State of California
Air Resources Board

Staff Discussion Paper

Renewable Natural Gas from Dairy and Livestock Manure

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BACKGROUND AND SUMMARY

Reduction of methane emissions associated with livestock manure management operations is a major component of the California Air Resources Board's (ARB) Short-Lived Climate Pollutant (SLCP) Reduction Strategy[1] to reduce methane emissions by 40% from 2013 levels by 2030. Manure management practices at California dairies currently account for 25% of the State's methane emissions, primarily from the storage of flushed manure from milking cows in open lagoons where the manure undergoes anaerobic respiration. Open lagoons allow methane—a highly potent greenhouse gas (GHG)—to vent freely to the atmosphere. Biogas control systems, or digesters, avoid venting and capture biomethane (renewable natural gas, or RNG) for either destruction or use as a fuel.

Historically, the Low Carbon Fuel Standard (LCFS)[2] took a conservative approach in crediting transportation fuel production from livestock manure management operations. For example, in pathway CNG004 in the Carbon Intensity Lookup Tables in the prior regulation assumed that, in the absence of the fuel project, the methane from the lagoons would have been captured and destroyed.[3] This represented the most conservative baseline scenario (or reference case), but it did not match the true operational practice of most dairies with flush systems, and therefore undervalued the GHG savings delivered by these project types. As a result, ARB has not issued any LCFS credits for manure-to-biomethane to date.

During the preparation for readoption of the LCFS rule in 2015, ARB recognized this potentially undervalued GHG reduction opportunity and moved to strengthen the incentive for these projects.[4] Consistent with the SLCP Strategy, ***ARB is now approving digester pathway applications that use an "avoided methane venting" baseline scenario***.

Third-party verification of credits will be an important part of the LCFS program moving forward.[5] A robust quantification and verification framework for avoided methane from livestock projects already exists through the ARB-approved Compliance Offset Protocol

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[1] The SLCP Strategy is available at: https://www.arb.ca.gov/cc/shortlived/shortlived.htm

[2] The current LCFS regulation is available at: https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf.

[3] See page 67 of the prior LCFS regulation, available at: https://www.arb.ca.gov/regact/2011/lcfs2011/frooalapp.pdf

[4] ARB has approved one livestock waste pathway assuming avoided methane venting and this pathway will be used as an example in this paper. ARB certified this as a prospective pathway under the old rule and later recertified it as a legacy pathway under the new rule. This prospective pathway included an operating condition that requires third-party verification in accordance with the Compliance Offset Protocol. The prospective LCFS Pathway Summary is available at: https://www.arb.ca.gov/fuels/lcfs/2a2b/apps/calbio-sum-122115.pdf

[5] For a general description of this topic see: https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/verification_whitepaper_102116.pdf

Livestock Projects (Livestock Protocol).[6] ARB plans to use the same quantification and verification framework—with minor modifications as discussed in this paper—to facilitate manure-to-RNG crediting under the LCFS.[7] The goal of this alignment is both to facilitate third-party verification and to allow a straightforward transition into LCFS crediting for project developers (and verifiers) already familiar with this protocol. ARB will impose this verification requirement, and other requirements discussed in this paper, as "operating conditions" for each manure-to-RNG pathway.[8]

Staff has estimated that qualifying manure-to-RNG fuel pathways under the LCFS could potentially earn Carbon Intensity (CI) scores ranging from -100 to -400 gCO$_2$e/MJ of bio-CNG. These representative CI scores account for the net reduction in GHG emissions achieved by diversion of manure from open lagoons that previously vented methane to the atmosphere, which would occur in the absence of the Biogas Control System (BCS or "digester") project.

Senate Bill (SB) 1383 signals that California intends to impose mandatory controls on methane emissions from the dairy industry as soon as 2024.[9] As long as efforts to reduce methane emissions from livestock operations remain voluntary, the opportunity to earn LCFS credits for avoided methane will add significant value and improve the economic feasibility of manure-to-biomethane transportation fuel projects. SB 1383 and the SLCP Strategy require ARB to provide guidance on the impact of such mandatory methane control requirements on LCFS credits.[10] ARB's goal is to describe a clear transition from the period where ARB incents these projects through credits (using the LCFS and Cap-and-Trade) to the period where mandatory control may be required. This paper begins the process of seeking stakeholder input on how to best facilitate the crediting of LCFS credits for biomethane from digesters.

