CDM Monitoring of Biogas Plants

A comprehensive overview on the requirements of the CDM
CDM Monitoring of Biogas Plants

The Clean Development Mechanism (CDM)

Requirements of the CDM

Meters & Calibration

Monitoring Report
The Greenhouse-Effect

<table>
<thead>
<tr>
<th>Greenhouse Gases</th>
<th>CO₂</th>
<th>CH₄</th>
<th>NₓO</th>
<th>PFC</th>
<th>HFCs</th>
<th>SF₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWP</td>
<td>1</td>
<td>21</td>
<td>210-310</td>
<td>9,200</td>
<td>11,700</td>
<td>23,900</td>
</tr>
</tbody>
</table>
The Kyoto Protocol

- The United Nations Framework Convention on Climate Change (UNFCCC)
  Adopted by the UN in 1992 (in force since 1994)

Annex I countries (industrial countries) to “aim” to reduce their emissions

“... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system ...”

(Article 2)

- Emission reduction targets quantified in the Kyoto Protocol 1997
- On average 5.2% during the period 2008 - 2012 (as compared to 1990)
The principle of CDM

**Sponsor**

- Technology transfer and investment

**Host**

- CER for fulfilling commitment

Need for “Certified Emission Reductions” (CER) in Annex I countries

Need for sustainable development, especially in the energy sector, in non-Annex I countries
CDM mode of operation

Host Party (non-Annex I) which doesn’t have an emission cap

Specific place in a host Party

GHG emissions projection

Baseline Scenario

Specific place in a host Party

GHG emissions

Project Scenario

An Annex I Party will get CERs

CERs

Non-Annex I Parties will benefit from project activities resulting in CERs [KP Art.12 para3(a)]

A total emission cap of an Annex I Party

Acquired CERs are added and emission cap increases.
Flexible Mechanisms

- Emission Trading (ET)
  - Stock like trade of emissions certificates

- Joint Implementation (JI)
  - Emission reduction in developed countries

- Clean Development Mechanism (CDM)
  - Emission reduction in developing countries

→ Worldwide self-preserving stable market for emission reductions
CDM Revenues

- 66 m$^3$ CH$_4$ destroyed will result in one CER
- Predictions on CER price are difficult
- With recovering economies it will rise
- Predictions by major banks between 20 € and 35 €

Source: http://www.co2e.com
CDM Monitoring of Biogas Plants

The Clean Development Mechanism (CDM)

Requirements of the CDM

Meters & Calibration

Monitoring Report
The CDM project cycle (1/2)

**Planning**
- Consideration of all related condition
- Providing of all required documents

**PDD Writing**
- Describing the technical aspects of the project
- Describing emission reductions

**Getting Approvals**
- Written approvals of countries involved

**Validation**
- Document review and on-site evaluation by third party
- Evaluation report according to standard procedure
The CDM project cycle (2/2)

**Registration**
- Registration by the CDM Executive Board
- Standard procedures, registration fees

**Monitoring**
- Strict requirements to all involved personnel and technology
- Data taking and storage according to standards

**Verification**
- Review of monitoring documents and on-site evaluation by third party
- Issuance request according to standard procedure

**Issuance**
- Verified amount of certificates will be issued by executive board
- Tax will be raised by Chinese government, 2% for Methane projects

**Distribution**
- Distribution (sales) of CERs shall exclusively be taken by project participants
- Current price: ~150 RMB
Ex ante calculation of emission reduction

\[ ER_{CH4} = BE_y - PE_y \]

<table>
<thead>
<tr>
<th>( ER_{CH4} )</th>
<th>Emission reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>( BE_y )</td>
<td>Baseline emission</td>
</tr>
<tr>
<td>( PE_y )</td>
<td>Project emission</td>
</tr>
</tbody>
</table>
**Baseline emission (1/2)**

\[ BE_y = GWP_{CH4} \cdot D_{CH4} \cdot UF_b \cdot \sum_{j,LT} MCF_j \cdot B_{0,LT} \cdot N_{LT,y} \cdot VS_{LT,y} \cdot MS\%_{LT,j} \]

