Tier 1 CI Calculator for Dairy and Swine Manure Biomethane

Instruction Manual

~~*December 19, 2023*~~ August 12, 2024

Contents

I. Introduction 2

II. T1 DSM Biomethane Calculator Overview 3

III. Manure-to-Biogas (LOP Inputs) Worksheet 5

A. Section L1: Baseline Methane Emissions from Anaerobic Storage/Treatment Systems ($BE_{CH4,AS}$) (Reference: [Equation 5.3 in LOP]) 5

1. Additional Details for Section L1 and Table 2 7

B. Section L2: Baseline Methane Emissions from Other Storage/Treatment Systems ($BE_{CH4,nAS}$) (Reference:[Equation 5.4 in LOP]) 8

C. Section L3: Project Methane Emissions from Venting Events ($CH_{4\ vent}$) in the Biogas Control System (BCS) (Reference: [Equation 5.6-Venting in LOP]) 9

1. Additional Details for Table 4 10

D. Section L4: Project Methane Emissions from the BCS Effluent Pond(s) ($PE_{CH4,EP}$) (Reference: [Equation 5.8 in LOP]) 10

E. Section L5: Project Methane Emissions from Non-BCS Related Sources ($PE_{CH4,nBCS}$) (Reference: [Equation 5.9 in LOP]) 11

IV. Avoided Emissions Worksheet 12

A. Section P1. Results from the "Manure-to-Biogas (LOP Inputs)" worksheet 12

B. Section P2. Avoided CH_4 Emissions Calculation Details 13

C. Section P3. Avoided CO_2 Emissions Calculation Details 13

V. Biogas-to-RNG Worksheet 13

A. Section 1. Applicant Information for Biomethane Production 13

B. Section 2. Biomethane Production Data 14

C. Additional Details for Section 2 and Table 9 19

D. Section 3. CNG, LNG, and L-CNG Production and Transport Data 21

1. Additional Details for Section 3 21

E. Section 4. CI Calculation Details 22

VI. EF Table Worksheet 22

A. “Grid Electricity (~~2021~~ eGRID Region)” table 22

B. “Fuels used in pathway” table 22

I. Introduction

This document provides detailed instructions for the use of the Tier 1 CI Calculator for Biomethane from Anaerobic Digestion of Dairy and Swine Manure (T1 DSM Biomethane Calculator). This calculator is to be used to calculate the composite carbon intensity (CI) for Compressed Natural Gas, Liquefied Natural Gas (LNG), and Liquefied and subsequently Compressed Natural Gas (L-CNG) from dairy cattle and swine manure anaerobic digesters. In this Calculator, only dairy cattle and swine manure are eligible for the avoided emissions credits for greenhouse gas (GHG) emission reductions. Pathways for biomethane from other types of manure or organic wastes (such as poultry litter, beef cattle manure, animal bedding, post-consumer food waste, and urban landscaping waste) should use the "Tier 1 CI Calculator for Biomethane from Anaerobic Digestion of Organic Waste." Each required specific input in the Calculator has been numerically labeled (i.e., 1.1, 1.2, etc.) so that users can follow the sequence and enter information as required.

Click here to download the T1 DSM Calculator

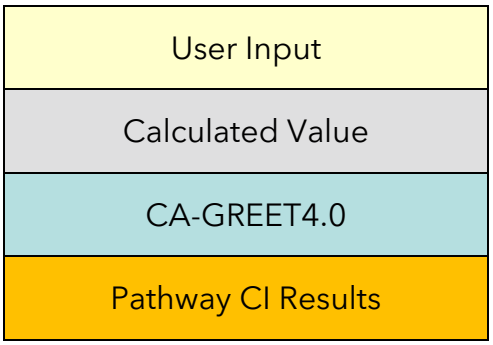
The T1 DSM Biomethane Calculator has been automated to perform CI calculations using factors from the CA-GREET4.0 model. Applicants are required to add facility information and verifiable monthly feedstock, operational energy use, fuel production and co-product data, and transport distances used in calculating the CI of biomethane from dairy and swine manure digesters. **All inputs selected and input by the applicant must meet the requirements of the monitoring plan for entities required to validate or verify pursuant to sections 95491.1(c) and are subject to verification unless specifically exempted.**

This Calculator also includes additional reference material such as greenhouse gas emissions factors and reference fuel specifications used in CA-GREET4.0 and certain emission factors from the Compliance Offset Protocol Livestock Projects (November 2014). The Calculator provides a detailed breakdown of the calculations used to determine the CI of each fuel pathway. The CI is not final until certified by the Executive Officer of the California Air Resources Board.

The applicant may only enter values or make selections in input fields designated by CARB for user input/selection, and may not change any other values or fields in the Calculator. Proposed calculator modifications to appropriately capture the fuel's system boundary require review and approval by the Executive Officer and would result in Tier 2 pathway classification.

II. T1 DSM Biomethane Calculator Overview

The Calculator uses the following color legend to differentiate required inputs, calculated values, etc., described below:



- "User Input" cells must be completed if the input is used by the fuel pathway. If the input is irrelevant, it may be left blank. All User Inputs are subject to verification as part of initial pathway certification and annual fuel pathway reporting (AFPR).
- "Calculated Value" cells contain formulas that provide a calculated result based on either user input data, or a value or an emissions factor (EF) from CA-GREET4.0.
- "CA-GREET4.0" cells contain input values from the CA-GREET4.0 model.
- "Pathway CI Results" cells contain calculated carbon intensity (CI) values.

The Calculated Value formulas and CA-GREET4.0 values cannot be modified without written permission from CARB. Approved modifications may require the use of a Tier 2 fuel pathway application.

The following table provides an overview of the worksheets used in the T1 DSM Biomethane Calculator.

