ARB Internal Pathway for the

Production of Biomethane from the

Mesophilic Anaerobic Digestion of Wastewater Sludge at a

Publicly Owned Treatment Works (POTW)

Staff Response to Public Comments

The comment numbers used in this document correspond to the comment numbers appearing on the Low Carbon Fuel Standard pathway application web page [http://www.arb.ca.gov/lispub/comm2/bccommlog.php?listname=lcfs2a2bcomments-ws]

Comment: [Comment #17] While a GHG emissions credit for "bypassed CO_2" (i.e., the CO_2 in the biogas that does not combust) was given to the case for avoided flaring of the biogas in the wastewater sludge-to-biomethane pathway, the bypassed CO_2 from the use of biogas in energy-consuming and power-producing devices in the pathway was not counted as process emissions. If a credit was given to the bypassed CO_2 in the avoided flaring of the biogas case, a debit must be accounted for on the process side, specifically in the tail gas of the biogas refining unit, and in biogas combusting devices such as gas turbines.

[Comment #19] ARB should demonstrate a carbon balance in order to find other potential errors. The first method is to simply assume that the process is biogenic carbon neutral. The pathway then boils down to energy consumption, fugitive methane, and CH_4 and N_2O emissions from combustion of the biogas.

Response: Staff agrees that a credit for "bypassed CO_2" was given in the pathway for the case where flaring of the biogas was avoided, and that the credit must be balanced with a debit of bypassed CO_2 emissions that occur from biogas combustion in energy-consuming and power-producing devices such as gas turbines, and from separation of the CO_2 from the CH_4 in the biogas refining unit. Those emissions were computed but not accounted for in the pathway well-to-wheels GHG impact analysis. As a result, staff has made the correction by removing the credit for "bypassed CO_2" in the avoided flaring of the biogas credit estimation. The final CI for biomethane derived from wastewater sludge digested anaerobically now reflects a lower credit for avoided flaring of the biogas.

Comment: [Comment #17] The methane (CH_4) slip and carbon dioxide (CO_2) in the tail gas of the biogas refining unit is generally too lean to combust alone, and must be mixed with natural gas or digester gas so that it can be flared, or oxidized in a thermal or catalytic oxidizer. The pathway needs to account for methane slip as fugitive methane emissions, or as oxidized CO_2 from a flare or thermal oxidizer.

Response: The issue raised by the commenter is related to the accounting of methane emissions in the tail gas of the biogas refining unit. Staff concurs with the commenter. Staff modeled the biogas refining technology based upon pressure swing adsorption or PSA, which can achieve a methane recovery efficiency of 92 percent, leaving about 8 percent methane in the tail gas.[1] This fraction of methane in the tail gas may be flared with additional methane or biogas, or may be oxidized in a thermal oxidizer.

However, other biogas refining technologies such as membrane separation produce a lower recovery of methane from the biogas mixture. The methane rich tail gas from this process is then typically directed to the combined heat and power (CHP) plant, or to a compliant energy producing device such as an internal combustion engine or micro-turbine to produce additional power.[2] In this case, the total energy of the methane in the tail gas is productively recovered without having to flare or oxidize the methane to carbon dioxide.

Staff agrees that accounting for tail gas methane emissions is the more conservative approach to model the pathway. The pathway's fuel carbon intensity now reflects methane emissions in the tail gas which are oxidized to carbon dioxide.

Comment: [Comment #18] The commenter has asked the Air Resources Board why the proposed pathway was only developed for biomethane derived from wastewater sludge digested under mesophilic operating conditions? Would the pathway for biomethane be applicable to a POTW that operated its digesters under thermophillic operating conditions? Many POTWs are reengineering their sludge digestion practices to this condition.

Response: In selecting modeling parameters for the life cycle analysis of the biomethane fuel, staff decided to produce a pathway based upon the sludge digestion practices of a broad majority of POTWs operating in the State of California. Based on a survey[3] administered to over 250 California POTWs by the California Association of Sanitation Agencies, staff determined that over 150 POTWs operate anaerobic digesters for biosolids stabilization. Of those found to be digesting wastewater organics, the majority of them (more than 90 percent) were

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[1] California Air Resources Board, 2012. "Proposed Low Carbon Fuel Standard (LCFS) Pathway for the Production of Biomethane from High Solids Anaerobic Digestion (HSAD) of Organic (Food and Green) Wastes," June 2012.

[2] Based upon staff conversation with, and technical correspondence sent by Adam Klaas of Unison Solutions, Dubuque, Iowa on May 30, 2014.

