



VERIFICATION / CERTIFICATION REPORT

RATCHABURI FARMS BIOGAS PROJECT AT VEERACHAI FARM IN THAILAND

(UNFCCC Registration Ref. No. 1554)

Monitoring Period:
28 March 2008 to 31 March 2011

REPORT No. 2012-0196

REVISION No. 02

DET NORSKE VERITAS



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Approved by Michael Lehmann	Organisational unit: DNV KEMA Energy & Sustainability Accredited Climate Change Services
Client: Danish Energy Agency	Client ref.: Sorensen Emmik Ole

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Summary:

DNV Climate Change Services AS (DNV) has performed the verification of the emission reductions reported for the "Ratchaburi Farms Biogas Project at Veerachai Farm" in Thailand (UNFCCC Registration Ref. No. 1554 for the period 28 March 2008 to 31 March 2011

In our opinion, the GHG emission reductions reported for the project in the monitoring report (Version 02) of 12 September 2012 are fairly stated.

The GHG emission reductions were calculated correctly on the basis of the approved monitoring methodologies monitoring AMS-III.D (version 11) and AMS-I.D (version 10) and the monitoring plan contained in the revised Project Design Document dated 2 February 2012, approved on 4 September 2012.

DNV Climate Change Services AS is able to certify that the emission reductions from the "Ratchaburi Farms Biogas Project at Veerachai Farm" in Thailand during the period 28 March 2008 to 31 March 2011 amount to 115 268 tonnes of CO₂ equivalent.

Report No.: 2012-0196		Subject Group: Environment					
Report title: Ratchaburi Farms Biogas Project at Veerachai Farm in Thailand							
Work carried out by: Simon Wong Yon Sing							
Work verified by: Felipe Lacerda Antunes							
Date of this revision: 15 January 2013	Rev. No.: 02	Number of pages: 28					
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	Process Industry						
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Abbreviations

AWMS	Animal Waste Management System
B ₀	Maximum methane potential
CAR	Corrective Action Request
CDM	Clean Development Mechanism
CEF	Carbon Emission Factor
CER	Certified Emission Reduction(s)
CH ₄	Methane
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent
DNV	Det Norske Veritas
EGAT	Electricity Generating Authority of Thailand
ER	Emission Reduction
FAR	Forward Action Request
GHG	Greenhouse gas(es)
GWP	Global Warming Potential
HRT	Hydraulic Retention Time
IPCC	Intergovernmental Panel on Climate Change
MCF	Methane conversion factor
MP	Monitoring Plan
PDD	Project Design Document
PE	Poly-ethylene
PM	Power Meter
PP	Project Proponent
PS	Clean Development Mechanism Project Standard
QA/QC	Quality Assurance/Quality Control
UASB	Upflow Anaerobic Sludge Blanket
UNFCCC	United Nations Framework Convention for Climate Change
VCF	Veerachai Farm
VVS	Clean Development Mechanism Validation and Verification Standard

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1 INTRODUCTION

Danish Energy Agency has commissioned DNV Climate Change Services AS (DNV) to carry out the verification and certification of the emission reductions reported for the “Ratchaburi Farms Biogas Project at Veerachai Farm” (the project) for the period 28 March 2008 to 31 March 2011. This report contains the findings from the verification and a certification statement for the certified emission reductions.

1.1 Objective

Verification is the periodic independent review and *ex-post* determination by a Designated Operational Entity (DOE) of the monitored reductions in GHG emissions that have occurred as a result of the registered CDM project activity during a defined monitoring period.

Certification is the written assurance by a DOE that, during a specific period in time, a project activity achieved the emission reductions as verified.

The objective of this verification was to verify and certify the emission reductions reported for the “Ratchaburi Farms Biogas Project at Veerachai Farm” for the period 28 March 2008 to 31 March 2011.

1.2 Scope

The scope of the verification is to verify that:

- The project activity has been implemented and operated in accordance with the registered PDD or any approved revised PDD;
- The monitoring plan complies with the monitoring methodology and the actual monitoring complies with the monitoring plan, including compliance with any guidance provided by the Board regarding deviations from the provisions of a registered plan and/or methodology;
- The data and calculation of GHG emission reductions have been assessed to correctly support the emission reductions being claimed.

The verification shall ensure that reported emission reductions are complete and accurate in order to be certified.

1.3 Description of the project activity

Project Parties:	Thailand and Denmark
Title of project activity:	Ratchaburi Farms Biogas Project at Veerachai Farm
UNFCCC registration No:	1554
Baseline and monitoring methodology	AMS-III.D (version 11) and AMS-I.D (version 10)
Project Participants:	Danish Ministry of Climate and Energy/Danish Energy Agency (Annex I Party- Denmark),



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Veerachai Farm Rangwai (Host Party- Thailand)

Location of the project activity: Moo 4, Thung Luang Sub-District, Pak Thor District, Ratchaburi

13°24.558N 99°41.403E

Project's crediting period: 28 March 2008 to 27 March 2018 (fixed)

Period verified in this verification: 28 March 2008 to 31 March 2011

The swine farm has employed high-rate anaerobic wastewater treatment reactors used for the treatment of the effluent in the project. This technology is based on the high suspended solids up flow anaerobic sludge blanket (H-UASB) system, which is a modification of the general UASB concept. A hydrolytic tank (or buffer tank) is added upstream of the conventional UASB plant. It was verified on-site that biogas from the H-UASB is captured and stored under a polyethylene cover placed over the buffer tank, and from there the biogas is sent through polyethylene (PE) pipes and pumped to the gas engines that generate electricity that is used in electrical power applications at the farm.

Final effluent from the anaerobic treatment plants is percolated across a series of sand filter beds in a batch-fed system, operating on a 4-5 day batch cycle. The details on the buffer tanks, H-UASB, gas engines, sand filter bed and type of verified to be consistent with the details provided in the approved revised CDM-PDD /5/.

The removed solids are aerobically dried on the top of the filter bed, and once dry, removed for use as a fertilizer. The treated effluent is channelled to open lagoons, where further facultative breakdown of the organic load occurs. From there, the final effluent is recycled and reused in barn flushing operations. This is in accordance with the approved revised CDM PDD /5/.

1.4 Methodology for determining emission reductions

Emission reductions will be based on AMS-III.D (version 11) /43/ and AMS-I.D (version 10) /44/. As per AMS-III.D (version 11) /43/, baseline emissions (BE) are determined by selecting the lower of

- i) The actual amount of methane generated by the digester, captured and sent to the gas engines and flare
- ii) The amount of methane emission reductions that has been calculated *ex-ante* in the PDD /5/ based on livestock population data and IPCC default emission factors.

Project emissions are calculated from the methane captured but not destroyed in the flare due to incomplete combustion of biogas in the flare (i.e. flare efficiency) and the CO₂ emissions from use of electricity for the operation of the facility. The methane emissions from methane captured but not destroyed in the flare are determined *ex-post* based on measurements of the flare efficiency as per the revised PDD /5/. The CO₂ emissions as a result of the project electricity consumption was estimated *ex-ante* in the revised PDD based on the rated power of equipment installed in the project activity /5/.

As per AMS-I.D version 10 /44/, the emission reductions of the project activity are based on the amount of grid electricity that is displaced. The baseline emissions are determined by the



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electricity generated by the biogas multiplied by the CO₂ emission coefficient for the displaced electricity from the grid. No project emissions are claimed as the project activity is utilizing biogas with biogenic origins to produce renewable energy.

According to the AMS-III.D version 11 /43/ and AMS-I.D version 10 /44/, there is no leakage (L_o) to be considered. The final reported emission reductions were determined as the difference between baseline emissions and project emissions and leakage ($ER_{net} = BE - PE - L_o$).

2 METHODOLOGY

DNV has assessed and determined that the implementation and operation of the project activity, and the steps taken to report emission reductions comply with the CDM criteria and relevant guidance provided by the Board. The assessment involved a desk review of relevant documentation as well as an on-site visit(s). The assessment includes:

- i) The biogas flow to the gas engines and flare monitored with biogas flow meters (calibration certificates /11//12//13//14//15//16//17//27//28/);
- ii) The methane content of the biogas in order to determine the amount of methane that has been captured for flaring and electricity generation monitored with portable methane analyser (calibration certificates /18/);
- iii) Electrical power for grid electricity displacement measured by the electricity meters (calibration certificates /19//20//21//22//23//24/);
- iv) The weighted average emissions for the grid in Thailand updated yearly /3/;
- v) Quantity of sludge removed from the treatment system and its application measured with truck scale (calibration certificates /25//26/).

