LCFS Life Cycle Fuel Pathway Report
Method 2B Application: Topock LNG Plant to LNG and L-CNG
Applied Natural Gas Fuels, Inc.

1. Company Overview:

Applied Natural Gas Fuels, Inc. (ANGF) operates a Liquefied Natural Gas (LNG) Plant in Topock, Arizona. The facility has the capacity to produce 86,000 gallons of LNG per day. It is conveniently adjacent to a pipeline system owned by Kinder Morgan (formerly El Paso Natural Gas). The feeding natural gas (NG) provided by [redacted] to Topock, Arizona—a distance of about [redacted] miles.

2. LNG Production Process:

The Topock LNG Plant, located about 3 miles from the California border, supplies LNG to customers in California by loading LNG onto diesel and LNG-fueled tractors pulling special LNG trailers.. These trucks then offload the fuel to wholesale customers' tanks before the customers dispense it into their vehicles. ANGF also operates two vehicle refueling stations in Barstow and Ontario, California. These two stations dispense LNG and LCNG to NG-powered vehicles.

The LNG process consists of several processes as described below:

- The NG pipelined from [redacted] is stripped of impurities until it is over 98% methane (CH_4).
- CO_2, H_2S, other Sulfur components, moisture, mercury, and particles are stripped via acid gas removal and disposal, gas dehydration, mercury removal, and particle filtration. Stripping is powered by a natural gas-fueled turbine. Stripping prevents corrosion in the pipeline and crystallization of CO_2 during cryogenic processes. The emissions associated with these processes include CO, VOC, SOx, NOx, H_2S, particulates, and many toxic organic compounds.
- The purified quality NG then is cooled down to a -260°F liquid in a heat exchanger that uses mixed refrigerant gas technology.
- The finished LNG is then transported to wholesale customer tanks and to the Ontario and Barstow refueling stations. The main energy used in the plant is natural gas received from [redacted]. Some electricity is used for supporting services and at the pumps. Efficiency of the LNG process is calculated by the ratio of the amount of the finished LNG over the amount of NG received. Details energy usage, LNG production, and LNG transportation data for 2011-2012 are shown in Table 1 below.
- The LNG is then vaporized and compressed from a liquid and dispensed as L-CNG into trucks and passenger cars.

Table 1: Detailed Key Input Parameters of Topock LNG Plant for 2011-2012

1. Process Fuels	Units	2011	2012	Average
Natural Gas Purchased	Million MMBtu	[redacted]	[redacted]	[redacted]
Electricity usage at the plant	Million kWh	[redacted]	[redacted]	[redacted]
Electricity usage at Barstow Station	Million kWh	[redacted]	[redacted]	[redacted]
Electricity usage at Ontario Station	Million kWh	[redacted]	[redacted]	[redacted]
Efficiency	%	[redacted]	[redacted]	[redacted]
2. LNG Transportation				
Diesel HD Trucks	Miles/round trip	[redacted]	[redacted]	[redacted]
Total Diesel HD trucks	Million Miles	[redacted]	[redacted]	[redacted]
Total LNG Truck	Million Miles	[redacted]	[redacted]	[redacted]
3. LNG Production				
Total LNG Production[1]	Million Gallons	[redacted]	[redacted]	[redacted]
Delivery to CA customers[2] Total Gallons	Million Gallons	[redacted]	[redacted]	[redacted]
Delivery to CA customers[3] LNG only	Million Gallons	[redacted]	[redacted]	[redacted]
4. L-CNG Production				
Compressed LNG to L-CNG dispensed in CA[4]	Million Gallons	[redacted]	[redacted]	[redacted]
Percentage of LNG Dispensed at Barstow	%	[redacted]	[redacted]	
Percentage of L-CNG Dispensed at Barstow	%	[redacted]	[redacted]	
Percentage of LNG Dispensed at Ontario	%	[redacted]	[redacted]	
Percentage of L-CNG Dispensed at Ontario	%	[redacted]	[redacted]	

[1] Includes LNG for transportation, non-transportation and fuel delivered outside of CA
[2] Transportation only; includes LNG and LCNG
[3] Transportation only; LNG only; includes wholesale and retail
[4] Transportation only; LCNG only; includes wholesale ([redacted] million gallons in 2011 and [redacted] in 2012) and retail ([redacted] million gallons in 2011 and [redacted] in 2012)

3. CA-GREET Model

When the energy use, transportation, and fuel production data from Table 1 is entered into the CA-GREET model, the calculations summarized in Table 2a are performed. As shown in Table 2b, the final result is a pathway CI of 76.48 gCO_2e/MJ for LNG and 76.87 CO_2e/MJ for L-CNG.

