MONITORING REPORT FORM (CDM-MR) *
Version 01 - in effect as of: 28/09/2010

CONTENTS

* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

MONITORING REPORT
Version No.: 01, 05/04/2011

Methane Recovery and Utilization at United Plantations Berhad, Jendarata Palm Oil Mill, Malaysia
UNFCCC Reg. No: 1153
Period No.: 02, (01/05/2009 – 28/02/2011)

SECTION A. General description of the project activity

A.1. Brief description of the project activity:

This monitoring report is prepared for the project titled "Methane Recovery and Utilization at United Plantations Berhad, Jendarata Palm Oil Mill, Malaysia", located in the state of Perak, Malaysia. The Project was commissioned in the month of September 2006 and was registered with UNFCCC with the registration number **1153** on 8th November 2007.

In the baseline scenario, POME is treated using deep open anaerobic lagoons, followed by facultative and aerobic treatment in shallow lagoons. The treated effluent is finally used for land application in the oil palm plantation. This process is similar to the baseline scenario. The discharge for the effluent is in compliance with the Effluent Discharge Standards of the Malaysian Department of Environment[1].

The project activity is a biogas comprising closed continuous-flow stirred tanks (CSTR) anaerobic digester for the treatment of POME. The biogas generated will be supplied to the nearby palm oil refinery, Unitata, where the biogas is combusted in a steam boiler to generate steam for the refinery process. The biogas used in the refinery boiler will displace the consumption of fuel oil. Excess gas is flared off in an open flare. Effluent from the anaerobic digester tanks will be discharge ed into the existing aerobic lagoons, where it is treated before final discharge to land application.

Key Information

Project Title	Methane Recovery and utilisation at United Plantations Berhad, Jendarata Palm Oil Mill, Malaysia
Project Registration Number	1153
CDM Registration Date	08/11/07
Project Commissioning Date	01/09/06
Project Host	United Plantations Bhd
Project Participants	Danish Ministry of Climate and Energy / Danish Energy Agency
Crediting Period	08/11/07 – 07/11/14 (7 years - Renewable)

[1] Environmental Quality Act 1974: Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977

Project Location	United Plantation Berhad, Jendarata Estate, 36009 Teluk Intan, Perak Darul Ridzuan, Malaysia.

Monitoring Period	01/05/09 – 28/02/11
Monitoring Report Number	02
Reporting Date	31/03/11
Site Visit Date	22/03/11

Methodologies Used	AM0013 ver. 04
Emission Reductions in reporting period	82,093 tCO_{2eq}
Name of person/entity preparing the monitoring report	**Henrik Rytter Jensen and Yogaanandh Tanggaraju** Danish Energy Management 37-1, The Capsquare Residences, No.2, Persiaran Capsquare, 50100 Kuala Lumpur, Malaysia Tel : +603 2694 3033 Fax : +603 2694 4033 E-mail: hrj@dem.dk; yat@dem.dk

A.2. Project Participants

Name of Party involved ((host) indicates a host Party)	Private and/or public entity (ies) project participants (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Malaysia (host)	**Private entity: United Plantations Bhd**	**No**
Denmark	**Public Entity: Danish Ministry of Climate and Energy / Danish Energy Agency**	**No**

A.3. Location of the project activity:

United Plantation Berhad,
Jendarata Estate,
36009 Teluk Intan,
Perak Darul Ridzuan, Malaysia.

GPS Coordinates: *$3^0$50' 9" N and $100^0$57' 90" E*

A.4. Technical description of the project

Continuous-flow Stirred Tank Reactors

A closed tank anaerobic digestion technology, based on the continuous flow stirred tank reactor system (CSTR) with sludge return design, is implemented for the palm oil mill effluent (POME) treatment at United Plantations Jendarata Palm Oil Mill to displace the treatment of POME in the existing deep open lagoon system for anaerobic digestion. The CSTR system is equipped with a dual-function complete mixing mechanism, comprising pump-aided circulation and gas-lifting mixing, to maximize the anaerobic digestion efficiency. The complete-mixed system facilitates long-term continuous operations without needs of any interruptions for sludge removal. The anaerobic digestion will be operating under mesophilic conditions with temperature ranging from 35-40^0C. The digester system for the project activity is designed with a hydraulic retention time of minimum 18 days. The floating roof design for the tanks allows a significant volume of buffer storage capacity for the biogas.

Biogas Boiler

The biogas captured is mainly utilized for steam generation using the existing 10 t/h fuel oil-fired Mashall Boiler at Unitata Berhad, an associated company located adjacent to UP Jendarata Palm Oil Mill. The boiler is fitted with a Dunphy dual burner with automatic control, which allows biogas combustion for steam generation, at approximately 11 barg. The biogas displaces the use of medium fuel oil for the boiler at Unitata Berhad.

Open-flare system

Excess biogas from the digesters is flared using an open flare system, where flaring efficiency is 50% based on ''Tool to determine project emissions from flaring gases containing methane'' (ver. 01).

Nevertheless, due to project participants failing to install a continuous methane analyzer, where the values have to be averaged hourly or a shorter time interval to monitor the methane fraction in the biogas flared, the flare efficiency will be estimated to be 0%; estimated conservatively.

Project Layout

The project 27 parameters registered under the monitoring plan of the PDD.

- Flow rate of organic wastewater into the digester (F_{dig}) – **F1**
- COD concentration of organic wastewater into the digester ($COD_{c,baseline}$) – **COD1**
- COD concentration of the effluent that leaves the lagoon ($COD_{a,out}$) – **COD2**
- COD concentration of the effluent that enters the lagoon which is assumed to be equal to the COD input to the digesters ($COD_{a,in}$) – **COD 1** (2)
- Temperature of lagoon[2] (T_{lag})
- Depth of lagoon (D_{lag}) – *Depth indicator*
- Quantity of thermal energy that would be consumed in year y at the project site in the absence of the project activity using fossil fuel ($HG_{Bl,y}$) – **F5**
- Operating hours per year of the refinery boiler fired on biogas (h_{boiler})
- Operating hours per year of the refinery using steam from biogas boiler ($H_{refinery}$)
- Flow rate of organic wastewater from the digester (F_{dig_out}) – **F1(2)**
- COD concentration in discharged effluent from digester (COD_{c,dig_out}) – **COD2 (2)**
- Amount of electricity in the year y that is consumed at the project site for the project activity ($EL_{Pr,y}$) – **E1**
- Flow rate of sludge applied to land (F_{la}) – **F7**
- COD concentrations in sludge used for land application ($COD_{c,la}$)– **COD3**
- Amount of biogas collected in the outlet of the bio-digester measured using a continuous flow meter (FR_{bio}) – **F3**
- Percentage of biogas that is methane in the outlet of the bio-digester (PCH4,bio) – **CH1**
- Flow rate of biogas entering the flare ($FR_{f,inlet}$) – **F2**
- Project emissions from flaring of the residual gas stream ($PE_{flare,y}$)
- Detection of flame in the open flare being on or off (Flame detection)
- Flow rate of the biogas entering the heat generation equipment ($FR_{e,inlet}$) – **F4**
- Flow rate of the heat generation equipment stack gases ($FR_{e,s}$) – **F6**
- Methane content in stack gas of heat generation equipment ($P_{CH4,e,s}$) – **CH3**[3]
- Fraction of time gas is combusted in the heat generation equipment ($T_{comb,e}$)
- Amount of sludge applied to land (S_o) – **TSS**
- Nitrogen content in the sludge used for land application, for estimating N_2O emission in project emission (NC) – **N**
- Regulations and incentives relevant to effluent
- Detection of physical leakage of digester tanks

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[2] Data from Malaysian Meteorological Services for Sitiawan district (Perak state) is used to monitor this parameter

[3] Quarterly stack analysis is conducted using accredited (ISO 17025/SAMM) laboratory. Results shows no methane detection to up to 0.01% (vol/vol).

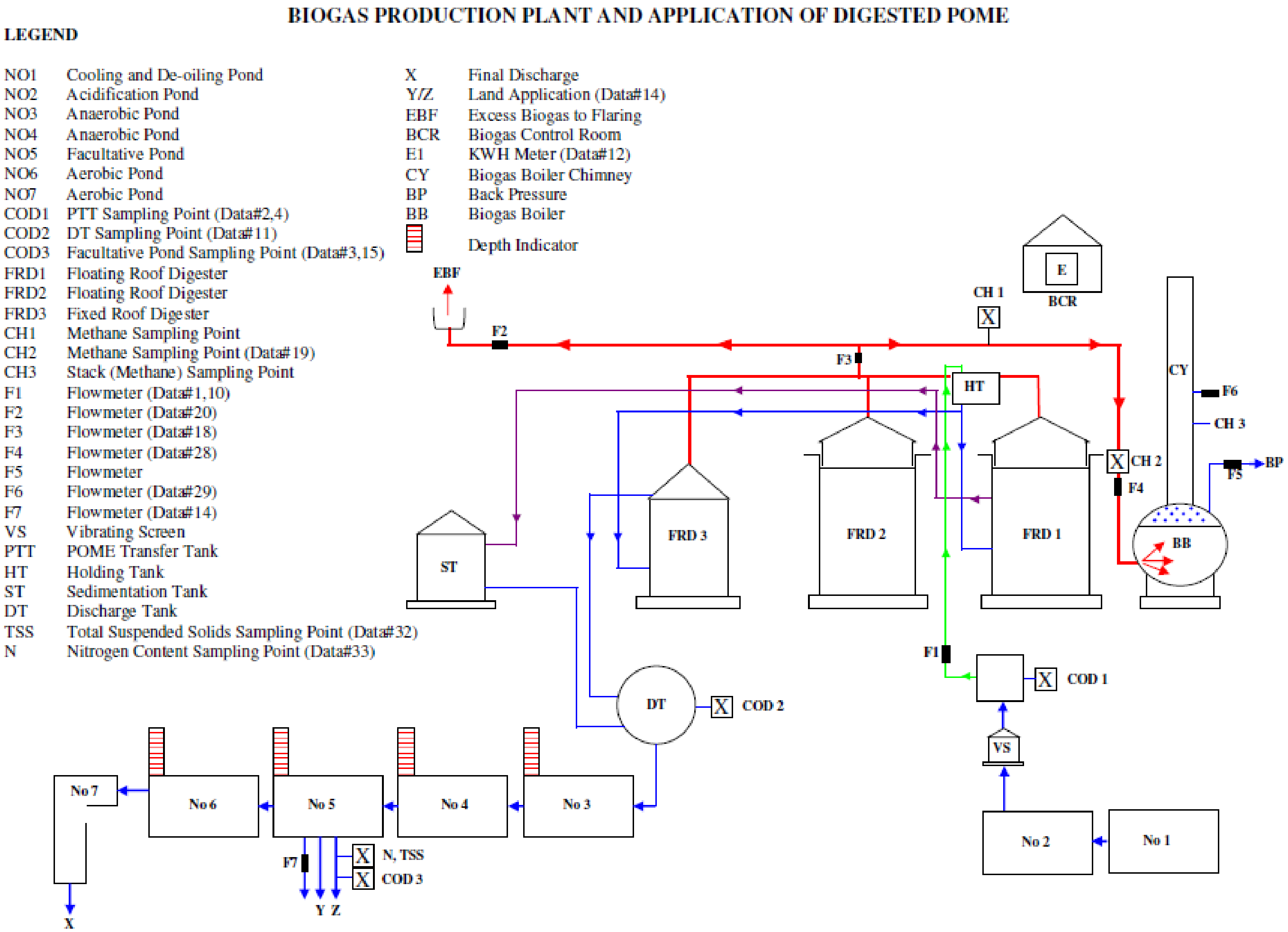

Figure 1: Flowchart of the project with main components and labels for monitoring points.

