MAAS ENERGY WORKS

Life-Cycle Assessment of FM Jerseys Digester Project

Upgrading Facility Location
16301 Road 124, Tipton, California
93272 United States

Mailing Address
3711 Meadow View Drive
Redding, CA 96002

Submitted By
Maas Energy Works, LLC

Contents

Introduction

This Well-to-Wheels lifecycle analysis report was prepared to define the California Low Carbon Fuel Standard (LCFS) Tier 2 pathway application for dairy manure to compressed natural gas (CNG) from the FM Jerseys (FMJ) site. Cows at FM Jersey Dairy are housed in a combination of free stalls and open lots. The collected manure passes into a covered lagoon anaerobic digester; the biogas is the feedstock to an onsite upgrading facility. The gas is then upgraded to pipeline quality and is sent via truck to Calgren Dairy Fuels (CDF) where it is injected into a common carrier pipeline. Ultimately dispensed for transportation use as CNG for the purpose of credit generation under the LCFS program. The inputs for the lifecycle modeling in the Tier 1 Simplified Calculator is from July 2021 to June 2023. The resulting carbon intensities (CI) of the CNG in these pathways is –426.46 g $CO2eMJ^{-1}$

CDF sells the biomethane as CNG and generates environmental credits under the LCFS program and environmental credits under RFS2, respectively, under Calgren Dairy Fuels (Facility ID: 72421, RFS ID: 6560) that became effective in August 2022. FMJ previously has not participated in the Cap-and-Trade offset program.

Manure Management

The baseline case represents dairy operations before the digester project was in place, and the project case represents dairy operations after the digester project was in place. Within the Manure-to-Biogas (LOP Inputs) tab of the DSM Calculator, the baseline is represented by tables L1 and L2, while the project is represented by tables L4, and L5. Calculated volatile solids (VS) capture rates resulting from manure management practices are displayed in the application's Mass balance.

FM Jerseys
Overview

Blue Boxes show flushed sections of the dairy
Orange Boxes show the manure lagoons
The red box shows the separator
Green Box shows the Covered Lagoon digester
CH4 Upgrading Equipment

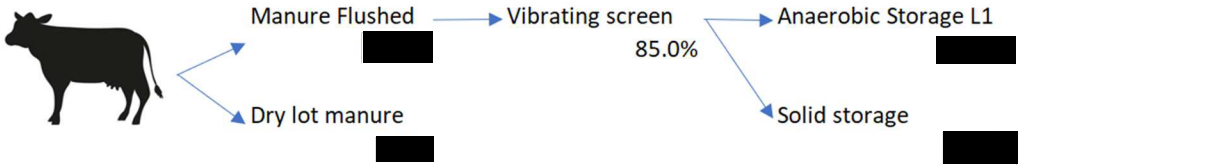
Baseline

The dairy and original manure lagoon were constructed in 2017. Cows at FM Jersey Dairy are housed in a combination of free stalls and open lots. The cows in the free stalls have no access to exercise pens, this results in [redacted] VS collection for the cows. For dry cows housed in open lot corrals, not all the manure falls on collectable surfaces. Using values adopted by Climate Action Reserve in its Cap-and-Trade verification studies and similarly used in other research articles, we calculate that [redacted] of the VS from open lot dry cows is collected by flushing the concrete feeding/transfer lanes. This [redacted] VS rate is used for the other herd types. The remaining [redacted] is modeled as degrading on the open lot. All captured manure passes over a vibrating slope screen separator which removes 15% of the Volatile Solids. The removed solids are dried and used as bedding or land applied. The remaining VS passes to the storage lagoons in the baseline or the digester in the project.

