_2O$ | Excluded | Excluded for simplification. This is conservative. |
| Project Activity | Wastewater treatment Processes | $CO_2$ | Included | $CO_2$ emissions from the grid electricity consumption for biogas generation and distribution are accounted. |
| | | $CH_4$ | Included | Emissions through degradable organic carbon in treated wastewater are accounted for.<br>• Fugitive emissions from biogas release in capture system,<br>• Emissions form incomplete flaring are accounted for.<br>• The generated sludge from MABR will be dried and will be subsequently applied in land application. This emission source is assumed to be zero. |
| | | $N_2O$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |

| Source | Source | Gas | Included/Excluded | Justification/Explanation |
|---|---|---|---|---|
| | Thermal generation process | $CO_2$ | Included | Emissions through fossil fuel consumption in project activity are accounted for.<br>• The fuel oil consumption for hot oil boiler which used as backup system.<br>• The LPG consumption for start up of radiant tube burner system. |
| | | $CH_4$ | 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. |
| | On-site Electricity use | $CO_2$ | Excluded | The auxiliary load for gas engine will be supplied from biogas generation. |
| | | $CH_4$ | 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.4. Description of baseline and its development:**

>>

The following paragraphs describe the

1) baseline scenario of the project based on the applied methodology and
2) values applied to estimate the baseline emissions.

**1a) Wastewater treatment system (methane avoidance)**

The most likely baseline scenario is a continuation of the open anaerobic lagoon-based treatment of wastewater without methane recovery. Lagoon based wastewater treatment systems involve low investment and low O&M costs. This type of system is used extensively in Thailand[9]. Lagoons are the technology of choice in tropical situations and any other area where legislation does not require more engineered solutions. This prevailing practice is in full compliance with the requirements of the relevant authorities of Thailand[10].

Hence, there are no obvious reasons for the proponent to alternate this prevailing practice, as it complies with the legal framework in Thailand, it was and still is the most low-cost technology solution. The current lagoon system is in good condition for the next 15 years.

The project activity involves the installation of a sequential stage of wastewater treatment through MABR with methane recovery and combustion of produced biogas (see section B.2 for detailed justification). From the MABR the wastewater continues to flow to the existing open lagoon treatment system without

[9] Thai Biogas Plants- High Rate Anaerobic Fixed Film Technology for Agro Industry Wastewater; Chaiprasert P, et. al., KMUTT, 2003

[10] http://www.pcd.go.th/info_serv/en_reg_std_water04.html#s1

sludge treatment. The baseline of the proposed project activity correspond to AMS III.H, version 14, para 1, scenario (vi).

**1b) Thermal heat generation (fuel switch from HFO to biogas)**
The baseline scenario is the continued consumption of HFO for drying purposes within the starch processing. There are no other less emission intensive fuels available at the same costs and the same operation risk to the project proponent. The project activity is in line with AMS I.C, version 17, para 1, as stated under section B.2.

**1c) Power generation (export to the national grid)**
The baseline scenario is the generated electricity fed into the Thailand national grid. The electricity in Thailand continued heavily depends on conventional thermal power generation, such as based on petroleum, coal and mostly from natural gas for its energy source. The generated electricity from the project activity will be exported in order to displace some portion of the electricity generation in the grid system. The project activity is in line with AMS I.D, version 16, para 1, as stated under section B.2.

**2) Values applied for the estimation of baseline emission**
CS is a family managed business and was established in 2005 and commenced operations in 2006. The company has a production capacity of 200 tonnes of native starch per day[11]. From year 2007 to 2009 the plant has been possessing on average 123 tonne per day[12]. On average the wastewater amount per tonne starch produced is 14.76 $m^3$. The wastewater has a high organic content which is on average 17,639 mg COD/ litre[13]. The wastewater is treated through 8 cascading open lagoon-based ponding system. The depth of these ponds is 5.0 m. Methane generation from the digestion of organic content takes place due to the depth of the lagoons, the climate conditions, the COD content of the wastewater and the anaerobic conditions in the ponds.

Although the objective of the plant owner is to run the plant with available capacity, during the annual rainy season the starch production is reduced and even stopped for few months per year. Unfortunately the plant owner was not able to provide full and detailed production and consumption data as CS has not installed a comprehensive monitoring management, yet. Therefore a 14 days analysis was executed in order to measure the baseline values. The following values were analyzed:

a) wastewater flow
b) COD inflow (wastewater which flows into the first lagoon)
c) COD outflow (wastewater of the lagoon no.8)

Table 7: The data used to determine the baseline emissions

| Parameters | Variables | Value | Unit | Source |
|---|---|---|---|---|
| Volume of wastewater | $Q_{ww,y}$ | 449,639 | $m^3$/yr | Test report by 3rd party and the plant production record from year 2007- |

[11] Plant operation license

[12] Data from Charoensuk’s production record

[13] Measurement campaign on 12 -25 February 2010

| Parameters | Variables | Value | Unit | Source |
|---|---|---|---|---|
| | | | | 2009 |
| The inflow COD of the baseline system | $COD_{inflow}$ | 17,639 | tonnes/$m^3$ | Test report by 3rd party |
| The outflow COD of the baseline system | $COD_{outflow,BL}$ | 144 | tonnes/$m^3$ | Test report by 3rd party |
| Methane correction factor for the wastewater treatment system | $MCF_{ww,treatment,BL,i}$ | 0.8 | - | Table 6.8 default MCF values for industrial wastewater, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 5, p. 6.21, table 6.8. |
| Global Warming Potential of Methane | $GWP_{CH4}$ | 21 | $tCO_2/tCH_4$ | AMS III.H version 14, para 20 |
| Methane producing capacity of the wastewater | $B_{o,ww}$ | 0.25 | $kgCH_4$/kg COD | 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 5, p. 6.21. |
| The net quantity of steam/heat supplied by the project activity | $EG_{thermal,y}$ | 33.82 | TJ/yr | Calculation shown in annex 3 |
| $CO_2$ emission factor of the fossil fuel | $EF_{FF, CO2}$ | 75.50 | $tCO_2$/TJ | table 1.4 default CO2 emission factors for combustion , 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2, p. 6.23. |
| Quantity of net electricity supplied to the grid | $EG_{BL,y}$ | 1,639.75 | MWh/yr | Calculation is provided in annex 3. |
| $CO_2$ Emission Factor of the grid | $EF_{CO2,grid,y}$ | 0.5453 | $tCO_2$/MWh | Calculation is provided in annex 3. |

| Parameters | Variables | Value | Unit | Source |
|---|---|---|---|---|
| Thermal energy from HFO replacing by renewable energy | $NCV_{fuel}$ | 39.77 | MJ/Litre | Data from Thailand energy situation in year 2008[14] |

**B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:**

The proposed project intervention will result in GHG emission reductions. In section B.4. it has been demonstrated that in the absence of the proposed project, the current practice of wastewater treatment at the plant site, would be the most likely baseline scenario. This means, that methane will continue to be generated in and emitted from the open anaerobic lagoon system to the atmosphere.
The implementation of the proposed project faces certain challenges or barriers, both during implementation and operation. In line with the applicable CDM regulation - Appendix B of the simplified modalities and procedures for small-scale CDM project activities - Attachment A to Appendix B[15] – those barriers need to be explained and documented.

In line with the requirements of the EB the proponent is providing explanations to show that the project activity would not have occurred due to at least one of the following barriers:

(a) Investment barrier: a financially more viable alternative to the project activity would have led to higher emissions;
(b) Technological barrier: a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions;
(c) Barrier due to prevailing practice: prevailing practice or existing regulatory or policy requirements would have led to 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.

The project proponent has opted to argue for the additionality of the project due to the investment barrier.

The investment barrier is elaborated on in the following section.

***Investment barrier***
The treatment of wastewater in anaerobic open lagoons is a prevalent and standard industry practice, being by far the least cost option for wastewater treatment that at the same time meets the legal discharge limit. While other options, such as the installation of an anaerobic digester (the Project carried out without CDM), require significant investments. To illustrate that the Project is financially unattractive on a

[14]Thailand energy situation 2008, http://www.dede.go.th/dede/fileadmin/upload/nov50/feb52/re1_pre_ener_2551.pdf
[15] Available under: http://cdm.unfccc.int/Reference/Guidclarif/ssc/methSSC_guid05.pdf, additional information is available in the guideline “INDICATIVE SIMPLIFIED BASELINE AND MONITORING METHODOLOGIES FOR SELECTED SMALL-SCALE CDM PROJECT ACTIVITY CATEGORIES”, version 12 (EB41/ Annex 20)

business-as-usual basis, the project IRR is selected as the financial indicator to be applied for the benchmark analysis for the project activity.

For the purpose of CDM additionality assessment, project developers have considered a conservative benchmark in terms of CDM. In essence, the project developer used the WACC as the benchmark for project IRR[16]. The following formula is used to calculate the WACC.

$$WACC = \frac{E}{E+D} \times Re + \frac{D}{E+D} \times Rd \times (1-T)$$

Where:
E / (E+D): Equity fraction in the Project
D / (E+D): Debt fraction in the Project
Re: Rate of expected return by shareholders[17]
Rd: Rate of expected return by loan providers[18]
T: Corporate tax rate

Table 8: WACC Calculation

| Parameter | Value | Comment |
|---|---|---|
| E / (E+D): Equity fraction in the Project[19] | 48% | Average D/E ratio of relevant industry |
| D / (E+D): Debt fraction in the Project[20] | 52% | Average D/E ration of relevant industry |
| Re: Rate of expected return by shareholders[21] | 17.20% | Average ROE of relevant industry |
| Rd: Rate of expected return by loan providers[22] | 6.95% | Average of Thai commercial bank MLR |

[16] According to para 12, guidelines on the assessment of investment analysis, Version 3, EB 51 annex 58.

[17] Return on Equity (ROE), of the companies listed in energy sector of Stock Exchange of Thailand during year 2007-2009, is used to represent the cost of equity. This data is obtained from the SET's market statistics. It is calculated as net profits divided by the equities. http://www.set.or.th/en/market/market_statistics.html

[18] Minimum Lending Rate (MLR), of all commercial banks registered in Thailand during years 2007 - 2009, is used to represent the cost of debt. This data is obtained from the Bank of Thailand.
http://www.bot.or.th/english/statistics/financialmarkets/interestrate/_layouts/application/interest_rate/IN_Rate.aspx

[19] Equity fraction, of the companies listed in energy sector of Stock Exchange of Thailand during year 2007-2009, is used to represent the cost of equity. This data is obtained from the SET's market statistics. It is calculated as net profits divided by the equities. http://www.set.or.th/en/market/market_statistics.html

[20] Debt fraction, of the companies listed in energy sector of Stock Exchange of Thailand during year 2007-2009, is used to represent the cost of equity. This data is obtained from the SET's market statistics. It is calculated as net profits divided by the equities. http://www.set.or.th/en/market/market_statistics.html

[21] Return on Equity (ROE), of the companies listed in energy sector of Stock Exchange of Thailand during year 2007-2009, is used to represent the cost of equity. This data is obtained from the SET's market statistics. It is calculated as net profits divided by the equities. http://www.set.or.th/en/market/market_statistics.html

| Parameter | Value | Comment |
|---|---|---|
| T: Corporate tax rate | 30% | At the time the decision was made |
| WACC: Weighted average cost of capital | 10.82% | |

The project IRR calculation was carried out based on the input values below:

Table 9: Data for Project IRR Calculation

| **Item** | Value (in million THB unless specified) |
|---|---|
| **Initial investment costs (Million baht)** [23] | 85.00 |
| **Average annual O&M Costs (Million baht)** [24] | 12.57 |
| **Heat selling price (baht/MJ)** [25] | 0.29 |
| **Electricity selling price (baht/kWh)** [26] | 2.90 |
| **Project expected lifespan (years)** | 15 |
| **Project IRR** | 3.54 %[27] [28] |

- Initial investment costs include cost of all new equipments, modification to the existing equipments, installation work, civil work construction for MABR, thermal generation system and gas engine.
- O&M costs include power consumption, chemical, labour cost and maintenance & overhaul cost for MABR, boiler and gas engine.

