



Life-Cycle Assessment of Montauk Monroeville Landfill Gas to CNG in California - San Diego Metropolitan Transit System

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BP Natural Gas and Power

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General Information

Montauk Energy Holdings, LLC (Montauk) operates the Monroeville LFG Recovery Facility, a landfill gas treatment facility in Monroeville, PA, to recover methane and process landfill gas to pipeline quality natural gas.

The anaerobic decomposition of organic wastes in landfills results in the generation of a biogas commonly referred to as landfill gas (LFG). [REDACTED]

[REDACTED] The product gas is distributed through EQT Corporation pipelines. Waste, or tail, gas is depressurized and regenerated and is sent to a flare or thermal oxidizer.

Propane is used as a process heat fuel, providing pilot gas for the flare. The propane is never co-mingled with the product gas.

[REDACTED] This estimate is based on the calculated average Actual Peak Capacity of the Monroeville facility using four years of data, 2007 and 2009-2011; 2008 was excluded from the average because of several months of downtime, thus not being representative of the facility's production capacity.

[REDACTED] Per EPA guidance, the lower heating value of methane and 77,000 BTU per gallon of renewable fuel were used to calculate the equivalent renewable fuel gallons.

Pipeline grade LFG is transported via pipeline from Monroeville to California for compression and sale. The following pathway was produced using two years (May 2013 – May 2015) of landfill gas production data and two (2) years (July 2011 – June 2013) of CNG compression data.¹

Process Description

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

[REDACTED]

- [REDACTED]
- [REDACTED]

¹ Please see Annex 2 for Monroeville Facility Energy Data Analysis, Annex 5 for gas sales receipts, and Annex 4 for CNG Station Electrical Efficiency Data

² Information is sourced from Annex 3 Engineering Review Report, pg. 4-5

[REDACTED]

Data Collection and Process Results

To estimate GHG emissions, the energy and materials necessary for the following processes needs to be determined: LFG Production Plant, Transport of Gas to California (Pipeline), and Compression.

LFG Production Plant

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

[REDACTED] The
Monroeville facility imports electricity to purify the landfill gas and uses the Waste Management flare located on the landfill property to combust off-gases generated during the purification steps and when the plant is not operating. Since Monroeville is utilizing a flare that already runs constantly, there is no additional pilot fuel required for combusting the Monroeville off-gas.

Table 1 below shows the available data provided by Monroeville for input biogas, product biogas, biogas consumed on-site, and imported electricity for the two years' worth of data. The balance of

³ Annex 2, Summary tab, cell H18 [REDACTED]

⁴ Please see Annex 2, Inlet tab, cell G2 for the calculation of this figure

⁵ Please see Annex 2, Summary tab, cell L5 for the calculation of this figure

the biogas consumed in the flare is calculated based on data provided by Monroeville. The table also shows the provided data converted to GREET model inputs. The Monroeville pathway utilizes the CA-GREET default values for LFG recovery.

[REDACTED] To determine combustion emissions from the consumed natural gas and landfill gas at the landfill gas plant, the GREET default values for natural gas combustion process for natural gas liquefaction (100% natural gas turbine) were chosen since they represent the processes more closely than natural gas compression (100% natural gas engine).

TABLE 1. MONROEVILLE LFG PLANT OPERATING ENERGY AND FLARE CREDIT⁶
 (THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

	Btu/MMBtu of Product Gas	Input Value	Btu/MMBtu of Product Gas	Changed Cells – NG Tab
[REDACTED]	[REDACTED]	[REDACTED]		
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Below is a simplified process diagram of the facility that includes the estimated energy flow associated with each step of the LFG recovery process.

⁶ Please see Annex 2, Summary tab for the calculations of the figures presented in this table
⁷ Please see Annex 5 for PDFs of gas sales invoices
⁸ Please see Annex 6 for PDFs of facility electricity bills
⁹ Please see Annex 1 for the Modified GREET model referred to in this report