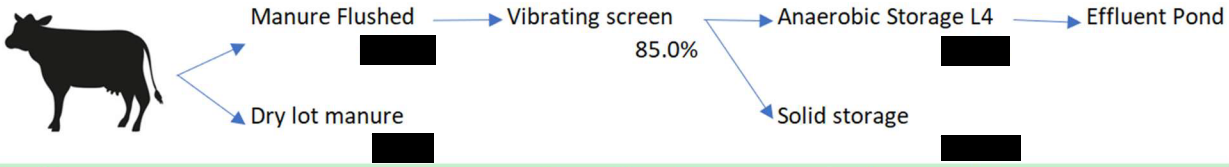
The total monthly contributing cow count averages roughly [redacted] cows. FMJ houses all milk cows in free stalls. Milking animals spend some time on exercise pens. See the below table for allocations. The captured manure passes over a vibrating slope screen separator. 15% of the VS is removed from the capture stream, where it is dried passively in windrows for ultimate field application. The remaining thin portion passes into anaerobic storage where it is later field applied.

Herd 1	Dairy cows (on feed)

Baseline

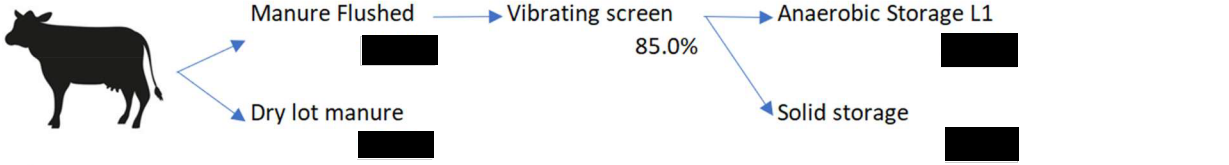


Project

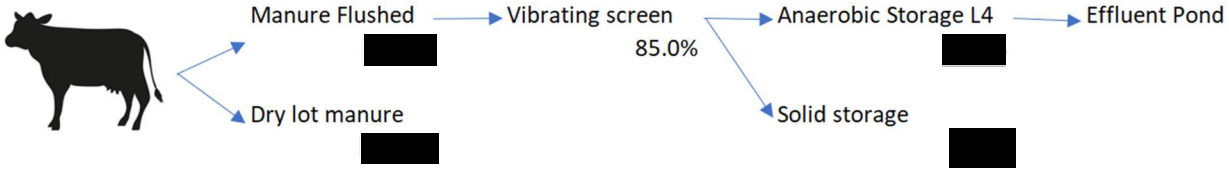


Herd 2	Non-milking dairy cows (on feed)

Baseline

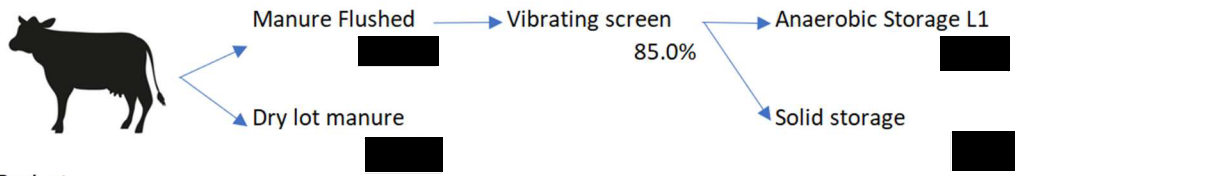


Project

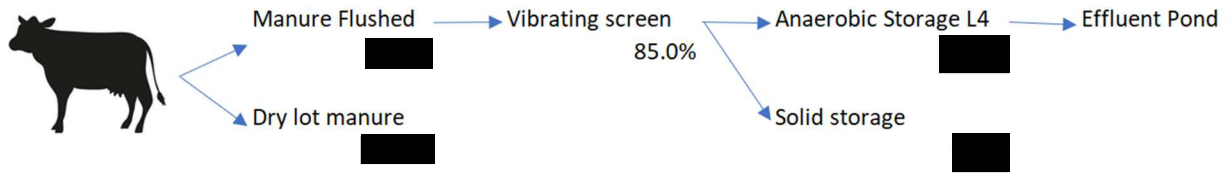


Herd 3	Heifers (grazing)

