

Monitoring Report

Voluntary Carbon Standard v. 1

Wastewater Treatment with biogas production (UASB) and heat utilization at General Starch Co. Ltd.

Monitoring Period: 01/01/2004 to 31/05/2007

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PROJECT BACKGROUND

By means of this Monitoring Report greenhouse gas emission reductions achieved by the project activity “Wastewater Treatment with biogas production (UASB) and heat utilization at General Starch” (WWT GS) are being verified and certified as per requirements of the Voluntary Carbon Standard, Version 1.

Further background information on the project activity can be found in the Project Design Document (PDD) and associated documents, which have also been submitted for validation as per requirements of the Voluntary Carbon Standard, Version 1. The PDD and associated documents are available upon request.

MONITORING BACKGROUND

Section B of the PDD (Application of the baseline and monitoring methodology) provides all details in regard to calculation of emission reductions and the monitoring plan to be followed by the project activity. Both the emission reduction calculations and the monitoring plan are based on the approved CDM methodologies AM 0022 version 4.

MONITORING RESULTS

Monitoring period

This is the first monitoring report of this project activity. It covers the period 01/01/2004 to 31/05/2007.

Presentation of monitoring results

All monitoring data is available in excel sheets “wwt_general_starch_LOG_monitoring_data04_05”, “wwt_general_starch/log/monitoring_data06_07”, wwt_general_starch_LOG_ water_bypass&HFO”

The spreadsheets include an extract of the log of monitored data of the project activity:

- covering the parameters associated with water volume, gas volume (generated and burnt), COD concentration, gas concentration taking into account of monitoring parameters ID no 1-5, 8-12, 16 of AM0022,
- process water consumption derived from starch production and benchmark figures derived from 2006 data covering the monitoring period,
- annual reports stating the quantity of dry starch production, HFO consumption.
- Calculation of gas production data for 113 days in 2004 and 73 days in 2005 from COD load information and average gas production per unit of COD load to compensate for a broken gas meter that did not provide meter readings on those days.

Baseline and emission reduction estimation calculation spread sheets in accordance with the PDD are provided in file “wwt_general_starch_XCS_ver_calc”.

Calculation methodology

Emission reductions were calculated on the basis of formulae provided in AM0022 version 4 and applied to the project on the basis of an ex-ante calculation in the project PDD.

As per the equations set out in AM0022, the following equations are used to calculate project emission reductions from monitored data.

Total project emissions (t CO₂eq)

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

$$E_{project} = E_{CH4_lagoons} + E_{CH4_NAWTF} + E_{CH4_IC+Leaks}$$

Where:

$E_{project}$ are the Total Project Emissions (tCO₂e)

$E_{CH4_lagoons}$ are the fugitive methane emissions from lagoons from equations 2 (tCO₂e)

E_{CH4_NAWTF} are the fugitive methane emissions from the new anaerobic waste water treatment facility (tCO₂e)

$E_{CH4_IC+leakss}$ are the methane emissions from inefficient combustion and leaks (tCO₂e)

Formula 1	2004	2005	2006	2007
E_{project}	40,521	45,394	13,770	11,575
E _{CH4_lagoons}	33,739	41,287	-	-
E _{CH4_NAWTF}	-	-	-	-
E _{CH4_IC+Leaks}	6,783	4,107	13,770	11,575

to end of May

Fugitive Methane Emissions from Lagoons

$$E_{CH4_lagoons} = M_{lagoon_anaerobic} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000$$

Where:

$E_{CH4_lagoons}$ is the methane emissions from the lagoons (tCO₂e)

$M_{lagoon_anaerobic}$ is the amount of organic material removed by anaerobic processes in the lagoon system (kg COD³)

EF_{CH4} is the methane emission factor (kg CH₄ / kg COD). A default COD to Methane conversion factor of 0.21kg CH₄/kgCOD is used⁴. If the methodology is used for waste water containing materials not akin to simple sugars a CH₄, a different emissions factor different has to be estimated and applied. Where a metric for organic wastewater flows other than COD is to be applied, the developer should set out the case for a relevant carbon emission factor.

