Thanks Anil for the discussion Tuesday on the issue with the RH credit calculation with GREET 3.0. I believe you had mentioned the plan was to change the definitions for the CI_{NG} and CI_{RNG} from "at the refinery gate" to "at the outlet of the SMR", which would then include the production of hydrogen within the SMR in the CI calculation. While there are additional emissions with the step of taking gas to hydrogen, I expected that the CI differential between fossil-based CNG and landfill-based RNG should be the same as the CI differential between fossil-based hydrogen and landfill-based hydrogen.

When I look in the current version of GREET 3.0, I see that the CI of fossil-based CNG is 95.68 g/MJ, and the CI of landfill-based RNG is 64.60 g/M, for a differential of 31.08 g/MJ. When I look at the hydrogen production, I see that the CI for fossil-based hydrogen is 126.16 g/MJ and the CI for landfill-based hydrogen is 114.97 g/MJ, for a differential of 11.19 g/MJ. I believe the difference has to do with the assumption for transport of the natural gas and landfill gas feedstock. For the fossil natural gas, the assumption is 3600 miles for natural gas to CNG but only 1000 miles for natural gas to hydrogen. For the renewable natural gas, the assumption is 1000 miles for landfill gas to CNG but 1600 miles for landfill gas to hydrogen. I believe these two different assumptions in transportation distance are what causes the differential between the two pathways that I described above.

I understand the transportation distance for the landfill gas will be a user input and will be specific to the pathway/ landfill. My concern is that the difference in assumption for transportation distance for fossil gas to CNG versus hydrogen will impact the RH credit calculations. To make the RH credit generation calculation effective, and offer a level playing field between CNG and RH, we'd suggest the language in the definition should say "at the exit of the hydrogen plant, using the same feedstock assumptions for Pipeline Average North American Fossil Natural Gas in pathway code CNGF". You may already have planned to add language to this effect in the definition, but looking at the current GREET model and the discrepancy reinforced for me that this is something that likely needs to be clarified in the regulation. I'm not sure what transportation distance was used to calculate CNGF but it appears that it is closer to 1000 miles versus 3600 miles. I believe using the same transportation distance for natural gas would result in the differential being the same.

We also will submit a comment on the updated definition of biomethane. Iogen has a concern with the update to the definition of "biomethane" and how this may impact renewable hydrogen. As defined in the LCFS, "renewable hydrogen means hydrogen derived from (1) electrolysis of water or aqueous solutions using renewable electricity; (2) catalytic cracking or steam methane reforming of biomethane; or (3) thermochemical conversion of biomass, including the organic portion of municipal solid waste (MSW).

The definition of biomethane is proposed to be updated to "Biomethane means methane derived from biogas, or synthetic natural gas derived from renewable resources, including the organic portion of municipal solid waste, gas which has been upgraded for use in natural gas vehicles"

Iogen is concerned that while renewable hydrogen must be derived from biomethane, the updated definition of biomethane seems to only include gas which is being used in natural gas vehicles, thereby precluding biomethane to be used for the production of renewable hydrogen. Iogen suggests that the definition of biomethane should be updated to include any qualifying transportation fuel. Iogen's suggested fix would be to update the definition of biomethane to:

- “Biomethane” means methane derived from biogas, or synthetic natural gas derived from renewable resources, including the organic portion of municipal solid waste, gas which has been upgraded to meet pipeline quality natural gas standards, for use in natural gas vehicles, or for use in producing renewable hydrogen.”

This definition includes pipeline book and trade transfers of pipeline quality gas and any direct feeding of biogas to refineries for renewable hydrogen production (which should in in the interest of the LCFS).

Thanks again Anil for your assistance on this, and if you have any questions please let us know.
Amanda

Amanda Black
Advisor, Engineering & Business Operations

Iogen Corporation
Tel: 613.733.9830 ext. 3458
Mobile: 613-219-2151
Fax: 613-482-8852
Amanda.Black@IOGEN.ca
www.iogen.ca

IOGEN®
CORPORATION

Renewable Hydrogen LCFS Formula Issue

June 11, 2018

Proposed Renewable Hydrogen Credit Calculation Formula

$$Credits^{H}_{RIC} = (CI_{NG} - CI_{RNG}) \times E_{RNG} \times C \times \frac{Volume^{XD}}{Volume^{TOTAL}}$$

Where:

$Credits^{H}_{RIC}$ is the amount of LCFS credits generated (a zero or positive value), in metric tons, by renewable hydrogen;

CI_{NG} is the carbon intensity of North American pipeline natural gas at refinery gate calculated using the CA-GREET3.0 model;

CI_{RNG} is the carbon intensity of the RNG, in gCO2e/MJ, at refinery gate and must be determined using the CA-GREET 3.0 model unless the Executive Officer has approved the use of a method that is at least equivalent to the calculation methodology used by CA-GREET3.0 model. The process for obtaining CI_{RNG} will be identical to Tier 2 fuel pathway applications, but the life cycle steps evaluated will stop at delivery of the RNG to the refinery gate;

E_{RNG} is the amount of RNG, in MJ, delivered to a refinery per quarter or per year;

$Volume^{XD}$ is the volume of CARBOB and diesel in gallons per quarter or per year sold, supplied, or offered for sale in California by the refinery;

$Volume^{TOTAL}$ is the total volume of CARBOB and diesel in gallons produced per quarter or per year; and

$C = 1.0 \times 10{-}6$ g/MT CO_2E

When RH Formula was developed, GREET 3.0 was not yet released

There is a critical difference between the way that GREET 2.0 and 3.0 handle and model the biogenic CO_2 offset ("energy credit"):

Emissions (g/MJ)	GREET 2.0	GREET 3.0*
LFG Extraction	10.9	0.8
Energy Credit	-66.4	-
LFG Processing	17.0	42.8
NG T&D	5.0	5.9
NG Compression	4.0	5.2
Tank-to-Wheel	60.7	4.9
Total	31.1	59.7

***Using values within GREET 3.0 model, which are higher than 2017 actual pathway averages**

GREET 2.0 includes an energy credit with the feedstock, prior to the refinery gate

GREET 2.0 included an energy credit with the feedstock, but then applied the same CO2 emissions at the tank-to-wheel step as fossil natural gas.