Verification team

Role	Last Name	First Name	Country	Type of involvement						
				Desk review	Site visit	Reporting	Supervision of work	Technical review	TA 15.2 competence	TA 1.2 competence
Team leader (Verifier)	Wong	Simon Yon Sing	Malaysia	✓	✓	✓	✓		✓	✓
Technical reviewer	Antunes	Felipe	Brazil					✓	✓	✓



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Duration of verification

Monitoring report publication: *15 December 2011*
Desk review: *15 December 2011 to 10 January 2012*
On-site assessment: *20 January 2012*
Reporting, calculation checks and QA/QC: *15 December 2011 to 15 January 2013*

2.1 Desk review

The monitoring report for the Ratchaburi Farms Biogas Project at VCF for the period 28 March 2008 to 31 March 2011 (version 01 dated 8 December 2011 /1/ published on the CDM website and Version 02 dated 12 September 2012 /1/), the calibration certificates of the biogas flow meters /11//12//13//14//15//16//17//27//28/;, power meters /19//20//21//22//23//24/ and methane analysers /18/, the monthly emission reduction calculation spread sheets /3/, and the operator recorded log sheets /4/ and the on-site CDM monitoring manual /2/ were assessed as a part of the verification. In addition, the project's revised approved monitoring plan /5/ and project design submitted via the combined validation opinion for project design changes and revision of monitoring plan /7/ and the project's validation report /8/ were reviewed.

The verification of the emission reductions has assessed all factors and issues that constitute the basis for emission reductions from the project as following:

- a) The actual measured flow of biogas to the flare and two gas engines from 28 March 2008 to 31 March 2011, verified through crosschecking the log sheet /4/ and verifying the calculations in the Emission Reduction (ER) spread sheet /3/. The quality of the meter reading was content of the biogas which is measured in the pipeline before the biogas is routed to the flare and two gas engines from 28 March 2008 to 31 March 2011 was verified through crosschecking the log sheet /4/ and verifying the calculations in the ER spread sheet /3/. The quality of the methane analyser reading was assured through calibration certificate of methane analyser /18/.
- c) Actual electrical power for grid electricity displacement measured by the electricity meter was verified through crosschecking the log sheet /4/ and verifying the calculations in the ER spread sheet /3/. The quality of the meter reading was assured through calibration certificate of power meters /19//20//21//22//23//24/.
- d) *Ex-post* calculated grid emission factor sources of the data are from Thailand's Ministry of Energy /3/.

Calibration records and certificates /11/-/24//27//28/ have been provided to the verification team. DNV can confirm that the monitoring equipment were calibrated covering this monitoring period as per the approved revised PDD, or in cases where there is calibration gap, adjustments were made in accordance with EB 52 Annex 60 /46/.

2.2 On-site assessment

On 20 January 2012, Simon Wong from DNV performed on-site assessments at Veerachai Farm, Thung Luang Sub-District, Pak Thor District, Ratchaburi. During this visit, DNV verified the actual implementation of the project and confirmed that the project is implemented and operated as described in the monitoring report and the revised approved



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CDM-PDD /5/. This includes confirming the operational stages of the project with physical and documented evidence /4/.

- The site visit comprised a check of the 3 buffer tanks, 9 H-UASB, two gas engines with 952 kW capacity each, sand filter beds, the biogas meters and electricity meters;
- Verifying the implementation and the effectiveness of operation and maintenance of the buffer tanks and H-UASB and biogas handling system;
- Verifying that the volumes of biogas produced by the reactor and sent to the flare and/or the gas engine are measured with a calibrated gas flow meters;
- Verifying that the electricity generated from the gas engine are measured with calibrated power meters; and
- Verifying that monitoring equipment is correctly operated and maintained.

2.3 Closing out of verification findings

The objective of this phase of the verification was to resolve any issues which needed be clarified prior to DNV's conclusion that i) the project activity has been implemented and operated in accordance with the registered PDD or any approved revised PDD, ii) the monitoring plan complies with the monitoring methodology and the actual monitoring complies with the monitoring plan and iii) the data and calculation of GHG emission reductions are correct.

A corrective action request (CAR) is issued, where:

- i. Non-conformities with the monitoring plan or methodology are found in monitoring and reporting and has not been sufficiently documented by the project participants, or if the evidence provided to prove conformity is insufficient;
- ii. Modifications to the implementation, operation and monitoring of the registered project activity has not been sufficiently documented by the project participants;
- iii. Mistakes have been made in applying assumptions, data or calculations of emission reductions which will impair the estimate of emission reductions;
- iv. Issues identified in a FAR during validation to be verified during verification have not been resolved by the project participants.

A clarification request (CL) shall be raised if information is insufficient or not clear enough to determine whether the applicable CDM requirements have been met.

A forward action request (FAR) is issued for actions if the monitoring and reporting require attention and/or adjustment for the next monitoring period.

The verification identified two corrective action requests (CAR) and two clarification requests (CL). The CARs and CLs were satisfactorily addressed by the project participants by among other revising the monitoring (please refer to Appendix A for further details). In addition to the changes made to the monitoring report as a result of the verification findings, the following changes to the monitoring report (Version 02 dated 12 September 2012) /1/ were made compared to the initial version of the monitoring report received for verification (Version 01 dated 8 December 2011):

- update the monitoring template to the MR template using VVS track.
- Incorporating the responses to the Request for Review raised on 6 December 2012

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3 VERIFICATION FINDINGS

This section summarises the findings from the verification of the emission reductions reported for the “Ratchaburi Farms Biogas Project at Veerachai Farm” for the period 28 March 2008 to 31 March 2011.

3.1 Remaining issues, CARs, FARs from previous validation / verification

This is the first verification and there are thus no forward action requests (FAR) from the previous verification. No forward action request (FAR) from the validation stage was identified in the validation report dated 16 January 2008 /8/.

3.2 Post registration changes

DNV submitted the notification for changes in PDD on 18 May 2011 before post registration changes could be submitted under the VVS track /42/. The notification for changes was deemed incomplete on 27 June 2011 by the CDM Secretariat.

DNV resubmitted the responses to the incompleteness message on 6 June 2012, whereby the re-submission was made under the VVS track which superseded the VVM track notification. In the post registration changes submission made under VVS track, DNV has also taken the opportunity to incorporate a request for revision of the monitoring plan to four monitoring parameters.

The post registration changes described in Appendix B were identified by DNV during this verification and accepted by the EB on 4 September 2012 /7/.

The assessment of compliance with the project description and the monitoring plan contained in the PDD, as described in the following sections, is based on the revised PDD (2 February 2012) /5/.

3.3 Project implementation

As part of the site visit, DNV was able to confirm that the project implementation is in accordance with the project description contained in the revised PDD dated 2 February 2012 /5/, approved on 4 September 2012 /7/. The changes from the registered PDD /6/ cover the following: i) 1 channel digester (covered lagoon) which is changed to 3 units of buffer tanks and ii) Electricity generator capacity was revised from 950 kW to two units of 952 kW each (name plate capacity) /5//7/.

The biogas produced is being used as a fuel in the biogas engines for electricity generation. The electricity produced was utilized on-site mainly in the swine farm for barn cooling and lighting. In this monitoring period, all electricity produced was utilized on-site.

The excess biogas is flared in an open flare system /1/. The quantity of biogas utilized for electricity generation and flared is being measured by flow meters. The biogas flow meters and electricity power meters were installed to measure various parameters mentioned in the monitoring plan of the approved revised PDD /5/ were found in operation.



3.4 Information (data and variables) provided in the monitoring report that is different from that stated in the registered PDD

The emission reductions for the AMS-III.D component of the project accumulated during the 36 months of the monitoring period from 28 March 2008 to 31 March 2011 are 115 268 tCO₂e, (based on measuring the amount of methane generated by the digester, captured and sent to the flare and gas engines /3/) while the equivalent value for the similar period in the revised PDD is 167 868 tCO₂e /5/. The differences are attributed to a) using the lower of either the monthly aggregated measured methane emissions or the *ex-ante* calculated Tier 2 approach in the PDD and because it was observed that biogas generation (301 066 m³/month) throughout the entire monitoring period (assuming 36 months) was lower compared to 504 528 m³/month (calculated from 6 054 346 m³/year) as per the revised PDD, b) there are no project emission of 5 537 tCO₂e/year as assumed *ex-ante* in the PDD due to the methane not captured by the project and released to the atmosphere, and c) the total installed capacity of the auxiliaries in the project has increased thus resulting in higher project emissions from this source.

The baseline emission from electricity displaced is calculated as 13 505 tCO₂e in the *ex-post* calculation. The baseline emission from electricity generation estimated to be 18 047 tCO₂e in the approved revised PDD for the reporting period. The measured baseline emission from renewable electricity production is lower than the estimate in the revised PDD due to the decrease in electricity generation as a result of a lower biogas generation.

3.5 Compliance of monitoring plan with monitoring methodology

DNV is able to confirm that the monitoring plan contained in the revised PDD dated 2 February 2012 /5/, accepted on 4 September 2012 /7/, is in accordance with the approved methodologies applied by the project activity, i.e. AMS-III.D version 11 /43/ and AMS-I.D version 10 /44/.

3.6 Compliance of monitoring with the monitoring plan

The monitoring has been carried out in accordance with the monitoring plan contained in the revised PDD dated 2 February 2012 /5/, accepted on 4 September 2012 /7/.

The below tables describe for each parameter, which is to be measured according to the monitoring plan, how DNV has verified that i) the actual monitoring complies with the monitoring plan and that ii) data have been assessed to correctly support the emission reductions being claimed.