PURPOSE

This discussion paper should assist stakeholders in providing useful feedback on how the LCFS pathway applicants can use the data collected and verified in accordance with

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[6] CARB (2014). The Livestock Projects Compliance Offset Protocol (adopted November 14, 2014). Available at: https://www.arb.ca.gov/cc/capandtrade/protocols/livestock/livestock.htm

[7] See §95488(c)(4)(I)5 of the current LCFS regulation on the ability of the Executive Officer to approve the use of additional calculation methodologies outside of the CA-GREET framework.

[8] Under the current LCFS regulation, biomethane from manure operations is classified as a "Tier 2" fuel pathway (see §95488(b)(2)(B) of the LCFS regulation). The Executive Officer may impose operating conditions applicable to each Tier 2 fuel pathway in a certification statement (see §95488(c)(5)(K)).

[9] Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) (codified in Health and Safety Code sections 39730.5-39703.8) available at: http://www.leginfo.ca.gov/pub/15-16/bill/sen/sb_1351-1400/sb_1383_bill_20160919_chaptered.htm

[10] Section 39730.7.(e) of Health and Safety Code was added by SB 1383. It directs ARB to provide guidance on credits generated from livestock and dairy projects pursuant to the Low-Carbon Fuel Standard no later than January 1, 2018.

the Livestock Protocol in conjunction with CA-GREET calculations to determine LCFS pathway CI scores. ARB will use input from stakeholders to develop a forthcoming guidance document, as required by SB 1383.

This discussion paper specifically applies to RNG used in the California transportation fuel market produced from methane that would otherwise be vented into the atmosphere from uncontrolled anaerobic treatment and/or storage of manure on dairy cattle and swine farms located either in or outside of California. Existing projects, which are currently receiving credits in the voluntary or Cap-and-Trade Compliance Offset markets, as well as new digester projects, may apply for an LCFS fuel pathway CI score.

To earn LCFS credits under the current LCFS regulation, applicants will be required to follow ARB's Livestock Protocol. The applicant will use project data collected and verified in accordance with the Livestock Protocol to determine the LCFS manure-to-RNG pathway CI score.

This document provides an overview of:

- project eligibility,
- qualifying end uses,
- LCFS requirements,
- CI determination, and
- potential LCFS regulatory amendments to the timing of credit generation, third-party verification, avoided methane crediting period and additionality.

In conjunction with this discussion paper, staff has developed a CA-GREET 2.0 template[11] for an example livestock (dairy) manure to bio-CNG pathway, for illustrative purposes. When finalized, the guidance and example calculation template will be useful to potential applicants in estimating their CI score and preparing an LCFS application, and will provide clarity to project developers seeking to construct new livestock manure methane capture systems and produce fuel to generate LCFS credits.

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[11] The draft CA-GREET template for an example Dairy Manure to Bio-CNG pathway is available for download at: http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet2-dairycng.xlsm

LCFS REQUIREMENTS FOR MANURE-TO-RNG PATHWAYS

The existing example of an approved livestock manure-to-RNG pathway with an avoided methane baseline is the Kern County Dairy Biogas Cluster. This pathway includes operating conditions stating that:

1. The applicant must use ARB's Compliance Offset Protocol for Livestock Projects (adopted November 14, 2014) to quantify the avoided methane for each of the anaerobic lagoon projects proposed to be developed for the Kern County Dairy Biogas Cluster ("CalBio"). Under this requirement, the following steps apply:
   - Project must be issued Registry Offset Credits following the requirements of the protocol and ARB's Cap-and-Trade Regulation;
   - Projects must retire Registry Offset Credits (ROCs) and apply for conversion of these credits into LCFS credits rather than ARB Offset Credits;
   - Any quantity of fuel receiving LCFS credits using this pathway shall not be used to claim credits under California's Cap-and-Trade Program or any other carbon market
2. CalBio shall provide quarterly data for two years to demonstrate the quantity of CNG produced from dairy biogas including methane emissions from covered lagoons, effluent ponds and venting, and total methane captured.
3. CalBio shall provide quarterly receipts for two years to demonstrate the electric power/natural gas consumed at the central upgrading unit and total compression energy at the facility.
4. The avoided methane credits estimated for this pathway may be changed in the future due to new regulatory requirements for methane destruction from anaerobic lagoons.
5. Any additional information related to the fuel's lifecycle or production volumes must be made available if requested by ARB.

