Component project activity design document form for small-scale CDM component project activities

(Version 05.0)

Complete this form in accordance with the Attachment "Instructions for filling out the component project activity design document form for CDM small-scale component project activities" at the end of this form.

COMPONENT PROJECT DESIGN DOCUMENT (CPA-DD)	
Title of the CPA	Thailand Small Scale Livestock Waste Management Program CPA 02
Version number of the CPA-DD	09
Completion date of the CPA-DD	18/08/2016
Title of the PoA to which the CPA is included	Thailand Small Scale Livestock Waste Management Program
Host Party	Thailand
Estimated amount of annual average GHG emission reductions	24,801 tCO_2e
Applied methodology(ies) and, where applicable, applied standardized baseline(s)	Methodology AMS III.D. ver. 18 – Methane recovery in animal manure management systems
Sectoral scope(s) linked to the applied methodology(ies)	Sectoral Scope 13 : Waste handling and disposal

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SECTION A. General description of CPA

A.1. Title of the proposed or registered PoA

PoA 8027: Thailand Small Scale Livestock Waste Management Program

A.2. Title of the CPA

Thailand Small Scale Livestock Waste Management Program CPA 02
Document version: 09
Date: 18/08/2016

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A.3. Description of the CPA

Thailand Small Scale Livestock Waste Management Program (hereafter, the "Project") is developed by Energy Research and Development Institute – Nakornping of Chiang Mai University (ERDI). The proposed activity will reduce greenhouse gas emissions from piggeries manure by converting anaerobic lagoons to flow closed anaerobic treatment digesters with biogas capture and power generation in Thailand. ERDI will provide complete CDM service to the participating farm as well as additional technical support for waste management system operation and monitoring. These technical capacity provided by ERDI will ensure long-term sustainability of the project activity.

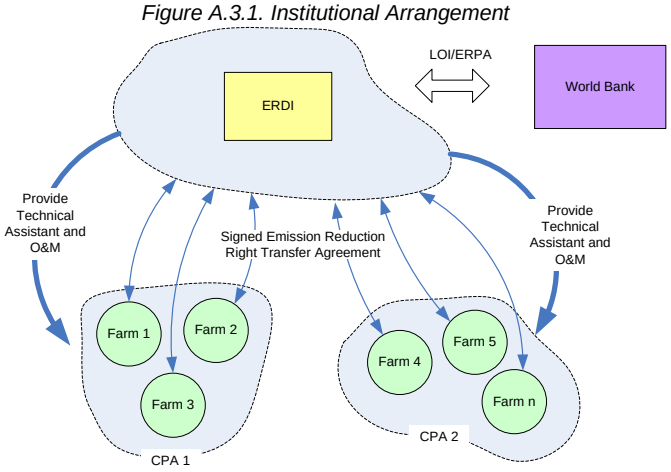
The treatment of livestock manure by way of anaerobic digester processes leads to the production of a biogas consisting of 60% methane (CH4). Currently most farms in Thailand employ normal scraping and hose-down cleaning of the animal waste with a series of anaerobic lagoons within the farms premises. This waste material is left to decay in the individual facility's anaerobic lagoon system, producing significant amounts of methane that is emitted directly to the atmosphere. This current livestock waste management practices contributes to significant air (odor) and water pollution in the areas close to the farms. The project will apply anaerobic digesters, which will capture the biogas and use it to generate electricity for on farm consumption or sale to the national grid.

In addition to improving the local environment quality, the project will also deliver local community benefits related to the creation of new jobs during the construction, operation and maintenance stages of the livestock wastewater management system and to the utilization of methane gas (CH4) as renewable energy resource for the farms. The project activities can also be replicated in other farms around the country which will lead to environmental awareness related to livestock waste management, renewable energy, and climate change.

1. General operating and implementing framework of PoA
The PoA aims to improve the piggeries waste management practice, reduce GHG emissions, and take advantage of the captured renewable energy of livestock farms in different areas of Thailand. The project activity is to convert anaerobic lagoons to an enclosed system, which capture and utilize methane to generate electricity for consumption within the participating farms.

Energy Research and Development Institute – Nakornping of Chiang Mai University (ERDI), is serving as coordinating/managing entity of the PoA. ERDI has overall responsibility for PoA and subsequent CPAs preparation and implementation. Operation and monitoring of each participating farm will be supervised by ERDI. Figure A.3.1 illustrated the institutional arrangement for the POA and CPA. ERDI is an excellence centre in energy-related fields that has been acknowledged at national and international levels. ERDI provide technologies and professional consulting services in energy conservation, renewable energy and other related engineering prospects for government and private organizations.

Figure A.3.1. Institutional Arrangement



Contribution to Sustainable Development

The project supports Thailand's sustainable development strategy in the following ways:

1) Effectively reducing CH_4 emissions from animal wastes. The project activity consists of an advanced improvement from the common practice of livestock waste treatment, reducing CH_4 and N_2O emissions from livestock waste through biogas digesters with methane capture and utilization;
2) Improving the local environment and human health. Properly handling of large quantities of animal waste is critical to protecting human health and the environmental quality. The advanced livestock waste management system to be employed will reduce the nuisance of odors and wastewater, benefiting both farmers' and children's health;
3) Creating job opportunities and increasing farmers' income. This project activity will increase local employment for skilled labor during production, installation, operation, and maintenance of the anaerobic digestion and electricity generation equipment and systems;
4) Localizing energy production. The project will diversify the source of the energy supply through biogas production and biogas-based power generation. The effort will substitute local energy for electricity from the grid which relies mainly on fossil fuel;
5) Establishing a positive model of swine waste management practice for other livestock operations. The project activity will apply new, advanced, and environmentally friendly technologies in treating swine wastes and associated utilization, which can be replicated on other livestock farms, which will dramatically reduce livestock-related GHG emissions.

2. Policy/measure or stated goal of the PoA

The PoA is addressing three important policies in Thailand.

- Notification of the Ministry of Natural Resources and Environment, Effluent Standard for Pig Farm [1] dated November 7, B.E. 2548 (2005) requires effluent discharges into watercourses from swine farms to have total suspended solids of below 150 mg/L and BOD of less than 60 mg/L.

[1] Published in the Royal Government Gazette, Vol. 122 Part 125 D, dated December 29, B.E. 2548 (2005)

The Notification has been announced since 2005, there are limited numbers of pig farms that able to meet the set standard through the application of advance anaerobic wastewater treatment proposed by the POA.

- Energy Development plan for B.E. 2551-2565 (2008-2022)[2]. The objective of the plan is to increase the percentage share of renewable energy from 6.4% in 2008 to 20% in 2022 with various measures including the promotion of energy from agriculture waste.

  The POA will provide strong support for the policy by providing incentives as well as technical assistance for the participating farm to generate renewable energy in line with the policy.

- Thailand Climate Change Strategy (2007-2011)[3]: Greenhouse gas mitigation through development of renewable energy from waste material.

3. Confirmation that the proposed PoA is a voluntary action by the coordinating/managing entity

The proposed PoA is a voluntary action by the coordinating/managing entity. All farms participate in the PoA voluntarily. The stated policies encourage the farms to adopt clean technologies for waste management and use alternative energy while reducing greenhouse gases. These actions are not mandatory.

A.4. Entity/individual responsible for the operation of CPA

The entity responsible for the CPA 02 is ERDI, the Energy Research and Development Institute – Nakornping of Chiang Mai University. ERDI is also the coordinating/managing entity (CME) of the PoA and thus the entity which communicates with the Board.

A.5. Technical description of the CPA

The CPA replaces an open anaerobic manure management system with an anaerobic digestion system with methane recovery and combustion.

The project improves current practices of open lagoons by substituting businesses as usual procedures for the new technology provided by ERDI. This results in methane recovery and mitigation of GHG emissions, by controlling the decomposition process of open-air lagoons and by capturing and combusting the produced biogas, which in turn produces renewable energy that would have otherwise been produced by non-renewable sources. The treatment of the manure from the swine activity is accomplished by the decomposition of the manure inside the biodigester which produces the biogas that is combusted in the enclosed flare system reducing the emissions of GHG's.

The technology employed by the SSC-CPA is anaerobic wastewater treatment technologies. Anaerobic digestion technologies capture methane for use in energy applications and provide other environmental benefits related to water and air quality, human health and GHG reduction. The waste from all farms described in each SSC-CPA is collected daily or every other day by hose flushing all material through a series of collection channels. These channels currently connect to anaerobic lagoons at these farms. The project connects these channels to (a) a screen, (b) a sand trap, and (c) a collection tank. The purpose of the screen and sand trap is to remove the undesirable inert material which could accumulate in the digester causing problems over time. The

[2] Announced by Department of Alternative Energy Development and Efficiency (DEDE) on 7 June 2007 http://www.dede.go.th/dede/fileadmin/upload/nov50/mar52/REDP_present.pdf

[3] http://www.onep.go.th/index.php?option=com_content&task=view&id=503

collection tank is to collect all separated waste material at one central point to be then pumped to the anaerobic digester following a daily digester charging schedule.

From the collection tank, waste is transferred to the anaerobic digester, of which the technology was designed by ERDI. The schematic design of the technology is illustrated in Figure

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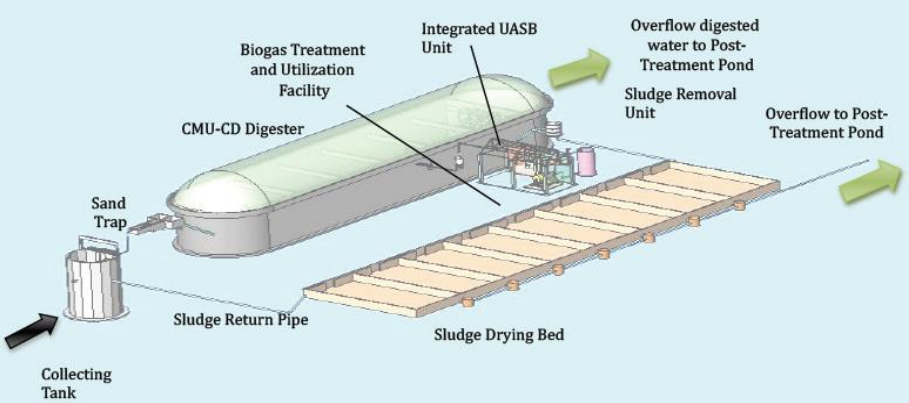
Figure A.5.1. – Schematic Design of ERDI Anaerobic Technology



The digestion tank first receives the separated waste material from the collection tank. The digestion tank serves three purposes: (a) it initiates the anaerobic process and establishes methanogenic activity; (b) it allows solids settling, which increases the Solids Retention Time (SRT) to about 40 days; and (c) the extended SRT maximizes gas production while allowing the remaining Chemical Oxygen Demand (COD) in the solid fraction to be desorbed into the liquid phase.

After the digestion tank reduces solids content and concentrates remaining COD in the liquid phase, the liquids flow into a high rate up-flow reactor. This type of reactor requires dilute wastes and can tolerate fine solids which form the biomass where the majority of microbial populations operate and convert the remaining COD into methane.

Electricity energy is generated by combusting the biogas produced from the digester. Hydrogen sulfide (H_2S) is removed with a biological scrubber to reduce the corrosive effects on the engines critical parts when combusted. Biological scrubbers contain sulfur-oxidizing bacteria to remove H_2S. Flaring unit is included in the gas use system to avoid venting of biogas

The anaerobic system produces two separate effluent streams. The first is solid, which due to biological activity are reduced to sludge. However, this material accumulates in the digestion tank and is removed periodically. The solids are removed to sludge drying beds and sold as fertilizer and soil conditioner. The second effluent stream is stabilized liquid from the up-flow anaerobic reactor. These liquids are proposed to flow to a clarifier and then flow to a series of storage ponds for further use as irrigation water and recycle within the farm.

The technical specifications of major equipment in the system are presented below:

Table A.5.1: Technical Specifications of Major Equipment in the System (farm-wise)

Farm	Digester (m^3)	Generator (kW)	Flare (type)
Charoenphansamchuk Farm	6,250	2 x 328 (operated at 260 kW)	Open

A.6. Party(ies)

Name of Party involved (host) indicates host Party	Private and/or public entity(ies) CPA implementer(s) (as applicable)	Indicate if the Party involved wishes to be considered as CPA implementer (Yes/No)
Thailand (host)	Energy Research and Development Institute – Nakornping of Chiang Mai University	No
Portugal	International Bank for Reconstruction and Development as Trustee of the Carbon Fund for Europe ; Government of Portugal – Portuguese Carbon Fund	No

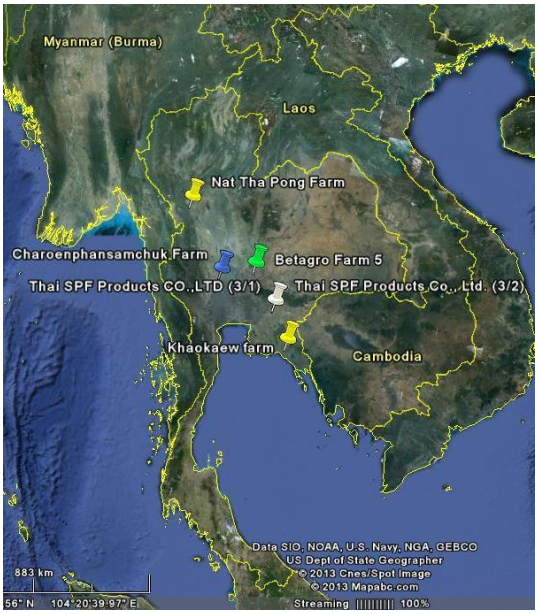
A.7. Geographic reference or other means of identification

The physical location of each of the participating farm of the small-scale CPA is contained in Table A.7.1.