A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity:

The approved baseline and monitoring methodology AM0013 Ver. 4: "Avoided methane emissions from organic waste-water treatment" is applied to the project activity.

A.6. Registration date of the project activity:

08/11/07

A.7. Crediting period of the project activity and related information (start date and choice of crediting period):

08/11/07 – 07/11/14 (7 years, Renewable)

A.8. Name of responsible person(s)/entity(ies):

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SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

Starting date of the operation of the project activity

The project was commissioned and became fully operational in September 2006. The project starting date was before the project registration date (08/11/07). All equipment pertaining to the project has been in operating mode since the project start date.

The data presented in this second monitoring report is covering the period from 01/05/09 to 28/02/10; the period where emission reductions are claimed for.

Information regarding the actual operation of the project activity

The biogas plant installation can be divided into 3 major components; *continuous-flow stirred tank reactor (CSTR), biogas boiler and open flare system.*

CSTR

The CSTR tanks have been installed and operating in good condition since the project commissioning date. The tanks have not undergone any change or modification since the project registration date. The project plant has installed 2 units of floating of roof tanks and 1 unit of fixed tank roof, each with a capacity of 2500 m^3.

Biogas boiler

The packaged boiler[4], located at the boiler house is fitted with a biogas burner[5]. The boiler operates daily, as it is the main boiler that supplies steam for process to the refinery. Additional steam for the refinery comes from the biomass boiler located in the neighboring palm oil mill and the medium fuel oil fired boilers. No modification has been made to the boiler since the project registration date.

Open-flare system

For the current monitoring period (01/05/09 – 28/02/11), flaring has only taken place during June 2009. All biogas produced from the site has been combusted in the boiler. Though not utilized frequently, the flare equipments are maintained in good operating condition. The efficiency of the flaring activity is fixed at 50%, due to it being an open-flare system. Nevertheless, as described in Section A.4 above, flaring efficiency is calculated as 0%.

B.2. Revision of the monitoring plan

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[4] Marshall Boiler, model FS6000; serial number of 98127.

[5] Dunphy burner, model THD 530 ZML VP RT; serial number 21865. Minimum gas inlet pressure is at 1.3 psi.

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Not applicable

B.3. Request for deviation applied to this monitoring period

Not applicable

B.4. Notification or request of approval of changes

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Not applicable

SECTION C. Description of the monitoring system

A total number of 27 parameters are monitored for this project activity. During the monitoring period (01/05/09 – 28/02/11), the data collection has been well managed and all records are in place. Most of the data are logged by SCADA software into a computer placed at the control room in the Unitata boiler house.

List of monitoring equipments

Symbol	Parameter	Type	Make/Model	Serial Number	Primary Data Recording
F_{dig}	Flowrate of organic wastewater into the	Magnetic flowmeter	Siemens Magflo 5100	7ME651 553114T296	SCADA
$COD_{c,baseline}$	COD concentration of organic wastewater into the	COD analysis kit	HACH DRB200/	Not available	Internal and external laboratory report
$COD_{a,out}$	COD concentration of the effluent that leaves the	COD analysis kit	HACH DRB200/	Not available	Internal and external laboratory report
$COD_{a,in}$	COD concentration of the effluent that enters the lagoon which is assumed to be equal to the COD input	COD analysis kit	HACH DRB200/ DR890	Not available	Internal and external laboratory report
T_{lag}	Temperature of lagoon	Data obtained from Malaysian Meteorological Services (MMS) Dept	Not Applicable	Not Applicable	MMS report
D_{lag}	Depth of lagoon	Measuring pole	Not Applicable	Not Applicable	Manual logsheet/logbook

Symbol	Parameter	Type	Make/Model	Serial Number	Primary Data Recording
$HG_{Bl,y}$	Quantity of thermal energy that would be consumed in year y at the project site in the absence of the project	Thermal mass flowmeter	Endress Hauser / 73W1H-SB4AA1AAA4 AA	8B02FC2000	SCADA
h_{boiler}	Operating hours per year of the refinery boiler fired on	Logsheet	Not Applicable	Not Applicable	Manual logsheet/logbook
$H_{refinery}$	Operating hours per year of the refinery using steam from biogas boiler	Logsheet	Not Applicable	Not Applicable	Manual logsheet/logbook
F_{dig_out}	Flow rate of organic wastewater from the	Magnetic flowmeter	Siemens Magflo 5100	7ME651 553114T296	SCADA
COD_{c,dig_out}	COD concentration in discharged effluent from	COD analysis kit	HACH DRB200/	Not available	Internal and external laboratory report
$EL_{Pr,y}$	Amount of electricity in the year y that is consumed at the project site for the	kWh / electricity meter	Lenin-MPI	2005-2035807	Manual logsheet/logbook
F_{la}	Flow rate of sludge applied to land	Magnetic flowmeter	Endress Hauser Promag 10 (2	8C0CC019000 / 87163719000	Manual logsheet/logbook
$COD_{c,la}$	COD concentrations in sludge used for land	COD analysis kit	HACH DRB200/	Not available	Manual logsheet/logbook
FR_{bio}	Amount of biogas collected in the outlet of the bio-digester measured using a continuous flow meter	Vortex flowmeter	Endress Hauser/72W1FH - SEOAA1AAA4	85029120000	SCADA
$P_{CH4,bio}$	Percentage of biogas that is methane in the outlet of the bio-digester	Gas analyzer	GA 2000 gas monitor	GA10356	Manual logsheet/logbook

Symbol	Parameter	Type	Make/Model	Serial Number	Primary Data Recording
$FR_{f,inlet}$	Flow rate of biogas entering the flare	Vortex flowmeter	Endress Hauser / 72F1H-	8A026E20000	SCADA
$PE_{flare,y}$	Project emissions from flaring of the residual gas	Calculated value			Not applicable
Flame detection	Detection of flame in the open flare being on or off	Thermocouple	Tempsens Instruments	Not available	SCADA
$FR_{e,inlet}$	Flow rate of the biogas entering the heat generation	Vortex flowmeter	Yokogawa DY100	S5F606169-624	SCADA
$FR_{e,s}$	Flow rate of the heat generation equipment stack gases	Vortex flowmeter	Codel VCEM 5000	VCEM5000-0059 TRX1 VCEM5000-0059 TRX1	SCADA
$P_{CH4,e,s}$	Methane content in stack gas of heat generation	External laboratory analysis			External laboratory report
$T_{comb,e}$	Fraction of time gas is combusted in the heat	Calculated value			Manual logsheet/logbook
S_o	Amount of sludge applied to land	External laboratory analysis			External laboratory report
NC	Nitrogen content in the sludge used for land application, for estimating	External laboratory analysis			External laboratory report
Regulations and incentives relevant to effluent	-	Monitored at renewal of crediting period			Not applicable
Physical leakage of digester tanks	Detection of physical leakage of digester tanks	Checks for leakage from tanks, monitoring point joints and piping are carried out monthly by the project proponent			Internal leakage test reports

Data Logging/Recording

Please refer to the table above.

Calibration status

Symbol	Type	Instrument ID	Make/Model	Serial Number	Calibration Frequency (Months)	Calibration date(s)
F_{dig}	Magnetic flowmeter	F1	Siemens Magflo 5100	7ME651 553114T296	12	05/11/10, 06/11/09, 14/11/08
$HG_{Bl,y}$	Thermal mass flowmeter	F5	Endress Hauser / 73W1H-SB4AA1AAA4AA	8B02FC2000	12	05/11/10, 06/11/09, 14/11/08
F_{dig_out}	Magnetic flowmeter	F1	Siemens Magflo 5100	7ME651 553114T296	12	05/11/10, 06/11/09, 14/11/08
$EL_{Pr,y}$	kWh / electricity meter	E1	Lenin-MPI	2005-2035807	12	15/10/10, 19/10/09, 15/12/08
F_{la}	Magnetic flowmeter	F7	Endress Hauser Promag 10 (2 units)	8C0CC019000 / 87163719000	12	05/11/10, 06/11/09, 14/11/08
FR_{bio}	Vortex flowmeter	F3	Endress Hauser/72W1FH-SEOAA1AAA4AA	85029120000	12	05/11/10, 06/11/09, 14/11/08

Symbol	Type	Instrument ID	Make/Model	Serial Number	Calibration Frequency (Months)	Calibration date(s)
$P_{CH4,bio}$	Gas analyzer	CH2	GA 2000 gas monitor	GA10356	12	28/04/10, 15/06/09, 30/07/08
$FR_{f,inlet}$	Vortex flowmeter	F2	Endress Hauser / 72F1H-SE0AA1AA4AA	8A026E20000	12	05/11/10, 06/11/09, 14/11/08
$FR_{e,inlet}$	Vortex flowmeter	F4	Yokogawa DY100	S5F606169-624	12	05/11/10, 06/11/09, 14/11/08
$FR_{e,s}$	Vortex flowmeter	F6	Codel VCEM 5000	VCEM5000-0059 TRX1 VCEM5000-0059 TRX2	24	21/09/10, 30/09/08