6. The magnitude of the credit for avoided methane from diversion of manure from anaerobic lagoon management is limited to existing permitted head of cattle at all supplying animal facilities in 2015.

Staff would like to follow this model for all manure-to-RNG pathway applications received under the current regulation. The following subsections discuss these potential requirements, highlighting exceptions and modifications from the Livestock Protocol that staff is interested in receiving feedback on to ensure consistency with the scope and system boundaries of the life cycle assessment (LCA) methodology used under the LCFS, and clarify the process applicants should follow to obtain a certified CI score and generate LCFS credits.

To the extent feasible, ARB would like to design the LCFS requirements to follow the existing process of evaluation with which livestock project developers, operators, registries, verification bodies, and ARB staff have already developed experience. This paper provides a discussion of the potential LCFS requirements to assist experienced stakeholders in commenting on the suggested implementation. Table 1 provides a comparison of the requirements for LCFS and the Livestock Protocol. The following sections discuss the requirements listed in detail.

Table 1. Comparison of Suggested LCFS Requirements for Manure-to-RNG Pathways to the Livestock Protocol

Areas where LCFS requirements are intended to be identical to the Livestock Protocol	Protocol Reference
Additionality requirements to ensure any crediting is for GHG reductions resulting from actions not required by law or beyond business as usual	Protocol, chapter 3.4
Offset project crediting period to define a reliable period of time for return on investment for project implementation	Protocol, chapter 3.6
The LCFS Pathway system boundary is a subset of the Livestock Protocol's Offset Project Boundary. See Figure 1 in this document.	Protocol, Figure 4.1
GHG sources and sinks; for example, emissions from enteric fermentation are considered outside the fuel system boundary and will not be included.	Protocol, Table 4.1
Project monitoring parameters	Protocol, Table 6.1
Livestock operation parameters including livestock categories, volatile solid excretion rates, qualifying digesters (closed tank reactor, covered lagoon) and collection efficiencies, IPCC methane conversion factors (MCF).	Protocol, Tables A.1 to A.5
Registry listing, monitoring, reporting, and third-party verification requirements.	Protocol, chapters 6-8
Equations for Baseline Methane Emissions	Protocol, Equations 5.2 to 5.4
Areas for discussion regarding potential divergence	**Reference**
Timing of application and reporting periods.	
Allocation of emissions between transportation fuel and other destruction methods.	
Regulatory compliance requirements.	Protocol, chapter 3.7
Emission factors for energy use, fuel properties (e.g., energy density) and global warming potentials (GWP)	Protocol, Equations 5.12 and 5.13

Timing of Application and Reporting Periods

Provisional applications under the LCFS require only three months of operational data, after which credits can be generated quarterly as dispensed fuel volumes are reported. In contrast, the Livestock Protocol grants offset credits in arrears after each 12 month reporting period plus the additional time required for the verification report. Further, the LCFS reporting is based around the four quarters in a calendar year (January to March, April to June, July to September, October to December), while the Livestock Protocol allows a rolling 12 month period.

One of the primary goals of aligning LCFS crediting with the Livestock Protocol is to take advantage of the third-party verification step. Under the Livestock Protocol, the Registry Offset Credits (ROCs) provide assurance by a third party that a project is likely

to meet all of the Livestock Protocol's criteria.

To be eligible for an LCFS CI that accounts for avoided methane, we propose that applicants must demonstrate that the project meets the requirements of the Livestock Protocol by generating ROCs issued by a registry that is approved by ARB to perform registry services under ARB's Cap-and-Trade Program.[12] Current staff thinking is that this showing should be made by the project creating ROCs either in the 12 months prior to, or within 18 months following, LCFS certification.