Table A.7.1: Location of the small-scale CPA

Farm	Nearest town	North coordinate	East Coordinate
Charoenphansamchuk Farm	Samchuk	14.751403	99.991675

Figure A.7.1: Map illustrating farm location



A.8. Duration of the CPA

A.8.1. Start date of the CPA

11/10/2009, the start date corresponds to the date when the Letter of Intent was signed.

A.8.2. Expected operational lifetime of the CPA

10 years

A.9. Choice of the crediting period and related information

Fixed crediting period

A.9.1. Start date of the crediting period

01/12/2014

A.9.2. Length of the crediting period

10 years, or no later than the end of the PoA

A.10. Estimated amount of GHG emission reductions

Emission reductions during the crediting period	
Years	Annual GHG emission reductions (in tonnes of CO_2e) for each year
01/12/2014-31/12/2014	2,066
2015	24,801

Emission reductions during the crediting period	
Years	Annual GHG emission reductions (in tonnes of CO_2e) for each year
2016	24,801
2017	24,801
2018	24,801
2019	24,801
2020	24,801
2021	24,801
2022	24,801
2023	24,801
01/01/2024-30/11/2024	22,734
Total number of crediting years	10
Annual average GHG emission reductions over the crediting period	24,801
Total estimated reductions (tonnes of CO_2e)	248,009

A.11. Public funding of the CPA

There is no public funding from Annex I parties supporting this PoA.

A.12. Debundling of small-scale component project activities

The proposed small-scale CPA of a PoA is not deemed to be a debundled component and the total size of CPA does not exceed the limits for small-scale CDM. The eligibility criteria has screened out debundled project by excluding project with the same project owner, whose location is less than 1 km. from another project site.

A.13. Confirmation for CPA

Prior to the inclusion of a CPA in the proposed PoA, agreements for CERs ownerships will be signed between the coordinating entity and the participating farms. Signed contract between ERDI and the participating farm is also an eligibility criteria of the PoA.

A.14. Contact information of responsible persons/ entities for completing the CDM-SSC-CPA-DD-FORM

Pruk Aggarangsi
Alongkorn Siripat
Energy Research and Development Institute - Nakornping
Chiang Mai University, Thailand

In collaboration with
Juha Antti Kalevi Seppala
Nontaya Krairiksh
Claudia Barrera
World Bank Group, IBRD
Climate and Carbon Finance Unit
1818 H Street NW
Washington, DC 20433

SECTION B. Environmental analysis

B.1. Analysis of the environmental impacts

The environmental analysis was undertaken at the PoA level. An Initial Environmental Evaluation Report (IEE) and Environmental Management Framework (EMF) were prepared for submission to the DNA.

Each participating farm will adopt its own Environmental Management Plan (EMP) drawn from the IEE of the POA. As per the Thai regulation, an eenvironmental impact assessment is not required for a typical CPA with installed electricity generation capacity less than 10 MW.

The analysis of environmental impacts of the project activities was undertaken in comparison of the impacts of the old anaerobic lagoon system. Four aspects of environmental impacts were identified as a result of the wastewater treatment operations, which are:

1. Air pollution – the biogas generated will be used to generate electricity for onsite consumption, this would reduce fossil fuel based electricity generation and related suspended particles, SOx and NOx are therefore reduced;
2. Wastewater pollution – the new wastewater system can remove more than 90% of organic matter in the wastewater so that environmental impacts of possible overflow during the rainy season or of groundwater contamination will be significantly reduced;
3. Odor – since the new wastewater treatment system operates in a closed system, undesirable odor will be significantly reduced; and
4. Solid waste disposal – the new system has installed a sand drying bed for sludge separation which will improve the handling of solid waste, whereby the environmental impacts is reduced.

SECTION C. Local stakeholder comments

C.1. Solicitation of comments from local stakeholders

The CPS farm stakeholder meeting was organized on 05/09/2013 at Office of the Village headman moo 2 Tambon Samchuk, Amphur Samchuk Suphanburi. Invitations were sent by letters. The consultation was well attended by 102 people were mainly the villages who live close to the project site.

C.2. Summary of comments received

Summary of comments received for CPS Farm:

Questions	Response
What are the disadvantages of Biogas Treatment Plant?	Operation is the key of Biogas plant. If The operator does not discharge sludge from the digester regularly, the volume of treated waste by the Digester could decrease making the efficiency of the Biogas plant decrease, causing bad smell.
Can Villagers use the electricity generated from biogas?	Electricity generated from biogas will be used in farm only.
What farm going to do with the Treated wastewater after treatment?	Treated wastewater after treatment are not discharged into natural water resources, All will recycle used for Agriculture.

Questions	Response
Can Villagers use the effluent from Post Treatment for growing rice?	Yes, Villagers can use the effluent from Post Treatment for growing rice.

C.3. Report on consideration of comments received

The stakeholder consultation at CPS Farm was also divided into four sessions: (1) Presentation of the project to the local stakeholders; (2) Description of what the CDM means for this project; (3) Description of the environmental impacts from this project and the topic of global warming in general; and (4) Q&A session. Since the reaction was positive and comments were requests for clarifications, no specific additional issues concerning project design were required.

SECTION D. Eligibility of CPA and estimation of emissions reductions

D.1. Reference of methodology(ies) and standardized baseline(s)

AMS-III.D. Methane recovery in animal manure management systems, version 18.0.

D.2. Applicability of methodology(ies) and standardized baseline(s)

The proposed CPA meets the applicability condition of methodology AMS III.D as follows:

Applicability conditions AMS III.D – Version 18.0	Reference of the documentation of the compliance of the CPAs
This methodology covers project activities involving the replacement or modification of existing anaerobic manure management systems in livestock farms to achieve methane recovery and destruction by flaring/combustion or gainful use of the recovered methane. This methodology is only applicable under the following conditions:	The project activity involves the replacement of existing anaerobic manure management systems which emits methane in livestock farms to achieve methane recovery and destruction by combustion/flaring use of the recovered methane, at an alternative site on existing farm.
(a) The swine population in the farm is managed under confined conditions;	Yes, all participating farms in the CPA manage their livestock under confined conditions as per the Baseline Farm Survey for each farm.
(b) Piggeries waste generated are not discharged into natural/public waterways;	No, livestock waste from participating farms has not been discharged into natural/public waterways. Livestock waste was kept in open anaerobic lagoon as per the IEE 2009 and Baseline Farm Survey for each farm.
(c) In the baseline scenario the retention time of manure waste in existing anaerobic lagoon is at least 1 month;	Yes, the retention time of manure waste in anaerobic lagoon is at least 1 month as per the mini Project Implementation Plan (mini PIP). The hydraulic retention time of each farm in the CPA is as follows: • Charoenphansamchuk Farm; 97 days
(d) The depth of the existing anaerobic lagoon is at least 1 meter;	Yes, the depth of the existing anaerobic lagoon is at least 1 meter as per the Baseline Farm Survey for each farm.

Applicability conditions AMS III.D – Version 18.0	Reference of the documentation of the compliance of the CPAs
(e) No methane recovery and destruction by flaring, combustion or gainful use takes place in the baseline scenario;	No, there is no methane recovery and destruction by flaring combustion or gainful use takes place in the baseline scenario of the participating farms since livestock waste was kept in open anaerobic lagoon as per the Baseline Farm Survey for each farm.
(f) The annual average temperature of baseline site where anaerobic manure treatment facility is located is higher than 5ºC.	Annual average temperature for each farm is as follows: • Charoenphansamchuk Farm: 27 °C Source: Thai Meteorological Department, Automatic Weather System (AWS), found online at http://www.aws-observation.tmd.go.th/web/reports/weather_years.asp
(g) The residual waste form the animal manure management system shall be handled aerobically.	The residual waste from the animal manure management systems will be handled aerobically as per Section D.6.3. of this CPA-DD.
(h) Technical measures shall be used to ensure that all biogas produced by the digester is used or flared.	All biogas produced by the digester is used or flared as per Section D.6.3. of this CPA-DD and the mini Project Implementation Plan (mini PIP) of each farm.
(i) The storage time of the manure after removal from the animal barns, including transportation, should not exceed 45 days before being fed into the anaerobic digester.	The storage time of the manure after removal from the animal barns, including transportation, does not exceed 45 days as per the mini Project Implementation Plans.
(j) If the proposed CPA includes new facilities (Greenfield projects) and project activities involving capacity additions compared to the baseline scenario, these will only be eligible if they comply with the related and relevant requirements in the General Guidelines to SSC CDM methodologies	The project does not involve a new facility.
(k) The requirements concerning demonstration of the remaining lifetime of the replaced equipment shall be met as described in the General Guidelines to SSC CDM methodologies.	The project activity does not seek to retrofit or modify an existing unit or equipment therefore this does not apply.
(l) The aggregate emission reductions should be less than or equal to 60 kt CO_2.	Documented as per Section D.6.4. and ER calculation spreadsheet. The aggregate emission reductions of the CPA calculated ex-ante is 24,801 tCO_2e is less than 60,000 tCO_2e.

D.3. Sources and GHGs

Source		Gas	Included/Excluded	Justification/Explanation
Baseline	Direct emissions from the uncovered anaerobic lagoon	CH_4	Included	Main emission source
		N_2O	Excluded	Excluded for simplification
		CO_2	Excluded	Excluded for simplification
	Emissions from Electricity consumption	CH_4	Excluded	Excluded for simplification
		N_2O	Excluded	Excluded for simplification
		CO_2	Excluded	Excluded for simplification
	Emissions from thermal energy generation	CH_4	Excluded	Excluded for simplification
		N_2O	Excluded	
		CO_2	Excluded	
	Emissions from	CH_4	Excluded	

Source		Gas	Included/Excluded	Justification/Explanation
Project Activity	thermal energy generation	N_2O	Excluded	Even though they are expected to be minor, emissions from fossil fuel combustion have been included.
		CO_2	Included	
	Emissions from onsite electricity use	CH_4	Excluded	Excluded for simplification
		N_2O	Excluded	
		CO_2	Included	The electricity consumed from the grid by the manure management facilities used by the project activity, will be accounted for.
	Direct emissions from the anaerobic digester process	CH_4	Included	Main emission source
		N_2O	Excluded	Excluded for simplification
		CO_2	Excluded	Excluded for simplification
	Direct emissions from the sludge pond	CH_4	Excluded	Excluded for simplification
		N_2O	Excluded	Excluded for simplification
		CO_2	Excluded	Excluded for simplification
	Emissions from flaring	CH_4	Included	Main emission source
		N_2O	Excluded	Excluded for simplification
		CO_2	Excluded	Excluded for simplification

The geographical boundary of the CPA is within Thailand. The participating farms under the CPA are located in Thailand, therefore within the geographical boundary of the registered PoA.

D.4. Description of the baseline scenario

As explained above, and as documented on the baseline surveys for each farm, in the baseline they are operating an open anaerobic wastewater system. For complete details, and applicability of the methodology please refer to section D.2. above.

D.5. Demonstration of eligibility for a CPA

The eligibility criteria for enrolling the CPA are as follows:

1. The CPA is located in Thailand (see Section A.7).
2. A Confirmation letter from the CPA implementer has been received sating that the CPA is not a component of another CDM programme, has not been registered as a project activity of another CDM project, is undergoing validation within another CDM project, nor is a debundled component of a large scale project activity . The **unique identification number** of this CPA is: 02: and the g**eographical coordinates** of each farm are shown in Section A.4.1.2. In addition, the CME has checked the UNFCCC website, and did not find the projects name or coordinates.
3. The CPA use the same technology as stated in the PoA. The feasibility study confirms the primary technology and biogas utilization situation.
4. The start date of the CPA is 11/10/2009.
5. The proposed CPA meets the applicability condition of methodology AMS III.D version 18 as previously stated in Section D.2.
6. The proposed CPA meets the project activity criteria to be eligible under this PoA:

(a) The range of wastewater treatment system size should be between 300 m^3 to 20,000 m^3;	Yes, the wastewater treatment system size for the participating farm in this CPA are: • Charoenphansamchuk Farm: 6,250 m^3

(b) The project is not located in a protected area and/or disputed area;	No, there are no participating farms located in protected areas as documented on their IEE Reports
(c) The owner of the project has been authorized to operate at the project location;	Yes, all participating farms have been authorized to operate as per their Business licence.
(d) There is available space for the project activity at the existing project location;	Yes, all participating farms have available spaces for the new treatment system at existing project location as per IEE Report.
(e) Availability of the necessary data (i.e. swine population etc.) for calculating of emission reduction and the crediting period as for the verification of emission reductions there needs to be reliable data at the farm.	The participating farms provided necessary data for calculating of emission reduction and the crediting period as per the mini PIP.
(f) Emission reductions claimed under the CPA are those derived only from avoided gas emissions into the atmosphere, from the use of methodology AMS.III.D. No credits will be claimed from any uses of the gas.	The emission reduction to be claimed from this CPA is only those accounted in the methodology AMS-III.D as per the demonstration in section D.6.3. of this CPA-DD.
(g) The storage time of the manure after removal from the animal barns, including transportation, does not exceed 24 hours before being fed into the anaerobic digester while the dry matter content of the manure when removed from the animal barns is less than 20%.	Even though the dry matter content of the manure when removed from the animal barns is less than 20%, it has been documented on the CPA- DD (and as per the project implementation plans) that the digesters shall be located at each of the farm sites and confirmed that waste shall be flushed, making sure that waste flows directly to the digester with no storage time. The location has also been confirmed by a site visit by ERDI staff. Therefore it is confirmed that the storage time of the manure after removal from the animal barns, does not exceed 24 hours before being fed to the digester.