Table 1: Worksheets Used in the T1 DSM Biomethane Calculator

Worksheet Name	Description
Introduction	Provides a brief introduction to the T1 DSM Biomethane Calculator.
Pathway Summary	Summary worksheet. Contains an overall summary of the key information entered in the "Manure-to-Biogas (LOP Inputs)", Avoided Emissions", and "Biogas-to-RNG" worksheets, and calculated CIs for livestock manure digester biogas to CNG, LNG, and L-CNG. If desired, a conservative margin of safety may be added to the calculated CI in this worksheet to establish the final CI, pursuant to section 95488.4(a) of the regulation. Also contains a section for pathway-specific operating conditions, to be completed by CARB staff prior to pathway certification.

Worksheet Name	Description
Manure-to-Biogas (LOP Inputs)	Calculation worksheet based on key equations from the Compliance Offset Protocol Livestock Projects[1] (Adopted on Nov. 14, 2014, "LOP" hereafter) to calculate baseline and project emissions. The user inputs related to baseline and project methane emissions are indicated in yellow cells, and automatically calculated values are in gray cells.
Avoided Emissions	Avoided methane calculation worksheet. Contains the values related to baseline and project methane emissions and the quantification of avoided methane and diverted CO_2 from land application.
Biogas-to-RNG	Calculation worksheet. Contains the user inputs related to fuel production (biogas to biomethane) indicated in yellow, automatically calculated values in gray cells, and estimated CI results in orange (absent of any added conservative margin of safety).
EF Table	Reference worksheet. Contains greenhouse gas emissions factors from the CA-GREET4.0 model used in the calculation of carbon intensities.
Reference	Reference worksheet. Contains specifications of fuels (i.e., HHV, LHV, density, carbon ratio), global warming potentials of greenhouse gases, unit conversions, tailpipe emissions, LNG boil-off emissions, and other information used in calculating CIs. The relevant tables in the LOP appendix are also listed in this worksheet.

The Introduction worksheet also contains links to LCFS Website Resources for a Program Overview, downloading LCFS Life Cycle Analysis Models and Documentation (Tier 1 Pathway Calculators and Instruction Manuals), and a link to the fuel pathway application process.

LCFS Website Resources
LCFS Program Overview
Tier 1 Pathway Calculators and Instruction Manuals
Pathway Application Process

Begin by selecting the "Manure-to-Biogas (LOP Inputs)" worksheet, then enter information for the sub-sections listed below.

[1] California Air Resources Board, *Compliance Offset Protocol Livestock Projects – Capturing and Destroying Methane from Manure Management Systems*. Adopted on November 14, 2014. https://www.arb.ca.gov/regact/2014/capandtrade14/ctlivestockprotocol.pdf

III. Manure-to-Biogas (LOP Inputs) Worksheet

The "Manure-to-Biogas (LOP Inputs)" worksheet contains the calculations for selected parameters of the baseline and the project methane emissions ("LOP" is the acronym for CARB's "Compliance Offset Protocol Livestock Projects" in this document). This worksheet consists of the following major sections:

- Section L1: Baseline Methane Emissions from Anaerobic Storage/Treatment Systems ($BE_{CH4,AS}$) (Reference: [Equation 5.3 in LOP])
- Section L2: Baseline Methane Emissions from Other Storage/Treatment Systems ($BE_{CH4,nAS}$) (Reference: [Equation 5.4 in LOP])
- Section L3: Project Methane Emissions from Venting Events ($CH_{4\ vent}$) in the Biogas Control System (BCS) (Reference: [Equation 5.6-Venting in LOP])
- Section L4: Project Methane Emissions from the BCS Effluent Pond(s) ($PE_{CH4,EP}$) (Reference: [Equation 5.8 in LOP])
- Section L5: Project Methane Emissions from Non-BCS Related Sources ($PE_{CH4,nBCS}$) (Reference: [Equation 5.9 in LOP])

All relevant site-specific inputs must be entered in their respective input fields.

A. Section L1: Baseline Methane Emissions from Anaerobic Storage/Treatment Systems ($BE_{CH4,AS}$) (Reference: [Equation 5.3 in LOP])

This section quantifies the modeled baseline methane emissions from the anaerobic storage/treatment system. Up to six livestock categories that deposit manure to the same baseline system can be modeled in this section. The following table lists the fields for Section L1.

Table 2: List of Input Fields for Section L1 of the CI Calculator

Field Name	Description and Instructions
L1.(1-6).1 Livestock Category (L)	Select a livestock category for each sub-section; each sub-section represents one specific livestock, and users can enter information for up to six livestock categories in six corresponding sub-sections.
L1.(1-6).2 Baseline Reporting Period	Please select either "12" or "24" months in this field. If the number of the baseline reporting month entered in L1.(1-6).6 does not match the entry in this field, an "ERROR" message will appear in the total baseline methane emission. Once the "24" is selected for the number of baseline reporting months, the applicant must continue to model 24 months baseline moving forward (including AFPRs).