Using above assumptions, the project IRR is calculated as 3.54 % and does not reach the benchmark of 10.82%. Thus the Project is not financially attractive and would not be implemented on a business as usual basis. The revenues from the sale of the CERs generated by the Project are expected to help alleviate the investment barrier and increase the IRR above the benchmark value. This expectation has led the project participant to progress further with the planning of the Project by seeking CDM assistance.

***Sensitivity Analysis***

To further demonstrate the investment barriers to the proposed project, a sensitivity analysis is also carried out for the relevant variables, such as the investment cost, electricity price, biogas generation etc.

[22] Minimum Lending Rate (MLR), of all commercial banks registered in Thailand during years 2007 - 2009, is used to represent the cost of debt. This data is obtained from the Bank of Thailand. http://www.bot.or.th/english/statistics/financialmarkets/interestrate/_layouts/application/interest_rate/IN_Rate.aspx

[23] Based on the proposal from biogas technology provider

[24] Based on the proposal from biogas technology provider

[25] Heat selling price is calculated from heating value of fuel oil at 39.77 MJ/litre, fuel oil price at 15.41 baht/litre and discount rate at 26%. This price also put in the energy selling agreement between NP Biopower and Charoensuk Starch date 1 August 2010 and 20 July 2011. If converting this price by heating value of biogas at 20.93 MJ/m$^3$ then this price is equivalent to 6.0 baht/m$^3$ of biogas

[26] Used data from EPPO for VSPP price during year 2009 at 2.60 baht/kWh (http://www.eppo.go.th/power/data/index.html) and adder of 0.3 Baht/kWh on top of the electricity tariff is considered for the first 7 years according to the renewable electricity campaign

[27] In case NP doesn't implement the power generation system, the total investment will be reduced to 60 Million baht and the project IRR is -2.92%.

[28] In case NP sell the biogas to CS at 6.0 baht/m$^3$ and ignore all costs/expenses related to the new thermal generation system. The project IRR in the base case is 7.23%

A summary of the analysis is provided in the following table. The analysis includes a 15 % increase and decrease of the relevant variables:

Table:10 Sensitivity calculation

| Variables | Project IRR @ 15 years | | Breakeven point[29] |
|---|---|---|---|
| | Increasing variable by 15% | Decreasing variable by 15% | |
| Investment cost | | 5.73% | Decrease 38% |
| Heat selling price | 6.34% | | Increase 43% |
| Electricity price | 5.55% | | Increase 62% |
| Biogas Generation | 7.66% | | Increase 28% |
| O & M cost for biogas | | 6.58% | Decrease 42% |

Remark

1) Initial investment costs:
   It is much more likely for the initial investment costs to increase than decrease, especially because of the recent rise in construction materials. Therefore, decreasing at the rate of 38% is quite impossible[30]. Sensitivity analysis using 15% decrease can be considered as a conservative assumption

2) Heat selling price:
   According to the historical fuel oil price in Thailand during the years 2006-2009, it shows that oil price increased slowly from year 2006 – 2007 and start to increase faster from Q 4 2007 to the highest level in mid of 2008 and then sharply decrease in Q3 of 2008 to the lowest level in Q4 of 2008 which is the same price level as in year 2004. Then oil price has increased slowly in year 2009 and decrease again in Q2 of 2010. From this fluctuation, it also shows that oil price is not likely to remain at the high price throughout the crediting period. No business owner could have predicted this and they would make decision based on an unpredictable figure. Therefore the only way, what business owners could do, is using the past historical figure to predict a future scenario. From this point, NP had used CS's actual 3 years historical oil price during the years 2007-2009 at 15.41 baht/litre for its feasibility study. The average highest price is 17.11 baht/litre in year 2008 which is 111% of the average price during 3 years. Therefore the sensitivity analysis using 15% increase can be considered as a conservative assumption.

3) Electricity price:
   According to the wholesale price of electricity published on Thai Energy Policy & Planning Office (EPPO)'s website. The maximum electricity unit cost was about 0.8% above our estimated price. Sensitivity analysis using 15% increase in electricity price can be considered as a conservative assumption.

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

[30] During validation, NP already signed agreement with technology supplier in the total amount more than the above breakeven point.

4) Biogas generation
   It is much more likely for the biogas generation to decrease than increase, especially because no previous experience of MABR operation at the plant and steady generation of biogas is subject to maintenance of the proper operating condition. Increasing of 28% for the biogas generation can't be applied as the biogas generation is set at the maximum potential and there is no room for increase in biogas generation beyond 15%[31] above the current assumption. Sensitivity analysis using 15% increase in biogas generation can be considered as a conservative assumption.

5) O&M costs:
   The major components of O&M costs are technical labour and parts/equipment replacement. As for the initial investment cost, it is much more likely for the O&M costs to increase than decrease over time. Therefore, decreasing at the rate of 42% is quite impossible. Sensitivity analysis using 15% decrease can be considered as a conservative assumption.

Therefore the sensitivity analysis confirms that the project activity is not a business as usual scenario.

It should also be noted that the level of project IRR discussed above for the project activity can only be achieved when the biogas generation is kept at the optimal level throughout the crediting period. The optimum operation of bioreactor, hence the optimal biogas recovery is subject to many factors such as wastewater quality (organic loading to the bioreactor, pH, alkalinity, solid content, and temperature), operational condition of the bioreactor (retention time, granule activity, etc) and so on. The biogas generation rate will be reduced easily when unfavourable condition for anaerobic microbial growth in the bioreactor occurs. Such an adverse condition for biogas generation could happen anytime, especially at the starting of the system. In addition, corrosive nature of biogas may cause additional cost requirement for unexpected equipment replacement which is not accounted in the financial analysis. To overcome such uncertainty, CDM assistance is necessary to realize this Project.

With the CDM revenue accounted, the project IRR could be significantly improved to 15.01%, surpassing the benchmark of 10.82%. Having this CDM revenue in mind, NP decided to pursue the development of the project activity using CDM scheme. Because CER revenue is only realized when biogas is recovered successfully, project developer will put forth every effort to maintain the system at its optimal operating condition.

**Prior considerations of CDM**

In accordance with "Guidance on the demonstration and assessment of prior consideration of the CDM", the table below demonstrates the serious prior consideration of the CDM by the project participants. As indicated below continuing real actions have also been taken by the project participants to secure CDM status for the project activity.

Table11: Demonstration of prior consideration of the CDM:

| Event | Timing | Evidence |
|---|---|---|
| CS and NP signed agreement with ALLIED CARBON (ACC) | 26 Aug 2008 | Agreement |

[31] based on the assumption of 85% MABR efficiency

| Event | Timing | Evidence |
|---|---|---|
| ACC signed agreement with local CDM consultants to develop documents for applying Thai DNA. | 24 Sep 2008 | Agreement |
| NP organized 1st Public Hearing Seminar | 9 Oct 2008 | Registration form |
| ACC submitted LoI to Thai DNA | 16 Oct 2008 | LoI |
| Thai DNA reply to ACC | 20 Oct 2008 | Letter from TGO |
| 1st upload for Global stakeholder'comment | Jan 2009 | www.unfccc.int |
| LoI signed by former project participants including the intention to develop the project as a CDM project | 31 July 2009 | LoI |
| PIN and form for prior consideration of CDM sent to UNFCCC | 17 Aug 2009 | Confirmation by UNFCCC |
| PIN and request for Letter of Endorsement from German DNA (dehst) | 17 Aug 2009 | Letter of Endorsement |
| Contract for services for CDM consultancy and for required measurements, stakeholder consultation and IEE | 21 Aug 2009 | Purchase order from EnBW |
| Withdrawal of the CDM project by ACC | 12 Nov 2009 | Mutual cancellation agreement |
| NP requested construction permit from Phetchompoo administrative organization | 22 Dec 2009 | Letter |
| NP got proposal from Biogas Supplier | 4 Jan 2010 | Proposal |
| NP Board decided to implement the project | 3 Feb 2010 | Board meeting |
| NP signed ERPA with EnBW | 20 Feb 2010 | ERPA |
| NP signed agreement with supplier to design MABR system | 22 Feb 2010 | Agreement |
| EnBW submitted form for prior consideration of CDM to UNFCCC | 24 Feb 2010 | Email |
| NP submitted newly LoI and the cancelation of 16 Oct 2008 to TGO | 9 Mar 2010 | LoI |
| NP organized 2nd Public Hearing Seminar | 26 Mar 2010 | Public Consultation Report |
| NP signed agreement with radiant tube burner supplier to install the system | 7 Apr 2010 | Agreement |

The CDM history of the Project started in 2008. The Project was formerly developed by the company ACC, NP and CS as project owner. The investor (ACC) started the CDM development by commissioning local CDM consultants, development of the PDD and commissioning of a DOE. The project participants stopped cooperation since the beginning of 2009. The project owner CS and NP respectively was not able to provide all financing by themselves therefore CS was looking for an alternative investor. Mid of 2009 EnBW, CS and other Thai company met each other and discussed cooperation possibilities in order to develop the CDM project. After several months of negotiations the CS decided to provide financing by himself and asked EnBW to develop the CDM development.

**Conclusion**

It can be concluded that the Project faces barriers that makes the Project additional as a CDM project. The Project would not be financially viable without the benefits of CDM: The IRR of the Project without CDM revenues is 4.30% and hence below the sector benchmark of 10.82%. Furthermore, the MABR technology poses significant risks as all staff has to be trained, a monitoring and analysis management plan has to be developed and implemented, and new technical equipment has to be maintained. The

project owners within the starch sector have a lot of doubts and worries about the new business to generate energy. As you can find a lot of biogas plants with bad performances. The benefits from CDM provide the determining incentive that CS overcomes the barriers. After the registration of the first CDM project in Thailand and not till then doubts on CDM were reduced and a lot of starch factories applied for CDM and biogas projects.

**B.6. Emission reductions:**

**B.6.1. Explanation of methodological choices:**

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The present project activity follows 3 approved small scale project methodologies and 4 Tools:

1. The AMS III.H small scale methodology for Methane Recovery in Wastewater Treatment, Version 14, Scope 13 with reference to EB 53, 2010.
2. The AMS I.C small scale methodology for Thermal energy production with or without electricity Version 17, Scope 1 with reference to EB 54, 2010.
3. The AMS I.D small scale methodology for Grid connected renewable electricity generation, Version 16, Scope 1 with reference to EB 54, 2010.
4. Tool to determine project emissions from flaring gases containing methane, EB 28 annex 13.
5. Tool to calculate the emission factor for an electricity system, Version 2, EB 50 annex 14.
6. Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion, Version 2, EB 41 annex 11.
7. Tool to calculate baseline, project and/or leakage emissions from electricity consumption Version 1, EB 39 annex 7.