7. The proposed CPA meets the additonality conditions as per the "Guidelines on the demonstration of additionality of small-scale project activities" v9 (previously known as attachment A to Appendix B) as follows:

Additionality	
(a) If the farm is operating, it has an open anaerobic wastewater system in the baseline; however if the farm is a new facility or involves capacity additions compared to the baseline scenario, it must comply with criteria (r) above.	The farms are operating an open anaerobic wastewater system in the baseline as documented on the projects site visit by ERDI. In addition the project provided the IEE 2009 and Baseline Farm Surveys, where it has also been documented that the site operates an open anaerobic lagoon.
(b) The technology used by the project activity is the same one provided by ERDI for all CPAs.	Documented on the signed contract between the participating farms and ERDI
(c) Project is not financially attractive without CDM revenues	Documented financial analysis in the section below, demonstrates that the project is not financially attractive without the CDM revenues

(d) The farm is compliant with the applicable Thai environmental rules and regulations	The participating farms are in compliance with the Notification of the Ministry of Natural Resources and Environment specifying the Effluent Standard for Pig Farm dated November 7, B.E. 2548 (2005) as per the IEE 2009.

8. The project has undertaken a stakeholder consultation as outlined in Section C. The lists of attendees and minutes of the meeting have been documented below.
9. There is no funding from Annex I country.

Demonstration of criteria c) above: Project is not financially attractive without CDM

Since the main barrier is that of the Investment barrier, the section below demonstrates how the farms in CPA02 would not have implemented this project activity, as continuation of the prevailing practice (anaerobic lagoons) is a more viable option that would have led to higher emissions.

An economic comparison was made for the proposed project activity with two scenarios: with and without CDM revenues; this was done for each farm individually. A summary of the analysis is shown below, and further details have been included in the Annex 3.

Project Assumptions:
All farms included in the PoA will use the same technology, as will be provided by the coordinating entity, ERDI. Each farm will install a biodigester system, which will collect biogas that will then be used for energy generation that will be used on-site, but no emission reductions will be claimed from the generation of energy.

For each farm we have that:
Benefits:

- Income from CDM revenue
- Income from sale of sludge as fertilizer
- Income from 'savings' due to energy that is no longer bought from the national grid

Investments:

- Cost of converting the open lagoons to covered anaerobic lagoon with biogas capture
- Cost of biogas engine generator sets
- Cost of operation and maintenance of the installed equipment
- Cost of operations related to CDM monitoring (additional laboratory analysis)

Conclusions:

- Income from electricity production and sales of fertilizer only will give a payback time of about 6 years at Charoenphansamchuk Farm.
- With the additional income from sales of CERs credits, the payback time is reduced to about 2 years at Charoenphansamchuk Farm.

The project activities with this high upfront investment costs can only start with the financial support of the local banks. Therefore, in order to get the bank loan support for the project activities, the income from the sales of CERs credits is crucial. It is essential to overcome this investment barrier.

Below are the tables with the summary of the analysis for each farm

Table B.3i) –Economic and benchmark comparison demonstrating the investment barrier (THB)

Farm	**IRR without CDM**	**Benchmark (WACC)**	**IRR with CDM**
1. Charoenphansamchuk Farm	12.74%	14.79%	36.39%

Source: Details of investment analysis are presented in Annex 3

The benchmark chosen for comparison is the weighted average cost of capital (WACC), which is estimated from the potential return on investment if the project takes 50% loan from the bank and 50% would have been invested in the stock market. The benchmark comparison shows that the project IRR without CDM is lower than the benchmark, while the project IRR with CDM is higher than the benchmark. Hence it can be concluded that the project would not be possible without revenue from CDM.

In order to test the robustness of the assumptions made, sensitivity analyses were carried out and the results are as follows:

Table B.3ii) –Sensitivity Analysis (THB) for Charoenphansamchuk Farm

Sensitivity	Investment Cost	Electricity Cost	Operating Expenses	WACC
10%	11.10%	14.67%	12.29%	14.79%
5%	11.89%	13.71%	12.52%	14.79%
0%	12.74%	12.74%	12.74%	14.79%
-5%	13.68%	11.76%	12.97%	14.79%
-10%	14.72%	10.78%	13.19%	14.79%

The sensitivity analyses show that in spite of the range of realistic and optimistic assumptions (±10% variation) made, the projects remain financially unattractive. Further analysis shows that the benchmark will be reached with very high variation in these key parameters (shown in the table below).

Farm	Investment Cost	Electricity Price	Operating Expenses
1. Charoenphansamchuk Farm	Decrease by more than 10%	Increase by more than 10%	Decrease by more than 45%

As of the fact that the country's annual average inflation rate[4] of only 3.23 per cent (during 2010-2005) and the regulated price of electricity, it is very unlikely that the electricity price would reach, and remain, at 10% of the current regulated price over the crediting period of 10 years. Since the investment costs, as well as annual operating expenses, were estimated based on the system design, significant decrease in these values is not foreseen. Moreover, the unlikelihood of the decrease of operating expenses can be justified by the annual inflation rate of 3.23% mentioned earlier.

In summary, continuation of the anaerobic lagoons is a more viable option than implementation of the project activity without CDM revenues.

Detailed Financial Analysis:

1. Charoenphansamchuk Farm

PLANT PARAMETER	
Operational power generator capacity (kW) Gen No.1	260[5]
Operational power generator capacity (kW) Gen No.2	260

[4] Bank of Thailand database: http://www2.bot.or.th/statistics/ReportPage.aspx?reportID=409&language=th

[5] The assumed generator capacities during the time of financial analysis were expected to be 270 kW installed capacity, of which 220 kW would be actual operating capacity. In reality, installed capacity is 328 kW, and operational capacity is 260 kW.

Runtime per day Gen No.1	14
Runtime per day Gen No.2	14
Operating Hours per year	9,240
Electricity Reduction (MW/year)	1,972
COST PARAMETER	
Project Cost (Thai Baht)	
1. Biogas System	13,851,333
2. Gas Engine & Electrical System	6,000,000
3. Other equipment	667,500
Total	**20,518,833**
Cost per year (Thai Baht/year)	
1.Waste Treatment Plant Maintenance	434,363
2. Operation Cost	640,671
3. Laboratory and Analysis Costs (without CDM)	20,200
4. Laboratory and Analysis Costs (with CDM)	77,000
Total (w/o CDM)	**1,095,234**
Total (w CDM)	**1,152,034**
REVENUE	
1. Electricity Cost Reduction (Average Sale Price 2.46 Bath/kWh)	4,850,667
2. Fertilizer	587,520
3. CERs Sale	4,432,435
4. ERDI Subsidy	3,369,600

FINANCIAL ANALYSIS - Without CDM				
Item/years	**0**	1	n+1	10
REVENUE				
Electricity cost reduction		4,850,667	4,850,667	4,850,667
Fertilizer		587,520	587,520	587,520
Fair value of assets				10,259,417
Total Revenue		5,438,187	5,438,187	15,697,604
OPERATING EXPENSE				
Initial Investment cost	20,518,833			
Depreciation		1,025,942	1,025,942	1,025,942
Expenses & Maintenance		1,095,234	1,095,234	1,095,234
Total Expense	20,518,833	2,121,176	2,121,176	2,121,176
Annual Revenues-Costs (before tax)	-20,518,833	3,317,012	3,317,012	13,576,428
Tax		995,103	995,103	4,072,928
Project Cash Flow	-20,518,833	3,347,850	3,347,850	10,529,441
IRR	**12.74%**			
Payback period	**6.19**			

FINANCIAL ANALYSIS - With CDM				
Item/years	**0**	1	n+1	10
REVENUE				
Electricity cost reduction		4,850,667	4,850,667	4,850,667
Fertilizer		587,520	587,520	587,520
CDM Revenue		4,432,435	4,432,435	4,432,435
Fair value of assets				10,259,417
Total Revenue		9,870,622	9,870,622	20,130,039

OPERATING EXPENSE				
Initial Investment cost	17,149,233			
Depreciation		1,025,942	1,025,942	1,025,942
Expenses & Maintenance		1,152,034	1,152,034	1,152,034
Depreciation	17,149,233	2,177,976	2,177,976	2,177,976
Annual Costs-Revenues (before tax)	-17,149,233	7,692,646	7,692,646	17,952,063
Tax		2,307,794	2,307,794	5,385,619
Project Cash Flow	-17,149,233	6,410,794	6,410,794	13,592,386
IRR	**36.39%**			
Payback period	**2.23**			

1) The farm is compliant with the applicable Thai environmental rules and regulations.

Compliance with the Notification of the Ministry of Natural Resources and Environment specifying the Effluent Standard for Pig Farm dated November 7, B.E. 2548 (2005).

In summary, as demonstrated by the above barriers, the CPA meets the additionality criteria as set on the PoA-DD.

As demonstrated, the small-scale CPA is in compliance with all requirements.

D.6. Estimation of emission reductions

D.6.1. Explanation of methodological choices

The emission reductions achieved by the project activity will be determined ex-post through direct measurement of the amount of methane fuelled, flared or gainfully used.

$$ER_y = BE_y - PE_y$$

Where:
ER_y: Emission reductions achieved by the project activity for year "*y*" (tCO_2e)
BE_y: Baseline emissions calculated
PE_y: Project emissions calculated

Baseline emissions are determined as follows:

$$BE_y = GWP_{CH4} * D_{CH4} * UF_b * \sum_{j,LT} MCF_j * B_{O,LT} * N_{LT,y} * VS_{LT,y} * MS\%_{B,j}$$

Where:

BE_y: Baseline emissions in year "*y*" (tCO_2e)

GWP_{CH4}: Global Warming Potential (GWP) for methane (25)

D_{CH4}: CH_4 density (0.00067 t/m³ at room temperature (20 ºC) and 1 atm pressure).

LT: Index for all types of livestock

j: Index for animal waste management system

MCF_j: Annual methane conversion factor (MCF) for the baseline animal waste management system "*j*"

$B_{O,LT}$: Maximum methane producing potential of the volatile solid generated for animal type "*LT*" (m³ CH_4/kg dm)

$N_{LT,y}$: Annual average number of animals of type "*LT*" in year "*y*" (numbers)

$VS_{LT,y}$: Volatile solids for livestock "*LT*" entering the animal manure management system in year "*y*" (on a dry matter weight basis, kg dm/animal/year)

$MS\%_{Bl,j}$: Fraction of manure handled in baseline animal manure management system "*j*"

UF_b: Model correction factor to account for model uncertainties (0.94)

Volatile solids for livestock according to 2006 IPCC Guidelines for National Greenhouse Gas, use IPCC default value in Table 10A-7 Manure Management Methane Emission Factor Derivation for Market Swine, and Table 10A-8 Manure Management Methane Emission Factor Derivation for Breeding Swine. There is no VS data available from nationally published resource. In case default IPCC values for VS are adjusted for a site-specific average annual weight, the following formula shall be used:

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Volatile solid for livestock "LT" entering the animal manure management system "j":

$$V_{Ly} = \left(\frac{W_s}{W_{default}} \right) * V_d^i * nd_y$$

Where:

W_s: Average animal weight of a defined livestock population at the site (kg)

$W_{default}$: Default average animal weight of a defined population, this data is sourced from IPCC 2006 (kg)

$VS_{default}$: Default value for the volatile excretion rate per day on a dry-matter basis for a defined livestock population (kg dm/animal/day)

nd_y: Number of days in year "*y*" where the animal manure management system is operational

The annual average number of animals ($N_{LT,y}$) are determined as follows:

$$N_{LT,y} = N_{da,y} * \left(\frac{N_{p,y}}{365} \right)$$

Where:

$N_{da,y}$ Number of days animal is alive in the farm in the year *y* (numbers)

$N_{p,y}$ Number of animals produced annually of type *LT* for the year *y* (numbers)

The calculation of the average number of animals ($N_{LT,y}$) is done monthly based on each farms internal records filled in by farm manager or assigned personnel. It presents the records of animal entries (purchase; births, internal transfer) and exit (ex: sale, death, internal transfer) and the final monthly record of animals per animal category (ex: nursery, farrow, fattening 1 and fattening 2, breeding male, breeding female, pregnant sow).Using this approach for calculating $N_{LT,y}$, it is not necessary to calculate separately an $N_{da,y}$ and $N_{p,y}$, since the number of days the animal are alive ($N_{da,y}$) and the number of animals produced per category LT ($N_{p,y}$) are already implicitly considered in the monthly records and taken into account when calculating $N_{LT,y}$. The farms internal records with weekly logs are then the input for the emission reduction calculation spreadsheet and aggregates the monthly average number of animals per animal category per farm for all farms included in the PDD

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Project activity emissions are determined as follows:

Project activity emissions consist of:

a) Physical leakage of biogas in the manure management systems which includes production, collection and transport of biogas to the point of flaring/combustion or gainful use ($PE_{PL,y}$);
b) Emissions from flaring or combustion of the gas stream ($PE_{flare,y}$);
c) CO_2 emissions from use of fossil fuels or electricity for the operation of all the installed facilities ($PE_{power,y}$).
d) CO_2 emissions from incremental transportation distances ($PE_{transp,y}$).
e) Emissions from the storage of manure before being fed into the anaerobic digester ($PE_{storage,y}$).

$$PE_y = PE_{PL,y} + PE_{flare,y} + PE_{power,y} + PE_{transp,y} + PE_{storage,y}$$

Where

PE_y: Project emissions in year "*y*" (tCO_2e)

$PE_{PL,y}$: Emissions due to physical leakage of biogas in year "*y*" (tCO_2e)

$PE_{flare,yr}$: Emissions from flaring or combustion of the biogas stream in the year "*y*" (tCO_2e)

$PE_{power,y}$: Emissions from the use of fossil fuel or electricity for the operation of the installed facilities in the year "*y*" (tCO_2e)

$PE_{transp,y}$: Emissions from incremental transportation in the year *y* (tCO_2e);

$PE_{storage,y}$: Emissions from storage of manure (tCO_2e)

As explained in the PoA-DD, waste collection from all farms described in this program are collected daily or every other day by hose flushing all material through a series of collection channels, operating by gravity. These channels, under the CPAs, will be connected to the waste treatment system installed at each farm as designed by the ERDI patented technology. This means that as per the technology to be implemented, the waste material will be flushed/pumped every day to the anaerobic digester following a daily digester charging schedule. Therefore, since there will be no incremental transportation under this PoA, as manure management systems will be implemented at the farms, and at the same time there will be no storage of manure as it will flow directly from the barns to the manure management system, the last two terms are determined to be zero. The other sources of project emissions are calculated as follows:

Project emissions due to physical leakage of biogas in year "*y*" ($PE_{PL,y}$)

$$PE_{PL,y} = AD_L * GWP_{CH4} * \sum_{i,T} B_{o,T} * MS\%_{i,y} * VS_{T,y} * MCF_{i,y}$$

Where:

$MS\%_{i,y}$: Fraction of manure handled in system "i" in year "y"

Project emissions from flaring of biogas stream ($PE_{flare,y}$)

Methane may be released as a result of incomplete combustion in case of biogas use for electricity production. To calculate project emissions from flaring of a residual gas stream containing methane ($PE_{flare,y}$) the *"Tool to determine project emissions from flaring gases containing Methane"* will be used.

