Monitoring report form for CDM programme of activities
(Version 03.0)

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT		
Title of the PoA	Thailand Small Scale Livestock Waste Management Program	
UNFCCC reference number of the PoA	PoA 8027	
Version numbers of the PoA-DD applicable to this monitoring report	14	
Version number of this monitoring report	3	
Completion date of this monitoring report	13/01/2020	
Monitoring period number	Monitoring period #03	
Duration of this monitoring period	01/01/2017 – 31/12/2018 (first and last days included)	
Monitoring report number for this monitoring period	1	
Coordinating/managing entity	Energy Research and Development Institute Nakornping of Chiang Mai University (ERDI)	
Host Parties	Host Party of the PoA	Is this the host Party of a CPA covered in this monitoring report?(yes/no)
	Thailand	Yes
Applied methodologies and standardized baselines	Methodology AMS III.D. ver. 18 – Methane recovery in animal manure management systems	
Sectoral scopes	Sectoral Scope 13: Waste handling and disposal	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by all CPAs covered in this monitoring report in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	0 tCO_2e	CPA 01: 13,476 tCO_2e CPA 02: 0 tCO_2e CPA 03: 39,470 tCO2e

Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the CPA-DDs for the CPAs covered in this monitoring report	239,594 tCO2e

PART I Monitoring of programme of activities (PoA)

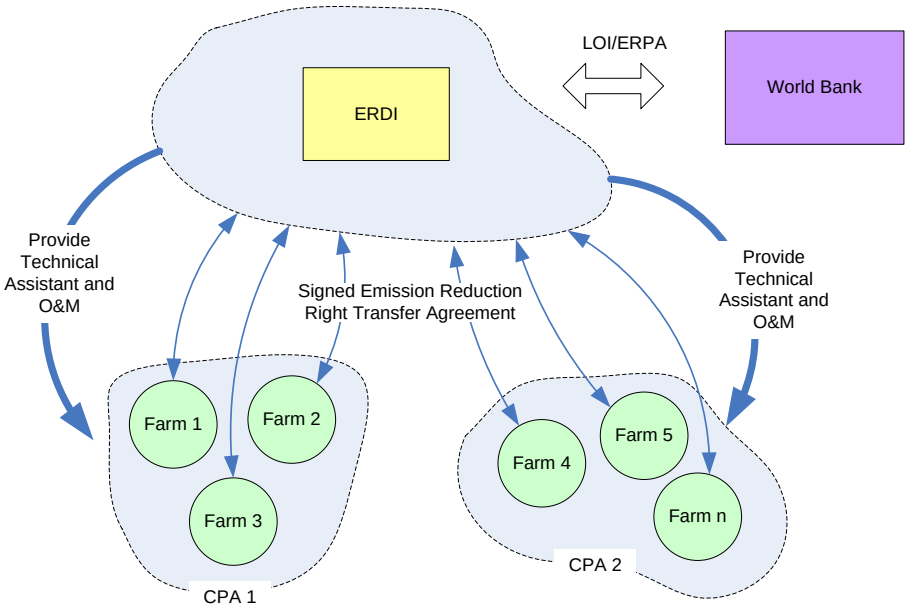
SECTION A. Description of PoA

A.1. General description of PoA

Thailand Small Scale Livestock Waste Management Program is a small-scale Programme of Activities (PoA), developed by Energy Research and Development Institute – Nakornping of Chiang Mai University (ERDI). The proposed activity is to reduce greenhouse gas (GHG) emissions from piggeries manure in Thailand by converting anaerobic lagoons to closed anaerobic treatment digesters with biogas capture and power generation. ERDI is responsible for complete CDM services to the participating farms, as well as additional technical support for waste management system operation and monitoring. These technical capacities provided by ERDI will ensure long-term sustainability of the project activity.

ERDI serves as a Coordinating/Managing Entity (C/ME) of this PoA, taking overall responsibility for the PoA and its small-scale CDM Programme Activity (SSC-CPA) preparation and implementation. Operation and monitoring of each participating farm has been supervised by ERDI. Figure 1 illustrates the institutional arrangement for the PoA and its subsequent CPAs. ERDI is an excellence centre in energy-related fields that has been acknowledged at national and international levels. It provides technologies and professional consulting services in energy conservation, renewable energy and other related engineering prospects for government and private organizations.

Figure 1 – Institutional Arrangement



The treatment of livestock manure by way of anaerobic digester processes leads to the production of a biogas consisting of 60% methane (CH_4). Without the adoption of the PoA, the farms would have employed normal scraping and hose-down cleaning of the animal waste with a series of anaerobic lagoons within the farms' premises. This waste material would have been left to decay in the individual facility's anaerobic lagoon system, producing significant amounts of methane directly to the atmosphere. These livestock waste management practices generally contribute to significant air (odour) and water pollution in the areas close to the farms. The PoA has applied anaerobic digesters to capture the biogas which has been utilised to generate electricity for the farms' internal consumption.

The installed technologies in this SSC-CPA are ERDI-designed anaerobic wastewater treatment digesters. The anaerobic digesters capture methane for use in power generation and provide other environmental benefits, human health and GHG reduction. The electricity generated from the project activities is utilized within the farm premises, reducing the dependence on electricity grid. Excess gas is channelled to the flare to avoid venting of biogas, as well as to ensure the project safety. The effluent from the digesters is discharged to a series of post-treatment lagoons for further use as irrigation water and recycles within the farm with no further discharge off-farm. Detailed project description and its activities are provided in Section B.1.

The inclusion date of CPA01 was with the registration of the PoA on 09/11/2012 while CPAs 02 and 03 were included on 28/11/2014. The project implementation details at each participating farm are delineated in Table 1.

Table 1 – Detailed Project Implementation (farm-wise)

Farm	Construction Commencement	Generator Installation	Commissioning Completion
Chokchaikansukorn Farm	July 2010	September 2010	September 2010
Khana Hybrid Co., Ltd (Phanomsarakham Farm 1)	September 2010	November 2010	November 2010
Laemthong Hybrid Co., Ltd (Wang Noi Farm)	May 2011	July 2011	July 2011
Charoenphansamchuk Farm	May 2010	Mar 2011	Nov. 9, 2012
Veerachai Nongpong Pig Farm	May 2010	July 2011	March. 5, 2013

A.1.1. Corresponding generic component project activities (CPAs)

Title and reference number of the corresponding generic CPA	Version of the PoA-DD	Sectoral scopes	Applied methodologies and standardized baselines
Single generic CPA as per Part II of PoA 8027 "Thailand Small Scale Livestock Waste Management Program CPA_".	14	13	Methodology AMS III.D. ver. 18 – Methane recovery in animal manure management systems

A.1.2. CPAs included in the PoA

Title and UNFCCC reference number of the CPA	Version of the PoA-DD	Title and reference number of the corresponding generic CPA	Crediting period type and duration	Covered in this monitoring report? (yes/no)
Thailand Small Scale Livestock Waste Management Program CPA 01 Ref number: 8027-0001	14	Single generic CPA as per Part II of PoA 8027 "Thailand Small Scale Livestock Waste	09/11/2012 – 08/11/2022	yes (except for Khana Hybrid Co., Ltd (Phanomsarakham Farm 1)

		Management Program CPA _”.		
Thailand Small Scale Livestock Waste Management Program CPA 02 Ref number: 8027-0002	14	Single generic CPA as per Part II of PoA 8027 “Thailand Small Scale Livestock Waste Management Program CPA_”.	01/12/2014 - 30/11/2024	yes
Thailand Small Scale Livestock Waste Management Program CPA 03 Ref number: 8027-0003	14	Single generic CPA as per Part II of PoA 8027 “Thailand Small Scale Livestock Waste Management Program CPA_”.	01/12/2014 - 30/11/2024	yes

A.2. Coordinating/managing entity

>>

Pruk Aggarangsi
Alongkorn Siripat
Energy Research and Development Institute – Nakornping
Chiang Mai University
239 Huay Kaew Rd.,
Suthep, Muang,
Chiangmai, Thailand

In collaboration with:

World Bank Group, IBRD
Climate and Carbon Finance Unit
1818 H Street NW
Washington, DC 20433

SECTION B. Implementation of PoA

B.1. Description of implemented PoA

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The management system of the PoA, has been implemented by ERDI as per the provisions on the registered PoA-DD, section C, registered in 09/11/2012. As such, contractual arrangements have been signed with each participating farm, required data has been transmitted by the farms to ERDI, and ERDI has been in charge of the record keeping system. Specifically, the following have been carried out:

i) A record keeping system for each CPA under the PoA has been set up: data collected by the farms has been submitted to the Project Implementation Unit at ERDI.
ii) A system to avoid double counting to avoid inclusions of new CPAs that may already be CDM projects has been put in place. Two additional CPAs have been included since the PoA was registered.
iii) A system to avoid the inclusion of debundled components of other CDM projects has been put in place. The four conditions mentioned in the PoA have been checked for the two CPAs that were included in 2014
iv) Provisions to ensure that the CPA operators are aware of and have agreed to be subscribed under the PoA have been put in place, as part of the fulfilment of the eligibility criteria of the PoA.

