APPENDIX G

DEFAULT CREDIT CALCULATION FOR INNOVATIVE CRUDE PRODUCTION METHODS

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Appendix G: Default Credit Calculation for Innovative Crude Production Methods

Default Credit Calculation for Solar Steam Generation

The proposed LCFS regulation requires that credit for use of solar-based steam generation be calculated as follows:

$$Credits_{Innov}(MT) = 29360 \frac{V_{steam} \times f_{solar}}{V_{crudeproduced}} \times V_{Innov} \times C$$

where,

$Credits_{Innov}(MT)$ means the amount of LCFS credits generated (a positive value), in metric tons, by the volume of a crude oil sold to California refineries and produced using the innovative production method;

V_{steam} means the overall volume, in barrels cold water equivalent, of steam injected;

f_{solar} means the fraction of injected steam that is produced using solar;

$V_{crudeproduced}$ means the volume, in barrels, of crude oil produced using the innovative method;

V_{Innov} means the volume, in barrels, of crude oil produced using the innovative method and sold to California refineries. If the innovative crude is sold to California refineries as part of a blend, then V_{Innov} is the volume of blend sold to California refineries multiplied times the volume fraction of innovative crude within the blend.

$$C = 1.0 \times 10^{-6} \frac{MT}{gCO_2e}$$

The value 29,360 has units of gCO_2e per barrel solar steam and accounts for the reduction in GHG emissions associated with displacing one barrel steam produced using natural gas with one barrel of steam produced using a solar power. The following assumptions were made in deriving this value:

- The displaced system is a natural gas fired, once through steam generator with an efficiency of 88 percent (LHV basis).
- The steam generator is fed water at an inlet temperature of 40 F and produces 75 percent quality saturated steam at 2000 psia (636 F). Enthalpies for liquid water at 40 F and liquid and vapor at 636 F are 8, 672, and 1,137 BTU/lb, respectively.
- The steam generator has an emission factor of 59,766 gCO_2e per MMBTU natural gas burned.

- Natural gas provided to the steam generator has an upstream fuel cycle emission factor of 13,027 gCO_2e per MMBTU natural gas supplied.
- Producing steam using the solar steam generator creates negligible GHG emissions as compared to the emissions displaced.

$$29360 \frac{gCO_2e}{bblsteam} = [(0.75 \times 1137 + 0.25 * 672) - 8] \frac{BTU}{lbsteam} \times 8.345 \frac{lb}{gal} \times 42 \frac{gal}{bbl} \times \frac{1}{0.88} \times \frac{1MMBTU}{10^6 BTU} \times (59766 + 13027) \frac{gCO_2e}{MMBTU}$$

Default Credit Calculation for Solar and Wind Power Generation

The proposed LCFS regulation requires that credit for use of solar or wind-based power generation be calculated as follows:

$$Credits_{Innov}(MT) = 511 \times \frac{E_{electricity} \times f_{renew}}{V_{crudeproduced}} \times V_{Innov} \times C$$

where,

$Credits_{Innov}(MT)$ mean the amount of LCFS credits generated (a positive value), in metric tons, by the volume of a crude oil sold to California refineries and produced using the innovative production method;

$E_{electricity}$ means the overall electricity consumption to produce the crude, in kW-hr;

f_{renew} means the fraction of consumed electricity that is produced using solar or wind power;

$V_{crudeproduced}$ means the volume, in barrels, of crude oil produced using the innovative method;

V_{Innov} means the volume, in barrels, of crude oil produced using the innovative method and sold to California refineries. If the innovative crude is sold to California refineries as part of a blend, then V_{Innov} is the volume of blend sold to California refineries multiplied times the volume fraction of innovative crude within the blend.

$$C = 1.0 \times 10^{-6} \frac{MT}{gCO_2e}$$

The value 511 has units of gCO_2e per kW-hr solar or wind electricity and accounts for the reduction in GHG emissions associated with displacing one kW-hr electricity produced using natural gas with one kW-hr electricity produced using a solar or wind power. The following assumptions were made in deriving this value:

- The displaced system is a natural gas fired combined cycle plant with an efficiency of 50.6 percent (LHV basis).
- The displaced electricity has a transmission efficiency of 93.5 percent.
- The natural gas turbine has an emission factor of 59,955 gCO_2e per MMBTU of natural gas burned.
- Natural gas provided to the turbine has an upstream fuel cycle emission factor of 10,850 gCO_2e per MMBTU natural gas supplied.
- Producing electricity using solar or wind power creates negligible GHG emissions as compared to the emissions displaced.

$$511\frac{gCO_2e}{kWhr} = 3412\frac{BTU}{kWhr} \times \frac{1MMBTU}{10^6 BTU} \times \frac{1}{0.506} \times \frac{1}{0.935} \times (59955 + 10850)\frac{gCO_2e}{MMBTU}$$