Emissions due to flaring of biogas in year "*y*" (tCO_2e)

$$PE_{flare,y} = \sum_{h=1}^{8760} T_{eR,h,G} * (1 - \eta_{flare,h}) * \frac{GWP_{CH4}}{1000}$$

Where:

$TM_{RG,h}$: Mass flow rate of methane in the residual gas in the hour *h* (kg/h)

$\eta_{flare,h}$: Flare efficiency in hour *h*

Mass flow rate of methane in the residual gas in the hour *h*

$$TM_{RG,h} = FV_{RG,h} * fv_{CH4,RG,h} * \rho_{CH4,n}$$

Where:

$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal (Nm^3/h) conditions in hour *h*

$fv_{CH4,RG,h}$: Volumetric fraction of methane in the residual gas on dry basis in hour *h* (NB: this corresponds to $fv_{i,RG,h}$ where *i* refers to methane).

$\rho_{CH4,n}$: Density of methane at normal conditions

The list of parameters, as required under the "*Tool to determine project emissions from flaring gases containing Methane"* will be monitored ex-post and $PE_{flare,y}$ will be adjusted accordingly.

Project emissions from the use of fossil fuel or electricity for the operation of the installed facilities $PE_{power,y}$

a) Project emissions from electricity consumption in year *y* ($PE_{EC,y}$)

As per the methodology, project emissions from electricity consumption are determined as per the procedures described in AMS-I.D "*Grid connected renewable electricity generation*". The following formula will be used to calculate project emissions from electricity consumption in year *y*.

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y})$$

$PE_{EC,y}$: Project emissions from electricity consumption in year *y* (tCO_2/yr)
$EC_{PJ,y}$: Quantity of electricity consumed by the project electricity consumption source *j* in year *y* (MWh/yr)
$EF_{EL,j,y}$: Emission factor for electricity generation for source *j* in year *y* (tCO_2/MWh)
$TDL_{j,y}$: Average technical transmission and distribution losses for providing electricity to source *j* in year *y*
j: Sources of electricity consumption in the project
k: Sources of electricity consumption in the baseline
l: Leakage sources of electricity consumption

In a case that the farm is connected to the grid, Option A will be used. The combined margin emission factor of the applicable electricity system is calculated, using the procedures in the "*Tool to calculate the emission factor for an electricity system*" ($EF_{EL,j/k/l,y} = EF_{grid,CM,y}$). The emission factor for an electricity system will be calculated ex-post for the year relevant to CPAs included under the PoA.

b) Project emissions from combustion of fossil fuel in process *j* in year y ($PE_{FC,i,y}$)

As per the methodology, for project emissions from fossil fuel consumption, the emission factor for the fossil fuel shall be used (tCO_2/tonne). Local values are to be used, if local values are difficult to obtain, IPCC default values may be used. The CO_2 emissions from fossil fuel combustion in process *j* are therefore calculated, as follows:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$

Where:
$PE_{FC,j,y}$: CO_2 emissions from fossil fuel combustion in process j during the year *y* (tCO_2e/yr);
$FC_{i,j,y}$: Quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit/yr);
$COEF_{i,y}$: CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)
i Fuel types combusted in process *j* during the year *y*

Due to data availability, $COEF_{i,y}$ is calculated following Option B of the Tool (based on net calorific value and CO_2 emission factor of the fuel type i) as follows:

$$COEF_{i,y} = NCV_{i,y} * EF_{CO2i,y}$$

Where
$NCV_{i,y}$: Net calorific value of the fuel type *i* in year *y* (GJ/ m^3)
$EF_{CO2i,y}$: CO_2 emission factor of fuel type *i* in year *y* (tCO_2/GJ)

Leakage

AMS-III.D, states that no leakage calculation is required.

D.6.2. Data and parameters fixed ex-ante

Data / Parameter	Capacity / for each participating farm
Unit	kW
Description	Operational generator capacity in each farm
Source of data	Farm Specific
Value(s) applied	• Charoenphansamchuk Farm: 2x260 kW
Choice of data or Measurement methods and procedures	The capacity of electricity generator is varied depending on the size of the system and the amount of biogas generated.
Purpose of data	Calculation of project emissions
Additional comment	-

Data / Parameter	$MS\%_{BL,j}$
Unit	%
Description	Fraction of manure being treated by the system
Source of data	Project design
Value(s) applied	100
Choice of data or Measurement methods and procedures	The current practice in the participating farms is to flush all manure into their open anaerobic lagoons. Therefore the fraction of manure being treated by the system is 100%.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	GWP_{CH4}
Unit	CO_2e
Description	Global Warming Potential of Methane
Source of data	2007 IPCC Fourth Assessment Report
Value(s) applied	21 for the first commitment period of the KP 25 for the second commitment period of the KP
Choice of data or Measurement methods and procedures	As per the Standard for Application of the GWP to CDM project activities and programmes of activities, for the second commitment period of the Kyoto Protocol. EB69 Annex 3. Based on values found online at http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14
Purpose of data	Calculation of baseline/project emissions
Additional comment	-

Data / Parameter	D_{CH4}
Unit	t/m3
Description	Density of methane at room temperature (20°C) and 1 atm pressure
Source of data	AMS-III.D Version 18, Paragraph 10
Value(s) applied	0.00067
Choice of data or Measurement methods and procedures	Value stated in AMS-III.D Version 18, Paragraph 10
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	MCF_j
Unit	%
Description	Annual methane conversion factor (MCF) for baseline animal waste management system "j"
Source of data	Table 10.17 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Chapter 10
Value(s) applied	80
Choice of data or Measurement methods and procedures	Currently the waste generated is directed to open lagoons. The average temperature in Thailand is greater than 27°C (source: http://www.tmd.go.th/climate/climate.php?FileID=7).
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	$B_{0,LT}$
Unit	m^3CH_4/kg dm
Description	Maximum methane producing potential of the volatile solid generate for animal type "LT"
Source of data	IPCC Guidelines for National Greenhouse Gas Inventories Annex 10A.2 Tables 10A-7 and 10A-8
Value(s) applied	

Region	Breeding swine	Market swine
North America	0.48	0.48
Western Europe	0.45	0.45
Eastern Europe	0.45	0.45
Oceania	0.45	0.45
Latin America	0.29	0.29
Africa	0.29	0.29
Middle East	0.29	0.29
Asia	0.29	0.29
Indian Subcontinent	0.29	0.29

Choice of data or Measurement methods and procedures	AMS-III.D. Version 18, Paragraph 10 stated that if country specific Bo values are not available, default values provided in tables 10 A-4 to 10 A-9 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories volume 4 Chapter 10 can be used. In Thailand, country specific value is not available hence adopting the value from IPCC. The chosen values for eastern European breed were applied in the baseline calculations as the swine breed and fattened in the participating farms are of Eastern European origin.[6] For baseline emissions each farm will apply either of the above values as the case may be. Otherwise, the lowest values shall be used for conservativeness.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	UF_b
Unit	-
Description	Model correction factor to account for model uncertainties
Source of data	AMS-III.D Version 18, Paragraph 10
Value(s) applied	0.94
Choice of data or Measurement methods and procedures	Value stated in AMS-III.D Version 18, Paragraph 10
Purpose of data	Calculation of baseline emissions
Additional comment	-

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[6] Breeding Swine, Department of Livestock Development www.dld.go.th

Data / Parameter	$VS_{LT,y}$
Unit	Kg dm/animal/year
Description	Volatile solids for livestock "LT" entering the animal manure management system in year "y"
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories Annex 10A.2 Tables 10A-7 and 10A-8
Value(s) applied	

Region	Breeding swine	Market swine
North America	0.5	0.27
Western Europe	0.46	0.3
Eastern Europe	0.5	0.3
Oceania	0.5	0.28
Latin America	0.3	0.3
Africa	0.3	0.3
Middle East	0.3	0.3
Asia	0.3	0.3
Indian Subcontinent	0.3	0.3

Choice of data or Measurement methods and procedures	Reference from AMS-III.D Version 18, Paragraph 10. Country specific value is not available in Thailand. Therefore, IPCC default values provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 chapter 10 table 10 A-4 to 10 A-9 can be used. The chosen values for eastern European breed were applied in the baseline calculations, as the swine breed and fattened in the participating farms are of Eastern European origin.[7] For baseline emissions each farm will apply either of the above values as the case may be. Otherwise, the lowest values shall be used for conservativeness.
Purpose of data	Calculation of baseline emissions
Additional comment	-

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North America: For breeding swine 0.5, for market swine 0.27¶
Eastern Europe: For breeding swine 0.5, for market swine 0.3¶
Western Europe: For breeding swine 0.46, for market swine 0.3

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Data / Parameter	Flare Efficiency (FE)
Unit	%
Description	The fraction of methane destroyed. The flare efficiency is defined as the fraction of time in which the gas is combusted in the flare, multiplied by the efficiency of the flaring process.
Source of data	*Tool to determine project emission from flaring gases containing methane*
Value(s) applied	50%
Choice of data or Measurement methods and procedures	For open flare 50% default value should be used, as it is not possible in this case to monitor the efficiency.
Purpose of data	Calculation of project emissions
Additional comment	-

[7] Breeding Swine, Department of Livestock Development www.dld.go.th

Data / Parameter	CEF_{grid}
Unit	tCO_2/MWh
Description	Emission coefficient of the electricity distribution system
Source of data	Office of Energy Policy and Planning (http://www.eppo.go.th) Electricity Generating Authority of Thailand (http://www.egat.co.th) Department of Alternative Energy Development and Efficiency (http://dede.go.th)
Value(s) applied	0.5661
Choice of data or Measurement methods and procedures	Calculated according to the tool to calculate emission, using publicly available statistic data published by Ministry of Energy. Simple OM has been calculated for national grid; given the low-cost/must-run resources constitute less than 50% of the total grid generation in average of the five most recent years. The calculation of BM for both grids is based on the five power plants that have been built most recently.
Purpose of data	Calculation of baseline emissions
Additional comment	Computations of grid CEFs is shown in Appendix 4

Data / Parameter	$w_{CH4,y}$
Unit	%
Description	Methane content in biogas in the year "y" on a dry basis (mass fraction)
Source of data	AMS-III.D Version 18,Table III.D.1
Value(s) applied	60
Choice of data or Measurement methods and procedures	Reference from AMS-III.D Version 18, Table III.D.1. As per the methodology, the option chosen for this project activity is to use the default value.
Purpose of data	Calculation of project emissions
Additional comment	-

D.6.3. Ex-ante calculation of emission reductions

Baseline emissions are calculated as the following
Volatile solids for livestock according to 2006 IPCC Guidelines for National Greenhouse Gas, use IPCC default value in Table 10A-7 Manure Management Methane Emission Factor Derivation for Market Swine, and Table 10A-8 Manure Management Methane Emission Factor Derivation for Breeding Swine. There is no VS data available from nationally published resource.