Field Name	Description and Instructions
L1.(1-6).3 Livestock Average Mass	The typical average mass of the livestock selected in L1.(1-6).1. See Table A.1 in the LOP.
L1.(1-6).4 Maximum CH_4 Potential	The maximum methane potential of the livestock selected in L1.(1-6).1. See Table A.2 in the LOP.
L1.(1-6).5 Livestock Excretion Rate	The daily manure excretion by the livestock selected in L1.(1- 6).1, measured in volatile solids. See Table A.2 and A.4 in the LOP.
L1.(1-6).6 Farm Name	Input the legal name of the farm from which the livestock population data is obtained.
L1.(1-6).7 Reporting Month	Input the months and year(s) corresponding to the operational data provided. See "Additional Details for Section L1 and Table 2" subsection below for more information.
L1.(1-6).8 Livestock Population	Monthly average population of the livestock selected in L1.(1-6).1. See "Additional Details for Section L1 and Table 2" subsection below for more information.
L1.(1-6).9 Calendar Days of the Month	Total calendar days of the reporting month.
L1.(1-6).10 Number of Reporting Days	Number of reporting days in the reporting month.
L1.(1-6).11 Average Temperature	Monthly average ambient temperature in degree Celsius. See "Additional Details for Section L1 and Table 2" subsection below for more information.
L1.(1-6).12 Van't Hoff-Arrhenius factor	Factor associated with chemical reaction.
L1.(1-6).13 Fraction of Volatile Solids Sent to Anaerobic Storage/Treatment System	The fraction of manure (volatile solids) that would be sent to the anaerobic storage/treatment system for each livestock category, taking into account any volatile solids removed by solid separation equipment in the baseline case, as if the project BCS was never installed. Values from Table A.9 of the LOP must be used if the solids separation technology is included in this table. This table can be found in the "Reference" worksheet. For modeling the manure (volatile solids) from more than six livestock categories/sources, please use a separate worksheet to calculate the weighted fraction of manure (volatile solids) average for each livestock category, and use the calculated weighted average as the inputs to ~~Fields L1.(1-6).12~~ Fields L1.(1-6).13.
L1.(1-6).14 Volatile Solids Available for Degradation	Monthly volatile solids available for degradation from anaerobic manure storage/treatment system 'AS' by the livestock selected in L1.(1-6).1.

Field Name	Description and Instructions
L1.(1-6).15 Retention Time and Drainage	Select the option that is applicable. If the volatile solids retention time in the anaerobic storage/treatment system is less than or equal to 30 days, or if during the month the anaerobic storage/treatment system is completely cleaned, the volatile solids retained in the system from this month must be set to zero. If the anaerobic storage/treatment system is cleaned every year, select "System Emptied in This Month" for the month when the anaerobic storage/treatment system is cleaned. If there is no regular storage/treatment system clean schedule, must select "System Emptied in This Month" each September. The applicant only needs to select one "System Emptied in This Month" for each year to model the lagoon cleanout. This requirement applies to both Tier 1 and Tier 2 pathways.
L1.(1-6).16 Carryover from Previous Month	The difference between the volatile solids (VS) available for degradation and the VS degraded from the previous month. If this is the first year of the project, enter zero in the first month; otherwise, enter the VS carried over from December of the previous year. Calculated herd populations are not allowed to establish the initial VS carryover.
L1.(1-6).17 Volatile Solids Degraded	Monthly volatile solids degraded by anaerobic manure storage/treatment system 'AS' by the livestock selected in L1.(1-6).1.
L1.(1-6).18 Baseline Methane Emissions, AS	The modeled baseline methane emissions from anaerobic manure storage/treatment systems.

1. Additional Details for Section L1 and Table 2

1. Baseline Reporting Period (Field 1.1.2)

   For both initial certification and AFPR, select either "12" or "24" based on the following conditions:

   (A) If less than 12 months of baseline data (including 12 months) is available, select "12".

   (B) If more than 12 months of baseline data is available, select "24".

   Once 24 months are selected for the baseline reporting period, the applicant must continue to model the 24-month baseline moving forward (including Annual Fuel Pathway Reports).

2. Livestock Population (Fields L1.(1-6).8)

   (A) ~~If less than 12 months of baseline data is available,~~ For the months when the livestock population is unavailable, use the monthly average livestock population calculated from the available months to substitute the livestock population in the months without data.

~~(B) If more than 12 but less than 24 months of baseline data is available, use the monthly average livestock population from the available months to substitute the livestock population in the months without data.~~

(B) The monthly average livestock population entered in Fields L1.(1-6).8 must not exceed the herd size limits set by any applicable local or state regulatory or other legal requirements.

3. Average Temperature (Fields L1.(1-6).11)

   Use monthly average ambient temperature in degree Celsius for each reporting month, even if the livestock population data was substituted by the monthly average livestock population in that month.

B. Section L2: Baseline Methane Emissions from Other Storage/Treatment Systems ($BE_{CH4,nAS}$) (Reference:[Equation 5.4 in LOP])

This section quantifies the baseline methane emissions from non-anaerobic storage/treatment systems. The following table lists the fields for Section L2.

Table 3: List of Input Fields for Section L2 of the CI Calculator

Field Name	Description and Instructions
L2.1 Other storage/treatment Systems	Select storage/treatment systems other than anaerobic storage/treatment system that are applicable from the drop-down menu.
L2.2 Methane Conversion Factor	The methane conversion factor for non-anaerobic storage/treatment system. See Table A.5 in the LOP. This factor is determined by the selection in L2.1.
L2.3 Manure Managed in Non-Anaerobic Storage/Treatment Systems	The fraction of manure (volatile solids) that would be sent to other storage/treatment systems for each livestock category, considering any volatile solids removed by solid separation equipment in the baseline case (as if the project BCS was never installed). Values from Table A.9 of the LOP must be used to calculate the fraction sent to non-anaerobic systems if the collected manure is sent to a solid separation system prior to anaerobic storage. This table can also be found in the "Reference" worksheet.
L2.4 Baseline Methane Emissions, non-AS	The modeled baseline methane emissions from non-anaerobic manure storage/treatment systems.

C. Section L3: Project Methane Emissions from Venting Events ($CH_{4\ vent}$) in the Biogas Control System (BCS) (Reference: [Equation 5.6-Venting in LOP])

This section quantifies the BCS system project methane emissions from venting events only. Other emissions directly associated with the biomethane production in the BCS project this CI Calculator evaluates in the "Biogas-to-RNG" worksheet. The following table lists the fields for Section L3.