> *Staff is seeking stakeholder feedback on how to prevent loss of credits for any period during the transition from generating Compliance Offset credits to LCFS credits.*
>
> *Are there any challenges in changing the reporting, monitoring and verification period to a calendar year?*

Allocation of Methane Emissions to the LCFS Transportation Fuel Pathway

As with other sources of RNG in the LCFS, the RNG from eligible livestock digester projects must be used in one of three ways in order to generate LCFS credits:

– produced and used on-site to fuel natural gas vehicles in California.

– injected into a natural gas pipeline that is physically connected to California and withdrawn in California for use as a feedstock to produce a vehicle fuel (e.g., CNG, LNG or hydrogen, including use of hydrogen in petroleum refineries). [13]

– provided directly to a facility that produces transportation fuel (e.g., ethanol or other liquid alternative fuel) for use as a source of process energy.

The CI score will consider only those emissions—including avoided emissions—associated with the captured biogas that has an end use in California's transportation market. This means that if a project is using or selling its fuel for multiple purposes, then a portion of the modeled baseline methane emissions and certain project methane emissions will be allocated to the fuel pathway, in proportion to the end use. Similarly, emissions from processes that are clearly unrelated to the LCFS pathway (e.g., emissions from exported electricity generation) can be completely excluded from the CI calculation. The allocation method is explained in more detail the LCA Methodology of this document.

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[12] Potential Offset Project Registries must submit an application to the ARB Compliance Offset Program and meet the requirements defined in section 95986 of the Cap-and-Trade regulation. The Cap-and-Trade regulation is available at:
https://www.arb.ca.gov/cc/capandtrade/capandtrade/unofficial_ct_030116.pdf

[13] For a discussion of how the accounting of pipeline injected RNG works in the LCFS see:
https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/041717discussionpaper_livestock.pdf

This means that a portion of the methane reduction quantified by the Livestock Protocol may not be converted to LCFS credit, and staff believes that the current regulations do not allow for the remainder to be converted to Compliance Offset Credits. Staff believes the use of methane for useful purposes is the best outcome for a livestock digester project, and will continue to evaluate how best to support this goal.

Staff is seeking stakeholder feedback on the importance of supporting the ability to participate in both LCFS and Cap-and-Trade.

Regulatory Compliance Requirement

The Livestock Protocol requires that an offset project must meet the regulatory compliance requirements set forth in section 95973(b) of the Cap-and-Trade Regulation. This includes compliance with all relevant federal, state, and local regulations that cover environmental and health and safety concerns that relate to the project. Currently, other LCFS pathways do not have the same type of requirement.

Staff is seeking stakeholder feedback on this Regulatory Compliance Requirement as it could relate to the LCFS pathway, and whether alignment is necessary between crediting for manure-to-biomethane and other LCFS pathways.

Emission factors for energy use, fuel properties (e.g., energy density) and global warming potentials (GWP)

As discussed in the following sections, there are minor differences between how the LCFS program and the Livestock Protocol calculate emissions from various portions of the project. Generally, staff is considering that energy use emissions should be determined using CA-GREET emission factors for consistency with other LCFS pathways. Equations from the Livestock Protocol that are used in determining the CI must substitute the LCFS Global Warming Potential (GWP) values from CA-GREET in place of the Cap-and-Trade Regulation's GWPs.

Provisional CI and Credit Generation

The LCFS application process[14] for a manure-to-RNG pathway is summarized briefly below, followed by additional detail on the requirements for a provisional CI.

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[14] For more information on application requirements and pathway classifications, see Guidance Document for LCFS New Pathway Applications. Available at: https://www.arb.ca.gov/fuels/lcfs/fuelpathways/newpathway-01062016.pdf

