Monitoring report form
(Version 05.1)

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

MONITORING REPORT		
Title of the project activity	Univanich Lamthap POME Biogas Project	
UNFCCC reference number of the project activity	2076	
Version number of the monitoring report	01	
Completion date of the monitoring report	31/05/2017	
Monitoring period number and duration of this monitoring period	5th Monitoring Period Duration of this Monitoring Period : 01/01/2014 – 31/12/2016	
Project participant(s)	Univanich Palm Oil Public Co. Ltd Carbon Bridge Pte Ltd Foundation Myclimate Government of the Principality of Liechtenstein	
Host Party	Thailand	
Sectoral scope(s)	13 : Waste handling and disposal	
Selected methodology(ies)	AM0022 ver.4 - Avoided wastewater and on-site energy use emissions in the industrial sector	
Selected standardized baseline(s)	N/A	
Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD	161,280 tCO_2e	
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	N/A	99,007 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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Univanich Palm Oil Public Co. Ltd constructed a covered in ground anaerobic reactor (CIGAR) at the Lamthap Factory in Krabi Province, Southern Thailand. The CIGAR is a 46,000 m3 lagoon with a series of inlet pipes, baffles, gas extraction pipes and a thick cover of HDPE sheeting. The biogas captured in the CIGAR is extracted in a large diameter pipe where it is stripped of condensation, dust, H2S and compressed treated with an H2S scrubber before being used to fuel two 952kW Guascor biogas engines and the electricity is sold to the Provincial Electricity Authority (PEA) and used onsite when the existing biomass generator was not operating. The excess biogas is combusted in an open flare. The second Guascor biogas engine was installed in April 2009. See Section B.1 for exact dates.

The wastewater is pumped from the factory, passed through a cooling tower/heat exchanger and delivered into a mixing tank and then pumped into the CIGAR. The effluent released from the CIGAR is recycled back or sent to a small settling pond where sediment is settled and returned to the CIGAR before the treated wastewater is pumped to the existing water treatment lagoons.

Sludge from the bottom of the CIGAR is removed periodically and used as fertiliser in the company's nearby oil palm plantations with a depth of less than 1 meter. No decanter cake was used during the monitoring period as the system was kept in balance during that period.

The project was fully commissioned on 13th March 2008. The second 952kW Guascor genset was installed in April 2009.

The project activity history

Event	Date	CERs claimed (tCO_2e)
Registration date	01/02/2009	-
1st monitoring period	01/02/2009 – 31/03/2009	4,346
2nd monitoring period	01/04/2009 – 31/12/ 2010	62,733
3rd monitoring period	01/01/2011 – 31/12/2012	82,936
4th monitoring period	01/01/2013 – 31/12/2013	40,326

The total Emission Reductions in this monitoring period, 01/01/2014 – 31/12/2016, are 99,007 tCO_2e

A.2. Location of project activity

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Univanich Lamthap Factory. The address of the Lamthap factory is 142 Moo 1 Tambol Toongsaitong, Lamthap District, Krabi 81120 Thailand

GPS : N07°59'59.6760", E099°19'49.2240"

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether the Party involved wishes to be considered as project participant (yes/no)
Thailand (host)	Univanich Palm Oil Public Co. Ltd Carbon Bridge Pte Ltd	No

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether the Party involved wishes to be considered as project participant (yes/no)
Liechtenstein	Foundation Myclimate Government of the Principality of Liechtenstein	Yes

A.4. Reference of applied methodology and standardized baseline

>>

AM0022 ver.4 – Avoided wastewater and on-site energy use emissions in the industrial sector Tool to determine project emissions from flaring gases containing methane – Version 1(EB28)

A.5. Crediting period of project activity

>>

Fixed crediting period of 10 years.
The start date of the crediting period is 01/02/ 2009

A.6. Contact information of responsible persons/entities

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Responsible person

Contact Person:	Mr. Sakol Tantanawat
Organization Name:	Univanich Palm Oil Public Company Ltd.
Address:	Box 8-9 Aoluk District Krabi 81110 THAILAND
Email:	sakol.t@univanich.com

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

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The commissioning period for the CIGAR began in January 2008 and the start date of full operation with electricity generation was on 13th March 2008. The sludge settling pond was commissioned at the end of October 2008 because there was minimal build-up of suspended sludge in the CIGAR in the early months of operation. The first volume of sludge was removed in late February 2009. The settling pond recycle pipe was not installed until October 2008 and therefore the settling pond recycle flow rate meter was only installed at this time. The second 952kW Guascor genset was installed in April 2009

The Project Activity was designed by Waste Solutions Ltd's using their CIGAR technology, which comprises a uniquely designed lagoon process with mixers, baffles and a thick HDPE cover. The CIGAR contains the organic rich effluent water in an anaerobic lagoon which optimises the contact with anaerobic bacteria to convert the organic matter into biogas. The CIGAR system optimises the mixing process to separate and capture the biogas, which is then collected in pipes, cleaned and stripped of hydrogen sulphide and fed to dedicated biogas engines. In case of any excess build-up of biogas the surplus gas will be flared.

The technology and the project process is as follows:

- Effluent collection and reticulation – the POME from the factory is pumped from the factory, passed through a cooling tower and delivered into a mixing / balancing tank.