Quality control process

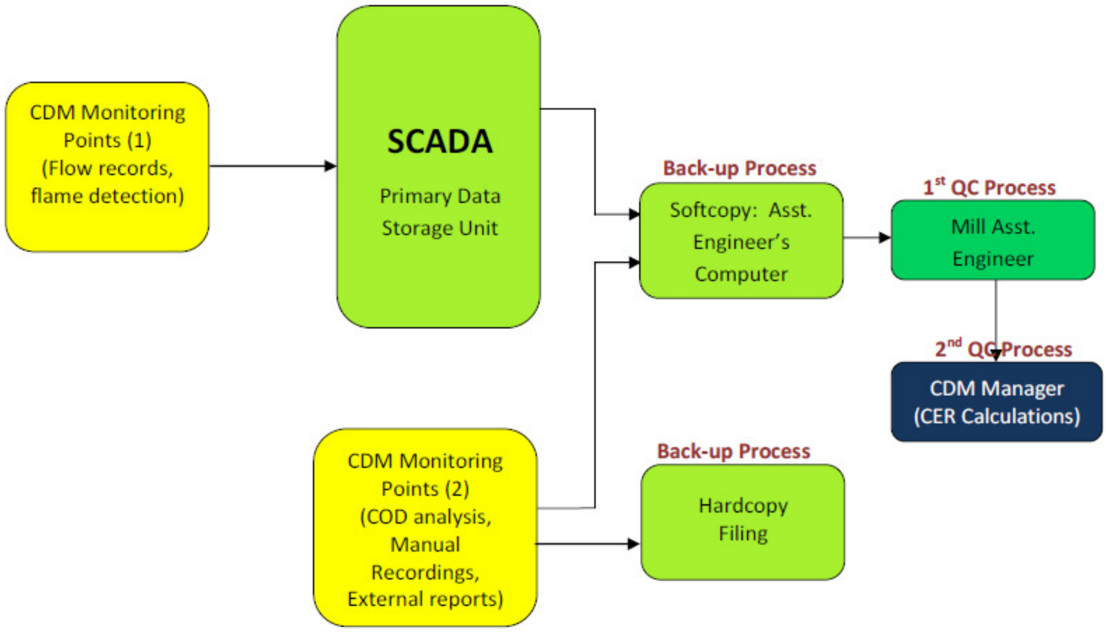

Figure 2: Communication Process on transfer of data at site

The data collected at the project site is transferred as per diagram above. The first set of CDM monitoring records, flow (POME flow, gas flow, steam flow, etc) and flame detection will be logged into the SCADA electronically. The SCADA system's data storage unit is located at the Unitata's refinery boiler house. The data will be transferred into an excel sheet for CER calculation (raw data file). The data or results on the second set of CDM monitoring records (analysis reports, manual recordings, etc), which are received as hardcopy, will be transferred into the same excel sheet for CER calculation. The hardcopy reports will be filed accordingly.

The 1st QC process takes place when the mill's assistant engineer, Mr. Arish receives all records from SCADA and external reports, prior to consolidating all data. The 2nd QC process takes place when the CDM Manager, receives the raw data file from the mill's assistant engineer. The CDM Manager will check through the data keyed into the raw data file before using them to compute the CER calculations.

SECTION D. Data and parameters

D.1. Data and parameters determined at registration and not monitored during the monitoring period, including default values and factors

Data / Parameter:	Palm Oil Mill Operating Capacity
Data unit:	t FFB/hr (or per day, per month, per year)
Description:	The mill capacity is represented by tonnage of fresh fruit bunch (FFB) processed per unit time.
Source of data used:	Mill owner
Value(s) :	45 t/hr, 600 t/day
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Additional comment:	This is the maximum operating capacity for the mill. The value may be used for estimation of POME flow, accumulating over a year, according to the operating daily operating hours of the mill.

Data / Parameter:	F_{dig}
Data unit:	m^3/day
Description:	Palm Oil Mill Effluent (POME) flow rate.
Source of data used:	Mill operator.
Value(s) :	400 m^3/day.
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Additional comment:	-

Data / Parameter:	Operating days per year
Data unit:	Days/year
Description:	This represents the number of days the mill is operating in a year.
Source of data used:	Mill operator.
Value(s) :	300 days/year
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline and project emission calculation
Additional comment:	-

Data / Parameter:	T_2
Data unit:	deg C
Description:	Ambient temperature based on monthly maximum, minimum and average temperature at or near project site.
Source of data used:	Malaysian Meteorological Services (MMS) Department.
Value(s) :	27.3 deg C (average); 23.6 deg C (min) and 32.5 deg C (max).
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Additional comment:	-

Data / Parameter:	Depth of anaerobic lagoon
Data unit:	meter (m)
Description:	Depth of the existing anaerobic lagoons.
Source of data used:	Mill owner.
Value(s) :	2-4 m
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Additional comment:	-

Data / Parameter:	B_o
Data unit:	kg CH_4/kg COD
Description:	Maximum methane production potential.
Source of data used:	IPCC
Value(s) :	0.21 kg CH_4/kg COD
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline and project emission calculation
Additional comment:	The default IPCC value for B_o is 0.25 kg CH_4/kg COD. Taking into account the uncertainty of this estimate, the project participant uses a value of 0.21 kg CH_4/kg COD as a conservative assumption for B_o, in accordance with the requirement of AM0013, Version 04, page 8.

Data / Parameter:	f_d
Data unit:	Fraction number
Description:	Fraction of anaerobic degradation due to depth
Source of data used:	AM0013 Version 4
Value(s) :	0.50
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Additional comment:	-

Data / Parameter:	$CEF_{Bl,therm}$
Data unit:	t CO_2-e/TJ
Description:	CO_2 emissions intensity for thermal energy generation.
Source of data used:	IPCC
Value(s) :	77.37 t CO_2-e/TJ_{oil}
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Additional comment:	-

Data / Parameter:	EF_{N2O}
Data unit:	kg N_2O/kg N
Description:	Emission factor of nitrogen from sludge applied to land.
Source of data used:	As recommended in AM0013.
Value(s) :	0.016 kg N_2O/kg N
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Additional comment:	-

D.2. Data and parameters monitored

Data / Parameter:	F_{dig}
Data unit:	m^3/month
Description:	Flow rate of organic wastewater into the digester.
Measured /Calculated /Default:	Measured
Source of data:	Measured by magnetic flowmeter with a totalizer
Value(s) of monitored parameter:	202,079 m^3 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Magnetic Flowmeter Make/Model: Siemens / MagFlo 6000 Accuracy class: IP67 Serial no: 7ME651 553114T296 Calibration frequency: Annual Date of initial calibration: 14/11/08 Date of 2nd calibration: 06/11/09 Date of last calibration: 05/11/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Hourly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Flowmeter is subjected to annual calibration by certified calibration company.

Data / Parameter:	$COD_{c,baseline}$
Data unit:	kg/m^3
Description:	COD concentration of organic wastewater into the digester.
Measured /Calculated /Default:	Measured
Source of data:	COD analysis report (internal and external)
Value(s) of monitored parameter:	96.23 kg/m^3 (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: COD analysis kit Make/Model: HACH DRB200 / HACH DR890 Accuracy class: Not applicable Serial no: Not available Calibration frequency: Not applicable

	Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Weekly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Internal COD tests are carried out by in-house laboratory at Unitata refinery, using certified APHA/USEPA methods. External COD tests are carried out by laboratory accredited by ISO 17025 and SAMM (Accreditation Certificate of Malaysian Laboratory)

Data / Parameter:	$COD_{a,out}$
Data unit:	kg/m^3
Description:	COD concentration of the effluent that leaves the lagoon.
Measured /Calculated /Default:	Measured
Source of data:	COD analysis report (internal and external)
Value(s) of monitored parameter:	18.60 kg/m^3 (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: COD analysis kit Make/Model: HACH DRB200 / HACH DR890 Accuracy class: Not applicable Serial no: Not available Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Weekly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Internal COD tests are carried out by in-house laboratory at Unitata refinery, using certified APHA/USEPA methods. External COD tests are carried out by laboratory accredited by ISO 17025 and SAMM (Accreditation Certificate of Malaysian Laboratory)

Data / Parameter:	$COD_{a,in}$
Data unit:	kg/m^3
Description:	COD concentration of the effluent that enters the lagoon which is assumed to be equal to the COD input to the digester.
Measured /Calculated /Default:	Measured
Source of data:	COD analysis report (internal and external)
Value(s) of monitored	96.23 kg/m^3 (average of 01/05/09 – 28/02/11)

parameter:	
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: COD analysis kit Make/Model: HACH DRB200 / HACH DR890 Accuracy class: Not applicable Serial no: Not available Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Weekly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Internal COD tests are carried out by in-house laboratory at Unitata refinery, using certified APHA/USEPA methods. External COD tests are carried out by laboratory accredited by ISO 17025 and SAMM (Accreditation Certificate of Malaysian Laboratory)

Data / Parameter:	T_{lag}
Data unit:	Degree C (to be converted to deg K)
Description:	To be obtained from the Malaysian Meteorology Services (MMS) Department network of ambient temperature monitoring. The ambient temperature data for a network site nearest to the project site will be used.
Measured /Calculated /Default:	Measured
Source of data:	Malaysian Meteorology Services (MMS) Department
Value(s) of monitored parameter:	25.8 °C (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Not applicable (Data is obtained from MMS department) Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	MMS is following international standard methods in its monitoring

	programmes.

Data / Parameter:	D_{lag}
Data unit:	m (metre)
Description:	Depth of lagoon.
Measured /Calculated /Default:	Measured
Source of data:	Measured by depth measurement pole(s)
Value(s) of monitored parameter:	2 m (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Depth measurement pole Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Depth of lagoon is monitored daily using a depth measuring pole.

Data / Parameter:	$HG_{Bl,y}$
Data unit:	MJ/yr
Description:	Quantity of thermal energy that would be consumed in year y at the project site in the absence of the project activity using fossil fuel.
Measured /Calculated /Default:	Measured (steam flow) and calculated (thermal energy)
Source of data:	Measured by thermal mass flowmeter
Value(s) of monitored parameter:	167,337,301 MJ (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Thermal mass flowmeter Make/Model: Endress Hauser / Prowirl 73 Accuracy class: IP 68 Serial no: 8B02FC2000 Calibration frequency: Annual Date of 1st calibration: 14/11/08 Date of 2nd calibration: 06/11/09 Date of last calibration: 05/11/10 Validity: 1 year

Measuring/ Reading/ Recording frequency:	Hourly
Calculation method (if applicable):	Steam flow records are multiplied with steam enthalpy at specific pressure, to derive amount of thermal energy, $HG_{BI,y}$
QA/QC procedures applied:	Flowmeter is subjected to annual calibration by certified calibration company.

Data / Parameter:	h_{boiler}
Data unit:	h/yr
Description:	Operating hours per year of the refinery boiler fired on biogas.
Measured /Calculated /Default:	Measured
Source of data:	Boiler operating hour records
Value(s) of monitored parameter:	16,056 h (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable; only for cross-checking on boiler's biogas consumption and steam generation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Manual logsheet records Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	-
QA/QC procedures applied:	-

Data / Parameter:	$H_{refinery}$
Data unit:	h/yr
Description:	Operating hours per year of the refinery using steam from biogas boiler.
Measured /Calculated /Default:	Measured
Source of data:	Refinery operating hour records
Value(s) of monitored parameter:	16,056 h (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable; only for cross-checking on refinery's consumption of steam from biogas boiler.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last	Type: Manual logsheet records Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable

calibration, validity)	Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	-
QA/QC procedures applied:	-

Data / Parameter:	F_{dig_out}
Data unit:	m^3/month
Description:	Flow rate of organic wastewater from the digester.
Measured /Calculated /Default:	Measured
Source of data:	Measured by magnetic flowmeter with a totalizer (same unit as F_{dig})
Value(s) of monitored parameter:	202,079 m^3 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Magnetic Flowmeter Make/Model: Siemens / MagFlo 6000 Accuracy class: IP67 Serial no: 7ME651 553114T296 Calibration frequency: Annual Date of initial calibration: 14/11/08 Date of 2nd calibration: 06/11/09 Date of last calibration: 05/11/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Hourly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	The flowmeter for F_{dig} and F_{dig_out} are the same unit. This is based on assumption that all POME influent into the digester equals to POME effluent out of the digester. Flowmeter is subjected to annual calibration by certified calibration company.