**<u>Estimating the Baseline emissions:</u>**

***<u>1. Baseline emissions from wastewater treatment (AMS III.H)</u>***

According to the methodology, the baseline emissions may consist of:

$$BE_y = BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y} \quad (1)$$

Where,

| | | |
|---|---|---|
| $BE_y$ | | Baseline emissions in year *y* ($tCO_2e$) |
| $BE_{power,y}$ | = | Baseline emissions from electricity or fuel consumption in year *y* ($tCO_2e$) |
| $BE_{ww,treatment,y}$ | = | Baseline emissions of the wastewater treatment systems affected by the project activity in year *y* ($tCO_2e$) |
| $BE_{s,treatment,y}$ | = | Baseline emissions of the sludge treatment systems affected by the project activity in year *y* ($tCO_2e$) |
| $BE_{ww,discharge,y}$ | = | Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year *y* ($tCO_2e$) |
| $BE_{s,final,y}$ | = | Baseline methane emissions from anaerobic decay of the final sludge produced in year *y* ($tCO_2e$) |

The project activity involves the baseline emissions as described below:

$BE_{ww, treatment, y}$: Baseline emissions of the wastewater treatment system will be accounted for the project as baseline scenario is the continuation of the present lagoon-based treatment of organic wastewater and release of biogas into the atmosphere.

The project activity does not involve in baseline emissions below,

$BE_{power, y}$: Baseline emissions from electricity consumption will not be accounted for project because the baseline and the project wastewater treatment plant does not consume different electricity or fuel.

$BE_{s, treatment,y}$: Baseline emissions of the sludge treatment systems will not be accounted for the project because the project activity does not involve in the sludge treatment system.

$BE_{ww,discharge,y}$: Baseline methane emissions from wastewater discharged into sea/river/lake will not be accounted for the project because the wastewater from existing open lagoon does not release into the sea/river/lake but partly use in starch factory .

$BE_{s,final,}$: Baseline methane emissions from anaerobic decay of the final sludge will not be accounted for the project because the sludge from existing open lagoons will give to the farmers nearby for using as fertilizer.

The baseline emissions from the open lagoon system are estimated based on the chemical oxygen demand (COD) of the effluent and the amount of wastewater from the starch plant that would have entered the lagoon in the absence of the project activity, the maximum methane producing capacity ($B_o$) and a methane conversion factor (MCF) that express what proportion of the effluent would be anaerobically digested in the open lagoons.

$$BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH_4} \quad (2)$$

Where,

| | | |
|---|---|---|
| $Q_{ww,i,y}$ | = | Volume of wastewater treated in baseline wastewater treatment system *i* in year *y* ($m^3$) |
| $COD_{removed,i,y}$ | = | Chemical oxygen demand removed by the baseline treatment system *i* in year *y* (tonnes/$m^3$), measured as the difference between inflow COD and the outflow COD in system *i* |
| $MCF_{ww,treatment,BL,i}$ | = | Methane correction factor for the wastewater treatment system *i* (MCF value as per table III.H.1) |
| *i* | = | Index for baseline wastewater treatment system |
| $B_{o,ww}$ | = | Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.25 kg $CH_4$/kg .COD) |
| $UF_{BL}$ | = | Model correction factor to account for model uncertainties (default value: 0.89) |
| $GWP_{CH4}$ | | Global warming potential for $CH_4$ (default value: 21) |

***2. Baseline emissions for fossil fuel consumption (AMS I.C)***

The captured biogas will be used for heat generation in starch drying purposes reducing the consumption of the heavy fuel oil at the starch plant. The baseline emissions associated with heat generation used in the starch plant is calculated as presented in the following formula, given in AMS I.C.

$$BE_{thermal,CO2y} = EG_{thermal,y} * EF_{FF,CO2} / \eta_{BL,thermal}$$ 3)

Where,

| | | |
|---|---|---|
| $BE_{thermal,CO2,y}$ | = | The baseline emissions from steam/heat displaced by the project activity during the year in $tCO_2e$ |
| $EG_{thermal,y}$ | = | The net quantity of steam/heat supplied by the project activity during the year y (TJ) |
| $EF_{FF, CO2}$ | = | The $CO_2$ emission factor of the fossil fuel that would have been used in the baseline plant; $tCO_2$ / TJ, obtained from reliable local or national data if available, otherwise, IPCC default emission factors are used |
| $\eta_{BL,thermal}$ | = | The efficiency of the plant using fossil fuel that would have been used in the absence of the project activity. |

According to para 21 of AMS.I.C. option (b) is selected to find out the efficiency of the plant using fossil fuel.

***3. Baseline emissions for grid connected renewable electricity generation (AMS I.D)***

The captured biogas will be utilized for generating electricity in order to export it into the national grid, thereby reducing fossil fuel consumption for electricity generation of the Thai electricity grid. The baseline emission associated with grid connected renewable electricity generation is calculated as per the following formula, given in AMS I.D.

$$BE_{power,y} = EG_{BL,y} * EF_{CO2,grid,y}$$ 4)

Where,

| | | |
|---|---|---|
| $EG_{BL,y}$ | = | Quantity of net electricity supplied to the grid as a result of the implementation of the CDM project activity in year *y* (MWh) |
| $EF_{CO2,grid,y}$ | = | $CO_2$ Emission Factor of the grid in year y ($tCO_2$/MWh) |

$CO_2$ Emission Factor of the grid = 0.5453 $tCO_2$/MWh for the year 2008 (refer Annex 3)

The project proponent has chosen to follow option (a) of the methodology, 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". Calculations are based on official sources and are furnished in Annex 3.

**<u>Estimating the Project Emissions:</u>**

***1. Project emissions from wastewater treatment (AMS III.H)***

Emissions arising from the project activity are calculated using the formula below:

$$PE_y = PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + PE_{figitive,y} + PE_{biomass,y} + PE_{flaring,y} + PE_{FF,}$$ (5)

All the components of the project emissions are described below.

| | | |
|---|---|---|
| $PE_y$ | = | Project activity emissions in the year *y* ($tCO_2e$) |
| $PE_{power, y}$ | = | Emissions from electricity or fuel consumption in year *y*, ($tCO_2e$) |
| $PE_{ww,treatment,y}$ | = | Methane emissions from wastewater treatment systems affected by the project activity and not equipped with biogas recovery, in year *y*,($tCO_2e$) |
| $PE_{s,treatment,y}$ | = | Methane emissions from sludge treatment systems affected by the project activity and not equipped with biogas recovery, in year *y*, ($tCO_2e$) |
| $PE_{ww, discharge,y}$ | = | Methane emissions from degradable organic carbon in treated wastewater in year *y*, ($tCO_2e$) |
| $PE_{y,s,final,y}$ | = | Methane emissions from anaerobic decay of the final sludge produced in year *y*, ($tCO_2e$) |
| $PE_{y,fugitive,y}$ | = | Methane emissions from biogas release in capture systems in year *y*, ($tCO_2e$) |
| $PE_{biomass,y}$ | = | Methane emissions from biomass stored under anaerobic conditions, ($tCO_2e$) |
| $PE_{flaring,y}$ | = | Methane emissions due to incomplete flaring in year *y* as per "Tool to determine project emissions from flaring gases containing methane", ($tCO_2e$) |
| $PE_{FF,y}$ | = | Project emissions from combustion of fossil fuels during the year y ($tCO_2e$) |

The project activity involves project emissions as stated below;

$PE_{power, y}$: Emissions from electricity consumption will be accounted for the project as the auxiliary equipments of the MABR system in the project activity will consume electricity from grid.

$PE_{ww,treatment,y}$: Methane emissions from wastewater treatment systems will be accounted for the project as the treated wastewater from MABR will be released into the existing open lagoon.

$PE_{fugitive,y}$: Methane emissions from biogas release in capture systems will be accounted for the project as the project activity involves to capture biogas for heating in factory process

$PE_{flaring,y}$ : Methane emissions due to incomplete flaring will be accounted for in the proposed project as flaring will occur in case of emergency.

The project activity does not involve in the project emissions as below;

$PE_{s,treatment,y}$: Methane emissions from sludge treatment systems will not be accounted for as the project activity does not involve sludge treatment.

$PE_{ww, discharge,y}$: Methane emissions from degradable organic carbon in treated wastewater will not be accounted as the treated wastewater in the project activity will not be released to any water body or open stream.

$PE_{s,final,y}$: Methane emissions from anaerobic decay of the final sludge will not be accounted for as the final sludge from MABR and open lagoon will be provided to the plantation area nearby and used as fertilizer.

$PE_{biomass,y}$ Methane emissions from biomass stored will not be accounted for the project emissions because the project activity does not involve the storage of biomass.

The project emissions calculation has been shown below.

***1 a) Project Emissions from power consumption ($tCO_2e$)***

| | | | | |
|---|---|---|---|---|
| $PE_{power,y}$ | = | Auxiliary consumption by the biogas plant (MWh/yr) | * | $EF_{CO2,grid,y}$ (t $CO_2$/MWh) |

**Where,**

$PE_{power,y}$ = Emissions from electricity or diesel consumption (t $CO_2$e/yr)
$EF_{CO2,grid,y}$ = Grid Carbon Emission Factor (t$CO_2$/MWh)

***1b) Project emissions from methane emissions from wastewater treatment system (t$CO_2$e)***

The formula calculates the emissions which occur from the MABR-treated wastewater which is channelled to the existing open lagoons.

$$PE_{ww,treatment,y} = Q_{ww,y} * COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ} * B_{o,ww} * UF_{PJ} * GWP_{CH_4} \quad (6)$$

Where,

| | | |
|---|---|---|
| $PE_{ww,treatment,y}$ | = | Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y*,(t$CO_2$e) |
| $Q_{ww,y}$ | = | Volume of wastewater treated in the year *y* ($m^3$) |
| $COD_{removed,PJ,k,y}$ | = | Chemical oxygen demand removed by the project wastewater treatment system *k* in the year *y* (tonnes/$m^3$) |
| $MCF_{ww,treatment,PJ}$ | | Methane correction factor for project wastewater treatment system *k* (default value: 0.8) |
| $B_{o,ww}$ | = | Methane producing capacity of the wastewater (default value: 0.25 kg $CH_4$/kg COD) |
| $UF_{PJ}$ | | Model correction factor (default value: 1.12) |
| $GWP_{CH4}$ | = | Global warming potential for $CH_4$ (default value: 21) |

***1c) Project emissions by methane emissions from biogas release in capture system (t$CO_2$e)***

Fugitive emissions from the capture and utilization/combustion/flare system are estimated in this component.