Since only parameter W_{site} (average animal weight for defined population) requires sampling, the sampling design was implemented as follows:

Target population: categories of swine

CPA 01 Chokchaikan sukorn Farm	**CPA 01 Wang Noi**	**CPA 02 CPS**	**CPA 03 Veerachai**
• Nursery	• Nursery	• Nursery	• Nursery
• Fattening 2	• Fattening 2	• Fattening 2	• Fattening 2
• Breed Male		• Breed Male	• Breed Male
• Breed Female		• Breed Female	• Breed female

Sampling method: simple random sampling approach with a level of confidence and precision of 90/10. This method is applicable because population is homogeneous within each category of swine.

Sample size: calculated for each swine category based on:

- Number of heads per category in the farm during a year (N_{LT})
- Use of a normal distribution (50%) to calculate optimum sample size

The following equation has been used to calculate the samples size:

$$n \geq \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Where:

n	Sample size
z	z-score (the number of standard deviations a given proportion is away from the mean) of confidence level of 90% (1.645)
p	Response distribution (50% used for normal distribution)
e	Relative precision (or margin of error)
N	Total number of heads (same as N_{LT})

This results in more samples and is more conservative than the equation for mean-value parameter as given below (equation 18 of Guideline: Sampling and surveys for CDM project activities and programmes of activities Version 04.0):

$$n \geq \frac{1.645^2 NV}{(N-1) \times 0.1^2 + 1.645^2 V}$$

Where:

n	Sample size
V	(SD / mean)²
N	Total number of heads (same as N_{LT})
Mean	our expected mean
SD	our expected standard deviation
1.645	represents the 90 % confidence required

0.1 represents the 10 % relative precision

The mean-value parameter calculation results less sample size. Thus, the first equation will be a conservative approach**.**

Collected data and analysis:

- The sample size for each type are calculated based on annual records of total heads per type of animal.
- The animal weight per type are collected at the weighting scale and reported.
- Spreadsheet calculations including collected data and analysis are provided together with this Monitoring Report.

Demonstration on whether the required confidence/ precision has been met:

- As calculated by the sample size formula, animals have been weighed to meet the sample size required to reach a 90/10 confidence level.

B.2. Post-registration changes to PoA

B.2.1. Corrections

>> not applicable

B.2.2. Inclusion of monitoring plan

>> not applicable

B.2.3. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

>> not applicable

B.2.4. Changes to programme design

>> not applicable

B.2.5. Changes specific to afforestation or reforestation activities

>> not applicable

PART II Monitoring of CPAs

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SECTION C. Implementation of CPAs

C.1. Description of implemented CPAs

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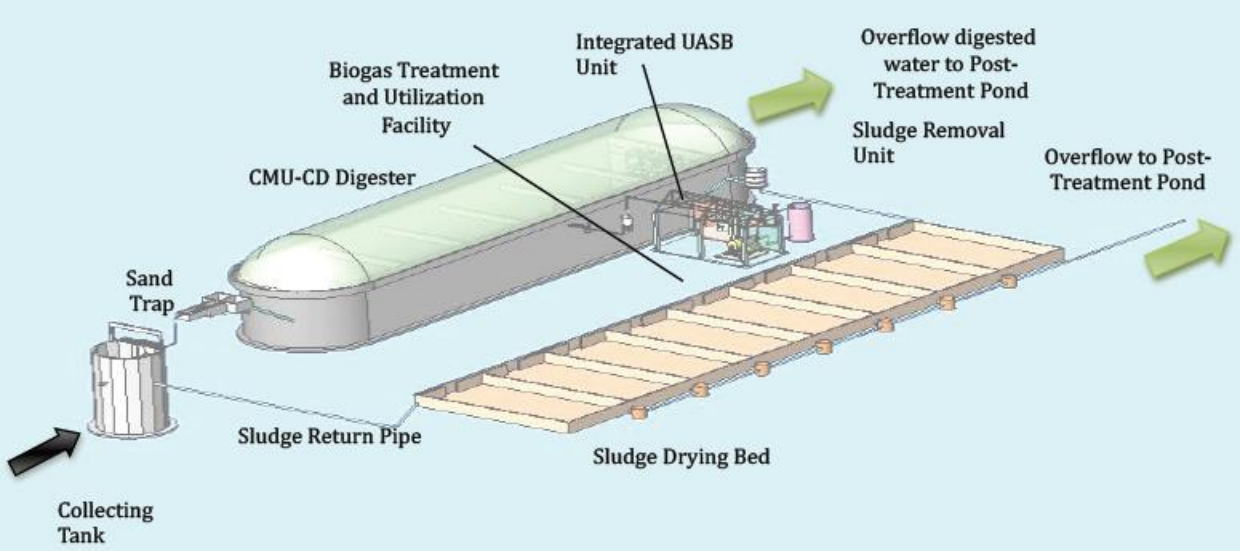
The technology employed by the SSC-CPA is anaerobic wastewater treatment technologies. Anaerobic digestion technologies capture methane for use in energy applications and provide other environmental benefits related to water and air quality, human health and GHG reduction. The waste from all farms described 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 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 2.

Figure 2 – 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 in Table 2.

Table 2 – Technical Specifications of Major Equipment in the System (farm-wise)

CPA	Farm	Digester (m^3)	Generator (kW)	Flare (type)
01	Chokchaikansukorn Farm	3,750	200x2 (Operated at 150 kW)	Open
01	Laemthong Hybrid Co., Ltd (Wang Noi Farm)	3,750	150x2 (Operated at 110kW/130kW)	Open
02	Charoenphansamchuk Farm	6,250	328x2 (Operated at 260 kW	Open
03	Veerachai Nongpong Pig Farm	10,000	1200 (Operated at 600 kW) 985 (stand-by)	Open

Project activities in CPA 01, which includes three pig farms, i.e. Chokchaikansukorn Farm; Khana Hybrid Co., Ltd (Phanomsarakham Farm 1) and Laemthong Hybrid Co., Ltd (Wang Noi Farm), have been up and running since the dates demonstrated in Section A.1 of this monitoring report (MR), except for Khana Hybrid Co., Ltd (Phanomsarakham Farm 1), which did not have any pigs from 1st July, 2016 and consequently did not have the wastewater treatment system in operation due to renovation of its farm during the last monitoring period and beyond. Thus, Khana Hybrid Co., Ltd is not included in this monitoring report. The wastewater treatment systems in the two other farms of this CPA have been continually in operation and all GHG emission reductions resulted from the project implementation have been incorporated and reported in this MR under CPA 01. Project activities in CPA 02 and CPA 03 have also been continually in operation since the dates demonstrated in section A.1 and all GHG emission reductions resulted from the project implementation have been incorporated and reported in this MR.

As mentioned in the previous monitoring report, a second generator of 985 kW as indicated in the table 2 was installed on January 2017 at CPA 03 Veerachai farm and is being run alternatively as a back-up with the original genset of 1200 kW.