1. **Charoenphansamchuk Farm**

Table D.6.3.1.:Volatile Solid value for Charoenphansamchuk Farm

VSdefault	Wdefault	Kg/VS/head/day	Wsite (kg)	Kg VSdefault /head/day	Kg VSdefault /head/year
Breeding (male)	180	0.45	0	0.00	0.00
Breeding (female)	180	0.5	0	0.00	0.00
Pregnant sow	180	0.5	0	0.00	0.00
Fattening 2	50	0.3	105	0.63	229.95
Fattening 1	50	0.3	65	0.39	142.35
Nursery	50	0.3	15	0.09	32.85
Farrow	50	0.3	0	0.00	0.00
(other type, any)	50	0.3	0	0.00	0.00

Table D.6.3.2.: Baseline emission for Charoenphansamchuk Farm

Type of animal	Nda,y no. of days alive in the farm (day)	$N_{p,y}$ Annual Production (no.)	$VS_{LT,y}$	$N_{LT,y}$	CH_4 production for each type of animal	$BE_{LT,y}$
Fattening 2 75-105	65	72,200	229.95	12,857.53	1,064,372	**29,515**
Fattening 1 25-75	65	76,000	142.35	13,534.25	693,576	
Nursery 6.5-25	45	80,000	32.85	9,863.01	116,640	

Project Activity Emission Reduction

I. Emissions due to physical leakage of biogas in year "y" (tCO_2e) for Charoenphansamchuk Farm

Type of animal	Amount of CH_4 leaked	Project Emissions due to physical leakage (tCO_2e)
Fattening 2 75-105	1,330,465	**3,925**
Fattening 1 25-75	866,970	
Nursery 6.5-25	145,800	

II. Methane Emission from flaring for Charoenphansamchuk Farm

PE flare,y	757	tCO_2e/y		Biogas,1
Flare Efficiency	0.5	Open flare	Produce(m^3/d)	4,080
Amount of Biogas send to flare			Electricity	3,624
	456	m^3/day	Utilization	3,624
Biogas Methane content	60%			
Number of operation day	330	days/year		
Density of CH_4	0.00067	t/m^3		

III. Project emissions from electricity consumption in year y for Charoenphansamchuk Farm

PE ec,y	32.33	tCO_2e/y
Amount of Electricity Consumed	53.73	MWh/year
Grid Emission Factor	0.5661	tCO_2e/MWh
TDL	6.30	%

Summary of Annual Emission Reduction for the CPA

Farm	Project Activity Emission (tCO_2e)	Baseline Emission (tCO_2e)	Emission Reduction (tCO_2e)
1. Charoenphansamchuk Farm	4,714	29,515	24,801
Total	4,714	29,515	24,801

D.6.4. Summary of the ex-ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
01/12/2014-31/12/2014	2,460	393	0	2,066
2015	29,515	4,714	0	24,801
2016	29,515	4,714	0	24,801
2017	29,515	4,714	0	24,801
2018	29,515	4,714	0	24,801
2019	29,515	4,714	0	24,801
2020	29,515	4,714	0	24,801
2021	29,515	4,714	0	24,801
2022	29,515	4,714	0	24,801
2023	29,515	4,714	0	24,801
1/1/2024-30/11/2024	27,056	4,321	0	22,734
Total	295,154	47,142	0	248,009
Total number of crediting years	10 years			
Annual average over the crediting period	29,515	4,714	0	24,801

D.7. Application of the monitoring methodology and description of the monitoring plan

D.7.1. Data and parameters to be monitored

Data / Parameter	$N_{LT,y}$
Unit	Number
Description	Number of animals produced annually of type *LT* for the year *y*
Source of data	Participating Farm
Value(s) applied	

Type of animal	1.Charoenphansamchuk Farm
Breeding (male)	0
Breeding (female)	0
Fattening 1	72,200
Fattening 2	76,000
Nursery	80,000
TOTAL	228,200

Measurement methods and procedures	The average number of animals per animal category is calculated monthly based on each farms records on logbooks for the farms operations. Monthly records of animal comprise: entries (purchase; births, internal transfer) and exit (ex: sale, death, internal transfer) and the final monthly record of animals.
Monitoring frequency	To be recorded monthly and aggregated and reported annually.
QA/QC procedures	The farms records in the logbooks will be crosschecked by ERDI to guarantee consistency; animal purchase and sale records are used to cross-check the information reported
Purpose of data	Calculation of baseline emissions
Additional comment	Data will be kept for two years after the end of the crediting period

Data / Parameter:	$N_{da,y}$
Unit:	Number
Description:	Number of days animal is alive in the farm in the year *y*
Measured / Calculated / Default:	Measured
Source of data:	Farm record
Value(s) of monitored parameter:	Please see explanation in data/parameter $N_{LT,y}$
Monitoring equipment:	N/A
Measuring / Reading / Recording frequency:	
Calculation method (if applicable):	
QA/QC procedures:	
Purpose of data:	
Additional comment:	The calculation of the average number of animals (NLT,y) is done monthly based on each farms internal records filled in by farm manager or assigned personnel. It presents the records of animal entries (purchase; births, internal transfer) and exit (ex: sale, death, internal transfer) and the final monthly record of animals per animal category (ex: nursery, farrow, fattening 1 and fattening 2, breeding male, breeding female, pregnant sow).Using this approach for calculating NLT,y, it is not necessary to calculate separately an Nda,y and Np,y, since the number of days the animal are alive (Nda,y) and the number of animals produced per category LT (Np,y)

	are already implicitly considered in the monthly records and taken into account when calculating NLT,y. The farms internal records with weekly logs are then the input for the emission reduction calculation spreadsheet and aggregates the monthly average number of animals per animal category per farm for all farms included in the DDs .

Data / Parameter:	$N_{p,y}$
Unit:	Number
Description:	Number of animals produced annually of type *LT* for the year *y*
Measured / Calculated / Default:	Measured
Source of data:	Participating Farm
Value(s) of monitored parameter:	Please see explanation in data/parameter $N_{LT,y}$
Monitoring equipment:	N/A
Measuring / Reading / Recording frequency:	
Calculation method (if applicable):	
QA/QC procedures:	
Purpose of data:	
Additional comment:	The calculation of the average number of animals ($N_{LT,y}$) is done monthly based on each farms internal records filled in by farm manager or assigned personnel. It presents the records of animal entries (purchase; births, internal transfer) and exit (ex: sale, death, internal transfer) and the final monthly record of animals per animal category (ex: nursery, farrow, fattening 1 and fattening 2, breeding male, breeding female, pregnant sow).Using this approach for calculating $N_{LT,y}$, it is not necessary to calculate separately an $N_{da,y}$ and $N_{p,y}$, since the number of days the animal are alive ($N_{da,y}$) and the number of animals produced per category *LT* ($N_{p,y}$) are already implicitly considered in the monthly records and taken into account when calculating $N_{LT,y}$. The farms internal records with weekly logs are then the input for the emission reduction calculation spreadsheet and aggregates the monthly average number of animals per animal category per farm for all farms included in the DDs.

Data / Parameter	W_{site}
Unit	Kg
Description	Average animal weight of a defined livestock population at the project site
Source of data	Farm records of animal average weight in each category in the farm annually
Value(s) applied	

Type of animal	1.Charoenphansamchuk Farm
Breeding (male)	0
Breeding (female)	0
Fattening 1	65
Fattening 2	105
Nursery	15
TOTAL	185

Measurement methods and procedures	Farm records of animal average weight using a scale in each category in the farm. Sampling procedures can be used to estimate this variable as per the "Standard for Sampling and Surveys for CDM Project Activities and Programme of Activities", version 02.0.
Monitoring frequency	Aggregated and reported annually
QA/QC procedures	Farm manager's signature is required on the record. The scale is calibrated according to the national standards and recalibrated at appropriate intervals according to manufacturer specifications, but at least once in three years.
Purpose of data	Calculation of baseline emissions
Additional comment	Data will be kept for two years after the end of the crediting period

Data / Parameter	$BG_{burnt,y}$
Unit	Nm^3
Description	Biogas volume in year *y*
Source of data	Flow meters
Value(s) applied	4,080 Nm^3 is used for each farm to calculate expected emission reductions. Will be measured ex-post
Measurement methods and procedures	The total amount of biogas collected shall be determined by the sum of the monitored amount of biogas supplied to generator ($BG_{elec,y}$) and the amount of biogas sent to the flaring system ($BG_{flare,y}$). The measurement method of each parameter can be referred to the relevant parameter table below.
Monitoring frequency	The gas flared and used will be monitored continuously with an accumulated volume recording (e.g. hourly/daily accumulated reading)
QA/QC procedures	Please refer to relevant parameter table
Purpose of data	Calculation of baseline emissions
Additional comment	Data will be kept for two years after the end of the crediting period

Data / Parameter	$BG_{elec,y}$
Unit	Nm^3
Description	Amount of biogas captured and used as fuel for the generator
Source of data	Flow meter
Value(s) applied	3,624 Nm^3 is used for each farm to calculate expected emission reductions. Will be measured ex-post
Measurement methods and procedures	The biogas flow meter shall be the equivalent of Orifice Plate or better with 95% accuracy. The meter will take into account the temperature and pressure of the biogas generated to provide accurate reading in Normal Cubic Meter (Nm^3). Data will be aggregated monthly and reported annually.
Monitoring frequency	Biogas used by the generator will be monitored continuously through the use of biogas flow meter at each farm every day.
QA/QC procedures	Flow meters are to be periodically calibrated according to the manufacturer's recommendation.
Purpose of data	Calculation of baseline emissions
Additional comment	At pressure 1 atm, 20 degree Celsius. Data will be kept for two years after the end of the crediting period

Data / Parameter	$BG_{flare,y}$
Unit	Nm^3
Description	Amount of biogas sent to flare
Source of data	Flow meter
Value(s) applied	456 Nm^3 is used for each farm to calculate expected emission reductions. Will be measured ex-post.
Measurement methods and procedures	The biogas flow meter shall be the equivalent of Orifice Plate or better with 95% accuracy. The meter will take into account the temperature and pressure of the biogas generated to provide accurate reading in Normal Cubic Meter (Nm^3). Data will be aggregated monthly and reported annually.
Monitoring frequency	Biogas sent to flare will be monitored continuously through the use of biogas flow meter at each farm every day.
QA/QC procedures	Flow meters are to be periodically calibrated according to the manufacturer's recommendation.
Purpose of data	Calculation of project emissions
Additional comment	At pressure 1 atm, 20 degree Celsius. Data will be kept for two years after the end of the crediting period

Data / Parameter	Flare operation
Unit	hours
Description	Flare operation in hour *h*
Source of data	Measurements by project participants
Value(s) applied	Not applicable
Measurement methods and procedures	A flame detector will indicate when the flare is operating or not.
Monitoring frequency	Continuous
QA/QC procedures	Flame detector will be operated and maintained as per manufacturer specifications
Purpose of data	Calculation of project emissions
Additional comment	As per the "*Tool to determine project emissions from flaring of gases containing methane*", since CPAs will use open flares, when the flare is operating a default value at 50% will be used for the flare

	efficiency. Data will be kept for two years after the end of the crediting period

Data / Parameter	EC_{PJy}
Unit	kWh
Description	Quantity of electricity consumed by the project from the grid
Source of data	Electricity meter recording
Value(s) applied	53,728
Measurement methods and procedures	Farm record on the electricity on-site consumption from the grid.
Monitoring frequency	Continuous
QA/QC procedures	Farm manager's signature is required on the record. The calibration of the electricity meter, owned by the national electricity authority, shall be requested by the CME/farm owner to be conducted at appropriate intervals according to manufacturer specifications, but at least once in three years.
Purpose of data	Calculation of project emissions
Additional comment	Only monitored if the farm consumes electricity from the grid For ex-ante calculations this parameter is assumed to be 53,728. . If monitoring of electricity consumed by the project cannot be isolated from the overall farm electricity consumption, EC_{PJy} will be derived from applying the assumption that electrical appliances are continuously utilized. Data will be kept for two years after the end of the crediting period

Data / Parameter	$EG_{y,Auxillairy}$
Unit	kWh
Description	Renewable electricity generated by the project activity, consumed by auxiliary equipment
Source of data	Farm record on the utilization of electrical appliances under the project activity, using renewable energy
Value(s) applied	0
Measurement methods and procedures	Farm record on the utilization of electrical appliances under the project activity.
Monitoring frequency	Monthly and aggregated annually
QA/QC procedures	Farm manager's signature is required on the record
Purpose of data	Calculation of project emissions
Additional comment	For ex-ante calculations this parameter is assumed to be 0 If recovered methane is used to power auxiliary equipment of the project it should be taken into account accordingly, using zero as its emission factor. Data will be kept for two years after the end of the crediting period

Data / Parameter	$FC_{i,j,y}$
Unit	m^3/yr
Description	Onsite combustion of fossil fuels of type *i* in process *j* during the year y
Source of data	Project Implementer
Value(s) applied	0
Measurement methods and procedures	Volumetric meter will be employed to measure the fossil fuel consumption continuously as per the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*" *version 02*. There will be a book of control for recording the measurements.
Monitoring frequency	Monthly and aggregated annually
QA/QC procedures	The consistency of metered fuel consumption quantities will with available purchase invoices from the financial records.
Purpose of data	Calculation of project emissions
Additional comment	For ex-ante calculations this parameter is assumed to be 0 Required to calculate project emissions from fossil fuel combustion. Data will be kept for 2 years after end of crediting period.

Data / Parameter	$NCV_{i,y}$
Unit	GJ/m^3
Description	Net calorific value of fuel type *i* in year *y*
Source of data	Values from the fuel supplier will be used.
Value(s) applied	Only used in ex-post calculations
Measurement methods and procedures	Values provided by the fuel supplier. Undertaken in line with national or international fuel standards.
Monitoring frequency	The NCV will be obtained for each fuel delivery, from which weighted average annual values should be calculated.
QA/QC procedures	Values will be verified to check that they are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements.
Purpose of data	Calculation of project emissions
Additional comment	Only to be monitored by CPAs where fossil fuel use is expected. Data will be kept for 2 years after end of crediting period or last issuance of CERs for the project activity.