Emissions (g/MJ)	GREET 2.0	GREET 3.0
LFG Extraction	10.9	0.8
Energy Credit	-66.4	-
LFG Processing	17.0	42.8
NG T&D	5.0	5.9
NG Compression	4.0	5.2
Tank-to-Wheel	60.7	4.9
Total	31.1	59.7

GREET 3.0 includes an energy credit that is essentially given at the Tank-to- Wheel step

GREET 3.0 does not include either of these values (they essentially cancel out), with the comment "Biogenic CO2 from LFG which is neutral (=0)" under the Tank-To-Wheel section

Emissions (g/MJ)	GREET 2.0	GREET 3.0
LFG Extraction	10.9	0.8
Energy Credit	-66.4	-
LFG Processing	17.0	42.8
NG T&D	5.0	5.9
NG Compression	4.0	5.2
Tank-to-Wheel	60.7	4.9
Total	31.1	59.7

As RH formula specifies the CI of the fuel "at the refinery gate"- under GREET 3.0, this does not include the energy credit

Applying the RH Formula in GREET 2.0:
Comparing Fossil Natural Gas to Renewable Natural Gas

Emissions (g/MJ)	Fossil Natural Gas	Renewable Natural Gas
NG/LFG Extraction	4.0	10.9
Energy Credit	-	-66.4
LFG Processing	3.3	17.0
NG T&D	6.0	5.0
NG Compression	4.0	4.0
Tank-to-Wheel	60.7	60.7
Total	78.1	31.1

Applying the RH Formula in GREET 2.0:
Comparing Fossil Natural Gas to Renewable Natural Gas
At the Refinery Gate

Emissions (g/MJ)	Fossil Natural Gas	Renewable Natural Gas
NG/LFG Extraction	4.0	10.9
Energy Credit	-	-66.4
LFG Processing	3.3	17.0
NG T&D	6.0	5.0
~~NG Compression~~	~~4.0~~	~~4.0~~
~~Tank-to-Wheel~~	~~60.7~~	~~60.7~~
~~Total~~	~~78.1~~	~~31.1~~
At the Refinery Gate	13.3	-33.6

CI Differential is ~ -50 g/MJ

Applying the RH Formula in GREET 3.0:
Comparing Fossil Natural Gas to Renewable Natural Gas

Emissions (g/MJ)	Fossil Natural Gas	Renewable Natural Gas
NG/LFG Extraction	6.1	0.8
Energy Credit		
LFG Processing	3.3	42.8
NG T&D	5.9	5.9
NG Compression	5.2	5.2
Tank-to-Wheel	60.7	4.9
Total	81.3	59.7

Applying the RH Formula in GREET 3.0:
Comparing Fossil Natural Gas to Renewable Natural Gas
At the Refinery Gate: no energy credit applied to RNG

Emissions (g/MJ)	Fossil Natural Gas	Renewable Natural Gas
NG/LFG Extraction	6.1	0.8
Energy Credit		
LFG Processing	3.3	42.8
NG T&D	5.9	5.9
~~NG Compression~~	~~5.2~~	~~5.2~~
~~Tank-to-Wheel~~	~~60.7~~	~~4.9~~
~~Total~~	~~81.3~~	~~59.7~~
At the Refinery Gate	15.3	49.5

CI Differential is ~ +35 g/MJ! (Higher emissions)

A modification to either the RH definition or credit calculation formula is required to include the biogenic credit

The biogenic credit is not included when using the current formula with GREET 3.0, however it is calculated at 55.8 g/MJ*. Iogen suggests either (modifications in red):

1. Modifying the definition of CI_{RNG} to include the biogenic credit:

CI_{RNG} is the carbon intensity of the RNG, in gCO2e/MJ, at refinery gate and must be determined using the CA-GREET 3.0 model unless the Executive Officer has approved the use of a method that is at least equivalent to the calculation methodology used by CA-GREET3.0 model. The process for obtaining CI_{RNG} will be identical to Tier 2 fuel pathway applications; ~~but~~ the life cycle steps evaluated will stop at delivery of the RNG to the refinery gate, but will include an appropriate offset for the biogenic nature of the RNG as calculated by CA-GREET 3.0.

2. Modifying the credit calculation to include the biogenic credit:

$$Credits^{H}_{RIC} = (55.8 + CI_{NG} - CI_{RNG}) \times E_{RNG} \times C \times \frac{Volume^{XD}}{Volume^{TOTAL}}$$

* Refer to tab "RNG" of GREET 3.0, cell M872. The biogenic credit is calculated and multiplied by zero. If the multiplication by zero is removed, the value that remains (the biogenic credit) is 55.8 g/MJ.