[3] California Association of Sanitation Agencies, 2013. Survey of Publicly-Owned Treatment Work (POTW) Facilities in the State of California, February 2013.

found to be operating at mesophilic temperatures in the range of 35 degrees Celsius. Since most POTWs in California practice mesophilic anaerobic digestion, staff developed a pathway for biomethane based upon the majority of POTW sludge digestion practices.

Staff responds that, while it is true that POTWs digesting their wastewater sludge under thermophillic operating conditions produce a greater amount of biogas, their digesters also consume more thermal energy to operate at a higher temperature (near 55 degree Celsius). Therefore, operating the digesters at a higher temperature also requires a larger "draw" of biogas for digester heating purposes, or a greater amount of heat recovery from the exhaust of the fuel combusting devices used to produce electrical energy on-site (such as the CHP unit). The GREET1 (2012) life cycle analysis model[4] used to model the GHG impacts of the proposed pathway suggests that wastewater sludge digested under thermophillic operating conditions allocates a lower amount of biogas to "application," (i.e., the allocated biogas for transportation fuel uses). This lower allocation of biogas to application is largely due to the increased thermal energy requirements of operating the digesters at a higher temperature.

Staff believes that the higher thermal energy demand to operate the digesters at thermophillic temperatures does not necessarily have to parasitically draw upon additional amounts of biogas generated in the digesters. Staged thermophillic digestion has been successfully implemented without supplementing the thermal energy demand with additional biogas firing to operate at thermophillic temperatures. Heat recovery from CHP was sufficient to meet the thermal energy demands of the thermophillic anaerobic digesters in this case,[5] suggesting that the CI of the transportation fuel could be similar for both types of sludge digesting practices, mesophillic as well as thermophillic. Staff encourages POTWs that digest their sludge under thermophillic operating conditions to apply for a pathway under the Method 2B LCFS application process.

Comment: [Comment #18] The commenter has asked if the Air Resources Board would give the same LCFS pathway co-product credit for on-site use of surplus co-generated electricity as that established for export of surplus co-generated electricity to the public grid?

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[4] See Worksheet "RNG" in the GREET1_2012 Model (Revision 2, December 2012) for the pathway's life cycle analysis developed by Argonne National Laboratories (ANL).

[5] Pursuant to information received from Alicia Chakrabarti of the East Bay Municipal Utility District (EBMUD). Staff notes that the EBMUD case study may not be applicable to thermophillic anaerobic digestion practiced at every wastewater treatment facility that digests wastewater sludge because biogas yields are influenced by co-digestion practices of food wastes, high-strength wastes, and fats, oils, and greases along with the municipal wastewater sludge.

Response: In response to the comment on the applicability of surplus co-generated electricity, staff confirms that the LCFS electricity co-product credit is applicable to the total quantity of co-generated electricity determined to be surplus, irrespective of where it is eventually consumed. The surplus co-generated electricity is assumed to displace marginal grid-based electrical power generation net of transmission line losses, and may either be consumed by a unit operating at the POTW, or be exported to the grid.

Comment: [Comment #18] The commenter has suggested that it appears the pathway proposed by the ARB is double counting the GHG emissions credit for the same amount of biogas; once for avoiding flaring of the biogas, and then awarding a LCFS credit for exporting surplus co-generated electricity. Please clarify in order to ensure the credibility of the pathway.

Response: Staff assumed that due to the high heat trapping potential of the biogas generated by the digestion of the wastewater sludge, the biogas will be required to be flared before being released into the atmosphere. Flaring of the biogas however, wastes useful energy. Therefore, a LCFS emissions credit was given to the pathway for avoiding flaring of the biogas. Biogas that would otherwise have been flared can instead be optimally allocated to the production of two products: biomethane fuel for transportation applications, and co-generated electricity for process operations. The quantity of electricity produced but not utilized by the pathway elements or process units is considered to be surplus relative to the demand established for the proposed pathway. This “surplus” co-generated electricity is an export from the power-generating unit of the pathway (for example, the CHP unit), and considered to be displacing grid-based electrical generation. Only a portion of the allocated biogas is credited for producing surplus co-generated electricity. Life cycle analysis permits a co-product credit if the co-product has a displacement effect in the marketplace.

The benefit of producing surplus electricity also comes at a cost. In this case, the cost was determined to be a charge of GHG emissions from the energy producing device to the pathway. Therefore, no double-counting has occurred, and the emissions credits proposed are consistent with other biomethane pathways certified by the Air Resources Board.