Data / Parameter	$EF_{CO2,i,y}$
Unit	tCO_2/GJ
Description	CO_2 emission factor of fuel type *i* in year y
Source of data	If there are no values provided by the fuel supplier, IPCC default values should be used: at the upper limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of chapter 1 of Vol 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories (there is no available data from the fuel supplier).
Value(s) applied	Only used in ex-post calculations
Measurement methods and procedures	-
Monitoring frequency	
QA/QC procedures	It will be checked against any future revision of IPCC Guidelines
Purpose of data	Calculation of project emissions
Additional comment	Only to be monitored by CPAs where fossil fuel use is expected. Data will be kept for two years after the end of the crediting period

Data / Parameter	$MS\%_{i,y}$
Unit	%
Description	Fraction on manure handled in system *i* in the project activity in year *y*
Source of data	Farm records
Value(s) applied	100
Measurement methods and procedures	All manure is expected to be processed in the digesters. Should any manure be diverted, the weight will be measured using a scale.
Monitoring frequency	A monthly confirmation that all waste is handled in the treatment system will be recorded in the farms logbook.
QA/QC procedures	Farm manager's signature is required on the record. The scale is calibrated according to the national standards and recalibrated at appropriate intervals according to manufacturer specifications, but at least once in three years.
Purpose of data	Calculation of baseline emissions
Additional comment	For ex-ante calculations it is assumed that 100% of the waste will be treated by the new treatment system. Data will be kept for two years after the end of the crediting period

Data / Parameter	nd_y
Unit	Days
Description	Number of days that the animal manure management system was operational
Source of data	Farm record
Value(s) applied	365
Measurement methods and procedures	The record on the number of days in year *y* where the treatment plant was not operational will be documented in a logbook and taken into account for the calculation of BEex-post.
Monitoring frequency	To be monitored monthly based on daily records, and reported annually.
QA/QC procedures	Farm manager's signature is required on the record
Purpose of data	Calculation of baseline emissions
Additional comment	Data will be kept for two years after the end of the crediting period

Data / Parameter	Proper soil application (not resulting in methane emissions) of the residual waste
Unit	%
Description	Ratio of final sludge treated aerobically over total sludge treated.
Source of data	Farm record of final sludge treated aerobically and sludge treated anaerobically.
Value(s) applied	100
Measurement methods and procedures	Farm record of final sludge treated aerobically and sludge treated anaerobically.
Monitoring frequency	Monthly
QA/QC procedures	Farm manager's signature is required farm data record sheet
Purpose of data	Calculation of project emissions
Additional comment	For ex-ante calculations this parameter is assumed to be 100 Data will be kept for two years after the end of the crediting period

Data / Parameter	Onsite inspections for each individual farm included in the project boundary
Unit	Not applicable
Description	Onsite inspections of the project boundary
Source of data	Farm monitoring record data
Value(s) applied	Not applicable
Measurement methods and procedures	Regular farm inspections to check that the equipments are working properly, maintenance are perform according to manufacturer's specification, and all monitoring data is recorded as required in the monitoring data record sheet.
Monitoring frequency	Annually
QA/QC procedures	Farm's manger signature is required on the monitoring data record sheet.
Purpose of data	Calculation of baseline and project emissions
Additional comment	

Data / Parameter	Genetic source of the production operations livestock
Unit	Not applicable
Description	Genetic source of the production operations livestock
Source of data	Farm monitoring record data
Value(s) applied	Oceania, North America, Western Europe or Eastern Europe, Latin America, Africa, Middle East, Asia or Indian Subcontinent
Measurement methods and procedures	Farm records
Monitoring frequency	Annually
QA/QC procedures	Farm's manger signature is required on the monitoring data record sheet.
Purpose of data	Calculation of baseline emissions
Additional comment	Data will be kept for two years after the end of the crediting period

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Annex I Party

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Data / Parameter	FFR
Unit	-
Description	Formulated Feed Rations
Source of data	Farm monitoring record data
Value(s) applied	Will be monitored ex-post.
Measurement methods and procedures	Farm records on FFR.
Monitoring frequency	Annually
QA/QC procedures	Farm's manager signature is required on the monitoring data record sheet.
Purpose of data	Calculation of baseline emissions
Additional comment	Data will be kept for two years after the end of the crediting period

Data / Parameter	$TDL_{j,y}$
Unit	-
Description	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*
Source of data	Ministry of Energy, "Electric Power in Thailand", 2011. Use recent, accurate and reliable data available in Thailand. http://www.dede.go.th/dede/images/stories/stat_dede/electric54_1.pdf
Value(s) applied	6.30%
Measurement methods and procedures	In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Monitoring frequency	Annually
QA/QC procedures	It would be checked against future revisions of *Electric Power in Thailand* published annually by the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy.
Purpose of data	Calculation of project emissions
Additional comment	Data will be kept for two years after the end of the crediting period

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D.7.2. Description of the monitoring plan

Monitoring will be implemented according to the monitoring plan to ensure that the real, measurable and long-term GHG emission reductions for the project activity are monitored and reported accordingly. The emission reductions achieved by the project activity will be determined ex-post through direct measurement of the amount of methane fuelled, flared or gainfully used. It is likely that the project activity involves manure treatment steps with higher methane conversion factors (MCF) than the MCF for the manure treatment systems used in the baseline situation, therefore the emission reductions 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 ($N_{LT,y}$, $MS\%_{i,y}$ and in case adjusted values for animal weight are used as defined in paragraph 10(c): $VS_{LT,y}$).

The emission reductions achieved in any year are the lowest value of the following:

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

Where:

$ER_{y,ex\text{-}post}$: Emission reductions achieved by the project activity based on monitored values for year "y" (tCO_2e)

$BE_{y,ex\text{-}post}$: Baseline emissions calculated using formula 1 using ex post monitored values of $N_{LT,y}$ and if applicable $VS_{LT,y}$

$PE_{y,ex\text{-}post}$: Project emissions calculated using formula 4 using ex post monitored values of $N_{LT,y}$, $MS\%_{i,y}$ and if applicable $VS_{LT,y}$

MDy: Methane captured and destroyed or used gainfully by the project activity in year "y" (tCO_2e)

$PE_{power,y,ex\text{-}post}$: Emissions from the use of fossil fuel or electricity for the operation of the installed facilities based on monitored values in the year "y" (tCO_2e)

In case of flaring/combustion MD_y will be measured using the conditions of the flaring process:

$$MD_y = BG_{burnt,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4}$$

Where:

$BG_{burnt,y}$: Biogas flared or combusted in year "y" (m^3)

$w_{CH4,y}$: Methane content in biogas in the year "y" (mass fraction)

FE: Flare efficiency in the year "y" (fraction)

Alternatively, if project activities utilize the recovered methane for power generation, $MD_{,y}$ may be calculated as follows, based on the amount of monitored electricity generation, without monitoring methane flow and concentration.

$$MD_y = \frac{EG_y \times 3600}{NCV_{CH4} \times EE_y} \times D_{CH4} \times GWP_{CH4}$$

Where:

EG_y = Total electricity generated from the recovered biogas in year *y* (MWh)

3600 = Conversion factor (1 MWh = 3600 MJ)

NCV_{CH4} = NCV of methane (MJ/Nm^3) use default value: 35.9 MJ/Nm^3)

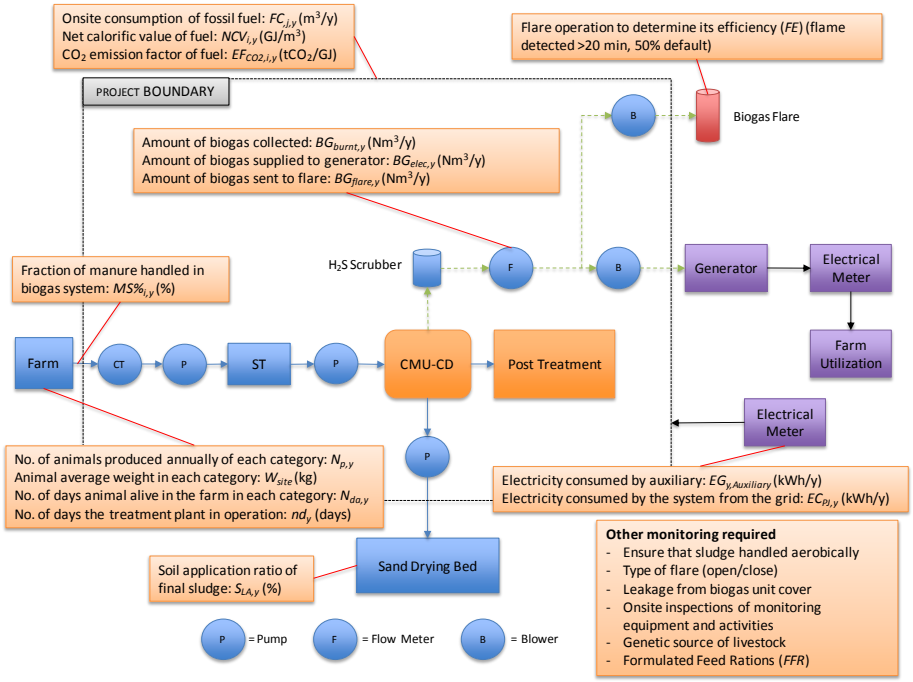
EE_y = Energy conversion efficiency of the project equipment, which is determined by adopting one of the following criteria:

- Specification provided by the equipment manufacture. The equipment shall be designed to utilize biogas as fuel, and efficiency specification is for this fuel. If the specification provides a range of efficiency values, the highest value of the range shall be used for the calculation;
- Default efficiency of 40 %

Project proponents shall provide evidence to the DOE that only the biogas recovered through the project manure management system is used for power generation; no other gas or fuels except a start-up fuel[8] are used.

1. What is required by the monitoring plan?

Figure B.6.1.: Illustrate monitoring equipment in the system



2. Who uses the monitoring plan?

ERDI will be responsible for coordinating the farm owners, providing technical service including organizing training to farmers involved, supervising the project implementation, as well as to organize technical support team to carry out the monitoring of the project implementation. The monitoring plan will be implemented as per the registered PoA in order to ensure that the monitoring process is credible, transparent and conservative.

More specifically, the ERDI will be responsible for collecting the monitoring data and drafting the monitoring report by working with the farm owners.

3. Monitoring

To ensure reliable field measurements and data collection quality, the following procedures should be followed for quality control:

[8] If a fuel is defined as a start-up fuel, it should not represent more than 1% of the total fuel utilized in the process, on energy basis.

- Standard operating procedures for the field measurements, including a) detailed processes for each element measured, and b) provisions for documentation for verification purposes, are provided in the CMU-CD operation manual in Thai)
- The procedures for emergency preparedness for cases where emergencies can cause unintended emissions and also the risk of fire on emergency condition; Procedure for the registration, monitoring, measurement and reporting procedure needs to be provided; and Corrective actions procedures in order to provide for more accurate future monitoring and reporting; are attached in Annex 4 and provided in CMU-CD operation manual.
- Training courses on field data collection and data analyses will be held for staff involved in the field measurement work.
- The list of the names of the field team and project leader who join the training and monitoring process will be filed accordingly.
- Any new staff will be trained adequately.

ERDI will be responsible for archiving data electronically and in printed form, for monitoring report preparation. Such data will be available until 2 years after the Project Activity has ended for comparison and analysis by the verifier. The data from monitoring report will be imported to excel sheets where equations of the methodology are integrated for the year.

SECTION E. Approval and authorization

Letters of Approval (LoAs) of the Parties involved were available at the time of submitting this CPA-DD, and have been provided along with the CPA-DD.

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Appendix 1. Contact information of CPA implementer(s) and responsible person(s)/ entity(ies) for completing the CDM-SSC-CPA-DD-FORM

CPA implementer and/or responsible person/ entity	☒ CPA implementer(s) ☐ Responsible person/ entity for completing the CDM-SSC-CPA-DD-FORM
Organization	Energy Research and Development Institute – Nakornping of Chiang Mai University
Street/P.O. Box	239 Huaykaew Rd.
Building	Chiang Mai University.
City	Suthep
State/Region	Chiang Mai
Postcode	50202
Country	Thailand
Telephone	+66-5394-2007
Fax	+66 5390-3763
E-mail	Prasert.134@gmail.com
Website	www.erdi.or.th
Contact person	Director
Title	Associate Professor
Salutation	Mr.
Last name	Rerkkriangkrai
Middle name	-
First name	Prasert
Department	-
Mobile	-
Direct fax	
Direct tel.	
Personal e-mail	Prasert.134@gmail.com

CPA implementer and/or responsible person/ entity	☐ CPA implementer(s) ☒ Responsible person/ entity for completing the CDM-SSC-CPA-DD-FORM
Organization	International Bank for Reconstruction and Development as Trustee of the Carbon Fund for Europe
Street/P.O. Box	1818 H St NW
Building	
City	Washington
State/Region	District of Columbia
Postcode	20433
Country	USA
Telephone	+1-202-473-4000
Fax	

E-mail	IBRD-Carbonfinance@worldbank.org
Website	
Contact person	Juha Seppala
Title	Carbon Finance Specialist
Salutation	Mr.
Last name	Seppala
Middle name	Antti Kalevi
First name	Juha
Department	Climate and Carbon Finance
Mobile	
Direct fax	
Direct tel.	+1-202-473-4759
Personal e-mail	

Deleted: jseppala@worldbank.org

CPA implementer and/or responsible person/ entity	☐ CPA implementer(s) ☐ Responsible person/ entity for completing the CDM-SSC-CPA-DD-FORM
Organization	Government of Portugal – Portuguese Carbon Fund
Street/P.O. Box	Rua da Murgueira, 9/9A, Apartado 7586, Zambujal, Alfragide
Building	-
City	Amadora
State/Region	-
Postcode	2611-865
Country	Portugal
Telephone	+351-21-470-9920
Fax	+351-21-471-9076
E-mail	nuno.lacasta@apambiente.pt
Website	-
Contact person	Nuno Lacasta
Title	Manager of the Portuguese Carbon Fund
Salutation	Mr.
Last name	Lacasta
Middle name	-
First name	
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Appendix 2. Affirmation regarding public funding

There is no diversion of ODA for this project.

