LCFS Guidance

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CALIFORNIA AIR RESOURCES BOARD

Low Carbon Fuel Standard Guidance 19-06 (Revised)

Determining Carbon Intensity of Dairy and Swine Manure Biogas to Electricity Pathways

A. Introduction

The California Air Resources Board's (CARB) Low Carbon Fuel Standard (LCFS) regulation, which appears at sections 95480 to 95503 of title 17, California Code of Regulations, is designed to reduce greenhouse gas emissions associated with the life cycle of transportation fuels used in California. CARB staff has prepared this guidance document to describe the regulatory requirements in a user-friendly format. Unlike the regulation itself, this document does not have the force of law. It is not intended to and cannot establish new mandatory requirements beyond those that are already in the LCFS Regulation, nor can it supplant, replace or amend any of the legal requirements of the regulation. Conversely, any omission or truncation of regulatory requirements does not relieve entities of their legal obligation to fully comply with all requirements of the regulation.

B. Background

Pursuant to section 95488.8(i)(1) of the LCFS Regulation, electricity produced from renewable or low-carbon intensity (CI) sources may be matched to electricity that is either used as a transportation fuel or used in electrolysis to produce hydrogen for transportation purposes using book-and-claim accounting.[1,2] LCFS stakeholders, particularly dairy and swine manure operations that do not have access to the natural gas common-carrier pipeline, have expressed interest regarding this opportunity for biogas-derived electricity.

Pursuant to the fuel pathway classification system described in section 95488.1, a Tier 2 fuel pathway application[3] is required for low-CI electricity. A Tier 2 pathway applicant may use the CA-GREET4.0 model or, subject to CARB approval pursuant to section 95488.3(a) and 95488.7(a), an equivalent or superior model, to determine the CI of the site-specific resource(s) and generation equipment. The Tier 1 Simplified CI Calculators for Biomethane[4] are designed to determine the CI of pathways where biomethane is dispensed as CNG, LNG, and L-CNG for transportation fueling; however, these calculators can be modified to determine the CI of biogas-derived electricity.

The purpose of this document is to provide technical guidance on how a Tier 1 calculator for biomethane has been modified to determine the CI of biogas-derived electricity as part of a Tier 2 application. The Tier 1 Simplified CI Calculator for Biomethane from Anaerobic Digestion of Dairy and Swine Manure is utilized as an example for a pathway in which biogas is supplied to a stationary reciprocating engine and generator set with 30% electrical efficiency.

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[1] Book-and-claim accounting refers to the chain-of-custody model in which decoupled environmental attributes, such as Renewable Energy Certificates, are used to represent the ownership and transfer of transportation fuel under the LCFS without regard to physical traceability.

[2] For more information on book-and-claim accounting for low-CI electricity see LCFS Guidance 19-01; note that the biogas or other fuel must be directly supplied to the electricity generation unit. For more information on book-and-claim accounting for biomethane see LCFS Guidance 19-05; note that these provisions are applicable to the use of biomethane in natural gas vehicles and hydrogen production

[3] Tier 2 requirements and application process are described in section 95488.7. Refer to the Application Checklist for Tier 2 Electricity pathways for specific documentation requirements, available at: https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwayapplicationprocess.htm.

[4] All Board-approved life cycle analysis tools including Tier 1 Simplified CI Calculators and Instruction Manuals are available at: http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm.

C. POTENTIAL MODIFICATIONS TO SIMPLIFIED CI CALCULATOR TO SUPPORT A TIER 2 APPLICATION

A Tier 1 Simplified CI Calculator has been modified to determine the CI of biogas-derived electricity as part of a Tier 2 fuel pathway application. The following steps provide an illustrative example for a hypothetical pathway in which all biogas captured from a dairy or swine manure digester is cleaned and supplied to an onsite electricity generation unit; note that additional modifications may be necessary depending on the specific pathway's processing steps, metering, and equipment. Consult with LCFS Fuels Evaluation Section staff for assistance if the biogas is supplied to more than one end use, as the instructions in this specific document do not pertain to such a scenario.