GWP_{CH4} is the Global Warming Potential of methane ($GWP_{CH4} = 21$)

Formula 2 (project)	2004	2005	2006	2007
E_{CH4_lagoons}	33,739	41,287	0	0
M _{lagoon_anaerobic}	6,666	8,158	0	0
EF _{CH4}	0.241	0.241	0.241	0.241
GWP _{CH4}	21	21	21	21

to end of May

Whereby the mass balance in the considered lagoon system provides the amount of organic material removed by anaerobic processes.

$$M_{lagoon_anaerobic} = M_{lagoon_total} - M_{lagoon_aerobic} - M_{lagoon_chemical_ox} - M_{lagoon_deposition}$$

Where:

M_{lagoon_total} is the total amount of organic material removed in the lagoon system from equation 5 (kg COD)

$M_{lagoon_aerobic}$ is the amount of organic material degraded aerobically in the lagoon system (kg COD). Surface aerobic losses of organic material in pond based systems equal to 254 kg COD per hectare of pond surface area and per day is assumed to be lost through aerobic processes.

Where other more project specific losses can be determined, these should be applied.

$M_{lagoon_chemical_ox}$ is the amount of organic material lost through chemical oxidation in the lagoon system (kg COD)

$M_{lagoon_deposition}$ is the amount of organic material lost through deposition in the lagoon system from equation 6 (kg COD)

	to end of May			
Formula 3 (project)	2004	2005	2006	2007
$M_{lagoon_anaerobic}$	6666	8158	0	0
M_{lagoon_total}	8,150	9,641	792	381
$M_{lagoon_aerobic}$	1,483	1,483	1,483	1,483
$M_{lagoon_chemical_ox}$	-	-	-	-
$M_{lagoon_deposition}$	-	-	-	-

Registered project No 1040 (Korat Waste to Energy) carried out a sensitivity analysis to determine the suitability of the surface oxidation factor utilised in this project analysis. Also, deposition, total removal and chemical oxidation are project specific factors that must be quantified on a project-specific basis. Considering strong similarities between the two projects, the analysis was applied to this project.

To assess the amount of COD entering the lagoon system the amount two waste water flows need to be quantified:

- the amount of COD actually entering the lagoon system from the new wastewater treatment facility which is equivalent to the amount of COD entering the new wastewater treatment facility minus the amount of COD removal as a result of the new wastewater treatment facility, and
- the amount of COD actually entering the lagoon system, bypassing the new wastewater treatment facility.

The first part is determined with:

$$M_{lagoon_input} = M_{input_total} \cdot (1 - R_{NAWTF})$$

Where:

M_{lagoon_input} is the input of organic material from the new project anaerobic waste water treatment facility into the lagoon system (kg COD)

M_{input_total} is the total amount of organic material fed into the new project water treatment facility (kg COD)

R_{NAWTF} is the total organic material removal efficiency of the new project water treatment facility (-). It is a project specific factor used to estimate how much COD will be removed from the system. The most appropriate manner to estimate this factor is to undertake pilot plant trials with a pilot scale digester system prior to project implementation. Where this is not possible, manufacturers estimates as to equipment removal efficiencies may be applied. This factor will be used to determine estimates of COD flows to the project lagoon system, and the related monitoring methodology (AM0022 "Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector") sets out how the actual amount of COD can be monitored to allow calculation of actual project emissions.

The second part is determined with

$$M_{lagoon_input_bypass} = M_{input_bypass}$$

Where

M_{input_bypass} is the total organic material that is entering the lagoon untreated. It is equivalent to the waste water flow of the bypass and the same COD load (mg/l) as measured for the waste water entering the lagoon.

The second part is not recognized by AM0022 even though AM0022 monitoring method identifies this parameters. It is, however, not included in the calculation for AM0022 projects. For the purposes of this calculation M_{lagoon_input} is defined as

M_{lagoon_input} (as defined in AM0022) plus $M_{lagoon_input_bypass}$.