Summary of LCFS Application Steps

1. Compile and submit all information required under the LCFS regulation section 95488(c)(4) including at least three months of operational data that is required for the LCFS fuel pathway (i.e. all Livestock Protocol monitoring parameters and data required for all RNG pathway applications under the LCFS including upgrading facility energy use and RNG production), and other documentation and supporting evidence required for Tier 2 fuel pathway applications pursuant to the LCFS regulation section 95488(c)(4). In addition,
   a. if ROCs were awarded for a previous reporting period, submit the verified project data (the spreadsheet used to calculate the baseline and project emissions of the Livestock Protocol), the verification report, and information required under Livestock Protocol Chapter 7. Applicants should notify the registry with whom the existing project is listed of the intention to apply for an LCFS pathway.
   b. if the project has not been awarded ROCs for a previous reporting period, an operating condition will be imposed requiring the applicant or operator to satisfy the Livestock Protocol requirements to be awarded ROCs within 18 months of submitting the initial LCFS pathway application.[15] The applicant should apply to an approved registry for listing before beginning the LCFS application process.
2. After the provisional CI has been certified, an applicant may not report to the LCFS for credit generation until the requirements of section 95488(e) evidence of transport mode (demonstration of pipeline injection and/or sales to a qualifying end use in California) have been met.
3. LCFS credits will be generated for each quarterly reporting period. However, under the requirements for provisional credits of section 95488(d)(2), the applicant must continue to submit operational records quarterly until data covering 24 months of commercial production has been submitted. At any time during those two years, the provisional CI can be revised and the reporting party's LCFS credit account balance can be adjusted based on the quarterly operational data and annual verification report.
4. After ROCs are awarded, staff will work with the applicant and registry or verifier as needed to ensure LCFS credits were not overestimated and that the correct quantity of ROCs are retired for conversion to LCFS credits.
5. The applicant or operator must continue to submit the verified project data, the spreadsheet used to obtain the results of Livestock Protocol equations, and the verification report covering all quarterly reporting periods in which LCFS credits were generated, or forfeit all LCFS credits generated under the pathway.

The provisional CI will be determined on the basis of this information, which can be used to report fuel volumes and generate LCFS credits, provided that the applicant continues to supply operational data by the end of each quarter covering the prior quarter's operation.

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[15] If this operating condition is not met the applicant would forfeit all LCFS credits generated under the pathway.

Pursuant to the LCFS regulation section 95488(d)(2), the Executive Officer may revise the provisional CI and adjust the credits in the reporting party's LCFS credit account balance on the basis of the quarterly operational data submitted until the plant has been in full commercial production for more than two years. If the operational CI appears to be lower than the provisional CI, the Executive Officer will not adjust the CI or credit balance.

POTENTIAL REGULATORY AMENDMENTS

Upcoming regulatory amendments offer an opportunity to place requirements outlined in the Livestock Protocol (which will currently be required as an operating condition for each certified livestock digester pathway) into the LCFS rule itself. Staff will consider adopting provisions that expand the third-party verification requirements to include verification points relevant to the LCFS pathway. Staff may also consider changes to the timing of reporting periods and credit generation for livestock digester pathways.

> *Staff is seeking stakeholder recommendations for any modifications in the LCFS regulation's application process for livestock digester projects.*

Timing of Credit Generation

The current regulation does not include a provision to allow credits to be awarded beyond the quarterly reporting deadline; therefore, if the operational CI is demonstrated to be lower than the certified CI, no additional credits can be awarded after annual verification. Credit adjustment only occurs when an excess of credits have been generated. Due to the magnitude of potential credit generation per mega joule of fuel for livestock pathways, staff could consider a regulatory amendment to delay credit generation until after the operational CI is verified in each year. This would ensure that regulated parties for livestock pathways receive the full credit value in each reporting period, and eliminate the need for credit adjustments thereby maximizing confidence for credit buyers in the credits issued for livestock projects.

Alternatively, credit generation could be divided into two steps: a portion of credits—representing the pathway CI under the conservative "avoided flaring" reference case assumption—to be awarded each quarter, with the majority—representing the avoided methane emissions—to be calculated after verification and awarded annually.

Yet another alternative could be to require, or to optionally allow, more frequent verification. Quarterly verification, including site visits, would maximize confidence in the quantity of credits generated, with minimal delay in credit generation, yet could impose significantly higher costs.

Staff believes one of these alternatives could help to improve credit buyer confidence and reduce uncertainty or variability in methane emission reductions achieved. Note that regulatory changes to the timing of credit generation for all fuel pathways is under

consideration for the upcoming LCFS rulemaking along with the development of a third-party verification program.