Table 4: List of Input Fields for Section L3 of the CI Calculator

Field Name	Description and Instructions
L3.1 Reporting Month	The months and year(s) correspond to the operational data provided. For provisional pathways, a minimum of three months of operational data is required with the initial reporting month fixed at the time of certification. The months modeled in Field L3.1 must also be included in Fields L1.(1-6).6. This is not a user-defined input. The operational data reporting months are input in Field 2.3 in the "Biogas-to-RNG" worksheet.
L3.2 Maximum Biogas Storage of the BCS System	The maximum biogas storage of the BCS system must be calculated using project-specific information and design documentation.
L3.3 Average Daily Biogas Production for the 7 Days Preceding the Venting	This volume flow must come from the monitored project-specific flow data corrected to standard conditions. See Equation 5.7 in the LOP for the biogas volume correction for temperature and pressure.
L3.4 Number of Days for the Uncontrolled Venting	This must be monitored and recorded at least daily from the time of discovery; it must date back to the last field check date without any uncontrolled venting events.
L3.5 Quarterly Methane Concentration	The quarterly methane concentration is used for the entire month in which it is taken and for all subsequent months until a new methane concentration is taken. A weighted average of more frequent samples may also be used.
L3.6 Vented Biogas Flow (metered)	Input monthly vented raw dry biogas flow (in Standard Cubic Feet at 60°F, 1 atm). See "Additional Details for Table 4" subsection below for more information.
L3.7 Biomethane Content in Vented Biogas (metered)	Input monthly weighted average methane concentration in vented raw dry biogas. See "Additional Details for Table 4" subsection below for more information.
L3.8 Project Methane Emissions from Venting	Results of the monthly quantity of methane that is vented to the atmosphere due to BCS venting events.

1. Additional Details for Table 4

1. Methane emissions from the vented biogas events can be calculated by using two methods:

   Method 1: Estimation based on the Equation 5.6 in LOP (Fields L3.2 - L3.5);

   Method 2: Calculation based on metering data for controlled venting events (Fields L3.6 - L3.7).

   Applicant can populate data either in Fields L3.2 - L3.5 or in Fields L3.6 - L3.7 depending on the data availability to report the biogas venting event.

D. Section L4: Project Methane Emissions from the BCS Effluent Pond(s) ($PE_{CH4,EP}$) (Reference: [Equation 5.8 in LOP])

This section quantifies the methane emissions from the BCS pond where the effluent from the BCS project is held. The following table lists the fields for Section L4.

Table 5: List of Input Fields for Section L4 of the CI Calculator

Field Name	Description and Instructions
L4.1 Livestock Category	These are the same livestock categories selected in Section L1. For modifications to this section, please update Section L1.
L4.2 Average Population	Average population of each livestock category based on monthly population data for a given reporting period.
L4.3 Livestock Excretion Rate	Daily manure excretion by the livestock category, measured in volatile solids. See Table A.2 and A.4 in the LOP. These are the same values entered in fields L1.(1- 6).4.
L4.4 Maximum CH_4 Potential	Maximum methane potential of each livestock category. See Table A.2 in the LOP. These are the same values entered in fields L1.(1-6).4.
L4.5 Fraction of Volatile Solids Sent to BCS System	Fraction of manure (volatile solids) that would be sent to the BCS for each livestock category, considering any volatile solids removed by solid separation equipment before the manure goes into the BCS by following values from Table A.9. This table can be found in the "Reference" worksheet.
L4.6 Fraction of Volatile Solids Removed before Effluent is Sent to Effluent Ponds	Fraction of the effluent (exiting the BCS) volatile solids removed by different separation equipment before the effluent is sent to the effluent ponds. Volatile solids removed from the digester effluent by solid separation equipment must follow the values established in Table A.9. This table can also be found in the "Reference" worksheet.
L4.7 Methane Potential of the VS to Effluent Ponds	Results of the methane potential of manure (volatile solids) that is sent to the effluent ponds daily by the livestock category.

Field Name	Description and Instructions
L4.8 Number of Reporting Days	Total number of reporting days in the reporting period.
L4.9 Methane Conversion Factor	Methane conversion factor for the effluent pond (liquid/slurry uncovered). See Table A.5 in the LOP.
L4.10 Project Methane Emission from Effluent Ponds	Results of the total methane emissions from the project BCS effluent ponds.

E. Section L5: Project Methane Emissions from Non-BCS Related Sources ($PE_{CH4,nBCS}$) (Reference: [Equation 5.9 in LOP])

This section quantifies the project methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent pond. The following table lists the fields for Section L5.

Table 6: List of Input Fields for Section L5 of the CI Calculator

Field Name	Description and Instructions
L5.1.a Non-BCS Storage/Treatment Systems for Manure	Select the Non-BCS Storage/Treatment Systems for manure as applicable from the drop-down menu.
L5.1.b Other Storage/Treatment Systems for Effluent	Select other storage/treatment systems used to store/treat effluent (exiting BCS) as applicable from the drop-down menu.
L5.2 Methane Conversion Factor	Methane conversion factor for non-anaerobic storage/treatment system. See Table A.5 in the LOP. This factor is determined by the selection in L5.1.a and L5.1.b.
L5.3 Manure/Effluent Managed in Non-BCS (Other) Systems	The fraction of manure and effluent (volatile solids) that would be sent to the non-BCS (other) systems for each livestock category, considering any volatile solids removed by solid separation equipment in the baseline case, as if the project BCS was never installed. Values from Table A.9 of the LOP must be used if the solids separation technology is captured in this table. This table can be found in the "Reference" worksheet.
L5.4 CH_4 Emission Factor, non-BCS	Methane emission factor for the livestock population from non-BCS related sources.
L5.5 Project Methane Emissions, non-BCS	The modeled project methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent pond.