3.6.1 Monitoring parameters

According to the monitoring plan of the registered PDD /5/, there are 8 parameters to be monitored:

- Biogas flow to gas engines, **Q_G**
- Amount of the biogas sent to the flare, **Biogas Flared**
- Methane content in biogas, **f_{G,CH4}**
- Electricity generated by gas engines, **KW_{E,GENERATED}**



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- Quantity of sludge removed from the treatment system and its application, **Sludge application**
- Fraction of methane destroyed by flaring process, **Flare efficiency**
- Auxiliary electricity consumption for biogas system, **E_{power}**
- Grid Carbon Emission Factor, **CEF**

The following tables are related to the parameters in the monitoring plan / methodology:

	Assessment/ Observation
Data / Parameter: (as in monitoring plan of PDD):	Q_G <i>Biogas flow to gas engines.</i>
Measuring frequency:	Continuously
Reporting frequency:	Daily
Is measuring and reporting frequency in accordance with the monitoring plan and monitoring methodology? (Yes / No)	Yes, daily recording and monthly summary /5/.
Type of monitoring equipment:	Measured by three gas flow meters for the two gas engines: 1) Gas flow meter for Engine 1 from Kobold, S/N: 4830. This meter was retired on 15 July 2010 and replaced with FCI, S/N: 311614, 2) Gas flow meter for Engine 1 from Fluid Components International LLC (FCI) type ST51, S/N: 311614, 3) Gas flow meter for Engine 2 from Kobold, S/N: 5591.
Is accuracy of the monitoring equipment as stated in the monitoring plan? If the monitoring plan does not specify the accuracy of the monitoring equipment, does the accuracy of the monitoring equipment comply with local/national standards, or as per the manufacturer's specification?	The approved revised PDD /5/ mentions an accuracy of $\pm 5\%$ accuracy. Nevertheless, the monitoring equipment employed in this monitoring period is Kobold and FCI meters, which has an accuracy of $\pm 1.5\%$ of reading for Kobold gas flow meter /29/ and $\pm 2\%$ of reading for FCI gas flow meter /36/, as per the manufacturer's specification. Thus, DNV has accepted that the monitoring equipment represent good monitoring practise.
Calibration frequency /interval:	Kobold recommends calibration every 36 months, as evidenced from the manufacturer's letter /30/. FCI recommends calibration every 18 months, as evidenced from the manufacturer's manual

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	/36/.
Is the calibration interval in line with the monitoring plan? If the monitoring plan does not specify the frequency of calibration, does the selected frequency represent good monitoring practise?	The approved revised PDD /5/ does not specify the calibration frequency however mentions that it will be subjected to regular maintenance. DNV could determine that the calibration frequencies are following the manufacturer's recommendation. Thus the calibration frequency represents good monitoring practise.
Company performing the calibration:	<p>1) Gas flow meter for Engine 1 from Kobold, S/N: 4830 was calibrated on 7 February 2008 /11/ and is valid until 6 February 2011, calibrated again on 21 February 2009 /12/ and is valid until 20 February 2012 and calibrated again on 19 February 2010 /13/ and is valid until 18 February 2013. All calibration was performed by Jiamphattana Energy International Co., Ltd. This meter was retired on 15 July 2010 and replaced with FCI, S/N: 311614,</p> <p>2) Gas flow meter for Engine 1 from Fluid Components International LLC (FCI), S/N: 311614 was calibrated on 14 December 2009 by the manufacturer FCI /14/, and is valid until 13 June 2011,</p> <p>3) Gas flow meter for Engine 2, S/N: 5591 was calibrated on 13 July 2008 by the manufacture Kobold /15/ and is valid until 12 July 2011, calibrated again on 21 February 2009 /16/ and is valid until 20 February 2012 and calibrated again on 19 February 2010 /17/ and is valid until 18 February 2013. The last two calibrations were performed by Jiamphattana Energy International Co., Ltd.</p>
Did calibration confirm proper functioning of monitoring equipment? (Yes / No):	Yes, calibration confirms that the biogas meter is working within the permissible error range.
Is(are) calibration(s) valid for the whole reporting period?	The meters employed for the monitoring of the biogas flow to gas engine 1 (F1) and biogas flow to gas engine 2 (F2) are all calibrated and the calibrations performed are valid throughout the monitoring period.
If applicable, has the reported data been cross-checked with other available data?	The data reported has been verified with the log sheets /4/ and monthly reports /3/.
How were the values in the monitoring report verified?	Plant log book



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Does the data management ensure correct transfer of data and reporting of emission reductions and are necessary QA/QC processes in place?	Yes, all data from the log sheet /4/ and monthly report was verified and deemed to be in order. DNV can determine all data applied in the emission reduction calculation spread sheet /3/ were correct and from the original record.
In case project participants have temporarily not monitored the parameter, has either i) a deviation been approved by the CDM EB or ii) has the parameter been estimated as stipulated by Appendix 1 to the CDM Project Standard?	Not applicable.

	Assessment/ Observation
Data / Parameter: (as in monitoring plan of PDD):	Biogas Flared <i>Amount of the biogas sent to the Flare</i>
Measuring frequency:	Continuously
Reporting frequency:	Daily
Is measuring and reporting frequency in accordance with the monitoring plan and monitoring methodology? (Yes / No)	Yes, daily recording and monthly summary /5/.
Type of monitoring equipment:	Gas flow meter from FCI type ST 98, S/N: 285369. The meter (F3) was put into operation on 1 January 2010.
Is accuracy of the monitoring equipment as stated in the monitoring plan? If the monitoring plan does not specify the accuracy of the monitoring equipment, does the accuracy of the monitoring equipment comply with local/national standards, or as per the manufacturer's specification?	Not mentioned in the PDD. Nevertheless, the monitoring equipment is of high accuracy at 1% of reading + 0.5% of full scale reading as per the manufacturer's manual /35/. This is good monitoring practise.
Calibration frequency /interval:	FCI recommends calibration every 18 months /35/, as evidenced from the manufacturer's manual.
Is the calibration interval in line with the monitoring plan? If the monitoring plan does not specify the frequency of calibration, does the selected frequency represent good monitoring practise?	The approved revised PDD /5/ does not specify the calibration frequency however mentions that it will be subjected to regular maintenance. DNV could determine that the calibration frequencies are following the manufacturer's recommendation. Thus the calibration frequency represents good monitoring practise.
Company performing the calibration:	FCI calibrated the meter on 26 November 2007

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	/27/ and is valid until 25 May 2009, while Miracle International Technology Co., Ltd. calibrated the meter on 21 July 2011 and is valid until 20 January 2013 /28/.
Did calibration confirm proper functioning of monitoring equipment? (Yes / No):	Yes, calibration confirms that the biogas meter is working within the permissible error range.
Is(are) calibration(s) valid for the whole reporting period?	<p>The open flare system was installed on 29 July 2008 to serve as back-up combustion for the biogas when the gas engines are not operating or in cases of generated biogas exceeding the capacity of the gas engines.</p> <p>The gas flow meter (S/N: 285369) was installed on 1 January 2010. The gas flow meter (S/N: 285369) was not valid during its installation as the last calibration performed was on 26 November 2007 /27/, which was valid until 25 May 2009.</p> <p>The next calibration was undertaken on 21 July 2011 /28/, which resulted in a calibration gap between 26 May 2009 and 20 July 2011. Therefore, adjustment of 1.264% of the reading recorded from the biogas flow meter is applied for the readings recorded from 26 May 2009 to the end of the monitoring period. It was verified from the manufacturer specification that the range of flow is 0-800 Nm³/hour corresponding to 4-20 mA of the electronic signal, thus 1.264% of the readings have been appropriately included in the adjustment throughout the period of delayed calibration. Negative adjustments on this parameter were made for the baseline emission calculations (BE_{CH4}), while positive adjustments on this parameter were made for the project emission calculations (E_{flare}).</p> <p>The adjustment was justified considering that the delayed calibration on 21 July 2011 /28/ shows that the equipment has error of 1.264%, more than the specification of 1% of the reading recorded + 0.5% of full scale, thus the adjustment of 1.264% is consistent with EB 52 Annex 60 /46/.</p>
If applicable, has the reported data been cross-checked with other available data?	The data reported has been verified with the log sheets and monthly reports /3/.



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How were the values in the monitoring report verified?	Plant log book
Does the data management ensure correct transfer of data and reporting of emission reductions and are necessary QA/QC processes in place?	Yes, all data from the log sheet /4/ was verified and deemed to be in order. DNV can determine all data applied in the emission reduction calculation spread sheet were correct and from the original record /3/.
In case project participants have temporarily not monitored the parameter, has either i) a deviation been approved by the CDM EB or ii) has the parameter been estimated as stipulated by Appendix 1 to the CDM Project Standard?	Not applicable.

