Monitoring report form for CDM programme of activities

(version 01.0)

Complete this form in accordance with the Attachment "Instructions for filling out the monitoring report form for CDM programme of activities" at the end of this form.

MONITORING REPORT		
Title of the programme of activities (PoA)	Thailand Small Scale Livestock Waste Management Program	
UNFCCC reference number of the PoA	PoA 8027	
Version number(s) of the PoA-DD(s) applicable to this monitoring report	14	
Coordinating/managing entity (CME)	Energy Research and Development Institute Nakornping of Chiang Mai University	
Version number of this monitoring report	6.3	
Completion date of this monitoring report	10/03/2017	
Monitoring period number and dates covered by this monitoring report	Monitoring period #01 09/11/2012 – 31/12/2014 (first and last days included)	
Monitoring report number for this monitoring period	1	
Host Party(ies)	Host Party(ies) of the PoA	Is this a host Party to a specific-case CPA covered in this monitoring report?(yes/no)
	Thailand	Yes
Sectoral scope(s)	Sectoral Scope 13 : Waste handling and disposal	
Selected methodology(ies)	Methodology AMS III.D. ver. 18 – Methane recovery in animal manure management systems	
Selected standardized baseline(s)	N/A	
Total amount of GHG emission reductions or net GHG removals by sinks for all specific-case-case CPAs in the PoA covered in this monitoring report	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	13,858 tCO_2e

PART I - Programme of activities

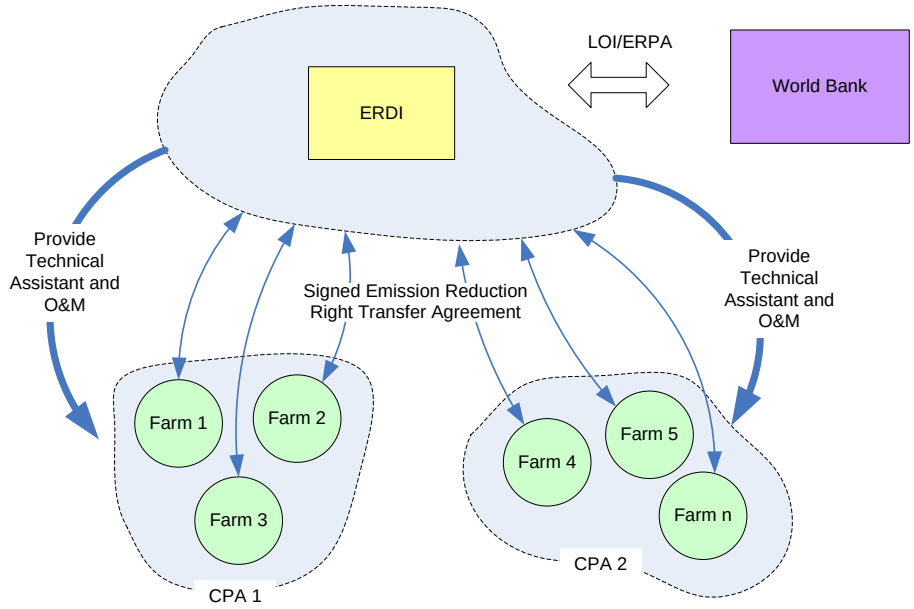
SECTION A. Description of PoA

A.1. Brief description of the 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 was with the registration of the PoA on 09/11/2012. 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

As a result of the project implementation since its inclusion date up to the end of the year 2014, its actual GHG emission reductions achieved in this defined monitoring period (09/11/2012 – 31/12/2014) are 13,858 tonnes of carbon dioxide equivalent (tCO_2e).

A.1.1. Generic CPA(s)

Title, identification/reference number and/or version number of the generic CPA(s) of the PoA	Sectoral scope(s)	Applied methodology(ies) or combination of methodologies and/or standardized baseline(s)
Single generic CPA as per Part II of PoA "Thailand Small Scale Livestock Waste Management Program CPA". Version 14 dated 18/08/2016.	Sectoral Scope 13	Methodology AMS III.D. ver. 18 – Methane recovery in animal manure management systems

A.1.2. Specific-case CPA(s) covered in this monitoring report

Reference number of the specific-case CPA included in the PoA as of the end of this monitoring period	Title, identification/ reference number and version number of the generic CPA to which the specific-case CPA applies	Crediting period dates of the specific-case CPA	Is this specific-case CPA covered in this monitoring report? (yes/no)
CPA 01	Thailand Small Scale Livestock Waste Management Program CPA 01. Version 14	09/11/2012 – 08/11/2022	yes
CPA 02	Thailand Small Scale Livestock Waste Management Program CPA 02. Version 9	01/12/2014-30/11/2024	no
CPA 03	Thailand Small Scale Livestock Waste Management Program CPA 03. Version 9	01/12/2014-30/11/2024	no

A.2. Contact information of the coordinating/managing entity (CME) and/or responsible persons(s)/entity(ies)

>>

Pruk Aggarangsi

Alongkorn Siripat
Energy Research and Development Institute – Nakornping
Chiang Mai University
239 Huay Kaew Rd.,
Suthep, Muang,
Chiangmai, 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. Implementation of PoA

B.1. Implementation of the management system of the PoA

>>
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 Immplementation 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 iclusion 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 fullfullment of the eligibility criteria of the PoA.

B.2. Implementation of single sampling plan(s)

>>
Since only parameter W_{site} (average animal weight for defined population) requires sampling, and only one CPA has been reported under this Monitoring Report, the sampling design was implemented as follows:

Target population: categories of swine

Chokchaikansukorn
- Nursery
- Fattening 2
- Breed Male
- Breed Female
- Farrow

Khana Hybrid (Phanom)
- Nursery
- Fattening 1
- Fattening 2

Wang Noi
- Nursery
- Fattening 1
- Fattening 2

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})

Collected data and analysis:

- The records of total heads per type of animal have been taken monthly at each farm; and aggregated and reported annually.
- The numbers of samples are calculated.
- The animal weight per type are collected at the weighting scale and reported every weighing period/time.
- 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 weighted to meet the sample size required to reach a 90/10 confidence level.