<table>
<thead>
<tr>
<th>(BE_y)</th>
<th>Baseline emission in year “y” (tCO(_2)e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(GWP_{CH4})</td>
<td>Global Warming Potential of CH(_4) (21)</td>
</tr>
<tr>
<td>(D_{CH4})</td>
<td>CH(_4) density (0.00067 t/m(^3) at 20 °C and 1 atm)</td>
</tr>
<tr>
<td>(LT)</td>
<td>Index of all types of livestock</td>
</tr>
<tr>
<td>(j)</td>
<td>Index of animal waste management system</td>
</tr>
<tr>
<td>(MCF_j)</td>
<td>Annual methane conversion factor (MCF) for the baseline animal waste management system “j”</td>
</tr>
<tr>
<td>(B_{0,LT})</td>
<td>Maximum methane producing potential of the volatile solid generated for animal type “LT”(m(^3) CH(_4)/kg dry matter)</td>
</tr>
<tr>
<td>(N_{LT,y})</td>
<td>Annual average number of animal of type “LT” in year “y” (numbers)</td>
</tr>
<tr>
<td>(VS_{LT,y})</td>
<td>Volatile solids for livestock “LT” entering the animal manure management system in year “y” (on a dry matter weight basis, kg dm/animal/year)</td>
</tr>
<tr>
<td>(MS%_{BL,j})</td>
<td>Fraction of manure handled in baseline animal manure management system “j”</td>
</tr>
<tr>
<td>(UF_b)</td>
<td>Model correction factor to account for model uncertainties(0.94)</td>
</tr>
</tbody>
</table>
Baseline emission (2/2)

\[ E_{bl} = E_{P_{BIO}} \cdot E_{F_{grid}} \]

<table>
<thead>
<tr>
<th>( E_{bl} )</th>
<th>Baseline electricity generation emissions (tCO₂/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( E_{P_{BIO}} )</td>
<td>Electricity produced by biogas generator unit for grid electricity replacement (MWh)</td>
</tr>
<tr>
<td>( E_{F_{grid}} )</td>
<td>Baseline emission efficient of East China Power Grid (kg CO₂e/kwh). The calculation of ( E_{F_{grid}} ) is provided in a separate spreadsheet in Annex 3 - Baseline information.</td>
</tr>
</tbody>
</table>
Project Emission

\[ PE_y = PE_{PL,y} + PE_{flare,y} + PE_{power,y} \]

<table>
<thead>
<tr>
<th>( PE_y )</th>
<th>Project emission in year “y” (tCO(_2)e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( PE_{PL,y} )</td>
<td>Emission due to physical leakage of biogas in year “y” (tCO(_2)e)</td>
</tr>
<tr>
<td>( PE_{flare,y} )</td>
<td>Emission from flaring or combustion of the gas stream in year “y” (tCO(_2)e)</td>
</tr>
<tr>
<td>( PE_{power,y} )</td>
<td>Emissions from the use of fossil fuels or electricity for the operation of all the installed facilities</td>
</tr>
</tbody>
</table>
Example: Biogas plant in Shanghai

- Dairy farm with 10,000 cows of Western Europe genetic origin
- Baseline scenario: open lagoon
- Installation of a biogas plant and a grid connected 1 MW gas engine
- Emission reduction by destruction of methane in baseline and by production of electricity from renewable energy
### Baseline emission from AMMS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$GWP_{CH4}$</td>
<td>21</td>
</tr>
<tr>
<td>$D_{CH4}$</td>
<td>0.00067 (t/m³)</td>
</tr>
<tr>
<td>$LT$</td>
<td>1</td>
</tr>
<tr>
<td>$j$</td>
<td>1</td>
</tr>
<tr>
<td>$MCF_j$</td>
<td>$0.73$ for an uncovered lagoon and an annual mean temperature of $14°$ $C$</td>
</tr>
<tr>
<td>$B_{0,LT}$</td>
<td>$0.24$ (m³ CH₄/kg dry matter) for dairy cows of Western Europe genetic origin</td>
</tr>
<tr>
<td>$N_{LT,y}$</td>
<td>10,000</td>
</tr>
<tr>
<td>$VS_{LT,y}$</td>
<td>1861.5 (kg/head/year) for dairy cows of Western Europe genetic origin</td>
</tr>
<tr>
<td>$MS%_{BL,j}$</td>
<td>1</td>
</tr>
<tr>
<td>$UF_b$</td>
<td>0.94</td>
</tr>
<tr>
<td>$PE_y$</td>
<td>$43,135$ tCO₂e</td>
</tr>
</tbody>
</table>
Baseline emission from grid electricity production

