Production of CNG from Dairy Digester Biogas
(Bakersfield, CA)
CalBio LLC

Summary

CalBio proposes to build a dairy manure digester cluster in Bakersfield, CA that captures biogas generated in anaerobic lagoons and converts it into CNG for use in vehicles. The carbon intensity (CI) of the proposed Dairy Digester Biogas to CNG pathway is –276.24 g CO_2e/MJ.

Pathway Summary

A Well-To-Tank (WTT) fuel cycle analysis of dairy biogas to CNG includes all steps from biogas capture by the covered lagoons in Bakersfield to CNG compression at retail stations. Tank-to-wheel (TTW) analysis includes fuel combustion in a vehicle. Together, WTT and TTW analysis are combined to provide a total well-to-wheel (WTW) analysis that determines the fuel cycle greenhouse gas emissions, also known as carbon intensity (CI), associated with dairy digester biogas to CNG.

The dairy digester cluster produces raw biogas, which is collected and transported to the upgrading faculty by a network of pipelines located within a10 miles radius. The raw biogas is cleaned up in the central upgrading unit to produce pipeline-quality biomethane. The source of energy for the upgrading unit is California average grid electricity. The biomethane is transported via pipeline to retail stations where it is compressed to CNG. The CNG is delivered to light duty and heavy-duty CNG vehicles. This document details the energy and inputs required to produce CNG from dairy biogas.

The framework for the pathway is provided by the CA-GREET Dairy Biogas to CNG pathway. The system boundary diagram in Figure 1 shows the components that form the Dairy Digester Biogas to CNG pathway. Indirect land use change (ILUC) impact of this pathway is negligible.

Avoided GHG emissions due to methane capture by converting the open lagoon to the covered lagoon are estimated using the Compliance Offset Protocol for Livestock Projects. The avoided GHG emissions (methane) are verified independently by a third party.

This document summarizes the input parameters necessary to represent CalBio's pathway and the life cycle energy and greenhouse gas emission results calculated by the CA_GREET1.8b model.

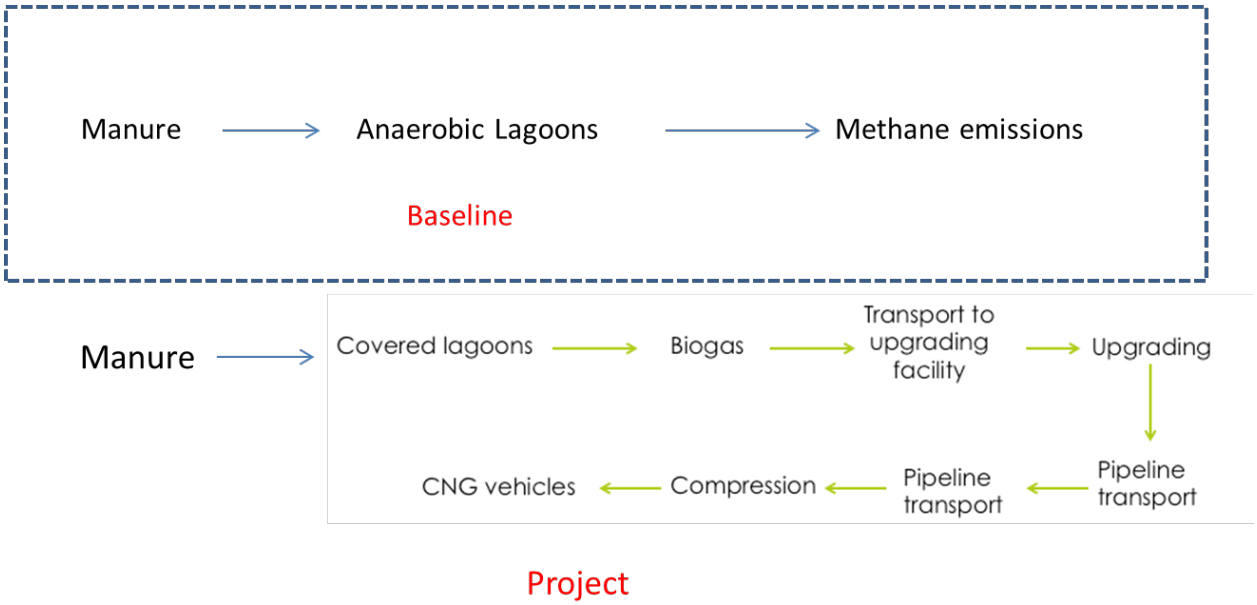

Figure 1. System Boundary Diagram for Dairy Digester Biogas to CNG

Result Summary

The well-to-tank (WTT) results for CNG from biogas is -319.61 g CO2e/MJ. These results include GHG offset credits from methane avoidance. The TWW emissions include vehicle methane and N_2O emissions. The well-to-wheel (WTW) emissions are -276.24 g CO2e/MJ.

