Life-Cycle Assessment of Altamont Landfill Gas to LNG and LCNG in California – Tier 2 Application

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Submitted to:

High Mountain Fuels

Prepared by

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General Information

The High Mountain Fuels LNG Plant is located in Livermore, CA. It is owned and operated by High Mountain Fuels, a joint venture between Waste Management and Linde. The plant processes, cleans and liquefies LFG from the Altamont Landfill to LNG that is distributed to stations in California for use as LNG or LCNG by Waste Management. The registered capacity of the landfill plant is [redacted] renewable equivalent gallons per year. Waste Management Renewable Energy (WMRE) operates a previously installed turbine electricity generation plant that takes landfill gas to electricity that supplies electricity to the LNG landfill gas plant. The energy and emissions associated with the electricity produced for LNG production are included in this analysis.

LNG is transported via truck around California. Three different carbon intensities have been developed to encompass the possible transportation distances: [redacted] is the farthest location LNG is delivered and this pathway will be used for all LNG transported farther 50 miles. The following pathways were produced using 2 years (Jan 2015 – December 2016) of landfill gas liquefaction and electricity generation data.[1]

Data Collection and Process Results

To estimate GHG emissions, the energy and materials necessary for the following processes needs to be determined: LFG Extraction and Liquefaction Plant, Electricity Generation, and Transport.

Feedstock Production

(This Section contains Confidential Business Information)

Landfill Gas Extraction

The recovery energy and emissions are based on the LFG pathway default of 99.54% recovery efficiency in the Tier 1 Calculator using 100% electric blowers to recover and transport the landfill gas to the processing plant. The electricity for the blowers comes from the onsite power generation unit. Using the default energy efficiency, approximately 1.35kWh of electricity is needed per MMBtu of raw landfill gas.[2] [redacted]

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[1] Please see Energy Template, High Mountain Fuels Tab.
[2] Please see Energy Template, High Mountain Fuels Tab, cell G44 for the calculation

Figure1. Proximity between High Mountain Fuels (identified location) and the Altamont Landfill

Also, since the landfill gas upgrading is taking place during the liquefaction stage, the efficiency for RNG Upgrating is changed to [redacted]. These values are changed to [redacted] so there is no double counting of emissions in the CA-GREET model.

TABLE 1. CELL UPDATES – RNG EXTRACTION AND UPGRADING[3]

	Input Value	Changed Cells – RNG Tab of Tier 2 CA-GREET
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Fuel Production - Liquefaction

Landfill Gas Processing/Liquefaction

The data from High Mountain Fuels show a total of [redacted] were sent to the LNG facility for January 2015 – December 2016. The gas had an average methane content of approximately [redacted] from sampling data over the 2 year time period.[5] WMRE produces

[3] Please see Energy Template
[4] Please see Energy Template, High Mountain Fuels Tab
[5] Please see Energy Template, High Mountain Fuels Tab

onsite electricity to extract and liquefy the landfill gas and uses the flare located on the landfill property to combust off-gases generated during the purification steps.

For the electricity generation plant, ICF reviewed the monthly generation plant reports and extracted the data for LFG methane content, total flow to the turbines (in kscf), and total electricity produced. The MMBtus of LFG from the electricity plant allocated to liquefaction and LFG extraction were quantified by calculating the Btu of landfill gas and natural per kWh produced[6] and multiplying by the total kWh sent from the electricity plant to the LNG plant plus the electricity used for LFG extraction. [redacted]

