# Source Reference 21

# Cornerstone Environmental Group, LLC September 2012 Project 120408 report for SmartFerm Anaerobic Digestion Facility at Agromin's Oxnard Facility

# AUTHORITY TO CONSTRUCT / PERMIT TO OPERATE APPLICATION

# DRY FERMENTATION ANAEROBIC DIGESTERS WITH COMBINED HEAT & POWER RECOVERY

**Pilot Demonstration Project - SmartFerm Anaerobic Digestion Facility at Agromin's Oxnard Facility**

Prepared for
Zero Waste Energy, LLC
California Wood Recycling, Inc. DBA Agromin Horticultural Products

September 2012

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Project 120408

**Authority to Construct / Permit to Operate Application**
**Pilot Demonstration Project - Dry Fermentation Anaerobic Digesters with Combined Heat & Power Recovery**
**at Agromin's Oxnard Facility**

The material and data in this report were prepared under the supervision and direction of the undersigned.

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# 3 PROJECT EMISSIONS

## 3.1 Fugitive Material Handling

Particulate matter (PM) will be emitted as loading/unloading of organic material to the DFAD facility takes place within a building or on Agromin's existing outdoor concrete mixing pad. However, the high moisture content (approximately 60 percent) of the waste will reduce the amount of airborne dust emitted from the waste handling.

### 3.1.1 DFAD Emission Calculation Inputs and Assumptions

- Maximum organic waste delivered per year: 5,000 tpy;
- Maximum hours of loading/unloading per day: 12 hours per day (hr/day);
- Average amount of organic waste delivered/handled per hour: 17 tons/hr;
- Maximum amount of organic waste delivered/handled per hour: 75 tons/hr[1];
- Maximum hours of operation: 8,760 hours per year (hr/yr);
- Average moisture content of waste: 60 percent; and
- Emissions from mobile equipment not included.

[1]Calculations were based on the conservative assumption that the facility is able to accept up to 200 tons/hr, the maximum handle per hour will be 75 tons/hr.

### 3.1.2 Emission Factors

- AP-42 Section 13.2.4, *Aggregate Handling and Storage Piles*, November 2006.
- Mean wind speed: 7.2 miles per hour (mph)[1].

A summary of emissions from material handling is provided in Table 3-1.

**Table 3-1 – Fugitive Material Handling**

| Pollutant | Potential to Emit[1] | | |
|---|---|---|---|
| | lb/hr | lb/day | ton/yr |
| $PM_{2.5}$ | 0.59 | 0.59 | 0.007 |
| $PM_{10}$ | 3.9 | 3.9 | 0.049 |
| Total PM | 8.2 | 8.2 | 0.10 |

$PM_{2.5}$ = particulate matter less than or equal to 2.5 microns
$PM_{10}$ = particulate matter less than or equal to 10 microns
Note: Assumes material is maintained at proper moisture in accordance with The Agromin Arnold Road Dust Suppression Protocol

[1] California Climate Data Archive, representative mean wind speed at Oxnard Airport 1996 - 2006 (http://www.calclim.dri.edu/ccda/comparative/avgwind.html). Applied outdoor wind speed indoors.

## 3.2 DFAD Process Emissions

*Proposed Source Number:* *S-1*

During the fermentation phase of the DFAD process, the digesters are sealed and all of the lean biogas produced with a methane content of up to 20 percent during initial fermentation is directly collected in the lean biogas storage and therefore there are no emissions during this phase. This biogas is used for "scavenging" biogas in the digesters, which is a means to enhance the methane content of the lean gas and create new channels in the material that result in enhanced percolation absorption. Rich biogas produced during the anaerobic digestion phase of the DFAD process, containing 21 to 60 percent methane, is initially mixed in the percolate tank and then stored in the rich biogas storage bladder prior to use in the CHP. At the end of the "shutdown" phase of fermentation, for approximately 1 hour per digester, the methane concentration of the biogas decreases from 20 percent to less than 1 percent. During this time, the lean gas is sent to the biofilter to be oxidized.

The total methane emissions through the biofilter are presented in Section 3.4.4.