Table 1. Total Carbon Intensity for CalBio dairy digester biogas to CNG pathway (g CO_2e/MJ)

Pathway	Direct CI	Indirect LUC	Total
Dairy digester biogas to CNG	-276.24	0	--276.24

CalBio dairy digester biogas to CNG pathway

Biogas production in covered lagoons

Due to moderate climate in Bakersfield, California, the covered lagoons are not heated to maintain temperatures. There are no energy requirements for handling, storage and disposal of manure as they are based on gravity flow. Therefore, there is no energy use in biogas production.

On the other hand by converting the open lagoons to the covered lagoons, the methane that otherwise would have been released to the atmosphere is captured. Since there are still some methane releases from storage/treatment ponds, venting operations and leakage from the covered lagoon, the net avoided

methane emission is less than what is released from the open lagoons. These methane emissions are estimated using the Compliance Offset Protocol for Livestock Projects. The baseline methane emissions and project methane emissions are summarized in Table 2 below. As shown below, the net emission avoided methane is 1294.2 MT/yr.

Table 2: Baseline and project methane emissions from one of the covered lagoons in Bakersfield, CA.

Project methane emissions	Amount (MT CH4/yr)
Digester Leakage	Redacted
Venting	Redacted
Effluent ponds	Redacted
Storage/Treatment	Redacted
Total project CH4 emissions	Redacted
Baseline methane emissions	Redacted
Net offset	1294.2
Net Methane output from upgrading	1876.9

Methane emissions from biogas production and capture are then calculated per unit of fuel produced. The net of these values becomes the subtotal CI (avoided reference case methane emissions, biogas production and capture stages) that is input to CA-GREET from the Offset Protocol calculations.

Net methane emissions from biogas production and capture are calculated per unit of fuel produced as:

$$\frac{1294\ \frac{MT\ CH4}{yr} \times 10^6 \frac{g}{MT}}{1876.9\ \frac{MT\ CH4}{yr} \times \frac{ft^3}{20.3\ g} \times \frac{962\ Btu}{ft^3}} = -14{,}550.6\ \frac{g\ CH_4}{MMBtu}$$

$$= -363{,}765\ \frac{g\ CO_2e}{MMBtu} = -344.78 \frac{g\ CO_2e}{MJ}$$

The remaining emissions from biogas upgrading and transport are calculated directly in CA-GREET1.8b using default parameters. Once operational, the applicant will submit data to verify the emissions and energy use in upgrading.

Figure 2 shows the site location of the proposed dairy digester cluster in Bakersfield, CA. Figure 3 shows the location of the upgrading facility and proposed pipeline network for gathering biogas.

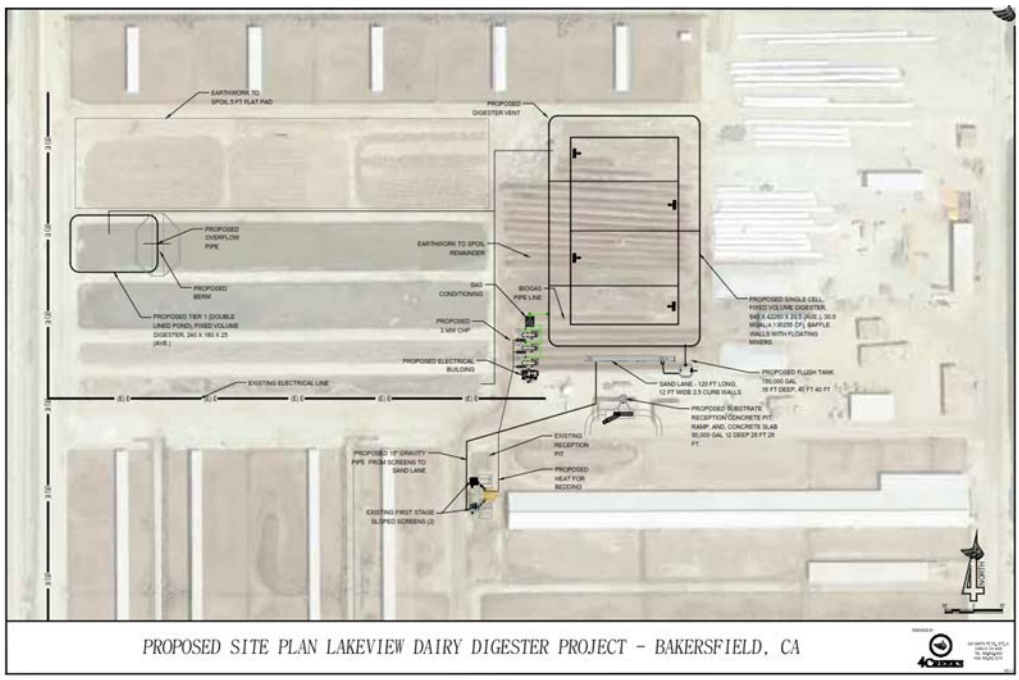

Figure 2: Proposed site plan in Bakersfield, CA

Biogas transport to upgrading facility

The raw biogas from the covered lagoons is transported to the upgrading facility via pipeline. The transport distance is 10 miles. Pipeline energy and leakage parameters for raw biogas are assumed to be equivalent to the default energy and leakage parameters for natural gas.