> *Staff is seeking stakeholder feedback on developing regulatory amendment provisions to the LCFS regulation to balance concerns with uncertainty or variability in CI and timeliness of credit generation.*

LCFS Third-Party Verification Requirements

The LCFS verification program would invite verification bodies accredited by the ARB Cap-and-Trade Program with experience performing verifications of livestock offset projects to apply for accreditation to verify these projects under LCFS.

Third-party verification requirements for livestock pathways under the LCFS will be informed by the verification process currently required under the Livestock Protocol, as the LCFS system boundary for RNG production from manure is essentially a subset of the Livestock Protocol's project boundary (see Figure 1 in the LCA Methodology section). Additional monitoring and verification requirements specific to the upgrading process, pipeline transmission, and final use of the fuel are currently under consideration for all RNG pathways.[16]

Additionality

The additionality requirements of the Livestock Protocol and those referenced in the Livestock Protocol from the Cap-and-Trade Regulation[17] are currently required for livestock pathways under the LCFS.

Regulatory amendments to the LCFS could also clarify that emission reductions must be additional to reductions required by California state law for both in-and out-of-state projects. Therefore, if the state of California enacts a law to regulate methane emissions from livestock manure management operations, as signaled in SB 1383, only the avoided emissions that are additional to California's legal requirement would likely be eligible for a CI that reflects avoided methane.

As discussed in the SLCP Strategy, once regulatory requirements to reduce manure methane emissions from the dairy sector are in effect, new projects would not be eligible for the avoided methane credit as the reductions would not be additional to regulation, which becomes the baseline scenario. However, LCFS may still be able to credit for some reductions for livestock projects in place before the new requirements

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[16] See ARB Staff Discussion Paper for Fossil and Renewable Natural Gas as a Transportation Fuel, April 13, 2017. https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/041717discussionpaper_ng.pdf

[17] The Protocol chapter 3.4 and Cap-and-Trade regulation Section 95973(a)(2) require that: e*mission reductions must exceed those required by any law, regulation, or legally binding mandate and would not otherwise occur in a conservative business-as-usual scenario; project commencement date must occur after December 31, 2006.*

take effect.

> *Staff is seeking stakeholder feedback on how/if LCFS crediting for avoided methane should continue for existing projects if California puts a mandatory regulation in place for livestock manure management. ARB's goal is to describe a clear transition from the period where ARB incents these projects through credits to the period where mandatory control may be required. This paper begins the process of seeking stakeholder input on how to best facilitate that transition for LCFS credits.*

LCA METHODOLOGY

The lifecycle analysis methodology for manure-to-RNG pathways relies on energy use, metered methane and other raw data, certain equations and monitoring parameters from the Livestock Protocol, as well as the emissions factors and methodology from the CA-GREET model.

The following modifications must be made to all Livestock Protocol equations and monitoring parameters to allow for CI determination under the LCFS:

1. Provide all metered biogas volumes in standard cubic feet to allow for the use of CA-GREET gas properties and conversion factors in downstream CI calculations. Biomethane sales gas quantities should be reported in energy units (as reported on invoices or other supporting documentation).
2. Provide calculated methane emissions in metric tons of the constituent gas (e.g., MT CH_4) rather than converting to CO_2 equivalent. Equations must substitute the LCFS Global Warming Potential (GWP) values from CA-GREET in place of the Cap-and-Trade Regulation's GWPs.
3. Provide disaggregated metered volume to each "destruction device" or end use (flare, engine, boiler, turbine, upgrading, or direct pipeline).

LCFS System Boundary

The LCFS system boundary (dashed lines) for an example pathway and the Livestock Protocol project boundary (solid red line) are shown in Figure 1. The LCFS system boundary is essentially a subset of the Livestock Protocol system boundary. Emissions from the destruction of biogas by flaring are excluded from the LCFS pathway, along with the equivalent portion of avoided baseline methane emissions.