SECTION C. Post-registration changes to the PoA (including the generic CPA(s))

C.1. Corrections

>>

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

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. For baseline emissions each farm will apply either of the below values as the case may be. The values to be applied are as shown in the following table:

	***B_o** (m3CH4/kg VS)*		***VS (**kg/hd/day**)***	
Region	**Breeding swine**	**Market swine**	**Breeding swine**	**Market swine**
North America	0.48	0.48	0.5	0.27
Western Europe	0.45	0.45	0.46	0.3
Eastern Europe	0.45	0.45	0.5	0.3
Oceania	0.45	0.45	0.5	0.28
Latin America	0.29	0.29	0.3	0.3
Africa	0.29	0.29	0.3	0.3

Middle East	0.29	0.29	0.3	0.3
Asia	0.29	0.29	0.3	0.3
Indian Subcontinent	0.29	0.29	0.3	0.3

C.2. Inclusion of a monitoring plan to the registered PoA-DD (including its generic CPA-DD(s)), if a monitoring plan was not included at the time of registration

>>
N/A

C.3. Permanent changes to the monitoring plan as described in the registered PoA-DD, applied methodology, or applied standardized baseline

>>

C.4. Changes to the programme design of the registered PoA-DD (including corresponding changes to project design of the generic CPA-DD(s)) and updates to the eligibility criteria for inclusion of specific-case CPAs in the PoA

>>
N/A

C.5. Types of changes specific to afforestation and reforestation activities

>>
N/A

PART II - Specific-case component project activity(ies)

SECTION D. Description of specific-case CPA(s)

>>

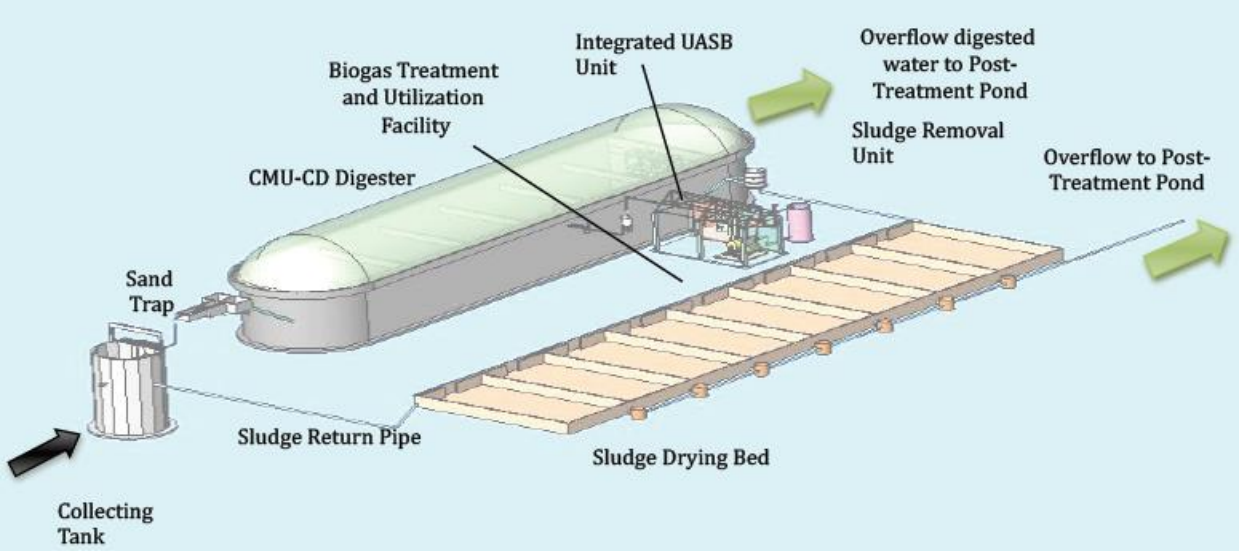
D.1. Brief description of implemented specific-case CPA(s)

>>

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

Farm	Digester (m^3)	Generator (kW)	Flare (type)
Chokchaikansukorn Farm	3,750	200x2 (Operated at 150 kW)	Open
Khana Hybrid Co., Ltd (Phanomsarakham Farm 1)	3,750	150x2 (Operated at 130 kW)	Open
Laemthong Hybrid Co., Ltd (Wang Noi Farm)	3,750	150x2 (Operated at 110kW/130kW)	Open

All 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). These wastewater treatment systems in all three 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 a single MR.

D.2. Geographical references or other means of identification of the location of the specific-case CPA(s)

>>

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 is contained in Table 3 and Figure 3.

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

Farm	Nearest town	North coordinate	East Coordinate
Chokchaikansukorn Farm	Dankwian	14° 52’ 25.3”	102° 10’ 20.9”
Khana Hybrid Co., Ltd (Phanomsarakham Farm 1)	Nongsonghong	13° 46’ 27.6”	101° 24’ 37.4”
Laemthong Hybrid Co., Ltd (Wang Noi Farm)	Payom	14° 11’ 45.3”	100° 39’ 28.7”

Figure 3 – Map Illustrating Farm Locations

SECTION E. Post-registration changes to specific-case CPA(s)

E.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

>>
Given that for this monitored period electricity consumed by the project could not be isolated from the overall farms electricity consumption, $EC_{PJ,y}$ has been conservatively derived by applying the assumption that electrical appliances are continuously utilized, and a corresponding value has been applied.

Since weighing data for years 2012 and 2013 could not be obtained for the parameter W_{site}, this parameter is reported as zero for the period 09/11/2012 to 31/12/2013 as per the CDM Standard.

E.2. Corrections

>>
NA

E.3. Changes to the start date of the crediting period of the specific-case CPA(s)

>>
NA

E.4. Inclusion of a monitoring plan into the specific-case CPA(s) that was not included at registration

>>
NA

E.5. Permanent changes to the monitoring plan as described in the registered specific-case CPA-DD(s), applied methodology or standardized baseline

>>
NA

E.6. Changes to project design of the specific-case CPA(s)

>>
Farm Chokchaikansukorn has installed two biogas electric generator with capacity 200 kW each out of which one is used as standby. Phanomsarakham Farm 1 has installed two biogas electric generator with capacity 150 kW each and operated at 130 kW each. Wang Noi Farm has installed two biogas electric generator with capacity 150 kW each and operated at 130 kW and 110 kW.