Baseline



Project



FM Jerseys
Baseline Manure Flow

Blue Boxes show flushed sections of the dairy
Orange Boxes show the manure lagoons
The red box shows the separator

Project

FMJ completed construction of the digester project started in 2019 and was completed in March 2021. After installation of the project, the dairy sends the same manure flow to the vibrating slope screen separator. The manure now flows into the digester, digestate from the lagoon digester then passes to a storage lagoon where it is subsequently used to irrigate fields. Digestion of the manure, now controlled, is more complete. Significantly, methane emissions previously released to the atmosphere are now captured and processed for use as vehicle fuel.

FM Jerseys
Project Manure Flow

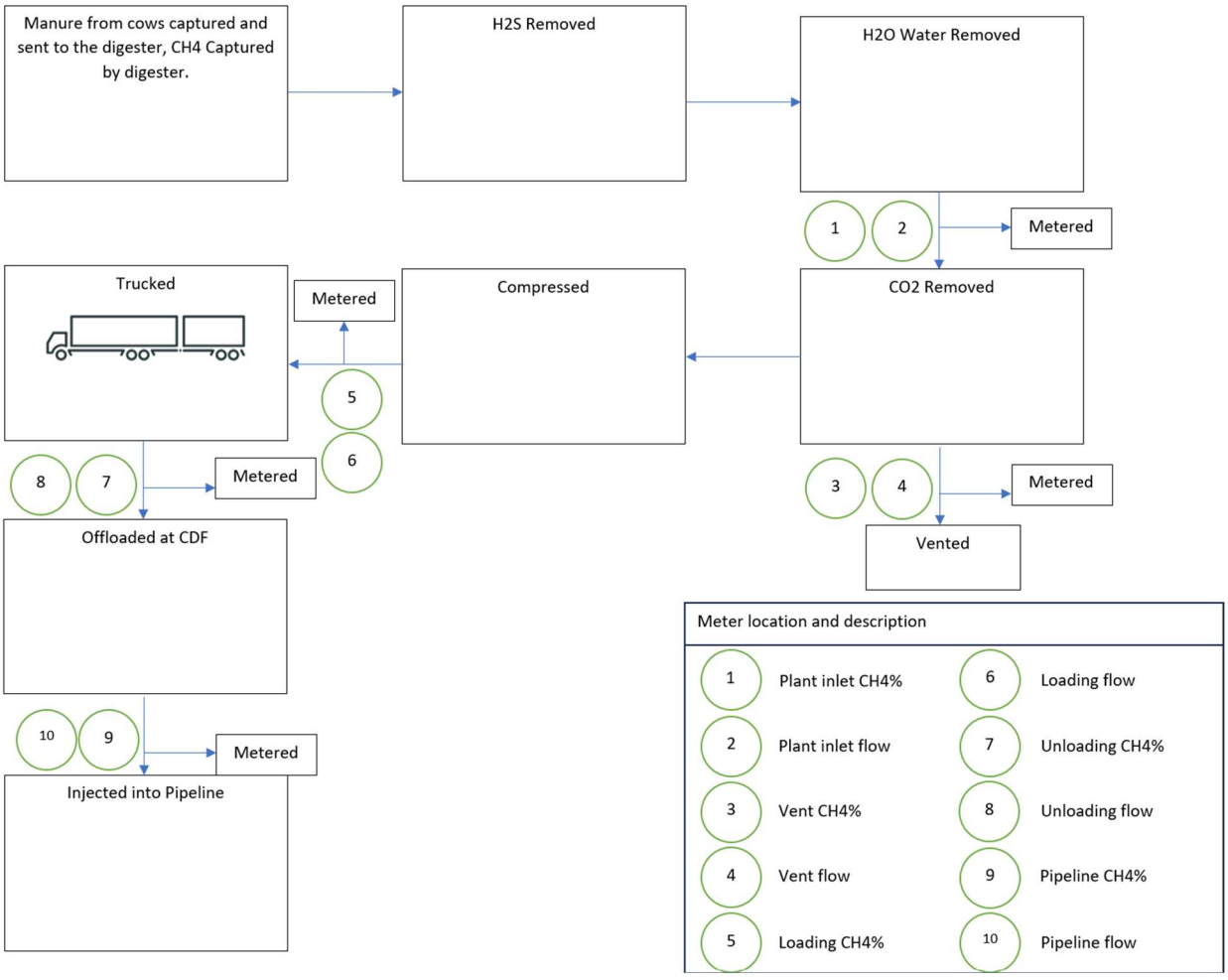
Blue Boxes show flushed sections of the dairy
Orange Boxes show the manure lagoons
The red box shows the separator
Green Box shows the Covered Lagoon digester
CH4 Upgrading Equipment