Total Material Removed in the Lagoon System is:

$$M_{lagoon_total} = M_{lagoon_input} \cdot R_{lagoon}$$

Where:

M_{lagoon_total} is the total amount of organic material removed in the lagoon system through various routes (kg COD)

R_{lagoon} is the total organic material removal ratio of the lagoon (-). It is a project specific factor, and is equal to the proportion of organic material removed (through all routes) within the boundaries of the lagoon system under consideration. This factor should be determined by carrying out a series of biochemical tests prior to project implementation. These tests will determine the COD flows into the system, and the COD flows out of the system at the system boundary. The relative difference of COD flowing in and out of the system over a period of time will allow determination of the Total Organic Material Removal Ratio.

and where M_{lagoon_input} includes $M_{lagoon_input_bypass}$

Due to the lack of measurement data for $M_{lagoon_input_bypass}$ (FM 2 has not been in operation in 2004 nor 2005) the flow of wastewater bypassing the new waste water treatment facility is estimated using

benchmark data for the use of water in starch production and a water balance approach, defining the quantity of waste water bypassing the new waste water treatment facility as the difference between water usage and water flows into the new waste water treatment facility.

	Month	Root cassava(kg)	Wet Starch(kg)	Dryer Starch(ton)	Heavy oil(ltr)	Bio gas(m ³)	Water to reactor m3/a	water/root (l/kg)	Total water use (m3)	Water bypassing reactor (m3)	COD load mg/l	COD entering lagoon bypass (kg)
2004	Total	488,523,305	117,615,174	123,223	4,648,430	791,967	470,437	2.52	1,232,157	761,720	11807	8,993,626
2005	Total	462,510,492	105,518,142	126,967	4,187,578	2,573,465	426,633	2.52	1,166,547	739,914	14479	10,713,217
2006	Total	499,479,381	122,336,917	148,404	2,466,719	9,317,439	1,319,869		1,319,869	-		
2007	January	61,789,690	16,079,257	17,968	326,807	992,781						
2007	February	52,355,220	14,550,586	16,187	205,531	1,084,753						
2007	March	57,873,710	15,011,728	18,511	203,723	1,281,558						
2007	April	53,829,500	12,475,499	15,783	154,275	1,165,882	509,557		509,557	-		
Benchmark from 2006 and 2007 data (for which no waste water was bypassing reactors):							1,829,426	2.52	1,829,426			
Benchmark		725,327,501										

General Starch provided data for root processing for 2004 to 2007. A water use per kg root benchmark is defined (2.52 l/kg root) using flow meter data for waste water entering the new waste water treatment facility for 2006 and 2007 (water to reactor), years in which no waste water was bypassing the new waste water treatment facility due to the capacity expansion of the new waste water treatment facility in 2006 (UASB2).

This benchmark is applied to the total root processing in 2004 and 2005 (total water use). The waste water flow bypassing the reactor is defined using a hydrological balance:

$$WW_{\text{bypass}} = WW_{\text{total_use}} - WW_{\text{input}}$$

To determine $M_{\text{lagoon_input_bypass}}$ WW_{bypass} is multiplied with the average COD load for 2004 and 2005, using measured data at the reactor inlet.

$M_{\text{lagoon_anaerobic}}$ becomes zero when all wastewater is treated in the new waste water treatment facility as all remaining COD entering the lagoon is removed on aerobic basis.

Material Deposition into the Lagoon System is:

$$M_{\text{lagoon_deposition}} = M_{\text{lagoon_input}} \cdot R_{\text{deposition}}$$

Where:

$R_{\text{deposition}}$ is the organic material deposition ratio of the lagoon. It is equal to the proportion of organic material physically sedimented in lagoons within the project boundaries. It is a project specific factor derived by assessing the relative ability of COD in the waste water stream to sediment in the project boundaries, through pre project analysis.

to end of May

Formula 4 (project)	2004	2005	2006	2007
$M_{\text{lagoon_input}}$	9,274	10,971	901	433
$M_{\text{input_total}}$	6,859	6,308	22,067	10,605
R_{NAWTF}	95.92%	95.92%	95.92%	95.92%
$M_{\text{input_lagoon_bypass}}$	8,994	10,713	-	-