Appendix 3. Applicability of methodology(ies) and standardized baseline(s)

For further details please see section D.2.

Appendix 4. Further background information on ex ante calculation of emission reductions

Grid Emission Factor 2008

The emission factor was calculated based on the Tool to calculate the emission factor for an electricity system" – Version 02.2.1.

The latest data available for the calculation of emission reduction prior to the stakeholder consultation is 2008.

Step 1: Identify the relevant electricity systems
The relevant electric power system for the project is Thailand national grid. The DNA has not published a delineation of the project electricity system.

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)
(a) This optional step is not undertaken thus Option 1 is selected (i.e., Option I: Only grid power plants are included in the calculation; Option I corresponds to the procedure contained in earlier versions of this tool).

Step 3: Select a method to determine the operating margin (OM) The calculation of the operating margin emission factor is based on (a) Simple OM. This method is selected because the low cost must run resources constitute less than 50% on average of the five most recent years.

Year	Hydro	Fuel Oil	Diesel Oil	Coal & Lignite	Natural Gas	Others (RE)	Total	% low cost must run
2004	6,040	7,138	551	17,993	80,489	2	112,213	5%
2005	5,798	8,244	414	18,334	85,703	2	118,495	5%

2006	8,125	8,350	143	22,051	86,339	3	125,011	7%
2007	8,114	3,646	174	28,716	88,166	3	128,819	6%
2008	7,113	1,454	180	29,480	94,549	5	132,781	5%

Source: Table 17 National Grid Generation by Energy Sources, Electric Power in Thailand 2008 (DEDE), http://www2.dede.go.th/km_berc/downloads/menu2/รายงานประจำปี%202547-2551/การใช้พลังงานไฟฟ้าของประเทศ/Elec_2551.pdf

The table above shows that the percentage of low cost must run resources from 2004-2008 are less than 50%. Hence Simple OM method is selected.

The ex ante option is selected, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required.

Step 4: Calculate the operating margin emission factor according to the selected method
The calculation is based on the fuel type, total fuel consumption and the total net electricity generation (Option B of the tool) for three consecutive years (using the latest available data at the time of the publication of the PDD for stakeholder comments, i.e., 2006, 2007, 2008).

Option B can be selected in this case because: the necessary data for Option A is not available and Option I has been chosen in Step 2).

$$EF_{grid,OMsimple,y} = \frac{\sum_{i} \left(FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y} \right)}{EG_{y}}$$

Where:

$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)

$FC_{i,y}$ = Amount of fossil fuel type *i* consumed in the project electricity system in year y (mass or volume unit)

$NCV_{i,y}$ = Net Calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)

$EF_{CO2,i,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)

EG_y = Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost / must-run power plants / units, in year *y* (MWh)

i = All fossil fuel types combusted in power sources in the project electricity system in year *y*

y = The relevant year as per the data vintage chosen in Step 3.

Data for Simple OM calculation:

EGAT's grid generation and fuel consumption data 2006-2008.

Type of Fuel	Source	Unit	2008	2007	2006
Hydro	Total	Gwh	7,113	8,114	8,125
Emission		tCO2	0	0	0
Natural Gas	Total	GWh	94,549	88,166	86,339
Amount of Fuel use	Annually	MMscf	907,327	783,137	857,103
Emission		tCO2	50,253,213	43,374,826	47,471,507
Fuel Oil	Total	GWh	1,454	3,646	8,350

Type of Fuel	Source	Unit	2008	2007	2006
Amount of Fuel use		Ml.	358	936	2,030
Emission		tCO2	1,074,943	2,810,466	6,095,349
Diesel	Total	GWh	180	174	143
Amount of Fuel use		Ml.	45	23	41
Emission		tCO2	118,984	60,814	108,408
Lignite	EGAT	GWh	29,480	28,716	22,051
Amount of Fuel use		Mt.	21	20	17
Emission		tCO2	26,732,617	24,506,458	21,408,543
Imported Power		Gwh	2,785	4,491	5,159
Emission			0	0	0
Total Generating	**Total**	**GWh**	**135,561**	**133,307**	**130,167**
Total Emission	**Total**	**tCO2**	**78,179,758**	**70,752,565**	**75,083,806**
Grid Emission Factor		**tCO2/MWh**	**0.5767**	**0.5307**	**0.5768**
				Average Grid Emission Factor	**0.5614**

Source: Electric Power in Thailand 2008 (DEDE).

Fuel Type	NCV[1] (MJ/unit)	Effective CO_2 emission Factor[2] (tCO2/TJ)	CO_2 emission per fuel unit (t/unit)	CO_2 emission coefficient	Unit
Natural Gas	1.02	54.3	5.54E-05	55.39	tCO_2/mscf
Fuel Oil	39.77	75.5	3.00E-03	3,002.64	tCO_2/mlitre
Diesel	36.42	72.6	2.64E-03	2,644.09	tCO_2/mlitre
Lignite[3]	13.72	90.9	1.25E-03	1,247,148	tCO_2/mt
Imported Coal[4]	26.37	89.5	2.39E-03	2,386,965	tCO_2/mt

Notes:1 Electric Power in Thailand 2008 (DEDE), p. 42.

2 IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories

3 NCV of lignite is an average from 4 types of lignite. Source: Electric Power in Thailand 2008 (DEDE), page 42. http://www.dede.go.th/dede/fileadmin/upload/cc/EleThai110951.pdf

4 Applied CO_2 emission factor of Other Bituminous Coal from table 1.4 of 2006 IPCC Guidelines for conservativeness

Operating Margin = 0.5614 [9]

Step 5: Calculate the build margin (BM) emission factor.

In terms of vintage of data, Option 1 is chosen. The build margin emission factor is determined by applying *ex-ante* option based on the most recent information available. Therefore, for the first crediting period, the build margin emission factor will be calculated *ex-ante* based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

According to the tool, the sample group of power units m used to calculate the build margin should be determined as per the following procedure, consistent with the data vintage selected above:

a) Identify the set of five power units, excluding power units registered as CDM Project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-units}}$, in GWh), as follows:

[9] For complete details please refer to the grid emission calculation spreadsheet

List of five most recently power plant units ($SET_{5\text{-units}}$) and their generation ($AEG_{SET\text{-}5\text{-}units}$, in GWh)

IPP	Fuel Type	Unit	Date of commissioning	Generation in 2008 (GWh)
Ratchburi Power	Natural gas	Unit 2	01-Jun-08	3,720
		Unit 1	01-Mar-08	
Gulf Power Generation Co., Ltd.	Natural gas	Unit 2	1-Mar-08	9,195
		Unit 1	5-May-07	
BLCP Power Limited*	Coal	Unit 2	14-Nov-06	5,400.5
Total				**19,922**

Source: The list of power plant is available at www.http://www.eppo.go.th/power/index.html and the generation data is from Table 8 of *Electric Power in Thailand 2008* (DEDE).
Remark: *The generation of BLCP is determined as per one unit from the total of two, or half of the plan's generation reported in *Electric Power in Thailand 2008* (DEDE).

b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%,}$ in GWh) as follows:

List of new power units recently supplying electricity to the grid that comprising 20% of annual electricity generation ($AEG_{SET\text{-}\geq 20\%,}$ in GWh)

IPP	Fuel Type	Unit	Date of commissioning	Generation in 2008 (GWh)
Ratchburi Power	Natural gas	Unit 2	01-Jun-08	3,720
		Unit 1	01-Mar-08	
Gulf Power Generation Co., Ltd.	Natural gas	Unit 2	01-Mar-08	9,195
		Unit 1	05-May-07	
BLCP Power Limited	Coal	Unit 2	14-Nov-06	10,801
		Unit 1	13-Aug-06	
Eastern Power & Electric Co., Ltd.	Natural gas		25-Mar-03	2,670
Glow IPP, Ltd.	Natural gas		31-Jan-03	5,146
Total				**31,532**

Source: The list of power plant is available at www.http://www.eppo.go.th/power/index.html and the generation data is from Table 8 of *Electric Power in Thailand 2008* (DEDE).

c) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample});

The most recently built plants $SET_{\geq 20\%}$ have generated 31,532 GWh electricity representing 23.3% of the overall electricity generated by all power plants in the national grid in year 2008 while the set of five power units $SET_{5\text{-units}}$, excluding power units registered as CDM Project activities, that started to supply electricity to the grid most recently have generated 19,922 GWh. For the nation grid, the most recent capacity additions constituting 20% of the system represent a larger annual generation than the five most recently added power units, and is therefore chosen as the sample group for the build margin.

Therefore, since $SET_{\geq 20\%}$ is the set of power units that comprises the larger annual electricity generation, $SET_{\geq 20\%}$ is the SET_{sample}. Provided that 20% falls on part of the power generation of Glow IPP power plant, Glow IPP power plant is therefore fully included in the

calculation as per the *Tool to Calculate the Emission Factor for an Electricity System* – version 2.2.1). The most recent capacity additions representing 20% of the system comprise larger annual generation than the five most recent plants, and are therefore the chosen as the build margin sample group as $SET_{sample-CDM}$. Steps (e) and (f) are ignored.

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, calculated as follows:

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

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid in year *y* (MWh)
$EF_{EL,m,y}$ = CO_2 emission factor of fossil fuel type *i* in year y (tCO_2/MWh)
m = Power units included in the build margin
i = All fossil fuel types combusted in power plant /unit *m* in year *y*
y = Most recent historical year for which power generation data is available

Electricity generation efficiency in 2008

Power Plant/Company	Fuel Type	Efficiency (Btu/kWh)	Efficiency (TJ/GWh)	CO_2 emission* (tCO_2)
Ratchburi Power	Natural gas	9,287	9.79779	1,979,113
Gulf Power Generation Co., Ltd.	Natural gas	6,950	7.33225	3,660,908
BLCP Power Limited	Coal	9,100	9.60050	9,280,703
Eastern Power & Electric Co., Ltd.	Natural gas	6,811	7.18561	1,041,776
Glow IPP, Ltd.	Natural gas	6,910	7.29005	2,037,043
Total				**17,999,543**

Source: Plant efficiency data, in Btu/kWh, is from Table 18 of *Electric Power in Thailand 2008* (DEDE).
Remark: - CO_2 emission (tCO_2) is determined by Generation in 2008 (GWh) * Efficiency (TJ/GWh) * Effective CO_2 emission Factor (tCO_2/TJ) of fuel type.
- Effective CO_2 emission factors (tCO_2/TJ) of natural gas (54.3) and coal (89.5) are based on the IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories.

Build Margin = 0.5708[10]

Step 6. ***Calculate the combined margin emission factor***
The combined margin emissions factor is calculated as follows:

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

Where:

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

[10] For complete details please refer to the grid emission calculation spreadsheet

W_{BM} = Weighting of build margin emissions factor (%)

As the project is category belong to other project W_{OM} = 0.5 and W_{BM} = 0.5 for the first crediting period.

Baseline Emission Factor for Thailand National Grid system in 2008

Margin	Weight	Emission Factor
OM	0.5	0.5614
BM	0.5	0.5708
Baseline		**0.5661**

Appendix 5. Further background information on monitoring plan

Monitoring Parameters, Frequency, Equipment Archiving and Responsibility

In order to fully comply with the QA/QC procedures will be applied right from the source of the data itself. The data will be captured in a log. The data collection template will be use to keep record of data for each parameter to be measured in the monitoring plan as illustrate in the template below. The location of each monitoring equipments is illustrated in Figure 1 and Table 1 shown equipment archiving and monitoring responsibility.