IV. Avoided Emissions Worksheet

The "Avoided Emissions" worksheet contains the additional calculation worksheet for avoided methane and CO_2 credits, and consists of the following major sections:

- Section P1. Results from the "Manure-to-Biogas (LOP Inputs)" worksheet
- Section P2. Avoided CH_4 Emissions Calculation Details
- Section P3. Avoided CO_2 Emissions Calculation Details

A. Section P1. Results from the "Manure-to-Biogas (LOP Inputs)" worksheet

All the values in this section are calculated values based on the quantification methodology by ARB's "Compliance Offset Protocol Livestock Projects" (detailed calculation can be found in the "Manure-to-Biogas (LOP Inputs)" worksheet). The following table lists the fields for Section P1 of the "Avoided Emissions" worksheet.

Table 7: List of Input Fields for Section P1 of the CI Calculator

Field Name	Description and Instructions
P1.1 Select Digester Type	Select either "Covered Lagoon" or "Enclosed Vessel" as the type of livestock manure digester operated.
P1.2 Monthly Data	Input the months and year(s) corresponding to the operational data provided.
P1.3 Baseline methane emissions ($BE_{CH4\ Mod}$)	Results of monthly baseline methane emissions calculated using Equation 5.2 from the LOP.
P1.4 Project methane emissions	This field includes a label for project methane emissions and does not require an input
P1.4.a Venting methane ($CH_{4\ vent}$)	Results of the monthly quantity of methane that is vented to the atmosphere due to the digester venting events. These are calculated values based on the $CH_{4\ vent,\ j}$ formula provided in the "Equation 5.6" section from the LOP.
P1.4.b Effluent ponds methane ($PE_{CH4,EP}$)	Result of monthly methane emissions from the digester effluent pond. This is the calculated value based on Equation 5.8 from the LOP.
P1.4.c Storage/Treatment methane ($PE_{CH4,nBCS}$)	Result of monthly methane emissions from the non-digester sources (waste treatment and storage). This is the calculated value based on Equation 5.9 from the LOP.
P1.4.d Digester leakage	Results of the monthly quantity of methane leakage from the digester.

B. Section P2. Avoided CH_4 Emissions Calculation Details

This section contains an example of calculating the avoided methane emissions from land application. There are no user inputs in this section.

C. Section P3. Avoided CO_2 Emissions Calculation Details

This section contains an example of calculating the avoided CO_2 emissions diverted from land application. There are no user inputs in this section.

V. Biogas-to-RNG Worksheet

The "Biogas-to-RNG" worksheet contains the main CI calculation worksheet and consists of the following major sections:

- Section 1. Applicant Information
- Section 2. Biomethane Production Data
- Section 3. CNG, LNG, and L-CNG Production and Transport Data
- Section 4. CI Calculation Details

A. Section 1. Applicant Information for Biomethane Production

The following table lists the fields used in Section 1 of the Biogas-to-RNG worksheet.

Table 8: List of Input Fields for Section 1 of the CI Calculator

Field Name	Description and Instructions
1.1 Company Name and ID Ex. Applicant, LLC (CXXXX)	Input the legal name of the fuel pathway applicant/holder and company ID, which is the registered fuel producer in the Alternative Fuels Portal (AFP). If not available, contact CARB for LCFS Company ID.
1.2 Facility Name and ID Ex. Production, LLC (F0XXXX)	Input the legal name of the fuel production facility and company ID. This is the Facility Name in the AFP (Examples of the fuel production facility include the upgrading facility for RNG, the facility housing the fuel cell for electricity). If not available, contact CARB for LCFS Facility ID.
1.3 Facility Physical Address (Upgrading facility for RNG)	Input the physical address of the fuel production facility. Do not use the mailing address or address of the company's headquarters.
1.4.a Digester Location (Street, City)	Input the physical address of the anaerobic digester, to include the street and city name. Example: "1001 I Street, Sacramento".

Field Name	Description and Instructions
1.4.b Digester Location (State)	Select the state of the digester's physical address from the drop-down menu.
1.5 LNG Liquefaction Facility Location (Street, City, State)	Input the physical address of the liquefaction facility, including the street, city, and state.
1.6 CNG Dispensing Station(s) Location (Street, City, State)	Location of California CNG dispensing station (Street, City, State). For distribution to multiple California stations, use Bakersfield as the endpoint in determining the Standard Station Centroid location. See "Additional Details for Section 2 and Table 9" subsection below for more information.
1.7 LNG Dispensing Station(s) Location (Street, City, State)	Location of LNG dispensing station (Street, City, State). For multiple stations, calculate a centroid location based on a weighted average of fuel dispensing stations to which LNG is supplied. See "Additional Details for Section 3" subsection below Table 10 for more information.
1.8 L-CNG Dispensing Station(s) Location (Street, City, State)	Location of L-CNG station (Street, City, State). For multiple stations, calculate a centroid based on a weighted average of fuel dispensing stations to which L-CNG is supplied. See "Additional Details for Section 3" subsection below Table 10 for more information.
1.9 Digester Type	The digester type is the same selection appeared on the "Avoided Emissions" worksheet, section P1.1: either "Covered Lagoon" or "Enclosed Vessel". To update this value, please do so in the "Avoided Emissions" worksheet.
1.10 Average Annual Temperature (°C)	The calculated average annual temperature in °C. This is not a user-defined input.
1.11 Names of All Intermediate Facilities (e.g., manure sources not co-located with the biogas upgrading facility)	An intermediate Facility means a facility in a fuel supply chain, which is not the fuel production facility, that contributes site-specific data for the determination of a fuel pathway carbon intensity. For dairy and swine manure to RNG pathway, the intermediate facility represents the farms supplying manure to the digesters. Enter the name of each intermediate facility included in this fuel pathway. Please refer to LCFS Guidance 20-01 [2] for details.

B. Section 2. Biomethane Production Data

The following table lists the fields used in Section 2 of the Biogas-to-RNG worksheet. Additional details are included below Table 9.