## 3.3 CHP Engine Emissions

*Proposed Source Number:* *S-2*

Agromin proposes to install 1 biogas-fired spark ignition CHP reciprocating internal combustion (IC) engine with a maximum power generation capacity of 100 kW and a maximum thermal output of 145 kW resulting in an overall system energy efficiency of 89.94 percent. Basic design parameters for the engine and controls for this project are provided in Table 3-2:

**Table 3-2 - CHP Engine Specifications**

| Manufacturer | 2G – Cenergy Power Systems Technologies, Inc. |
|---|---|
| Model | 2G 100 BG – 100-kW Biogas |
| Maximum Power Output | 147 BHP |
| Fuel | Biogas |
| Fuel Consumption | 27 $ft^3$/min |
| Exhaust Gas Flow Rate | 229 $ft^3$/min |
| Exhaust Gas Temperature | 356°F |

kW = kilowatt
BHP = brake-horsepower
$ft^3$/min = cubic feet per minute
°F = degrees Fahrenheit

### 3.3.1 Emission Calculation Inputs and Assumptions

- Hours of operation: 8,760 hr/yr; and
- Methane content of biogas: 60 percent

### 3.3.2 Emission Factors

- $SO_2$: Based on the concentration of $H_2S$ in biogas. The facility has provided a design concentration of 300 parts per million by volume (ppmv) in the biogas which is based on concentrations measured in commercial-scale DFAD facilities in Germany
- Assume 100 percent of the $H_2S$ is converted to $SO_2$ during combustion.
- $PM/PM_{10}$: 0.017 grams per brake horsepower-hour (g/bhp-hr) per 2G-Cenergy.
- Nitrogen Oxide ($NO_x$) (as nitrogen dioxide [$NO_2$]): 1.0 g/bhp-hr. Based on data provided by engine manufacturer (2G Cenergy).
- Carbon Monoxide (CO): 1.5 g/bhp-hr. Based on data provided by engine manufacturer (2G Cenergy).
- Reactive Organic Compounds (ROC): 0.19 g/bhp-hr. Based on data provided by engine manufacturer (2G Cenergy).
- Greenhouse Gases (GHGs): Based on United States Environmental Protection Agency's (USEPA's) GHG Mandatory Reporting Rule.
- Formaldehyde: 0.07 g/bhp-hr. Based on data provided by engine manufacturer (2G Cenergy).

### 3.3.3 Emission Control – Carbon Filter

- $SO_2$ control: 80 percent, per manufacturer (2G-Cenergy).

Criteria pollutant potential to emit (PTE) is provided in Table 3-3. Detailed emission calculations are provided in Appendix B.

**Table 3-3 – CHP Engine (147-bhp)**
**Criteria Pollutant Emissions**

| Pollutant | Emission Factor | Potential to Emit | | |
|---|---|---|---|---|
| | | lb/hr | lb/day | ton/yr |
| CO | 1.5 g/bhp-hr | 0.5 | 12 | 2.1 |
| $NO_x$ | 1. 0 g/bhp-hr | 0.32 | 7.8 | 1.4 |
| PM[1] | 0.017 g/bhp-hr | 0.01 | 0.14 | 0.03 |
| $SO_2$ | 0.051 g/bhp-hr [2] | 0.02 | 0.4 | 0.1 |
| ROC | 0.19 g/bhp-hr[3] | 0.06 | 1.5 | 0.3 |

[1] Assume all particulate matter (PM) is 2.5 micrograms or less. Therefore, PM emissions are equal to $PM_{10}$ and $PM_{2.5}$ emissions.
[2] Based on $H_2S$ concentration of 300 ppmv in biogas.
[3] Per 2G Cenergy. Reactive organic compound (ROC) emissions do not include formaldehyde which is a product of combustion.
$NO_x$ = nitrogen oxides
$SO_2$ = sulfur dioxide

Formaldehyde is formed during the combustion of biogas. Emission data for formaldehyde is based on the engine manufacturer's data and is shown in Table 3-4. Detailed calculations are provided in Appendix B.

**Table 3-4 – CHP Engine (147-bhp)**
**Formaldehyde Emissions**

| Formaldehyde Emission Factor (g/bhp-hr) | Controlled Potential to Emit | | |
|---|---|---|---|
| | lb/hr | lb/day | ton/yr |
| 0.07 | 0.02 | 0.5 | 0.10 |

g/bhp-hr = grams per brake horsepower-hour

GHG emissions from the engines were calculated using emission factors from the Mandatory Reporting of GHG Emissions (Code of Federal Regulations [CFR] 40 Part 98) and are shown in Table 3-5. Note that $CO_2$ emissions from the combustion of biogas are considered biogenic. Biogenic $CO_2$ emissions are not included when evaluating applicability of the GHG Tailoring Rule[2]. Detailed emission calculations are provided in Appendix B.