GENERAL INFORMATION	
FORM TYPE:	**FORM NUMBER:**
DATA TO BE MEASURED:	**CDM ID:**
DESCRIPTION OF LOCATION:	**PERSON RESPONSIBLE FOR DATA LOGGING:** **NAME: DEPARTMENT:**
INSTRUMENTATION INFORMATION	
INSTRUMENT ID:	**INSTRUMENT TYPE:**
MANUFACTURER/MODEL:	**SERIAL NUMBER:**
MEASUREMENT RANGE AND UNIT: **UPPER MEASUREMENT LIMIT:** **LOWER MEASUREMENT LIMIT:**	**INSTRUMENT CALIBRATION INFORMATION:** **LAST CALIBRATION DATE:** **NEXT CALIBRATION DATE:** **UNCERTAINTY LEVEL:**
INSTRUCTIONS REQUIRED	
MONITORING FREQUENCY:	**MAX. REPORTING UNCERTAINTY:**
BEFORE DATA READING:	**ABNORMAL SITUATION:**
AFTER DATA READING:	**SPECIAL REQUIREMENTS:**
DATA LOG	

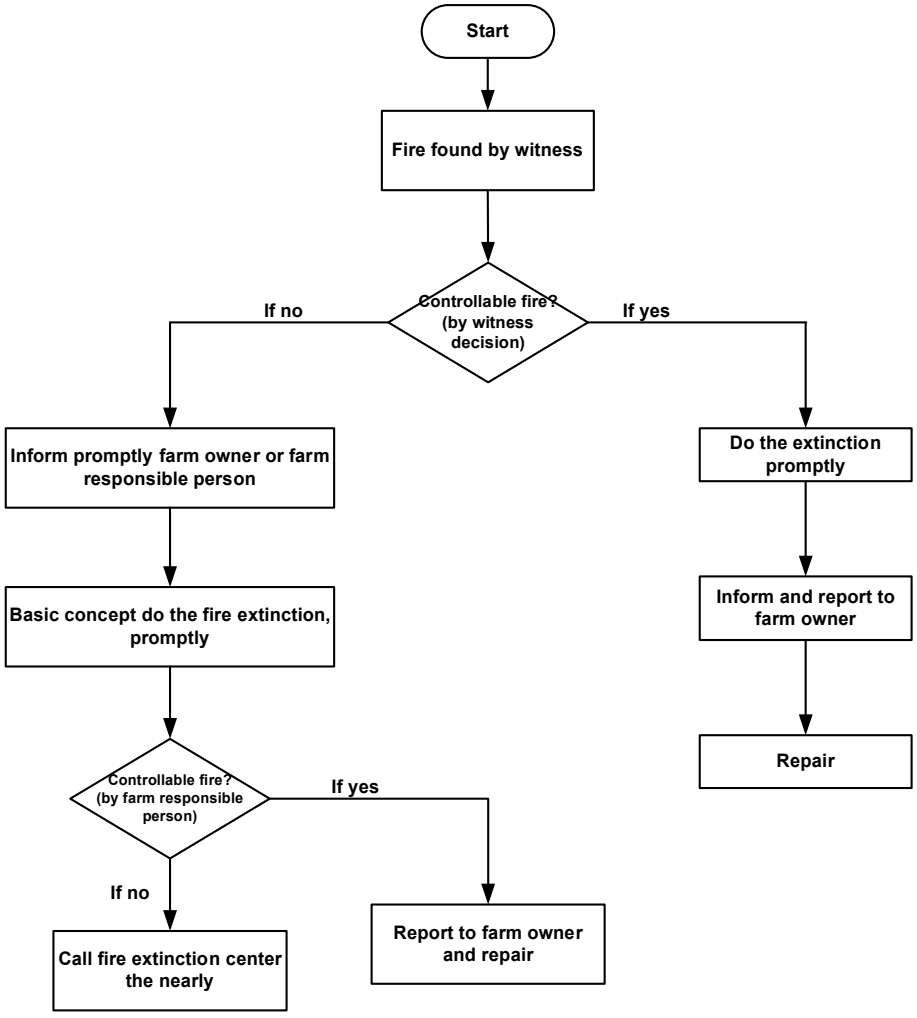
Table 1 Equipment Archiving and Responsibility

ID	Data Type	Data variable	Unit	Measured (M), Calculated (C), or Estimated (E)	Recording Frequency	Archiving of data	Comment	Responsibility
$N_{da,y}$	Time	No. of days animal is alive in the farm in each category	day	M	Daily	Paper and transferred to electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$N_{p,y}$	Number of Animal	No of animals produced annually in each category	heads	E	Daily	Paper and transferred to electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$W_{site,y}$	Weight	Animal average weight in each category	kg	M	Weekly	Paper and transferred to electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$BG_{burnt,y}$	Volume	Biogas volume in year *y*	Nm^3	M	Continuous	Electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$BG_{elec,y}$	Volume	Amount of Biogas sent to electricity generator	Nm^3	M	Continuous	Electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$BG_{flare,y}$	Volume	Amount of Biogas sent to flare	Nm^3	M	Continuous	Electronic	Daily data aggregated for Monthly data, when flare is in operation	Biogas Plant Operator/Farm
Flare operation	Time	hours of operation of the flare	hours	M	Continuously	Electronic	Measured continuously when the flare is in operation	Biogas Plant Operator/Farm

ID	Data Type	Data variable	Unit	Measured (M), Calculated (C), or Estimated (E)	Recording Frequency	Archiving of data	Comment	Responsibility
$EC_{PJ,y}$	Energy	Quantity of electricity consumed by the project from the grid	kWh	M	Continuous	Electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$EG_{y,Auxillairy}$	Energy	Renewable electricity consumed by the projects auxiliary equipment	kWh	M	Continuous	Electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$FC_{i,j,y}$	Volume	Onsite combustion of fossil fuels type *i*	m^3	M	Continuous	Electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$NCV_{i,y}$	Volume per unit	Net calorific value of fossil fuel type *i*	GJ/m^3	M	Every batch	Paper and transferred to electronic	Values from the fuel supplier	Biogas Plant Operator/Farm
$EF_{CO2,i,y}$	Volume per unit	CO_2 emission factor of fossil fuel type *i*	tCO_2/GJ	M	Annually	Paper and transferred to electronic	Values from the fuel supplier, otherwise IPCC default values	Biogas Plant Operator/Farm
$MS\%_{i,y}$	Percentage	Fraction of manure handled in waste management system *i*	%	E	Daily	Paper and transferred to electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
nd_y	Time	No. of days the treatment system was in operation	days	M	Daily	Paper and transferred to electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$S_{LA,y}$	Percentage	Ratio of final sludge treated aerobically over total sludge treated	%	M	Daily	Paper and transferred to electronic	Daily data aggregated for Monthly data	Biogas Plant Operator/Farm
$GS_{y,}$	-	Genetic source of livestock	-	M	Annual	Paper and transferred to electronic	Checked annually	Biogas Plant Operator/Farm

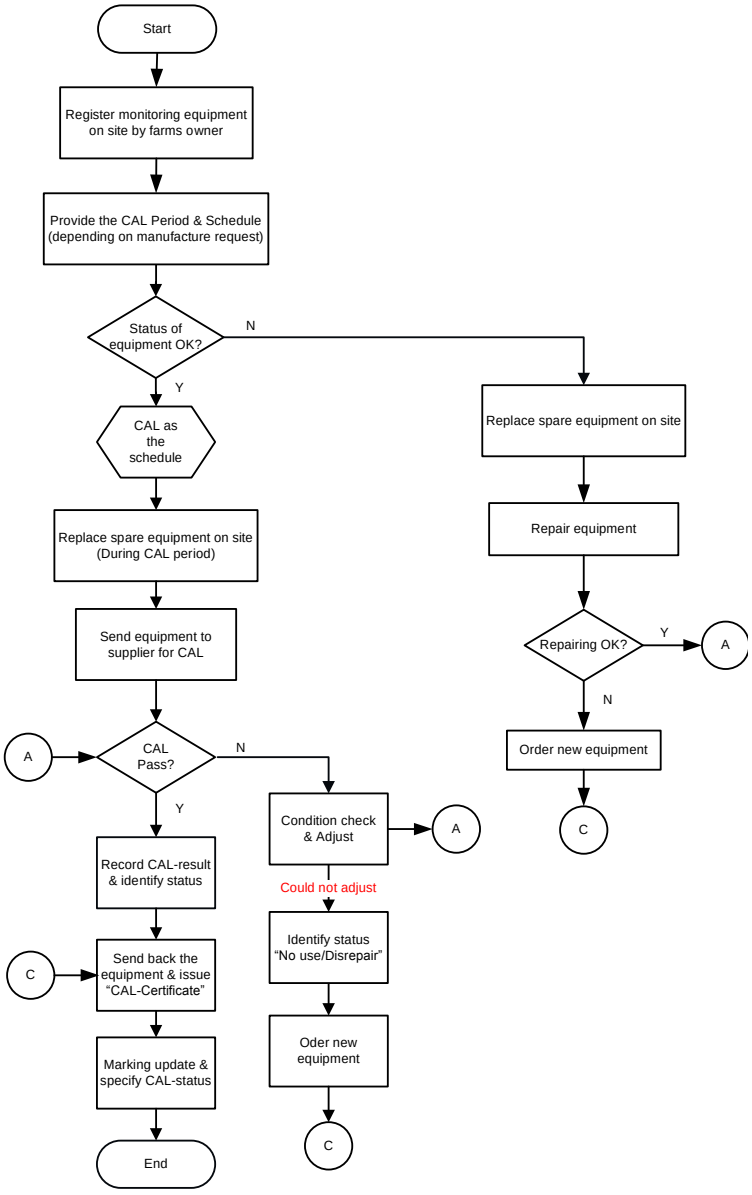
ID	Data Type	Data variable	Unit	Measured (M), Calculated (C), or Estimated (E)	Recording Frequency	Archiving of data	Comment	Responsibility
FFR	-	Formulated Feed Rations	-	M	Monthly	Paper and transferred to electronic	Monthly check from veterinarian	Biogas Plant Operator/Farm
$TDL_{j,y}$	Percentage	Average technical transmission and distribution losses for providing electricity to source j in year y	%	Provided by the Ministry of Energy	Annually	Electronic	Checked annually	Biogas Plant Operator/Farm

The procedures for emergency preparedness, for cases where emergencies can cause unintended emissions and also the risk of fire on emergency condition, are shown below:

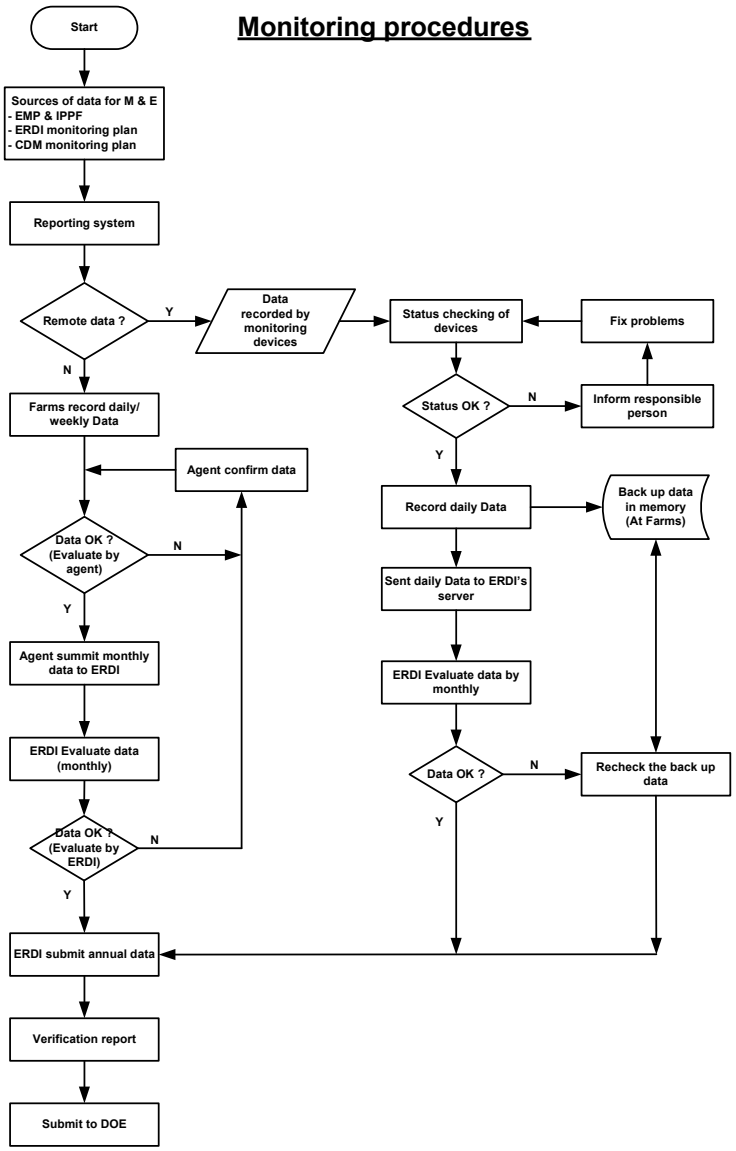


The procedure for the registration, monitoring, measurement and reporting are provided below.

Monitoring system registration and Calibration procedures



Monitoring procedures



Appendix 6. Summary of post registration changes

Version 9, dated 18/08/2016:

- Introduction of alternative values for parameters B_o and $VS_{LT,y}$ regarding instances where swine of different origin are used.

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Deleted: <#>Introduction of alternative way of calculating $N_{LT,y}$ based on practise followed at the participating farms.¶
Clarification for calculation of quantity of electricity consumed by the project from the grid ($EC_{PJ,y}$)¶
Update to version 4.0 of the PoA-DD template¶
Alternative method for calculating MD,y introduced, following approved version 19.0 of the methodology.¶

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Document information

Version	*Date*	*Description*
05.0	15 April 2016	Revision to ensure consistency with the "Standard: Applicability of sectoral scopes" (CDM-EB88-A04-STAN) (version 01.0).
04.0	9 March 2015	Revisions to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Editorial improvement.
03.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the component project activity design document form for small-scale CDM component project activities (these instructions supersede the "Guidelines for completing the component project activity design document form for small-scale component project activities" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a CPA implementer and/or responsible person/ entity for completing the CDM-SSC-CPA-DD-FORM in A.14. and Appendix 1; • Add general instructions on post-registration changes in paragraph 4 and 5 of general instructions and **Error! Reference source not found.**; • Change the reference number from *F-CDM-SSC-CPA-DD* to *CDM-SSC-CPA-DD-FORM*; • Editorial improvement.
02.0	13 March 2012	EB 66, Annex 17 Revision required to ensure consistency with the "Guidelines for completing the component project design document form for small-scale component project activities".
01.0	27 July 2007	EB33, Annex44 Initial adoption.

Deleted: Appendix 6

Version	*Date*	*Description*

Decision Class: Regulatory
Document Type: Form
Business Function: Registration
Keywords: component project activity, project design document, SSC project activities