[2] California Air Resources Board, *Low Carbon Fuel Standard (LCFS) Guidance 20-01 Fuel Production Facility and Intermediate Facility Registration in the Alternative Fuels Portal*. February 2020. *https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/lcfsguidance_20-01.pdf*

Table 9: List of Input Fields for Biogas Processing

Field Name	Description and Instructions
2.1 Select Regional Electricity Mix for Biomethane	Choose the electricity mix corresponding to the zip code for the region where the livestock manure digester biogas upgrading plant is located. The Calculator includes 27 eGRID zone mixes, U.S. Average, Brazilian average mix (Brazil), Canadian average mix (Canada), and User Defined Mix included in the drop-down menu. For facilities in the U.S., select one of 27 eGRID zones available for the U.S. If the upgrading facility is located outside the U.S. and not in Brazil or Canada, select "User Defined Mix". For facilities that use biogas for electricity production, choose the "User Defined Mix" electricity option in field 2.1. If "User Defined Mix" is selected, consult with CARB staff to develop an emission factor for the "User Defined Mix" to be input as detailed in the Grid Electricity (~~2021~~ eGRID Region) table in the "EF Table" worksheet. Data sources for "User Defined Mix" electricity mixes must be documented in the Supplemental Documentation attached to the CI Calculator.
2.2a Provisional Pathway?	No user input is needed in this field. If at least 3 months but less than 24 months of operational data is reported, it shows "Yes". If 24 months of operational data is reported, it shows "No".
2.2b Number of Project Reporting Month	No user input is needed in this field. It automatically calculates how many reporting months in the project operational data period, and the calculated value is used in relevant calculations in the calculator.
2.3 Reporting Month	Input the months and year(s) corresponding to the operational data provided. For a provisional pathway, a minimum of three months of operational data is required to meet provisional requirements. The months reported here must be included in Fields L1.(1-6).7 in the "Manure-to-Biogas (LOP Inputs)" worksheet. If less than 24 months of operational data is reported in the Annual Fuel Pathway Reports, the operational data period must include the initial reported months established during pathway certification.
2.4 Total Raw Biogas Flow (metered)	Input monthly total raw dry biogas flow (in Standard Cubic Feet at 60°F, 1 atm) data for 24 months (at least 3 months if provisional) of operation. See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.5 Biomethane Content (% Methane)	Input monthly weighted average methane concentration in raw dry biogas for 24 months (at least 3 months if provisional) of operation. See the "Additional Details for Section 2 and Table 9" subsection below for more information.

Field Name	Description and Instructions
2.6 Flared Biogas Flow, (metered)	Input monthly flared raw dry biogas flow (in Standard Cubic Feet at 60°F, 1 atm) data for 24 months (at least 3 months if provisional) of operation. See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.7 Biomethane Content (% Methane)	Input monthly weighted average methane concentration in flared raw dry biogas for 24 months (at least 3 months if provisional) of operation. See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.8 Raw Biogas Flow to Upgrading (metered)	Input monthly raw biogas use (in Standard Cubic Feet at 60°F, 1 atm) for producing transportation fuels. See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.9 Biomethane Content (% Methane)	Input monthly weighted average methane concentration data (measured in raw dry biogas) for 24 months (at least 3 months if provisional) of operation. See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.10 Diesel (baseline manure transport and handling)	Input monthly total diesel use (in gallons at ambient temperature) to transport and handle manure in the baseline case for 24 months (at least 3 months if provisional) in this field.
2.11 Utility Sourced NG (baseline)	Input monthly total fossil natural gas use (baseline case) from a pipeline source (or other) in MMBtu from utility invoices (reported in HHV) for 24 months (at least 3 months if provisional) of operation.
2.12 Grid Electricity (baseline manure pumping and solids separation)	Input monthly total electricity use (baseline case) from the grid in kWh from utility invoices for 24 months (at least 3 months if provisional) in this field.
2.13 Grid Electricity (for digester heating)	Input monthly total electricity use (digestion process) from the grid in kWh from utility invoices for 24 months (at least 3 months if provisional) in this field.
2.14 Raw Biogas (for digester)	Input monthly raw biogas use (in MMBtu in LHV) for heat generation during the digestion process.
2.15 Biomethane (for digester heating)	Input monthly biomethane use (in MMBtu in HHV) for heat generation in a small industrial boiler (10-100 MMBtu/hr input) during the digestion process.
2.16 Utility Sourced NG(digester project)	Input monthly total fossil natural gas use (digestion process) from a pipeline source (or other) in MMBtu from utility invoices (reported in HHV) for 24 months (at least 3 months if provisional) of operation.
2.17 Diesel (digester project manure transport and handling)	Input monthly total diesel use (in gallons at ambient temperature) in transporting and handling manure for the digestion process for 24 months (at least 3 months if provisional).

Field Name	Description and Instructions
2.18 Other Fuel Used (for digester)	Select the fuel type from the dropdown menu, and input the monthly total fuel use for the digestion process for 24 months (at least 3 months if provisional). If any of "User-Defined Fuel-1", "User-Defined Fuel-2", "User-Defined Fuel-3" is selected, input the fuel name, unit, and emission factors in the "Fuels used in pathway" table in "EF Table" worksheet.
2.19 Utility Sourced NG (upgrading and compression)	Input monthly total fossil natural gas use (biomethane upgrading and compression) from a pipeline source (or other) in MMBtu from utility invoices (reported in HHV) for 24 months (at least 3 months if provisional) of operation.
2.20 Raw Biogas (as Process Fuel for upgrading and compression)	Input monthly raw biogas use (in MMBtu in LHV) for upgrading and compression.
2.21 Biomethane (as Process Fuel for upgrading and compression)	Input monthly biomethane use (in MMBtu in HHV) as process fuel in a small industrial boiler (10-100 MMBtu/hr input) for the biomethane upgrading and compression process.
2.22 On-Site Electricity from Biogas (upgrading and compression)	Input monthly total electricity use (biomethane upgrading and compression) from the electricity generated on-site from a biogas-fueled reciprocating engine (in kWh).
2.23 Grid Electricity (upgrading and compression)	Input monthly total electricity use (biomethane upgrading and compression) from the grid in kWh from utility invoices for 24 months (at least 3 months if provisional) in this field.
2.24 Diesel (upgrading and compression)	Input monthly total diesel use (in gallons at ambient temperature) for the biomethane upgrading and compression process for 24 months (at least 3 months if provisional).
2.25 Other fuel used (upgrading and compression)	Select the fuel type from the dropdown menu, and input the monthly total fuel use for upgrading and compression for 24 months (at least 3 months if provisional). If any of "User-Defined Fuel-1", "User-Defined Fuel-2", "User-Defined Fuel-3" is selected, input the fuel name, unit, and emission factors in the "Fuels used in pathway" table in "EF Table" worksheet.
2.26 Buy Back fossil NG to boost Btu prior to pipeline injection	Input monthly total quantity of buyback fossil NG (in MMBtu, HHV) if NG is used to boost biomethane energy content to meet pipeline specification. This quantity is not used in CI calculations. Subtract this quantity of fossil NG when reporting pipeline injected biomethane in field 2.31. See the "Additional Details for Section 2 and Table 9" subsection below for more information.