The changes of actual installed capacities in all three CPA 1 farms lead to lower IRR compared with the planned set-up envisioned at the time of registration due to lower actual operating capacity of generators, higher investment cost and fewer actual operating hours. Thus the changes in generator numbers and installed capacities do not need prior approval from the EB, as financial analysis still leads to the projects not achieving the benchmark IRR (in fact, they would achieve lower IRR wirthout CDM). CPA-DD has been revised to include mention of actual capacities and to note that the additionality is not affected.
-Chokchaikansukorn IRR assumed 12.08% without CDM and in reality 7.90%.
-Phanomsarakham IRR assumed 10.75% without CDM and in reality 4.88%.
-Wang Noi IRR assumed 9.64% without CDM and in reality -3.67%.
These changes do not affect the (i) scale of the project activity and (ii) applicability of the applied methodology.

E.7. Types of changes specific to afforestation and reforestation specific-case CPA(s)

>>
NA

SECTION F. Description of the monitoring system of specific-case CPA(s)

>>

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 report ed accordingly. The GHG emission reductions achieved by the project activity were determined ex-post through direct measurement of the amount of methane fuelled, 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 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 12: $VS_{LT,y}$).

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

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

Where:

$ER_{y,ex-post}$	Emission reductions achieved by the project activity based on monitored values for year "*y*" (tCO_2e)
$BE_{y,ex-post}$	Baseline emissions calculated using formula (1) (see Section E.1) using ex post monitored values of $N_{LT,y}$ and if applicable $VSL_{T,y}$
$PE_{y,ex-post}$	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)
$PE_{power,y,ex-post}$	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:

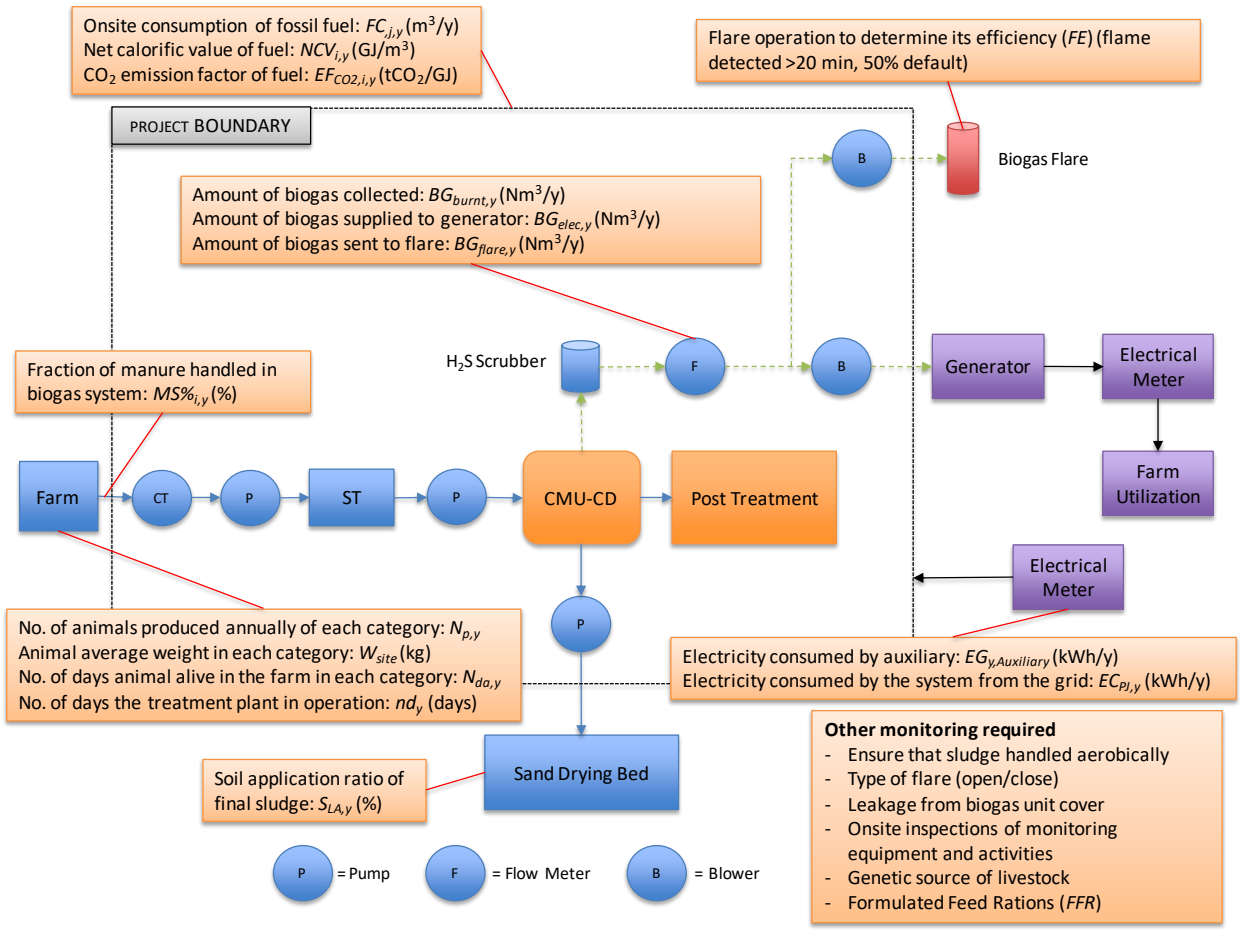
$$MD_y = BG_{burnt,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4} \quad (12)$$

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)

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 G. Data and parameters

G.1. Data and parameters fixed ex ante, at registration, inclusion or renewal of crediting period

(Copy this table for each piece of data and 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:	ChokchaiKansu Farm: 200 kW x2 (Operated at 150 kW) Khana Hybrid Farm: 150 kW x2 (Operated at 130 kW) Wang Noi Farm: 150 kW x2 (Operated at 110kW/130kW)
Choice of data or measurement methods and procedures	-
Purpose of data:	Calculation of project emissions
Additional comment:	-

Data / Parameter:	$MS\%_{BI,j}$
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:	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	-
Purpose of data:	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:	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:	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. 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.[1] 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:	In this MR, the value of ***Asia*** region is applied for conservative manner of the ex-post calculation.