	Assessment/ Observation
Data / Parameter: (as in monitoring plan of PDD):	f_{G,CH4} <i>Methane content in the biogas</i>
Measuring frequency:	At least once a month
Reporting frequency:	At least once a month
Is measuring and reporting frequency in accordance with the monitoring plan and monitoring methodology? (Yes / No)	Yes, the PDD requires at least quarterly measurement and quarterly recording /5/. Project proponent calculates a monthly average from the recordings and applies the monthly average in the emission reduction calculation.
Type of monitoring equipment:	Portable methane analyser from Riken Keiki, S/N: 772020050RN.
Is accuracy of the monitoring equipment as stated in the monitoring plan? If the monitoring plan does not specify the accuracy of the monitoring equipment, does the accuracy of the monitoring equipment comply with local/national standards, or as per the manufacturer's specification?	Revised PDD mentions accuracy up to $\pm 5\%$ using near infrared spectrometry or other quantitative process. The infrared portable analyser of Riken Keiki has an accuracy of $\pm 5\%$ at full scale of reading /32/. This monitoring equipment represents good monitoring practice.
Calibration frequency /interval:	Riken Keiki recommends once every 12 months /31/.
Is the calibration interval in line with the monitoring plan? If the monitoring plan does not specify the frequency of calibration, does the selected frequency represent good monitoring practise?	The revised approved PDD /5/ does not refer to any standard. DNV could determine that the calibration frequency once every 12 months is in line with the manufacturer's recommendation /31/. This frequency represents good monitoring practise.

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Company performing the calibration:	<p>Riken Keiki S/N: 772020050RN was calibrated on the following dates:</p> <ul style="list-style-type: none"> - 15 January 2008 and is valid until 14 January 2009, - 12 July 2008 and is valid until 11 July 2009 2009, - 23 January 2009 and is valid until 22 January 2010, - 20 July 2009 and is valid until 19 July 2010, - 18 January 2010 and is valid until 17 January 2011, - 9 July 2010 and is valid until 8 July 2011, - 6 February 2011 and is valid until 5 February 20112 <p>All calibrations were performed by Jiamphattana Energy International Co., Ltd. /18/</p>
Did calibration confirm proper functioning of monitoring equipment? (Yes / No):	Yes, the calibrations confirmed that the analyser is working within the permissible error range.
Is(are) calibration(s) valid for the whole reporting period?	The calibrations performed for Riken Keiki is valid throughout the monitoring period.
If applicable, has the reported data been cross-checked with other available data?	The data reported has been verified with the log sheets /4/ and monthly reports /3/.
How were the values in the monitoring report verified?	Plant log book
Does the data management ensure correct transfer of data and reporting of emission reductions and are necessary QA/QC processes in place?	Yes, all data from the log sheet and monthly report was crosschecked and deemed to be in order. DNV can determine all data applied in the emission reduction calculation spread sheet /3/ were correct and from the original records /4/.
In case project participants have temporarily not monitored the parameter, has either i) a deviation been approved by the CDM EB or ii) has the parameter been estimated as stipulated by Appendix 1 to the CDM Project Standard?	Not applicable.



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	Assessment/ Observation
Data / Parameter: (as in monitoring plan of PDD):	KW_{E,GENERATED} <i>Electricity generated by gas engines</i>
Measuring frequency:	Continuously
Reporting frequency:	Daily
Is measuring and reporting frequency in accordance with the monitoring plan and monitoring methodology? (Yes / No)	Yes. Continuously monitored and recorded daily.
Type of monitoring equipment:	Power meters: Merlin Gerin type PM 500 (S/N: 10100) Carlo Gavazzi type WM3-96 (S/N: BH2820039101)
Is accuracy of the monitoring equipment as stated in the monitoring plan? If the monitoring plan does not specify the accuracy of the monitoring equipment, does the accuracy of the monitoring equipment comply with local/national standards, or as per the manufacturer's specification?	Not mentioned in the PDD /5/. Nevertheless, the monitoring equipment is of accuracy $\pm 1.0\%$ as per the manufacturer's specification /33//34/. This represents good monitoring practise.
Calibration frequency /interval:	The national standard as recommended by Provincial Electricity Authority is once a year /37/.
Is the calibration interval in line with the monitoring plan? If the monitoring plan does not specify the frequency of calibration, does the selected frequency represent good monitoring practise?	The approved revised PDD does not specify calibration intervals for power meter. DNV could determine that the calibration frequency (once every year) is in line with national standards from Provincial Electricity Authority. This calibration frequency represents good monitoring practise.
Company performing the calibration:	Provincial Electricity Authority performed the calibrations for S/N: 10100 and BH2820039101
Did calibration confirm proper functioning of monitoring equipment? (Yes / No):	Yes, calibrations confirm that the electricity meters are working within the permissible error range.
Is(are) calibration(s) valid for the whole reporting period?	No. There were calibration gaps identified for the two meters. Merlin Gerin was calibrated on 19 November 2007 /19/, 16 September 2008 /20/, 27 October 2009 /21/ and 15 December 2010 /22/. The calibration for 19 November 2007 /19/ is



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	<p>valid until 18 November 2008, while the calibration on 16 September 2008 is valid until 15 September 2009 /20/. The next calibration was on 27 October 2009 /21/, thus a calibration gap between 16 September 2009 and 26 October 2009 was identified. A maximum permissible error of 1% was deducted to the measured values used for baseline emission calculations. This is justified as the delayed calibration on 27 October 2009 /21/ shows an error of 0.006%, thus the adjustment of 1% is conservative and consistent with EB 52 Annex 60 /46/.</p> <p>The calibration on 27 October 2009 is valid until 26 October 2010 /21/. The next calibration was performed on 15 December 2010 /22/, thus a calibration gap between 27 October 2010 and 14 December 2010 was identified. A maximum permissible error of 1% was deducted to the measured values used for baseline emission calculations. This is justified as the delayed calibration on 15 December 2010 /22/ shows an error of 0.004% thus the adjustment of 1% is conservative and consistent with EB 52 Annex 60 /46/.</p> <p>Carlo Gavazzi was calibrated prior the installation of the gas engine as part of the biogas engine package, 27 October 2009 /23/ and 15 December 2010 /24/. The second gas engine was only installed on December 2008. The calibration on 27 October 2009 is valid until 26 October 2010 /23/. The next calibration was on 15 December 2010 /24/, thus a calibration gap between 27 October 2010 and 14 December 2010 was identified. A maximum permissible error of 1% was deducted to the measured values used for baseline emission calculations. This is justified as the delayed calibration on 15 December 2010 shows an error of 0.007% thus the adjustment of 1% is conservative and consistent with EB 52 Annex 60 /46/.</p>
If applicable, has the reported data been cross-checked with other available data?	The data reported has been verified with the operators log sheets /4/.
How were the values in the monitoring	Plant log book

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report verified?	
Does the data management ensure correct transfer of data and reporting of emission reductions and are necessary QA/QC processes in place?	Yes, all data from the log book was crosschecked and deemed to be in order. DNV can determine all data applied in the emission reduction calculation spread sheet were correct and from the original record /3/.
In case project participants have temporarily not monitored the parameter, has either i) a deviation been approved by the CDM EB or ii) has the parameter been estimated as stipulated by Appendix 1 to the CDM Project Standard?	Not applicable.

	Assessment/ Observation
Data / Parameter: (as in monitoring plan of PDD):	Sludge Application
Measuring frequency:	As required (when sludge removal occurs)
Reporting frequency:	As required (when sludge removal occurs)
Is measuring and reporting frequency in accordance with the monitoring plan and monitoring methodology? (Yes / No)	Yes. In accordance with the monitoring instructions of the project participants, the project participants determine the need to remove sludge, coordinate with maintenance staff to schedule sludge removal, perform sludge removal, properly dispose sludge and document the disposal method /5/.
Type of monitoring equipment:	Measurement of truck weight and application of the sludge. Trucks are measured on Mettler Toledo weighing scale (S/N: 5078670 – 5FA).
Is accuracy of the monitoring equipment as stated in the monitoring plan? If the monitoring plan does not specify the accuracy of the monitoring equipment, does the accuracy of the monitoring equipment comply with local/national standards, or as per the manufacturer's specification?	Not mentioned in the PDD, however the accuracy of +/-20kg is as per calibration certificate /25//26/.
Calibration frequency /interval:	Two years.
Is the calibration interval in line with the monitoring plan? If the monitoring plan does not specify the frequency of calibration, does the selected frequency represent good monitoring practise?	No calibration interval defined in the PDD. Nevertheless the calibration interval of 2 years is in line with The Weights and Measures Act /38/.
Company performing the calibration:	28 March 2008 - V T Tan Scale Co., Ltd. /25/



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	20 October 2011 – by Weights and Measures Brand Office (Region 0.2 Ratchaburi) /26/
Did calibration confirm proper functioning of monitoring equipment? (Yes / No):	Calibration was performed from 28 March 2008 /25/ and is valid until 27 March 2010 and 20 October 2011 and is valid until 19 October 2013 /26/.
Is(are) calibration(s) valid for the whole reporting period?	There is a calibration gap between 27 March 2010 and 19 October 2011. As the sludge were shown in-situ that it has been sun dried and land applied aerobically, thus the delayed calibration has no impact on the accuracy of the emission reduction reported.
If applicable, has the reported data been cross-checked with other available data?	By reviewing the plant log book /3/ records. In addition, observations on site visit shows that the sludge in sun-dried on the sand bed adjacent to the plant at thickness not more than 15cm. The dried sludge that was sent for land application was measured on the weighing scale before being sent to the nearby plantation land.
How were the values in the monitoring report verified?	Plant log book /3/
Does the data management ensure correct transfer of data and reporting of emission reductions and are necessary QA/QC processes in place?	Yes, all data from the log book was crosschecked and deemed to be in order DNV can determine all data applied in the emission reduction calculation spread sheet were correct and from the original record /3/.
In case project participants have temporarily not monitored the parameter, has either i) a deviation been approved by the CDM EB or ii) has the parameter been estimated as stipulated by Appendix 1 to the CDM Project Standard?	Not applicable.