C.2. Location of CPAs

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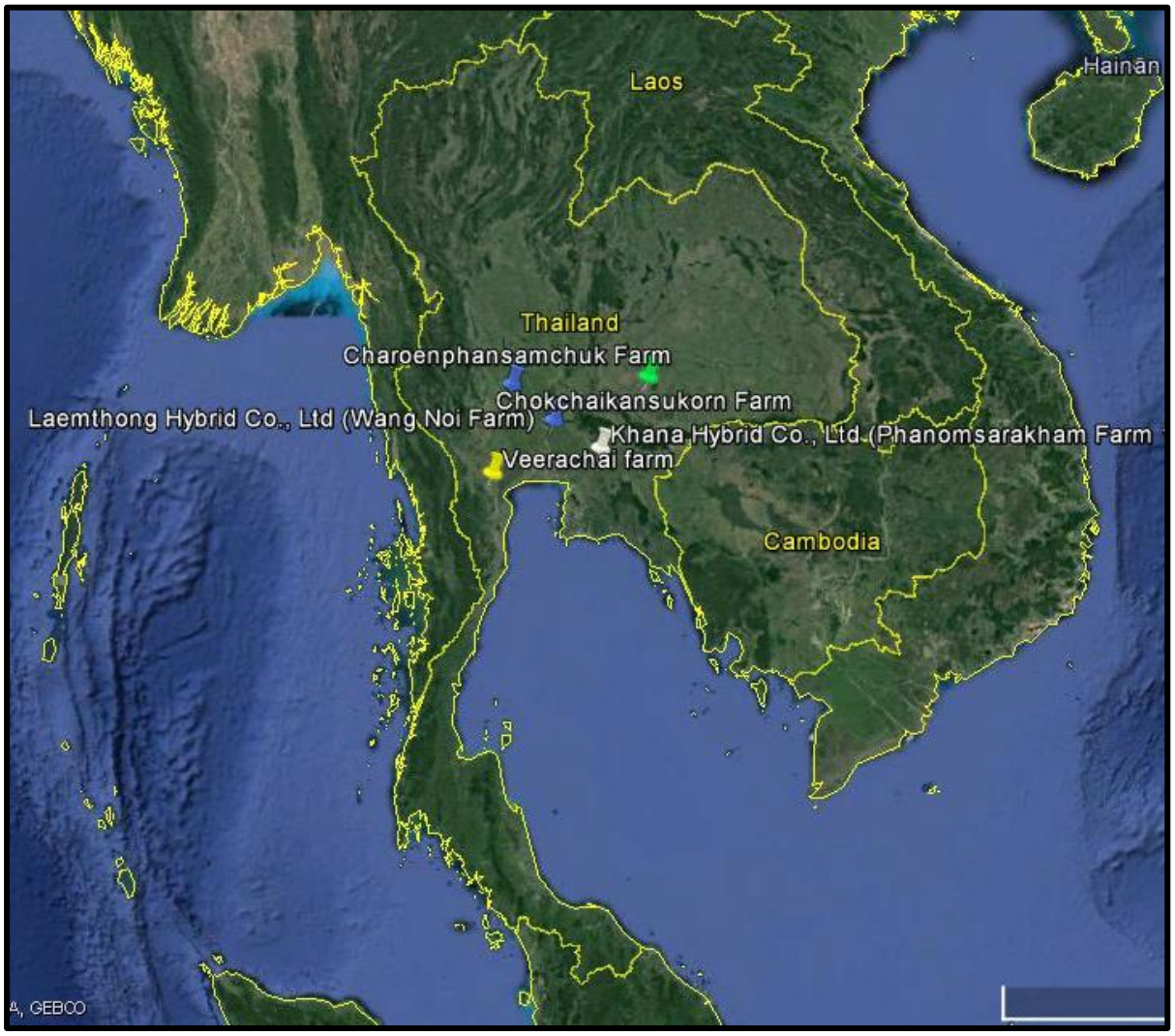
The PoA covers all 75 provinces of Thailand, while the physical location of each of the participating farms of the small-scale CPA 8027-0001, CPA 8027-002 and CPA 8027-003 are contained in Table 3 and Figure 3.

Table 3 – Locations of Participating Farms in small-scale CPA

CPA	Farm	Nearest town	North coordinate	East Coordinate
01	Chokchaikansukorn Farm	Dankwian	14° 52’ 25.3”	102° 10’ 20.9”
01	Khana Hybrid Co., Ltd (Phanomsarakham Farm 1)[1]	Nongsonghong	13° 46’ 27.6”	101° 24’ 37.4”
01	Laemthong Hybrid Co., Ltd (Wang Noi Farm)	Payom	14° 11’ 45.3”	100° 39’ 28.7”
02	Charoenphansamchuk Farm	Samchuk	14.751403	99.991675
03	Veerachai Nongpong Pig Farm	Ratchaburi	13° 23’ 20”	99° 42’ 4”

[1] Not included in this report as the farm is undergoing renovation.

Figure 3 – Map Illustrating Farm Locations



C.3. Post-registration changes to CPAs

C.3.1. Temporary deviations from the monitoring plans in the included CPA-DDs, applied methodologies, standardized baselines or other methodological regulator documents

>> not applicable

C.3.2. Corrections

>> not applicable

C.3.3. Changes to the start date of the crediting period

>> not applicable

C.3.4. Inclusion of monitoring plan

>> not applicable

C.3.5. Permanent changes to the included monitoring plans, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

>> not applicable

C.3.6. Changes to project design

>> not applicable

C.3.7. Changes specific to afforestation or reforestation CPA

>> not applicable

SECTION D. Description of monitoring system of CPAs

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Monitoring was 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 GHG emission reductions achieved by the project activity were determined ex-post through direct measurement of the amount of methane fueled, flared or gainfully used. It was foreseen 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 gwpch4
s 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 12: $VS_{LT,y}$).

The emission reductions achieved are the lowest value of the following:

$$ER_{y,ex\text{-}post} = min\ [(BE_{y,ex\text{-}post} - PE_{y,ex\text{-}post}) , (MD_y - PE_{power,y,ex\text{-}post})] \quad (11)$$

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) (see Section E.1) using ex post monitored values of $N_{LT,y}$ and if applicable $VSL_{T,y}$
$PE_{y,ex\text{-}post}$	Project emissions calculated using formula (4) (see Section E.2) using ex post monitored values of $N_{LT,y}$, $MS\%_{i,y}$ and if applicable $VS_{LT,y}$
MD_y	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:

$$MD_y = BG_{burnt,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4} \quad (12)$$

Where:

$BG_{burnt,y}$	Biogas flared or combusted in year "y" (Nm^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.

$$MD_y = EG_y \times 3600 / (NCV_{CH4} \times EE_y) \times D_{CH4} \times GWP_{CH4}$$

Where:

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

3600 = Conversion factor (1 MWh = 3600 MJ)

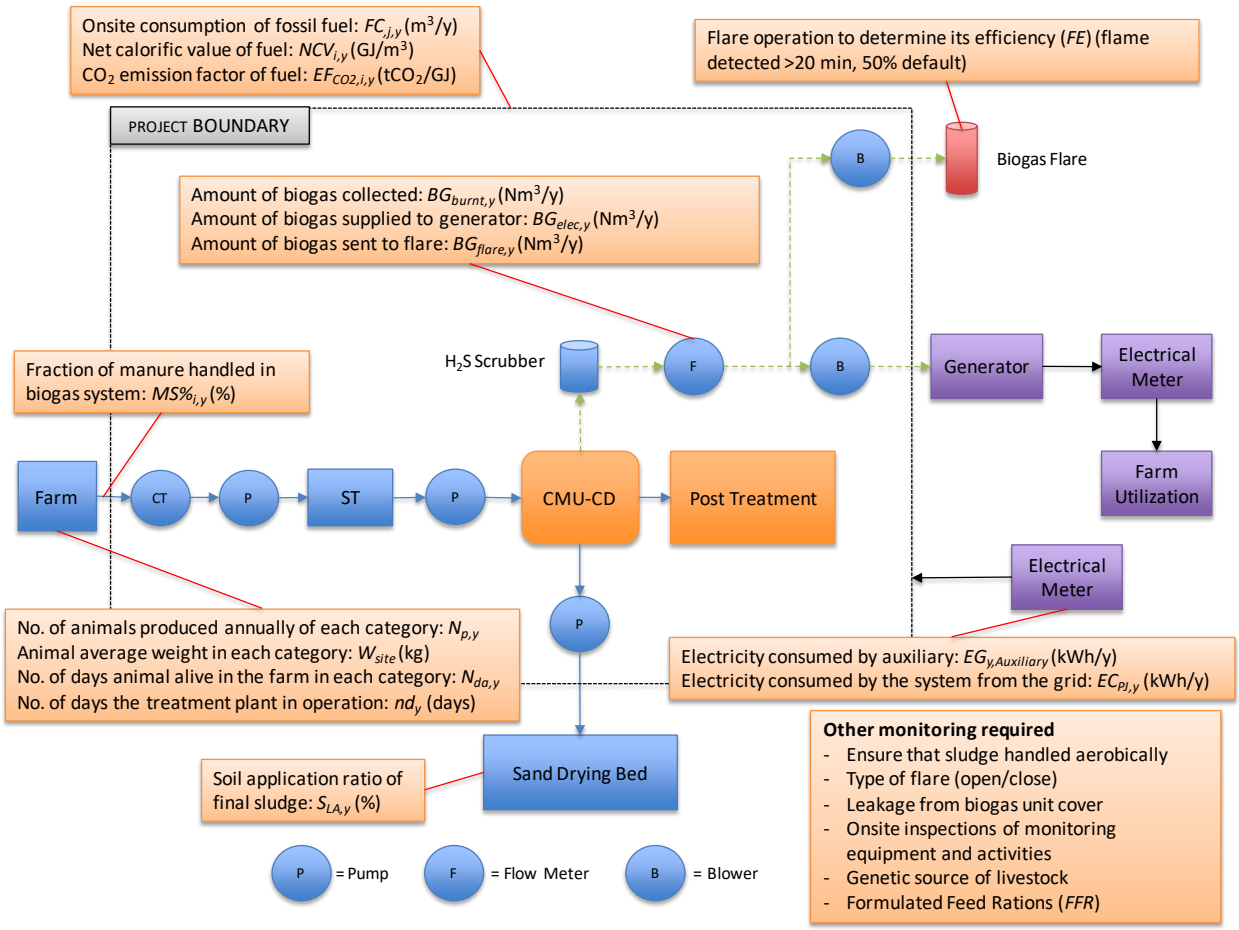
NCV_{CH4} = NCV of methane (MJ/Nm3) use default value: 35.9 MJ/Nm3)

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 %

Monitoring equipment is systematically illustrated in Figure 4.