Data / Parameter:	$VS_{LT,y}$
Unit:	Kg dm/animal/year

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

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.[2] 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:	In this MR, the value of ***Asia*** region is applied for conservative manner of the ex-post calculation.

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:	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:	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)

[2] Breeding Swine, Department of Livestock Development www.dld.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:	Calculation of baseline emissions
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:	Calculation of project emissions
Additional comment:	-

G.2. Data and parameters monitored

(Copy this table for each piece of data and 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:	Laemthong Hybrid (Wang Noi):

	2012 (Nov-Dec)	2013	2014	Period Total
Nursery	29,999	154,430	153,347	337,776
Fattening 1	13,422	68,416	51,922	133,760
Fattening 2	4,649	32,934	55,619	93,202
Breed Male	-	-	-	-
Breed Female	-	-	-	-
Farrow	-	-	-	-

Chokchaikansukorn:

	2012 (Nov-Dec)	2013	2014	Period Total
Nursery	9,916	39,256	46,568	95,740
Fattening 1	-	-	-	-
Fattening 2	13,868	91,415	83,045	188,328
Breed Male	80	352	260	692
Breed Female	3,222	17,546	18,633	39,401
Farrow	7,458	30,372	27,544	65,374

Khana Hybrid (Phanom):

	2012 (Nov-Dec)	2013	2014	Period Total
Nursery	15,032	136,194	141,881	293,107
Fattening 1	10,001	50,248	65,707	125,956
Fattening 2	12,219	55,606	52,175	120,000
Breed Male	-	-	-	-
Breed Female	-	-	-	-
Farrow	-	-	-	-

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	Calculation of baseline emissions
Additional comment:	Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.

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:	$\boldsymbol{N_{p,y}}$
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 $\boldsymbol{N_{LT,y}}$
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
Measured / Calculated / Default:	Measured
Source of data:	Farm records of animal weight in each category in the farm annually
Value(s) of monitored parameter:	

Type of animal	Chochaikansukorn	Khana Hybrid (Phanom)	Wang Noi
Breeding (male)	198.08	-	-
Breeding (female)	170.02	-	-
Fattening 1	-	45.02	51.40
Fattening 2	87.40	90.37	90.18
Nursery	14.60	16.74	12.98
farrow	4.70	-	-

Monitoring equipment:

Weighing scale

Farm	Equipment	Calibration frequency
Wang Noi	WI-P	N/A (every 3 years)
Chokchai	Commandor HP-05	N/A (every 3 years)
Phanom	Jadever JIK-8CAB	N/A (every 3 years)

Calibration of weighing scales took place as follows:

Farm	Serial Number	Installation Date	Calibration Certificate No.	Calibration Date	Expiration Date
Wang Noi	2013016	N/A	1603391S	22/03/2016	21/03/2019 (in 3 years)
Chokchai	0000719	N/A	1603467S	25/03/2016	24/03/2019 (in 3 years)
Phanom	IK2131237N4785	N/A	111/2559	11/02/2016	10/02/2019 (in 3 years)

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 G.3.
Calculation method (if applicable)	Sample weights have been taken for year 2014, however acknowledging that no sample was taken during the months of 2012 nor 2013, and in order to be conservative, no ERs are claimed for 2012 and 2013. -

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	Calculation of baseline emissions
Additional comment:	Records have been provided to the verifying DOE. Since calibration was conducted after the monitoring period addressed in this report, values reported for this parameter have been adjusted downwards by the maximum uncertainty of measurement (5%) during calibration of the scales. Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013

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 ($BG_{elec,y}$) and the amount of biogas sent to the flaring system ($BG_{flare,y}$).
Source of data:	Flow meters
Value(s) of monitored parameter:	
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	Calculation of baseline emissions
Additional comment:	Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.

	2012 (Nov-Dec)	2013	2014	Period Total
Wang Noi	55,374	387,371	381,168	823,913
Chokchai	41,708	534,815	494,210	1,070,733
Phanom	97,762	677,347	555,994	1,331,103

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

	2012 (Nov-Dec)	2013	2014	Period total
Wang Noi	54,203	379,584	381,168	814,955
Chokchai	41,708	534,815	494,210	1,070,733
Phanom	97,230	671,004	554,175	1,322,409

<table>
<tr><td>Monitoring equipment:</td><td>The same type of flow meter is installed at the 3 farms in CPA1; biogas utilised in the generator has been continuously monitored through the use of the below equipment.

<table>
<tr><td>Monitoring equipment type:</td><td>Endress-Hauser
Proline t-mass 65, Thermal mass flowmeter</td></tr>
<tr><td>Accuracy class:</td><td>±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)</td></tr>
<tr><td>Calibration frequency:</td><td>Every 2 to 3 years (recommended)</td></tr>
</table>

Detailed information of flow meter at each farm:
<table>
<tr><td>Farm</td><td>Serial Number</td><td>Installation Date</td><td>Calibration Certificate No.</td><td>Calibration Date</td><td>Expiration Date</td></tr>
<tr><td>Wang Noi</td><td>F5147D02000</td><td>30/10/2012</td><td>4409089374-02/05</td><td>09/04/2014</td><td>08/04/2016</td></tr>
<tr><td>Chokchai</td><td>EC0A3E02000</td><td>28/10/2012</td><td>4409089374-03/05</td><td>10/04/2014</td><td>10/04/2016</td></tr>
<tr><td>Phanom</td><td>F6006402000</td><td>31/10/2012</td><td>4409089374-05/05</td><td>11/04/2014</td><td>11/04/2016</td></tr>
</table>
</td></tr>
<tr><td>Measuring / Reading / Recording frequency:</td><td>Measured continuously</td></tr>
<tr><td>Calculation method (if applicable)</td><td>-</td></tr>
<tr><td>QA/QC procedures:</td><td>Flow meters have been calibrated according to the manufacturer’s recommendation.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment:</td><td>All flow meters had been factory calibrated before installation. This covers the period of use between their installation date and calibrations in 2014. Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.</td></tr>
</table>

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

<table>
<tr><td></td><td>2012 (Nov-Dec)</td><td>2013</td><td>2014</td><td>Period total</td></tr>
<tr><td>Wang Noi</td><td>1,171</td><td>7787</td><td>0</td><td>8,958</td></tr>
<tr><td>Chokchai</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Phanom</td><td>532</td><td>6,343</td><td>1,819</td><td>8,694</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment:</td><td>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.