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$EP_{BIO}$</td>
<td>7884 MWh</td>
</tr>
<tr>
<td>$EF_{grid}$</td>
<td>0.78255 tCO$_2$/MWh</td>
</tr>
<tr>
<td>$E_{bl}$</td>
<td>6,169 tCO$_2$e/year</td>
</tr>
</tbody>
</table>

Project emission from leakage

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$PE_{PL,y}$</td>
<td>6,286 (tCO$_2$e)</td>
</tr>
<tr>
<td>$PE_{power,y}$</td>
<td>0</td>
</tr>
<tr>
<td>$PE_{power,y}$</td>
<td>556 (tCO$_2$e)</td>
</tr>
<tr>
<td>$PE_{y}$</td>
<td>6,842 (tCO$_2$e)</td>
</tr>
</tbody>
</table>
Estimated emission reduction

- Overall annual emission reduction of this project: 42,461 tCO$_2$e
- If the project gets registered and the monitoring is carried out according to the requirements, 42,461 CERs will be issued and can be sold annually.
CDM Monitoring of Biogas Plants

The Clean Development Mechanism (CDM)

Requirements of the CDM

Meters & Calibration

Monitoring Report
Monitoring Livestock

- Grid
  - E-02
  - Power
- Biogas System AD-01
  - T-01
  - P-01
  - F-02
  - S-01
  - F-01
- Livestock LS-01
- Manure
- Water (F-07, T-02, P-02)

- Flare Unit FL-01
  - S-02
  - FL-Exh
- Power System GE-01
  - S-03
  - GE-Exh
- Power System E-01
  - E-01
  - Power
- Heat System HE-01
  - S-04
  - HE-Exh
- Heat (T-03, P-03)
- Steam (T-04, P-04)
Livestock

**nd<sub>y</sub>:** The number of days that the animal manure management system capturing methane and flaring/combusting or gainfully using methane was operational

**MS%<sub>i,y</sub>:** The fraction of manure handled in the manure management system

**W<sub>site</sub>:** The average weight of the livestock

**N<sub>L,T,y</sub>:** The livestock population

The consistency between these values and indirect information (records of sales, records of food purchases) shall be assessed. Significant changes in livestock population and average weight shall be explained.
Monitoring Biogas System

Grid

Biogas System AD-01

Livestock LS-01

Power System GE-01

Flare Unit FL-01

Power System GE-01

Power System GE-01

Power System GE-01

Heat System HE-01

Other

Other

Other

Other

Other

Power

Power

Power

Power

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

Water

W
The VS of the manure is usually checked quarterly to ensure 100% of manure enters the digester.

Continuous measurement of pressure/temperature and sampling of the methane concentration is required to determine the methane density and mass flow.

The fraction of methane in the biogas should be measured with a continuous analyzer or, alternatively, with periodical measurements at a 95% confidence level.
The annual fossil fuel or electricity used to operate the facility or power auxiliary equipment shall be monitored.

Alternatively it shall be assumed that all relevant electrical equipment operate at full rated capacity, plus 10% to account for distribution losses, for 8760 hours per annum.

The proper soil application (not resulting in methane emissions) of the final sludge must be ensured.
Flaring Process

Monitoring Flaring Process

- **F-03** Amount of biogas flared

- **S-02** Methane content in exhaust gas for determination of the efficiency of the flaring process and emissions from flaring of biogas. This will usually be done by measuring temperature and applying a standard value.

  - Voluntarily continuous monitoring of flaring efficiency (eff. of flaring process multiplied by fraction of time in which the gas is flared)
  - Alternatively 90% standard. If this option is chosen, continuous check of compliance with the manufacturer’s specification (Temperature, Biogas Flow) is required
Power System

Amount of biogas utilized for electrical energy generation

Sampling of exhaust gas composition to monitor the fraction of methane combusted. This is not required by CDM. The engine efficiency can be assumed to be 1.