Formula 5 (project)	2004	2005	2006	2007
$M_{\text{lagoon_total}}$	8,150	9,641	792	381
$M_{\text{lagoon_input}}$	9,274	10,971	901	433
R_{lagoon}	87.88%	87.88%	87.88%	87.88%

Formula 6 (project)	2004	2005	2006	2007
$M_{\text{lagoon_deposition}}$	-	-	-	-
$M_{\text{lagoon_input}}$	9,274	10,971	901	433
$R_{\text{deposition}}$	-	-	-	-

Methane emissions from new anaerobic waste water treatment facility

In accordance with AM0022, methane emissions from the ABR at KWTE should be assessed and estimated based on measurements, technology supplier data and expert estimates. They may be disregarded if documented evidence for their insignificance is given.

Methane emissions from Inefficient Combustion Emissions

Methane emissions from inefficiency combustion are calculated as:

$$E_{CH_4_IC+Leaks} = \left(\sum_r V_r \cdot C_{CH_4_r} \cdot (1 - f_r) \cdot GWP_{CH_4} \right) + PE_{flare}$$

Where:

the sum is made over two routes r for methane destruction (heating and power generation);

V_r is the biogas combustion process volume in route r (Nm³)

C_{CH_4} is the methane concentration in biogas (tCH₄/Nm³) to be measured on wet basis.

f_r is the proportion of biogas destroyed by combustion (-)

PE_{flare} are the project emissions from flaring of the residual gas stream (tCO₂e) calculated following the procedures described in the "Tool to determine project emissions from flaring gases containing Methane". PE_{flare} can be calculated on an annual basis or for the required period of time using this tool.

Formula 7	2004	2005	2006	2007
$E_{CH_4_IC+Leaks}$	6,783	4,107	13,770	11,575
$E_{CH_4_IC_heat}$	115	210	1,226	822
V_{heat}	786,720	1,429,749	8,364,074	5,607,566
f_{heat}	99%	99%	99%	99%
$E_{CH_4_IC_elec}$	-	-	-	-
V_{elec}	-	-	-	-
f_{elec}	98.0%	98.0%	98.0%	98.0%
PE_{flare}	6,667	3,898	12,544	10,753
GWP_{CH_4}	21	21	21	21
$C_{CH_4_r}$	0.00047	0.00047	0.00047	0.00047

In the project activity, biogas will be flared when biogas production exceeds the capacity of the dual fuel burners or during maintenance shut down of the starch plant. Project emissions from the flare will be calculated using the “Tool to determine project emissions from flaring gases containing Methane”. Since no continuous monitoring takes place, the default flare efficiency prescribed by the tool is utilized. The calculation steps for project emissions are as follows:

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

This step calculates the residual gas mass flow rate in each hour h , based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

Formula 1 flaring tool:

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

Where:

$FM_{RG,h}$: Mass flow rate of the residual gas in hour h (kg/h)

$\rho_{RG,n,h}$: Density of the residual gas at normal conditions in hour h (kg/Nm³)

$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h (Nm³/h)

to end of May

Flaring tool: 1	2004	2005	2006	2007
$FM_{RG,h}$	153	89	288	247
$\rho_{RG,n,h}$	0.901	0.901	0.901	0.901
$FV_{RG,h}$	170	99	319	274
V_1	1,364,357	797,637	2,566,871	2,200,468

As stated in the “Tool to determine project emissions from flaring gases containing Methane”, a simplified approach may be taken, in which only the volumetric fraction of methane is measured and the difference to 100% is considered as nitrogen (N₂). From this simplified composition of the gas $\rho_{RG,n,h}$ is calculated as:

Formula 2 flaring tool

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

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 (101 325)
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)

with $MM_{RG,h} = 65\% \times 16 + 35\% \times 28$

STEP 2 though STEP 4 are not applicable for this project

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

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($f_{VCH4,RG,h}$) and the density of methane ($\rho_{CH4,n}$) in the same reference conditions (normal conditions and dry or wet basis). Considering that the gas is cooler than 60 degree Celsius, the reported density is expressed on dry basis already.