Figure 4 – Monitoring Equipment in the System



ERDI is 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 for each CPA has been implemented as per the registered PoA in order to ensure that the monitoring process is credible, transparent and conservative.

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

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

- 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 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.

ERDI is the coordinating/managing entity (CME) of this program. Contractual arrangements will be signed with each participating farm, the installation of the anaerobic waste treatment system and the monitoring system. Data will be transmitted on a monthly basis to ERDI that will be in-charge of the record keeping, while key operational data will be transmitted daily to ERDI via remote data access system.

Data collected at the SSC-CPA level will be sent to ERDI that has designated one of its departments to be Project Implementation Unit (PIU) for collecting, treating and archiving CDM data. This department is qualified to manage data and records as it is part of its normal assignment. Paper and electronic records will be kept during the entire crediting period of each SSC-CPA (10 years) and two years after the crediting period. All the monitored parameters will be included in the Information System implemented by ERDI.

SECTION E. Data and parameters

E.1. Data and parameters fixed ex ante

(Copy this table for each data or parameter.)

Data/Parameter	**Capacity / for each participating farm**
Unit	kW
Description	Installed generator capacity in each farm
Source of data	Farm Specific
Value(s) applied	CPA 01 ChokchaiKansu Farm: 200 kW x2 (Operated at 150 kW) CPA 01 Wang Noi Farm: 150 kW x2 (Operated at 110kW/130kW) CPA 02 CPS Farm: 2x328 kW (Operated at 260 kW) CPA 03 Veerachai Farm :1,200 kW (Operated at 600 kW) 985 kW (stand-by)
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions

Additional comments	-

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	-
Purpose of data/parameter:	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:	25 for the second commitment period of the KP
Choice of data or measurement methods and procedures	-
Purpose of data/parameter:	Calculation of baseline/project emissions
Additional comment:	-

Data / Parameter:	D_{CH4}
Unit:	t/m^3
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	-
Purpose of data/parameter:	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	-
Purpose of data/parameter:	Calculation of baseline emissions

Additional comment:	-

Data / Parameter:	$B_{o,LT}$
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 B_o 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. Ex-ante, 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.[2] Ex-post, 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/parameter:	Calculation of baseline emissions
Additional comment:	In this MR, the breeding female genetic is Large white and Landrace from England and used breeding male is Durox from Canada (i.e. N. America) and Denmark. The value of Western Europe instead of N. America region is applied to be conservative in the ex-post calculation for Breeding swine. The market swine are offspring of the breeding swine, thus the conservative value for Market swine from Western Europe is also applied.

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

[2] genetic source certificate

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. Ex-ante, 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.[4] Ex-post, 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/parameter:	Calculation of baseline emissions
Additional comment:	In this MR, the value of North America region is applied for conservative manner of the ex-post calculation for Market swine and Western Europe for Breeding swine.

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	-
Purpose of data/parameter:	Calculation of baseline emissions
Additional comment:	-

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	-
Purpose of data/parameter:	Calculation of project emissions
Additional comment:	-

Data / Parameter:	EF_{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	-
Purpose of data/parameter:	Calculation of baseline emissions

[4] Genetic certificate

Additional comment:	-

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	-
Purpose of data/parameter:	Calculation of project emissions
Additional comment:	-

E.2. Data and parameters monitored

(Copy this table for each data or parameter.)

Data/Parameter	$N_{LT,y}$
Unit	Number
Description	Number of animals produced annually of type *LT* for the year *y*
Measured/calculated/ default	Measured
Source of data	Farm records
Value(s) of monitored parameter	CPA 01 Laemthong Hybrid (Wang Noi):

	2017	2018	Period Total
Nursery	13,476	13,589	27,065
Fattening 1	-	-	-
Fattening 2	7,808	8,163	15,971
Breed Male	-	-	-
Breed Female	-	-	-
Farrow	-	-	-

Chokchaikansukorn:

	2017	2018	Period Total
Nursery	2,664	2,703	5,367
Fattening 1	-	-	-
Fattening 2	10,228	9,790	20,018
Breed Male	42	37	79
Breed Female	1,444	1,412	2,856
Farrow	-	-	-

CPA 02
CPS

	2017	2018	Period Total
Nursery	9,682	9,299	18,981
Fattening 1	-	-	-
Fattening 2	11,346	15,095	26,441
Breed Male	60	64	124
Breed Female	123	128	251
Farrow	-	-	-

CPA 03
Veerachai

	<table><tr><td></td><td>2017</td><td>2018</td><td>Period Total</td></tr><tr><td>Nursery</td><td>31,916</td><td>43,664</td><td>75,580</td></tr><tr><td>Fattening 1</td><td>-</td><td>-</td><td>-</td></tr><tr><td>Fattening 2</td><td>51,982</td><td>59,268</td><td>111,250</td></tr><tr><td>Breed Male</td><td>49</td><td>50</td><td>99</td></tr><tr><td>Breed Female</td><td>10,563</td><td>11,019</td><td>21,582</td></tr><tr><td>Farrow</td><td></td><td>-</td><td>-</td></tr></table>
Monitoring equipment	Farm records.
Measuring/reading/recording frequency	Data has been recorded by the number of swine and the date in/out the farm for each swine category. Records of animal comprise: entries (purchase; births, internal transfer) and exit (ex: sale, death, internal transfer) and the final monthly record of animals. Records have been taken monthly and aggregated and reported annually.
Calculation method (if applicable)	-
QA/QC procedures	The farms records in the logbooks have been crosschecked by ERDI to guarantee consistency; animal purchase and sale records are used to cross-check the information reported.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	

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 ***NLT,y***
Monitoring equipment:	N/A
Measuring / Reading / Recording frequency:	Please refer to additional comment below
Calculation method (if applicable):	N/A
QA/QC procedures:	
Purpose of data/parameter:	
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:	Records of Participating Farm
Value(s) of monitored parameter:	Please see explanation in data/parameter NLT,y and refer to excel spreadsheet calculations for exhaustive monitored values
Monitoring equipment:	N/A
Measuring / Reading / Recording frequency:	Please refer to additional comment below.
Calculation method (if applicable):	N/A
QA/QC procedures:	
Purpose of data/parameter:	
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
Measured / Calculated / Default:	Measured
Source of data:	Farm records of animal weight in each category in the farm annually
Value(s) of monitored parameter:	2017 CPA 01

Type of animal	Wang Noi	Chochaikansukorn
Breeding (male)	-	251.68
Breeding (female)	-	186.00
Fattening 1	-	-
Fattening 2	96.5	100.99
Nursery	11.0	20.28

CPA 02

Type of animal	CPS
Breeding (male)	247.3
Breeding (female)	189.5
Fattening 1	115.2

Fattening 2	-
Nursery	17.7
Farrow	-

CPA 03

Type of animal	Veerachai
Breeding (male)	248.2
Breeding (female)	190.9
Fattening 1	-
Fattening 2	115.4
Nursery	20.0
Farrow	-

2018

CPA 01

Type of animal	Wang Noi	Chochaikansukorn
Breeding (male)	-	257.12
Breeding (female)	-	189.75
Fattening 1	-	-
Fattening 2	98.4	104.51
Nursery	10.9	19.45

CPA 02

Type of animal	CPS
Breeding (male)	243.8
Breeding (female)	187.9
Fattening 1	-
Fattening 2	113.0
Nursery	17.6

CPA 03

Type of animal	Veerachai
Breeding (male)	248.7
Breeding (female)	191.1
Fattening 1	-
Fattening 2	114.3
Nursery	18.5
Farrow	

Monitoring equipment: Weighing scale

Details as follows:

CPA/Farm	Equipment type	Accuracy class	Serial Number	Calibration Frequency	Date of last Calibration	Validity
CPA 01 Wang Noi	WI-P	±5%	2013016	every 3 years	22/03/2016	22/03/2016 - 21/03/2019
CPA 01 Chokchai	Commandor HP-05	±5%	0000719	every 3 years	25/03/2016	25/03/2016 - 24/03/2019
CPA 02 CPS	Mettler Toledo Kingbird	±5%	0042546AJ	every 3 years	19/12/2017	19/12/2017 - 18/12/2020

	CPA 03 Veerachai	Mettler Toledo Kingbird	±5%	B3016741 14	every 3 years	20/12/2017	20/12/2017 - 19/12/2020

Measuring / Reading / Recording frequency:	Weighing has been done on-site as supervised by the Farm Managers. Data has been reported annually as per the sampling procedure explained in Section B.1.
Calculation method (if applicable)	
QA/QC procedures:	The scales have been calibrated by an independent third-party auditor. The scales are calibrated once every 3 years.
Purpose of data/parameter	Calculation of baseline emissions
Additional comment:	The weight site values in tables were discounted in ER calculation spreadsheets for year 2017 for CPS and Veerachai farms since there was a delay in calibration of the weighing scales for these farms.