	Assessment/ Observation
Data / Parameter: (as in monitoring plan of PDD):	Flare efficiency <i>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.</i>
Measuring frequency:	Whenever the surplus biogas sent to flare.

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Reporting frequency:	The approved revised PDD does not specify measuring frequency of the flare efficiency. The project proponent has not installed the monitoring equipment.
Is measuring and reporting frequency in accordance with the monitoring plan and monitoring methodology? (Yes / No)	The flare efficiency measured whenever the surplus biogas sent to flare.
Type of monitoring equipment:	Monitoring equipment to measure flare efficiency has not been installed and the project proponent has assumed that the flaring operation has an efficiency of 0%.
Is accuracy of the monitoring equipment as stated in the monitoring plan? If the monitoring plan does not specify the accuracy of the monitoring equipment, does the accuracy of the monitoring equipment comply with local/national standards, or as per the manufacturer's specification?	The monitoring plan does not specify the accuracy.
Calibration frequency /interval:	Not Applicable. Only maintenance provisions were mentioned which is once a year in the approved revised PDD.
Is the calibration interval in line with the monitoring plan? If the monitoring plan does not specify the frequency of calibration, does the selected frequency represent good monitoring practise?	Not Applicable. The project proponent has not installed the monitoring equipment to measure the flare efficiency.
Company performing the calibration:	Not Applicable. The project proponent has not installed the monitoring equipment to measure the flare efficiency.
Did calibration confirm proper functioning of monitoring equipment? (Yes / No):	Not Applicable. The project proponent has assumed that the flaring operation has an efficiency of 0%.
Is(are) calibration(s) valid for the whole reporting period?	Not Applicable. The project proponent has assumed that the flaring operation has an efficiency of 0%.
If applicable, has the reported data been cross-checked with other available data?	As there is no biogas sent to the flare throughout this monitoring period, there were no available data recorded for this parameter.
How were the values in the monitoring report verified?	Not Applicable. The project proponent has assumed that the flaring operation has an efficiency of 0%.
Does the data management ensure correct	Not Applicable. The project proponent has



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transfer of data and reporting of emission reductions and are necessary QA/QC processes in place?	assumed that the flaring operation has an efficiency of 0%.
In case project participants have temporarily not monitored the parameter, has either i) a deviation been approved by the CDM EB or ii) has the parameter been estimated as stipulated by Appendix 1 to the CDM Project Standard?	Not applicable.

Auxiliary electricity consumption for biogas system (E_{power})

According to section B.6.1 of the approved revised PDD /5/ of the project activity, the *ex-ante* determined electricity consumption per year per auxiliary equipment was estimated to be approximately 150.47 MWh/year for the year 2008. For monitoring purpose, the equipment installed on-site was crosschecked with the latest list of equipment provided by the project host /9/.

Grid carbon emission factor (CEF)

This parameter is not a measured parameter but calculated based on weighted average of the emissions of the current generation mix. For *ex-post* this value is re-estimated every year, based on the current changes in the grid mix. At the time of verification, DNV was not able to verify the data for the year 2011 in which project generation occurs in this monitoring period, which spans from 2008 to 2011. The Thailand grid data for 2011 was only released on 30 October 2012 from the Ministry of Energy's Department of Alternative Energy Development and Efficiency (DEDE) which is after the request for issuance was made on 3 October 2012. The grid data for 2010 was only released in 18 October 2011. Hence, the data required to calculate the emission factor for year y is usually only available later than six months after the end of year y (but before 18 months).

Since the data to calculate weighted average emissions for Thailand would not be released on the same year where the generation occurs, the project proponent has adopted (y-1) approach for the generation in 2008, 2009, 2010 and 2011. Such approach is consistent with footnote 40 in VVS paragraph 245(e), since DNV has assessed at time of site visit and reassessed prior to submitting for issuance that the most recent data publicly available is still data for 2010.

Thus, the emission reductions occurred in 2008 has been checked to adopt the weighted average of the emissions calculated for the year 2007 (0.559 tCO₂/MWh), emission reductions occurred in 2009 applying weighted average of the emissions calculated for the year 2008 (0.550 tCO₂/MWh), the emission reductions in 2010 adopted the grid emission factor calculated for the year 2009 (0.556 tCO₂/MWh) and emission reductions in 2011 adopted the grid emission factor calculated for the year 2010 (0.546 tCO₂/MWh) /3/.

The sources of the data are from Thailand's Ministry of Energy /39//40/. DNV has checked and verified that the data input used is consistent with the data available from Thailand's Ministry of Energy /39//40/. The calculation of the grid carbon emission factor is consistent with the calculation formulae in the registered PDD, which is based on paragraph 12 of AMS-I.D version 10 /44/. The project proponent has correctly applied the amount of electricity generation based on the latest data for the monitoring period.



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Calibration records /11//12//13//14//15//16//17//18//19//20//21//24//25//26/ have been provided to the verification team. DNV can confirm that the monitoring equipment were calibrated covering this monitoring period as per the approved revised PDD, or in cases where there is calibration gap, adjustments were made in accordance with EB 52 Annex 60 /46/.

3.7 Assessment of data and calculation of emission reductions

GHG emission reductions were correctly calculated using applicable formulae and considerations of the baseline and monitoring methodologies AMS-III.D Version 11 /43/ and AMS-I.D version 10 /44/.

3.7.1 Baseline emissions

In accordance with the monitoring plan and AMS-III.D (version 11) /43/, baseline emissions have been checked and found to be determined by selecting for each site the lower of;

- i) The actual amount of methane generated by the digester, captured and sent to the flare and
- ii) The amount of methane emission reductions that has been calculated *ex-ante* in the PDD based on livestock population data and IPCC default emission factors.

The amount of methane emission reductions that were calculated *ex-ante* in the PDD /5/ based on livestock population data and IPCC default emission factors as well as the project emissions due to the project's electricity consumption have been correctly applied.

The actual amount of methane generated by the digester, captured and sent to the flare is determined based on the amount of methane sent to the gas engines and flare, which is a function of the flow of biogas and the methane content of the biogas /1//5/. It was checked via the calibration certificates /11//12//13//14//15//16//17//27//28/ that the gas flow meters are normalized at the condition of 20°C and 1 atm and the corresponding methane density of 0.67 kg/m³ was applied in the calculation.

AMS-III.D version 11 /43/ has been correctly applied to the emission reduction calculation by comparing the baseline emissions estimated *ex-ante* in the PDD /5/ with the metered amount of methane sent to the gas engines and then selecting the lower of these. From these baseline emissions then the project emissions (due to electricity consumption and incomplete flaring) are subtracted /3/.

The baseline emission from electricity generation is calculated in accordance to AMS.I-D /43/ as:

$$BE_{\text{electricity}} = KW_{E, \text{GENERATED}} \times CEF$$

Where:

BE _{electricity}	Baseline electricity generation emissions (tCO ₂ e)
KW _{E, GENERATED}	Electricity produced by the biogas generator unit for grid electricity replacement (MWh)
CEF	Grid Carbon Emission Factor (tCO ₂ e/MWh)

The amount of the electricity generated measured by power meters coded PM1 /19//20//21//22/ and PM2 /23//24/. The baseline emission is determined by multiplying amount



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of the electricity produced with emission coefficient for electricity grid (tCO₂e/MWh). The CEF emission coefficient for electricity grid (tCO₂e/MWh) is calculated based on the weighted average of the emissions of the generation mix in Thailand /1/. The CEF is calculated as 0.559 tCO₂e/MWh, 0.550 tCO₂e/MWh, 0.556 tCO₂e/MWh and 0.546 tCO₂e/MWh for 2008, 2009, 2010, and 2011 respectively.

3.7.2 Project emissions

Project emissions are the CO₂ emissions as a result of the project's electricity consumption and methane emissions due to incomplete combustion of biogas in the flare (i.e. flare efficiency). The electricity consumption was estimated *ex-ante* in the validated PDD /5/ based on the power consumption of the equipment installed, however due to the increase in the electrical installations, the electricity consumption has been updated to reflect the latest auxiliaries installed.

Other project emissions listed in AMS-III.D methodology: a) methane not captured by the project and released to the atmosphere is not applicable as all methane is captured and is utilised for electricity generation or flared, b) emissions from combustion of non-biogenic methane is not applicable as there is no combustion of such activities in the project activity, c) emissions from fossil fuels for the operation of the facility is not applicable as the facilities are consuming electricity and d) anaerobic emissions from the sludge leaving the digester is not applicable as the sludge were shown in-situ that it has been sun dried and land applied aerobically.