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y} \quad (7)$$

Where,

| | | |
|---|---|---|
| $PE_{fugitive,y}$ | = | Emissions from methane release in capture system in the year *y* (t$CO_2$e) |
| $PE_{fugitive,ww,y}$ | = | Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment system in the year *y* (t$CO_2$e) |
| $PE_{fugitive,s,y}$ | = | Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year *y* (t$CO_2$e) |

Since there will be no anaerobic sludge treatment, $PE_{fugitive,y} = PE_{fugitive,ww,y}$

$$PE_{fugitive,ww,y} = (1 - CFE_{ww}) * MEP_{ww,treatment,y} * GWP_{CH_4} \quad (8)$$

Where,

| | | |
|---|---|---|
| $CFE_{ww}$ | = | Capture efficiency of the biogas recovery equipment in the wastewater treatment (default value: 0.9) |
| $MEP_{ww,\ treatment,y}$ | = | Methane emission potential of wastewater treatment systems equipped with biogas recovery system in the year *y* (tonnes) |
| $GWP_{CH4}$ | = | Global warming potential for $CH_4$ (default value: 21) |

$$MEP_{ww,treatment,y} = Q_{ww,y} * B_{o,ww} * UF_{PJ} \sum_k COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} \quad (9)$$

Where,

| | | |
|---|---|---|
| $Q_{y,ww}$ | = | Volume of wastewater treated in the year *y* ($m^3$) |
| $B_{o,ww}$ | = | Methane producing capacity of the wastewater (default value: 0.21 kg $CH_4$/kg COD) |
| $UF_{PJ}$ | = | Model correction factor to account for model uncertainties (1.12) |
| $COD_{removed,PJ,k,y}$ | = | Chemical oxygen demand removed by the treatment system *k* of the project activity equipped with biogas recovery in the year *y* (tonnes/$m^3$) |
| $MCF_{ww,treatment,PJ,k}$ | = | Methane correction factor for the project wastewater treatment system *k* equipped with biogas recovery equipment (default value: 0.8) |

***1d) Project emissions by emission due to incomplete flaring ($tCO_2e$)***

Project emissions from flaring are calculated as the sum of emissions from each hour h, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour h ($\eta_{flare,h}$), as follows:

$$PE_{flaring,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH4}}{1000} c \quad (10)$$

Where,

| | | |
|---|---|---|
| $PE_{flare,y}$ | = | Project emissions from flaring of the residual gas stream in year y ($tCO_2e$) |
| $TM_{RG,h}$ | = | Mass flow rate of methane in the residual gas in the hour h /kg/h) |
| $\eta_{flare,h}$ | = | Flare efficiency in hour h (%) |
| $GWP_{CH4}$ | = | Global warming potential for $CH_4$ (default value: 21) |

***2. Project emissions for fossil fuel consumption (AMS I.C) ($tCO_2e$)***

According to applied methodology AMS I.C ver 17, para 35 and Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion and Tool to calculate baseline, project and/or leakage emissions from electricity consumption, project emissions are account for the fuel oil consumption at the backup HFO boiler and the LPG consumption for start up of radiant tube burner.

$$PE_{FF,y} = PE_{FC,j,y}$$

Where,

| | | |
|---|---|---|
| $PE_{FF,y}$ | = | Project emissions from combustion of fossil fuels during the year y ($tCO_2e$) |
| $PE_{FC,j,y}$ | = | $CO_2$ emissions from fossil fuel combustion in process j during the year y ($tCO_2e$) |

***3. Project emissions for grid connected renewable electricity generation (AMS I.D) ($tCO_2e$)***

According to applied methodology AMS I.D ver 16, para 19 project emissions are not applicable and does not occur in the described project activity respectively.

**<u>Estimating the leakage:</u>**

There is no leakage expected from the project activity as the used biomass is a residue which is not used in the baseline and has no value.

**<u>Estimating the Emission Reduction:</u>**

$$ER_{y,exante} = BE_{y,exante} - (PE_{y,exante} + LE_{y,exante}) \quad (11)$$

Where,

| | | |
|---|---|---|
| $ER_{y,ex\ ante}$ | = | Ex ante emission reduction in year *y* ($tCO_2e$) |
| $LE_{y,ex\ ante}$ | = | Ex ante leakage emission in year *y* ($tCO_2e$) |
| $PE_{y,ex\ ante}$ | = | Ex ante project emission in year *y* ($tCO_2e$) |
| $BE_{y,\ ex\ ante}$ | = | Ex ante baseline emission in year *y* ($tCO_2e$) |

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

*(Copy this table for each data and parameter)*

| **Data / Parameter:** | **Annual starch production** |
|---|---|
| Data unit: | tonnes/year |
| Description: | Tonnes of native starch produced per year |
| Source of data used: | Plant records |
| Value applied: | 30,470 |
| Justification of the choice of data or description of measurement methods and procedures actually | The annual production of starch that is based on the historical recorded data during year 2007-2009 at the plant. This figure is used for the estimation of the total amount of wastewater generation from the starch plant. |

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

| **Data / Parameter:** | **Wastewater generation rate** |
|---|---|
| Data unit: | $m^3$/tonne of starch |
| Description: | Quantity of wastewater generated per tonne starch produced |
| Source of data used: | Calculation from measured data |
| Value applied: | 14.76 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Measurement campaign as specified in AMS-III.H, version 14 |
| Any comment: | |

| **Data / Parameter:** | **COD inflow** |
|---|---|
| Data unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand of wastewater inflow to the baseline treatment system |
| Source of data used: | Sample data |
| Value applied: | 0.017639 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | COD measurement campaign as specified in AMS-III.H, version 14 |
| Any comment: | |

| **Data / Parameter:** | **COD outflow** |
|---|---|
| Data unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand of wastewater outflow from the baseline treatment system |
| Source of data used: | Sample data |
| Value applied: | 0.000144 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | COD measurement campaign as specified in AMS-III.H, version 14 |
| Any comment: | |

| **Data / Parameter:** | $\mathbf{COD_{ww,treated,y}}$ |
|---|---|
| Data unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand of wastewater outflow from the treatment system in |

| | |
|---|---|
| | project activity (MABR) |
| Source of data used: | Estimate based on MABR digester efficiency at 85% |
| Value applied: | 0.002646 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Digester efficiency is given by the technology supplier |
| Any comment: | The technology supplier guarantees 85% |

| **Data / Parameter:** | **$COD_{removed,i,y}$** |
|---|---|
| Data unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand removed by the baseline treatment system |
| Source of data used: | Calculation |
| Value applied: | 0.0173495 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | |
| Any comment: | $COD_{removed,i,y}$ is the difference between COD inflow and COD outflow |

| **Data / Parameter:** | **$COD_{removed,PJ,k,y}$** |
|---|---|
| Data unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand removed by the treatment system, MABR, of the project activity equipped with biogas recovery |
| Source of data used: | Calculation |
| Value applied: | 0.012624 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | |
| Any comment: | $COD_{removed,PJ,k,y}$ is the difference between COD inflow and COD outflow |

| **Data / Parameter:** | **$COD_{removal\ efficiency}$** |
|---|---|
| Data unit: | % |
| Description: | Chemical oxygen demand removal efficiency of the baseline wastewater treatment system |
| Source of data used: | Calculation |
| Value applied: | 99.18 |
| Justification of the choice of data or description of | |

| | |
|---|---|
| measurement methods and procedures actually applied : | |
| Any comment: | $COD_{removal\ efficiency}$ is the $COD_{removed,i,y}$ divided by COD inflow multiplied with 100. |

| **Data / Parameter:** | **$MCF_{ww,treatment.BL,i}$** |
|---|---|
| Data unit: | No unit |
| Description: | Methane correction factor for baseline wastewater treatment system that will be equipped with methane recovery and combustion |
| Source of data used: | IPCC default value for anaerobic decay of the untreated wastewater |
| Value applied: | 0.8 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | If the depth of the open lagoons is more than 2 m, the MCF value of 0.8 in table III.H.1, para 21 in AMS III.H, version 14, is used. |
| Any comment: | |

| **Data / Parameter:** | **$MCF_{ww,treatment.PJ,k}$** |
|---|---|
| Data unit: | No unit |
| Description: | Methane correction factor for project wastewater treatment system that will be equipped with methane recovery and combustion |
| Source of data used: | Default value of 2006 IPCC Guidelines for National Greenhouse Gas Inventories for anaerobic decay of the untreated wastewater |
| Value applied: | 0.8 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | If the depth of the open lagoons is more than 2 m, the MCF value of 0.8 in table III.H.1, para 21 in AMS III.H, version 14, is used. |
| Any comment: | |

| **Data / Parameter:** | **$B_{o,ww}$** |
|---|---|
| Data unit: | $tCH_4$/tCOD |
| Description: | Methane producing capacity of the wastewater |
| Source of data used: | Default value of 2006 IPCC Guidelines for National Greenhouse Gas Inventories for domestic wastewater |
| Value applied: | 0.25 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | IPCC value of 0.25 kg $CH_4$/kg COD, the value is adopted from methodology AMS III.H “Methane recovery in wastewater treatment” version 14, page 6. |
| Any comment: | |

| **Data / Parameter:** | **$CFE_{ww}$** |
|---|---|
| Data unit: | % Percentage |
| Description: | Capture efficiency of the biogas recovery equipment in the wastewater treatment systems |
| Source of data used: | Para 27 of AMS III H methodology, version 14. |
| Value applied: | 90 |
| Justification of choice of data or description of measurement methods & procedures actually applied : | Essential to calculate fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment. |
| Any comment: | |

| **Data / Parameter:** | **$\rho_{CH4,n}$** |
|---|---|
| Data unit: | $kg/m^3$ |
| Description: | Density of methane at normal conditions |
| Source of data used: | |
| Value applied: | 0.7168 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | The value is adopted from Approved consolidated baseline methodology ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" Version 9.1, EB 43, Page 9. |
| Any comment: | |

| **Data / Parameter:** | **Quantity of HFO used** |
|---|---|
| Data unit: | litres/year |
| Description: | Average litres of HFO used per year |
| Source of data used: | Plant records |
| Value applied: | 1,071,497 |
| Justification of choice of data or description of measurement methods & procedures actually applied : | The annual HFO consumption that is based on the historical recorded data during year 2007-2009 at the plant. |
| Any comment: | litres/year |

| **Data / Parameter:** | **$NCV_{HFO}$** |
|---|---|
| Data unit: | MJ/kg |
| Description: | Energy content of Fuel Oil |
| Source of data used: | Thailand energy situation 2008, page 32 |
| Value applied: | 39.77 |
| Justification of choice of data or description of measurement | Essential to calculate Heat requirement for replacing Fuel Oil |

| | |
|---|---|
| methods & procedures actually applied : | |
| Any comment: | |

| | |
|---|---|
| Data / Parameter: | **$EF_{FF, CO2}$** |
| Data unit: | $tCO_2$ / TJ |
| Description: | The $CO_2$ emission factor of the fossil fuel that would have been used in the baseline plant |
| Source of data used: | Lower default value, Table 1.4, 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| Value applied: | 75.5 |
| Justification of choice of data or description of measurement methods & procedures actually applied : | The default value stated in table 1.4 for Residual Fuel Oil. |
| Any comment: | |

| | |
|---|---|
| **Data / Parameter:** | **$NCV_{biogas}$** |
| Data unit: | MJ/kg |
| Description: | Energy content of Biogas |
| Source of data used: | Thailand energy situation 2008, page 32 |
| Value applied: | 20.93 |
| Justification of choice of data or description of measurement methods & procedures actually applied : | Essential to calculate Biogas Requirement for replacing Fuel Oil ($m^3$). |
| Any comment: | |

| | |
|---|---|
| **Data / Parameter:** | **$GWP_{CH4,}$** |
| Data unit: | $CO_2e$ |
| Description: | Global Warming Potential for methane |
| Source of data used: | 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| Value applied: | 21 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Value stated in Para 20, AMS-III.H Version 14 |
| Any comment: | |

| | |
|---|---|
| **Data / Parameter:** | **$\eta_{th}$** |
| Data unit: | % Percentage |
| Description: | Efficiency of the thermal oil heater. |
| Source of data used: | Boiler supplier |

| | |
|---|---|
| Value applied: | 79.0% |
| Justification of choice of data or description of measurement methods & procedures actually applied : | According to para 21 (option b) of AMS I.C. methodology, version 17.<br>This data is based on the highest of the efficiency values provides by two manufacturers (SCHERRER and InPlan) |
| Any comment: | The data is essential to determine the baseline emission from fossil fuel consumption. |

| **Data / Parameter:** | $\eta_{flare,h}$ |
|---|---|
| Data unit: | % Percentage |
| Description: | Open flare efficiency in hour h based on measurements or default values |
| Source of data used: | tool to determine project emissions from flaring gases containing methane |
| Value applied: | 0% |
| Justification of choice of data or description of measurement methods & procedures actually applied : | In case of open flare, the flare efficiency cannot be measured in a reliable manner (i.e. external air will be mixed and will dilute the remaining methane). And a default value of 50% is to be used provided that it can be demonstrated that the flare is operational (e.g. through a flame detection system reporting electronically on continuous basis). If the flare is not operational the default value to be adopted for flare efficiency is 0% |
| Any comment: | Maintenance of the flare is to be conducted according to manufacturer's specification |

| **Data / Parameter:** | $EF_{CO2,grid,y}$ |
|---|---|
| Data unit: | t $CO_2$/MWh |
| Description: | $CO_2$ Emission Factor of the grid in year y |
| Source of data used: | Calculated value. |
| Value applied: | 0.5453 (based on the data of year 2008) |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | The project activity involves electricity supply to grid. Estimated as combined margin emission factor using the latest approved version of the "Tool to calculate the emission factor for an electricity system". |
| Any comment: | This $EF_{CO2,grid,y}$ value is used for entire of crediting period. |

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

>>

To calculate the baseline and project emissions, the following assumptions were made for the project activity.