Data / Parameter:	COD_{c,dig_out}
Data unit:	kg/m^3
Description:	COD concentration in discharged effluent from digester.
Measured /Calculated /Default:	Measured
Source of data:	COD analysis report (internal and external)
Value(s) of monitored parameter:	18.60 kg/m^3 (average of 01/05/09 – 28/02/11)
Indicate what the data are	For project emission calculation

used for (Baseline/ Project/ Leakage emission calculations)	
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: COD analysis kit Make/Model: HACH DRB200 / HACH DR890 Accuracy class: Not applicable Serial no: Not available Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Weekly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Internal COD tests are carried out by in-house laboratory at Unitata refinery, using certified APHA/USEPA methods. External COD tests are carried out by laboratory accredited by ISO 17025 and SAMM (Accreditation Certificate of Malaysian Laboratory)

Data / Parameter:	$EL_{Pr,y}$
Data unit:	MWh/yr
Description:	Amount of electricity in the year y that is consumed at the project site for the project activity.
Measured /Calculated /Default:	Measured
Source of data:	Measured by a kWh or electricity meter
Value(s) of monitored parameter:	337,268 MWh (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: kWh/electricity meter Make/Model: MPI Lenin Accuracy class: Class 2 Serial no: 2005-2-35807 Calibration frequency: Annual Date of initial calibration: 15/12/08 Date of 2nd calibration: 19/10/09 Date of last calibration: 15/10/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	kWh meter is subjected to annual calibration by certified personnel (Energy Commission of Malaysia) and calibration company

Data / Parameter:	F_{la}
Data unit:	m^3/yr
Description:	Flow rate of sludge applied to land.
Measured /Calculated /Default:	Measured
Source of data:	Measured by 2 units of magnetic flowmeter
Value(s) of monitored parameter:	139,578 m^3 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Magnetic flowmeter Make/Model: Endress Hauser / Promag 10 Accuracy class: IP 68 Serial no: 8C0CC019000 / 87163719000 Calibration frequency: Annual Date of initial calibration: 14/11/08 Date of 2nd calibration: 06/11/09 Date of last calibration: 05/11/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Flowmeter is subjected to annual calibration by certified calibration company.

Data / Parameter:	$COD_{c,la}$
Data unit:	kg/m^3
Description:	COD concentrations in sludge used for land application.
Measured /Calculated /Default:	Measured
Source of data:	COD analysis report (internal and external)
Value(s) of monitored parameter:	3.62 kg/m^3 (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: COD analysis kit Make/Model: HACH DRB200 / HACH DR890 Accuracy class: Not applicable Serial no: Not available Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Weekly

Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Internal COD tests are carried out by in-house laboratory at Unitata refinery, using certified APHA/USEPA methods. External COD tests are carried out by laboratory accredited by ISO 17025 and SAMM (Accreditation Certificate of Malaysian Laboratory)

Data / Parameter:	FR_{bio}
Data unit:	m^3/yr
Description:	Amount of biogas collected in the outlet of the Bio-digester measured using a continuous flow meter.
Measured /Calculated /Default:	Measured
Source of data:	Measured by vortex flowmeter
Value(s) of monitored parameter:	7,871,170 m^3 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Vortex flowmeter Make/Model: Endress Hauser / Prowirl 72 Accuracy class: IP 68 Serial no: 8A026E20000 Calibration frequency: Annual Date of initial calibration: 14/11/08 Date of 2nd calibration: 06/11/09 Date of last calibration: 05/11/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Hourly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Flowmeter is subjected to annual calibration by certified calibration company.

Data / Parameter:	$P_{CH4,bio}$
Data unit:	%
Description:	Percentage of biogas that is methane in the outlet of the bio-digester
Measured /Calculated /Default:	Measured
Source of data:	Measured by gas analyser
Value(s) of monitored parameter:	58.67% (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline and project emission calculation

Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Gas analyser Make/Model: Geotechnical Instruments/GA 2000 Accuracy class: IP 68 Serial no: GA10356 Calibration frequency: Annual Date of initial calibration: 30/07/08 Date of 2nd calibration: 16/06/09 Date of last calibration: 28/04/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Gas analyser is subjected to annual calibration by certified calibration company.

Data / Parameter:	$FR_{f,inlet}$
Data unit:	m^3/yr
Description:	Flow rate of biogas entering the flare
Measured /Calculated /Default:	Measured
Source of data:	Measured by a vortex flowmeter
Value(s) of monitored parameter:	29,360 m^3 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Vortex flowmeter Make/Model: Endress Hauser / Prowirl 72 Accuracy class: IP 68 Serial no: 8A026E20000 Calibration frequency: Annual Date of initial calibration: 14/11/08 Date of 2nd calibration: 06/11/09 Date of last calibration: 05/11/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Flowmeter is subjected to annual calibration by certified calibration company.

Data / Parameter:	$PE_{flare,y}$
Data unit:	tCO_{2eq}/yr
Description:	Project emissions from flaring of the residual gas stream in year y (**$PE_{flare,y}$**)
Measured /Calculated	Calculated

/Default:	
Source of data:	Measurements from $FR_{f,inlet}$ and $PCH_{4,bio}$
Value(s) of monitored parameter:	440.06 tCO_{2eq} (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Not applicable (Calculated value) Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Hourly
Calculation method (if applicable):	Calculation is based on Step 1 to Step 7 of the '*'Tool to determine project emissions from flaring gases containing methane*''
QA/QC procedures applied:	-

Data / Parameter:	Flame Detection
Data unit:	On/off
Description:	Detection of flame in the open flare being on or off.
Measured /Calculated /Default:	Measured
Source of data:	Measured by thermocouple in the flare system
Value(s) of monitored parameter:	Not applicable (values are 'on' or 'off')
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Thermocouple Make/Model: Tempsens Instruments Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Continuous
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	-

Data / Parameter:	$FR_{e,inlet}$
Data unit:	m^3/yr
Description:	Flow rate of the biogas entering the heat generation equipment

Measured /Calculated /Default:	Measured
Source of data:	Measured by a vortex flowmeter
Value(s) of monitored parameter:	8,449,575 m^3 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Vortex flowmeter Make/Model: Yokogawa / DY100 Accuracy class: IP 68 Serial no: S5F606169-624 Calibration frequency: Annual Date of initial calibration: 14/11/08 Date of 2^{nd} calibration: 06/11/09 Date of last calibration: 05/11/10 Validity: 1 year
Measuring/ Reading/ Recording frequency:	Hourly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Flowmeter is subjected to annual calibration by certified calibration company.

Data / Parameter:	$FR_{e,s}$
Data unit:	m^3/yr
Description:	Flow rate of the heat generation equipment stack gases
Measured /Calculated /Default:	Measured
Source of data:	Measured by a vortex flowmeter
Value(s) of monitored parameter:	172,185,350 m^3 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For baseline emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Infrared Correlation Make/Model: Codel / VCEM 5000 series Accuracy class: IP 66 Serial no: VCEM5000-0059TRX1 / VCEM5000-0059TRX2 Calibration frequency: Once in 2 years Date of initial calibration: 30/09/08 Date of last calibration: 21/09/10 Validity: 2 years
Measuring/ Reading/ Recording frequency:	Hourly
Calculation method (if applicable):	Not applicable

QA/QC procedures applied:	Flowmeter is subjected to calibration once in two years by certified calibration company.

Data / Parameter:	$P_{CH4,e,s}$
Data unit:	%
Description:	Methane content in stack gas of heat generation equipment
Measured /Calculated /Default:	Measured
Source of data:	Measurements are conducted by external accredited laboratory, on a quarterly basis
Value(s) of monitored parameter:	0.01% (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Not applicable (measurements conducted by external laboratory) Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Quarterly analysis
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	External sampling and analysis is conducted by 3rd party laboratory certified with ISO 17025 and SAMM. No methane is detected in the stack gas from boiler for the monitoring period. Applied value is the detection limit of the analysis unit.

Data / Parameter:	$T_{comb,e}$
Data unit:	Fraction/ratio
Description:	Fraction of time gas is combusted in the heat generation equipment
Measured /Calculated /Default:	Calculated
Source of data:	Data calculated based on biogas flowrate and boiler running hours
Value(s) of monitored parameter:	1 (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable (as a cross checking tool against biogas combustion rate in the boiler)
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last	Type: Not applicable (calculated value) Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable

calibration, validity)	Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	-

Data / Parameter:	S_o
Data unit:	Kg/yr
Description:	Amount of sludge applied to land
Measured /Calculated /Default:	Measured
Source of data:	Analysis are conducted by external accredited laboratory, on a monthly basis
Value(s) of monitored parameter:	187,228 kg (01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project emission calculation
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Not applicable (analysis conducted by external laboratory) Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	Sludge concentration results from the lab are multiplied with flow of effluent to land application.
QA/QC procedures applied:	External sampling and analysis is conducted by 3rd party laboratory certified with ISO 17025 and SAMM.

Data / Parameter:	NC
Data unit:	Kg N / kg sludge
Description:	Nitrogen content in the sludge used for land application, for estimating N_2O emission in project emission.
Measured /Calculated /Default:	Measured
Source of data:	Analysis are conducted by external accredited laboratory, on a monthly basis
Value(s) of monitored parameter:	0.0023 kgN/kg sludge (average of 01/05/09 – 28/02/11)
Indicate what the data are used for (Baseline/ Project/ Leakage emission	For project emission calculation

calculations)	
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Not applicable (analysis conducted by external laboratory) Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	External sampling and analysis is conducted by 3rd party laboratory certified with ISO 17025 and SAMM.

Data / Parameter:	Regulations and incentives relevant to effluent
Data unit:	-
Description:	-
Measured /Calculated /Default:	Measured
Source of data:	Malaysian Government publications
Value(s) of monitored parameter:	Not applicable (parameter monitored at renewal of crediting period)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	For project baseline
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable
Measuring/ Reading/ Recording frequency:	At renewal of crediting period
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Quality control for the existence and enforcement of relevant regulations and incentives is beyond bounds of the project activity. Instead, the DOE will verify the evidence collected.

Data / Parameter:	Physical leakage of digester tanks
Data unit:	Yes/no
Description:	Detection of physical leakage of digester tanks.
Measured /Calculated /Default:	Measured (manual soap test and handheld gas detector for leakage checks)
Source of data:	Leakage test reports
Value(s) of monitored parameter:	Not applicable (measurements are only to determine whether leakage is evident or not)
Indicate what the data are	For project emission calculations

used for (Baseline/ Project/ Leakage emission calculations)	
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: Not applicable Make/Model: Not applicable Accuracy class: Not applicable Serial no: Not applicable Calibration frequency: Not applicable Date of last calibration: Not applicable Validity: Not applicable
Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Data uncertainty level will be low. The monitoring work will be verified by supervisors-in-charge.

