Greenhouse Gas Reporting for Industrial Wastewater Treatment Plants

Kira E. Darlow
Environmental Analyst
sc&a, inc.
1608 Spring Hill Rd, Suite 400 • Vienna, VA 22182
📞 703-893-6600 ext. 209 • 🚫 kdarlow@scainc.com

This presentation is for informational purposes only and is not intended to be relied upon for determination of the requirements for any particular project or need. Appropriate professionals should be consulted for a particular project.
Plan to Cover

- Who needs to report wastewater treatment plant (WWTP) emissions to EPA by September 28, 2012?

- What information is needed to calculate greenhouse gas (GHG) emissions from a WWTP?

- What information gets reported to EPA?
Who reports WWTP GHGs?

Subpart II applies only to four industries:
- Pulp and Paper Manufacturing (Subpart AA)
- Petroleum Refining (Subpart Y)
- Food Processing: manufacture or process meat, poultry, fruits or vegetables
- Ethanol Production: produce ethanol from the fermentation of sugar, starch, grain, or cellulosic biomass or synthetically from petrochemical feedstocks

Report methane (CH\textsubscript{4}) emissions from anaerobic process treating industrial wastewater and/or sludge:
- Anaerobic reactors
- Anaerobic lagoons
- Anaerobic digesters
Reporting Threshold for Subpart II

- **Petroleum refineries:**
  - Any facility applicable to subpart Y.

- **Pulp and paper manufacturing:**
  - Any facility applicable to subpart AA

- **Ethanol production and Food processing:**
  - Total annual GHG emissions ≥25,000 MT CO$_2$e from industrial wastewater treatment (Subpart II), stationary fuel combustion (A), miscellaneous use of carbonates (U) and all categories in Table A-4:
    - Ferroalloy production (K)
    - Fluorinated gas production (L)
    - Hydrogen production (P)
    - Iron & steel production (Q)
    - Lead production (R)
    - Magnesium production (T)
    - Glass production (N)
    - Electronics manufacturing (I)
    - Zinc production (GG)
    - Industrial waste landfills (TT)
    - Petroleum and Natural Gas Systems (W)
Whole System

Raw Wastewater → Primary Wastewater Treatment → Anaerobic Wastewater Treatment → Treated Wastewater

Primary Wastewater Treatment → Solids

Solids → Anaerobic Sludge Digestion → Solids

Anaerobic Sludge Digestion → CH₄ Leakage

CH₄ Leakage → Biogas (CH₄) Recovery

Biogas (CH₄) Recovery → Biogas Destruction Device

Biogas Destruction Device → CO₂, CH₄, H₂O

CH₄ Generated → CH₄ Leakage
CH₄ Generation without Recovery - 1

Calculation inputs for each process:

- Weekly average chemical oxygen demand (COD) or 5-day biochemical oxygen demand (BOD₅) concentrations
- Volume of wastewater entering anaerobic treatment process (Flow)
- Default values for maximum CH₄ production potential (B₀) and methane conversion factor (MCF) from Table II-1

\[ CH₄G_n = \sum_{w=1}^{52} [Flow_w \times (COD_w \text{ or } BOD₅,w) \times B₀ \times MCF \times 0.001] \]
## Emission Factors

<table>
<thead>
<tr>
<th>Emission Factors</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_0$ - for facilities monitoring COD</td>
<td>0.25 kg CH$_4$/kg COD</td>
</tr>
<tr>
<td>$B_0$ - for facilities monitoring BOD$_5$</td>
<td>0.60 kg CH$_4$/kg BOD$_5$</td>
</tr>
<tr>
<td>MCF - anaerobic reactor</td>
<td>0.8</td>
</tr>
<tr>
<td>MCF - anaerobic deep lagoon (depth &gt;2m)</td>
<td>0.8</td>
</tr>
<tr>
<td>MCF - anaerobic shallow lagoon (depth &lt;2m)</td>
<td>0.2</td>
</tr>
</tbody>
</table>
For each anaerobic wastewater treatment plant process **without** CH$_4$ recovery, report metric tons CH$_4$ emitted according to Equation II-3 (spreadsheet tab II-3):

\[ CH_4 E_n = CH_4 G_n \]