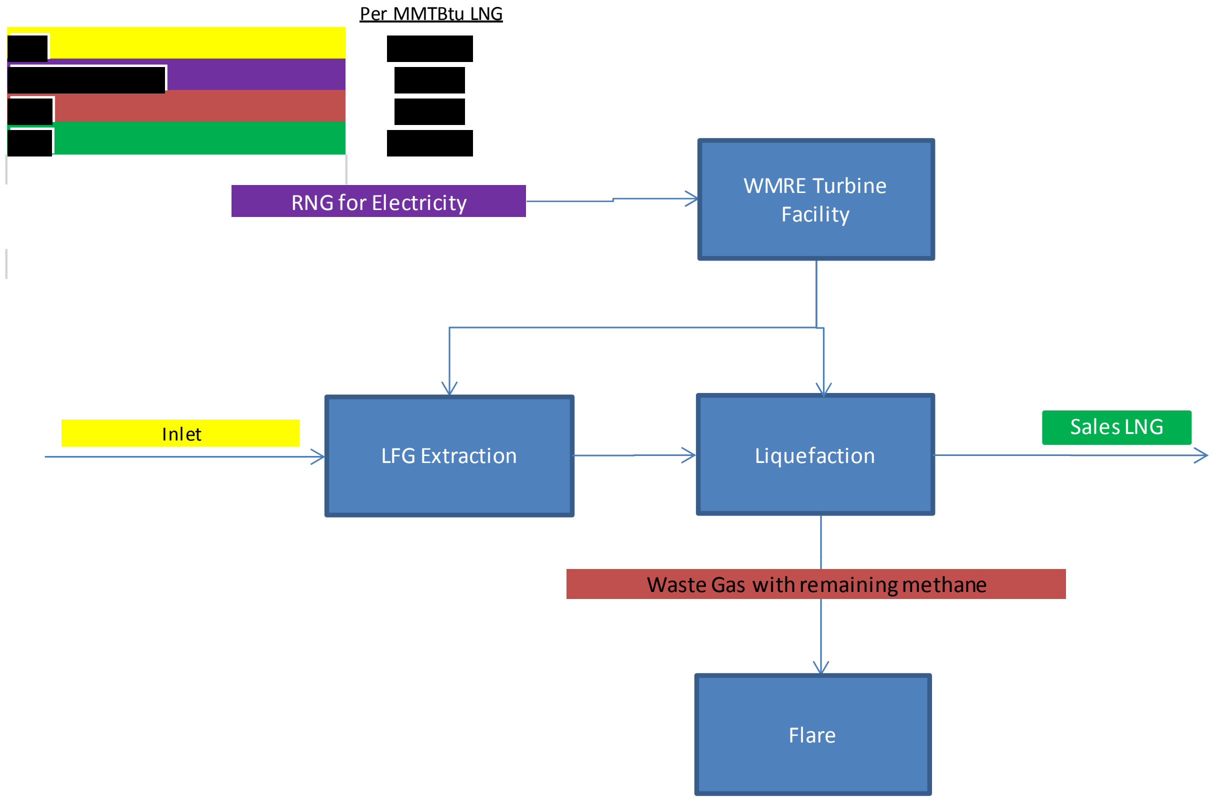
Table 2 below shows the available data provided by High Mountain Fuels for input biogas, product biogas, biogas consumed on-site, and imported electricity for the two years' worth of data. The balance of the biogas consumed in the TOX is calculated based on data provided by High Mountain Fuels. The table also shows the provided data converted to GREET model inputs. The High Mountain Fuels pathway utilizes the CA-GREET default values for LFG recovery. [redacted].

TABLE 2. HIGH MOUNTAIN FUELS LFG PLANT OPERATING ENERGY AND FLARE CREDIT[7]

	Facility Data	Btu/MMBtu	Input Value	Changed Cells – RNG Tab of Tier 2 CA-GREET
[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] See cell E41 of the Energy Template, High Mountain Fuels Tab.
[7] Please see Energy Template



Model Modifications

ICF converted colum [redacted] from electricity export to “Onsite Electricity Production” using emission factors for small turbines (column F on the EF tab). The emission factors for the landfill gas consumed in the thermal oxidizer in cells [redacted] were modified to include all LFG sent to both the high BTU plant and the electricity plant.

Fuel Transport

Three different transport distances were identified to span the likely pathways (1 mile and 50 miles) and the most conservative transport distances (457 miles). The table below shows the LNG and LCNG stations where the LNG can be delivered to. The Livermore Station, across the street from the landfill, is the station for the one mile distance pathway. [redacted] would use the 50 mile distance pathway and all other stations would use the 457 mile distance pathway. ICF modified [redacted] on the RNG tab to link to [redacted] on the T&D_Flowcharts tab to allow for easy manipulation of the transport distance. The distances of 1 mile, 50 miles and 457 miles were entered into cell [redacted] of the RNG tab.

			2016 LNG Volume (gal)												
LNG Usage Location	Region	Distance from Altamont LNG Plant (mi)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total 2016
[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]	[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]
[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]	[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]
[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]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Also, the model was adjusted to positively identify that boil off controls are utilized at the stations and storage facilities through identifying “Yes” in cell [redacted] on the RNG tab.

LCNG Conversion

ICF used the Tier 1 Calculator default values for LCNG regasification and compression efficiency shown in the table below. The table also shows the cells modified with the Tier 1 calculator values.

TABLE 3. HIGH MOUNTAIN FUELS PATHWAY RESULTS

	Tier 1 Default Value	Cell Modified on NG Tab	Cell Modified on RNG Tab
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]		[redacted]

High Mountain Fuels Fuel Pathway Results

Selected Electricity Grid Mixes and Region for Crude Oil Use

The CAMX 2012 eGRID region was used to model the entire High Mountain Fuels facility since the entire fuel cycle occurs in California. When running the Tier 2 calculator for High Mountain Fuels, the following options were chosen:

- Cell D5 – Option 1
- Cell B6 – Landfill Gas
- Cell C6 – LNG
- Cell E7 – LNG Pathway (RNG Source)

When the CA-GREET model is run completely with the modifications listed above, the table below shows the complete pathway results. The total WTW CI is taken from cell X728 of the RNG tab for LNG and AL728 for LCNG for each distance.

TABLE 4. HIGH MOUNTAIN FUELS PATHWAY RESULTS

GHG Emissions (gCO_2e/MJ)	LNG 1 mile	LCNG 1mile	LNG 50 miles	LCNG 50 miles	LNG 457 miles	LCNG 457 miles
Feedstock Production						
[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]	[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]
gCO_2e/MJ WTW	**7.38**	**9.95**	**7.74**	**10.31**	**10.70**	**13.27**