- Feed distribution – from the mixing/balancing tank the POME is pumped into the CIGAR. Waste decanter cake (a fine biomass waste product from the palm oil milling process) may be added to keep the system in balance to provide 'food' to maintain the bacteria population. To date no decanter cake has been added to the system.
- CIGAR process – the CIGAR is a 46,000 m3 lagoon with a series of inlet pipes, baffles, gas extraction pipes and a thick cover of HDPE sheeting. In the CIGAR the POME follows a series of processes and baffle walls that maximize mixing and contact with the anaerobic bacteria to promote the release of biogas.
- Effluent Discharge or Recycle – the effluent released from the CIGAR is either recycled or sent to a small settling pond where sediment is settled and returned to the CIGAR. The treated waste leaving the treatment system boundary is then pumped to existing water treatment lagoons.
- Sludge, which consists of active bacteria, perished bacteria, and cell debris from the waste water is collected periodically in the bottom of the CIGAR and either recirculated back to the CIGAR as slurry or removed by pump and used as fertilizer in the company's nearby oil palm plantations.
- Gas extraction and pumping – the gas is extracted in a large diameter pipe where it is stripped of condensation, dust, H2S and compressed to be sent to the biogas engines.
- Biogas engines – two dedicated Guascor biogas engines connected to 952kW generator capacity are installed to produce electricity. The second genset was installed in April 2009.
- An open flare is installed to combust any excess biogas not used by the gas engines

The specification of main machines installed in the project activity

Main Machine	Type/Model	Quantity	Capacity
Biogas Digester	Covered in ground anaerobic reactor (CIGAR)	1	46,000 m^3
Gas engine	Guascor SFGLD560	2	952 kw
Biogas flare	Open flare	1	650 Nm^3/hr

B.2. Post-registration changes

B.2.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

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Not applicable for this monitoring period

B.2.2. Corrections

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Not applicable for this monitoring period

B.2.3. Changes to start date of crediting period

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Not applicable for this monitoring period

B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration

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Not applicable for this monitoring period

B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline

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Not applicable for this monitoring period

A Revision of the Monitoring Plan was approved by the CDM EB on 21/10/2013 (PRC ref no. 2076-001)

B.2.6. Changes to project design of registered project activity

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Not applicable for this monitoring period

B.2.7. Types of changes specific to afforestation or reforestation project activity

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Not applicable for this monitoring period

SECTION C. Description of monitoring system

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Data processing and archiving

Measurements from the monitoring instruments are transmitted to the Fuji data logger through analogue signals and viewed using PHR Data Viewer software. These raw data files are converted to CSV and saved in excel spreadsheet format and then collated to the CDM Data Reporting spreadsheet (LBP008). Measurements for the Methane Flare Tool (necessary every 1 minute) are transmitted to the Brainchild data logger through analogical signals and viewed using Historical Viewer software. These raw data files are converted to CSV file and transferred to the Flare spreadsheet.

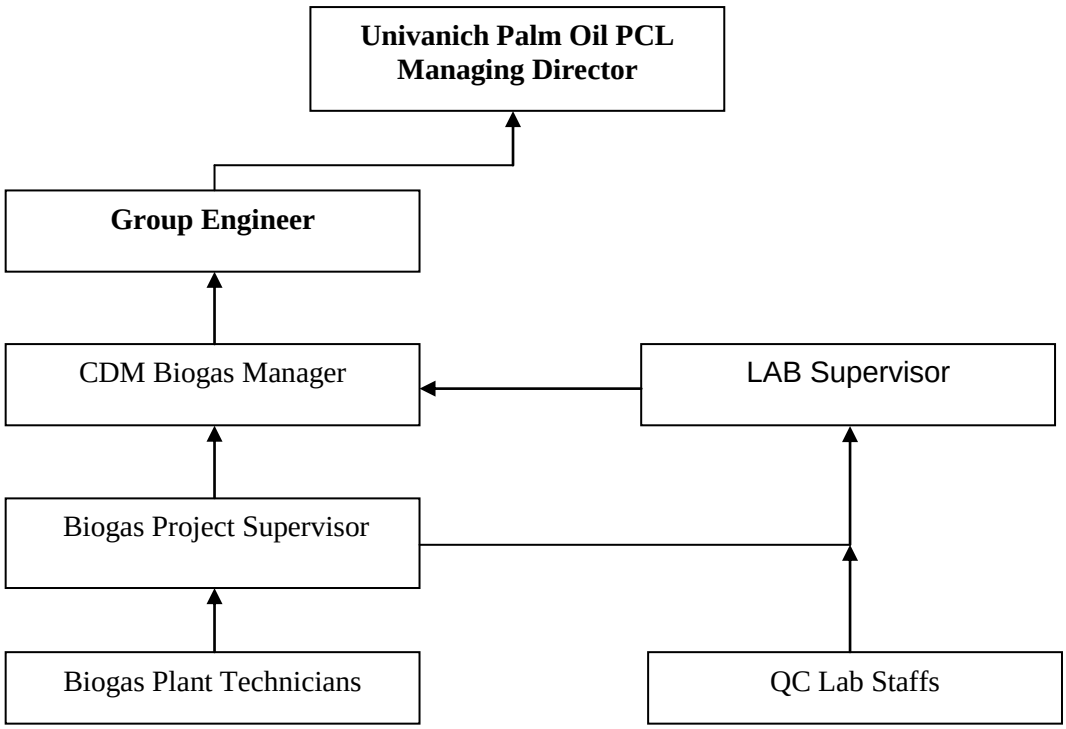
The manual readings for wastewater analysis and electricity meters are recorded in daily forms and entered manually into the CDM Data Reporting spreadsheet (LBP008).

The Raw electronic data and electronic LBP008 files and OMM files are saved on a separate computer for backup.