According to section B.6.1 of the approved revised PDD /5/ of the project activity, the *ex-ante* determined electricity consumption per year per auxiliary equipment was estimated to be approximately 150.47 MWh/year for the year 2008. However, there was additional installation in the equipment in December 2008, whereby a new submerge pump, pump for de-sludge and motor for mixing were installed, thus resulting in energy consumption of 333.58 MWh/year from December 2008 onwards. The project emission from electricity consumption /5/ is estimated to be 489 tCO₂e, while the flaring occurred on January, February, March and August 2010 resulted project emissions of 1 306 tCO₂e

In the *ex-post* /1//3/ determination of project emissions, the total project emission due to electricity for the operation of the facility and flare inefficiency has been summed up to 1 795 tCO₂e. The measured project emission is 89.4% lower than expected project emission in the PDD /5/ as the project scenario does not consider the 5 537 tCO₂e annually assumed *ex-ante* in the PDD due to the methane not captured by the project and released to the atmosphere since all methane are captured and subsequently utilised for electricity generation or flaring. In addition, the total installed capacity of the auxiliaries in the project has increased thus resulting in higher project emissions from this source.

3.7.3 Leakage

DNV was able to verify the analysis and calculation of the emission reductions in the monitoring report /1/, and confirm that the calculations are complete and transparent. According to the methodologies AMS-III.D /43/ and AMS-I.D /44/, leakage calculations has been checked to be nil during the validation.



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3.7.4 Emission reductions:

According to the applied methodologies, the emission reductions (ER) should be calculated as:

$$ER_y = BE_y - PE_y - LE_y$$

The biogas flared and combusted in gas engines, electricity generation and consumption and emission reductions claimed for the proposed period could be found in the ER calculation spreadsheet /3/. The amount of baseline emissions (BE), project emissions (PE) and total emission reductions (ER) were as shown in the following table.

CDM monitoring period		Emission reductions by project activity (tCO ₂ e)			
Start date	End date	BE	PE	Leakage	ER
28 March 2008	31 March 2011	117 063	1 795	0	115 268

The claimed total emission reductions ER_y is 115 268 tCO₂e reported for the period 28 March 2008 to 31 March 2011. This is lower to the estimated value in the approved revised PDD of 167 868 tCO₂e (c.f. Section 3.3).

3.8 Quality of evidence to determine emission reductions

The biogas flow has been monitored in Nm³ biogas/hour unit by gas flow meters. The meters have been installed and calibrated accordingly by the manufacturer /11//12//13//14//15//16//17//27//28/. Methane content in the biogas has been monitored at least once a month by calibrated methane analyser /18/. Calibration delays for the monitoring equipment are captured in the spread sheet /3/ and the adjustments made were found to be in accordance consistent with EB 52 Annex 60 /46/.

The data presented in the monitoring report were assessed by reviewing in detail project documentation, interviews with representatives of Danish Energy Management A/S and VCF Group Co., Ltd. collection of monitoring data, observation of established monitoring and reporting practices and assessment of the reliability of monitoring equipment. This has enabled the verification team to assess the accuracy and completeness of the reported monitoring results and verify the correct application of the approved monitoring methodology. All necessary documentation is collected, referenced and aggregated and is easily accessible in excel format.

3.9 Management system and quality assurance

The project is operated and managed by Veerachai Farm, who is the project proponent. The site has establish a data measurement and recording protocol for all relevant data needed, based on the monitoring plan outlined, and taking into account the QA/QC comments in section B.7.1 of the revised PDD /5/.

Veerachai Farm has implemented an Emergency Preparedness Plan and Procedures at the plant. The procedure contains instructions on how to handle an emergency situation in the plant, and measures to be taken to ensure that there is no unintended methane leakage from the system.



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The project has a well-defined management system in order to ensure a successful operation of the project and the credibility and verifiability of the ERs achieve. The organisational structure, responsibilities, competencies, non-conformance handling, internal audits and management review for the project was found to be adequate. The quality of meter readings is assured through calibration of biogas flow meters the calibration certificates of the biogas flow meters /11//12//13//14//15//16//17//27//28/, power meters /19//20//21//22//23//24/ and methane analyser /18/, and the quality of the monthly emission reduction calculation spread sheets /3/ assured through cross checking of readings between the raw data recorded on-site and the results submitted for verification.

The management and operational system: the responsibilities and authorities for monitoring and reporting are in accordance with the responsibilities and authorities stated in the monitoring plan

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4 CERTIFICATION STATEMENT

DNV Climate Change Services AS (DNV) has performed the verification of the emission reductions that have been reported for the “Ratchaburi Farms Biogas Project at Veerachai Farm” (UNFCCC Registration Reference No. 1554) for the period 28 March 2008 to 31 March 2011.

The project participants are responsible for the collection of data in accordance with the monitoring plan and the reporting of GHG emissions reductions from the project.

It is DNV’s responsibility to express an independent verification statement on the reported GHG emission reductions from the project.

DNV conducted the verification on the basis of the monitoring methodology AMS-III.D (version 11) and AMS-I.D (version 10), the monitoring plan contained in the revised approved Project Design Document of version 6 dated 2 February 2012 and the monitoring report (Version 02 dated 12 September 2012). The verification included i) checking whether the provisions of the monitoring methodology and the monitoring plan were consistently and appropriately applied and ii) the collection of evidence supporting the reported data.

DNV’s verification approach draws on an understanding of the risks associated with reporting of GHG emission data and the controls in place to mitigate these. DNV planned and performed the verification by obtaining evidence and other information and explanations that DNV considers necessary to give reasonable assurance that reported GHG emission reductions are fairly stated.

In our opinion the GHG emissions reductions of the “Ratchaburi Farms Biogas Project at Veerachai Farm” (UNFCCC Registration Ref. No. 1554) for the period 28 March 2008 to 31 March 2011 are fairly stated in the monitoring report (Version 02) dated 12 September 2012.

The GHG emission reductions were calculated correctly on the basis of the approved baseline and monitoring methodology AMS-III.D (version 11) and AMS-I.D (version 10) and the monitoring plan contained in the revised approved PDD of version 6 dated 2 February 2012.

DNV Climate Change Services AS is able to certify that the emission reductions from the “Ratchaburi Farms Biogas Project at Veerachai Farm” during the period 28 March 2008 to 31 March 2011 amount to 115 268 tonnes of CO₂ equivalent.

Kuala Lumpur and Oslo, 15 January 2013

Simon Wong

Simon Wong
Verifier
DNV Kuala Lumpur, Malaysia

Michael Lehmann

Michael Lehmann
Director of Services and Technologies
DNV Climate Change Services AS



5 REFERENCES

Documents provided by the Project Participants that relate directly to the GHG components of the project. These have been used as direct sources of evidence for the periodic verification conclusions, and are usually further checked through interviews with key personnel.

- /1/ Danish Energy Management A/S: Monitoring Report for “Ratchaburi Farms Biogas Project at Veerachai Farm” for period 27 March 2008 – 31 March 2011, Version 01 dated 8 December 2011 and Version 02 dated 12 September 2012
- /2/ Danish Energy Management A/S and VCF Group Co., Ltd: CDM Monitoring Manual “Ratchaburi Farms Biogas Project at Veerachai Farm”, December 2011 version 2.1.
- /3/ Veerachai Farm: Revised excel spread sheets with emissions reductions calculations for “Ratchaburi Farms Biogas Project at Veerachai Farm” for 27 March 2008 – 31 March 2011:
 -1554_CER cal 2008 ver02_12Sep2012.xls
 -1554_CER cal 2009 ver02_12Sep2012.xls
 -1554_CER cal 2010 ver02_12Sep2012.xls
 -1554_CER cal 2011 ver02_12Sep2012.xls
 - 1554_Grid emission factor calculation_120201.xls
- /4/ Veerachai Farm: Extracts of operator log sheets recording the monitored parameters for this crediting period.
- /5/ Danish Energy Management A/S: Approved revised Project Design Document of “Ratchaburi Farms Biogas Project at Veerachai Farm” version 6 of 2 February 2012 approved on 4 September 2012.
- /6/ Danish Energy Management A/S: Project Design Document of “Ratchaburi Farms Biogas Project at Veerachai Farm” version 4 of 15 January 2008.
- /7/ DNV: Validation opinion for the notification of changes “Ratchaburi Farms Biogas Project at Veerachai Farm”, approved on 4 September 2012.
- /8/ DNV: Validation Report for “Ratchaburi Farms Biogas Project at Veerachai Farm” dated 16 January 2008, (Report No. 2007-2047).
- /9/ Veerachai Farm: List of instrument installed in VCF Farm. (no date)
- /10/ Veerachai Farm: Emergency plan for the biogas and power plant. (no date)
- /11/ Calibration and certificate report issued for gas flow meter Kobold by Jiamphattana Energy International Co., Ltd.:
 S/N: 4830 calibrated on 7 February 2008 (due date for subsequent calibration: 6 February 2011).
- /12/ Calibration and certificate report issued for gas flow meter Kobold by Jiamphattana Energy International Co., Ltd.:
 S/N: 4830 calibrated on 21 February 2009 (due date for subsequent calibration: 20 February 2012).
- /13/ Calibration and certificate report issued for gas flow meter Kobold by Jiamphattana Energy International Co., Ltd.:



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- S/N: 4830 calibrated on 19 February 2010 (due date for subsequent calibration: 18 February 2013).
- /14/ Calibration and certificate report issued for Fluid Components International LLC (FCI) type ST51 meter by FCI
S/N: 311614 calibrated on 14 December 2009 (due date for subsequent calibration: 13 June 2011).
- /15/ Calibration and certificate report issued for gas flow meter Kobold by Kobold:
S/N: 5591 calibrated on 13 July 2008 (due date for subsequent calibration: 12 July 2011).
- /16/ Calibration and certificate report issued for gas flow meter Kobold by Jiamphattana Energy International Co., Ltd.:
S/N: 5591 calibrated on 21 February 2009 (due date for subsequent calibration: 20 February 2012).
- /17/ Calibration and certificate report issued for gas flow meter Kobold by Jiamphattana Energy International Co., Ltd.:
S/N: 5591 calibrated on 19 February 2010 (due date for subsequent calibration: 18 February 2013).
- /18/ Calibration and certificate report issued for methane gas analyser from Riken Keiki by Jiamphattana Energy International Co., Ltd.:
S/N: 772020050RN calibrated on 15 January 2008 (due date for subsequent calibration: 14 January 2009).
S/N: 772020050RN calibrated on 12 July 2008 (due date for subsequent calibration: 11 July 2009).
S/N: 772020050RN calibrated on 23 January 2009 (due date for subsequent calibration: 22 January 2010).
S/N: 772020050RN calibrated on 20 July 2009 (due date for subsequent calibration: 19 July 2010).
S/N: 772020050RN calibrated on 18 January 2010 (due date for subsequent calibration: 17 January 2011).
S/N: 772020050RN calibrated on 9 July 2010 (due date for subsequent calibration: 8 July 2011).
S/N: 772020050RN calibrated on 6 February 2011 (due date for subsequent calibration: 5 February 2012).
- /19/ Calibration and certificate report issued for PM 500 electricity meter by Provincial Electricity Authority
S/N: 10100 calibrated on 19 November 2007 (due date for subsequent calibration: 18 November 2008).
- /20/ Calibration and certificate report issued for PM 500 electricity meter by Provincial Electricity Authority
S/N: 10100 calibrated on 16 September 2008 (due date for subsequent calibration: 15 September 2009).
- /21/ Calibration and certificate report issued for PM 500 electricity meter by Provincial Electricity Authority



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- S/N: 10100 calibrated on 27 October 2009 (due date for subsequent calibration: 26 October 2010).
- /22/ Calibration and certificate report issued for PM 500 electricity meter by Provincial Electricity Authority
S/N: 10100 calibrated on 15 December 2010 (due date for subsequent calibration: 14 December 2011).
- /23/ Calibration and certificate report issued for WM3-96 electricity meter by Provincial Electricity Authority
S/N: BH2820039101 calibrated on 27 October 2009 (due date for subsequent calibration: 26 October 2010).
- /24/ Calibration and certificate report issued for WM3-96 electricity meter by Provincial Electricity Authority
S/N: BH2820039101 calibrated on 15 December 2010 (due date for subsequent calibration: 14 December 2011).
- /25/ Calibration and certificate report issued for the truck scale by V T Tan Scale Co., Ltd.:
S/N: 5078670 – 5FA calibrated on 28 March 2008 (due date for subsequent calibration: 27 March 2010).
- /26/ Calibration and certificate report issued for the truck scale by Weights and Measures Brand Office (Region 0.2 Ratchaburi):
S/N: 5078670 – 5FA calibrated on 20 October 2011 (due date for subsequent calibration: 19 October 2013).
- /27/ Calibration and certificate report issued for Fluid Components International LLC (FCI) type ST98 meter by FCI
S/N: 285369 calibrated on 26 November 2007 (due date for subsequent calibration: 25 May 2009).
- /28/ Calibration and certificate report issued for Fluid Components International LLC (FCI) type ST98 meter by Miracle International Technology Co., Ltd.
S/N: 285369 calibrated on 21 July 2011 (due date for subsequent calibration: 20 January 2013).
- /29/ Kobold Flow meter manual where the manufacturer has confirmed accuracy range of $\pm 1.5\%$ of reading (no date).
- /30/ Letter from Kobold confirming that 3 years calibration interval for the flow meters dated 29 August 2011.
- /31/ Riken Keiki methane analyser manual confirming calibration of once annually (no date)
- /32/ Riken Keiki methane analyser manual confirming accuracy range $\pm 5.0\%$ of reading. (no date)
- /33/ Carlo Gavazzi electricity meter manual where the accuracy range is indicated for Type WM3-96 (no date) <https://www.gavazzionline.com/pdf/WM396.pdf>
- /34/ PowerLogic power-monitoring units electricity meter manual where the accuracy range is indicated for PM500 (no date)
[http://www.global-download.schneider-electric.com/85257578007E5C8A/all/584B14AFC5C53E3288257578004AE0FA/\\$File/plsed303022en%20\(web\).pdf](http://www.global-download.schneider-electric.com/85257578007E5C8A/all/584B14AFC5C53E3288257578004AE0FA/$File/plsed303022en%20(web).pdf)



VERIFICATION / CERTIFICATION REPORT

- /35/ Fluid Components International LLC (FCI) type ST98 manual confirming accuracy range 1% of reading + 0.5% of full scale reading and calibration performed every 18 months (no date)
- /36/ Fluid Components International LLC (FCI) type ST51 manual confirming accuracy range $\pm 2.0\%$ and calibration performed every 18 months (no date)
- /37/ Provincial Electricity Authority confirming calibration of once annually (no date)
- /38/ Weights and Measures Act 1999 (last accessed 17 November 2011)
<http://www.dit.go.th/diteng/contentdet.asp?typeid=15&catid=108&ID=1159>
- /39/ Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand: “*Thailand Energy Situation*” 2007
<http://www.dede.go.th/>
- /40/ Energy Policy and Planning Office (EPPO), Ministry of Energy, Thailand “Energy Statistics” for 2007, 2008, 2009 and 2010. <http://www.eppo.go.th/>

Background documents related to the design and/or methodologies employed in the design or other reference documents.

- /41/ CDM Executive Board: *Clean Development Mechanism Validation and Verification Standard*, version 02.0
- /42/ CDM Executive Board: *Clean Development Mechanism Project Standard*, version 01.0
- /43/ CDM Executive Board: *Simplified baseline and monitoring methodology AMS-III.D – Methane recovery in agricultural and agro industrial activities*. Version 11
- /44/ CDM Executive Board: *Simplified baseline and monitoring methodology AMS-I.D – Grid connected renewable electricity generation*. Version 10
- /45/ CDM Executive Board: *Tool to determine project emissions from flaring gases containing methane*, version 1, Annex 13 EB 28
- /46/ CDM Executive Board: *Guidelines for assessing compliance with the calibration frequency requirement*, version 1, Annex 60 EB 52

Persons interviewed during the initial verification, or persons who contributed with other information that are not included in the documents listed above.

- /47/ Siam Phoolchaoen, Royal Danish Embassy Bangkok
- /48/ Sureeporn Chuensit, Danish Energy Management A/S
- /49/ Karsten Holm, Danish Energy Management A/S
- /50/ Akkaradej Tachasattaya, VCF Group Co., Ltd.

APPENDIX A

CORRECTIVE ACTION REQUESTS, CLARIFICATION REQUESTS AND FORWARD ACTION REQUESTS

Corrective action requests

CAR ID	Corrective action request	Response by Project Participants	DNV's assessment of response by Project Participants
CAR 1	Biogas engine capacity as observed during the site visit and the capacity stated in the monitoring report is inconsistent.	The commercial contract for gas engine, signed on 1 January 2007 between VCF Group Co., Ltd (Rangwai) and Jiamphattana Energy International Co., Ltd., states that the capacity of gas engine no.2 is 957 kW. The supplier admitted (via phone call during verification visit) that this is a typing error. The correct capacity is 952 kW as shown on the nameplate. Therefore the capacity of gas engine no.2 is corrected in the Monitoring Report version 02 dated 12/09/2012.	OK, the corrected biogas engine set capacity is now reflected in the revised PDD which has been submitted to CDM EB for approval and the monitoring report Version 02 dated 12 September 2012 /1/ This CAR is closed.