SECTION E. Emission reductions calculation

Raw data for baseline and project emission calculations

Input data for baseline and project emission calculations – 'Data Input' sheet of UP Biogas CER Calculation file

Month	Data #5	Data #4(#2)	Data #15	Data #11(#3)	Data #1	Data #28	Data #18	Data #19
	T_{lag} Ambient Temperature	**$COD_{a,in}$** COD into lagoon	**$COD_{c,la}$** COD for land app.	**COD_{c,dig_out}** COD out of digester	**F_{dig}** Feed to AD tanks	**$FR_{e,inlet}$** Biogas consumed in boiler	**FR_{bio}** Amount of Biogas out of digester	**$P_{CH4,bio}$** % of Methane in biogas consumed
	^{O}C	**kg/m^3**	**kg/m^3**	**kg/m^3**	**m^3**	**Nm^3**	**Nm^3**	**%**
May 2009	28.0	94.536	2.670	17.260	10,485	410,033	377,477	55.35
Jun 2009	28.3	97.755	3.312	17.491	7,265	212,960	204,101	57.79
Jul 2009	27.4	98.388	3.840	20.150	9,106	354,208	329,186	61.90
Aug 2009	27.2	102.948	3.770	20.471	8,196	371,239	341,125	57.91
Sep 2009	27.3	116.693	3.310	22.803	8,530	388,408	361,331	57.91
Oct 2009	27.2	113.222	3.670	20.784	6,855	444,387	388,900	57.06
Nov 2009	26.8	99.655	2.940	19.285	10,569	447,101	418,347	58.44
Dec 2009	27.0	100.375	3.100	18.243	11,132	460,547	425,956	59.08
Jan 2010	23.6	102.886	3.670	18.310	10,177	428,621	402,686	61.54
Feb 2010	24.5	105.578	3.840	20.245	6,912	306,485	287,830	58.62
Mar 2010	24.5	96.085	3.390	20.863	7,006	300,925	278,447	58.19
Apr 2010	25.0	95.221	3.630	18.808	8,356	389,460	366,132	59.07
May 2010	25.1	76.998	3.540	15.781	8,043	316,736	299,215	57.03
Jun 2010	24.3	86.873	3.890	18.233	10,092	395,823	368,500	59.40
Jul 2010	24.2	80.600	3.320	17.095	10,152	386,049	362,341	59.81
Aug 2010	24.2	85.232	3.216	17.668	10,060	388,043	363,721	57.86
Sep 2010	24.2	86.708	5.120	19.690	11,662	469,722	430,769	59.47

Oct 2010	24.2	91.906	4.010	18.491	11,065	488,082	447,338	58.49
Nov 2010	24.2	92.275	5.120	17.980	10,042	414,481	384,071	58.84
Dec 2010	24.2	96.892	4.101	17.173	10,346	443,251	412,498	59.52
Jan 2011	28.0	92.887	2.055	16.952	8,553	320,613	319,475	58.97
Feb 2011	28.0	103.308	4.150	15.319	7,475	312,401	301,724	58.43

Month	Data #14	Data #20	For Data #22		For Data #12	Data #12	For Data #32
	F_{la} Vol. Effluent for land application	$FR_{f,inlet}$ Biogas flared	% of Methane in biogas flared	No. of operational days in month	Power supply from biomass boiler	$EL_{Pr,y}$ Power consumed a biogas plant	Concentration of sludge solid applied to land
	m^3	**Nm^3**	**%**	**days**	**hrs/month**	**kWh/month**	**kg/m^3**
May 2009	2,550	0	0.00	31	490	14,736	1.42
Jun 2009	4,085	29,360	60.61	30	462	15,896	0.58
Jul 2009	5,288	0	0.00	31	330	16,464	0.83
Aug 2009	4,557	0	0.00	31	543	16,132	1.64
Sep 2009	4,447	0	0.00	30	576	16,008	0.96
Oct 2009	5,408	0	0.00	31	585	16,912	1.53
Nov 2009	7,642	0	0.00	30	504	16,608	1.01
Dec 2009	6,565	0	0.00	31	450	17,324	0.87
Jan 2010	7,533	0	0.00	31	166	16,564	0.71
Feb 2010	7,855	0	0.00	28	122	11,336	1.64
Mar 2010	5,386	0	0.00	31	293	11,084	1.09
Apr 2010	5,827	0	0.00	30	272	15,996	0.78
May 2010	8,685	0	0.00	31	274	15,184	0.91
Jun 2010	8,428	0	0.00	30	377	16,272	0.56
Jul 2010	7,995	0	0.00	31	471	15,464	1.25
Aug 2010	5,406	0	0.00	31	424	15,200	2.63

Sep 2010	4,476	0	0.00	30	422	15,976	2.16
Oct 2010	7,218	0	0.00	31	378	15,724	2.05
Nov 2010	6,715	0	0.00	30	331	15,016	2.16
Dec 2010	8,029	0	0.00	31	283	14,856	1.49
Jan 2011	8,649	0	0.00	31	121	14,752	1.79
Feb 2011	6,834	0	0.00	28	149	13,764	1.70

Month	**Data #33**	**Data #22**	**Data #29**	**Data #30**	**For Data #9**	**For Data #9**
	NC Nitrogen content in sludge	**$^*PE_{flare}$** Project emission ffrom flaring	**$FR_{e,s}$** Flow rate of boiler stack gas	**$P_{CH4,e,s}$** CH_4 content in stack gas (quarterly)	Steam output	Steam enthalpy
	kg N/kg sludge	**t CO_{2eq}/month**	**Nm^3/month**	**%**	**t/month**	**kJ/kg**
May 2009	0.0023	0.00	9,319,430	0.0100	2,941	2778.9
Jun 2009	0.0023	440.06	5,168,498	0.0100	1,579	2778.9
Jul 2009	0.0023	0.00	7,754,021	0.0100	2,534	2779.3
Aug 2009	0.0023	0.00	7,098,957	0.0100	2,652	2782.1
Sep 2009	0.0026	0.00	6,704,344	0.0100	2,747	2781.4
Oct 2009	0.0023	0.00	10,415,729	0.0100	2,968	2782.7
Nov 2009	0.0022	0.00	9,463,404	0.0100	3,296	2782.1
Dec 2009	0.0021	0.00	10,348,989	0.0100	3,378	2782.1
Jan 2010	0.0023	0.00	9,836,401	0.0100	3,105	2778.5
Feb 2010	0.0022	0.00	9,311,065	0.0100	2,187	2781.0
Mar 2010	0.0025	0.00	7,899,015	0.0100	2,187	2781.0
Apr 2010	0.0029	0.00	11,243,545	0.0100	2,846	2780.0
May 2010	0.0025	0.00	9,645,440	0.0100	2,213	2780.0
Jun 2010	0.0023	0.00	9,587,093	0.0100	2,695	2780.0

Jul 2010	0.0022	0.00	9,537,232	0.0100	2,652	2779.2
Aug 2010	0.0020	0.00	9,582,465	0.0100	2,825	2779.2
Sep 2010	0.0021	0.00	9,919,155	0.0100	3,261	2781.7
Oct 2010	0.0021	0.00	3,665,900	0.0100	3,342	2779.6
Nov 2010	0.0021	0.00	3,753,788	0.0100	2,958	2779.2
Dec 2010	0.0020	0.00	4,630,778	0.0100	3,208	2779.2
Jan 2011	0.0021	0.00	2,928,424	0.0100	2,454	2721.0
Feb 2011	0.0021	0.00	4,371,677	0.0100	2,260	2719.0

Ambient temperature record, $f_{t,monthly}$ & $MCF_{baseline,m}$ calculations – 'Temp, ft, MCF' sheet of UP Biogas CER Calculation file

Month	**Data #5**		
	T_{lag} Ambient temperature	**$f_{t,monthly}$**	**$MCF_{baseline,m}$**
	^{o}C		
May 2009	28.0	0.8455	0.3762
Jun 2009	28.3	0.8668	0.3857
Jul 2009	27.4	0.8057	0.3585
Aug 2009	27.2	0.7907	0.3519
Sep 2009	27.3	0.7985	0.3554
Oct 2009	27.2	0.7896	0.3514
Nov 2009	26.8	0.7615	0.3389
Dec 2009	27.0	0.7768	0.3457
Jan 2010	23.6	0.5815	0.2588
Feb 2010	24.5	0.6290	0.2799
Mar 2010	24.5	0.6301	0.2804
Apr 2010	25.0	0.6536	0.2908
May 2010	25.1	0.6631	0.2951
Jun 2010	24.3	0.6173	0.2747
Jul 2010	24.2	0.6114	0.2721
Aug 2010	24.2	0.6120	0.2723
Sep 2010	24.2	0.6118	0.2722
Oct 2010	24.2	0.6118	0.2722
Nov 2010	24.2	0.6118	0.2722
Dec 2010	24.2	0.6118	0.2722
Jan 2011	28.0	0.8459	0.3764
Feb 2011	28.0	0.8459	0.3764

COD inflow and outflow calculations – 'COD in out' sheet of UP Biogas CER Calculation file

Month	**Data #4 (#2)**	**Data #15**	**Data #11 (#3)**	**Data #1**	**Derived**		
					Total COD Inflow & Outflow, month		
	$COD_{a,in}$	**$COD_{c,la}$**	**COD_{c,dig_out}**	**F_{dig}**	**$COD_{baseline}$**	**COD_{dig_out}**	**$COD_{out,land}$**
	kg/m^3	**kg/m^3**	**kg/m^3**	**m^3**	**kg/m**	**kg/m**	**kg/m**
May 2009	94.536	2.670	17.260	10,485	963,217	152,975	27,995
Jun 2009	97.755	3.312	17.491	7,265	686,128	103,014	24,062
Jul 2009	98.388	3.840	20.150	9,106	860,951	148,522	34,967
Aug 2009	102.948	3.770	20.471	8,196	812,862	136,880	30,899
Sep 2009	116.693	3.310	22.803	8,530	967,160	166,275	28,234
Oct 2009	113.222	3.670	20.784	6,855	750,980	117,319	25,158
Nov 2009	99.655	2.940	19.285	10,569	1,022,177	172,745	31,073
Dec 2009	100.375	3.100	18.243	11,132	1,082,865	168,569	34,509
Jan 2010	102.886	3.670	18.310	10,177	1,009,723	148,995	37,350
Feb 2010	105.578	3.840	20.245	6,912	703,214	113,389	26,542
Mar 2010	96.085	3.390	20.863	7,006	649,418	122,414	23,750
Apr 2010	95.221	3.630	18.808	8,356	765,332	126,829	30,332
May 2010	76.998	3.540	15.781	8,043	590,825	98,457	28,472
Jun 2010	86.873	3.890	18.233	10,092	837,461	144,752	39,258
Jul 2010	80.600	3.320	17.095	10,152	784,547	139,843	33,705
Aug 2010	85.232	3.216	17.668	10,060	825,082	145,383	32,353
Sep 2010	86.708	5.120	19.690	11,662	951,483	169,913	59,709
Oct 2010	91.906	4.010	18.491	11,065	972,574	160,229	44,371
Nov 2010	92.275	5.120	17.980	10,042	875,211	129,138	51,415
Dec 2010	96.892	4.101	17.173	10,346	960,019	135,241	42,429
Jan 2011	92.887	2.055	16.952	8,553	776,889	127,411	17,576
Feb 2011	103.308	4.150	15.319	7,475	741,206	83,491	31,021

E.1. Baseline emissions calculation

The calculations of the lagoon baseline emissions and electricity (or thermal energy) baseline emissions are shown as follows.