Quality check of data and equipment

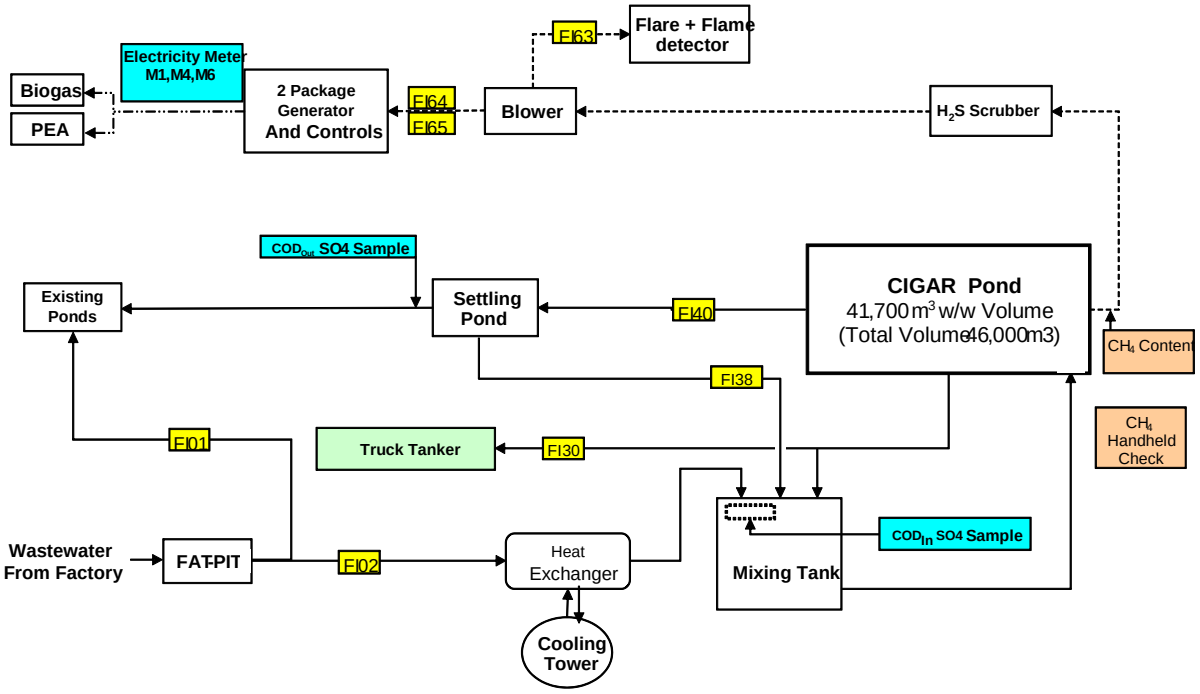
The full annual data set used for preparation of CDM Monitoring Report is quality crossed checked before final release. The roles and responsibilities for the project is outlined below:

Management Structure

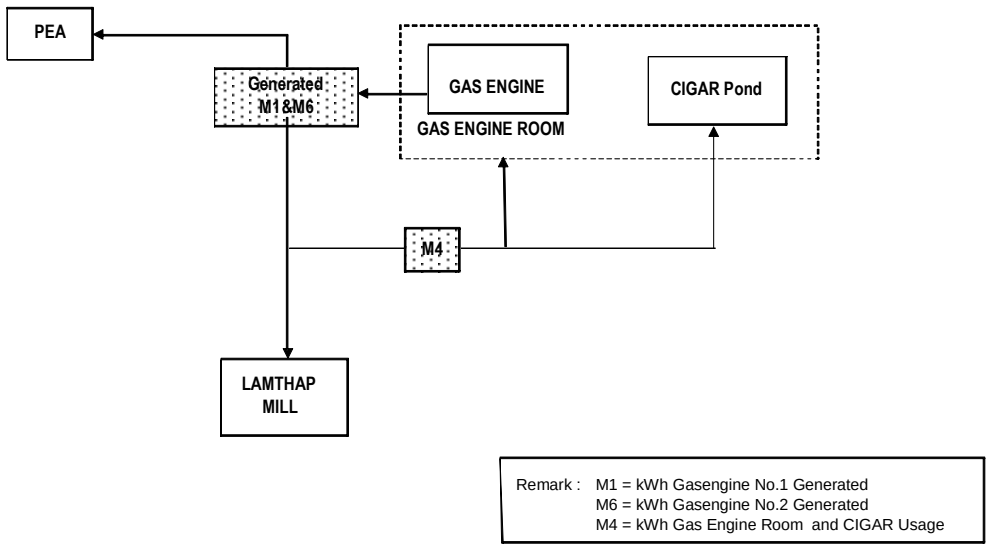


The CDM Biogas Manager prepares the Monitoring Report with the advice from Carbon Bridge Pte Ltd.

The relevant Diagrams showing monitoring equipment are as follows:



Electricity Meter Diagram



SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

Data/parameter:	EFCH4
Unit	kg CH4/kg COD
Description	Methane Emissions Factor
Source of data	AM 0022v4
Value(s) applied)	0.21
Choice of data or measurement methods and procedures	Based on research conducted on palm oil mill effluent for one year (Yacob et al, 2005) which showed the average removals to be 0.232 kg CH4/kg POME COD loaded. However to be conservative, the lowest documented value for EFCH4 was used, and 1 standard deviation was subtracted from the average, which gives 0.21 kg CH4/kg COD.
Purpose of data	Baseline and Project emissions
Additional comments	-

Data/parameter:	R_{lagoon}
Unit	%
Description	Total organic material removal ratio of the lagoon
Source of data	Yacob et al, 2006
Value(s) applied)	86%
Choice of data or measurement methods and procedures	Estimated by the project developer using historical COD for POME entering and leaving the open lagoon treatment system. Rlagoon for Years 4.-10 is adjusted by an uncertainty factor of 0.89 to account for higher POME throughput in the lagoon systems for these years.
Purpose of data	Baseline and Project emissions
Additional comments	-

Data/parameter:	Rdeposition
Unit	%
Description	Organic material deposition ratio
Source of data	Registered PDD, pg 22
Value(s) applied)	5%

Choice of data or measurement methods and procedures	The Sedimentation Appendix 3 in AM22v4 states „The first task will be to determine whether the waste water contains material that is likely to sediment, and assess whether the pond dynamics are such that such sedimentation will occur": 1. At the Lamthap Mill, the waste water does not contain material likely to sediment – this is because the Lamthap milling process includes a decanter (not centrifuge) which removes „decanter cake" that is the material in POME that usually sediments. At Lamthap, the decanter cake (which looks like ground coffee) is separated and disposed in a large deep pit. 2. The team then checked the pond dynamics to confirm this and held discussions with the Site Managers - the lagoons (especially the first lagoon) has never once been desludged or filled with sediment, demonstrating that sedimentation is unlikely. This is different to the Univanich TOPI Mill which did not have a decanter and has been desludged over time. Therefore, the team did not proceed to onsite sedimentation test, as the first step of the sedimentation methodology was cleared. (Note ACM14v2 which has replaced AM22, now makes this sedimentation tests mandatory). However, because this is a Gold Standard project which asks to follow conservative factors, we still applied a deposition ratio of COD, based on literature research of removals in other POME lagoons in Malaysia. Research conducted (Yacob et al, 2006) and published in reputable journal, showed sedimentation would be low at around 4-5% in the POME project that was tested for 1 year.
Purpose of data	Baseline and Project emissions
Additional comments	-