The electricity produced and fed into the grid
Heat Utilization (Steam)

Amount of biogas utilized for electrical energy generation

Continuous measurement of pressure/temperature/flow to determine the amount of energy that was transferred to the water.

Sampling of exhaust gas composition to monitor the fraction of methane combusted. This is not required by CDM. The engine efficiency can be assumed to be 1.
Monitoring other BG utilization

Grid

Biogas System AD-01

Livestock LS-01

Power System GE-01

Heat System HE-01

Flare Unit FL-01

Other

Other

Power

Power

Heat

Steam

Water

Manure

E-02

F-02

S-01

F-01

F-03

F-04

F-05

F-06

F-07

T-01

P-01

T-02

P-02

T-03

P-03

T-04

P-04

S-02

S-03

S-04

FL-Exh

GE-Exh

HE-Exh

Exh
Other Application

The recovered methane may also be utilised for other applications instead of flaring or combustion, e.g. Bottling of upgraded biogas or upgrading and distribution in piped networks to groups of other end users or into natural gas distribution.

Continuous measurement of the amount of biogas used for various (n-application) purposes in the project activity: e.g., heat, electricity, flare, injection into natural gas distribution grid, etc. The difference is considered as loss due to physical leakage and deducted from the emission reductions.
Example: Electricity production
List of parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measurement Frequency</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity delivery to the public grid</td>
<td>Daily</td>
<td>99.8% or according to the national standard</td>
</tr>
<tr>
<td>Electricity input for operation of biogas plant</td>
<td>Daily</td>
<td>99.8% or according to the national standard</td>
</tr>
<tr>
<td>Volatile solid (VS) content of animal slurry that entering the digester</td>
<td>common practice: four times a year to make sure 100% of manure is treated in biogas plant.</td>
<td>Test at the qualified labs or testing centers at the city level</td>
</tr>
<tr>
<td>Quantity of animal slurry that entering the digester</td>
<td>Daily</td>
<td>95% according to methodology</td>
</tr>
<tr>
<td>Biogas flow</td>
<td>Measured continuously, recorded daily</td>
<td>95% according to methodology</td>
</tr>
<tr>
<td>Biogas pressure</td>
<td>Measured continuously, recorded daily</td>
<td>95% according to methodology</td>
</tr>
<tr>
<td>Biogas temperature</td>
<td>Measured continuously, recorded daily</td>
<td>95% according to methodology</td>
</tr>
<tr>
<td>Methane fraction in biogas</td>
<td>Measured continuously, recorded daily</td>
<td>95% according to methodology</td>
</tr>
<tr>
<td>Temperature in the exhaust gas of the flare</td>
<td>Measured when flaring biogas</td>
<td>95% according to methodology</td>
</tr>
</tbody>
</table>
CDM Monitoring of Biogas Plants

The Clean Development Mechanism (CDM)

Requirements of the CDM

Meters & Calibration

Monitoring Report
Monitoring & Reporting

- The whole project will be inspected by a third party to confirm the accordance with the CDM requirements
- All relevant parameters have to be provided, measured or calculated
- All meters have to be calibrated by an authorized technician or institute according to manufacturers requirements
- Meter accuracies have to be in line with national standards
- A monitoring manual has to be compiled for the local staff
Yearly Project Verification

• Yearly (or half-yearly/quarterly) report on actual emission reduction has to be compiled and submitted to a DOE

• On-site verification by DOE to ensure correctness of all data and information

• After successful verification issuance can be requested

• Issued CERs can be sold with spot prices on stock markets
Thank you for you attention

China Office

• 100125 Beijing Chaoyang District, Liangmaqiaolu 42, Guangming Apartment 0708
  P +86 10 64688669 - 0  F +86 10 64688669 - 21

中国办公室

• 100125北京朝阳区亮马桥路光明饭店0708室
  电话: 010 64688669 转 0  传真: 010 64688669 转 21

hhuenteler@upm-cdm.eu