Oregon Clean Fuels Program

Determining the Carbon Intensity of Biogas to Electricity Pathways

Implementing the Clean Fuels Program Electricity 2021 Rulemaking

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Introduction

This document pertains to determining the carbon intensity of biogas to electricity pathways within Oregon using the Oregon Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation 3.0 model. These pathways continue to advance, also in the state of Oregon, as we accelerate the transition to transportation electrification.[1,2] The OR-GREET 3.0 model includes well-to-wheels modeling of vehicle/fuel systems and excludes vehicle cycle modeling for vehicles and end-of-life use or reuse of materials and components (e.g., electric vehicles).

Please review details about book-and-claim accounting used for matching renewable electricity generation to electric vehicle charging separately.[3]

Background

Pursuant to Oregon Administrative Rule 340-253-0400(6)[4], a regulated party, credit generator, or aggregator has an option to develop a fuel pathway to be reviewed and potentially certified under 340-253-0450.

Under that rule, fuel pathway applications fall into two tiers: (a) tier 1 and (b) tier 2. [5]

(a) A Tier 1 applicant may include a conventionally produced alternative fuel of a type that has been well-evaluated through Oregon and/or California low carbon fuel standards.
(b) A tier 2 applicant may use the OR-GREET 3.0 model or, subject to DEQ approval under section OAR 340-253-0450(5)(a), an equivalent or superior model to determine the CI of the site-specific resource(s) and generation equipment.

Application Process and Requirements

The tier 1 simplified CI calculators are designed to determine the CI of pathways where biomethane is dispensed as compressed natural gas, liquefied natural gas, and liquefied to compressed natural gas for transportation fueling. However, the simplified tier 1 calculators can be modified to determine the CI of biogas-derived electricity as part of a tier 2 application.

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[1] https://olis.leg.state.or.us/liz/2016R1/Downloads/MeasureDocument/sb1547
[2] Mintz, M. and P. Voss. Database of Renewable Natural Gas (RNG) Projects: 2020 Update, Argonne National Laboratory, October 2020, https://www.anl.gov/es/reference/renewable-natural-gas-database.
[3] 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 CFP without regard to physical traceability. See more details about Chain-of_custody under OAR 340-253-0450(7)(d).
[4] Available at: https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=277332
[5] All CFP-approved life cycle analysis tools including Tier 1 simplified calculators and instructions manuals are available at: https://www.oregon.gov/deq/ghgp/cfp/Pages/Clean-Fuel-Pathways.aspx

The current OR-GREET manual for tier 1 simplified carbon intensity calculators[6] provides instructions on biomethane pathways. This document provides additional guidance for modifications to the Tier 1 simplified calculator for biomethane from anaerobic digester of dairy and swine manure for electricity generation.

Three main topics are covered in this document:
(1) Avoided emissions accounting for mixed-materials inputs for a combined CI, and
(2) The "adjustment factor" accounting for the average efficiency of the generator set used in natural gas- and biogas-derived electricity in Oregon power plants, and
(3) Modifications to the biomethane from anaerobic digester of dairy and swine manure simplified calculator for biogas to electricity pathways.

Although this document focuses on modifying the biomethane from anaerobic digester of dairy and swine manure simplified calculator, applicants should consult with CFP staff regarding any additional potentially necessary modifications for other organic material inputs used for biogas to electricity pathways.

(1) Avoided emissions from mixed-material inputs for a combined CI

Suppose a producer uses multiple feedstocks from the same production system (e.g., dairy cow manure and other dairy waste from a dairy production system). In that case, the applicant must populate the simplified calculator for biomethane from anaerobic digester of dairy and swine manure for each input to that system, considering the "other" waste products would not be credited for avoided methane emissions like manure is. Then, the resultant CI values from the multiple feedstocks are combined using a weighted average considering the total amount of each feedstock input in the system and the total amount of biogas produced.