Data/parameter:	**Surface Oxidation Rate**
Unit	Kg COD/hectare
Description	The amount of organic material degraded aerobically in the lagoon
Source of data	AM0022v4 pg 3
Value(s) applied)	254
Choice of data or measurement methods and procedures	Further details of this figure are explained extensively in Appendix 1 of AM0022v4.
Purpose of data	Baseline and Project emissions
Additional comments	-

Data/parameter:	**CEF**
Unit	tCO2/MWh
Description	Carbon emission factor for the electricity displaced by the electricity generated using biogas
Source of data	Registered PDD, p23
Value(s) applied)	0.5098
Choice of data or measurement methods and procedures	The electricity produced by the project will offset electricity from the Thailand National electricity grid.
Purpose of data	Baseline emissions
Additional comments	-

Data/parameter:	**Flare combustion efficiency $\eta_{flare,h}$**
Unit	%

Description	Default factor to determine flare emission
Source of data	Registered PDD, p24
Value(s) applied)	50
Choice of data or measurement methods and procedures	The mass flowrate and mass fraction of methane of the biogas entering the flare will be monitored and using the default factor, the project emissions from the flare will be calculated. • The flare efficiency in the hour h ($\eta_{flare,h}$) is 0% if the flame is not detected for more than 20 minutes during the hour h. • 50%, if the flare is detected for more than 20 minutes during the hour h.
Purpose of data	Project emissions
Additional comments	-

Data/parameter:	**Methane density at standard conditions**
Unit	Kg CH4 / Nm3 biogas
Description	Density of methane at standard temperature and pressure
Source of data	Tool to determine project emissions from flaring gases containing methane - Version 1(EB28), pg 12
Value(s) applied)	0.716
Choice of data or measurement methods and procedures	As per "Tool to determine project emissions from flaring gases containing Methane" December 2006
Purpose of data	Project emissions
Additional comments	-

D.2. Data and parameters monitored

Data/parameter:	**1. POME flows entering system boundary**
Unit	m^3/year
Description	POME flow entering system boundary
Measured/calculated/default	Measured
Source of data	Measured by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 363,083.3
Monitoring equipment	
Measuring/reading/recording frequency:	continuously
Calculation method (if applicable):	-
QA/QC procedures:	Flow meters factory calibrated and a calibration certificate issued. The flow meters will be calibrated regularly according to manufacturer's specifications.
Purpose of data:	Baseline emissions calculation

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold Magnetic flow meter	±0.3%	A0738372	2 years	10/02/2014 02/02/2015 28/11/2016	2 years

Additional comments:	-

Data/parameter:	**2a. POME flows leaving project treatment facility**
Unit	m^3/year
Description	POME flows leaving project treatment facility
Measured/calculated/default	Measured
Source of data	Measured by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 330,690
Monitoring equipment	

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold Magnetic flow meter	±0.3%	S/N. A0723936	2 years	30/04/2013 11/02/2014 02/02/2015 29/11/2016	2 years

Measuring/reading/recording frequency:	continuously
Calculation method (if applicable):	
QA/QC procedures:	Flow meters factory calibrated and a calibration certificate issued. The flow meters will be calibrated regularly according to manufacturer's specifications
Purpose of data:	Project emission calculations
Additional comments:	-

Data/parameter:	**2b. POME flows leaving project treatment facility and being recycled back to digester**
Unit	m^3/year
Description	POME flows leaving project treatment facility and being recycled back to digester
Measured/calculated/default	Measured
Source of data	Measured by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 2 610
Monitoring equipment	

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold Magnetic flow meter	±0.3%	S/N. A0737740	2 years	30/04/2013 11/02/2014 04/02/2015 29/11/2016	2 years

Measuring/reading/recording frequency:	Measured continuously; recorded hourly; reported daily
Calculation method (if applicable):	-

QA/QC procedures:	Flow meters factory calibrated and a calibration certificate issued. The flow meters will be calibrated regularly according to manufacturer's specifications.
Purpose of data:	Project emission calculations
Additional comments:	-

Data/parameter:	**3. POME organic material concentration entering project boundary**
Unit	Kg COD/m^3
Description	POME organic material concentration entering project boundary
Measured/calculated/default	Measured by Univanich laboratory
Source of data	Sampled by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 71.020
Monitoring equipment	

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Hach DR2800	±1%	S/N. 1218955	1 year	25/01/2013 23/01/2014 26/01/2015 26/01/2016	1 year

Measuring/reading/recording frequency:	Daily
Calculation method (if applicable):	measured in mg/L and simple unit conversion to kgCOD/m3 by dividing the value by 1,000 to be in the same units as the Monitoring Plan
QA/QC procedures:	COD concentration analysed by accredited laboratory on a weekly basis. The equipment supplier of Univanich Hach equipment undertakes service tests of the COD equipment to ensure it is functioning correctly.
Purpose of data:	Project emission calculations
Additional comments:	-

Data/parameter:	**4. POME organic material concentration leaving project boundary**
Unit	Kg COD/m^3
Description	POME organic material concentration leaving project boundary
Measured/calculated/default	Measured
Source of data	Sampled by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 7.357

<table>
<tr><td>Monitoring equipment</td><td>
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<tr><th>Type</th><th>Accuracy Class</th><th>Serial Number</th><th>Calibration Frequency</th><th>Last Calibration</th><th>Validity</th></tr>
<tr><td>Hach DR2800</td><td>±1%</td><td>S/N. 1218955</td><td>1 year</td><td>25/01/2013
23/01/2014
26/01/2015
26/01/2016</td><td>1 year</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Daily</td></tr>
<tr><td>Calculation method (if applicable):</td><td>measured in mg/L and simple unit conversion to kgCOD/m3 by dividing the value by 1,000 to be in same units as the Monitoring Plan.</td></tr>
<tr><td>QA/QC procedures:</td><td>COD concentration analysed by accredited laboratory on a weekly basis.
The equipment supplier of Univanich Hach equipment undertake service tests of the COD equipment to ensure it is functioning correctly</td></tr>
<tr><td>Purpose of data:</td><td>Project emission calculations</td></tr>
<tr><td>Additional comments:</td><td>-</td></tr>
</table>