- For these processes, CH$_4$ emitted = CH$_4$ generated
### CH₄ Recovery – Equation

\[
R_n = \sum_{m=1}^{M} \left[ (V)_m \times (K_{MC})_m \times \frac{(C_{CH4})_m}{100\%} \times 0.0423 \times \frac{520^\circ R}{(T)_m} \times \frac{(P)_m}{1\text{atm}} \times \frac{0.454}{1,000} \right]
\]

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>( (V)_m )</td>
<td><strong>Cumulative volumetric biogas flow</strong> during the measurement period (acf)</td>
</tr>
<tr>
<td>( (C_{CH4})_m )</td>
<td><strong>Average concentration of CH₄</strong> during the measurement period (vol %)</td>
</tr>
<tr>
<td>( (K_{MC})_m )</td>
<td>Moisture correction term for the measurement period, volumetric basis</td>
</tr>
<tr>
<td>( (T)_m )</td>
<td><strong>Average temp at which flow is measured</strong> for the measurement period (°R). If the flow rate meter automatically corrects for temp to 520°R, use ((T)_m = 520°R)</td>
</tr>
<tr>
<td>( (P)_m )</td>
<td><strong>Average pressure at which flow is measured</strong> for the measurement period (atm). If the flow rate meter automatically corrects for pressure to 1 atm, use ((P)_m = 1 \text{ atm})</td>
</tr>
<tr>
<td>0.0423</td>
<td>Density of CH₄ lb/scf at 1 atm and 520°R or 60°F</td>
</tr>
<tr>
<td>( \frac{0.454}{1,000} )</td>
<td>Conversion factor (metric ton/lb)</td>
</tr>
</tbody>
</table>
CH₄ Recovery – Moisture Correction Term

(K_Mc)_m may equal 1 or some fraction related to the (f_H2O)_m variable, depending on whether biogas flow and CH₄ concentration are measured wet or dry.

(f_H2O)_m = average moisture content of biogas during the measurement period, volumetric basis, (cubic feet water per cubic feet biogas)

<table>
<thead>
<tr>
<th>Volumetric Biogas Flow [(V)_m]</th>
<th>CH₄ Concentration [(C(CH₄))_m]</th>
<th>(K_Mc)_m =</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet basis</td>
<td>Wet basis</td>
<td>1</td>
</tr>
<tr>
<td>Dry basis</td>
<td>Dry basis</td>
<td>1</td>
</tr>
<tr>
<td>Wet basis</td>
<td>Dry basis</td>
<td>[1-(f_H2O)_m]</td>
</tr>
<tr>
<td>Dry basis</td>
<td>Wet basis</td>
<td>1/[1-(f_H2O)_m]</td>
</tr>
</tbody>
</table>
### Calculation Tab “II-4”

#### Subpart II: Industrial Wastewater Treatment

### Equation II-4: Calculating Methane Recovery in Metric Tons

**OPTIONAL SPREADSHEET FOR FACILITY REGULATORY PURPOSES**

This spreadsheet is protected and contains locked cells to ensure that you do not inadvertently alter any of the included formulas and calculations. To remove this protection and alter this spreadsheet, right-click the 'worksheet' tab near the bottom of the screen and select “Unprotect Sheet.” When prompted for the password, type “SHH” and click “OK.” Please note that making changes to an unprotected sheet could result in incorrect calculations and that you are responsible for the accuracy of the data you report to EPA. For additional help, visit the Microsoft Excel Support website (https://office.microsoft.com/en-us/excel-help).