Table 12: Baseline and project parameters

| Value/Parameter | Value | Unit | Description | Comment |
|---|---|---|---|---|
| $Q_{ww,y}$ | 449,639 | $m^3$/year | Volume of wastewater treated in the year y | The volume was calculated based on measurement campaign according to AMS |

| Value/Parameter | Value | Unit | Description | Comment |
|---|---|---|---|---|
| | | | | III.H and the historical production data |
| $COD_{inflow}$ | 17,639 | Tonnes/$m^3$ | The inflow COD of the baseline system | measurement campaign according to AMS III.H |
| $COD_{outflow,BL}$ | 144 | Tonnes/m3 | The outflow COD of the baseline system | measurement campaign according to AMS III.H |
| $MCF_{ww,treatment,BL,i}$ | 0.8 | | Methane correction factor for the wastewater treatment system | Table 6.8 default MCF values for industrial wastewater, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 5, p. 6.21, table 6.8. |
| $GWP_{CH4}$ | 21 | $tCO_2/tCH_4$ | Global Warming Potential of Methane | AMS III.H version 14, para 20 |
| $B_{o,ww}$ | 0.25 | $kgCH_4$/kgCOD | Methane roduction capacity of the wastewater | 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 5, p. 6.21. |
| $EG_{thermal,y}$ | 33.82 | TJ/yr | Thermal energy from HFO replacing by renewable energy | Calculation shown in annex 3 |
| $EF_{FF, co2}$ | 75.5 | $tCO_2$/TJ | Emission factor of HFO | table 1.4 default CO2 emission factors for combustion , 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2, p. 6.23. |
| $NCV_{fuel}$ | 39.77 | MJ/Litre | Thermal energy from HFO replacing from renewable energy | Data from Thailand energy situation in year 2008 |
| $EG_{BL,y}$ | 1,639.75 | MWh/year | Quantity of net electricity supplied to the grid | Calculation shown in annex 3 |
| $EF_{CO2,grid,y}$ | 0.5453 | $tCO_2$/MWh | $CO_2$emission factor of the grid | Calculation shown in annex 3 |

**1. The baseline emissions are calculated as follows:**

*a*

*a. Baseline Emission from fossil fuel consumption ($tCO_2e$) according to AMS I.C.*

$$BE_{thermal,y} = \underset{(TJ/yr)}{EG_{thermal,y}} * \underset{(t\ CO2/TJ)}{EF_{FF,CO2}} / \eta_{BL,thermal}$$ [32]

[32] As per paragraph 21 of AMS-I.C version 17, option (b) Highest of the efficiency values provided by two manufacturers, SCHERRER and InPlan, for units with similar specifications, using the baseline fuel.

= 33.82 * 75.5/ 79%
= 3,232

*b. Baseline emissions from grid connected renewable electricity generation ($tCO_2e$) according to AMS I.D*

$$BE_{power,y} = EG_{BL,y} \text{ (MWh/yr)} * EF_{CO2,grid,y} \text{ (t } CO_2\text{/MWh)} \quad (2)$$

= 1,639.75 * 0.5453
= 894

*c. Baseline emissions of the wastewater treatment system ($tCO_2e$) according to AMS III.H*

The baseline emissions from the lagoons are estimated based on the difference of chemical oxygen demand (COD) of the effluent that enters into the existing lagoon system and the COD of the effluent in the last lagoon, the maximum methane producing capacity ($B_o$) and a methane conversion factor (MCF) that expresses what proportion of the effluent would have been anaerobically digested in the open lagoons. As the baseline emissions are calculated and determined ex-post the values are based on the existing treatment and a 14 days measuring campaign.

$$BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{removed,i,y} * MCF_{treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH_4} \quad (3)$$

$BE_{ww,\ treatment,\ y}$ ($tCO_2e$) = 449,639 * (0.017495*0.89) * 0.8 * 0.25 * 0.89 * 21
= 26,170

Therefore

$BE_y$ ($tCO_2e$) = $BE_{thermal,y} + BE_{power,y} + BE_{ww,treatment,y}$
= 3,232+ 894 + 26,170
= 30,297

**2. Estimating the Project Emissions:**

As project emissions occur only in the project activity related with AMS III.H, all following calculations are related to AMS III.H methodology.

The project emissions are calculated as follows:

*a. Project emissions from power consumption*

$$PE_{power,y} = \text{Auxiliary consumption by the biogas plant (MWh/yr)} * EF_{CO2,grid,y} \text{ (t } CO_2\text{/MWh)} \quad (4)$$

$PE_{power,y}$ ($tCO_2e$) = 663 * 0.5453
= 362

*b. Methane emissions from wastewater treatment system ($tCO_2e$)*

$$PE_{ww,treatment,y} = Q_{ww,y} * COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} * B_{o,ww} * UF_{PJ} * GWP_{CH_4} \quad (5)$$

| | | |
|---|---|---|
| $PE_{ww,treatment,y}$ ($tCO_2e$) | = | 449,639 * 0.002624 * 0.8 * 0.25 * 1.12 * 21 |
| | = | 5,551 |

*c. Methane emissions from biogas release in capture system ($tCO_2e$)*

$$MEP_{ww,treatment,y} = Q_{ww,y} * B_{o,ww} * UF_{PJ} * \sum_k COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} \quad (6)$$

| | | |
|---|---|---|
| $MEP_{ww,treatment,y}$ (t) | = | 449,639 * 0.25 * 1.12 * 0.014993 * 0.8 |
| | = | 1,510 |

$$PE_{fugitive,ww,y} = (1 - CFE_{ww}) * MEP_{ww,treatment,y} * GWP_{CH_4} \quad (7)$$

| | | |
|---|---|---|
| $PE_{fugitive,ww,y}$ ($tCO_2e$) | = | (1 – 0.9) * 1,510 * 21 |
| | = | 3,171 |

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y} \quad (8)$$

Since there will be no anaerobic sludge treatment, $PE_{fugitive,y} = PE_{fugitive,ww,y}$

| | | |
|---|---|---|
| $PE_{fugitive,y}$ | = | 3,171 |

Therefore

| | | |
|---|---|---|
| $PE_y$ ($tCO_2e$) | = | $PE_{power,y}$ + $PE_{ww,treatment,y}$ + $PE_{fugitive,y}$ |
| | = | 362 + 5,551+ 3,171 |
| | = | 9,083 |

**3. Estimating the leakage:**

There is no leakage expected from the project activity.

**4. Estimating the Emission Reduction:**

$$ER_y = BE_y - (PE_y + leakage) \quad (9)$$

| | | |
|---|---|---|
| $ER_y$ (t $CO_2e$) | = | 30,297 – (9,083 + 0) |
| | = | 21,213 |

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

>>

The emission reduction achieved by the project activity is limited to the ex post calculated baseline emissions minus project emissions using the actual monitored data for the project activity. The emission reductions achieved in any year are the lowest value of the following:

$$ER_{y,ex\ post} = \text{Min}\ [\ (BE_{y,ex\ post} - PE_{y,ex\ post} - LE_{y,ex\ post}), (MD_y - PE_{power,y} - PE_{biomass,y} - LE_{y,ex\ post})]$$

Where,

| | | |
|---|---|---|
| $ER_{y,ex\ post}$ | = | Emission reduction achieved by the project activity based on monitored values for year *y* ($tCO_2e$) |
| $BE_{y,ex\ post}$ | = | Baseline emission calculated using ex post monitored values |
| $PE_{y,ex\ post}$ | = | Project emission calculated using ex post monitored values |
| $MD_y$ | = | Methane captured and destroyed/gainfully used by the project activity in the year *y* ($tCO_2e$) |

Summary of Emissions Reduction over the crediting period:

| Year | Estimation of project activity emission ($tCO_2$ e) | Estimation of baseline emission ($tCO_2$ e) | Estimation of leakage ($tCO_2$ e) | Estimation of overall emission reductions ($tCO_2$ e) |
|---|---|---|---|---|
| 2011 | 9,083 | 30,297 | 0 | 21,213 |
| 2012 | 9,083 | 30,297 | 0 | 21,213 |
| 2013 | 9,083 | 30,297 | 0 | 21,213 |
| 2014 | 9,083 | 30,297 | 0 | 21,213 |
| 2015 | 9,083 | 30,297 | 0 | 21,213 |
| 2016 | 9,083 | 30,297 | 0 | 21,213 |
| 2017 | 9,083 | 30,297 | 0 | 21,213 |
| 2018 | 9,083 | 30,297 | 0 | 21,213 |
| 2019 | 9,083 | 30,297 | 0 | 21,213 |
| 2020 | 9,083 | 30,297 | 0 | 21,213 |
| Total (tonnes of t $CO_2$ e) | 90,833 | 302,965 | 0 | 212,132 |