<table>
<tr><td>Monitoring equipment type:</td><td>Endress-Hauser
Proline t-mass 65, Thermal mass flowmeter</td></tr>
</table>
</td></tr>
</table>

	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:

Farm	Serial Number	Installation Date	Calibration Certificate No.	Calibration Date	Expiration Date
Wang Noi	F5147C02000	30/10/2012	4409089374-01/05	09/04/2014	08/04/2016
Chokchai	D3048402000	10/10/2014	SV2014-237	22/10/2014	21/10/2016
Phanom	F6006302000	31/10/2012	4409089374-04/05	11/04/2014	10/04/2016

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	Calculation of project emissions
Additional comment:	Delay in calibration at Chokchai does not impact ER calculation, as there was no flaring at Chokchai farm during monitoring period. Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.

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:	

Farm	hours
Laemthong Hybrid (Wang Noi)	111
Chochaikansukorn	0
Khana Hybrid (Phanom)	111

Monitoring equipment:	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

Farm	Serial Number
Wang Noi	TH102459
Chokchai	TH101256
Phanom	TH103419

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	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. Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.

Data / Parameter:	$EC_{PJ,y}$
Data unit:	kWh
Description:	Quantity of electricity consumed by the project from the grid
Measured / Calculated / Default:	Measured/Calculated
Source of data:	Electricity meter / conservative estimate
Value(s) of monitored parameter:	Refer to calculation spreadsheet for more detailed values

	2012 (Nov-Dec)	2013	2014	Period total
Wang Noi	24.46	146.73	146.73	317.92
Chokchai	21.02	126.14	126.14	273.31
Phanom	18.25	109.50	109.50	237.25

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**

Phanom:

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	1.5	24	36	13,140	13.14
				Total	**109,500**	**109.50**

Monitoring equipment:	For the current monitoring period, a temporary deviation is applied as per para 2, appendix 1 of the CDM Project Standard v9.0 at the 3 farms in CPA1, since the monitoring of electricity consumed by the project cannot be isolated from the overall farm electricity consumption.
Measuring / Reading /	NA

Recording frequency:	
Calculation method (if applicable)	-
QA/QC procedures:	Farm's reported equipment has been checked by ERDI staff
Purpose of data	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	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	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	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	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 three farms in CPA1 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	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:	782 (over this crediting period)
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	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	Calculation of project emissions
Additional comment:	Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.

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 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.
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	Calculation of baseline and project emissions
Additional comment:	NA

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:	Wang Noi: Unknown Chokchai: Unknown Phanom: Unknown
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	Calculation of baseline emissions
Additional comment:	Using IPCC default values for Asia for all three farms, as genetic source is unclear. Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.

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	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	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. Only accounting for year 2014 values in ER calculations due to unavailability of Wsite values for 2012 and 2013.

G.3. Implementation of specific-case CPA level 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 below tables.

Wang Noi		Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
				2012			
Population size	N	29,999	13,422	4,649	N/A	N/A	N/A
Distribution	p	0.5	0.5	0.5	N/A	N/A	N/A
Margin of error	e	0.1	0.1	0.1	N/A	N/A	N/A
Confidence level	%	90	90	90	N/A	N/A	N/A
z-score	z	1.645	1.645	1.645	N/A	N/A	N/A
Intermediate calculation		67.650625	67.650625	67.650625	N/A	N/A	N/A
Sample size	**n**	**68**	**68**	**67**	**N/A**	**N/A**	**N/A**
				2013			
Population size	N	154,430	68,416	32,934	N/A	N/A	N/A
Distribution	p	0.5	0.5	0.5	N/A	N/A	N/A
Margin of error	e	0.1	0.1	0.1	N/A	N/A	N/A
Confidence level	%	90	90	90	N/A	N/A	N/A

z-score	z	1.645	1.645	1.645	N/A	N/A	N/A
Intermediate calculation		67.650625	67.650625	67.650625	N/A	N/A	N/A
Sample size	**n**	**68**	**68**	**68**	**N/A**	**N/A**	**N/A**
2014							
Population size	N	153,347	51,922	55,619	N/A	N/A	N/A
Distribution	p	0.5	0.5	0.5	N/A	N/A	N/A
Margin of error	e	0.1	0.1	0.1	N/A	N/A	N/A
Confidence level	%	90	90	90	N/A	N/A	N/A
z-score	z	1.645	1.645	1.645	N/A	N/A	N/A
Intermediate calculation		67.650625	67.650625	67.650625	N/A	N/A	N/A
Sample size	**n**	**68**	**68**	**68**	**N/A**	**N/A**	**N/A**

Chokchai		**Nursery**	**Fattening 1**	**Fattening 2**	**Breed Male**	**Breed Female**	**Farrow**
2012							
Population size	N	9,916	-	13,868	80	3,222	7,458
Distribution	p	0.5	N/A	0.5	0.5	0.5	0.5
Margin of error	e	0.1	N/A	0.1	0.1	0.1	0.1
Confidence level	%	90	N/A	90	90	90	90
z-score	z	1.645	N/A	1.645	1.645	1.645	1.645
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	67.650625
Sample size	**n**	**68**	**N/A**	**68**	**37**	**67**	**68**
2013							
Population size	N	39,256	-	91,415	352	17,546	30,372
Distribution	p	0.5	N/A	0.5	0.5	0.5	0.5
Margin of error	e	0.1	N/A	0.1	0.1	0.1	0.1
Confidence level	%	90	N/A	90	90	90	90
z-score	z	1.645	N/A	1.645	1.645	1.645	1.645
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	67.650625
Sample size	**n**	**68**	**N/A**	**68**	**57**	**68**	**68**
2014							
Population size	N	46,568	-	83,045	260	18,633	27,544
Distribution	p	0.5	N/A	0.5	0.5	0.5	0.5
Margin of error	e	0.1	N/A	0.1	0.1	0.1	0.1
Confidence level	%	90	N/A	90	90	90	90
z-score	z	1.645	N/A	1.645	1.645	1.645	1.645
Intermediate calculation		67.650625	N/A	67.650625	67.650625	67.650625	67.650625
Sample size	**n**	**68**	**N/A**	**68**	**54**	**68**	**68**