Project Description

Biogas Upgrading to Biomethane

The captured gas is comprised of methane, carbon dioxide and trace constituents such as hydrogen sulfide. Biogas production flow data is recorded and measured every 15 minutes using a flow meter and methane concentration which is measured continuously and recorded every 15 minutes. The resulting cleanup up biomethane is also metered every 15 minutes and the methane concentration is metered continuously. The CNG is then transported via truck where it is loaded and unloaded BOL. At Calgren, there is a meter recording flow and CH4 content every 15 minutes. Electricity for digester operations at FM Jersey Dairy is supplied by PG&E.

The inlet biogas is anticipated to contain 60 -70 percent methane (CH4), 25-30 percent carbon dioxide (CO2), approximately 1-6 percent moisture content, and trace amounts of nitrogen (N2), oxygen (O2), and hydrogen sulfide (H2S). The regulated pollutant in the inlet digester gas is VOCs, NH3 Sulfur, and H2S. The gas has the H2S and H20 removed before being metered. There is a membrane system which removes the CO2. This process cleans the Biogas to pipeline specifications. The CNG is then compressed for transport and sent to CNG for injection into common carrier pipeline. No non-renewable material is blended with the biogas prior to final flow and gas analyzer readings. All off the compressors are single-screw, oil-filled. The heat of compression is removed from the oil via air coolers. The heat of compression is removed by a heat exchanger.