Based on AM0013 ver.04

Baseline Emissions - Lagoon

$$\underset{(kg/yr)}{CH_4\ emissions} = \underset{(kg\ COD/month)}{Total\ COD_{available,m}} \times \underset{(kg\ CH_4/kg\ COD)}{B_o} \times MCF_{baseline}$$

Where:

$COD_{available,m}$ = Is the monthly Chemical Oxygen Demand available for conversion which is equal to the monthly COD entering the digester or directed to land application $COD_{baseline,m}$ plus COD carried on from the previous month.
$COD_{baseline,m}$ = Is the monthly Chemical Oxygen Demand of effluent entering lagoons or directed to land application (measured).
B_o = Is the maximum methane producing capacity. The default IPCC value is 0.25 kg
CH_4/kg COD = Taking into account the uncertainty of the estimate, a value of 0.21 kg CH_4/kg COD should be used as a conservative estimate.
$MCF_{baseline}$ = is the monthly methane conversion factor (fraction)

$$AD = 1 - \left[\frac{COD_{a,out}}{COD_{a,in}} \right]$$

Where:

$COD_{a,out}$ = is the COD that leaves the lagoon with the effluent
$COD_{a,in}$ = is the COD that enters the lagoon

$$MCF_{baseline,m} = f_d * f_{t,monthly} * 0.89$$

Where:

f_d = is the fraction of anaerobic degradation due to depth as per table 1
f_t = is the fraction of anaerobic degradation due to temperature
0.89 = is an uncertainty conservativeness factor (for an uncertainty range of 30% to 50%) to account for the fact that the equation used to estimate f_t,monthly assumes full anaerobic degradation at 30^{O}C.

$f_{t,monthly}$ is calculated as follows:

$$f_{t,monthly} = \exp\left[\frac{E * (T_2 - T_1)}{R * T_1 * T_2}\right]$$

Where:
$f_{t,monthly}$ = anaerobic degradation factor due to temperature.
E = Activation energy constant (15,175 cal/mol).
T_2 = Ambient temperature (Kelvin) for the climate.
T_1 = 301.16 (273.16° + 30°).
R = Ideal gas constant (1.987 cal/Kmol).

(Sheet '4 Baseline Emission Lagoon' of UP Biogas CER Calculation file)

Month	Derived							
	$COD_{baseline,m}$	$COD_{carry\ on,m}$	$COD_{available,m}$	$COD_{removed\ sludge}$	$f_{t,monthly}$	$MCF_{baseline,m}$	$CH_{4,emis,m}$	tCO_{2eq}
	kg/m	kg/m	kg/m	kg/m			kg/m	t/m
May 2009	963,217	1,468,521	2,431,738	0	0.8455	0.3762	192,134	4,034.81
Jun 2009	686,128	1,465,717	2,151,845	0	0.8668	0.3857	174,312	3,660.56
Jul 2009	860,951	1,356,245	2,217,196	0	0.8057	0.3585	166,944	3,505.82
Aug 2009	812,862	1,402,087	2,214,949	0	0.7907	0.3519	163,664	3,436.94
Sep 2009	967,160	1,396,966	2,364,126	0	0.7985	0.3554	176,420	3,704.81
Oct 2009	750,980	1,505,186	2,256,166	0	0.7896	0.3514	166,482	3,496.12
Nov 2009	1,022,177	1,466,437	2,488,614	0	0.7615	0.3389	177,102	3,719.14
Dec 2009	1,082,865	1,518,696	2,601,561	0	0.7768	0.3457	188,846	3,965.78
Jan 2010	1,009,723	1,893,872	2,903,595	0	0.5815	0.2588	157,780	3,313.38
Feb 2010	703,214	2,053,522	2,756,736	0	0.6290	0.2799	162,040	3,402.83
Mar 2010	649,418	1,957,212	2,606,631	0	0.6301	0.2804	153,487	3,223.24
Apr 2010	765,332	1,824,781	2,590,113	0	0.6536	0.2908	158,192	3,322.03
May 2010	590,825	1,795,485	2,386,310	0	0.6631	0.2951	147,873	3,105.34
Jun 2010	837,461	1,702,350	2,539,811	0	0.6173	0.2747	146,507	3,076.65
Jul 2010	784,547	1,809,483	2,594,030	0	0.6114	0.2721	148,223	3,112.68
Aug 2010	825,082	1,853,912	2,678,994	0	0.6120	0.2723	153,206	3,217.32
Sep 2010	951,483	1,917,294	2,868,777	0	0.6118	0.2722	164,013	3,444.28
Oct 2010	972,574	2,028,052	3,000,626	0	0.6118	0.2722	171,551	3,602.58
Nov 2010	875,211	2,139,344	3,014,555	0	0.6118	0.2722	172,348	3,619.30
Dec 2010	960,019	2,028,052	2,988,071	0	0.6118	0.2722	170,833	3,587.50
Jan 2011	776,889	1,820,793	2,597,682	0	0.8459	0.3764	205,357	4,312.49
Feb 2011	741,206	1,602,217	2,343,424	0	0.8459	0.3764	185,256	3,890.39

Baseline Emissions – Electricity (Heat) (Only the thermal energy section of this formula is applicable to the calculations)

Based on AM0013 ver.04

$$BE_{elec/heat} = EG_y * CEF_{Bl,elec,,y} + EG_{d,y} * CEF_{grid} + HG_{Bl,y} * CEF_{Bl,therm,y}$$

Where:

EG_y = Is the amount of electricity in the year y that would be consumed at the project site in the absence of the project activity (MWh).

$CEF_{Bl,elec,y}$ = Is the CO_2 emission factor for electricity consumed at the project site in the absence of the project activity (tCO_{2eq}/MWh)

$EG_{d,y}$ = Is the amount of electricity generated utilizing the biogas collected during project activity and exported to the grid during the year y (MWh)

CEF_{grid} = Is the CO_2 emission factor for the grid where electricity is exported tCO_{2eq}/MWh)

$HG_{Bl,y}$ = Is the quantity of thermal energy that would be consumed in year y at the project site in the absence of the project activity (MJ) using fossil fuel.

$CEF_{Bl,therm,y}$ = Is the CO_2 emissions intensity for thermal energy generation (tCO_{2eq}/MJ)

(Sheet '5 Baseline Boiler Emission' of UP Biogas CER Calculation file)

Month	For Data #9	Derived	Data #9 (Derived)	Derived
	Steam generated in boiler	Steam Enthalpy	$HG_{Bl,y}$	BE_{heat}
	t/month	kJ/kg	TJ/yr	tCO_{2eq}/month
May 2009	2,941	2778.90	8.17	744.13
Jun 2009	1,579	2778.90	4.39	399.65
Jul 2009	2,534	2779.30	7.04	641.36
Aug 2009	2,652	2782.10	7.38	671.76
Sep 2009	2,747	2781.40	7.64	695.72
Oct 2009	2,968	2782.70	8.26	752.06
Nov 2009	3,296	2782.10	9.17	834.99
Dec 2009	3,378	2782.10	9.40	855.64
Jan 2010	3,105	2778.50	8.63	785.49
Feb 2010	2,187	2781.00	6.08	553.76
Mar 2010	2,187	2781.00	6.08	553.84
Apr 2010	2,846	2780.00	7.91	720.35
May 2010	2,213	2780.00	6.15	560.25
Jun 2010	2,695	2780.00	7.49	682.10
Jul 2010	2,652	2779.20	7.37	671.17
Aug 2010	2,825	2779.20	7.85	714.84
Sep 2010	3,261	2781.70	9.07	826.07
Oct 2010	3,342	2779.60	9.29	845.81
Nov 2010	2,958	2779.20	8.22	748.47
Dec 2010	3,208	2779.20	8.92	811.90
Jan 2011	2,454	2778.50	6.82	620.99
Feb 2011	2,260	2719.00	6.14	559.51

E.2. Project emissions calculation

The project emissions for the project are from the sources below;

a) *Lagoon*
b) *Tank leakage*
c) *Flare & Boiler*
d) *Electricity consumption*
e) *Sludge for land application*

Project Emissions - Lagoon

Based on AM0013 ver.04

$$\underset{\text{(kg/yr)}}{\text{CH}_4\text{ emissions from the lagoons}} = \underset{\text{(kg COD/yr)}}{COD_{dig\_out}} \times \underset{\text{(kg CH}_4\text{/kg COD)}}{B_o} \times MCF_{dig\_out}$$

Where:
COD_{dig_out} = Is Chemical Oxygen Demand of effluent entering lagoons (measured)
B_o = Is maximum methane producing capacity as in the baseline
MCF_{dig_out} = Is methane conversion factor (fraction) estimated as described in the baseline section above

(Sheet '6 Project Emissions Lagoon' of UP Biogas CER Calculation file)

Month	Data #14	Data #11	Data #15	Derived		
	F_{la}	COD_{c,dig_out}	$COD_{c,la}$	$COD_{dig\ out}$	CH_4 emission	CH_4 emission from lagoon
	m^3/month	kg/m^3	kg/m^3	kg/month	kg/month	tCO_{2eq}/month
May 2009	2,550	17.260	2.670	37,206	2,940	62
Jun 2009	4,085	17.491	3.312	57,923	4,692	99
Jul 2009	5,288	20.150	3.840	86,243	6,494	136
Aug 2009	4,557	20.471	3.770	76,104	5,623	118
Sep 2009	4,447	22.803	3.310	86,685	6,469	136
Oct 2009	5,408	20.784	3.670	92,561	6,830	143
Nov 2009	7,642	19.285	2.940	124,908	8,889	187
Dec 2009	6,565	18.243	3.100	99,409	7,216	152
Jan 2010	7,533	18.310	3.670	110,279	5,992	126
Feb 2010	7,855	20.245	3.840	128,859	7,574	159
Mar 2010	5,386	20.863	3.390	94,112	5,542	116
Apr 2010	5,827	18.808	3.630	88,440	5,402	113
May 2010	8,685	15.781	3.540	106,318	6,588	138
Jun 2010	8,428	18.233	3.890	120,889	6,973	146
Jul 2010	7,995	17.095	3.320	110,127	6,293	132
Aug 2010	5,406	17.668	3.216	78,125	4,468	94
Sep 2010	4,476	19.690	5.120	65,217	3,729	78
Oct 2010	7,218	18.491	4.010	104,523	5,976	125
Nov 2010	6,715	17.980	5.120	86,356	4,937	104
Dec 2010	8,029	17.173	4.101	104,957	6,001	126
Jan 2011	8,649	16.952	2.055	128,834	10,185	213.88
Feb 2011	6,834	15.319	4.150	76,333	6,034	126.72