$$TM_{RG,h} = FV_{RG,h} \times f_{VCH4,RG,h} \times \rho_{CH4,n}$$

Where:

$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (Nm^3/h)

$f_{VCH4,RG,h}$: Volumetric fraction of methane in the residual gas on dry basis in hour h

$\rho_{CH4,n}$: Density of methane at normal conditions (kg/m)

				to end of May
Flaring tool: 13	2004	2005	2006	2007
$TM_{RG,h}$	79	46	149	127
$FV_{RG,h}$	170	99	319	274
$f_{VCH4,RG,h}$	0.65	0.65	0.65	0.65
$\rho_{CH4,n}$	0.716	0.716	0.716	0.716

STEP 6: Determination of the hourly flare efficiency

The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the approach selected by project participants to determine the flare efficiency (default value or continuous monitoring).

In case of open flares and use of the default value for the flare efficiency, the flare efficiency in the hour h ($\eta_{flare,h}$) is:

50%, if the flare is detected for more than 20 minutes during the hour h

As the temperature will be 850°C for more than 40 minutes during the hour h, the 50% default was selected.

STEP 7: Calculation of annual project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions from each hour h, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour h ($\eta_{flare,h}$), as follows:

Formula 15 Flaring tool

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

Where:

$TM_{RG,h}$: Mass flow rate of methane in the residual gas in the hour h

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

GWP_{CH_4} : Global Warming Potential of methane valid for the commitment period

				to end of May
Flaring tool: 15	2004	2005	2006	2007
$PE_{flare,y}$	6,667	3,898	12,544	10,753
$TM_{RG,h}$	79	46	149	127
$\eta_{flare,h}$	50%	50%	50%	50%
GWP_{CH_4}	21	21	21	21

Considering that the volumetric flow of gas to the flare is not measured directly and other parameters are not measured on an hourly basis, the figures in these equations are based on hourly averages using annual reported data and using the simplifications and default values provided by the flaring tool.

Methane Emissions from Leaks in Biogas System

Leaks in the biogas system include leaks from the anaerobic digester and leaks from the biogas pipeline delivery system. This is estimated to be zero in the project emissions estimates, corresponding to registered project No 1040 (Korat Waste to Energy).

The UASB reactor gas collection system consists of a gas-tight concrete, coated gas dome and the delivery pipe to the boiler site is less than 2km in length.

Baseline emissions

Baseline emissions

The baseline scenario for the project is based on what would have happened in the absence of the project activities. In this case, the baseline scenario will be continued operation of the open lagoon system:

Formula (8) AM 22 v4

$$E_{BL} = E_{CH_4_lagoons_BL} + E_{CO_2_heat_BL} + E_{CO_2_power_BL}$$

Where:

E_{BL} are the Total Baseline Emissions (tCO₂e)

$E_{CH_4_lagoons_BL}$ are the fugitive methane emissions from lagoons in the baseline case (tCO₂e). They are calculated with baseline data based on equation 2 in the section on project emissions.

$E_{CO_2_heat+power_BL}$ are the CO₂ emissions from on site fossil heat and/or power generation in the baseline case (tCO₂) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

$E_{CO_2_grid_BL}$ are the CO₂ emissions related to electricity supplied by the grid in the baseline case (tCO₂) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

Total baseline emissions are calculated as:

to end of May

Formula 8	2004	2005	2006	2007
E_{BL}	64,409	70,763	105,655	49,727
$E_{CH4_lagoons_BL}$	62,997	68,196	90,638	39,659
$E_{CO2_heat_BL}$	1,412	2,567	15,017	10,068
$E_{CO2_power_BL}$	-	-	-	-

To calculate $E_{CH4_lagoons_BL}$, formulas 2 to 6 are applied using baseline data.