Data / Parameter:	$BG_{burnt,y}$
Unit:	Nm^3
Description:	Biogas volume in year *y*
Measured / Calculated / Default:	Calculated by the sum of the monitored amount of biogas supplied to generator ($_{o,y}$) and the amount of biogas sent to the flaring system ($BG_{flare,y}$).
Source of data:	Flow meters
Value(s) of monitored parameter:	

CPA	Farm	2017	2018	Period Total
01	Wang Noi	300,186	339,642	639,828
01	Chokchai	383,846	351,045	734,891
02	CPS	0	0	0
03	Veerachai	2,076,851	1,894,438	3,971,290

Monitoring equipment:	Please refer to flow meter details on parameters $BG_{elec,y}$ and $BG_{flare,y}$ below
Measuring / Reading / Recording frequency:	Monitored continuously
Calculation method (if applicable)	-
QA/QC procedures:	Please refer to relevant parameter table.
Purpose of data/parameter	Calculation of baseline emissions
Additional comment:	Discounted flows due to delay in calibration for CPA 01 farms. For CPA 02 CPS, there was a failure in recording of gas flow to engine from 01/01/2017 to 31/12/2018, so no readings were taken. Emission reductions for CPA 2 (CPS farm) not claimed for the monitoring period. Discounted flows for CPA 03 due to delay in calibration of flowmeter.

Data / Parameter:	$BG_{elec,y}$
Unit:	Nm^3
Description:	Amount of biogas captured and used as fuel for the generator
Measured / Calculated / Default:	Measured
Source of data:	Flow meter
Value(s) of monitored parameter:	Refer to calculation spreadsheet for detailed values

CPA	Farm	2017	2018	Period total
01	Wang Noi	300,186	339,642	639,828

	01	Chokchai	383,846	351,045	734,891
	02	CPS	0	0	0
	03	Veerachai	2,076,851	1,894,438	3,971,290

Monitoring equipment:

Biogas utilised in the generator has been continuously monitored through the use of the equipment below.

The same type of flow meter is installed at the 3 farms in CPA 01 and CPA 02

Monitoring equipment type:	Endress-Hauser Proline t-mass 65, Thermal mass flowmeter
Accuracy class:	±1.5 % of reading for 100 % to 10 % of range (at reference conditions) ±0.15 % of full scale for 10 % to 1 % of range (at reference conditions)
Calibration frequency:	Every 2 to 3 years (recommended)

CPA 03

Monitoring equipment type:	FCI. FLUID COMPONENTS INTERNATIONAL LLC
Accuracy class:	(at ≥ 0.75 SFPS [≥ 0,21 NMPS] 2) Standard: ± 2% reading ± 0.5% full scale Optional: ± 1% reading ± 0.5% full scale
Calibration frequency:	Every 2 to 3 years (recommended)

Detailed information of flow meter at each farm:

CPA	Serial Number	Installation Date	Date of last Calibration	Validity
01 Wang Noi	F5147D02000	30/10/2012	10/08/2015	10/08/2015-09/08/2017
			25/08/2017	25/08/2017-24/08/2019
01 Chokchai	EC0A3E02000	28/10/2012	11/08/2015	11/08/2015-10/08/2017
			17/11/2016	17/11/2016-16/11/2018
			26/08/2019	26/08/2019-25/08/2021
02 CPS	D3048502000	06/05/2015	6/05/2015	06/05/2015-05/05/2017
			28/08/2017	28/08/2017-27/08/2019
03 Ve erachai	1200kw: 493548	01/07/2015	01/07/2015(factory calibrated)	-/07/2015-30/06/2017
			19/08/2019	19/08/2019-18/08/2021
	985kw:493549	01/2017	01/2017	01/2017-31/12/2019

Measuring / Reading / Recording frequency:	Measured continuously
Calculation method (if applicable)	-
QA/QC procedures:	Flow meters have been calibrated according to the manufacturer's recommendation.

Purpose of data/parameter	Calculation of baseline emissions
Additional comment:	All flow meters had been factory calibrated before installation. Discounted flows for CPA 01, CPA 03 farms due to delayed calibration. Alternatively, if the recovered methane is used for power generation, and if no flow meter recording is available, this parameter will not be reported for monitoring. No ER claims are made for CPA 02 since there are no flow rates recorded.

Data / Parameter:	$BG_{flare,y}$
Data unit:	Nm^3
Description:	Amount of biogas sent to flare
Measured / Calculated / Default:	Measured
Source of data:	Flow meter
Value(s) of monitored parameter:	Refer to calculation spreadsheet for detailed values

CPA	Farm	2017	2018	Period total
01	Wang Noi	0	0	0
01	Chokchai	0	0	0
02	CPS	0	0	0
03	Veerachai	0	0	0

Monitoring equipment: The same type of flow meter is installed at the 3 farms in CPA1; biogas sent to flare has been continuously monitored through the use of the below equipment.

Monitoring equipment type:	Endress-Hauser Proline t-mass 65, Thermal mass flowmeter
Accuracy class:	±1.5 % of reading for 100 % to 10 % of range (at reference conditions) ±0.15 % of full scale for 10 % to 1 % of range (at reference conditions)
Calibration frequency:	Every 2 to 3 years (recommended)

Detailed information of flow meter at each farm:

CPA	Serial Number	Installation Date	Date of last Calibration	Validity
01 Wang Noi	F5147C02000	30/10/2012	10/08/2015	10/08/2015-09/08/2017
			10/08/2017	10/08/2017-09/08/2019
01 Chokchai	D3048402000	10/10/2014	22/10/2014	22/10/2014-21/10/2016
			2/12/2016	2/12/2016-1/12/2018
02 CPS	L20CFE02000	24/02/2016	24/02/2016	24/02/2016-23/02/2018
03 Veerachai		24/11/2019	24/11/2019	24/11/2019-23/11/2021

Measuring / Reading / Recording frequency:	Measured continuously
Calculation method (if applicable)	-
QA/QC procedures:	Flow meters have been calibrated according to the manufacturer's recommendation.
Purpose of data/parameter	Calculation of project emissions
Additional comment:	Delay in calibration at for CPAs 01, 02 farms do not impact ER calculation, as there was no flaring at the farms during the monitoring period. There was no meter installed at CPA 03 Veerachai, as they will not claim ERs for flaring and there was

	no flaring during the monitoring period. The date for installation of the meter for CPA03 was on Nov 24,2019

Data / Parameter:	**Flare operation**
Data unit:	Hours
Description:	Flare operation in hour *h*
Measured / Calculated / Default:	Measured
Source of data:	Farm records
Value(s) of monitored parameter:	2017 CPA | Farm | hours 01 | Laemthong Hybrid (Wang Noi) | 0 01 | Chochaikansukorn | 0 02 | CPS | 0 03 | Veerachai | 0 2018 CPA | Farm | hours 01 | Laemthong Hybrid (Wang Noi) | 0 01 | Chochaikansukorn | 0 02 | CPS | 0 03 | Veerachai | 0
Monitoring equipment:	For CPA 01, 02 and 03, a thermocouple type K, Model TH-10 with SUS316L from IES ELECTRIC Co., Ltd., is used to measure temperature. An upper temperature is limited to 1100 °C. It indicates when the flare is operating or not. The temperature and flaring time will be automatically recorded. Accuracy of a type K thermocouple falls within standard range of ± 2.2C% or ±.75%. See for example: http://www.thermometricscorp.com/thertypk.html CPA | Farm | Serial Number 01 | Wang Noi | TH102459 01 | Chokchai | TH101256 02 | CPS | TH105214 03 | Veerachai | TH106574
Measuring / Reading / Recording frequency:	Continuous
Calculation method (if applicable)	-
QA/QC procedures:	The Thermocouple model TH-10, does not require any specific maintenance or calibration.
Purpose of data/parameter	Calculation of project emissions
Additional comment:	As per the "*Tool to determine project emissions from flaring of gases containing methane*", since CPAs are using open flares, when the flare is operating a default value at 50% has been used for the flare efficiency. Data will be kept for two years after the end of the crediting period.