Biogas Upgrading

The raw biogas is upgraded at the central upgrading facility. Electricity is used to operate the upgrading unit. The input parameters for the upgrading unit are presented below in Table 3.

Table 3. Key Parameter Inputs for biogas upgrading

CA_GREET Inputs	Units	
Plant Energy	(Btu/mmbtu)	166,231
Process Fuel Shares (Fossil)		
Electricity	% of total	100%
Feed loss	% of biogas	1%

Biomethane transport to retail stations via pipeline

The biomethane is injected into the utility pipeline located close to the central upgrading facility and is transported to retail stations. Transport emissions are calculated using the CA-GREET model default distance of 1500 miles. The region is set to California Marginal as specified in the Regional LT.

Table 4. Input Parameters for Biomethane Transport

Mode	Distance (mi)	Mode Share
Pipeline	1500	100%

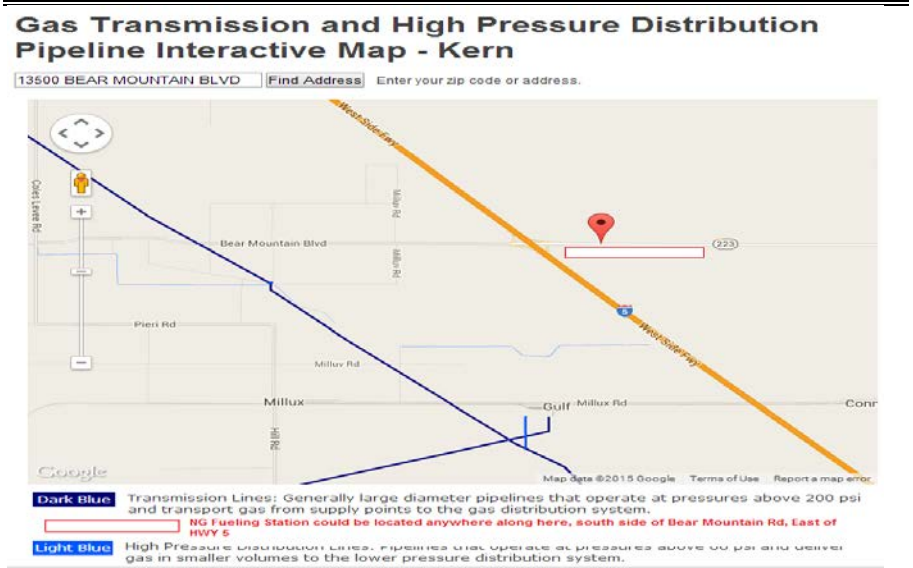

Fig. 3.Map of the natural gas pipeline in the vicinity of the proposed upgrading facility.

Modifications to the CA_GREET Model

CalBio has conducted its analysis of well to wheel carbon intensity for this pathway using (CA_GREET, v.1.8b (Dec. 2009) (See http://www.arb.ca.gov/fuels/lcfs/ca_greetl.8b_dec09.xls)). The standard inputs and parameters specified in CA_GREET remain unchanged except as noted in Table 4 as shown below. Emissions from CNG production from dairy biogas are calculated by selecting California Marginal in the regional LT tab.

Table 5. Changes to Input Parameters of GREET 1.8b Model

Parameters	CA_GREETv1.8b	CA_GREETv1.8b	CalBio_CA_GREETv1.8b
	Worksheet Location	**Default Cell Value**	**Dairy biogas to CNG**
Biogas Collection Electricity	NGFN79	100%	0%
Biogas production			
CO2 credit	NGFP107	-66378 g/mmbtu	-363764.6 g/mmbtu
Biogas upgrading			
Electricity	NGF091	65,686 btu/mmbtu	166,231btu/mmbtu
Feed Loss	NGFO92	0 btu/mmbtu	10101btu/mmbtu
Natural gas	NGF085	143,504 btu/mmbtu	0 btu/mmbtu

Life Cycle Results

The life cycle energy and greenhouse gas emission results for CNG production from dairy biogas are shown below. The complete data set for biogas production, upgrading, transport and compression as well as the total WTW emissions are presented in Table 6. The GREET inputs for each step in the life cycle are included in the Modification to the CA_GREET model section of this document.

Table 6. Energy and Greenhouse Gas Results for the dairy digester to CNG pathway (Btu/mmBtu and g/mmBtu)

	Results are specified as BTU or grams per MMBTU of CNG
Energy Inputs (Btu/mmBtu)	
Total energy	383,725
Fossil fuels	284,014
Coal	92,496
Natural gas	188,887
Petroleum	2,631
Emissions (g/mmBtu)	
VOC	3.187
CO	17.893
CH_4	257.553
N_2O	0.386
CO_2	20297
Avoided methane	-14550.6
Total GHG (gCO_2e/mmBtu)	-337205.2
(g CO_2e/MJ)	**-319.61**
Indirect Land Use Change	0
TWW emissions (g CO_2e/MJ)	43.37
Total Carbon Intensity	**-276.24**