Phanom		**Nursery**	**Fattening 1**	**Fattening 2**	**Breed Male**	**Breed Female**	**Farrow**
2012							
Population size	N	15,032	10,001	12,219	N/A	N/A	N/A
Distribution	p	0.5	0.5	0.5	N/A	N/A	N/A
Margin of error	e	0.1	0.1	0.1	N/A	N/A	N/A
Confidence level	%	90	90	90	N/A	N/A	N/A
z-score	z	1.645	1.645	1.645	N/A	N/A	N/A

Intermediate calculation		67.650625	67.650625	67.650625	N/A	N/A	N/A
Sample size	**n**	**68**	**68**	**68**	**N/A**	**N/A**	**N/A**
2013							
Population size	N	136,194	50,248	55,606	N/A	N/A	N/A
Distribution	p	0.5	0.5	0.5	N/A	N/A	N/A
Margin of error	e	0.1	0.1	0.1	N/A	N/A	N/A
Confidence level	%	90	90	90	N/A	N/A	N/A
z-score	z	1.645	1.645	1.645	N/A	N/A	N/A
Intermediate calculation		67.650625	67.650625	67.650625	N/A	N/A	N/A
Sample size	**n**	**68**	**68**	**68**	**N/A**	**N/A**	**N/A**
2014							
Population size	N	141,881	65,707	52,175	N/A	N/A	N/A
Distribution	p	0.5	0.5	0.5	N/A	N/A	N/A
Margin of error	e	0.1	0.1	0.1	N/A	N/A	N/A
Confidence level	%	90	90	90	N/A	N/A	N/A
z-score	z	1.645	1.645	1.645	N/A	N/A	N/A
Intermediate calculation		67.650625	67.650625	67.650625	N/A	N/A	N/A
Sample size	**n**	**68**	**68**	**68**	**N/A**	**N/A**	**N/A**

As demonstrated at the site visit, and as per the evidences provided to the DOE, the sample size per animal category of 68 has been met for year 2014. However, acknowledging that no sample was taken for the last months of 2012 and 2013, a conservative approach has been applied by the project entity, and no ERs being claimed for 2012 and 2013.

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 weighing is conducted by sampling no more than six swine individuals for each type on monthly basis. 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 H. Calculation of GHG emission reductions or net GHG removals by sinks

H.1. Calculation of baseline emissions or baseline net GHG removals by sinks

>>

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

Where:

BE_y	Baseline emissions in year "*y*" (tCO_2e)
GWP_{CH4}	Global Warming Potential (GWP) for methane (21 and 25 for first and second commitment period, respectively)
D_{CH4}	CH_4 density (0.00067 t/m^3 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*" (m^3 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:

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

$$VS_{LT,y} = \left(\frac{W_{site}}{W_{default}} \right) * VS_{default} * nd_y \quad (2)$$

Where:

$W_{s\ i}$ 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 numbers of animals ($N_{LT,y}$) are determined as follows:

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

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 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.

By following formulae (1)-(3), a sample BE_y calculation of livestock type "nursery" (*LT* = nursery) at Wang Noi Farm during 2014 (*y* = 2014) is illustrated below.

$VS_{LT,y}$	W_{site}	$W_{default}$	$VS_{default}$	nd_y
28.43	12.98	50	0.3	365

BE_y	GWP_y	D_{CH4}	UF_b	MCF_j	$B_{o,LT}$	$N_{LT,y}$	$VS_{LT,y}$	$MS\%_{Bl,j}$
1,326	25	0.00067	0.94	80	0.29	12,768	28.43	1

H.2. Calculation of project emissions or actual net GHG removals by sinks

>>

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 ($PE_{storage,y}$).

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

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}	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*" ($PE_{PL,y}$)

$$PE_{PL,y} = 0.1 * GWP_{CH4} * D_{CH4} * UF_b * \sum_{i,LT} B_{o,LT} * N_{LT,y} * VS_{LT,y} * MS\%_{Bl,j} \quad (5)$$

Where:

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

By following formula (5), a sample $PE_{PL,y}$ calculation of livestock type "nursery" (*LT* = nursery) at Wang Noi Farm during 2014 (*y* = 2014) is illustrated below.

$PE_{PL,y}$	GWP_y	D_{CH4}	$B_{o,LT}$	$N_{LT,y}$	$VS_{LT,y}$	$MS\%_{i,y}$
176	25	0.00067	0.29	12,768	28.43	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)

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{flare,h}) * \frac{GWP_{CH4}}{1000} \quad (6)$$

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*

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

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 2014 (*y* = 2014) is illustrated below.

$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
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 2014 (*y* = 2014) 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.

H.3. Calculation of leakage

>>

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 three farms under CPA 01.

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 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 $VS_{LT,y}$).

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

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

Where:

$ER_{y,ex-post}$	Emission reductions achieved by the project activity based on monitored values for year *y* (tCO_2e)
$BE_{y,ex-post}$	Baseline emissions calculated using formula 1 using ex-post monitored values of $N_{LT,y}$ and if applicable $VS_{LT,y}$
$PE_{y,ex-post}$	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)
$PE_{power,y,ex-post}$	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:

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

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 $ER_{y,ex-post}$ calculation of Wang Noi Farm during 2014 (*y* = 2014) is illustrated below.

MD_y	$BG_{flare,y}$	$BG_{elec,y}$	$w_{CH4,y}$	D_{CH4}	*FE*	*Combustion Efficiency*	GWP_{CH4}
3,831	0	381,168	0.60	0.00067	50%	100%	25

$ER_{y,ex-post}$	$BE_{y,ex-post}$	$PE_{y,ex-post}$	MD_y	$PE_{power,y,ex-post}$
3,739	6,448	949	3,831	91

Below are the calculations of emission reductions resulted from the project activities at each participating farms under CPA 1 over the monitoring period (09/11/2012 – 31/12/2014).