#### Equation II-4:

\[ R_i = \sum V_i \cdot \left( K_{C_{CH_4}} \cdot \frac{C_{CH_4}}{100} \cdot \frac{520R}{T_h} \cdot \frac{Q}{18m} \cdot 1.00 \right) \]

### Input Data

This calculation spreadsheet can be used for up to 4 aerobic processes at an industrial wastewater treatment facility. Only processes which recover biogas should be included on this spreadsheet.

#### Pressure Tab 4

- **[G] = Index for processes at the facilities, used in Equation II-4**
- **[M] = Total number of measurement periods in a year. Use 365 for daily averaging of continuous monitoring, as provided in paragraph (b)(1) of 40 CFR 503. Use 52 for weekly sampling, as provided in paragraph (b)(2).**

Select the basis for \( V_i \) from the drop down menu.

Select the basis for \( C_{CH_4} \) from the drop down menu.

### Methane Recovery (metric tons) from Equation II-4

<table>
<thead>
<tr>
<th>Process</th>
<th>( R_i )</th>
<th>Annual quantity of CH4 recovered from the 5th anaerobic reactor, sludge digester, or (biogas from anaerobic reactor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process 1 of 4</td>
<td>( R_i )</td>
<td>[Biogas]</td>
</tr>
<tr>
<td>Process 2 of 4</td>
<td>( R_i )</td>
<td>[Biogas]</td>
</tr>
<tr>
<td>Process 3 of 4</td>
<td>( R_i )</td>
<td>[Biogas]</td>
</tr>
<tr>
<td>Process 4 of 4</td>
<td>( R_i )</td>
<td>[Biogas]</td>
</tr>
</tbody>
</table>
CH$_4$ Leakage

- Raw Wastewater
- Primary Wastewater Treatment
  - Solids
  - Anaerobic Sludge Digestion
    - Solids
    - CH$_4$ Leakage
    - R$_n$
- Anaerobic Wastewater Treatment
- Treated Wastewater
- Solids to Disposal
- Biogas Destruction Device
  - CH$_4$ Leakage
  - R$_n$
CH$_4$ Leakage – Equation

\[ CH_4 L_n = R_n \times \left( \frac{1}{CE} - 1 \right) \]

- $R_n = \text{CH}_4$ recovered
- $CE = \text{Collection Efficiency as defined by EPA in Table II-2}$

40 CFR, Part 98, Subpart II, Table II-2

<table>
<thead>
<tr>
<th>Anaerobic Process Type</th>
<th>Cover Type</th>
<th>Methane CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered anaerobic lagoon</td>
<td>Bank to bank, impermeable</td>
<td>0.975</td>
</tr>
<tr>
<td>(biogas capture)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modular, impermeable</td>
<td>0.7</td>
</tr>
<tr>
<td>Anaerobic sludge digester; anaerobic reactor</td>
<td>Enclosed vessel</td>
<td>0.99</td>
</tr>
</tbody>
</table>
CH₄ Destruction & Emissions

- **Raw Wastewater**
- **Primary Wastewater Treatment**
  - Solids
  - Anaerobic Sludge Digestion
    - Solids to Disposal
    - CH₄Ln
    - CH₄Ln
- **Anaerobic Wastewater Treatment**
  - Solids
  - Biogas Destruction Device
    - Rn
    - CH₄Ln
    - CO₂, CH₄, H₂O
- **Treated Wastewater**
**CH₄ Destruction & Emissions – Equation**

\[ CH₄E_n = CH₄L_n + R_n \left(1 - (DE₁ × f_{Dest_1})\right) + R_n \left(1 - (DE₂ × f_{Dest_2})\right) \]

- Previously calculated inputs for \(CH₄L_n\) (leakage) and \(R_n\) (\(CH₄\) recovered).

- \(DE₁\) and \(DE₂\) = destruction efficiencies for primary and secondary destruction devices (lesser of 0.99 and manufacturers specified \(DE\); use \(DE=1\) if either “device” is to send biogas off site).