Data / Parameter:	$EC_{PJ,y}$
Data unit:	kWh
Description:	Quantity of electricity consumed by the project from the grid
Measured /	Calculated

Calculated / Default:	
Source of data:	conservative estimate using maximum rating and continuous use of equipment
Value(s) of monitored parameter:	Please refer to calculation spreadsheet for more detailed values

CPA	Farm	2017(MWh)	2018(MWh)	Period total
01	Wang Noi	146.73	146.73	293.46
01	Chokchai	126.14	126.14	252.29
02	CPS	196.22	196.22	392.44
03	Veerachai	353.9	353.9	707.81

CPA 01
Wang Noi:

Equipment	**No. of unit**	**Power (kW)**	**Operation (hr/day)**	**Daily electricity consumption (kWh)**	**Energy consumption per year (kWh)**	**Energy consumption per year (MWh)**
FEED PUMP	2	7.5	24	360	131,400	131.40
BIOGAS BLOWER	1	1.75	24	42	15,330	15.33
				Total	**146,730**	**146.73**

Chokchai:

Equipment	**No. of unit**	**Power (kW)**	**Operation (hr/day)**	**Daily electricity consumption (kWh)**	**Energy consumption per year (kWh)**	**Energy consumption per year (MWh)**
FEED PUMP	2	5.5	24	264	96,360	96.36
BIOGAS BLOWER	1	3.4	24	82	29,784	29.78
				Total	**126,144**	**126.14**

CPA 02
CPS:

Equipment	**No. of unit**	**Power (kW)**	**Operation (hr/day)**	**Daily electricity consumption (kWh)**	**Energy consumption per year (kWh)**	**Energy consumption per year (MWh)**
Feed Pump (CT1)	2	5.5	24	264	96,360	96.36
Feed Pump (CT2)	2	3.7	24	178	64,824	64.82
Biogas Blower	1	4	24	96	35,040	35.04
				Total	**196,224**	**196.22**

CPA 03
Veerachai:

Equipment	**No. of unit**	**Power (kW)**	**Operation (hr/day)**	**Daily electricity consumption (kWh)**	**Energy consumption per year (kWh)**	**Energy consumption per year (MWh)**
Feed Pump (CT)	2	11	24	528	192,720	192.72
Sludge Pump	2	3.7	24	177.6	64,824	64.824
Blower	1	11	24	264	96,360	96.36
				Total	**353,904**	**353.904**

Monitoring equipment:	For the current monitoring period, maximum load is considered for electricity consumption at the 4 farms in CPA 01, 02 and 03 as consistent in the registered CPA-DDs, since the monitoring of electricity consumed by the project cannot be isolated from the overall farm electricity consumption.
Measuring / Reading / Recording frequency:	N/A
Calculation method (if applicable)	Please refer to ER calculation spreadsheet.
QA/QC procedures:	Farm's reported equipment has been checked by ERDI staff
Purpose of data/parameter	Calculation of project emissions
Additional comment:	Only monitored if the farm consumes electricity from the grid Since the monitoring of electricity consumed by the project cannot be isolated from the overall farm electricity consumption, $EC_{PJ,y}$ has been derived from applying the assumption that electrical appliances are continuously utilized, and a corresponding value applied.

Data / Parameter:	$EG_{y,Auxillairy}$
Data unit:	kWh
Description:	Renewable electricity generated by the project activity, consumed by auxiliary equipment
Measured / Calculated / Default:	Measured
Source of data:	Farm record on the utilization of electrical appliances under the project activity, using renewable energy
Value(s) of monitored parameter:	0
Monitoring equipment:	Farm record on the utilization of electrical appliances under the project activity.
Measuring / Reading / Recording frequency:	Monthly and aggregated annually
Calculation method (if applicable)	-
QA/QC procedures:	Farm manager's signature is required on the record
Purpose of data/parameter	Calculation of project emissions
Additional comment:	All energy generated at the farm was utilized at the farm with no off-farm sale. As it is not possible to isolate the consumption of renewable energy for auxiliary equipment from the total energy used at the farm, it has been left at zero (0). The monitored value has no effect on ER calculations as the emission factor for renewable energy is zero (0).

Data / Parameter:	$FC_{i,j,y}$
Data unit:	m^3/yr
Description:	Onsite combustion of fossil fuels of type *i* in process *j* during the year y
Measured / Calculated / Default:	Measured
Source of data:	Project Implementer
Value(s) of monitored parameter:	0
Monitoring equipment:	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.
Measuring / Reading / Recording frequency:	Monthly and aggregated annually
Calculation method (if applicable)	-
QA/QC procedures:	The consistency of metered fuel consumption quantities will with available purchase invoices from the financial records.
Purpose of data/parameter	Calculation of project emissions
Additional comment:	No fossil fuel has been used at any of the project sites.

Data / Parameter:	$NCV_{i,y}$
Data unit:	GJ/m^3
Description:	Net calorific value of fuel type *i* in year *y*
Measured / Calculated / Default:	Measured
Source of data:	Values from the fuel supplier will be used.
Value(s) of monitored parameter:	Only used in ex-post calculations
Monitoring equipment:	Values provided by the fuel supplier. Undertaken in line with national or international fuel standards. The NCV will be obtained for each fuel delivery, from which weighted average annual values should be calculated.
Measuring / Reading / Recording frequency:	The NCV will be obtained for each fuel delivery, from which weighted average annual values should be calculated.
Calculation method (if applicable)	-
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/parameter	Calculation of project emissions
Additional comment:	No fossil fuel has been used at any of the project sites.

Data / Parameter:	$EF_{CO2,i,y}$
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor of fuel type *i* in year y
Measured / Calculated / Default:	Measured
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) of monitored parameter:	0
Monitoring equipment:	-
Measuring / Reading / Recording frequency:	-
Calculation method (if applicable)	-
QA/QC procedures:	It will be checked against any future revision of IPCC Guidelines

Purpose of data/parameter	Calculation of project emissions
Additional comment:	No fossil fuel has been used at any of the project sites.

Data / Parameter:	$MS\%_{i,y}$
Data unit:	%
Description:	Fraction on manure handled in system *i* in the project activity in year *y*
Measured / Calculated / Default:	Measured
Source of data:	Farm records
Value(s) of monitored parameter:	100
Monitoring equipment:	All manure at the five farms in CPA 01, 02 and 03 is handled in the treatment system
Measuring / Reading / Recording frequency:	Farm's operational records. Manure is collected daily or every other day by hose flushing all material through a series of collection channels, operating by gravity.
Calculation method (if applicable)	-
QA/QC procedures:	Farm manager's signature is required on the record.
Purpose of data/parameter	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
Data unit:	Days
Description:	Number of days that the animal manure management system was operational
Measured / Calculated / Default:	Measured
Source of data:	Farm record
Value(s) of monitored parameter:	Please refer to calculation spreadsheet for more detailed values for each farm of the CPAs
Monitoring equipment:	The record on the number of days in year *y* where the treatment plant not operational was documented in a logbook and taken into account for the calculation of $BE_{ex\text{-}post}$. To be monitored monthly based on daily records and reported annually.
Measuring / Reading / Recording frequency:	Monitored daily. Operational days and monthly summarized values for relevant parameters are presented in the ER spreadsheet.
Calculation method (if applicable)	-
QA/QC procedures:	Farm manager's signature is required on the record
Purpose of data/parameter	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**
Data unit:	%
Description:	Ratio of final sludge treated aerobically over total sludge treated.
Measured / Calculated / Default:	Measured
Source of data:	Farm records

Value(s) of monitored parameter:	100
Monitoring equipment:	Farm record of final sludge treated aerobically, and sludge treated anaerobically.
Measuring / Reading / Recording frequency:	Daily, reported monthly
Calculation method (if applicable)	-
QA/QC procedures:	Farm manager's signature is required farm data record sheet
Purpose of data/parameter	Calculation of project emissions
Additional comment:	

Data / Parameter:	**Onsite inspections for each individual farm included in the project boundary**
Data unit:	Not applicable
Description:	Onsite inspections of the project boundary
Measured / Calculated / Default:	
Source of data:	Farm's records
Value(s) of monitored parameter:	Not applicable
Monitoring equipment:	Regular farm inspections to check that the equipment are working properly, maintenance are performed according to manufacturer's specification, and all monitoring data is recorded as required in the monitoring data record sheet.
Measuring / Reading / Recording frequency:	Annually
Calculation method (if applicable)	-
QA/QC procedures:	Farm's manger signature is required on the monitoring data record sheet.
Purpose of data /parameter	Calculation of baseline and project emissions
Additional comment:	-

Data / Parameter:	Genetic source of the production operations livestock
Data unit:	Not applicable
Description:	Genetic source of the production operations livestock
Measured / Calculated / Default:	Measured
Source of data:	Farm monitoring record data
Value(s) of monitored parameter:	CPA 01 Wang Noi: Western Europe, N. America CPA 01 Chokchai: Western Europe, N. America CPA 02 CPS: Western Europe, N. America CPA 03 Veerachai: Western Europe, N. America
Monitoring equipment:	Farm's records
Measuring / Reading / Recording frequency:	Annually
Calculation method (if applicable)	-
QA/QC procedures:	Farm's manger signature is required on the monitoring data record sheet.
Purpose of data/parameter	Calculation of baseline emissions
Additional comment:	

Data / Parameter:	***FFR***
Data unit:	-
Description:	Formulated Feed Rations
Measured / Calculated / Default:	Measured
Source of data:	Farm's records
Value(s) of monitored parameter:	At each farm formulated feed rations (FFR) which are optimized for swine according to stage of growth, category, weight gain/productivity and/or genetics were used.
Monitoring equipment:	Farm records on FFR.
Measuring / Reading / Recording frequency:	Annually
Calculation method (if applicable)	-
QA/QC procedures:	Farm's manager signature is required on the monitoring data record sheet.
Purpose of data/parameter	Calculation of baseline emissions
Additional comment:	Data will be kept for two years after the end of the crediting period.