**Table 3-5 – CHP Engine (147-bhp)**
**Greenhouse Gas Emissions**

| Pollutant | Emission Factor (kg/MMBTU) | Potential to Emit (per engine) |
|---|---|---|
| | | ton/yr |
| $CO_2$ | 52.07 | 487 |
| $CH_4$ | 0.0032 | 0.03 |
| $N_2O$ | 0.00063 | 0.005 |

Kg/MMBTU = kilogram per million British thermal unit
$CO_2$ = carbon dioxide
$CH_4$ = methane
$N_2O$ = nitrous oxide

## 3.4 Enclosed Flare Emissions

*Proposed Source Number: S-3*

The enclosed flare will operate strictly as an emergency backup unit. An emergency would generally be defined as an unplanned outage of the CHP resulting in an accumulation of biogas or a biogas production imbalance requiring the destruction of

[2] Federal Register Vol. .76, No. 139, July 20, 2011. U.S. EPA deferred for a period of 3 years requirements of PSD and Title V permit programs for sources of biogenic $CO_2$ emissions.

biogas that cannot otherwise be stored. The enclosed flare will have a maximum design capacity of 88 cubic feet per minute (cfm) (3.0 million British thermal units per hour [MMBTU/hr] assuming 60 percent methane content). The flare exhaust will be emitted vertically with varying dispersion.

### 3.4.1 Emission Calculation Inputs and Assumptions

- Maximum capacity: 88 standard cfm of biogas;
- Maximum hours of operation: 168 hr/yr; and
- Maximum methane content of gas burned in flare: 60 percent.

### 3.4.2 Emission Factors

- $SO_2$: Based on concentration of $H_2S$ in biogas. The facility has provided a design concentration of 300 ppmv in the biogas.
- Assume 100 percent of the $H_2S$ is converted to $SO_2$ during combustion.
- $PM/PM_{10}$: $1.7 \times 10^{-5}$ lb/dry standard cubic feet methane (AP-42 – Municipal Solid Waste Landfills enclosed flare emission factor, Table 2.4-5, November 1998).
- $NO_x$ (as $NO_2$): 0.06 lb/Million British Thermal Units (MMBTU). Based on manufacturer's information.
- CO: 0.11 lb/MMBTU. Based on manufacturer's information.
- ROC: Concentration of non-methane organic compounds (NMOC) is 82 micrograms per liter (ug/l), equivalent to approximately 16 ppmv[3].
- GHGs: Based on USEPA's GHG Mandatory Reporting Rule.

### 3.4.3 Emission Control

- ROC control: 99.5 percent, per flare manufacturer.
- $SO_2$ control: 80 percent (carbon filter)

A summary of potential emissions from the enclosed flare is provided in Table 3-6.

[3] Based on highest concentration sampled in the digester gas at the East Bay Municipal Utility District's (EBMUD) wastewater treatment plant (WWTP). This value has been used in Title V permits for WWTPs permitted by the Bay Area Air Quality Management District (BAAQMD) including the Santa Rosa Wastewater Treatment facility, City of Sunnyvale Water Pollution Control plant, and the San Jose Santa Clara Water Pollution Control facility.

**Table 3-6 – Enclosed Flare**
**Criteria Pollutant Emissions**

| Pollutant | Emission Factor (before control) | Control Efficiency | Potential to Emit | | |
|---|---|---|---|---|---|
| | | | lb/hr | lb/day | ton/yr[3] |
| CO | 0.11 lb/MMBTU | NA | 0.35 | 8.4 | 0.03 |
| $NO_x$ | 0.06 lb/MMBTU | NA | 0.19 | 4.6 | 0.02 |
| PM[1] | 1.7 x 10-5 lb/dscf methane | NA | 0.052 | 1.24 | 0.004 |
| $SO_2$ | 60 ppmv Sulfur [2] | 80 percent | 0.05 | 1.28 | 0.004 |
| ROC | 16 ppmv | 99.5 percent | 0.00010 | 0.002 | 0.00001 |

[1] Assume all particulate matter (PM) is 2.5 micrograms or less. Therefore PM emissions are equal to $PM_{10}$ and $PM_{2.5}$ emissions.
[2] Based on an hydrogen sulfide ($H_2S$) concentration of 300 ppmv in biogas.
[3] Based on the flare operating 168 hours per year.
CO = carbon monoxide
$NO_x$ = nitrogen oxides
$SO_2$ = sulfur dioxide
ROC = reactive organic compounds

The biogas produced by the DFAD process will not contain significant concentrations of hazardous air pollutants (HAPs). Combustion of the biogas in the flare will eliminate any HAPs in the biogas.

GHG emissions from the flare were calculated using emission factors from the 40 CFR Part 98 Mandatory Reporting of Greenhouse Gas Emissions. Detailed emission calculations are provided in Appendix B.