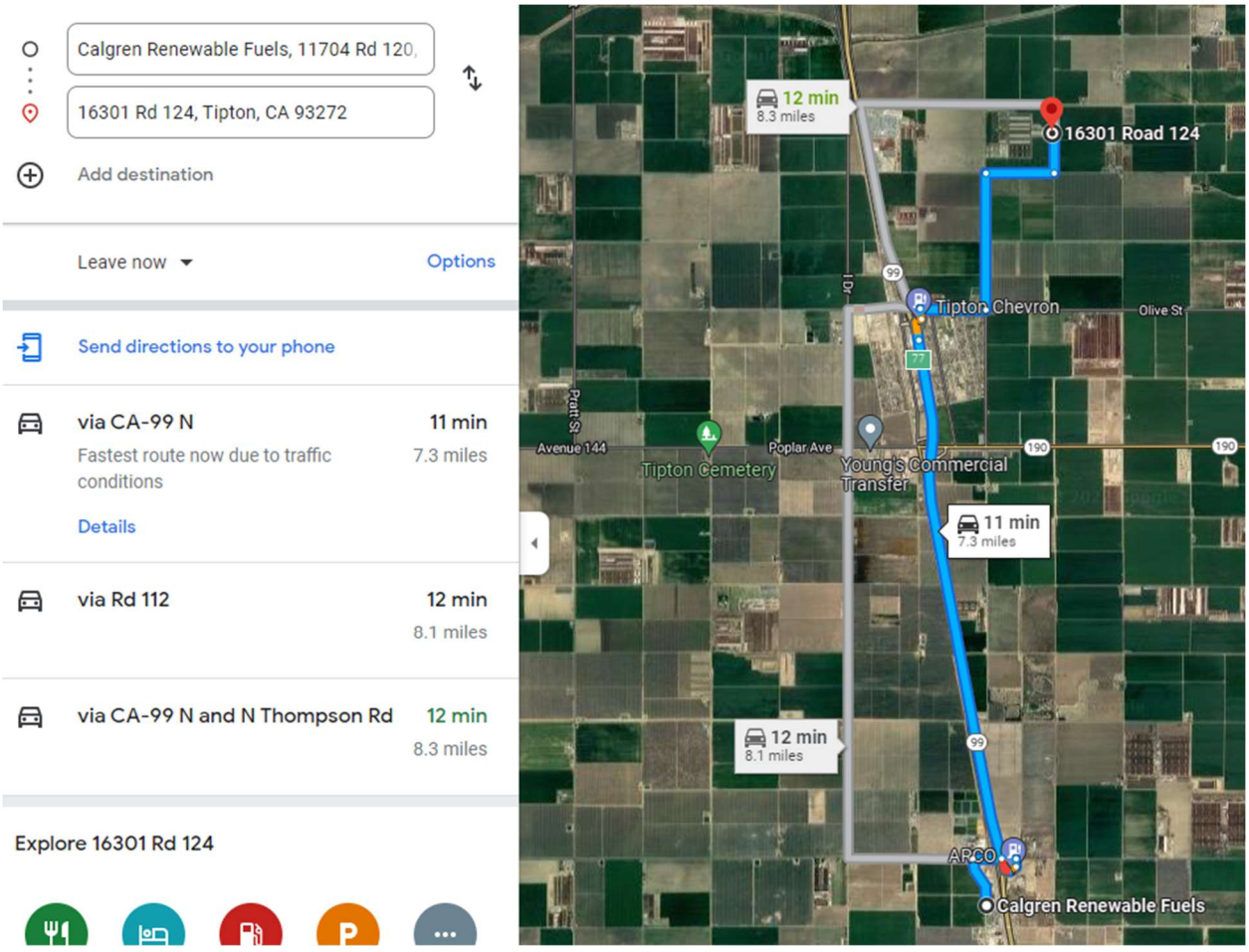


Biomethane Injection

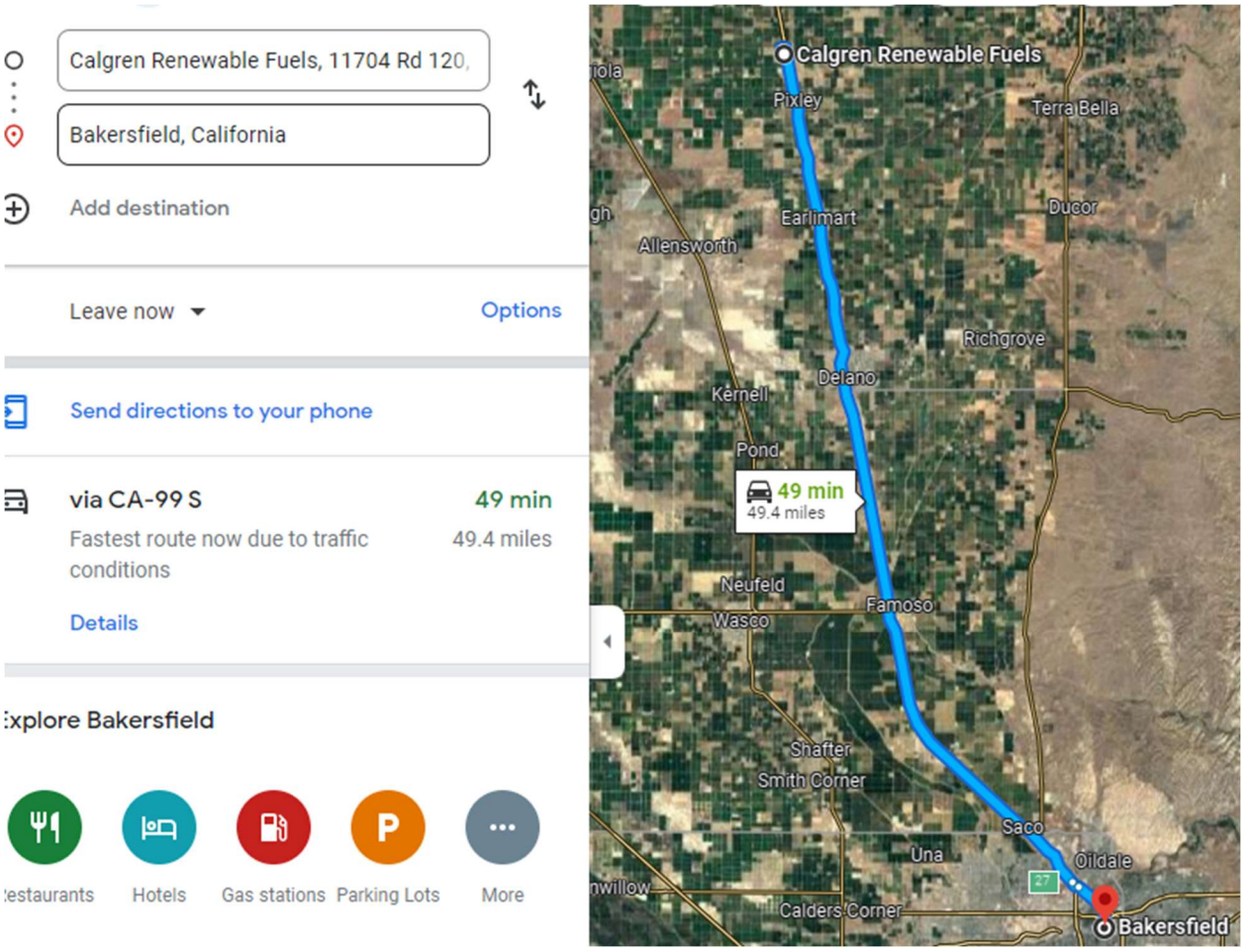
The trucked gas is offloaded at Calgren. To be conservative, the minimum volume of the loaded and unloaded volume monthly is used as the volume injected. The portion for FMJ is allocated amongst the other CNG sources that Calgren is injecting from. The gas is then delivered to the SoCal Gas common carrier pipeline and is metered by the utility company.

In the case the biogas is not in agreement with the utility company's pipeline specifications, a vent can be utilized. Any vented is accounted for as a fugitive emission.