Formula (2 (baseline)) AM 22 v4

$$E_{CH4_lagoons_BL} = M_{lagoon_anaerobic_BL} * EF_{CH4} * GWP_{CH4} / 1000$$

to end of May

Formula 2 (baseline)	2004	2005	2006	2007
$E_{CH4_lagoons_BL}$	62,997	68,196	90,638	39,659
$M_{lagoon_anaerobic_BL}$	12,448	13,475	17,909	7,836
EF_{CH4}	0.241	0.241	0.241	0.241
GWP_{CH4}	21	21	21	21

Formula (3 (baseline)) AM 22 v4

$$M_{lagoon_anaerobic_BL} = M_{lagoon_total_BL} - M_{lagoon_aerobic_BL} - M_{lagoon_chemical_ox_BL} - M_{lagoon_deposition}$$

to end of May

Formula 3 (baseline)	2004	2005	2006	2007
$M_{lagoon_anaerobic}$	12448	13475	17909	7836
$M_{lagoon_total_BL}$	13,931	14,958	19,392	9,320
$M_{lagoon_aerobic_BL}$	1,483	1,483	1,483	1,483
$M_{lagoon_chemical_ox_BL}$	-	-	-	-
$M_{lagoon_deposition_BL}$	-	-	-	-

Formula (11) AM 22v4 (corresponding to the logic of formula (4) AM 22 v4 in the project scenario

$$M_{lagoon_input_BL} = M_{input_total}$$

to end of May

Formula 4 (baseline)	2004	2005	2006	2007
$M_{lagoon_input_BL}$	15,852	17,021	22,067	10,652
$M_{input_total_BL}$	6,859	6,308	22,067	10,652
R_{NAWTF}	0.00%	0.00%	0.00%	0.00%
$M_{input_lagoon_bypass_BL}$	8,994	10,713	-	-

Formula (5 (baseline)) AM 22 v4

$$M_{lagoon_total_BL} = M_{lagoon_input_BL} * R_{lagoon}$$

Formula 5 (baseline)	2004	2005	2006	2007
$M_{\text{lagoon_total_BL}}$	13,931	14,958	19,392	9,320
$M_{\text{lagoon_input_BL}}$	15,852	17,021	22,067	10,605
R_{lagoon}	87.88%	87.88%	87.88%	87.88%

Formula (6 (baseline)) AM 22 v4

$$M_{\text{lagoon_deposition_BL}} = M_{\text{lagoon_input_BL}} \cdot R_{\text{deposition}}$$

Formula 6 (baseline)	2004	2005	2006	2007
$M_{\text{lagoon_deposition_BL}}$	-	-	-	-
$M_{\text{lagoon_input_BL}}$	15,852	17,021	22,067	10,652
$R_{\text{deposition}}$	-	-	-	-

Result from formula (9), AM 22 v4:

Whereby on Site Heat Generation Emissions displaced by generation based on biogas collected in the anaerobic treatment facility are calculated as follows (replacement of power from the grid does not apply):

In calculating CO₂ emissions from on site heat displaced by biogas collected in the anaerobic treatment, the use of fossil fuels is considered:

Formula (9) AM 22 v4

$$E_{\text{CO}_2_heat} = F \cdot NCV \cdot EF$$

Where:

F is the corresponding amount of fossil fuel displaced by the use of biogas for the generation of on site heat (unit). This is estimated as product of : (1) Average specific fuel consumption for the output of the facility, estimated using 3 years historical data; and (2) the annual production
NCV is the net calorific value of the fossil fuel considered (TJ/unit). Site specific local NCV values should be applied where available; however, should this information not be available, IPCC data may suffice for that specific country.⁷

EF is the carbon emission factor of the fossil fuel considered (tCO₂/TJ).

Formula 9	2004	2005	2006	2007
$E_{\text{CO}_2_heat}$	1,412	2,567	15,017	10,068
F	452	821	4,804	3,221
NCV	0.0404	0.0404	0.0404	0.0404
EF	77.37	77.37	77.37	77.37

In order to calculate the quantity of fuel that is displaced by biogas, the two fuels are substituted on the basis of equivalent delivered energy. The following energy densities are used:

- 1 m3 biogas at 65% concentration of methane = 23.2 MJ
- Combustion efficiency on HFO as well as biogas is considered to be 100 % in absence of the manufactures data.
- 1 ton of heavy fuel oil = 40.400 MJ
- Therefore: 1m3 biogas = 0.0005743 tons of heavy fuel oil

A 65% concentration default value is used in the absence of continuously monitored data.