Project Emissions – Tank Leakage

Based on AM0013 ver.04

$PE_{CH4\_leak} = Q_{CH4}$ x 1% x GWP

Where:
Q_{CH4} = Is quantity of methane generated in the digesters for the month
GWP = Global warming potential of methane (21)

$Q_{CH4} = COD_t$ x EF

Where:
COD_t = Is quantity of COD generated in the digesters for the month
EF = Emission factor of methane

$EF = B_o$ x MCF

Where:
Bo = Maximum methane production potential
MCF = Methane correction factor (0.85; based on published data for anaerobic digesters, pg 34 of PDD)

Sheet '7Project Emission Tank Leakage' of UP Biogas CER Calculation file

Month	**Derived**		
	COD_t	**Q_{CH4}**	**PE_{CH4_leak}**
	kg/month	**t CH_4/month**	**t CO_{2eq}/month**
May 2009	991,212	211	44.23
Jun 2009	710,190	151	31.69
Jul 2009	895,918	190	39.98
Aug 2009	843,761	179	37.65
Sep 2009	995,394	212	44.42
Oct 2009	776,138	165	34.64
Nov 2009	1,053,250	224	47.00
Dec 2009	1,117,375	237	49.86
Jan 2010	1,047,072	223	46.73
Feb 2010	729,756	155	32.57
Mar 2010	673,169	143	30.04
Apr 2010	795,665	169	35.51
May 2010	619,298	132	27.64
Jun 2010	876,719	186	39.12
Jul 2010	818,251	174	36.51
Aug 2010	857,435	182	38.26
Sep 2010	1,011,193	215	45.12
Oct 2010	1,016,945	216	45.38
Nov 2010	926,626	197	41.35
Dec 2010	1,002,448	213	44.73
Jan 2011	794,466	169	35.45
Feb 2011	772,227	164	34.46

Project Emissions – Flare & Boiler

Based on ''Tool to determine project emissions from flaring gases containing methane'' ver. 01

STEP 1: Determination of mass flow rate of the residual gas that is flared

$$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h}$$

Where:

Variable	SI Unit	Description
$FM_{RG,h}$	kg/h	Mass flow rate of the residual gas in hour h
$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour h
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n}$$

Where:

Variable	SI Unit	Description
$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour h
P_n	Pa	Atmospheric pressure at normal conditions (101325)
R_u	$Pa.m^3/kmol.K$	Universal ideal gas constant (8 314)
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
T_n	K	Temperature at normal conditions (273.15)

$$MM_{RG,h} = \sum_i (fv_{i,h} * MM_i)$$

Where:

Variable	SI Unit	Description
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
$fv_{i,h}$	-	Volumetric fraction of component i in the residual gas in the hour h
MM_i	kg/kmol	Molecular mass of residual gas component i
i		The components CH_4, CO, CO_2, O_2, H_2, N_2

STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

(As a simplified approach, project participant only measures volumetric fraction of methane and considers the difference to 100% as being carbon dioxide)

$$fm_{j,h} = \frac{\sum_i fv_{i,h} \cdot AM_j \cdot NA_{j,i}}{MM_{RG,h}}$$

Where:

Variable	SI Unit	Description
$fm_{j,h}$	-	Mass fraction of element j in the residual gas in hour h
$fv_{i,h}$	-	Volumetric fraction of component i in the residual gas in the hour h
AM_j	kg/kmol	Atomic mass of element j
$NA_{j,i}$	-	Number of atoms of element j in component i
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
j		The elements carbon, hydrogen, oxygen and nitrogen
i		The components CH_4, CO, CO_2, O_2, H_2, N_2

Step 3 and 4 is not applicable as methane combustion efficiency is not continuously monitored but fixed at 50% (if temperature is above 500^0C for more than 20minutes for the hour *h*).

STEP 5: Determination of methane mass flow rate in the residual gas on a dry basis

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

Where:

Variable	SI Unit	Description
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour h
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour h (NB: this corresponds to $fv_{i,RG,h}$ where i refers to methane).
$\rho_{CH4,n}$	kg/m^3	Density of methane at normal conditions (0.716)

Step 6 is not applicable as methane flaring efficiency, $\eta_{flare,h}$ is fixed at 50% for open flare (if temperature is above 500^0C for more than 20minutes for the hour *h*).

STEP 7: Calculation of annual project emissions from flaring

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

Where:

Variable	SI Unit	Description
$PE_{flare,y}$	tCO_{2eq}	Project emissions from flaring of the residual gas stream in year y
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour h
$\eta_{flare,h}$	-	Flare efficiency in hour h
GWP_{CH4}	tCO_{2eq}/tCH_4	Global Warming Potential of methane valid for the commitment period

Sheet '8Project Emission Flare & Boiler' of UP Biogas CER Calculation file

Month	Data #29	For Data #9	Data #30			Data #22	
	$FR_{e,s}$	Steam generated in boiler	$P_{CH4,e,s}$	CH_4 emission in boiler stack	Emission due to combustion of CH_4		Total CH_4 emission
					Boiler	$PE_{flare,y}$	
	Nm^3	t	%	kg/month	tCO_{2eq}/m	tCO_{2eq}/m	tCO_{2eq}/m
May 2009	9,319,430	2941	0.01	664.48	13.954	0.00	13.95
Jun 2009	5,168,498	1579	0.01	368.51	7.739	440.06	447.80
Jul 2009	7,754,021	2534	0.01	552.86	11.610	0.00	11.61
Aug 2009	7,098,957	2652	0.01	506.16	10.629	0.00	10.63
Sep 2009	6,704,344	2747	0.01	478.02	10.038	0.00	10.04
Oct 2009	10,415,729	2968	0.01	742.64	15.595	0.00	15.60
Nov 2009	9,463,404	3296	0.01	674.74	14.170	0.00	14.17
Dec 2009	10,348,989	3378	0.01	737.88	15.496	0.00	15.50
Jan 2010	9,836,401	3105	0.01	701.34	14.728	0.00	14.73
Feb 2010	9,311,065	2187	0.01	663.88	13.941	0.00	13.94
Mar 2010	7,899,015	2187	0.01	563.20	11.827	0.00	11.83
Apr 2010	11,243,545	2846	0.01	801.66	16.835	0.00	16.83
May 2010	9,645,440	2213	0.01	687.72	14.442	0.00	14.44
Jun 2010	9,587,093	2695	0.01	683.56	14.355	0.00	14.35
Jul 2010	9,537,232	2652	0.01	680.00	14.280	0.00	14.28
Aug 2010	9,582,465	2825	0.01	683.23	14.348	0.00	14.35
Sep 2010	9,919,155	3261	0.01	707.24	14.852	0.00	14.85
Oct 2010	3,665,900	3342	0.01	261.38	5.489	0.00	5.49
Nov 2010	3,753,788	2958	0.01	267.65	5.621	0.00	5.62
Dec 2010	4,630,778	3208	0.01	330.17	6.934	0.00	6.93
Jan 2011	2,928,424	2454	0.01	208.80	4.385	0.00	4.38
Feb 2011	4,371,677	2260	0.01	311.70	6.546	0.00	6.55

Project Emissions – Electricity Consumption

Based on AM0013 ver.04

$$PE_{elec/heat} = EL_{y} * CEF_{d} + HG_{Pr,y} * CEF_{Pr,therm,y}$$

$EL_{P,y}$ = Is the amount of electricity in the year y that is consumed at the project site for the project activity (MWh).
CEF_{d} = Is the CO_2 emissions factor for electricity consumed at the project site during the project activity (tCO_{2eq}/MWh), estimated as described below. Factor is zero if biogas is used to produce electricity.
$HG_{Pr,y}$ =Is the quantity of thermal energy consumed in year y at the project site due to the project activity (MJ).
$CEF_{Pr,therm,y}$ = Is the CO_2 emissions intensity for thermal energy generation (tCO_{2eq}/MJ), estimated as per method described for baseline thermal energy use. Factor is zero if biogas is used for generating thermal energy.

Sheet '9Project Emission Electricity Consumption' of UP Biogas CER Calculation file

Month		Data #9a and 9b		Derived	Data #12	Derived	
	No. of days in a particular month	h_{Boiler} $H_{refinery}$	Power supply		$EL_{Pr,y}$	Power consumed from grid for project activity	Emissions from electricity consumption from grid
			Biomass boiler	Grid			
	days	hrs	hrs	hrs	kWh/month	MWh/month	tCO_{2eq}/month
May 2009	31	744	490	254	14,736	5.040	3.18
Jun 2009	30	720	462	258	15,896	5.696	3.59
Jul 2009	31	744	330	414	16,464	9.170	5.78
Aug 2009	31	744	543	201	16,132	4.358	2.75
Sep 2009	30	720	576	144	16,008	3.193	2.01
Oct 2009	31	744	585	159	16,912	3.624	2.28
Nov 2009	30	720	504	216	16,608	4.978	3.14
Dec 2009	31	744	450	294	17,324	6.836	4.31
Jan 2010	31	744	166	578	16,564	12.875	8.11
Feb 2010	28	672	122	550	11,336	9.278	5.85
Mar 2010	31	744	293	451	11,084	6.717	4.23
Apr 2010	30	720	272	448	15,996	9.948	6.27
May 2010	31	744	274	470	15,184	9.591	6.04
Jun 2010	30	720	377	343	16,272	7.751	4.88
Jul 2010	31	744	471	273	15,464	5.679	3.58
Aug 2010	31	744	424	320	15,200	6.542	4.12
Sep 2010	30	720	422	298	15,976	6.612	4.17
Oct 2010	31	744	378	366	15,724	7.729	4.87
Nov 2010	30	720	331	389	15,016	8.120	5.12
Dec 2010	31	744	283	461	14,856	9.198	5.79
Jan 2011	31	744	121	623	14,752	12.346	7.78
Feb 2011	28	672	149	523	13,764	10.718	6.75

Project Emissions – Land application of sludge; **Sheet '10 Project Emission Land Application Sludge'** ***of UP Biogas CER Calculation file***

Based on AM0013 ver.04

Month	**Data #14**	**Data #15**	**Derived**		
	F_{la}	**$COD_{c,la}$**	**Total COD applied to land**	**CH_4 emission from land application**	**Emission from land application**
	m^3	**kg/m^3**	**kg/month**	**kg/month**	**tCO_{2eq}/month**
May 2009	2,550	2.670	6,809	71	1.50
Jun 2009	4,085	3.312	13,530	142	2.98
Jul 2009	5,288	3.840	20,304	213	4.48
Aug 2009	4,557	3.770	17,180	180	3.79
Sep 2009	4,447	3.310	14,720	155	3.25
Oct 2009	5,408	3.670	19,849	208	4.38
Nov 2009	7,642	2.940	22,468	236	4.95
Dec 2009	6,565	3.100	20,351	214	4.49
Jan 2010	7,533	3.670	27,644	290	6.10
Feb 2010	7,855	3.840	30,163	317	6.65
Mar 2010	5,386	3.390	18,259	192	4.03
Apr 2010	5,827	3.630	21,151	222	4.66
May 2010	8,685	3.540	30,746	323	6.78
Jun 2010	8,428	3.890	32,786	344	7.23
Jul 2010	7,995	3.320	26,543	279	5.85
Aug 2010	5,406	3.216	17,386	183	3.83
Sep 2010	4,476	5.120	22,918	241	5.05
Oct 2010	7,218	4.010	28,945	304	6.38
Nov 2010	6,715	5.120	34,382	361	7.58
Dec 2010	8,029	4.101	32,928	346	7.26
Jan 2011	8,649	2.055	17,773	187	3.92
Feb 2011	6,834	4.150	28,362	298	6.25

Project Emissions – Land application of sludge (cont.)