- \(f_{Dest_1}\) and \(f_{Dest_2}\) = fraction of hours device was running (device operating hours/8760 hours per year).
For each anaerobic wastewater treatment plant process with CH₄ recovery, report metric tons CH₄ emitted according to Equation II-6 (spreadsheet tab II-6):

\[ CH₄E_n = CH₄L_n + R_n \left( 1 - (DE₁ \times f_{Dest\_1}) \right) + R_n \left( 1 - (DE₂ \times f_{Dest\_2}) \right) \]

For these processes, CH₄ emitted = (CH₄ leaked) + (CH₄ not destroyed)
Total Site WWTP Emissions

- Raw Wastewater
  - Primary Wastewater Treatment
    - Anaerobic Wastewater Treatment
    - Solids
      - Anaerobic Sludge Digestion
        - Solids to Disposal
        - Biogas (CH₄) Recovery
          - CH₄ Leakage
          - Biogas (CH₄) Recovery
            - Biogas Destruction Device
              - CH₄ Generated
              - CO₂, CH₄, H₂O

Total Site WWTP Emissions – Equation

\[ CH_4 E_T = \sum_{n=1}^{j} CH_4 E_n \]

- Total site methane WWTP emissions = sum of all individual process methane WWTP emissions
- Includes all outputs from:
  - Equation II-3 (\(CH_4\) Generation)
  - Equation II-6 (\(CH_4\) Emitted from Recovery Process)
Diagram or description of each anaerobic wastewater treatment process

- Identify the processes. Anaerobic processes must be identified as:
  - Anaerobic reactor.
  - Anaerobic deep lagoon (depth more than 2 meters).
  - Anaerobic shallow lagoon (depth less than 2 meters).
  - Anaerobic sludge digester.

- Provide a unique identifier for each anaerobic process.
- Indicate how the processes are related to each other.
- Include average depth in meters of each anaerobic lagoon.
- Note whether biogas generated by each anaerobic process is recovered.
Using Substitute Data

- **For each missing value of COD or BOD$_5$ or wastewater flow**, use the arithmetic average of the quality-assured values of those parameters for the weeks immediately preceding and immediately following the missing data.

- **For each missing value of CH$_4$ content or biogas flow rates**, use the arithmetic average of the quality-assured values of that parameter immediately preceding and immediately following the missing data.

- For any parameter, **if no quality-assured data are available prior to the missing data**, the substitute data value must be the first quality-assured value obtained after the missing data period. If the “after” value is not obtained by the end of the reporting year, use the last quality-assured value obtained “before” the missing data period.
References and Links

- Optional Calculation Spreadsheets: [http://www.ccdsupport.com/confluence/display/help/Optional+Calculation+Spreadsheet+Instructions](http://www.ccdsupport.com/confluence/display/help/Optional+Calculation+Spreadsheet+Instructions)
- e-GGRT Subpart II Reporting Instructions: [http://www.ccdsupport.com/confluence/display/help/Subpart+II+-+Industrial+Wastewater+Treatment](http://www.ccdsupport.com/confluence/display/help/Subpart+II+-+Industrial+Wastewater+Treatment)
- e-GGRT Subpart II Reporting Form: [http://www.ccdsupport.com/confluence/display/help/Reporting+Form+Instructions](http://www.ccdsupport.com/confluence/display/help/Reporting+Form+Instructions)
- Training Presentations for e-GGRT: [http://www.epa.gov/ghgreporting/reporters/training/index.html](http://www.epa.gov/ghgreporting/reporters/training/index.html)
- 40 CFR, Part 98: [http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=00029dacc88b66fb92eb9eb4b91163fa;rgn=div5;view=text;node=40%3A22.0.1.1.3;idno=40;cc=ecfr](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=00029dacc88b66fb92eb9eb4b91163fa;rgn=div5;view=text;node=40%3A22.0.1.1.3;idno=40;cc=ecfr)