1. Enter all required data for the manure management and digester operations in the 'Manure-to-Biogas (LOP Inputs)' tab, and for the biogas-electricity generation operations in the 'Biogas-to-RNG' tab, using the Tier 1 calculator Instruction Manual[5] as guidance. Specifically:

    a. In the "Biogas-to-RNG" tab, enter the monthly metered quantity of raw biogas produced in standard cubic feet (SCF) and the methane concentration (%) in raw biogas in fields 2.4 and 2.5, respectively. If this is the same quantity as "raw biogas at inlet to cleanup/upgrading," entries in fields 2.8 and 2.9 may be duplicated from fields 2.4 and 2.5.
    b. In the "Biogas-to-RNG" tab, enter metered monthly biomethane input to electricity production in fields 2.32 and metered electricity produced in 2.33 for total on-site electricity production from biomethane. The total biomethane used (MMBtu, HHV) in the operational data period will appear in cell AE54 and the total electricity generated will appear in cell AF52.
    c. If any biogas or biomethane or biomethane-derived electricity is consumed onsite, enter the metered monthly consumption in field 2.20, 2.21 or 2.22, and consult with CARB staff regarding any additional potentially necessary modifications.
    d. In the "Biogas-to-RNG" tab, leave field 2.31blank.

[5] All Board-approved life cycle analysis tools including Tier 1 Simplified CI Calculators and Instruction Manuals are available at: http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm.

2. Determining the CI adjustment factor using project-specific electricity generation efficiency:

   To incentivize the utilization of energy efficient designs and technologies that enhance production of low carbon fuels (including electricity) to displace conventional fossil fuels, a technical CI adjustment factor is included in the CI calculation of biogas-derived electricity pathways that reflect avoided methane emissions. This adjustment serves to reasonably limit the LCFS incentive for low-efficiency pathways relative to higher efficiency ones. Without this adjustment, pathways with low efficiency generation would receive about the same amount of LCFS credit as high efficiency pathways, and therefore there would be no incentive to install higher efficiency electrical generating equipment.

   Similar adjustments are included in the Tier 1 Simplified CI Calculators for Biomethane from Anaerobic Digestion of Organic Waste and Dairy and Swine Manure. In the Tier 1 Biomethane pathways, the carbon balance is used to determine the theoretical maximum quantity of methane that could have been produced. The carbon balance approach is not applicable to electricity; therefore, for this modified calculator, CARB staff selected 50% as a reasonable efficiency benchmark based on the average efficiency of NG-derived electricity at California power plants and the best available technologies for electricity production, including solid oxide fuel cells.[6,7]

   The calculation of the adjustment factor (f_{adj}) is illustrated below:

$$f_{adj} = \frac{\eta_e}{\eta_{benchmark}} = \frac{kWh_{produced} \times 3{,}412\ Btu/kWh}{MMBtu_{(HHV)biogas\ consumed} \times\ 10^6\, Btu/MMBtu\ \times 50\%}$$

[6] California Energy Commission (October 2018). Thermal Efficiency of Natural Gas-Fired Generation in California 2018 Update. CEC-200-2018-011

[7] Solid Oxide Fuel Cells use natural gas to generate electricity and may achieve 50–60% electrical efficiency. See e.g., Solid Oxide Fuel Cells fueled with biogas: Potential and constraints (2019). Renewable Energy, Volume 134. Available at: http://www.sciencedirect.com/science/article/pii/S0960148118313478

A thermodynamic comparison of solid oxide fuel cell-combined cycles (2018). Journal of Power Sources, Volume 397. Available at: http://www.sciencedirect.com/science/article/pii/S0378775318307432

Where,

- η_e represents the electrical efficiency of the generating unit, if less than 50%, and is determined for each project using the total quantity of biogas (in MMBtu, HHV) supplied to the power generating unit and the quantity of electricity generated over the operational data period. If the electrical efficiency is greater than or equal to 50%, no adjustment is required (f_{adj} = 1.0).
- $\eta_{benchmark}$ represents the benchmark efficiency of 50%.

For example, the adjustment factor of an IC engine genset with an efficiency of 30% is calculated as:

$$f_{adj} = \frac{\eta_e}{\eta_{benchmark}} = \frac{30\%}{50\%} = 0.6$$

The adjustment factor is applied to the subtotal CI to determine the final CI. This subtotal CI includes net methane from the digester (avoided methane), fugitive methane from biogas cleanup, and net CO_2 (engine emissions and CO_2 diverted from the baseline scenario); emissions from energy use (e.g., grid electricity or utility natural gas) are not adjusted.

The applicant is not required to provide any additional information; these calculations are done automatically in the modified calculator using the user supplied inputs.

> **Note:** Cell C93 of the "Biogas to RNG" tab has the default stationary reciprocating engine used to produce electricity from biogas; if another technology is used, this cell should be relabeled accordingly.