**Table 3-7 – Enclosed Flare**
**Greenhouse Gas Emissions**

| Pollutant | Emission Factor (before control) | Potential to Emit | | |
|---|---|---|---|---|
| | | lb/hr | lb/day | ton/yr[1] |
| $CO_2$ | 52.07 kg/MMBTU | 364 | 8,730 | 31 |
| $CH_4$ | 0.0032 kg/MMBTU | 0.02 | 0.54 | 0.002 |
| $N_2O$ | 0.00063 kg/MMBTU | 0.004 | 0.11 | 0.0004 |
| $CO_2e$ | NA | 366 | 8,774 | 31 |

[1] Based on the flare operating 168 hours per year.
$CO_2$ = carbon dioxide
$CH_4$ = methane
$N_2O$ = nitrous oxide
$CO_2e$ = carbon dioxide equivalent
NA = Not applicable
kg/MMBTU = kilogram per million metric British thermal unit

### 3.4.4 Methane Emissions

The biofilter will control methane emissions resulting from the digester termination phase. At the end of the termination phase, the methane concentration decreases from 20 percent to approximately 1 percent over a 70 minute period. A detailed graph showing methane and carbon dioxide concentrations in the biogas versus time is provided in Appendix B.

To calculate methane emissions during the end of the termination phase, a weighted average methane concentration was determined for 4 representative methane concentration levels (20, 10, 5, and 1 percent), based on the amount of time the methane concentration remained at or near each concentration level. Based on this, the exhaust from the digester (200 cubic meters per hour) is assumed to have an average methane concentration of 2.5 percent by volume (see Appendix B for detailed calculations).

## 3.5 Emergency Backup Generator

Pursuant to Rule 74.9 the emergency backup generator will not exceed 200 hours of operation in one calendar year and is exempt from emission standards. The generator emissions are exhausted vertically and unobstructed.

## 3.6 Facility Total Emissions

Total facility potential emissions provided in the following tables:

- Table 3-7 – Criteria Pollutants;
- Table 3-8 – Toxic Air Contaminants; and
- Table 3-9 – Greenhouse Gas

**Table 3-8**
**Facility Wide Potential Emissions**
**Criteria Pollutants (ton/yr)**

| Source | CO | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | ROC |
|---|---|---|---|---|---|---|
| Material Handling | 0 | 0 | 0.05 | 0.05 | 0 | 0 |
| CHP Engine | 2.1 | 1.4 | 0.03 | 0.03 | 0.07 | 0.3 |
| Emergency Flare | 0.029 | 0.016 | 0.004 | 0.004 | 0.004 | 0.00001 |
| Biofilter | 0 | 0 | 0 | 0 | 0 | 0 |
| **Facility Total** | **2.2** | **1.4** | **0.08** | **0.08** | **0.08** | **0.3** |

CO = carbon monoxide
$NO_x$ = nitrogen oxides
$PM_{2.5/10}$ = less than or equal to 2.5/10 microns
$SO_2$ = sulfur dioxide
ROC = Reactive organic compounds

**Table 3-9 - Facility Wide Potential Emissions**
**Toxic Air Contaminants (ton/yr)**

| Source | Formaldehyde |
|---|---|
| CHP Engine | 0.10 |
| **Facility Total** | **0.10** |

**Table 3-10 - Facility Wide Potential Emissions**
**Greenhouse Gases (ton/yr)**

| Source | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$[1] |
|---|---|---|---|---|
| CHP Engine | 487 | 0.03 | 0.01 | 490 |
| Emergency Flare | 31 | 0.002 | 0.0004 | 31 |
| Biofilter | 0 | 6.93 | 0 | 145.5 |
| Facility Total | 518 | 6.96 | 0.01 | 666 |
| Biogenic $CO_2$ | 518 | - | - | - |
| **Facility Total $CO_2e$ (without biogenic $CO_2$)** | | | | 148.3 |

$CO_2$ = carbon dioxide
$CH_4$ = methane
$N_2O$ = nitrous oxide
$CO_2e$ = carbon dioxide equivalent
[1] For each source the carbon dioxide equivalent has been factored.

# 4 OFFSET REQUIREMENTS

Facility-wide offsets as specified by Rule 26.2 emission standards are as follows:

- 5.0 tpy of ROC;
- 5.0 tpy of $NO_x$;
- 15.0 tpy of $PM_{10}$; and
- 15.0 tpy of $SO_x$.

This project's emissions are well below these limitations and no emission offsets are required for this project.