<table>
<tr><td>Data/parameter:</td><td>5. Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent the grid, less any electricity consumed by the biogas plant</td></tr>
<tr><td>Unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent the grid</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Measured by project developer</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>01/01/2014 – 31/12/2016 = 18,803.840</td></tr>
<tr><td>Monitoring equipment</td><td>
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<tr><th>Type</th><th>Accuracy Class</th><th>Serial Number</th><th>Calibration Frequency</th><th>Last Calibration</th><th>Validity</th></tr>
<tr><td>WM3-96(M1)</td><td>±1.0%</td><td>S/N. BH011002500 N/BG3390022 100P</td><td>1 year</td><td>11/11/2013
12/11/2014
04/11/2015
19/11/2016</td><td>1 year</td></tr>
<tr><td>WM3-96(M6)</td><td>±1.0%</td><td>S/N. BI1330005101 E/BI2480013001P</td><td>1 year</td><td>11/11/2013
12/11/2014
04/11/2015
19/11/2016</td><td>1 year</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Continuously</td></tr>
<tr><td>Calculation method (if applicable):</td><td>Measured in kWh and simple unit conversion to MWh by dividing by 1,000 to be in the same units as the Monitoring Plan.</td></tr>
<tr><td>QA/QC procedures:</td><td>Meters will undergo maintenance and calibration according to appropriate industry standards.</td></tr>
<tr><td>Purpose of data:</td><td>Baseline emission calculations</td></tr>
<tr><td>Additional comments:</td><td>-</td></tr>
</table>

<table>
<tr><td>Data/parameter:</td><td>5b. Electricity used to operate the biogas plant.</td></tr>
<tr><td>Unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Electricity used to operate the biogas plant.</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Measured by project developer</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>01/01/2014 – 31/12/2016 = 902.119</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>Type</th><th>Accuracy Class</th><th>Serial Number</th><th>Calibration Frequency</th><th>Last Calibration</th><th>Validity</th></tr>
<tr><td>PM700 (M4)</td><td>±1.0%</td><td>S/N. 0068001327</td><td>1 year</td><td>11/11/2013
12/11/2014
04/11/2015
19/11/2016</td><td>1 year</td></tr>
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</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>continuously</td></tr>
<tr><td>Calculation method (if applicable):</td><td>Measured in kWh and simple unit conversion to MWh by dividing by 1,000 to be in the same units as the Monitoring Plan.</td></tr>
<tr><td>QA/QC procedures:</td><td>Meters will undergo maintenance and calibration according to appropriate industry standards.</td></tr>
<tr><td>Purpose of data:</td><td>Baseline emission calculations</td></tr>
<tr><td>Additional comments:</td><td>-</td></tr>
</table>

Data/parameter:	**6a. Surplus biogas sent to flare**
Unit	Nm^3 biogas
Description	Surplus biogas sent to flare
Measured/calculated/default	Measured
Source of data	Measured by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 1,271,236

Monitoring equipment	

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold Fluidic Oscillator flow meter (FI63)	±1.5%	S/N. 5329	3 years	30/04/2013 12/02/2014 04/02/2015 01/12/2016	3 years
Kobold TWD-B9410213T (TI63)	± 0.75°C at 90°C	08T-04 / C10-024	1 year	27/04/2013 12/02/2014 02/02/2015 26/11/2016	1 year
Kobold SEN-3251 (PI63)	±0. 5%	08P4212P /260PVSX	2 years	27/04/2013 11/02/2014 02/02/2015 26/11/2016	2 years

Measuring/reading/recording frequency:	Continuously
Calculation method (if applicable):	-
QA/QC procedures:	Flow meters will factory calibrated and a calibration certificate issued. The meters calibrated regularly according to manufacturer's specifications.
Purpose of data:	Used in conservative check as per Equation 13
Additional comments:	-

Data/parameter:	**6b. FVRG,h Volumetric flow rate of the residual gas in dry basis at normal (NTP) conditions in the hour *h***
Unit	Nm3/h
Description	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour. Normalised to take into account pressure and temperature. To calculate project emissions from flare.
Measured/calculated/default	Measured
Source of data	Measurements by project participants using a flow meter.
Value(s) of monitored parameter	Refer to Flare tool Excel sheet

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>Type</th><th>Accuracy Class</th><th>Serial Number</th><th>Calibration Frequency</th><th>Last Calibration</th><th>Validity</th></tr>
<tr><td>Kobold Fluidic Oscillator flow meter (FI63)</td><td>±1.5%</td><td>S/N. 5329</td><td>3 years</td><td>30/04/2013
12/02/2014
04/02/2015
01/12/2016</td><td>3 years</td></tr>
<tr><td>Kobold TWD-B9410213T (TI63)</td><td>± 0.75°C at 90°C</td><td>08T-04 / C10-024</td><td>1 year</td><td>27/04/2013
12/02/2014
02/02/2015
26/11/2016</td><td>1 year</td></tr>
<tr><td>Kobold SEN-3251 (PI63)</td><td>±0. 5%</td><td>08P4212P /260PVSX</td><td>2 years</td><td>27/04/2013
11/02/2014
02/02/2015
26/11/2016</td><td>2 years</td></tr>
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<tr><td>Measuring/reading/recording frequency:</td><td>continuously.</td></tr>
<tr><td>Calculation method (if applicable):</td><td>-</td></tr>
<tr><td>QA/QC procedures:</td><td>The flow meter will undergo maintenance according to the manufacturer’s standards.
Flow meters will be calibrated regularly according to manufacturer’s specifications.</td></tr>
<tr><td>Purpose of data:</td><td>Project emission calculations</td></tr>
<tr><td>Additional comments:</td><td>Also used to monitor flowrate according to Manufacturer’s Specification where biogas flowrate should be below 650m3/hour.</td></tr>
</table>

