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# Method 2B Application for Ehrenberg LNG Plant

**Date:** **Updated** December 21, 2010
**To:** Mike Eaves
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**From:** Jeff Rosenfeld
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**Subject:** Clean Energy Ehrenberg LNG WTW GHG Emissions

**Re:** The Ehrenberg LNG Plant

The Ehrenberg plant is located in Ehrenberg, Arizona, on the border between Arizona and California. It is owned and operated by Desert Gas Services (DGS), LLC. The plant has a capacity of 50,000 gallons of LNG per day, and an average production rate of 45,000 gallons of LNG per day. DGS has signed a long-term contract with Clean Energy Fuels Corp. to supply its growing LNG customer demand. The LNG process is a conventional turbo-expander plant. High pressure natural gas from a transmission pipeline is compressed to 3,000+ psig using electric driven compressors. This high pressure gas is run through a turbo expander to produce the ultra low temperatures (from Joule Thompson expansion) required to liquefy the natural gas. About 30% of the natural gas entering the plant is liquefied in the process. About 70% of the inlet gas remains as a gas and has to be compressed to pipeline pressures where it is put back into the transmission pipeline. The process has a secondary process heater (2,500,000 Btu/hr rated input). The process heater is to regenerate the dryer beds used to remove moisture from the inlet pipeline natural gas. There is also an amine boiler that removes CO2 (2,500,000 Btu/hr rated input).

The efficiency of the Ehrenberg plant is 1.43 kWh/gallon. The heater and boiler operate 35% and 95% of the time, consuming 21,000,000 and 57,000,000 Btu per day respectively. This equates to 1,733 Btu/LNG gallon with a 45,000 gallon per day average production level. The baseline California produced LNG pathway utilizes 1.14kWh/gallon where all of the electricity is from CA marginal electricity. To replicate the California produced pathway to compare with the Ehrenberg Plant, the process efficiency was calculated for the California LNG plant, and the Ehrenberg LNG Plant, as shown in the table below. Conversion factors utilized for electricity were 3412 Btu/kWh. Efficiency is calculated as LNG energy produced divided by the sum of LNG energy produced and total energy consumed in the process, this case is all electricity.

| All Units in Btus per gallon of LNG | California LNG Plant | Ehrenberg LNG Plant |
|---|---|---|
| LNG Produced | 80,968 | 80,968 |
| Electricity Used | 3,890 | 4,879 |
| Natural Gas Used | - | 1,733 |
| Efficiency | (80968)/(80968+3890) = 95.42% | (80968)/(80968+4879+1733) = 92.45% |

The GREET model LNG pathway was then modified to adjust efficiency (cell AD66 on the "NG" tab) and process energy to 100% electricity (cell AD 79). Also, California marginal electricity mix was chosen for the electricity mix. This produced the results shown in the table below which were taken from cells I152-I157. The table also shows a difference of 3.47 g/MJ in the liquefaction stage. Conversion from g/MMBtu to g/MJ was done using the conversion factor of 1055.055 MJ/MMBTU as is done in the CA-GREET model.

| | California LNG Plant | Ehrenberg LNG Plant |
|---|---|---|
| gVOC/MMBTU | 0.762 | 1.281 |
| gCO/MMBTU | 2.792 | 4.708 |
| gCH4/MMBTU | 10.541 | 17.777 |
| gN2O/MMBTU | 0.124 | 0.209 |
| gCO2/MMBTU | 5021.474 | 8468.805 |
| gCO2e/MMBTU | 5328.84 | 8987.16 |
| gCO2e/MJ | 5.05 | 8.52 |
| Increase over California LNG Plant (gCO2e/MJ) | | 3.47 |

The 5.05 gCO2e/MJ matches the value in the CA-GREET v1.8b supplied by ARB and listed on page 14 of the report "**Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources"**[1] states the following:

[1] http://www.arb.ca.gov/fuels/lcfs/092309lcfs_lng.pdf

*Note: When using the 90% liquefaction case in California, the energy inputs translate to 1.14 kWh/gal of energy use where all the electricity is derived from grid based marginal California electricity. Based on this input, the GHG emissions are calculated to be **5.04 gCO2e/MJ**. Therefore the only change for the two pathways modeled here is that for the 80% efficiency one, the liquefaction GHG emissions are **15.79 gCO2e/MJ** (Table 4.04). For the 90% efficiency case, the corresponding emissions are **5.04 gCO2e/MJ**. This is the only difference in GHG emissions between the 80% and 90% efficiency cases modeled here for liquefaction in California.

