**ATTACHMENT 13**

**EXAMPLE CALCULATION OF CO2E SAVINGS**

Applicants shall provide calculations which show the amount of carbon dioxide equivalent emissions which the station is expected to prevent from being released during three years of operation. Applicants shall determine and explain the carbon intensity (CI) of the pathway(s) associated with the hydrogen for each station. The CI is the amount of life cycle greenhouse gas emissions, per unit of fuel energy (such as hydrogen dispensed), expressed in grams of carbon dioxide equivalent per megajoule (gCO2e/MJ). The CIs for accepted pathways can be found in the 2015 Low Carbon Fuel Standard (LCFS) Regulation:

<http://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf>

Should an applicant propose a station pathway not included in the LCFS regulation, they should determine and explain the CI in terms of gCO2e/MJ. For more information, applicants are encouraged to check the entire regulation.

**STANDARD VALUES**

The values in this section apply for all stations in general.

The LCFS Compliance Schedule for 2011 to 2020 for Gasoline and Fuels Used as a Substitute for Gasoline (Table 1 on page 32 of the LCFS Regs) shows these CI values:

2017: 95.02 gCO2e/MJ

 2018: 93.55 gCO2e/MJ

 2019: 91.08 gCO2e/MJ

 2020: 88.62 gCO2e/MJ

Energy Economy Ratio (EER) for Hydrogen:Gasoline: 2.5 gallons gasoline/kg hydrogen[[1]](#footnote-1)

Energy density of gasoline: 115.83 MJ/gallon of gasoline[[2]](#footnote-2)

Energy density of hydrogen: 120.00 MJ/kg of hydrogen2

**STATION-SPECIFIC VALUES**

The values in this section should be carefully selected and justified by the applicant in their application.

*Anticipated fuel dispensed per day*, for example, from April 30, 2017 – April 30, 2020:

2017: 40 kg/day (0.3 years)

2018: 80 kg/day (1 year)

2019: 160 kg/day (1 year)

2020: 200 kg/day (maximum capacity; 0.7 years)

The applicant shall also select the appropriate CI for hydrogen to be dispensed at the station. In this example, compressed hydrogen from central reforming of natural gas (HYGN003) is used: 105.65 gCO2e/MJ[[3]](#footnote-3)

**EXAMPLE CALCULATION:**

Annual hydrogen dispensed:

Year-fraction \* days/year \* fuel dispensed per day

2017: 0.3 years \* 365 days/year \* 40 kg H2/day = 4,380 kg H2

2018: 1 year \* 365 days/year \* 80 kg H2/day = 29,200 kg H2

2019: 1 year \* 365 days/year \* 160 kg H2/day = 58,400 kg H2

2020: 0.7 years \* 365 days/year \* 200 kg H2/day = 51,100 kg H2

Total hydrogen dispensed:

4,380 + 29,200 + 58,400 + 51,100 = 143,080 kg hydrogen dispensed over three years

Annual displaced gasoline usage:

Annual hydrogen dispensed \* EER

2017: 4,380 kg H2 \* 2.5 gal gasoline/kg = 10,950 gallons of gasoline

2018: 29,200 kg H2 \* 2.5 gal gasoline/kg = 73,000 gallons of gasoline

2019: 58,400 kg H2 \* 2.5 gal gasoline/kg = 146,000 gallons of gasoline

2020: 51,100 kg H2 \* 2.5 gal gasoline/kg = 127,750 gallons of gasoline

Total displaced gasoline usage:

Total hydrogen dispensed \* EER

10,950 + 73,000 + 146,000 + 127,750 =

357,700 gallons of gasoline (and substitutes) displaced over three years

Annual avoided carbon dioxide equivalent (CO2e) emission from the displaced gasoline usage:

Annual displaced gasoline usage \* energy density of gasoline \* CI of gasoline for the given year \* tonnes per gram

2017: 10,950 gal gasoline \* 115.83 MJ/gal \* 95.02 gCO2e/MJ \* 1 tonne/1,000,000 grams) = 121 tonnes CO2e

2018: 73,000 gal gasoline \* 115.83 MJ/gal \* 93.55 gCO2e/MJ \* 1 tonne/1,000,000 grams) = 791 tonnes CO2e

2019: 146,000 gal gasoline \* 115.83 MJ/gal \* 91.08 gCO2e/MJ \* 1 tonne/1,000,000 grams) = 1,540 tonnes CO2e

2020: 127,750 gal gasoline \* 115.83 MJ/gal \* 88.62 gCO2e/MJ \* 1 tonne/1,000,000 grams) = 1,311 tonnes CO2e

Total avoided carbon dioxide equivalent (CO2e) emission from displaced gasoline usage:

121 + 791 + 1,540 + 1,311 tonnes CO2e = 3,763 tonnes CO2e over three years of data collection

Total CO2e emission associated with the hydrogen dispensed at the station:

Year-fraction \* days/year \* fuel dispensed per day \* energy density of hydrogen \* CI of the hydrogen \* tonnes per gram =

(0.3 years \* 365 days/year \* 40 kg H2/day \* 120.00 MJ/kg H2 \* 105.65 gCO2e/MJ \* 1 tonne/1,000,000 grams) +

(1 year \* 365 days/year \* 80 kg H2/day \* 120.00 MJ/kg H2 \* 105.65 gCO2e/MJ \* 1 tonne/1,000,000 grams) +

(1 year \* 365 days/year \* 160 kg H2/day \* 120.00 MJ/kg H2 \* 105.65 gCO2e/MJ \* 1 tonne/1,000,000 grams) +

(0.7 years \* 365 days/year \* 200 kg H2/day \* 120.00 MJ/kg H2 \* 105.65 gCO2e/MJ \* 1 tonne/1,000,000 grams) =

56 + 370 + 740 + 648 tonnes CO2e = 1,814 tonnes CO2e over the three years of data collection

The predicted three-year total CO2e savings for this station would be:

3,763 tonnes CO2e - 1,814 tonnes CO2e = 1,949 tonnes CO2e

1. LCFS Regs, Table 4: “EER Values for Fuels Used in Light- and Medium-Duty, and Heavy-Duty Applications.”, page 45. [↑](#footnote-ref-1)
2. LCFS Regs, Table 3: “Energy Densities of LCFS Fuels and Blendstocks.”, page 42. [↑](#footnote-ref-2)
3. LCFS Regs, Table 6: “Tier 2 Lookup Table for Gasoline and Diesel and Fuels that Substitute for Gasoline and Diesel.”, page 66. [↑](#footnote-ref-3)