Field Name	Description and Instructions
2.27 Propane used to boost Btu prior to pipeline injection	Input monthly total quantity of propane (in gallons at ambient temperature) if propane is used to boost biomethane energy content to meet pipeline specification. This quantity is not used in CI calculations. Subtract this quantity of propane when reporting pipeline injected biomethane in field 2.31. See "Additional Details for Section 2 and Table 9" subsection below for more information.
2.28 Fuel used for Biomethane transport	Select the fuel type from the dropdown menu, and input the monthly total fuel use for transporting biomethane to the injection site for 24 months (at least 3 months if provisional). If any of "User-Defined Fuel-1", "User-Defined Fuel-2", "User-Defined Fuel-3" is selected, input the fuel name, unit, and emission factors in the "Fuels used in pathway" table in "EF Table" worksheet.
2.29 Flared biomethane including tail gas from upgrading (metered)	Input monthly total volume of biomethane flared, which includes the upgrading tail gas.
2.30 Biomethane Content (% Methane in Flared Gas)	Input monthly weighted average methane concentration in flared gas for 24 months (at least 3 months if provisional) of operation.
2.31 Biomethane Injected into Pipeline for Transportation Fuel Production (metered),(subtract buyback NG and Propane if used to boost Btu)	Input monthly total biomethane injected into the pipeline (in MMBtu) for 24 months (at least 3 months if provisional). The quantity must be supported by the sales receipts. See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.32 Biomethane to Electricity Production	Input monthly total biomethane (in MMBtu, HHV) used for electricity production on-site for 24 months (at least 3 months if provisional). Assuming 100% biomethane content.
2.33 On-site Electricity Production	Input monthly total electricity produced from the biomethane for 24 months (at least 3 months if provisional).
2.34 Export Electricity	Input monthly total electricity produced from the biomethane and exported for 24 months (at least 3 months if provisional).
2.35 NG pipeline Transmission	This field includes a label for NG pipeline transmission and does not require input.
2.35.a From upgrading facility to CNG Station	Input distance from the biogas processing facility to the intended CNG station in California. If fuel is sent to multiple stations, use the Standard Station Centroid of Bakersfield as the endpoint. See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.35.b From upgrading facility to LNG plant	Input distance (in miles) from the biogas processing facility to the liquefaction facility. This is required only if the pathway application includes LNG and L-CNG pathways. See the "Additional Details for Section 2 and Table 9" subsection below for more information.

Field Name	Description and Instructions
2.35.c Percentage of injected CNG that is converted into LNG	Input percentage of total injected CNG that will be converted into LNG (based on the value in Cell AD55). See the "Additional Details for Section 2 and Table 9" subsection below for more information.
2.36 User Defined Parameters	If "User Defined Mix" is selected in Field 2.1, consult with CARB staff to develop an emission factor for the user-defined mix to be input as detailed in the Grid Electricity (~~2021~~ eGRID Region) table in the "EF Table" worksheet. Data sources for User-Defined electricity mixes must be documented in the Supplemental Documentation attached to the CI Calculator.
2.37 Fugitive methane from upgrading (%)	The fugitive methane percentage is calculated based on the energy balance (not a user-defined input).
2.38 Maximum available biomethane for dispensing (MMBtu, LHV)	The maximum available biomethane for dispensing (MMBtu, LHV) is calculated based on the injected biomethane and pipeline evaporative loss (not a user-defined input).
"Calculate" Button	After all data in Section 2 are entered, click the "Calculate" button (cell E24) in Section 2 to calculate CI for the CNG pathway.

1. Additional Details for Section 2 and Table 9

1. Raw biogas sourced from the digester and sent to the upgrading facility (Field 2.4, and 2.8)

   (A) Requires a dedicated flow measurement system with temperature measurement to enable reporting of gas flow at 1 atm. pressure and 60°F (dry gas flow corrected for moisture) to account for the monthly total raw biogas volume sourced from the digester (Field 2.4) and the raw biogas volume used for upgrading to transportation fuels (Field 2.8). The flow measurement system must be calibrated per the manufacturer's requirement and scaled to measure the entire range of potential flow of biogas. Measurement must be continuous, and all data must be electronically archived (manual recording is not acceptable).

   (B) Field 2.6 represents the flared raw biogas, if applicable. If the quantity of flared raw biogas is not metered, the applicant may enter the difference between field 2.4 and field 2.8.

   (C) If there is no flared raw biogas reported in field 2.6, the same biogas flow data can be populated in field 2.4 and field 2.8, and the same methane concentration data can be populated in field 2.5 and field 2.9.

   (D) If biomethane is used for electricity generation on-site, the applicant must report the metered quantities of (1) biogas used for electricity generation, (2) electricity generated from biomethane, and (3) the exported electricity from biomethane.