CAR ID	Corrective action request	Response by Project Participants	DNV's assessment of response by Project Participants
CAR 2	<p>The following observations on-site were not consistent with the registered PDD:</p> <ul style="list-style-type: none"> a) QA/QC procedure on electricity meter by using heat rate and calculation method, b) The application of orifice plate in measuring the biogas flow (Q_G), and c) The accuracy of the portable gas analyzer used on-site is higher than the accuracy stated in the PDD. 	<p>There are minor changes to the implementation of the project activity as described in the following:</p> <ul style="list-style-type: none"> a) There is no heat application under the project, and hence no QA/QC procedure is relevant. This issue was included in the PRC which was approved by EB on 4 September 2012. b) The type-specific meter, installed for measuring the biogas flow was revised to a general term. This issue was included in the PRC which was approved by EB on the 4 September 2012. c) The PO has purchased a gas analyser different from what was anticipated. However, the calibrations indicate that the actual error is lower (<1%) than what had been stated in the registered PDD. The accuracy (+/-5%) of the analyser - in accordance with the instrument manual - has been added in the revised PDD. This issue was included in the PRC, which has been approved by the EB on the 4th September 2012. 	<p>OK. The following was checked by DNV:</p> <ul style="list-style-type: none"> a) The removal of QA/QC procedure has been made in the revised PDD, which is approved by EB on 4 September 2012, b) The generic term has been used to describe the type of flow meter used for measuring biogas flow, which is approved by EB on 4 September 2012, c) The accuracy of the gas analyser mentioned in the monitoring plan has been revised to no more than 5% which is approved by EB on 4 September 2012. <p>This CAR is closed.</p>

Clarification requests

CL ID	Clarification Request	Response by Project Participants	DNV's assessment of response by Project Participants
CL 1	Emergency preparedness procedures have been developed. Gas safety/explosion hazard was a concern during local stakeholder consultation. Further information on how due account is taken on gas safety as the biogas plant has already been in operation	<p>The translation of emergency plan has been attached.</p> <p>A gas detector was shown to the DOE. VCF has checked for leakage of digester/buffer tank cover two times a year.</p> <p>A training course (on biogas and power system maintenance and safety work) is hold every year. In addition the biogas and power plant supervisor was sent to be trained by the external organization. Please refer to attached documentation.</p> <ul style="list-style-type: none"> - 01 Emergency plan.pdf - 02-05 Training course 2008 – 2011.pdf - 06 Training certificate from the external organization.pdf <p>Other documentation that was requested by DNV during the visit.</p> <ul style="list-style-type: none"> - 07 List of motor in additional phase.pdf 	<p>OK, on-site assessment reveals that physical inspection are performed on regular basis and a copy of the gas safety and explosion hazard is shown in the biogas plant room in case any untoward events happen /10/.</p> <p>This CL is closed.</p>
CL 2	Clarification is sought on why the same adjusted amount of biogas flared was applied to both baseline and project emissions and whether this is conservative.	The approach in the initial MR was incorrect. The adjustment has been revised so that for baseline calculation the biogas volume is deducted by Maximum Permissible Error (-1%	Adjustment of 1% of the reading recorded from the biogas flow meter + 0.5% of full scale is applied for the readings recorded from 25 May 2009 to the end of the monitoring period. It was

CL ID	Clarification Request	Response by Project Participants	DNV's assessment of response by Project Participants
		reading - 0.5% full scale) of the meter readings, and for project emission calculation the data have been adjusted by adding the MPE.	<p>verified from the manufacturer specification that the range of flow is 0-800 Nm³/hour corresponding to 4-20 mA of the electronic signal, thus 0.5% of 800 Nm³ and 1% of the readings have been appropriately included in the adjustment throughout the period of delayed calibration. Negative adjustments on this parameter were made for the baseline emission calculations (BE_{CH4}), while positive adjustments on this parameter were made for the project emission calculations (E_{flare})</p> <p>The adjustment was justified considering that the delayed calibration on 21 July 2011 /28/ shows that the equipment has errors no more than 1.41%, thus the adjustment of 1.5% is conservative and consistent with EB 52 Annex 60 /46/.</p> <p>This CL is closed.</p>

Forward action requests from this verification

FAR ID	Forward action request	Response by Project Participants	DNV's assessment of response by Project Participants
	Not applicable		

APPENDIX B

POST REGISTRATION CHANGES

Type of post registration change	Description of post registration change*	Is prior approval by CDM EB required**?	In case prior approval by CDM EB is required, when was post registration change approved?
Corrections	<p>The corrections requested to the PDD are to:</p> <ul style="list-style-type: none"> a. <i>Throughout the PDD:</i> Correction of the terminology of the methane capture technology from ‘channel digester’ to ‘buffer tank’ which does not involve changes in the design, b. <i>Section A.4.1.4 and Annex 1 of the PDD:</i> The mailing address was corrected from Moo 1 Ban Nong Bua, Bo Kra Dan Sub-district to Moo 4, Thung Luang Sub-district, and the telephone and fax have been corrected as reflected in the revised PDD, and c. <i>Page 20 of the PDD:</i> The methane emissions in the registered PDD were calculated <i>ex-ante</i> using IPCC Tier 2 approach. Though there is no change to the approach, the ‘<i>average energy of feed intake per head per day</i>’ which was calculated using farm data is corrected to ‘<i>average gross energy of feed intake per head per day</i>’. Registered PDD’s ‘<i>daily intake per head</i>’ of 26.02 MJ/day is recalculated to ‘<i>average gross energy of feed intake per head per day</i>’ of 35.30 MJ/day. 	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<p>No prior approval required. Nevertheless, the corrections were submitted together as part of the post registration changes, which was approved on 4 September 2012.</p>
Temporary deviations from the registered monitoring plan and/or monitoring methodology	Temporary deviation not requested	<input type="checkbox"/> Yes <input type="checkbox"/> No	No deviation requested

Type of post registration change	Description of post registration change*	Is prior approval by CDM EB required**?	In case prior approval by CDM EB is required, when was post registration change approved?
Permanent changes from the registered monitoring plan or applied methodology	<p>Changes were made to the Section B.7.1 monitoring plan on the following aspect:</p> <ul style="list-style-type: none"> a. <i>Flare efficiency (%)</i>: Measurement method of the open flare system has been revised to be in line with the ‘Tool to determine project emissions from flaring gases containing methane’ Annex 13 EB 28, b. <i>Electricity generated ($KW_{E,GENERATED}$)</i>: QA/QC procedure on electricity meter by using heat rate and calculation method in the registered PDD. Since there is no application of heat in the project activity, the QA/QC description has been revised to maintenance and calibration method, which is more appropriate and reasonable, c. <i>Biogas flow (Q_G)</i>: The term “orifice plate” was replaced by a more generic term “flow meter” to offer more flexibility in the installation of the measurement equipment, while option of using ultrasonic meters which have high levels of accuracy (+/-2.5%) was removed as there was no commitment to use it due to high costs, and d. <i>Methane content in biogas (f_{G,CH_4})</i>: Measurement method of the portable gas analyzer has been revised by achieving accuracy up to +/-5% from +/-2.5%, in order to be consistent with the accuracy of the actual gas analyser used on-site, which has been verified by DNV through the manufacturer’s operation manual. 	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<p>No prior approval required. Nevertheless, the proposed changes in the monitoring plan were included after the initial notification of change on 18 May 2011 which was subjected to incompleteness message, and this was incorporated together as part of the post registration changes submission on 6 June 2012, which was approved on 4 September 2012.</p>

Type of post registration change	Description of post registration change*	Is prior approval by CDM EB required**?	In case prior approval by CDM EB is required, when was post registration change approved?
Changes to the project design of a registered project activity	<p>The changes requested to the PDD are to:</p> <ul style="list-style-type: none"> a. <i>Page 5 of the PDD:</i> Table 1 in the registered PDD is deleted as the technical summary of the treatment plant is no longer applicable. Information in the registered PDD which includes 1 ‘channel digester’ which is revised to 3 units of ‘buffer tank’ with the number of H-UASB reactors changed to nine (9) units, and b. <i>Page 20 of the PDD:</i> the total electricity generator capacity revised from 950 kW to 1904 kW (consisting of 2 units of 952 kW engine) due to inadvertent typographical error (952 kW instead of 950 kW mentioned in the registered PDD) and additional one more biogas generator of 952 kW. 	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	4 September 2012

* For further details refer to the “Post-registration changes request form” (F-CDM-PRC) and DNV’s assessment opinion on the changes

** Refer to Appendix 1 Appendix 1 to the CDM Project Standard /8/

APPENDIX C

CURRICULA VITAE OF THE VERIFICATION TEAM MEMBERS

Simon Wong Yon Sing

Simon Wong Yon Sing holds a Bachelor's Degree in Chemical Engineering with Environmental Engineering, with a year experience in the field of design and operation/maintenance of wastewater treatment as part of working in wastewater design & equipment supply services.

His experience in designing and maintaining the wastewater treatment systems covers the fields of various manufacturing and chemical industries in Malaysia.

He has experience of more than 5 years in validation and verification of numerous CDM projects in DNV, both in Malaysia and abroad. His qualification, industrial experience and experience in CDM demonstrate his sufficient sectoral competence in "Energy Generation from Renewable Energy Sources", "Waste Handling and Disposal" and "Animal Waste Management System".

Felipe Lacerda Antunes

Felipe Antunes holds a Master's Degree in Production Engineering (Quality) and a Post Graduate Diploma in Environmental Management and Industrial Waste Management and Treatment. Possesses an International experience of more than 10 years in the field of quality and environmental auditing, working two years as the responsible of the QMS of Rede Metrológica RS and since 1999 as a QMS and EMS auditor in DNV.

He has experience of more than 3 years in validation and verification of numerous CDM projects in DNV, both in South America & abroad. He has also been actively involved in Management System Audits such as ISO 9001, ISO 140001 and OHSAS 18001 standards in various industrial sectors for more than 10 years in DNV.

His qualification and experience in CDM demonstrate him sufficient sectoral competence in energy generation from renewable energy sources, waste handling and disposal, and animal waste management.