Data/parameter:	**7. Biogas sent to generator sets and used for electricity generation**
Unit	Nm^3 biogas
Description	Biogas sent to generator sets and used for electricity generation
Measured/calculated/default	Measured
Source of data	Measured by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 10,595,004

Monitoring equipment

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold Fluidic Oscillator flow meter (FI64)	±1.5%	S/N. 5331	3 years	30/04/2013 12/02/2014 04/02/2015 01/12/2016	3 years
Kobold Fluidic Oscillator flow meter (FI65)	±1.5%	S/N. 5836	3 years	30/04/2013 12/02/2014 04/02/2015 01/12/2016	3 years
Kobold TWD-B9410213T (TI64)	± 0.7°C at 80°C	08T-05/ C10-026/ 03042009	1 year	27/04/2013 12/02/2014 02/02/2015 26/11/2016	1 year
Kobold TWD-B9410213T (TI65)	± 0.75°C at 90°C	C10-025/0915 2008	1 year	27/04/2013 12/02/2014 02/02/2015 26/11/2016	1 year
Kobold SEN-3251 (PI64)	±0. 5%	08P4209P /C10-029/ 260SUP0	2 years	27/04/2013 11/02/2014 02/02/2015 26/11/2016	2 years
Kobold SEN-3251 (PI65)	±0. 5%	C10-027260PV SZ	2 years	27/04/2013 11/02/2014 02/02/2015 26/11/2016	2 years

Measuring/reading/recording frequency:	Continuously
Calculation method (if applicable):	-
QA/QC procedures:	Flow meters factory calibrated and a calibration certificate issued. Flow meters calibrated according to Manufacturer's specifications.
Purpose of data:	Used in conservative check as per Equation 13
Additional comments:	-

Data/parameter:	**8. Biogas methane concentration**
Unit	%
Description	Biogas methane concentration
Measured/calculated/default	Measured
Source of data	Measured by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 55.80

Monitoring equipment	<table><tr><th>Type</th><th>Accuracy Class</th><th>Serial Number</th><th>Calibration Frequency</th><th>Last Calibration</th><th>Validity</th></tr><tr><td>OLCT IR 100%</td><td>±3.0%</td><td>11052LL-011</td><td>1 year</td><td>18/12/2012 03/06/2014 16/12/2015</td><td>1 year</td></tr><tr><td>JE CH4 100% (backup inline analyser Gen1)</td><td>±2.5%</td><td>27612</td><td>1 year</td><td>18/12/2013 16/12/2014 16/12/2015 16/11/2016</td><td>1 year</td></tr><tr><td>JE CH4 100% (backup inline analyser Gen2)</td><td>±2.5%</td><td>30196</td><td>1 year</td><td>17/12/2013 16/12/2014 16/12/2015 16/11/2016</td><td>1 year</td></tr></table>
Measuring/reading/recording frequency:	continuously
Calculation method (if applicable):	-
QA/QC procedures:	The methane analyser is calibrated annually. Quarterly calibration of methane concentration as conducted using a hand held methane analyzer according to LBP012 and documented in LBP009.
Purpose of data:	used to calculate project emissions and in conservative check as per Equation 13
Additional comments:	

Data/parameter:	**9. Project emissions from flaring of the residual gas stream**
Unit	tCO_2
Description	Project emissions from flaring of the residual gas stream
Measured/calculated/default	Measured/Calculated
Source of data	Measured/Calculated
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 3,953.1

Monitoring equipment	

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold Fluidic Oscillator flow meter (FI63)	±1.5%	S/N. 5329	3 years	30/04/2013 12/02/2014 04/02/2015 01/12/2016	3 years
Kobold TWD-B9410213T (TI63)	± 0.75°C at 90°C	08T-04 / C10-024	1 year	27/04/2013 12/02/2014 02/02/2015 26/11/2016	1 year
Kobold SEN-3251 (PI63)	±0. 5%	08P4212P /260PVSX	2 years	27/04/2013 11/02/2014 02/02/2015 26/11/2016	2 years

Measuring/reading/recording frequency:	continuously
Calculation method (if applicable):	-
QA/QC procedures:	Flow meters calibrated every 3 years as according to Manufacturers specifications. Meters are checked monthly to ensure they are operating.
Purpose of data:	Project emission calculation
Additional comments:	-

Data/parameter:	**10. Amount of chemical oxidizing agents entering /leaving system boundary**
Unit	mg/L
Description	Measurement of the presence of sulphate in the POME
Measured/calculated/default	Measured
Source of data	project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 309/190
Monitoring equipment	Measured by external laboratory - Saint Envir Co., Ltd (Bangkok).
Measuring/reading/recording frequency:	Quarterly samples of POME will be tested for the volume of sulphates.
Calculation method (if applicable):	Measured by external laboratory - Saint Envir Co., Ltd (Bangkok) using the Turbidimetric method. Average calculated from quarterly sample results.
QA/QC procedures:	An accredited laboratory will be used for testing, as in the test of the COD.
Purpose of data:	Baseline and project emission calculations

Additional comments:	The production process does not use any oxidative chemical compounds. However, low levels of H2S are found in the gases which indicate that there is some natural presence of sulfur in the palm oil residues, which may occur from sulfates, or from proteins which are not oxidative and would not result in removal of COD. The amount of COD removed through the reduction of the sulfates is assumed to be 1% of COD (organic matter) entering the system. This assumption will be monitored and verified exposte, by testing the amount of sulfates in the wastewater and using the stochiometric equation to determine the volume of COD lost.