2. Methane content (% Methane in Field 2.5, 2.7, and 2.9)

Input monthly weighted average methane concentration (dry gas basis). Methane measurement must be recorded every 15 minutes (at a minimum) with instrumentation capable of electronic archival (manual recording will not be acceptable). The methane measurement system requires calibration per the manufacturer's requirement and is scaled to measure the entire potential range of methane concentration in the biogas.

3. Field 2.21 represents the biomethane used for biogas upgrading.

4. Although the Calculator can accommodate facilities that use biomethane to generate electricity for biogas upgrading, applicants must declare the use of on-site electricity generation and consult CARB staff prior to submission of a pathway application. A dedicated meter to quantify biogas-derived electricity in kWh (Field 2.22) must be used to report the use of this electricity in the calculator.

5. Dedicated metering of buyback NG and propane (Fields 2.26 and 2.27)

   For digester gas upgrading facilities that use buyback natural gas (NG) or propane to boost the Btu of biomethane prior to pipeline injection (to meet pipeline specifications), dedicated metering must be installed to substantiate quantities of NG or propane used for this purpose. If dedicated metering is not installed or not verifiable, all NG reported in Field 2.26 will be added to NG and propane reported in Field 2.19 (and considered used for upgrading biogas).

6. Field 2.31 represents the Net biomethane injected into the pipeline.

   Because the monthly total quantity of the pipeline injection (in MMBtu) may include NG and/or propane blended with biomethane to meet pipeline specifications, the use of any non-renewable gas must be explicitly disclosed through invoices. The quantity entered in Field 2.31 shall include only the net biomethane quantity; any fossil inputs must be subtracted from the actual quantity injected into the pipeline that was purchased by the local utility or other party. This is consistent with quantities reported for RIN generation under the RFS, which is based on the Btu of the pipeline quality biogas after treatment, and prior to any blending with non-renewable fuel or injection into a pipeline.

   Note: CI calculations for biomethane are performed on a net maximum available biomethane for dispensing (Field 2.38), which is calculated by subtracting all buyback fossil NG and propane used to boost biomethane Btu, and pipeline evaporative loss from renewable biomethane (in MMBtu) injected into the pipeline.

7. Pipeline transport distance for renewable natural gas (Fields 2.35.a and 2.35.b)

   For pipeline transport distance from a biogas processing facility to a CNG dispensing station or to a liquefaction facility, driving distances between the two locations may be determined using a publicly available web-based mapping. For RNG to CNG pathways which use multiple dispensing stations, staff used fuel sales data for Q1 and Q2, 2017, and calculated a volume-weighted Standard Station Centroid, which was found to be just below Bakersfield. Based on the centroid approach, applicants using multiple dispensing stations may use driving distance from a digester in the U.S. or Canada to Bakersfield, CA as the pipeline transmission distance in the CI Calculator

(or Tier 2 if applicable). Alternatively, the applicant could choose to use a more conservative value, such as the distance to the farthest fueling facility, in order to minimize the risk of exceeding the certified CI as a result of changes in the supply chain.

8. Percentage of injected CNG that is converted into LNG (Field 2.35.c)

   For LNG pathway application, enter the percentage of total injected net biomethane (LHV, Cell AD55) that is liquefied into LNG. Invoices or contracts may be used to establish this value.

C. Section 3. CNG, LNG, and L-CNG Production and Transport Data

Table 10 provides details of inputs for LNG and L-CNG pathways. Additional details are included below Table 10.

Table 10: List of Input Fields for Section 3 of the CI Calculator

Field Name	Description and Instructions
3.1 LNG, L-CNG Facility Name and ID	Facility Name and ID should represent the Facility registered name (Facility Name in the AFP). If not available, contact CARB for LCFS Facility ID.
3.2 Transport Distance from Liquefaction Plant to station by HD Truck (miles)	Input distance from the liquefaction facility to the intended LNG or LCNG dispensing station in California. Additional details are included below Table 10.
3.3 Liquefaction EF (gCO_2e/gallon LNG)	If applying for a Bio-LNG or Bio-L-CNG pathway, enter the most recent validated/verified emission factor for the LNG facility. Data sources must be documented in the Supplemental Documentation attached with the CI Calculator.
3.4 LNG Truck Type	Select the truck type used to transport Bio-LNG to dispensing station(s) in California.
3.5 LNG Storage System Type	Enter the storage type used to store the Bio-LNG.

1. Additional Details for Section 3

1. Transport of LNG to dispensing facility (Field 3.2)

   Driving distance between any two locations may be determined using a publicly available web-based driving distance if fuel is dispensed at a single station. If multiple dispensing facilities are utilized, a volume-weighted average transport distance based on 24 months (at least 3 months if provisional) of sales records must be used for LNG distribution to fueling facilities. Alternatively, the applicant could choose to use a more conservative value, such as the distance to the farthest fueling facility, in

order to minimize the risk of exceeding the certified CI as a result of changes in the supply chain.

D. Section 4. CI Calculation Details

This section contains an example pathway CI calculation with a detailed breakdown of all calculations used for CI determination based on information entered by the user and applicable reference data.

VI. EF Table Worksheet

The "EF Table" worksheet contains the emission factors used in the pathway's carbon intensity calculation.

A. "Grid Electricity (~~2021~~ eGRID Region)" table

If "User Defined Mix" is applicable, consult with CARB staff to develop an emission factor for the "User Defined Mix" to be input in this table. Data sources for "User Defined Mix" electricity mixes must be documented in the Supplemental Documentation attached to the CI Calculator.

B. "Fuels used in pathway" table

If any of "User-Defined Fuel-1 (MJ)", "User-Defined Fuel-2 (MJ)", or "User-Defined Fuel-3 (MJ)" is applicable, please consult with CARB staff to develop the emission factor to be input in this table.