3. Calculating emissions from electricity production:

   The emission factors for biogas electricity production using a stationary reciprocating engine (in g CO2e/MMBtu of biogas input) are built into the "EF Table" tab of the calculator. If another technology is used to produce electricity from biogas, the modified calculator automatically accounts for emissions from electricity production using a method other than a stationary reciprocating engine based on the adjustment factor determined in 2. above.

4. Convert the CI result to per MJ of electricity:

Several other modifications in the "Biogas-to-RNG" tab appropriately incorporate the emissions from electricity generation and the adjustment factor from previous steps, and calculate the final CI of the biogas electricity:

Applicant should consult with CARB staff regarding any additional potentially necessary modifications.

D. CONTACT

If you have questions regarding the above information, please visit the LCFS Contacts webpage: https://www.arb.ca.gov/fuels/lcfs/contact.htm.

E. APPENDIX

This appendix includes the detailed modifications to the Tier 1 Calculator described above

1. In the "Avoided Emissions" tab the following formulas were modified to use Cell C45, which references the quantity of biogas supplied to electricity generation rather than the quantity of biomethane pipeline injected in cell C43:

   a. In cell C47, replace the allocation factor formula with **=C45/C40**.
   b. In cell C50, replace the net allocation formula with **=IFERROR(C49/C45,0)**. Similarly, in cell G51 of the same tab, replace the diverted CO2 emissions formula with **=IFERROR(G50/C45,0)**.
   c. In the "EF Table" tab, starting from cell D89, add the following parameters and formulas to calculate the adjustment factor:

2. In the "EF Table" tab, starting from cell D89, the following parameters and formulas were added to calculate the adjustment factor (f_{adj}):

	D	E
89	Engine Efficiency (LHV), %	='Biogas-to-RNG'!AF52*Reference!F49/'Biogas-to-RNG'!AE55
90	Engine Efficiency (HHV), %	='Biogas-to-RNG'!AF52*Reference!F49/'Biogas-to-RNG'!AE54
91	Benchmark Efficiency (HHV), %	50%
92	CI Adjustment Factor	=IF(E90/E91<1,E90/E91,1)

3. In the “EF Table” tab, starting from cell E65, the following parameters and formulas were added to apply the adjustment factor to the combustion emission factors for biogas electricity production using a stationary reciprocating engine.

	C	D	E
64	**Biogas electricity production**		**Adjusted Carbon Balance using ratio in E92**
65	**Stationary Reciprocating Engine**		**g/MMBtu Biogas input**
66	VOC	62.7	=D66*$E$92
67	CO	273.5	=D67*$E$92
68	CH4	446.0	=D68*$E$92
69	N2O	0.9	=D69
70	CO2	57521.6	=D70*$E$92
71	Subtotal gCO2e/MJ	65.9	=(E66*Reference!$B$22+E67*Reference!$B$23+E68*Reference!$B$20+E69*Reference!$B$21+E70)/Reference!$H$45

4. Several modifications were made in the “Biogas-to-RNG” tab appropriately incorporate the emissions from electricity generation and the adjustment factor from previous steps, and calculate the final CI of the biogas electricity:

    a. In “Section 4. CI Calculation Details,” modify each formula from cell F64 to cell F80, by replacing $AH$58 with $AE$55. This modification changes the functional unit of the CI from “per MMBtu available biomethane for dispensing” to “per MMBtu biomethane used for electricity production.”
    b. In cells G67:G68, cells G73:G75 and cells G79:G80, replace =Reference!$H$45 with =Reference!$H$45*'EF Table'!$E$92. This modification accounts for the efficiency of electricity generation calculated above.
    c. Clear original content in cells B82:G89 and cells C91:G91, because the pipeline transmission, compression, liquefaction, and transportation of CNG and/or LNG are not relevant in this pathway.
    d. From cell B90 to cell G99, modify according to the following table. All blank cells in the following table do not contain values and their original content from the Tier 1 calculator should be deleted.

	B	C	D	E	F	G
90	**Manure to Electricity**					**gCO_2e/MJ**
91	**CAMX**					
92		**Reciprocating engine emissions**				
93						
94						**='EF Table'!E71**
95		**Credits**			Methane avoided	**='Avoided Emissions'!C52*'EF Table'!E92**
96					CO2 diverted	**='Avoided Emissions'!G52*'EF Table'!E92**
97					Final electricity CI	**=IF(AE52=0,0,(G70+G81+G95+G96+G94)/'EF Table'!E89)**
98						
99						