Data / Parameter:	$TDL_{j,y}$
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*
Measured / Calculated / Default:	Provided by the Ministry of Energy
Source of data:	Ministry of Energy. Use recent, accurate and reliable data available in Thailand.
Value(s) of monitored parameter:	6.10%
Monitoring equipment:	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Measuring / Reading / Recording frequency:	Annually
Calculation method (if applicable)	-
QA/QC procedures:	Checked against the *Electric Power in Thailand* published by the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy.
Purpose of data/parameter	Calculation of project emissions
Additional comment:	The TDL used in the calculation is for the year 2013 from "Thailand Energy Statistics (Preliminary) 2013", published by DEDE, Ministry of Energy. (Weblink: http://www.dede.go.th/download/stat58/statistics2556r_p.pdf) However, for conservativeness due to project GHG emissions related to the consumption of electricity, a value of 10% will be applied for this monitoring period.

E.3. Implementation of sampling plan

>>

Desired Precision and Sampling Size

Parameter W_{site} was monitored following a sampling approach as per the monitoring plan (defined in Section B.2). For each farm, a representative sample of animals was weighed for each of the swine categories, as applicable, i.e. Nursery, Fattening 1, Fattening 2, Breed Male, Breed Female and Farrow. An annual sampling size was appropriately determined at a 90/10 precision and the results are presented in the tables below.

CPA 01

Wang Noi		Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
				2017			
Population size	N	13,476	N/A	7,808	N/A	N/A	N/A
Distribution	p	0.5	N/A	0.5	N/A	N/A	N/A
Margin of error	e	0.1	N/A	0.1	N/A	N/A	N/A
Confidence level	%	90	N/A	90	N/A	N/A	N/A
z-score	z	1.645	N/A	1.645	N/A	N/A	N/A
Intermediate calculation		67.650625	N/A	67.650625	N/A	N/A	N/A
Sample size	**n**	**68**	**N/A**	**68**	**N/A**	**N/A**	**N/A**
				2018			
Population size	N	13,588	N/A	8,161	N/A	N/A	N/A
Distribution	p	0.5	N/A	0.5	N/A	N/A	N/A
Margin of error	e	0.1	N/A	0.1	N/A	N/A	N/A
Confidence level	%	90	N/A	90	N/A	N/A	N/A
z-score	z	1.645	N/A	1.645	N/A	N/A	N/A
Intermediate calculation		67.650625	N/A	67.650625	N/A	N/A	N/A
Sample size	n	**68**	**N/A**	**68**	**N/A**	**N/A**	**N/A**

Chokchai		Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
				2017			
Population size	N	2,664	N/A	10,228	42	1,444	N/A
Distribution	p	0.5	N/A	0.5	0.5	0.5	N/A
Margin of error	e	0.1	N/A	0.1	0.1	0.1	N/A
Confidence level	%	90	N/A	90	90	90	N/A
z-score	z	1.645	N/A	1.645	1.645	1.645	N/A
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	N/A
Sample size	**n**	**66**	**N/A**	**68**	**26**	**65**	**N/A**
				2018			
Population size	N	2,703	N/A	9,790	37	1,412	N/A
Distribution	p	0.5	N/A	0.5	0.5	0.5	N/A
Margin of error	e	0.1	N/A	0.1	0.1	0.1	N/A
Confidence level	%	90	N/A	90	90	90	N/A
z-score	z	1.645	N/A	1.645	1.645	1.645	N/A
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	N/A
Sample size	**n**	**66**	**N/A**	**68**	**24**	**65**	**N/A**

CPA 02 CPS

CPS		Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
				2017			
Population size	N	9,678	N/A	11,315	60	123	N/A
Distribution	p	0.5	N/A	0.5	0.5	0.5	N/A
Margin of error	e	0.1	N/A	0.1	0.1	0.1	N/A
Confidence level	%	90	N/A	90	90	90	N/A
z-score	z	1.645	N/A	1.645	1.645	1.645	N/A
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	N/A
Sample size	**n**	**68**	**N/A**	**68**	**32**	**44**	**N/A**

CPS		Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
				2018			
Population size	N	9,299	N/A	15,095	64	128	N/A
Distribution	p	0.5	N/A	0.5	0.5	0.5	N/A
Margin of error	e	0.1	N/A	0.1	0.1	0.1	N/A
Confidence level	%	90	N/A	90	90	90	N/A
z-score	z	1.645	N/A	1.645	1.645	1.645	N/A
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	N/A
Sample size	**n**	**68**	**N/A**	**68**	**33**	**45**	**N/A**

CPA 03

Veerachai		Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
				2017			
Population size	N	30,455	N/A	51,982	49	10,563	N/A
Distribution	p	0.5	N/A	0.5	0.5	0.5	N/A
Margin of error	e	0.1	N/A	0.1	0.1	0.1	N/A
Confidence level	%	90	N/A	90	90	90	N/A
z-score	z	1.645	N/A	1.645	1.645	1.645	N/A
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	N/A
Sample size	**n**	**68**	**N/A**	**68**	**29**	**68**	**N/A**
				2018			
Population size	N	43,664	N/A	59,268	50	11,019	N/A
Distribution	p	0.5	N/A	0.5	0.5	0.5	N/A
Margin of error	e	0.1	N/A	0.1	0.1	0.1	N/A
Confidence level	%	90	N/A	90	90	90	N/A
z-score	z	1.645	N/A	1.645	1.645	1.645	N/A
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	N/A

Sample size	**n**	**68**	**N/A**	**68**	**29**	**68**	**N/A**

As per the evidences provided to the DOE, the sample size per animal category has been met for year 2017 and 2018.

Sampling Procedure and Quality Control
The scale—i.e. digital type, with accuracy to be within 50 grams—at each participating farm was tuned onsite using a weight set which was calibrated according to the national standards and recalibrated at appropriate intervals according to manufacturer specifications. The weight of each individual was recorded on a paper form and signed by the farm personnel who perform the weighing. A supervisor conducted random checks. Once the record forms were completed, a farm manager signed off. The records have been kept in both hard copy and electronic format. A copy has been provided to the verifying DOE.

SECTION F. Calculation of emission reductions or net anthropogenic removals

F.1. Calculation of baseline emissions or baseline net removals

>>

$$BE_y = GWP_{CH4} * D_{CH4} * UF_b * \sum_{j,LT} MCF_j * B_{0,LT} * N_{LT,y} * VS_{LT,y} * MS\%_{Bl,j} \quad (1)$$

Where:

BE_y	baseline emissions in year "y" (tCO_2e/yr)
GWP_{CH4}	Global Warming Potential of CH_4 (21 and 25 for first and second commitment perio respectively)
D_{CH4}	CH4 density (0.00067 t/m^3 at room temperature (20ºC) 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" in percentages (digester in project scenario).
$B_{0,LT}$	Maximum methane producing potential of the volatile solid generated for animal type "LT" (m^3 CH_4/kg dm)
$N_{LT,y}$	Annual average number of animals of type "LT" in year "y" (numbers) calculated using the formula below.
$VS_{LT,y}$	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:

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

$$VS_{site,LT,y} = (W_{site} / W_{default}) \times VS_{default} * nd_y \quad (2)$$

Where:

$VS_{site,LT,y}$	Adjusted volatile solid excretion for livestock "LT" entering the animal manure management system in year "y" (on a dry matter weight basis, kg dm/animal/year)
W_{site}	Average site animal weight for defined population, in kg

$W_{default}$	Default average animal weight for defined population, in kg.
$VS_{default}$	Default value (IPCC) for the volatile solid excretion per day on a dry-matter basis for defined livestock population, in kg-dm/animal/day
nd_y	Number of days in year "y" where the treatment plant was operational

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

$$N_{LT,y} = N_{da,y} * (N_{p,y}/365) \quad (3)$$

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 farm 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 a $N_{da,y}$ 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.