Data/parameter:	**11. Gen set combustion efficiency**
Unit	%
Description	Gen set combustion efficiency
Measured/calculated/default	Measured
Source of data	Measured by project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 99.815%
Monitoring equipment	Conducted by external laboratory
Measuring/reading/recording frequency:	annually
Calculation method (if applicable):	100%-0.185% = 99.815% Test results of methane emissions from biogas engine tested by CEM Technology (Thailand) Co. Ltd. according to USEPA standards. Average of both engines = 0.185% (Engine 1= 0.23%, Engine 2 = 0.14% for year 2014 , For 2015, 2016 Average of both engines < 0.000001%
QA/QC procedures:	The Biogas supervisor is responsible for co-ordinating this process. This test will be conducted through an independent service to determine combustion efficiency.
Purpose of data:	Project emission calculation
Additional comments:	-

Data/parameter:	**12. Flow of POME directly to the current water treatment system, and bypassing the new POME treatment facility**
Unit	m^3
Description	Flow of POME directly to the current water treatment system, and bypassing the new POME treatment facility
Measured/calculated/default	Measured
Source of data	Measured by developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 442
Monitoring equipment	
Measuring/reading/recording frequency:	continuously
Calculation method (if applicable):	-

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold Magnetic flow meter	±0.3%	S/N. A0732088	2 years	30/04/2013 11/02/2014 02/02/2015 28/11/2016	2 years

QA/QC procedures:	The flow meter will be calibrated regularly according to manufacturer"s specifications.
Purpose of data:	Project emission calculation
Additional comments:	-

Data/parameter:	**13. Loss of biogas from pipe line**
Unit	%
Description	Loss of biogas from pipe line
Measured/calculated/default	Measured as per procedure in LPD013
Source of data	project developer
Value(s) of monitored parameter	01/01/2014 – 31/12/2016 = 0
Monitoring equipment	-
Measuring/reading/recording frequency:	annually
Calculation method (if applicable):	-
QA/QC procedures:	The process will be conducted annually by the Biogas Supervisor and overseen by the Factories Manager.
Purpose of data:	Project emission calculation
Additional comments:	-

Data/parameter:	**14. Organic material removed from POME facility**
Unit	tCOD
Description	Organic material removed from POME facility
Measured/calculated/default	Removals of COD after monitoring and prior to entry to the lagoon system will recorded to ensure CH4 emissions are not overestimated. This may be material screened out after the POME concentration is recorded.
Source of data	Measured by project developer.
Value(s) of monitored parameter	0
Monitoring equipment	-
Measuring/reading/recording frequency:	daily
Calculation method (if applicable):	-
QA/QC procedures:	The Biogas Supervisor is responsible for ensuring that the COD measure has been taken by the Biogas Plant Technicians at the correct location and after any screenings have been removed. The Internal Audit manager will be responsible for random checks on the whole process.
Purpose of data:	Project emission calculation
Additional comments:	COD test will be carried out after any screening of the POME, therefore this value is expected to be zero.

Data/parameter:	**15. Other flare operation parameters – Flame detector**
Unit	On – Off
Description	Detection unit
Measured/calculated/default	Measured

Source of data	Measured by project developer
Value(s) of monitored parameter	Refer to Flare tool Excel sheet
Monitoring equipment	Flame Ionization Detector(FID)
Measuring/reading/recording frequency:	continuously
Calculation method (if applicable):	-
QA/QC procedures:	The detector will be checked on a quarterly basis to ensure that it is operational and functioning correctly.
Purpose of data:	Project emission calculation
Additional comments:	As per Tool to determine project emissions from flaring gases containing Methane". Used to demonstrate that the flare is operational (e.g. through a flame detection system reporting electronically on continuous basis)). If the flare is not operational for more than 20mins the default value to be adopted for flare efficiency is 0%.

Data/parameter:	**16. Pressure of biogas sent to flare**
Unit	mBar
Description	Pressure of biogas sent to flare
Measured/calculated/default	Measured by project developer
Source of data	Pressure transmitter
Value(s) of monitored parameter	02/03/2014 = 47.1 mBars 11/06/2014 = 31.2 mBars 16/09/2014 = 18.2 mBars 16/12/2014 = 28.7 mBars 11/03/2015 = 48.7 mBars 13/06/2015 = 39.2 mBars 22/09/2015 = 36.5 mBars 07/12/2015 = 37.4 mBars 31/03/2016 = 64.6 mBars 13/06/2016 = 39.5 mBars 01/09/2016 = 24.4 mBars 03/12/2016 = 33.5 mBars
Monitoring equipment	
Measuring/reading/recording frequency:	Quarterly
Calculation method (if applicable):	-
QA/QC procedures:	The transmitter will be calibrated before use and calibrated regularly according to manufacturer's specifications.

Type	Accuracy Class	Serial Number	Calibration Frequency	Last Calibration	Validity
Kobold SEN-3251 (PI63)	±0. 5%	08P4212P /260PVSX	2 years	27/04/2013 11/02/2014 02/02/2015 26/11/2016	2 years

Purpose of data:	As per Tool to determine project emissions from flaring gases containing Methane". Used to demonstrate that the flare complies with manufactures specification of pressure supplied between 10-100 mBar.
Additional comments:	-

Data/parameter:	**17. methane emitted from covered lagoon**
Unit	Signal of methane detected
Description	methane emitted from covered lagoon
Measured/calculated/default	monitored via portable gas detector around perimeter of covered lagoon to identify any leaks
Source of data	Monitored by project developer
Value(s) of monitored parameter	No leakage
Monitoring equipment	<table><tr><th>Type</th><th>Accuracy Class</th><th>Serial Number</th><th>Calibration Frequency</th><th>Last Calibration</th><th>Validity</th></tr><tr><td>Testo 316-1</td><td></td><td>31143.20</td><td>2 years</td><td>25/04/2012 15/01/2014 17/12/2015</td><td>2 years</td></tr></table>
Measuring/reading/recording frequency:	Daily
Calculation method (if applicable):	This parameter for safety check only - the more conservative method for calculating methane emitted from the covered lagoon (ECH4_NAWTF) will be applied following Equation 30 of ACM14v4, whereby the default factor for leaks FLbiogas,digest is applied at 0.05 m³ biogas leaked/m³ biogas produced.
QA/QC procedures:	Portable gas detector will be calibrated as per manufacturer's specifications. Daily recordings will be logged and maintenance engineer notified immediately to rectify any leaks. Date and time repair will be logged.
Purpose of data:	Monitoring parameter for safety check only.
Additional comments:	-

D.3. Implementation of sampling plan

>>

N/A

SECTION E. Calculation of emission reductions or GHG removals by sinks

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

>>

Total estimated baseline emissions are the sum of fugitive methane emissions from the existing lagoon-based water treatment system and CO_2 emissions from the generation of heat on site and/or of power on and off site. *The equation is*

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{CO2\_heat\_BL} + E_{CO2\_power\_BL}$$

Where: E_{BL} are the Total Baseline Emissions (tCO_2e)

$E_{CH4\_lagoons\_BL}$ are the fugitive methane emissions from lagoons in the baseline case (tCO_2e).