For the example shown, in which energy produced from biogas is exported outside of the system boundary, emissions from electricity generation and combustion in a boiler would be excluded from the pathway; likewise, the CI would not account for the avoided emissions for the quantity of biogas that is captured and used to generate heat and power. If, instead, the electricity or thermal energy produced from biogas is directly

provided (behind the utility meter) and utilized within the LCFS system boundary (e.g., by the digester to enhance biogas production by heating and mixing, or at the upgrading facility) then emissions from these processes would be included in the CI calculation.
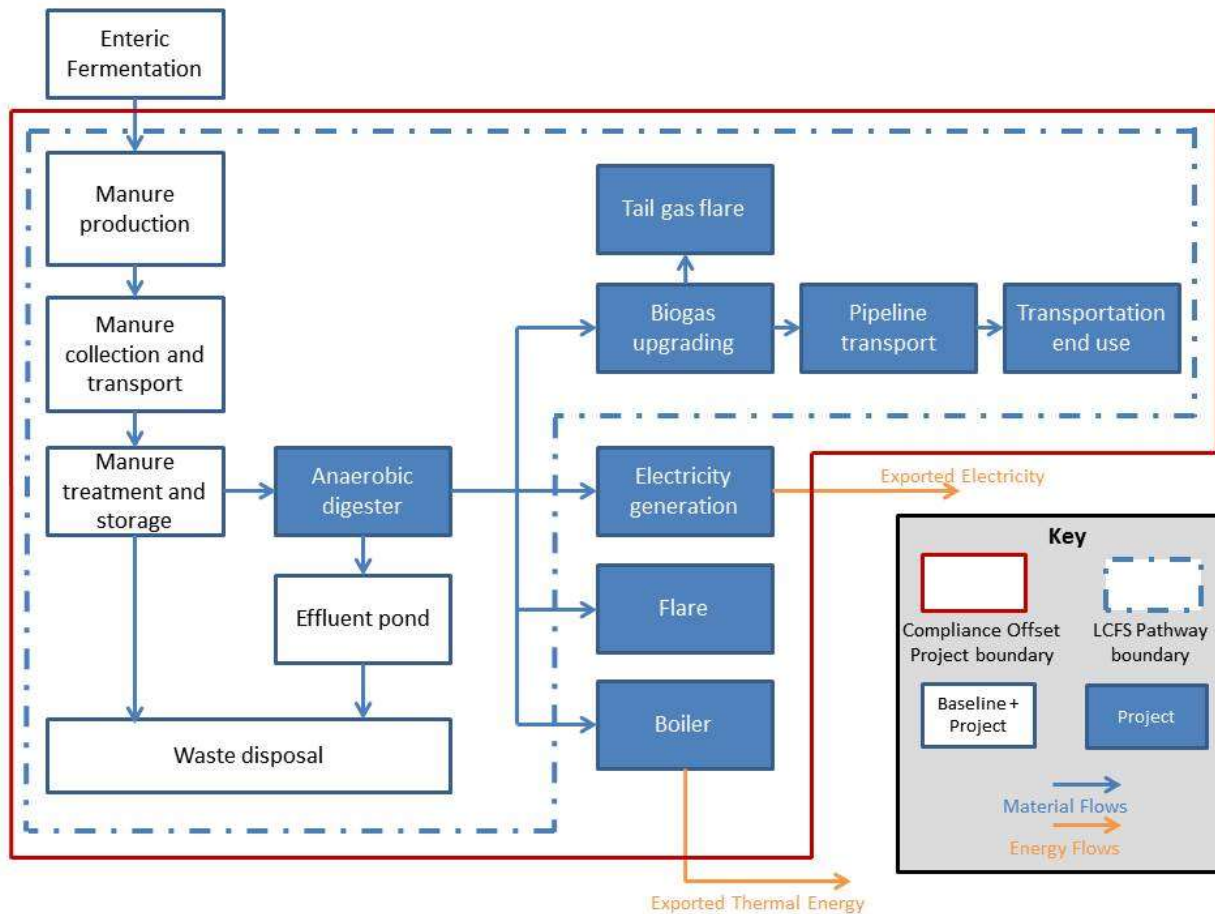
Figure 1: System Boundaries for Livestock Protocol and LCFS Manure-to-RNG Pathways

Example CA-GREET template

In conjunction with this paper, staff developed and posted a CA-GREET model template that provides an example of a project in which a dairy captures biogas using a covered lagoon digester. In this example, 73% of the total methane in captured biogas is upgraded, injected to the pipeline, and sold to a fueling facility in California where it is ultimately compressed to bio-CNG and dispensed to natural gas vehicles. In this example, the remaining 27% of methane in captured biogas is flared at the digester, before reaching the upgrading facility, and no biogas is used for electricity generation or thermal energy.