CPA 1-1: Laemthong Hybrid Co., Ltd (Wang Noi Farm)

SITE ID	YEAR	November 2012 - December 2014					
	MONTH						
CPA1 - 1	ANIMAL TYPE LTy	Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
SITE NAME	NLT,y - DATA FROM FARM	12,963	5,126	3,590			
	$W_{default}$	50	50	50			
	W site - DATA FROM FARM	12.98	51.40	90.18			
	$VS_{default}$	0.30	0.30	0.30			
	nd_y	782	782	782			
	NLT * Nd	10,137,456	4,008,314	2,807,394			
	$VS_{(LT,y)}$	61	241	423			
	UF b	0.94	0.94	0.94			
	$B_{0,LT}$	0.29	0.29	0.29			
	GWP_{CH4}	GWP =21 and 25 for the yrear 2012 and post-2012, respectively					
	D_{CH4}	0.00067	0.00067	0.00067			
	MCF	80	80	80			
	$MS\%_{Bl,j}$	1	1	1			
	MS% i,y - DATA FROM FARM	1	1	1			
Wang Noi Farm	**$BE_{y,ex\text{-}post}$**	1,325.83	1,777	3,346			-
	$PE_{PL,y}$	176	236	445			-
	$PE_{power,y}$	198					
	BG_{flare}	8,958					
	ηflare, h	0.50					
	WCH4	0.60					
	Flare Operating Hours	111					
	FV RG,h	81					
	$fv_{CH4,RG,h}$	0.60					
	TM RG,H	35					
	$PE_{flare,y}$	47					
	$PE_{transp,y}$	0					
	$PE_{storage,y}$	0					
	TOTAL BEy, ex-post						**6,448**
	TOTAL PEy, ex-post						**1,102**
	BE y, ex-post - PEy, ex-post						**5,346**

SITE ID	SITE NAME	Monitoring Data	TOTAL November 2012 - December 2014
CPA1 - 1	Wang Noi Farm	Global Warm Potential - FROM IPCC	25
		Methane Concentration - W_{CH4} (Default 60% from Methodology)	0.60
		Methane Density - D CH4 (t/m3) (Deafult value from Methodology)	0.00067
		Flare Efficiency - FE (Default 50% value for Open flare from methodology)	0.5
		Combustion Efficiency from Generators (100% - Default value from methodology)	1.00
		Flare operating Hours	111
		$BG_{flare,y}$ (NM^3)	8,958
		$BG_{elec,y}$ (Nm^3)	814,955
		$BG_{burnt,y}$ (m^3)	823,913
		MDy flare (MDy = BGflare,y * WCH4,y * DCH4,y * FE * GWPCH4)	44
		MDy-energy (MDy = BGelec,y * WCH4,y * DCH4,y * CE * GWPCH4)	8,103
		MD_y (MDy = MDy energy + MDy flare)	3,831
		Electricity Consumption from the grid	318
		EFgrid	
		TDL	
		PEelectricity	198
		Fossil fuel consumption	-
		PEfossil	-
		PEpower y, ex-post = PEfossil fuel + PEelectricity	198
		MDy - PEPower y,ex-post	3,632

CPA 01-2: Chokchaikansukorn Farm

SITE ID	YEAR	Total					
	MONTH	November 2012- December 2014					
CPA1 - 2	ANIMAL TYPE LTy	Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
SITE NAME	NLT,y - DATA FROM FARM	3,670		7,248	25	1,457	2,500
	$W_{default}$	50		50	180	180	50
	W site - DATA FROM FARM	14.60		87.40	198.08	170.02	4.70
	$VS_{default}$	0.30		0.30	0.30	0.30	0.30
	nd_y	782		782	782	782	782
	NLT * Nd	2,869,765		5,667,867	19,874	1,139,657	1,954,741
	$VS_{(LT,y)}$	69		410	258	222	22
	UF b	0.94		0.94	0.94	0.94	0.94
	$B_{0,LT}$	0.29		0.29	0.29	0.29	0.29
	GWP_{CH4}	GWP =21 and 25 for the yrear 2012 and post-2012, respectively					
	D_{CH4}	0.00067		0.00067	0.00067	0.00067	0.00067
	MCF	80		80	80	80	80
	$MS\%_{BI,j}$	1		1	1	1	1
	MS% i,y - DATA FROM FARM	1		1	1	1	1
Chokchaikansukorn Farm	**$BE_{y,ex\text{-}post}$**	453	-	4,847	10	587	86
	$PE_{PL,y}$	60	-	645	1	78	11
	$PE_{power,y}$	170					
	BG_{flare}	0					
	ηflare, h	0.50					
	WCH4	0.60					
	Flare Operating Hours	0					
	FV RG,h	0					
	$fv_{CH4,RG,h}$	1					
	TM RG,H	0					
	$PE_{flare,y}$	0					
	$PE_{transp,y}$	0					
	$PE_{storage,y}$	0					
	TOTAL BEy, ex-post						**5,983**
	TOTAL PEy, ex-post						**966**
	BE y, ex-post - PEy, ex-post						**5,017**

SITE ID	SITE NAME	Monitoring Data	TOTAL November 2012 - December 2014
CPA1 - 2	Chokchai	Global Warm Potential - FROM IPCC	25
		Methane Concentration - W_{CH4} (Default 60% from Methodology)	0.60
		Methane Density - D CH4 (t/m3) (Deafult value from Methodology)	0.00067
		Flare Efficiency - FE (Default 50% value for Open flare from methodology)	0.5
		Combustion Efficiency from Generators (100% - Default value from methodology)	1.00
		Flare operating Hours	-
		$BG_{flare,y}$ (NM^3)	-
		$BG_{elec,y}$ (Nm^3)	1,070,733
		$BG_{burnt,y}$ (m^3)	1,070,733
		MDy flare (MDy = BGflare,y * WCH4,y * DCH4,y * FE * GWPCH4)	-
		MDy-energy (MDy = BGelec,y * WCH4,y * DCH4,y * CE * GWPCH4)	10,694
		MD_y (MDy = MDy energy + MDy flare)	4,967
		Electricity Consumption from the grid	273
		EFgrid	
		TDL	
		PEelectricity	170
		Fossil fuel consumption	-
		PEfossil	-
		PEpower y, ex-post = PEfossil fuel + PEelectricity	170
		MDy - PEPower y,ex-post	4,796