$E_{CO2\_heat+power\_BL}$ are the CO_2 emissions from onsite fossil heat and/or power generation in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

$E_{CO2\_grid\_BL}$ are the CO_2 emissions related to electricity supplied by the grid in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

On site heat generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility. The proposed project does not generate any heat for on or off site use, then $E_{CO2\_heat\_BL} = 0$

On site and/or off site grid power generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility.

For the full calculations and formula please refer to Emission Reduction calculation spreadsheet.

Total Baseline Emissions (01/01/2014 - 31/12/2016)	**E_{BL}**	**tCO_2e**	**114,213**
1. Fugitive methane emissions that would have been released from lagoons in the baseline case	**$E_{CH4\_lagoons\_BL}$**	tCO_2e	105,086
Amount of organic material that would have been removed by anaerobic processes in the lagoon system	**$M_{lagoons\_anaerobic\_BL}$**	kg COD	20,016,452
Amount of organic material that would have been removed in the lagoon system	**$M_{lagoon\_total\_BL}$**	kg COD	22,176,917
Amount of organic material that would have been degraded aerobically in the lagoon system	**$M_{lagoon\_aerobic\_BL}$**	kg COD	770,567
Amount of organic material that would have been lost through chemical oxidation in the lagoon system	**$M_{lagoon\_chemical\_ox\_BL}$**	kg COD	99,864
Amount of organic material that would have been lost through deposition in the lagoon system	**$M_{lagoon\_deposition\_BL}$**	kg COD	1,289,314
Total amount of organic material that would have been fed to the lagoon system	**$M_{input\_total\_BL}$**	kg COD	25,786,275
2. CO_2 emissions related to electricity supplied by the grid in the baseline case	**$E_{CO2\_power\_BL}$**	tCO_2	9,126

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

>>

Total estimated project emissions are the sum of fugitive methane emissions from the existing lagoon-based water treatment system, from possible methane emissions from the new anaerobic waste water treatment facility, from incomplete biogas combustion and biogas leaks. Total Project emissions are estimated using the following equations.

$$E_{project} = E_{CH4\_lagoons} + E_{CH4\_NAWTF} + E_{CH4\_IC+leaks}$$

For the full calculations and formula please refer to Emission Reduction calculation spreadsheet.

Total Project Emissions (01/01/2014-31/12/2016)	**$E_{project}$**	**tCO_2e**	**16,106**
1. Methane emissions from the lagoons	$E_{CH4\_lagoons}$	tCO_2e	6,069
Amount of organic material removed by anaerobic processes in the lagoon system	$M_{lagoons\_anaerobic}$	kg COD	1,155,961
Total amount of organic material removed in the lagoon system	M_{lagoon_total}	kg COD	2,102,787
Amount of organic material degraded aerobically in the lagoon system	$M_{lagoon\_aerobic}$	kg COD	770,567
Amount of organic material lost through chemical oxidation in the lagoon system	$M_{lagoon\_chemical\_ox}$	kg COD	55,573
Amount of organic material lost through deposition in the lagoon system	$M_{lagoon\_deposition}$	kg COD	120,686
Organic material removed from POME facility - removals of organic material from after sampling point and before entering the anaerobic digester	$M_{lagoon\_screenings}$	kg COD	0
Organic material diverted from the CIGAR and sent direct to lagoons	M_{lagoon_bypass}	kg COD	31,377
Input of organic material from CIGAR water treatment facility into the lagoon system	M_{lagoon_input}	kg COD	2,413,725
2. Methane emissions from inefficient combustion emissions	$E_{CH4\_IC+Leaks}$		4,112
Methane emissions from inefficient combustion emissions	E_{CH4_IC}	tCO_2e	158.601
Methane emissions from leaks from pipeline	E_{CH4_Leaks}	tCO_2e	0
Project emissions from flaring of the residual gas stream - see Flare Tool Spreadsheet	PE_{Flare}	tCO_2e	3,953.1
Methane emissions from leakage of biogas	E_{CH4_NAWTF}	tCO_2e	5,926

E.3. Calculation of leakage

>>

Leakage			
According to AM0022v4 leakage is considered negligible	**Leakage**	tCO_2	0

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

Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	GHG emission reductions or net GHG removals by sinks (t CO_2e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
Total 01/01/2014-31/12/2016	114,214	16,106	0		99,007	99,007

E.5. Comparison of actual emission reductions or net GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO_2e)	161,280 (2014 : 53,668) (2015 : 52,668) (2016 : 53,994)	99,007

E.6. Remarks on difference from estimated value in registered PDD

>> The actual emission reductions are lower than estimated in the PDD due to lower volume of wastewater than predicted in PDD.

Appendix 1. Contact information of project participants and responsible persons/entities

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Univanich Palm Oil Public Company Ltd.
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City	
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Country	Thailand
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E-mail	john.clendon@univanich.com
Website	www.univanich.com
Contact person	Mr. John Clendon
Title	Managing Director
Salutation	Mr.
Last name	Clendon
Middle name	
First name	John
Department	
Mobile	
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Direct tel.	+66 75 634 484
Personal e-mail	john.clendon@univanich.com

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Carbon Bridge Pte Ltd
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Country	Singapore
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Fax	
E-mail	bmcintosh@carbon-bridge.com
Website	www.carbon-bridge.com
Contact person	
Title	Managing Director

Salutation	Ms.
Last name	McIntosh
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Project participant and/or responsible person/ entity	☐ Project participant ☒ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Univanich Palm Oil Public Company Ltd.
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Document information

Version	*Date*	*Description*
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	28 May 2010	EB 54, Annex 34. Initial adoption.

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