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

### B.7.1 Data and parameters monitored:

| **Parameter:** | $Q_{ww,i,y}$ |
|---|---|
| Unit: | $m^3$/year |

| | |
|---|---|
| Description: | Volume of wastewater treated in the anaerobic digestion system |
| Source of data: | Measured data |
| Value of data: | - |
| Brief description of measurement methods and procedures to be applied: | The data is measured continuously by using electronic flow meters. Aggregated annually for calculations. |
| QA/QC procedures to be applied (if any): | The flow meter will undergo maintenance / calibration subject to manufacturer's recommendation |
| Any comment: | Used for the project emission and baseline emissions calculation |

| **Parameter:** | $\mathbf{COD_{ww,untreated,y}}$ |
|---|---|
| Unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand of the wastewater entering the anaerobic treatment reactor/system with methane capture |
| Source of data: | Measured data |
| Value of data: | - |
| Brief description of measurement methods and procedures to be applied: | Daily sampling and analysis will be carried out in the in-house lab adhering to internationally accepted standards and will be archived electronically. Yearly average values will be used for the estimation of emissions. |
| QA/QC procedures to be applied (if any): | The data will be cross-checked with samples analyzed by an external accredited laboratory regularly . |
| Any comment: | - |

| **Parameter:** | $\mathbf{COD_{ww,treated,y}}$ |
|---|---|
| Unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand of the treated wastewater leaving the new anaerobic digestion system. |
| Source of data: | Measured data |
| Value of data: | - |
| Brief description of measurement methods and procedures to be applied: | Daily sampling and analysis will be carried out in the in-house lab adhering to internationally accepted standards and archived electronically. Yearly average values will be used for the estimation of emissions. |
| QA/QC procedures to be applied (if any): | The data will be cross-checked with samples analyzed by an external accredited laboratory regularly |
| Any comment: | |

| **Parameter:** | $\mathbf{COD_{ww,removed,PJ,k,y}}$ |
|---|---|
| Unit: | Tonnes/$m^3$ |
| Description: | Chemical oxygen demand removed by the treatment system, MABR, of the project activity equipped with biogas recovery |
| Source of data: | Calculated value. |
| Value of data: | - |
| Brief description of measurement methods | $COD_{ww,removed,PJ,k,y}$ is the difference between $\mathbf{COD_{ww,untreated,y}}$ and $\mathbf{COD_{ww,treated,y}}$ |

| | |
|---|---|
| and procedures to be applied: | |
| QA/QC procedures to be applied (if any): | |
| Any comment: | |

| **Parameter:** | **$F_{CH4}$** |
|---|---|
| Unit: | % |
| Description: | Percentage of methane in the biogas on volume basis. |
| Source of data: | Measured data |
| Value of data: | 60 |
| Brief description of measurement methods and procedures to be applied: | On-site sample analysis by using gas analyzer. Yearly average values will be used for the estimation of emissions. |
| QA/QC procedures to be applied (if any): | The equipment will undergo maintenance/calibration periodically according to the manufacturer's recommendation. |
| Any comment: | Used for the calculation of project emission and emission reduction. |

| **Parameter:** | **$Q_{biogas, burner, y}$** |
|---|---|
| Unit: | $Nm^3$/year |
| Description: | Biogas flow rate sent to radiant tube burner |
| Source of data: | Measured data |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Measured continuously by using on-site electronic gas flow meter. Aggregated annually for calculations. |
| QA/QC procedures to be applied (if any): | Flow meters will undergo maintenance/calibration according to manufacturer's recommendation. |
| Any comment: | |

| **Parameter:** | **$P_{biogas, burner}$** |
|---|---|
| Unit: | Psi |
| Description: | Biogas pressure at the inlet of the radiant tube burner |
| Source of data: | Measured data |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Electronically measured using pressure transmitter. |
| QA/QC procedures to be applied (if any): | Continuously monitored and hence the uncertainties are low. Pressure transmitter will undergo maintenance/calibration according to manufacturer's recommendation. |
| Any comment: | |

| **Parameter:** | **$T_{biogas, burner}$** |
|---|---|

| | |
|---|---|
| Unit: | °C |
| Description: | Temperature of biogas at the inlet of the radiant tube burner |
| Source of data: | Measured data |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Temperature of biogas will be measured by flow meters. |
| QA/QC procedures to be applied (if any): | Flow meters will undergo maintenance/calibration according to according to manufacturer's recommendation or appropriate industry standards. |
| Any comment: | |

| **Parameter:** | **$EG_{thermal,y}$** |
|---|---|
| Unit: | TJ/yr |
| Description: | Net quantity of thermal energy supplied by the project activity during the year *y* |
| Source of data: | Measured data |
| Value of data: | - |
| Brief description of measurement methods and procedures to be applied: | The heat is generated by combusting biogas in the radiant tube burner. The exhaust gas passes a heat exchanger and the hot gas is blown out. The blown out gas (hot air) is used for drying starch.<br>The heat is expressed as difference in the enthalpy of the exhaust gas and the hot air which is supplied to starch plant.<br><br>The enthalpy is determined based on the monitored mass flow, temperature and pressure. |
| QA/QC procedures to be applied (if any): | The equipment will undergo maintenance/calibration periodically according to the manufacturer's recommendation or relative local regulation to ensure accuracy. |
| Any comment: | - |

| **Parameter:** | **$Q_{biogas,\ gas\ engine,\ y}$** |
|---|---|
| Unit: | $Nm^3$/year |
| Description: | Biogas flow volume entering the gas engines |
| Source of data: | Measured data |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Measured continuously by using on-site electronic flow meters. Aggregated annually for calculations. |
| QA/QC procedures to be applied (if any): | Flow meters will undergo maintenance/calibration according to manufacturer's recommendation. |
| Any comment: | |

| **Parameter:** | **$P_{biogas,\ gas\ engine}$** |
|---|---|
| Unit: | Psi |
| Description: | Biogas pressure at the inlet of the gas engine |
| Source of data: | Measured data |

| | |
|---|---|
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Electronically measured using pressure transmitter. |
| QA/QC procedures to be applied (if any): | Continuously monitored and hence the uncertainties are low. Pressure transmitter will undergo maintenance/calibration according to manufacturer's recommendation. |
| Any comment: | |

| **Parameter:** | **$EG_{gross, y}$** |
|---|---|
| Unit: | MWh/yr |
| Description: | Gross electricity produced by the generating unit operating on biogas. |
| Source of data: | Measured data |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Measured continuously by using on-site electricity meter. Aggregated annually for calculations |
| QA/QC procedures to be applied (if any): | Electricity meter will undergo maintenance/calibration according to manufacturer's recommendation. |
| Any comment: | |

| **Parameter:** | $EG_{aux, biogas system, y}$ |
|---|---|
| Unit: | MWh/yr |
| Description: | Auxiliary electricity consumption by the biogas system |
| Source of data: | Measured value |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Measured continuously by using on-site electricity meter. Aggregated annually for calculations |
| QA/QC procedures to be applied (if any): | Electricity meter will undergo maintenance/calibration according to manufacturer's recommendation. |
| Any comment: | |

| **Parameter:** | $EG_{aux, gas engine, y}$ |
|---|---|
| Unit: | MWh/yr |
| Description: | Auxiliary electricity consumption by gas engine system |
| Source of data: | Calculated value. |
| Value of data: | |

| | |
|---|---|
| Brief description of measurement methods and procedures to be applied: | $EG_{aux,\ gas\ engine,\ y}$ is the difference between $EG_{gross,\ gas\ engine,\ y}$ and $EG_{net,\ gas\ engine,\ y}$ |
| QA/QC procedures to be applied (if any): | |
| Any comment: | |

| **Parameter:** | $EG_{BL,y}$ |
|---|---|
| Unit: | MWh/yr |
| Description: | Quantity of net electricity supplied to the grid |
| Source of data: | Measured data |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Measured continuously by using on-site electricity meter. Consolidated readings will be noted down on monthly basis**.** Aggregated annually for calculations. |
| QA/QC procedures to be applied (if any): | Electricity meter will undergo maintenance/calibration according to manufacturer's recommendation. |
| Any comment: | |

| **Parameter:** | $FC_{i,j,y}$ |
|---|---|
| Unit: | Mass or volume unit per year (i.e. tonnes/yr or $m^3$/yr) |
| Description: | Quantity of fuel type i combusted in process j during the year y |
| Source of data: | Onsite measurements |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | This parameter will be monitored by either mass or volume meters. In cases where fuel is supplied from small daily tanks, rulers can be used to determine mass or volume of the fuel consumed. |
| QA/QC procedures to be applied (if any): | The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. |
| Any comment: | |

| **Parameter:** | NCVi,y |
|---|---|
| Unit: | TJ per mass or volume unit (e.g. TJ/$m^3$, TJ/ton) |
| Description: | Weighted average net calorific value of fuel type i in year y |
| Source of data: | Regional or national default values |
| Value of data: | - |

| | |
|---|---|
| Brief description of measurement methods and procedures to be applied: | Review appropriateness of the values annually. |
| QA/QC procedures to be applied (if any): | |
| Any comment: | |

| **Parameter:** | **$EF_{FF, CO2}$** |
|---|---|
| Unit: | $tCO_2$ / TJ |
| Description: | The $CO_2$ emission factor of the fossil fuel that would have been used in the project activity |
| Source of data: | Default value, Table 1.4, 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| Value of data: | - |
| Brief description of measurement methods and procedures to be applied: | Any future revision of the IPCC Guidelines should be taken into account. |
| QA/QC procedures to be applied (if any): | |
| Any comment: | |

| **Parameter:** | **$Q_{biogas, flare,y}$** |
|---|---|
| Unit: | $Nm^3$/year |
| Description: | Biogas flow rate of the (surplus) residual biogas at flare inlet. |
| Source of data: | Measured data |
| Value of data: | - |
| Brief description of measurement methods and procedures to be applied: | On-site metering using electronic flow meters. Flow is measured continuously. Values will be averaged hourly. |
| QA/QC procedures to be applied (if any): | Flow meters will undergo maintenance/calibration according to appropriate industry standards. |
| Any comment: | Used for project emission and emission reduction calculations. |

| **Parameter:** | **$P_{biogas, flare}$** |
|---|---|
| Unit: | Psi |
| Description: | Biogas pressure at the inlet of the flare |
| Source of data: | Measured data |
| Value of data: | |
| Brief description of measurement methods and procedures to be applied: | Electronically measured using pressure transmitter. |
| QA/QC procedures to be applied (if any): | Continuously monitored and hence the uncertainties are low. Pressure transmitter will undergo maintenance/calibration according to manufacturer's |

| | |
|---|---|
| | recommendation. |
| Any comment: | |

| **Parameter:** | $\boldsymbol{\eta_{flare,h}}$ |
|---|---|
| Unit: | Percentage |
| Description: | Flare efficiency in hour *h* |
| Source of data: | tool to determine project emissions from flaring gases containing methane with reference to EB28, Annex 13 |
| Value of data: | 50 |
| Brief description of measurement methods and procedures to be applied: | The operational of open flare will be measured through a flame detection system reporting electronically on continuous basis. In case of open flares, the flare efficiency in the hour h ($\eta_{flare,h}$) is<br><br>0% if the flame is not detected for more than 20 minutes during the hour h.<br>50%, if the flame is detected for more than 20 minutes during the hour h. |
| QA/QC procedures to be applied (if any): | The flame detector wil be calibrated periodically according to the manufacturer's recommendation or relative local regulation to ensure accuracy. |
| Any comment: | |

| **Parameter:** | **Sludge application** |
|---|---|
| Unit: | t/year |
| Description: | Quantity of sludge removed from the treatment system and its application such as fertilizers in farms, plantations, etc. |
| Source of data: | Measured data |
| Value of data: | - |
| Brief description of measurement methods and procedures to be applied: | Sludge removal and its application will be measured whenever the sludge is removed from the biogas reactor and open lagoon systems and a record will be maintained in the plant. Aggregated annually for calculations (if any) |
| QA/QC procedures to be applied (if any): | Measurement will be carried out adhering to internationally recognized procedures |
| Any comment: | |

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

### B.7.2 Description of the monitoring plan:

>>

NP is well aware of the importance of having a good operational and management team in order to execute a well-defined monitoring plan for the project activity. From this perspective, NP has an operational and management structure, created exclusively to monitor the relevant plant parameters. The responsibility of data monitoring, archiving and analyzing will fall on different members of the monitoring team. This team will be composed of a managing director, a biogas project supervisor and an operational team as shown in the chart below. The biogas project supervisor will make sure that the monitoring system is properly implemented.