Table 2: CA-GREET Carbon Intensity Calculations

a. Input Conversions

Parameters	Values
Natural Gas purchase to use in the plant	[redacted] MMBtu/year
Natural Gas consumed in the plant	[redacted] MMBtu/year
Electricity used in the plant, at Barstow and Ontario stations	[redacted] Million kWh/year
Plant Efficiency	[redacted]
NG pipeline distance from [redacted] to Topock, AZ	[redacted] miles
[redacted] Diesel HD trucks usage	[redacted]
[redacted] LNG truck usage	[redacted]

b. Outputs for LNG

	Energy, Btu/MMBtu	GHG, gCO_2e/MJ
Well-to-tank (WTT)		
NA NG recovery	31,148	3.48
NA NG processing	31,855	3.73
NG pipelined to LNG Plant	9,367	0.98
LNG Production	117,824	7.30
LNG transportation & distribution	25,463	1.97
LNG storage	601	0.26
LNG dispensing	6,032	0.25
Total WTT	**222,290**	**17.98**
Tank-to-wheel (TTW)		
Carbon in Fuel (account for biogenic carbon)	1,000,000	56.00
CH_4 and N_2O tail pipe emissions	N/A	2.5
Total TTW	**1,000,000**	**57.73**
Total Well-to-Wheel (WTW)	**1,222,290**	**76.48**

c. **Outputs for L-CNG**

	Energy, Btu/MMBtu	GHG, gCO_2e/MJ
Well-to-tank (WTT)		
NA NG recovery	31,148	3.48
NA NG processing	31,855	3.73
NG pipelined to LNG Plant	9,367	0.98
LNG Production	117,824	7.30
LNG transportation & distribution	25,463	1.97
LNG storage	601	0.26
LNG dispensing	6,032	0.25
L-CNG (regasify/compress/dispense)	24,965	1.17
Total WTT	**247,255**	**21.39**
Tank-to-wheel (TTW)		
Carbon in Fuel (account for biogenic carbon)	1,000,000	55.20
CH_4 and N_2O tail pipe emissions	N/A	2.53
Total TTW	**1,000,000**	**57.73**
Total Well-to-Wheel (WTW)	**1,247,255**	**76.87**

The results shown in Table 2b and 2c are based on the following assumptions about the ANGF pathway:

a) Natural Gas Recovery and Processing: NG produced and processed in [redacted] is assumed to have the same carbon intensity as Northern American NG. The CI of Northern American NG is described in an ARB pathway document (California Air Resources Board 2009). The CIs are 3.48 and 3.73 g/MJ, respectively.

b) The NG pipeline distance from the NG production facility in [redacted] to Topock, AZ is assumed to be [redacted] miles. The transport carbon intensity is estimated to be 0.98 g/MJ of LNG produced.

c) The average total energy for liquefaction from the plant 2011-2012 data is: [redacted] MMBtu NG and [redacted] to produce [redacted] million gallons LNG, equivalent to [redacted] Btu/gal LNG. The CI is 7.30 g/MJ.

d) LNG Transportation: [redacted] of the LNG is transported by HD diesel trucks to two refueling stations in California (Barstow and Ontario), as well as to wholesale transportation customers. The remaining [redacted] is transported by [redacted]. The average roundtrip distance is [redacted] miles in 2011-2012. The carbon intensity is estimated to be 1.97 g/MJ of LNG produced.

e) LNG storage: Some of CH_4 is released or "boiled off" to keep the cargo cool. The model uses different boil-off rates for different locations: 0.05%/day at the storage plant, 0.1%/day during transportation and during refueling station storage. LNG stations equipped with recovery systems to recover any methane leaking. The carbon intensity is calculated to be 0.26 g/MJ of LNG produced.

f) LNG transported to CA is regasified, compressed, and dispensed as L-CNG. The carbon intensity is calculated to be 1.17 g/MJ of LNG produced.

g) Carbon in fuel, CH_4, and N_2O emission from LNG vehicles shown in Table 3: The detail calculation is shown in the LNG pathway published by ARB in September 2009 (California Air Resources Board 2009).

Table 3: Carbon Intensity for LNG used in LNG vehicles

Carbon in Fuel	56 g/MJ
CH_4 and N_2O tail pipe emissions	2.50 g/MJ

h) Carbon in fuel, CH_4, and N_2O emission from CNG vehicles shown in Table 4: The detail calculation is shown in Table 6.01 of the CNG pathway published by ARB in September 2009 (California Air Resources Board 2009).

Table 4: Carbon Intensity for L-CNG used in CNG vehicles

Carbon in Fuel	55.2 g/MJ
CH_4 and N_2O tail pipe emissions	2.53 g/MJ

References

California Air Resources Board. "Detailed California-Modified GREET Pathway for Compressed Natural Gas (CNG) from North American Natural Gas." Technical Report, 2009.

California Air Resources Board. "Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American Natural Gas." 2009.