Based on AM0013 ver.04

Month	For Data #32	Data #32	Data #33	Derived		Derived
	Concentration of sludge solid applied to land	S_O	NC	N_2O emission	N_2O emission	Total emission from land application and sludge
	kg/m3	kg sludge	kg N/kg sludge	kg/month	tCO_{2eq}/month	tCO_{2eq}/month
May 2009	1.415	3608.392	0.00231	0.13	0.04	1.54
Jun 2009	0.580	2369.300	0.00232	0.09	0.03	3.01
Jul 2009	0.830	4388.708	0.00227	0.16	0.05	4.53
Aug 2009	1.640	7473.316	0.00234	0.28	0.09	3.87
Sep 2009	0.958	4260.226	0.00258	0.18	0.05	3.30
Oct 2009	1.525	8247.810	0.00232	0.31	0.09	4.47
Nov 2009	1.013	7741.549	0.00217	0.27	0.08	5.04
Dec 2009	0.873	5731.070	0.00208	0.19	0.06	4.55
Jan 2010	0.710	5348.075	0.00233	0.20	0.06	6.16
Feb 2010	1.635	12842.925	0.00221	0.45	0.14	6.79
Mar 2010	1.085	5844.027	0.00247	0.23	0.07	4.10
Apr 2010	0.780	4544.904	0.00288	0.21	0.06	4.73
May 2010	0.910	7903.532	0.00253	0.32	0.10	6.88
Jun 2010	0.557	4694.5631	0.00234	0.18	0.05	7.28
Jul 2010	1.245	9953.526	0.00218	0.35	0.11	5.96
Aug 2010	2.630	14217.78	0.00203	0.46	0.14	3.98
Sep 2010	2.160	9668.592	0.00207	0.32	0.10	5.15
Oct 2010	2.050	14797.105	0.00210	0.50	0.15	6.54
Nov 2010	2.160	14504.832	0.00207	0.48	0.15	7.73
Dec 2010	1.490	11963.508	0.00202	0.39	0.12	7.38
Jan 2011	1.793	15506.761	0.002	0.53	0.16	4.08
Feb 2011	1.700	11617.970	0.002	0.39	0.12	6.37

E.3. Leakage calculation

Not applicable. The technology and machinery for the project activity is not transferred from another activity and thus no leakage is considered to take place.

E.4. Emission reductions calculation / table

Emission reductions

Emission reductions are calculated as the difference between baseline and project emissions, taking into account any adjustments for leakage.

Baseline Emissions (tCO_{2eq})	=	Baseline emissions from lagoons (tCO_{2eq})	+	Baseline emission from portion of fossil fuel displaced by boiler in heat generating equipment (tCO_{2eq})

Project emissions (tCO_{2eq})	=	Project emissions from lagoon (tCO_{2eq})	+	Project emissions from tank leakage (tCO_{2eq})	+	Project emissions from flare & boiler (tCO_{2eq})	+	Project emission from electricity consumption (tCO_{2eq})	+	Project emissions from sludge for land application (tCO_{2eq})

Emission reductions (tCO_{2eq})	=	Baseline emissions (tCO_{2eq})	+	Project emissions (tCO_{2eq})

Sheet ‘11 Project ER’ of UP Biogas CER Calculation file

Month	Baseline Emissions (BE)			Project Emissions (PE)						ER
	BE from lagoon	BE from boiler	Total BE	PE from lagoon	PE AD tank leakage	PE Flare & boiler stack	PE Electricity consumption	PE Land application of sludge	Total PE	Emission Reductions
	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}	tCO_{2eq}
May 2009	4,034.81	744.13	3,675.05	61.73	44.23	13.95	3.18	1.54	124.64	3,550.41
Jun 2009	3,660.56	399.65	2,054.25	98.53	31.69	447.80	3.59	3.01	584.62	1,469.62
Jul 2009	3,505.82	641.36	3,499.79	136.37	39.98	11.61	5.78	4.53	198.26	3,301.53
Aug 2009	3,436.94	671.76	3,442.93	118.09	37.65	10.63	2.75	3.87	172.99	3,269.94
Sep 2009	3,704.81	695.72	3,631.03	135.84	44.42	10.04	2.01	3.30	195.61	3,435.42
Oct 2009	3,496.12	752.06	3,864.96	143.43	34.64	15.60	2.28	4.47	200.42	3,664.55
Nov 2009	3,719.14	834.99	4,264.59	186.67	47.00	14.17	3.14	5.04	256.01	4,008.57
Dec 2009	3,965.78	855.64	4,385.86	151.54	49.86	15.50	4.31	4.55	225.75	4,160.11
Jan 2010	3,313.38	785.49	4,098.88	125.84	46.73	14.73	8.11	6.16	201.56	3,897.31
Feb 2010	3,402.83	553.76	3,956.59	159.06	32.57	13.94	5.85	6.79	218.20	3,738.38
Mar 2010	3,223.24	553.84	3,777.08	116.37	30.04	11.83	4.23	4.10	166.57	3,610.51
Apr 2010	3,322.03	720.35	4,042.39	113.43	35.51	16.83	6.27	4.73	176.77	3,865.62
May 2010	3,105.34	560.25	3,665.59	138.35	27.64	14.44	6.04	6.88	193.35	3,472.24
Jun 2010	3,076.65	682.10	3,758.74	146.44	39.12	14.35	4.88	7.28	212.09	3,546.66
Jul 2010	3,112.68	671.17	3,783.85	132.15	36.51	14.28	3.58	5.96	192.48	3,591.37
Aug 2010	3,217.32	714.84	3,932.16	93.82	38.26	14.35	4.12	3.98	154.53	3,777.62
Sep 2010	3,444.28	826.07	4,270.35	78.30	45.12	14.85	4.17	5.15	147.60	4,122.75
Oct 2010	3,602.58	845.81	4,448.39	125.49	45.38	5.49	4.87	6.54	187.77	4,260.62
Nov 2010	3,619.30	748.47	4,367.77	103.68	41.35	5.62	5.12	7.73	163.50	4,204.28
Dec 2010	3,587.50	811.90	4,399.41	126.01	44.73	6.93	5.79	7.38	190.85	4,208.55
Jan 2011	4,312.49	620.99	4,933.48	213.88	35.45	4.38	7.78	4.08	265.58	4,667.90
Feb 2011	3,890.39	559.51	4,449.90	126.72	34.46	6.55	6.75	6.37	180.85	4,269.04
Total	[redacted]	[redacted]	**86,703**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**4610**	**82,093**

E.5. Comparison of actual emission reductions with estimates in the CDM-PDD

The total emission reduction of the monitoring period is 82,093 tCO_{2eq}; the baseline emission is 86,703 tCO_{2eq} and the project emission is 4610 tCO_{2eq}.The emission reductions estimated for same period in the PDD was 63,177 $tCO_{2eq.}$ A comparison of the differences between the actual monitored values between the period 01/05/09 - 28/02/11 and the PDD projection is provided below.

Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period (prorated to a 12 months period)
Baseline Emissions (tCO_{2eq})	24,510	47,293
Project Emissions (tCO_{2eq})	4,239	2,515
Emission reductions (tCO_{2eq})	**20,271**	**44,778**

**Actual values (collected over a period of 22 months) are pro-rated to a period of 12 months, in order to compare it with the ex-ante estimations.*

Item	Difference	Percentage Difference
Baseline Emissions (tCO_{2eq})	22,783	+93%
Project Emissions (tCO_{2eq})	-1,724	-41%
Emission reductions (tCO_{2eq})	**24,507**	**121%**

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

The actual emission reductions (ER) achieved in this monitoring period, 01/05/09 – 28/02/11 (22 months) was tCO_{2eq}. The estimated value in the PDD is 20,271 tCO_{2eq} for a period of 12 months. Thus, by comparing a pro-rated 12 months figure of the actual ER achieved with the PDD value, the emission reductions achieved is 44,778 tCO_{2eq} (pro-rated 12-months figure), which shall be compared to the emission reductions estimated ex-ante in PDD amounting to 20,271 tCO_{2eq}.

The increase in ER is mainly due to the following factors;

1) **COD value of the incoming POME.**
The average COD value ($COD_{a,in}$) achieved during the monitoring period is 96.23 $kgCOD/m^3$. This is a parameter beyond the project proponent's control as the wastewater that leaves the mill consists of sources from the mill operation; eg steam from the sterilizer, wash water from the mill, hydro cyclone water, EFB press etc. The organic composition and loading of the raw effluent from the palm oil mill is outside the project boundary and not under control by the biogas plant.

Parameter	PDD value Kg/m^3	Actual value Kg/m^3	Change Pct.
CODa,in	52.00	96.23	+85%

As the $COD_{a,in}$ is 85% higher during the monitoring period as compared to the ex-ante assumption applied in the PDD, this increase explains the main factor for the increase in baseline emissions.

2) **Reduced flaring activities**
In the PDD, flaring was estimated to consume 15% of the biogas produced (page 32 of registered CDM PDD). Flaring activity would generate higher project emissions, since an open-flare system (50% efficiency) is installed at site. Nevertheless, since the demand from the refinery has been consistent throughout the monitoring period (minimal or no downtime), flaring was only carried out in the month of June 2009, for the entire monitoring period. The percentage of biogas used for flaring for the monitoring period is 0.4%; 29,360 m^3 gas flared out of a total 7,871,170 m^3 gas produced from the CSTR tanks.

Parameter	PDD value	Actual value (01/05/09 – 28/02/11)	Pro rated value (1 yr) Nm^3/yr	Change
$FR_{f,inlet}$ (Nm^3)	446,336	29,360	16,014	-96%
Project emissions from flare & boiler (tCO_{2eq})	2,325	698	381	-1,944

These 2 factors are the main contributors to the increase of CERs, during the monitoring period. The total increase in emission reduction is 24,507 tCO_{2eq}, as compared with the PDD.

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History of the document

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