(2) The adjustment factor for generator set efficiency

An "adjustment factor" is used to account for the average efficiency of the generator set (or genset) used in natural gas- and biogas-derived electricity in Oregon power plants because no electrical generation system currently converts 100% of the energy in methane or biomethane (or biogas) to electricity. Therefore, the CFP considers a 50% efficiency factor in the CI calculation for biogas to electricity pathways.

This adjustment serves to reasonably limit the LCFS incentive for negative CI value pathways (i.e., manure pathways that receive a methane emissions avoidance credit), where the facilities operate without higher efficiency electrical generating equipment[7].

We also considered that the energy lost as engine heat, depending on the system design, can be recovered heat to the digester, lowering overall operating costs.[8] The recovered heat from the genset is not directly accounted for in the efficiency calculation. However, it is indirectly accounted for as reduced input heat to the digester. Therefore, the total amount of heat available from biogas can be deduced from the higher heating value.

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[6] https://www.oregon.gov/deq/FilterDocs/Tier1ORgreetManual.pdf
[7] DEQ has aligned its adjustment factor with the recommendations of CARB for continuity between the programs and jurisdictions. Reference LCFS Guidance 19-06.
ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/lcfsguidance_19-06.pdf
[8] Target digester temperature range between 86–100° F for mesophillic and 122–140° F for thermophilic anaerobic digesters.

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. If the genset operates at a higher than 50% efficiency, the adjustment factor is not applicable.

Calculation:

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

$$f_{adj} = \frac{\eta_e}{\eta_{reference}} = \frac{23\%}{50\%} = 0.46$$

Where,

η_e represents the electrical efficiency of the generating unit, if less than 50%, determined using the quantity of biogas (in MMBtu, HHV) supplied to the power generating unit and the quantity of electricity generated over the operational data period. Again, the adjustment factor is not applicable if the system operates at a higher than 50% efficiency.

$\eta_{reference}$ represents the genset efficiency of 50%.

(3) How to modify the simplified calculator:

a. Enter all required data for the manure management and digester operations in the "manure-to-biogas (LOP inputs)" tab and the biogas-electricity generation operations in the 'biogas-to-RNG' tab, using the Tier 1 calculator instruction manual as guidance.
b. In the "avoided emissions" tab, alter the following formulas 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:
   i. In cell C47, replace the allocation factor formula with C45/C40.
   ii. In cell C50, replace C49/C43 with C49/C45.
   iii. Similarly, in cell G51 of the same tab, replace G50/C43 with G50/C45
c. For the adjustment factor, in the "EF table" tab, starting from cell D89, add the following parameters and formulas to calculate the adjustment factor:

	D	E
89	Reciprocating eng. Efficiency (LHV), %	='Biogas-to-RNG'!X52*Reference!F49/'Biogas-to-RNG'!W55
90	Reciprocating eng. Efficiency (HHV), %	='Biogas-to-RNG'!X52*Reference!F49/'Biogas-to-RNG'!W54
91	Benchmark efficiency (HHV), %	50%
92	Adjustment factor	=IF(E90/E91<1, E90/E91,1)

d. The emission factors for biogas electricity production using a stationary reciprocating engine (in g/MMBtu of biogas input) are built into the "EF table" tab. If another technology is used to produce electricity from biogas, the applicant should modify cells C76 to E83 to reflect the emissions of such technology. Applicants should consult with the CFP staff for assistance deriving appropriate emission factors for technologies other than a stationary reciprocating engine. Then, in the "EF table" tab, starting from cell E75, add the following parameters and formulas to apply the adjustment factor to the combustion emission factors for biogas electricity production using a stationary engine:

	C	D	E
75	**Biogas electricity production**		**Adjusted carbon balance using ratio in E92**
76	**Stationary Reciprocating Engine**	g/MMBtu biogas input	g/MMBtu biogas input
77	VOC	62.7	=D77*$E$92
78	CO	273.5	=D78*$E$92
79	CH4	446.0	=D79*$E$92
80	N2O	0.9	=D80
81	CO2	57561.1	=D81*$E$92
82	Subtotal **gCO2e/MJ**	66.0	=(E77*Reference!$B$22+E78*Reference!$B$23 +E79*Reference!$B$20+E80*Reference!$B$21+E81) /Reference!$H$45

e. Finally, convert the CI result to per MJ of electricity: Several 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:

   i. In "Section 2. biomethane production data," replace the original contents in cell D52 with =IFERROR(SUMPRODUCT(C28:C51/SUM(C28:C51),D28:D51),0), and in cell F52 with =IFERROR(SUMPRODUCT(E28:E51/SUM(E28:E51),F28:F51),0). This ensures the weighted average biomethane content is accounted for in the calculation.

   ii. In "Section 4. CI calculation details," modify each formula from cell F64 to cell F74 by replacing $V$55 with $W$55. This modification changes the functional unit of the CI from "per MMBtu biomethane injected into the pipeline" to "per MMBtu biogas used for electricity production."

   iii. In cell G67 and cells G71:G74, replace Reference!$H$45 with Reference!$H$45*'EF Table'!E92. This modification adjusts emissions that are associated with biogas combustion and fugitive emissions.

   iv. Delete original content in cells B76:G83 and cells C85:G85 because the pipeline transmission, compression, liquefaction, and transportation of CNG and LNG are not relevant in this pathway.

   v. From cell B84 to cell G93, modify according to the following table. Note: All blank cells in the following table do not contain values. The applicant should delete the original content in these cells—within the simplified calculator.

	B	C	D	E	F	G
84	**Manure to Electricity**					**gCO_2e/MJ**
85	**3-CAMX Mix**					
86		**Reciprocating engine emissions**				
87						
88						**='EF Table'!E82**
89				**Credits**	Methane avoided	**= 'Avoided Emissions'!C52*'EF Table'!E92**
90					CO2 diverted	**='Avoided Emissions'!G52*'EF Table'!E92**
91					Final electricity CI	**=IF(W52=0,0,(G68+G75+G89+G90+G88)/'EF Table'!E89)**
92						
93						

Points considered in the evaluation of efficiency-related factors include the following:

(1) Field operating efficiency is typically lower than a manufacturer's specified efficiency, depending on various factors (e.g., system scale, location, and ambient weather conditions).
(2) Tradeoffs between criteria pollutants and electricity efficiency exist, and managing a genset for criteria pollutant emissions (e.g., carbon monoxide, sulfur dioxide, nitrous oxides) influences its electricity efficiency.[9,10]

Applicants should also consider the following:

(1) RECs generated by biogas generators and used for reporting in the CFP must meet the new date and other requirements of the Green-e Standard under OAR 340-253-0470(5)(b).
(2) Please be sure to follow all pertinent local operating guidelines and regulations such as the biogas or biomethane from composting (e.g., in landfills or other facilities) operating guidelines in OAR 340-096-0090.[11]

Reporting Requirements

To maintain an active pathway eligible to generate credits, the applicant must file the annual fuel pathway report and seek third-party verification if required.

Third-Party Validation and Verification Requirements

The CFP staff will review the application and identify any site-specific inputs during the certification process.

Alternative formats

DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us.

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[9] Itodo, I. N., Yakubu, D. K., & Kaankuka, T. K. (2019). The Effects of Biogas Fuel in an Electric Generator on Greenhouse Gas Emissions, Power Output, and Fuel Consumption. *Transactions of the ASABE*, *62*(4), 951-958.
[10] Souza, S. N. D., Lenz, A. M., Werncke, I., Nogueira, C. E., Antonelli, J., & Souza, J. D. (2016). Gas emission and efficiency of an engine-generator set running on biogas. *Engenharia Agrícola*, *36*(4), 613-621.
[11] OAR 340-096-0090 Special Rules Relating to Composting: Operations Plan Approval. URL: oregon.public.law/rules/oar_340-096-0090