FMJ to Calgren



Calgren to Bakersfield

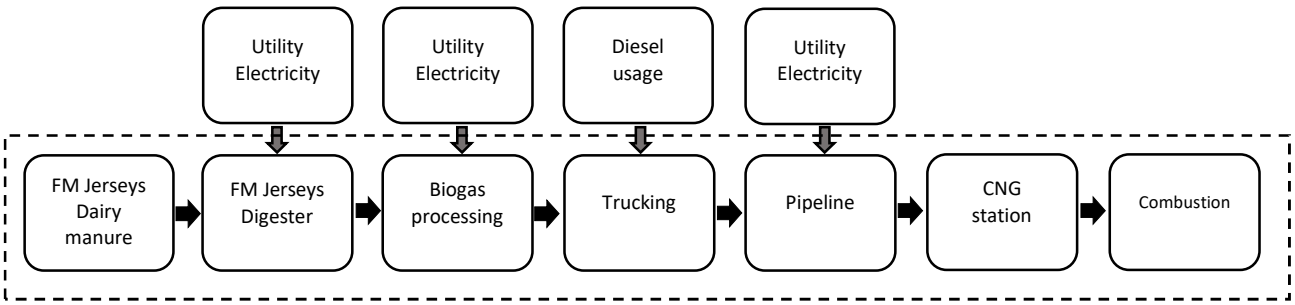


Transportation and Distribution

Biomethane is injected into the SoCal Gas utility pipeline and transported to CNG refueling stations for use as vehicle fuel in California. FMJ supplies biomethane to many dispensing stations in the state of California. Volumes delivered to these stations vary month-to-month. Transmission distance to CNG stations is incorporated in the DSM Calculator in 2.27a of the Biogas-to-RNG tab to determine fugitive pipeline emissions.

System Boundary

For this application, the system boundary is detailed in the diagram below. All other systems are outside of the boundary.



DSM Calculator Summary

Data Collection

GREET 3.0 baseline Manure-to-Biogas calculations require 12 months of baseline data. Since the FMJ project is not a Provisional Pathway, thus 24 months of baseline data is included in the FMJ DSM Calculator.

Below are the main files containing the source data for the DSM Calculators, and referenced in the associated report are the following:

Manure-to-Biogas (LOP Inputs) Tab

Herd counts for use in baseline calculations in Section L1 were determined using monthly herd counts submitted by the individual dairies to Maas Energy Works (MEW).

Average temperature in Section L1 is populated using the National Oceanic and Atmospheric Administration's website (https://www.weather.gov/hnx/hjomain).

In the mass balance file, there is a tab labeled "Manure," this tab is used to calculate the VS collection rates listed in Sections L1.11, L2.3, L4.5, and L5.3.

VS collection calculations consider herd exercise time, separator type pre- and post-operational digester, and herd milking frequency.

Biogas-to-RNG Tab

The application's "FMJ Mass Balance" file is included to support the Biogas-to-RNG inputs.

The mass balance "Monthly" tab includes raw data and calculations for Sections 2.4, 2.5, 2.6, 2.7, 2.11,2.21, 2.22, and 2.23.

Sections 2.4, and 2.5 incorporate volumes and methane concentrations aligned with regular Data Logger measurements. These measurements are logged once every 15 minutes.

Section 2.23 is sourced from the minimum of the loaded and unloaded volumes on a monthly basis.

The mass balance includes raw data and calculations for sections 2.10, 2.11, and 2.14

Sourced from utility bills provided by the individual dairies to MEW, Section 2.10 incorporates kWh of manure management equipment associated with manure contributing to the digester.

Miles from the upgrading FMJ RNG upgrading facility to Calgren is 7.1 miles, the average MPG of the trucks and the number of loads is used to calculate how many gallons of diesel is used.

Calgren to Bakersfield in 2.27a is 49.4 Miles.

Tier 1 DSM Calculator Modifications

Weighted Average Inlet Methane

The formulas in cells D52 and F52 on the Biogas-to-RNG were converted from straight averages of monthly weighted averages to weighted averages based on monthly flow and monthly weighted

average concentrations. The formula in cell D52 was converted to "=IFERROR(SUMPRODUCT(C28:C51/SUM(C28:C51),D28:D51),0)" and F52 was converted to "=IFERROR(SUMPRODUCT(E28:E51/SUM(E28:E51),F28:F51),0)".

Missing Data Provisions

For any missing data, other metering that may be available will be used, otherwise the methodology outlined in the Livestock Offset Protocol.

DSM Calculators Results

Below is a summary of the total carbon intensity (gCO2e/MJ) for the FMJ Dairy Digester:

CI calculation results - FM Jerseys Dairy Digester

Process stage	Carbon intensity (gCO2e/MJ)
Raw biogas production-digester	[redacted]
Biogas upgrading	[redacted]
NG Transmissions	[redacted]
CI for compression of CNG	3.50
Combustion for CNG vehicles	60.73
Methane credit	[redacted]
CO2 Diverted	[redacted]
Total (gCO2e/MJ)	-426.46