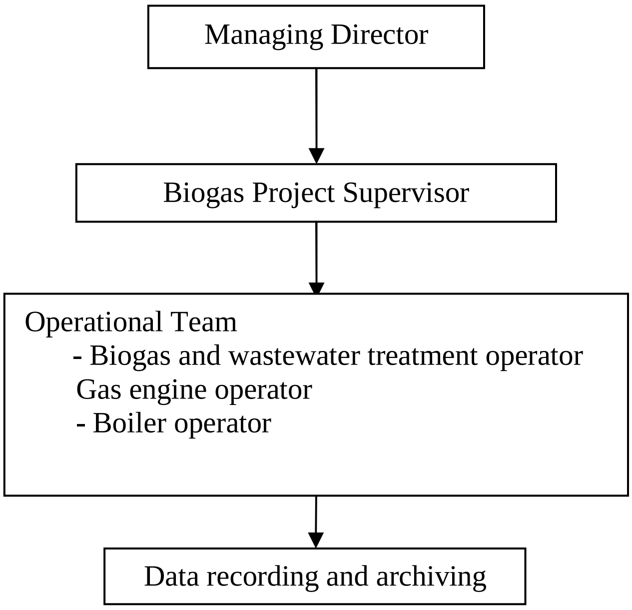


**Figure 6: Operational and management structure for monitoring**

Under the supervision of the biogas project supervisor, data monitoring and archiving will be done by the operational team. All the data will be recorded in hard copy according to the data archiving procedures and stored electronically in a systematic and transparent manner. The biogas project supervisor will review the archived data and submit a complete set of documentation to the managing director for internal verification regularly on monthly basis. The data provides the basis for ex-post emission reduction calculation. Based on the feedback from the managing director, the biogas project supervisor will review the data and apply quality check on a regular basis. This documentation will be verified again by an external independent Designated Operational Entity (DOE) annually.

**Quality assurance and quality control**

Calibration will be carried out in accordance with manufacturer's recommendation or at least once a year to ensure accuracy. NP will take responsibility for the quality assurance and quality control for recording, maintaining and archiving all the data by appointing consultants and/or technical support team to carry out the system analysis, equipment calibration and overall maintenance on a regular basis throughout the crediting period. NP will also provide sufficient number of staff for data collection and monitoring and impart necessary training in order to improve the efficiency of their work.

**Data logging, presentation and storing**

NP will monitor COD of the wastewater, the amount of biogas used in the radiant tube burner, gas engine set, flare, gross and net electricity produced, auxiliary electricity consumption, and electricity exported to the national grid using meters installed in the plant. The sludge disposal will also be monitored.

NP is responsible to implement the monitoring report according to the PDD. Daily operation and maintenance log books will be maintained by responsible operators. They will be able to provide detailed on-the-spot information about the operation of the plant. Any distinguishing event will be reported and

recorded as special log. The monitoring reports will be checked and discussed periodically. The monitored data will be sent to managing director and to the project participant in Germany. The distribution shall protect for data loss. The submitted data will be stored on soft files and hard copies in Germany. An additional set of monitored data will be stored in Thailand at the project site. Monitored data will be kept for at least 2 years after the full crediting period.

**Training**

NP's operation and management team will be trained by the technology suppliers for biogas plant, biogas boiler and gas engine to ensure that all staffs have an ability and knowledge to operate the systems. Operation manual for each system will be developed for the operational team. Work Instruction for sampling of COD will be developed for biogas and wastewater treatment operator. The CDM monitoring manual will be developed by CDM consultant and will be used for training the related operator.

**Emergency Procedure**

NP will implement an Emergency Procedure in the plant, for which a detailed manual will be developed. The manual will contain instructions on how to handle an emergency situation in the plant, and measures to be taken to ensure that there is no unintended methane leakage from the system. All the plant operators will be familiarised on the procedure.

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

>>
Date of completion of the baseline: 30/05/2010

Contact information of the person(s)/entity(ies) responsible for the application of the baseline and monitoring methodology to the project activity:

| | |
|---|---|
| Organization | Advance Energy Plus Co., Ltd. |
| Contact person | Mr. Anat Prapasawad |
| Telephone no. | +662 645 3347 |
| Email address | anat_p@aep.co.th |
| Date of completion | 30/05/2010 |

Advance Energy Plus Co., Ltd. is not a "project participant" listed in Annex 1.

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

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

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

>> 22/02/2010 (The date of signing agreement with supplier)

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

>>15 years 0 months

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

**C.2.1. Renewable crediting period**

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

>>

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

>>

**C.2.2. Fixed crediting period:**

**C.2.2.1. Starting date:**

>>

01/03/2011, or date of registration, which ever is later.

**C.2.2.2. Length:**

>>

10 years

## SECTION D. Environmental impacts

>>

**D.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:**

>>

This project does not require an Environmental Impact Assessment (EIA) under Thai Law.[33] The project has tight project boundaries, with immediate physical impacts focused within these boundaries. These include:

- Dramatic reduction in methane production and fugitive emissions from current lagoon system;
- Improved water quality in these lagoons;
- Improved biodiversity impacts within the lagoon system environs.

Outside these boundaries, impacts felt at a national level include:

- Reduced demand for fossil fuels and fossil fuel –based electricity oil products.

Nevertheless, TGO requests an Initial Environmental Evaluation (IEE) report for the issuance of the Letter of Approval (LoA).

**D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:**

>>

The environmental impacts are not significant.

[33] http://www.onep.go.th/eia/page2/type34.pdf

## SECTION E. Stakeholders' comments

>>

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

>>

The Public Consultation meeting was organized on March 26, 2010 near the project location, at the meeting room of Ban koh Rak Siad School, Phetchompoo Sub district, Kosumpee District, Kamphaengphet province, Thailand. Invitation letters were sent to the representatives of the involved various government organizations, local authorities, NGOs, academic institutions, members from the local community living nearby the project area and others. 42 participants from local authorities, Sub district Administration Organization and villagers living nearby the project location participated the meeting. The event was documented and summarized (including list of participant, questionnaires, pictures etc.) in order to apply for a LoA .

The project developers and project owner presented and shared detailed project information and its benefits. The event provided a forum for all participants to raise questions about project impact and exchange opinions. NP Biopower Co., Ltd. was represented by its Managing Director, CS was participating with its Managing Director, the project participant EnBW was participating, and the project developers were represented by Advance Energy Plus Co., Ltd. and Premier Energy Co., Ltd. The representatives from NP Biopower Co., Ltd., CS, Advance Energy Plus Co., Ltd. and Premier Energy Co., Ltd. were also present to answer the questions regarding the biogas technology and CDM-related issues, respectively**.**

### E.2. Summary of the comments received:

>>

The comments received emphasized on two main issues:

(i) quality of treated wastewater and
(ii) safety measure.

The comments and questions of the participants are summarized below:

Q: How many biogas does the system generate?
A: A pond can contain 80,000 $m^3$, so they can generate biogas more than 20,000 $m^3$ per day.

Q: (PEA) Is HDPE fire proof? How long is the life cycle of HDPE? Is the access to the biogas plant allowed for outsiders?
A: (Premier Energy) HDPE has heat resistant at 75 degree Celsius. Its life time is 10 years. And Outsider should not access the system because of safety reason.

Q: (Natural Resources and Environment Office) Does the bottom of pond sealed by HDPE? And do the existing 11 ponds remain?
A: There is no covering at the bottom of the pond but NP will compact soil for wastewater leakage preventing.

Q: (Chief of Phetchompoo Sub district) What is the current progress/stage of the project?
A: Soil compaction process. If participant would like to see the site now, all participants are invited for a site-visit.

Q: (Provincial Industry Office) What does NP do in case of fire of the system?
A: NP will construct fence around the site. Moreover we will have fire-fighting equipment and train NP worker before operating the biogas plant.

Q: (PEA) How does NP avoid leakage at the biogas plant, so that biogas will spread in the air?
A: Methane has lower density than air, so when the coverage of the biogas plant leaks, the cover will blow in the air immediately.

A: Where is NP Biopower company located? And how can the participants/neighbors contact them?
Q: NP Biopower is located at the same place as Charoensuk Starch (2005) Co., Ltd. People who would like to contact the company, can contact them directly at CS.

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

>>

At the beginning of the meeting, the project developers explained the complete details of the project to the participants. The key benefits from the biogas plant (reduced air pollution and water pollution and reduced foul smell compared to the existing open lagoon system) were also explained, which the participants understood well. There was hence no serious comment on the environmental impacts or safety aspects.

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

## Annex 1

### CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

| | |
|---|---|
| Organization: | NP Biopower Co., Ltd. |
| Street/P.O.Box: | Phraholyothin Road |
| Building: | |
| City: | Kamphaeng Phet |
| State/Region: | |
| Postfix/ZIP: | 62000 |
| Country: | Thailand |
| Telephone: | (66) 55 701 266 |
| FAX: | (66) 55 701 262 |
| E-Mail: | tansomsak@yahoo.com |
| URL: | |
| Represented by: | |
| Title: | Mr. |
| Salutation: | Director |
| Last Name: | Tancharoensukjit |
| Middle Name: | |
| First Name: | Somsak |
| Department: | |
| Mobile: | |
| Direct FAX: | |
| Direct tel: | |
| Personal E-Mail: | |

| | |
|---|---|
| Organization: | EnBW  Energie Baden-Württemberg AG |
| Street/P.O.Box: | Durlacher Allee 93 |
| Building: | |
| City: | Karlsruhe |
| State/Region: | |
| Postfix/ZIP: | 76131 |
| Country: | Germany |
| Telephone: | +49 721 6323102 |
| FAX: | +49 721 6323119 |
| E-Mail: | c.clashausen@enbw.com |
| URL: | |
| Represented by: | |
| Title: | |
| Salutation: | |
| Last Name: | Clashausen |
| Middle Name: | |
| First Name: | Christine |
| Department: | |
| Mobile: | |
| Direct FAX: | |

| | |
|---|---|
| Direct tel: | |
| Personal E-Mail: | |

**Annex 2**

**INFORMATION REGARDING PUBLIC FUNDING**

This project will not receive any public funding from Annex parties.

## Annex 3

## BASELINE INFORMATION

### A. Data used for Baseline estimation

| | |
|---|---|
| COD entering wastewater treatment lagoons | 17,639 mg/l |
| Wastewater generation | 449,639 $m^3$/year |
| $MCF_{ww, treatment,BL,i}$ - according to para 21 in AMS III H for Baseline Emissions | 0.8 |

### B. Lagoon condition

| | |
|---|---|
| Average Temperature (year 2008)[34] | 27.12 $^0$C |
| Volumetric COD loading | 0.14 kg COD/$m^3$ |

| Lagoon | Width (m) | Length (m) | Area ($m^2$) | Depth (m) | Volume ($m^3$) |
|---|---|---|---|---|---|
| 1 | 81.0 | 81.5 | 6,601.50 | 5.00 | 23,217 |
| 2 | 83.5 | 96.5 | 8,057.75 | 5.00 | 28,660 |
| 3 | 84.0 | 84.0 | 7,056.00 | 5.00 | 28,532 |
| 4 | 87.0 | 87.5 | 7,612.50 | 5.00 | 30,468 |
| 5 | 86.5 | 88.0 | 7,612.00 | 5.00 | 30,992 |
| 6 | 86.0 | 84.0 | 7,224.00 | 5.00 | 28,908 |
| 7 | 83.0 | 83.0 | 6,889.00 | 5.00 | 28,841 |
| 8 | 85.0 | 85.0 | 7,225.00 | 5.00 | 31,019 |

Data source: Project owner, Charoensuk Starch Co., Ltd

[34] http://www.tmd.go.th/agromet_report.php (9 November 2009)

## C. Estimation of thermal replacement and grid electricity generation:

i. Total methane generated

Total methane generated (t $CH_4$/year)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| = | $Q_{y,ww}$ | * | $COD_{removed,PJ,k,y}$ | * | Efficiency of digester (%) | * | $B_{o,ww}$ | * | $MCF_{ww,treatment}$ | * | $UF_{PJ}$ |
| = | 449,639 | * | 0.014993 | * | 0.85 | * | 0.25 | * | 0.8 | * | 1.12 |
| = | 1,348.33 | | | | | | | | | | |