Comment: [Comment #18] The commenter has asked the Air Resources Board why an emissions credit is not granted for the land application of biosolids generated from the sludge digestion process. This use of biosolids would displace synthetic fertilizers, and sequester carbon in the soil. More than 55 percent of the biosolids produced in California are land applied. The GREET1 Model used by staff for the life cycle analysis permits the calculation of an emissions equivalent synthetic fertilizer displacement effect from land application.

Response: Staff did not consider the synthetic fertilizer displacement effect from land application of biosolids mainly because biosolids produced from municipal wastewater sludge are required to undergo a process to reduce pathogen levels to meet Class A performance standards for biosolids. Biosolids that are not upgraded to Class A standards can only be applied to non-food crops or use as soil cover. Many POTWs incur a net cost to dispose of their biosolids, reducing the co-product value of those biosolids to the zero-to-marginal range. POTWs that market their biosolids as a soil amendment or fertilizer are encouraged to demonstrate the synthetic fertilizer nitrogen, phosphorus, and potassium displacement effects of their biosolids, and apply for an LCFS Method 2A pathway that includes an appropriate co-product credit.

Comment: [Comment #18] The commenter has asked the Air Resources Board how co-digestion (of food wastes) factors into the wastewater sludge-to biomethane pathway that ARB has proposed?

Response: The pathway for biomethane being proposed assumes that only municipal wastewater sludge would be digested anaerobically. With regards to the question concerning co-digestion of food wastes along with municipal wastewater sludge, a new pathway would have to be developed to account for the co-digestion of these feedstocks. A separate life cycle analysis would need to be performed that takes into consideration the differential biogas yields from food waste, as well as the energy expended to process the food waste (for example, energy expended for grinding, pumping, slurrying, and mixing operations). Staff has also established that the alternative fate of food and FOG (fats, oils, and greases) wastes is disposal in a landfill; therefore diversion of these wastes to an anaerobic digester additionally yields an avoided landfilling LCFS credit[6] which has the impact of lowering the CI of the fuel.

The pathway CI for biomethane derived from mesophillic anaerobic digestion of wastewater sludge may however be used for small amounts of energy-rich FOGs that are co-digested with the municipal wastewater sludge. The addition of FOGs alone to municipal wastewater sludge does not require significant pre-processing energy,[7] while the practice boosts biogas yields. The CI for the biomethane derived from wastewater sludge,

[6] California Air Resources Board, 2012. "Proposed Low Carbon Fuel Standard (LCFS) Pathway for the Production of Biomethane from High Solids Anaerobic Digestion (HSAD) of Organic (Food and Green) Wastes," June 2012.

[7] California Air Resources Board, 2012. "Proposed Low Carbon Fuel Standard (LCFS) Pathway for the Production of Biomethane from High Solids Anaerobic Digestion (HSAD) of Organic (Food and Green) Wastes," June 2012.

as specified in this pathway, would therefore become an upper limit in this case. As such, this pathway could be used by POTWs that co-digest FOGs.

Comment: [Comment #18] The commenter has asked whether the small-to-medium POTW pathway would apply to POTWs that process less than 5 MGD of wastewater inflows, and whether the medium-to-large POTW pathway would apply to POTWs that process over 100 MGD of wastewater inflows to the treatment plant?

Response: The two pathways described in staff's wastewater sludge-to-biomethane pathway document are distinguished from one another by biogas processing and use rather than wastewater inflow volumes. Inflow volumes are provided only to illustrate the treatment plant sizes that typically fall into these two categories. Wastewater treatment plants with inflow rates above and below the ranges specified in the pathway document may use these pathways, provided they meet the operating conditions for those pathways. Staff believes that all inputs used to derive the pathway CIs are linearly scalable. This implies that, if the biogas yields are larger because wastewater inflows to the wastewater treatment plant are large, then energy to process the wastewater sludge and refine the biogas will also be proportionately higher.

In order to use the small-to-medium POTW pathway, a treatment plant must meet these operating conditions:

- It meets all electrical energy needs using grid-based electricity
- It heats the digesters using a small biogas parasitic load; and
- It upgrades all biogas not used to heat the digesters into biomethane for use as a transportation fuel.

In order to use the medium-to-large POTW pathway, a treatment plant must meet these operating conditions:

- It meets all electrical energy needs using electricity generated on-site from refined digester gas combusted in a compliant device;
- It exports surplus co-generated electricity to the public grid,
- It heats the digesters using heat recovered from the exhaust of the compliant combustion device used to power the electrical generators; and
- It upgrades all biogas not used for electricity production into biomethane for use as a transportation fuel.