CPA 01-3: Khana Hybrid Co., Ltd (Phanomsarakham Farm 1)

CPA1 - 3	MONTH	November 2012- December 2014					
	ANIMAL TYPE LTy	Nursery	Fattening 1	Fattening 2	Breed Male	Breed Female	Farrow
SITE NAME	NLT,y - DATA FROM FARM	11,325	4,864	4,580			
	$W_{default}$	50	50	50			
	W site - DATA FROM FARM	16.74	45.02	90.37			
	$VS_{default}$	0.30	0.30	0.30			
	nd_y	782	782	782	-	-	
	NLT * Nd	8,856,496	3,803,648	3,581,479	-	-	
	$VS_{(LT,y)}$	79	211	424			
	UF b	0.94	0.94	0.94			
	$B_{0,LT}$	0.29	0.29	0.29			
	GWP_{CH4}	GWP =21 and 25 for the yrear 2012 and post-2012, respectively					
	D_{CH4}	0.00067	0.00067	0.00067			
	MCF	80	80	80			
	$MS\%_{Bl,j}$	1	1	1			
	MS% i,y - DATA FROM FARM	1	1	1			
Phanom Sarakham	**$BE_{y, ex-post}$**	1,586	2,069	2,943	-	-	
	$PE_{PL,y}$	211	275	391	-	-	
	$PE_{power,y}$	148					
	BG_{flare}	8,694					
	ηflare, h	0.50					
	WCH4	0.60					
	Flare Operating Hours	111					
	FV RG,h	78					
	$fv_{CH4,RG,h}$	1					
	TM RG,H	34					
	$PE_{flare,y}$	44					
	$PE_{transp,y}$	0					
	$PE_{storage,y}$	0					
	TOTAL BEy, ex-post	**6,598**					
	TOTAL PEy, ex-post	**1,068**					
	BE y, ex-post - PEy, ex-post	**5,530**					

SITE ID	SITE NAME	Monitoring Data	TOTAL November 2012 - December 2014
CPA1-3	Phanom	Global Warm Potential - FROM IPCC	25
		Methane Concentration - W_{CH4} (Default 60% from Methodology)	0.60
		Methane Density - D CH4 (t/m3) (Deafult value from Methodology)	0.00067
		Flare Efficiency - FE (Default 50% value for Open flare from methodology)	0.5
		Combustion Efficiency from Generators (100% - Default value from methodology)	1.00
		Flare operating Hours	111
		$BG_{flare,y}$ (NM^3)	8,694
		$BG_{elec,y}$ (Nm^3)	1,322,409
		$BG_{burnt,y}$ (m^3)	1,331,103
		MDy flare (MDy = BGflare,y * WCH4,y * DCH4,y * FE * GWPCH4)	43
		MDy-energy (MDy = BGelec,y * WCH4,y * DCH4,y * CE * GWPCH4)	13,134
		MD_y (MDy = MDy energy + MDy flare)	5,579
		Electricity Consumption from the grid	237
		EFgrid	
		TDL	
		PEelectricity	148
		Fossil fuel consumption	-
		PEfossil	-
		PEpower y, ex-post = PEfossil fuel + PEelectricity	148
		MDy - PEPower y,ex-post	5,430

Calculation of emission reductions from the CPA

SITE ID	SITE NAME	MD_y ($t CO_2e$)	$PE_{power,y,ex-post}$ ($t CO_2e$)	MDy - $PE_{power\ y,\ ex-post}$ ($t CO_2e$)	$BE_{y,ex-post}$ ($t CO_2e$)	$PE_{y,ex-post}$ ($t CO_2e$)	$BE_{y,ex-post}$ - $PE_{y,ex-post}$ ($t CO_2e$)	$ER_{y,ex-post} = min\ [(BE_{y,ex-post} - PE_{y,ex-post}), (MD_y - PE_{power,y,ex-post})]$
CPA 1 - 1	Wang Noi Farm	3,831	198	3,632	6,448	1,102	5,345	*3,632*
CPA 1 - 2	Chokchaikansukorn Farm	4,967	170	4,796	5,983	966	5,017	*4,796*
CPA 1 - 3	Phanomsarakham Farm	5,579	148	5,430	6,598	1,068	5,530	*5,430*
	TOTAL	**14,376**	**515**	**13,858**	**19,029**	**3,136**	**15,892**	**13,858**

H.4. Summary of calculation of GHG emission reductions or net GHG removals by sinks

Specific-case CPA reference number I.	Baseline emissions or baseline net GHG removals by sinks (tCO_2e)	Project emissions or actual net GHG removals by sinks (tCO_2e)	Leakage (tCO_2e)	GHG emission reductions or net GHG removals by sinks (tCO_2e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
CPA 01-1	3,831	198	0	0	3,632	3,632
CPA 01-2	4,967	170	0	0	4,796	4,796
CPA 01-3	5,579	148	0	0	5,430	5,430
Total	14,376	515	0	0	13,858	13,858

H.5. Comparison of GHG emission reductions or net GHG removals by sinks with estimates in the included CPA-DD(s)

Specific-case CPA reference number	Value estimated in ex ante calculation in the included CPA-DD(s)	Actual values achieved by the specific-case CPA(s) during this monitoring period
CPA 01	119,487	13,858
Total	119,487	13,858

H.6. Remarks on difference from the estimated value in the included CPA-DD(s)

>>

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.

Appendix 1. Contact information of coordinating/managing entity and/or responsible persons/entities

Coordinating/managing entity and/or responsible person/entity	☒ Coordinating/managing entity ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	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 5390-3760
E-mail	
Website	www.erdi.or.th
Contact person	Director
Title	Associate Professor
Salutation	Dr.
Last name	Aggarangsi
Middle name	-
First name	Pruk
Department	-
Mobile	-
Direct fax	
Direct tel.	
Personal e-mail	pruk.a@cmu.ac.th

Coordinating/managing entity and/or responsible person/entity	☐ Coordinating/managing entity ☒ Person/entity responsible for completing the CDM-MR-FORM
Organization name	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	

- - - - -

Document information

Version	*Date*	*Description*
01.0	1 April 2015	Initial publication.

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report, programme of activities