The Ehrenberg LNG is located 125 miles from the destination for LNG while the GREET default value for trucking distance is 50 miles. The table below shows three different pathways:

1) GREET default of 50 miles utilizing diesel trucks

2) Ehrenberg Plant distance of 125 miles utilizing diesel trucks

3) Ehrenberg Plant distance of 125 miles utilizing Westport HPDI trucks consuming 90% LNG and 10% diesel with an EER of 1.0

The numbers were inputted in cells CD93 (miles), CD95 (% diesel consumption) and CD97 (% LNG consumption) on the "T&D" tab and the results were taken from cells J152-J157 on the "NG" tab.

| | California LNG Plant – 50 miles 100% diesel | Ehrenberg LNG Plant – 125 miles 100% Diesel | Ehrenberg LNG Plant – 125 miles 10% Diesel and 90% LNG |
|---|---|---|---|
| gVOC/MMBTU | 0.159 | 0.397 | 0.379 |
| gCO/MMBTU | 0.718 | 1.794 | 1.018 |
| gCH4/MMBTU | 0.460 | 1.150 | 1.831 |
| gN2O/MMBTU | 0.009 | 0.023 | 0.024 |
| gCO2/MMBTU | 373.761 | 934.402 | 751.673 |
| gCO2e/MMBTU | 389.65 | 974.14 | 807.41 |
| gCO2e/MJ | 0.37 | 0.92 | 0.77 |
| Increase over California LNG Plant (gCO2e/MJ) | | 0.55 | 0.40 |

When the CA-GREET model is run completely with the modifications listed above, the table below shows the complete pathway results. The total pathway gCO2e/MMBtu results were taken from the sum of cells G163 and L 159 on the "NG" tab. The TTW gCO2e/MJ were taken from the Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) document.[2]

| | California LNG Plant – 50 miles 100% diesel | Ehrenberg LNG Plant – 125 miles 100% Diesel | Ehrenberg LNG Plant – 125 miles 10% Diesel and 90% LNG |
|---|---|---|---|
| gCO2e/MJ WTT | 13.88 | 17.90 | 17.75 |
| gCO2e/MJ TTW | 58.50 | 58.50 | 58.50 |
| gCO2e/MJ TTW | 72.38 | 76.40 | 76.25 |
| Increase over California LNG Plant (gCO2e/MJ) | | 4.02 | 3.87 |

The above table shows that the increase in WTW GHG emissions is 3.87g/MJ for the pathway that has a 125 mile driving distance on the Westport HPDI engine. This is an 8% in the WTT and 1.5% in WTW GHG emissions. Based on Section 95486 (e)(2), *"5-10" Substantiality Requirement*,[3] the Ehrenberg LNG Plant is more than 5.0 g/MJ less than the 80% efficiency plant look-up table value (WTT 24.63gCO2e/MJ, WTW 83.13 gCO2e/MJ) and within 5.0 g/MJ of the 90% efficiency look-up table value, and therefore should utilize the 90% efficiency table look-up value. Also, this plant meets the *"5-10" Substantiality Requirement* as 50,000 LNG gallons per day is approximately 13 million gasoline gallon equivalents per year.

[2] http://www.arb.ca.gov/fuels/lcfs/092309lcfs_lng.pdf

[3] Final Regulation Order, Subchapter 10. Climate Change, Article 4. Regulations to Achieve Greenhouse Gas Emissions Reductions, Subarticle 7. Low Carbon Fuel Standard, pg. 57. http://www.arb.ca.gov/regact/2009/lcfs09/lcfscombofinal.pdf