Emission reductions

$$ER = E_{BL} - E_{project}$$

to end of May

Formula 12	2004	2005	2006	2007
ER	23,888	25,368	91,885	38,152
E _{BL}	64,409	70,763	105,655	49,727
E _{project}	40,521	45,394	13,770	11,575

However, this figure needs to be adjusted should the determination of conservativeness show that deductions have to be made. As can be seen below, such adjustments are to be made, resulting in the following conservative estimate of emission reductions.

to end of May

	2004	2005	2006	2007
ER _{conservative}	15,653	20,229	91,885	38,152
ER	23,888	25,368	91,885	38,152
Conservativeness estimate	8,235	5,140	-16,194	-16,184

The quantity of verifiable VCU in the reporting period can therefore be summarized as:

Year	Estimation of emission reductions (tonnes of CO2eq)	Conservative estimation of emission reductions (tonnes of CO2eq)
2004	23,888	15,653
2005	25,368	20,229
2006	91,885	91,885
2007 to end May	38,152	38,152
Total estimated reductions (tonnes of CO2eq) of verification period	179,293	165,918

Determination of conservativeness

It must be verified this equation delivers a conservative estimate of emission reductions i.e. that the emissions of CH₄ from the lagoons in the baseline situation are not higher than the total emissions of biogas from the digester and the lagoons in the project situation. Therefore calculate:

$$E_{CH_4_lagoon_BL} - (E_{CH_4_lagoon} + E_{CH_4_nawtf} + E_{CH_4_coll})$$

to end of May

Formula 13	2004	2005	2006	2007
=	8,235	5,140	-16,194	-16,184
$E_{CH_4_lagoon_BL}$	62,997	68,196	90,638	39,659
$E_{CH_4_lagoon}$	33,739	41,287	-	-
$E_{CH_4_NAWTF}$	-	-	-	-
$E_{CH_4_Coll}$	21,023	21,769	106,832	55,843

MONITORING RESULTS SUMMARY

		Value			
ID no	Parameter	2004	2005	2006	Jan - May 2007
Monitoring parameter according to AM0022v4					
1	WW _{input}	470,437	426,633	1,319,869	638,995
2	WW _{out}	470,437	426,633	1,319,869	638,995
3	MCOD _{in}	6,858,554	6,307,839	22,066,994	10,604,866
4	MCOD _{out}	280,160	257,664	977,358	357,231
5	V _{boiler}	786,720	1,429,749	8,364,074	5,607,566
6	- blank -	NA	NA	NA	NA
7	EL	NA	NA	NA	NA
8	F	452	821	4,804	3,221
9	V ₁	1,364,357	797,637	2,566,871	2,200,468
10	V _{genset}	0	0	0	0
11	C _{CH4}	65%	65%	65%	65%
12	PE _{flare}	6,667	3,898	12,544	10,753
13	M _{ox_agent}	0	0	0	0
14	Eta _{genset}	NA	NA	NA	NA
15	Eta _{boiler}	98.5%	98.5%	98.5%	98.5%
16	WW _{bypass}	12,362,872	13,191,805	-	-
17	Loss _{pipeline}	0	0	0	0
18	M _{removed}	0	0	0	0
19	NCV _{biogas}	23.205	23.205	23.205	23.205
	V _{biogas produced}	2,151,077	2,227,386	10,930,945	7,808,034
	E _{CH4coll}	21,023	21,769	106,832	55,843
Other parameters					
	EF _{CH4}	0.241	0.241	0.241	0.241
	R _{lagoon}	87.88%	87.88%	87.88%	87.88%
	R _{deposition}	0	0	0	0
	E _{CH4_NAWTF}	0	0	0	0
	R _{NAWTF}	95.92%	95.92%	95.92%	95.92%
	CEF	NA	NA	NA	NA
	EF _{HFO}	77.367	77.367	77.367	77.367
	NCV _{HFO}	0.0404	0.0404	0.0404	0.0404
	Density _{CH4}	0.716	0.716	0.716	0.716
	f _{flare}	50%	50%	50%	50%