By following formulae (1)-(3), a sample BE_y calculation of livestock type "nursery" (*LT* = nursery) at Wang Noi Farm during 2017 (*y* = 2017) is illustrated below. Wsite considered a maximum uncertainty of -5% due to late calibration of weighing scale.

$VS_{LT,y}$	W_{site}	$W_{default}$	$VS_{default}$	nd_y
20.41	10.36	50	0.27	365

BE_y	GWP_y	D_{CH4}	UF_b	MCF_j	$B_{o,LT}$	$N_{LT,y}$	$VS_{LT,y}$	$MS\%_{BI,j}$
1,345	25	0.00067	0.94	80	0.,45	13,476	20.41	1

F.2. Calculation of project emissions or actual net removals

>>

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 ($PE_{storage,y}$).

$$PEy = PE_{PL,y} + PE_{flare,y} + PE_{power,y} + PE_{transp,y} + PE_{storage,y} \quad (4)$$

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)
$PE_{flare,y}$	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 section A.4.2.1 above, waste collection from all farms described in this project 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*" ($PE_{PL,y}$)

$$PE_{PL,y} = 0.10 * GWP_{CH4} * D_{CH4} * \sum_{j,LT} B_{0,LT} * N_{LT,y} * VS_{LT,y} * MS\%_{i,j} \quad (5)$$

Refer to BE_y formula (equation 1) for the value of the parameters applied in $PE_{PL,y}$ equation

By following formula (5), a sample $PE_{PL,y}$ calculation of livestock type "nursery" (LT = nursery) at Wang Noi Farm during 2017 (y = 2017) is illustrated below.

$PE_{PL,y}$	GWP_y	D_{CH4}	$B_{o,LT}$	$N_{LT,y}$	$VS_{LT,y}$	$MS\%_{i,y}$
220	25	0.00067	0.45	13,476	20.41	1

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)

$$PE_{flare,y} = \Sigma\, TM_{RG,h} * (1 - \eta_{flare,h}) * GWP_{CH4} / 1000 \quad (6)$$

Where:

$TM_{RG,h}$ mass flow rate of methane in residual gas in hour h in (kg/h) which is summed over the hours per year of operation.

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

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

$$TM_{RG,h} = FV_{RG,h} * fv_{CH4,RG,h} * \rho_{CH4,n} \quad (7)$$

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 (0.716 kg/m^3)

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.

By following formulae (6)-(7), a sample $PE_{flare,y}$ calculation of Wang Noi Farm during 2017 (y = 2017 is illustrated below.

$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH\,4,n}$
0	0	0.60	0.716

$PE_{flare,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_y
0	0	0.50	25

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*.

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \quad (8)$$

Where:

$PE_{EC,y}$ Project emissions from electricity consumption in year *y* (tCO_2/yr)
$EC_{PJ,j,y}$ 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
i 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.

By following formula (8), a sample $PE_{EC,y}$ calculation of Wang Noi Farm during 2017(y = 2017) is illustrated below. $PEpower,y = PE_{EC,y}$ since no fossil fuels are used.

$PE_{EC,y}$	$EC_{PJ,j,y}$	$EF_{EL,j,y}$	$TDL_{j,y}$
91.37	146.73	0.5661	10.00%

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:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y} \quad (9)$$

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:

$$COEF_{i,y} = NCV_{i,y} * EF_{CO2i,y} \quad (10)$$

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)

Since there has been no combustion of fossil fuel in all three participating farms under this CPA, formulae (9) and (10) will not be considered in the calculation of emission reduction of this reporting period.

F.3. Calculation of leakage emissions

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As per paragraph 17 of AMS-III.D, no leakage calculation is required.

The tables below demonstrate the results from the calculations of GHG emission reductions in accordance with the above calculation methods of all five farms under CPA 01, 02 and 03.

Ex-post Consideration of Emission Reductions:

The emission reductions achieved by the project activity has been determined ex-post through direct measurement of the amount of methane fueled, 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 $VS_{LT,y}$).

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

$$ER_{y,ex\text{-}post} = min\ [(BE_{y,ex\text{-}post} - PE_{y,ex\text{-}post}) , (MD_y - PE_{power,y,ex\text{-}post})] \quad (11)$$

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 $VS_{LT,y}$
MD_y	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/combustion process:

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

$$= (BG_{flare,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4}) + (BG_{elec,y} * w_{CH4,y} * D_{CH4} * Combustion\ Efficiency * GWP_{CH4}) \quad (12)$$

Where:

$BG_{burnt,y}$	Biogas flared or combusted in year *y* (Nm^3)
$w_{CH4,y}$	Methane content in biogas in the year *y* (mass fraction)
FE	Flare efficiency in the year *y* (fraction)

By following formulae (11)-(12), a sample $ER_{y,ex\text{-}post}$ calculation of Wang Noi Farm during 2017 (y = 2017 is illustrated below.

MD_y	$BG_{flare,y}$	$BG_{elec,y}$	$w_{CH4,y}$	D_{CH4}	FE	Combustion Efficiency	GWP_{CH4}
3,017	0	300,186	0.60	0.00067	50%	100%	25

$BE_{y,ex\text{-}post}$	$PE_{y,ex\text{-}post}$	MD_y	$PE_{power,y,ex\text{-}post}$
9,431	1,346	3,017	91

MD_y (t CO_2e)	$PE_{power,y,ex\text{-}post}$ (t CO_2e)	$MDy - PE_{power\ y,\ ex\text{-}post}$ (t CO_2e)	$BE_{y,ex\text{-}post}$ (t CO_2e)	$PE_{y,ex\text{-}post}$ (t CO_2e)	$BE_{y,ex\text{-}post} - PE_{y,ex\text{-}post}$ (t CO_2e)	$ER_{y,ex\text{-}post} = \min [(BE_{y,ex\text{-}post} – PE_{y,ex\text{-}post}), (MD_y – PE_{power,y,ex\text{-}post})]$ (t CO_2e)
3,017	91	2,926	9,431	1,346	8,085	2,926

For CPA 02 CPS, there was a problem in recording the biogas flow that was used for power generation for this monitoring period and there will be no claims for this monitoring period.

The calculations of emission reductions resulted from the project activities at each participating farms under CPA 01, 02, 03 over the monitoring period (01/01/2017 – 31/12/2018) are shown in detail in the ER calculation spreadsheets attached.

F.4. Calculation of emission reductions or net anthropogenic removals

CPA UNFCCC reference number	Baseline GHG emissions or baseline net GHG removals (tCO_2e)	Project GHG emissions or actual net GHG removals (tCO_2e)	Leakage GHG emissions (tCO_2e)	GHG emission reductions or net anthropogenic GHG removals (tCO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
CPA 01	13,816	340	0	0	13,476	13,476
CPA 02	0	245[7]	0	0	0[8]	0[9]
CPA 03	39,911	441	0	0	39,470	39,470
Total	53,727	1026	0	0	52,946	52,946

F.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the included CPA-DDs

CPA UNFCCC reference number	Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante (t CO_2e)
CPA 01	13,476	111,542
CPA 02	0	49,602
CPA 03	39,470	78,450

[7] Value is provided as part of monitoring data, calculation formula, but not used in overall emission reduction calculation as CPA 2 is not claiming any emission reductions.

[8] negative value is not considered as realized CER and therefore '0' value is taken

[9] negative value is not considered as realized CER and therefore '0' value is taken

Total	52,946	239,594

F.5.1. Explanation of calculation of "amount estimated ex ante for this monitoring period in the CPA-DD"

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The amount estimated ex ante for this monitoring period was taken from the amounts in the latest versions of the CPA-DDs in the CDM website, i.e. CPA 01 version 14 (55,771 tCO2e/yr), CPA 02 version 9 (24,801 tCO2e/yr), and CPA 03 version 9 (39,225 tCO2e/yr).

CPA UNFCCC reference number	Amount estimated ex ante ($t CO_2e$)
CPA 01	111,542
CPA 02	49,602
CPA 03	78,450
Total	239,594

F.6. Remarks on increase in achieved emission reductions

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The amount of emission reductions achieved in this monitoring period is lower than the estimated value in the registered CPA-DD, therefore no further remarks needs to be provided.

F.7. Remarks on scale of small-scale CPAs

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The amounts achieved per year for all the CPAs were under the limit of that type every year during the crediting period,i.e. Type III- less than 60,000 tCO2e/yr, and Type I- less than 15 MWe.

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Document information

Version	*Date*	*Description*
03.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for programmes of activities" (CDM-EB93-A07STAN); • Add a section on remarks on the observance of the scale limit of small-scale CPAs during the crediting periods; • Add "changes specific to afforestation or reforestation activities/CPA" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R PoAs between two commitment periods; • Make structural and editorial improvements.

02.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the "CDM project standard for programmes of activities (CDM-EB93-A07STAN); • Make editorial improvements.
01.0	1 April 2017	Initial publication.

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