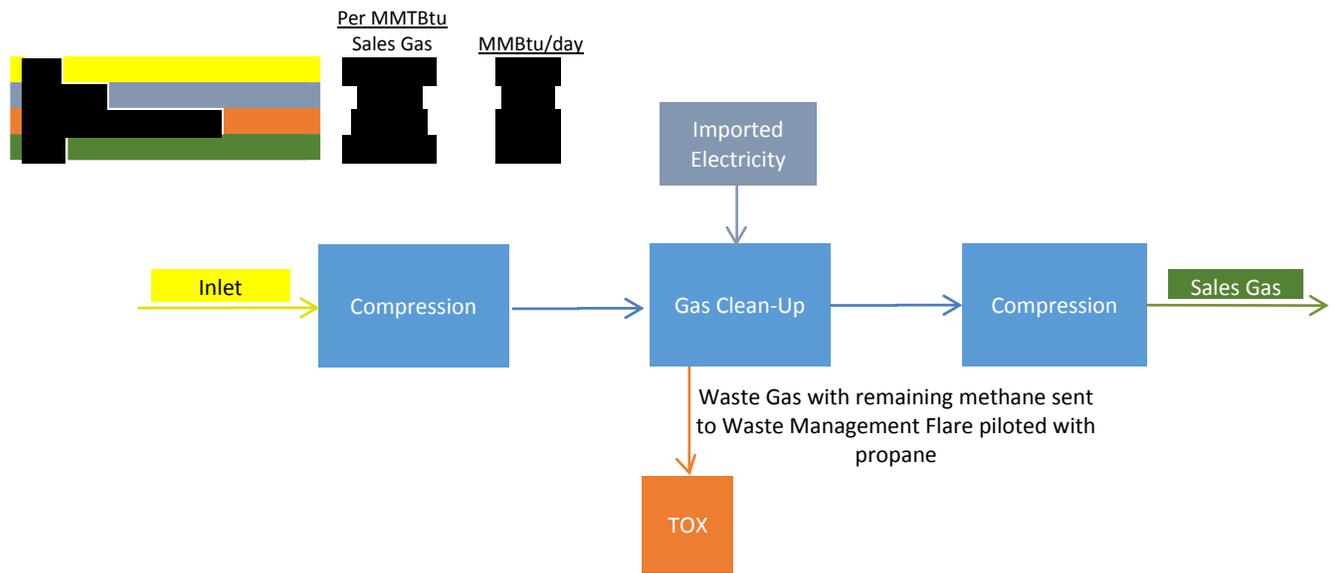


Figure 1. Monroe Process per MMTBtu and MMTBtu/day Energy Flows

The GREET model LFG pathway was then modified to adjust efficiency gas and process energy shares as listed in Table 2. The Southeast Asia region on the Regional LT tab was changed to the RFC West (RFCW) Region to represent the 2012 eGRID data for year 2009 (8th Edition¹⁰) where Monroe, PA is located. The ARB methodology of converting eGRID electricity mix to marginal mix was employed. This changed the electric mix cells of J83-J88 on the Region LT tab to those shown in Table 2. The remaining values from the Southeast Asia Region (now the RFCW region) were changed to match the US Average. The default LFG transport distance of one mile was used since the distance between the Monroe LFG Recovery Facility and the Monroe landfill is less than 1 mile, as can be seen in Figure 2 below.

¹⁰ eGrid 8th Edition Version 1.0, Year 2009 Summary Tables, created May 2012.
www.epa.gov/cleanenergy/documents/egridzips/eGRID_8th_edition_V1-0_year_2009_Summary_Tables.pdf



Figure 2. Proximity between Monroeville LFG Facility (identified location) and the Monroeville Landfill

TABLE 2. RFCW ELECTRICITY GRID MIX

	eGRID CY2009 Grid Mix	Marginal Grid Mix	CA-GREET Cell Regional LT Tab
Residual oil	0.76%	0.76%	J83
Natural gas	3.51%	27.92%	J84
Coal	69.88%	69.88%	J85
Nuclear	23.56%	0.00%	J86
Biomass	0.51%	0.51%	J87
Other (renewables)	1.73% (w/ hydro)	0.94% (w/o hydro)	J88

This produced the results for LFG to pipeline biogas shown in

Table 3 below. These values are taken from the NG Tab of the Modified GREET model which can be found in Annex 1 of the supporting documents submitted in conjunction with this report. Conversion from g/MMBtu to g/MJ was done using the conversion factor of 1055.055 MJ/MMBTU as is done in the CA-GREET model.

The recovery energy and emissions are based on ARB LFG pathway defaults of 4621.25 Btu of electricity/MMBtu of landfill gas.¹¹

¹¹ http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf; page 9.

TABLE 3. MONROEVILLE LFG PLANT GREENHOUSE GAS EMISSIONS

(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

	Recovery Emissions	Monroeville LFG Plant	CA-GREET Cell NG Tab
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Transportation to California by Pipeline

The pipeline transport distance was modified to [REDACTED] where the gas will be compressed. The distance was determined by the using the driving route most similar to the pipeline map. Google Maps was used to determine the driving routes with the I-10 route most similar to the pipeline map. The emissions were determined by linked cell E148 on the NG tab to cell F479 on the T&D_Flowcharts tab for LFG to CNG. The table below shows the pipeline transport emissions from cells F151-F157 on the NG Tab.

TABLE 4. MONROEVILLE LFG TRANSPORT GREENHOUSE GAS EMISSIONS

(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Transport Emissions	Monroeville LFG Transport
[REDACTED]	[REDACTED]

Compression

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Based on the submitted Confidential Business Information from SD Metro, SD Metro will be submitting for one pathway for their CNG Stations based on two (2) years of data (July 2011- June 2013). [REDACTED] Table 5 and

Table 6 below show the calculation from kWh/GGE to process efficiency and the cells that were changed and the results from cells G151- G157.

TABLE 5. CNG STATION PLANT OPERATING EFFICIENCY
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

All Units in Btus per GGE	Compression	Input Value	Changed Cells – NG Tab
[REDACTED]	[REDACTED]		
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

TABLE 6. CNG COMPRESSION GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Recovery and Processing Emissions	Compression
[REDACTED]	[REDACTED]

¹² Please see Annex 4 for the CNG station Electrical Efficiency Data

¹³ 109,772 Btu/GGE default CA-GREET value

Monroeville Fuel Pathway Results

When the CA-GREET model is run completely with the modifications listed above, the table below shows the complete pathway results. The WTT pathway gCO₂e/MJ results were taken from cell H158 which is the sum of cells E158 – G185 on the “NG” tab for CNG. The TTW gCO₂e/MJ was taken from the Detailed California-Modified GREET Pathway for Compressed Natural Gas (CNG) from Landfill Gas¹⁴.

TABLE 7. MONROEVILLE PATHWAY RESULTS

GHG Emissions (gCO ₂ e/MJ)	Monroeville LFG Plant to CNG
[REDACTED]	[REDACTED]
gCO₂e/MJ WTW	33.30

¹⁴ http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf

Appendix B: List of Supporting Annexes

Monroeville Pathways Annex 1 - Modified GREET model_LFG to CNG

Monroeville Pathways Annex 2 - Facility Energy Data Analysis

Monroeville Pathways Annex 3 - Engineering Review Report

Monroeville Pathways Annex 4 - SD Metro Calculation Summary File

Monroeville Pathways Annex 4a - SD Metro Invoices

Monroeville Pathways Annex 5 –Sales Gas Invoices

Monroeville Pathways Annex 6 –Electricity Invoices