The template is designed to receive as inputs some of the calculated results from the

Livestock Protocol, exactly as they are defined in the Livestock Protocol equations, such as the modeled baseline methane emissions (Livestock Protocol, Equations 5.1 to 5.3). Other CA-GREET inputs are raw data collected under the Livestock Protocol (Table 6.1. Project Monitoring Parameters), such as the metered amount of methane collected, and quantities of electricity and fuel used in specified operations.

Some Livestock Protocol parameters are used in modified equations for consistency with the LCFS methodology, particularly with respect to the allocation of emissions to transportation-related and non-transportation related end uses. For example, see Livestock Protocol Equation 5.6: Project Methane Emissions from the BCS; in this equation, the monthly volume of biogas from the digester to destruction devices is multiplied by the destruction efficiency of each device and reported as a weighted average of emissions from multiple devices. To facilitate the analogous LCFS calculations, the quantity of methane to each "device" or end use (flare, engine, boiler, turbine, upgrading, or direct pipeline) must be disaggregated in order to partition emissions to transportation-related and non-transportation related end uses.

The template is built into CA-GREET 2.0 and uses the same standard assumptions, operational data and calculations as other RNG pathways (e.g., landfill gas) for downstream operations including the upgrading facility (process energy inputs and gas throughput), pipeline transmission (quantity of gas injected, distance) and/or qualifying end uses in California.

Emissions from energy consumption are determined using CA-GREET emission factors for all tracked gases (VOC, CO, CO_2, CH_4 and N_2O).

The Protocol allows energy use emissions to be estimated if it is demonstrated during verification that project carbon dioxide emissions are to be equal to or less than 5% of the total project baseline emissions of methane.[18] For consistency with other RNG pathways under the LCFS, energy use in the biogas upgrading process must be determined using CA-GREET; however, staff is considering whether to allow estimation of energy use in manure and digester operations.

> *Staff is seeking stakeholder feedback on the typical magnitude, and range, of energy use emissions in livestock projects.*
>
> *Should staff consider allowing an estimation method for emissions from energy use in operations which are upstream of the biogas upgrading facility?*

Allocation of Emissions to the LCFS Pathway

Captured biogas may be destroyed or used in several ways: it may be destroyed by flare directly from the digester collection system or from upgrading (as the low methane-

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[18] See Protocol chapter 5.4(b).

concentration "tail gas" which cannot be recovered during purification); it may be used in a boiler to produce heat/steam, or in a generator to produce electricity; or it may be sent to a nearby facility in a dedicated, direct, biogas pipeline. Biogas which is purified to biomethane may also be used on-site to reduce demand for purchased energy, used on-site to fuel vehicles, or injected to the pipeline, from whence it may ultimately be sold to a utility for renewable power or to a natural gas vehicle fueling station. Hence, not all captured biomethane is delivered to a qualifying transportation end use, and an allocation is required to attribute emissions/credits to transportation and non-transportation end uses or destruction.

The CI score excludes portions of the methane emissions—including avoided emissions—that are not relevant to the transportation fuel pathway.

As shown in the example bio-CNG pathway in the CA-GREET template, staff is considering determining an allocation factor based on the simple proportion of biogas directed to upgrading over the total amount of biogas captured. The allocation factor would be multiplied by the baseline methane emissions to determine the quantity of avoided methane in the LCFS pathway. Likewise, project emissions from the digester and all upstream processes are multiplied by the allocation factor, while downstream processes are either fully included or excluded from the pathway CI score.

> *Staff is seeking stakeholder feedback on developing the allocation method that will be used to calculate the emissions that are accounted for in the LCFS pathway. Please consider process configurations that may require a more detailed method of allocation.*