Loss through capture & flare inefficiency = 151.01 $tCH_4$/yr

Total methane available = 1,348.33 – 151.01 = 1,197.31 $tCH_4$/yr

ii. Total biogas generated

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total Biogas Generated ($m^3$/year) | = | Total methane available ($tCH_4$/year) | / | Fraction of $CH_4$ in biogas ($m^3CH_4/m^3$biogas) | / | Density of methane ($kgCH_4/m^3CH_4$) | * | 1,000 |
| | = | 1,197.31 | / | 0.60 | / | 0.7168 | * | 1,000 |
| | = | 2,783,934 | | | | | | |

Fraction of CH4 in biogas ($m^3CH_4/m^3$biogas) = 0.6
Density of methane ($kgCH_4/m^3CH_4$) = 0.7168

iii. Total thermal energy to be supplied by the project to radiant tube burner

| | | | | | | |
|---|---|---|---|---|---|---|
| Heat produced by fuel oil (MJ/year) | = | Total fuel oil to be replaced by biogas (litre/year) | * | NCV of fuel oil (MJ/litre) | * | Existing Boiler efficiency (%) |
| | = | 1,076,497.33 | * | 39.77 | * | 79.0% |
| | = | 33,821,716.17 | | | | |

iv. Volume of biogas that replaces the fuel oil

| | | | | | | |
|---|---|---|---|---|---|---|
| Volume of biogas required to replace fuel oil ($m^3$/year) | = | Heat produced by fuel oil to be replaced by biogas (MJ/year) | / | Energy content of biogas ($MJ/Nm^3$) | / | New Boiler efficiency (%) |
| | = | 33,821,716.17 | / | 20.93 | / | 81.0% |

= 1,994,993

v. Volume of biogas that generate electricity

| | | | | |
|---|---|---|---|---|
| Total electricity generated by project (kWh/yr) | = | Total biogas remaining ($m^3$/yr) | * | Electricity produced per $m^3$ of biogas (kWh/$m^3$) |
| | = | 788,941 | * | 2.18 |
| | = | 1,719.15 | | |

| | | |
|---|---|---|
| Total electricity generated by the project | = | 1,719.15MWh/yr |
| Auxiliary Load for the system | = | 4.62 % |
| Net electricity generated by the project | = | 1,639.75 MWh/yr |
| | = | 1,639,750 kWh/yr |

## D. Grid Emission Factor for Thailand

***Step 1: Identify the relevant electric power system***

The "Tool to calculate the emission factor for an electricity system" (Version 02; 16 October 2009) defines a project electricity system as "the spatial extent of the power plants that can be dispatched without significant transmission constraints". On this basis the project electricity system is defined as the Thai national electricity grid.

***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; 16th October 2009)

***Step 3: Select a method to determine the Operating Margin (OM)***

The simple Operating Margin can only be used where low-cost/must run resources constitute less than 50% of total generation in the grid in either the average of the five most recent years or based on long-term normal for hydroelectricity production.

Low cost/must run resources constitute an average of less than 50% of total generation. On this basis, Option A, the Simple OM has been selected

| Year | Hydro (GWh) | Others low cost/must run (GWh) | Total low-cost/must-run resources (GWh)[35] | Total Thai grid generation (GWh)[36] | % of low-cost resources in total grid generation |
|---|---|---|---|---|---|

[35] Table 17 National grid generation by energy source excluded SPP and VSPP, electric power in Thailand 2008

| Year | Hydro (GWh) | Others low cost/must run (GWh) | Total low-cost/must-run resources (GWh)[35] | Total Thai grid generation (GWh)[36] | % of low-cost resources in total grid generation |
|---|---|---|---|---|---|
| 2004 | 6,040 | 2 | 6,042 | 125,727 | 4.8% |
| 2005 | 5,798 | 2 | 5,800 | 132,197 | 4.4% |
| 2006 | 8,125 | 3 | 8,128 | 138,742 | 5.9% |
| 2007 | 8,114 | 3 | 8,117 | 143,378 | 5.7% |
| 2008 | 7,113 | 5 | 7,118 | 147,427 | 4.8% |
| **Average 5 most recent years for which data is available** | | | | | **5.1%** |

***Step 4: Calculate the Operating Margin Emission Factor***

The simple OM emission factor is calculated as the generation-weighted average $CO_2$ emissions per unit net electricity generation ($tCO_2/MWh$) of all generating power plants serving the system, not including low cost / must-run power plants / units. It has been calculated according to Option B.

Option B is calculated based on the net electricity supplied to the grid by all power plants serving the system, not including low cost/must-run power plants, and the fuel types and total fuel consumption of the project electricity system

Note that a conservativeness factor of 95% was applied in the calculation of total emissions.

| Year | Fuel | $FC_{i,m,y}$ (unit) | $NCV_{i,y}$ (TJ/unit)[37] | EF $CO_{2,i,y}$ (tCO2/TJ)[38] | Total Emissions ($tCO_2$) | $EG_{m,y}$ (GWh) | $EF_{grid,OM,y}$ ($tCO_2/MWh$) |
|---|---|---|---|---|---|---|---|
| 2006 | Fuel oil (million l) | 2,030.17 | 39.77 | 75.50 | 6,095,859.50 | | |
| | Diesel (million l) | 40.44 | 36.42 | 72.60 | 106,927.08 | | |
| | Coal&Lignite (thousand tons) | 17,165.93 | 10.47 | 90.90 | 16,337,210.40 | | |
| | Natural gas (mmscf) | 857,103.00 | 1.02 | 58.30 | 50,968,487.00 | | |
| | **Total** | | | | **73,508,490.96** | **138,742** | **0.53** |
| 2007 | Fuel oil (million l) | 942.98 | 39.77 | 75.50 | 2,831,424.75 | | |
| | Diesel (million l) | 24.25 | 36.42 | 72.60 | 64,119.23 | | |
| | Coal&Lignite (thousand tons) | 20,548.83 | 10.47 | 90.90 | 19,556,794.13 | | |
| | Natural gas (mmscf) | 877,862.00 | 1.02 | 58.30 | 52,202,941.69 | | |
| | **Total** | | | | **74,655,264.30** | **143,378** | **0.52** |
| 2008 | Fuel oil (million l) | 357.55 | 39.77 | 75.50 | 1,073,592.14 | | |
| | Diesel (million l) | 45.45 | 36.42 | 72.60 | 120,173.98 | | |

[36] Table 16 National grid generation by types of power plants, electric power in Thailand 2008

[37] Table energy content of fuel (net calorific value), Oil and Thailand 2008

[38] Table 1.4, Default emission factors for stationary combustion in the energy industries, IPCC 2006

| Year | Fuel | $FC_{i,m,y}$ (unit) | $NCV_{i,y}$ (TJ/unit)[37] | EF $CO_{2,i,y}$ (tCO2/TJ)[38] | Total Emissions ($tCO_2$) | $EG_{m,y}$ (GWh) | $EF_{grid,OM,y}$ ($tCO_2$/MWh) |
|---|---|---|---|---|---|---|---|
| | Coal&Lignite (thousand tons) | 21,434.82 | 10.47 | 90.90 | 20,400,011.19 | | |
| | Natural gas (mmscf) | 907,327.00 | 1.02 | 58.30 | 53,955,107.38 | | |
| | **Total** | | | | **75,548,876.64** | **147,427** | **0.51** |
| **Total** | | | | | | | **0.521** |

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

The sample group of power units to be included in the build margin consists of either:
(a) The set of five power units built most recently
(b) The set of power capacity additions that comprise 20% of the system generation in MWh that have been built most recently

Option (b) comprising 20% of the system generation by most recently built power plants has been selected

| Name of power plant | Plant type | Date of commissioning | Installed capacity in 2008 (MW) | Generation in 2008 (GWh) [39] |
|---|---|---|---|---|
| Ratchaburi power 2 | | 1/6/2008 | 700.00 | 5,812,000 |
| Ratchaburi power 1 | Natural gas | 1/3/2008 | 700.00 | |
| Gulf Power Generation Co., Ltd. | Natural gas | 1/3/2008 | 1,468.00 | 9,195,000 |
| BLCP Co., Ltd. power 1 | | 14/11/2006 | 673.25 | 10,801,000 |
| BLCP Co., Ltd. power 2 | Coal | 13/8/2006 | 673.25 | |
| Glow IPP Co., Ltd. | Natural gas | 31/1/2006 | 713.00 | 5,146,000 |
| Eastern Power and Electric Co., Ltd. | Natural gas | 25/3/2006 | 350.00 | 2,670,000 |
| **Total Generation of 5 most recently built power units** | | | | **33,624** |
| **Total % grid contribution of 5 most recently built** | | | | **22.81%** |

***Step 6: Calculate the build margin emission factor***

The build margin emissions factor is the generation weighted average emission factor ($tCO_2$/MWh) of all power units m during the most recent year y for which power generation data is available.

| Plant Name | Commissioning Date | Fuel Type | Capacity (MW) | Generation (MWh) | Efficiency (Btu/kWh)[40] | Effective $CO_2$ emission Factor ($tCO_2$/MWh) | $CO_2$ emission ($tCO_2$) |
|---|---|---|---|---|---|---|---|
| Ratchaburi power 2 | 1/6/2008 | | 700 | | | | |
| Ratchaburi power 1 | 1/3/2008 | Natural gas | 700 | 5,812,000 | 7,051 | 0.426 | 2,477,393.321 |

[39] Table 8, Existing national grid power plant in 2008, electric power in Thailand 2008

[40] Table 18, Electric generation efficiency by types of power plants in 2008, electric power in Thailand 2008

| Plant Name | Commissioning Date | Fuel Type | Capacity (MW) | Generation (MWh) | Efficiency (Btu/kWh) [40] | Effective $CO_2$ emission Factor ($tCO_2$/MWh) | $CO_2$ emission ($tCO_2$) |
|---|---|---|---|---|---|---|---|
| Gulf Power Generation Co., Ltd. | 1/3/2008 | Natural gas | 1468 | 9,195,000 | 6,950 | 0.426 | 3,919,413.556 |
| BLCP Co., Ltd. power 1 | 14/11/2006 | | 673.25 | | | | |
| BLCP Co., Ltd. power 2 | 13/8/2006 | Coal | 673.25 | 10,801,000 | 9,100 | 0.873 | 9,425,384.640 |
| Glow IPP Co., Ltd. | 31/1/2006 | Natural gas | 713 | 5,146,000 | 6,910 | 0.426 | 2,193,507.576 |
| Eastern Power and Electric Co., Ltd. | 25/3/2006 | Natural gas | 350 | 2,670,000 | 6,811 | 0.426 | 1,138,100.511 |
| **$EF_{grid,BM,2008}$ ($tCO_2$/MWh)** | | | | | | | **0.570 ($tCO_2$/MWh)** |

### *Step 7: Calculate the combined margin emission factor*

The combined margin emission factor is calculated as:

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

| | Weighting emission factor | CO2 emission factor ($tCO_2$/MWh) |
|---|---|---|
| $EF_{grid,OM,2006-2008}$ ($tCO_2$/MWh) | 50% | 0.521 |
| $EF_{grid,BM,2008}$ ($tCO_2$/MWh) | 50% | 0.570 |
| **$EF_{grid,CM,y}$ ($tCO_2$/MWh)** | | **0.5453** |

## Annex 4

**MONITORING INFORMATION**

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