

**Staff Summary  
Method 2B Pathway Application  
Applied Natural Gas Fuels  
North American Landfill Gas to  
Liquefied Natural Gas (LNG) and Liquefied Compressed Natural Gas (L-CNG)  
(LNG012\_1 and CNG008\_1)**

Deemed Complete Date: October 31, 2013  
Posted for Comment Date: January 28, 2014  
Certified Date: February 7, 2014

**Pathway Summary**

Applied Natural Gas Fuels, Inc. (ANGF) operates a Liquefied Natural Gas (LNG) Plant in Topock, Arizona. The facility has the capacity to produce 90,000 gallons of LNG per day.

In June 2013, ARB staff approved a pathway application from ANGF for the production of LNG (LNG012)<sup>1</sup> and L-CNG (CNG008)<sup>1</sup> from North American landfill gas. The applicant calculated the carbon intensities (CIs) of these pathways to be 49.84 and 50.98 gCO<sub>2</sub>e/MJ, respectively. The lower of these CIs applies to LNG used in LNG-powered vehicles. The higher CI applies to LNG that is vaporized, compressed, and used in CNG-powered vehicles. This vaporized and recompressed product is known as liquefied-to-compressed natural gas (L-CNG).

In January 2013, ARB staff posted a similar Method 1 biomethane-to-CNG pathway (CNG006)<sup>2</sup>. This pathway has a CI of 33.02 gCO<sub>2</sub>e/MJ.

ANGF is now requesting modifications to these three above pathways based on the inclusion of data from calendar year 2012 in the CI calculations. The source biomethane for these pathways could be any landfill in the U.S. as long as the biomethane is injected into a pipeline and connected to CA. After the landfill gas (LFG) is processed into pipeline-quality biomethane, it would be conveyed to the ANGF's Topock plant by pipeline. The resulting CIs are (LNG012\_1) 40.91 gCO<sub>2</sub>e/MJ for LNG and (CNG008\_1) 41.68 gCO<sub>2</sub>e/MJ for L-CNG.

The energy use and emissions associated with the LFG collection, processing, and transport phases of ANGF's biomethane-based pathways are assumed to be the same as the corresponding values in pathway CNG006. The emissions associated with the liquefaction, transport, dispensing, and use of biomethane in LNG-powered vehicles are

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<sup>1</sup> LNG012 and CNG008: Northern America landfill gas to ANGF for LNG and L-CNG production: <http://www.arb.ca.gov/fuels/lcfs/2a2b/apps/angf-lfg-051713.pdf>

<sup>2</sup> CNG006: ARB, January 28, 2013. LCFS Life Cycle Fuel Pathway Report: North-American Landfill Gas to Compressed Natural Gas. <http://www.arb.ca.gov/fuels/lcfs/2a2b/internal/nalfg-cng-rpt-031513.pdf>

assumed to be the same as the corresponding values used in pathway LNG011\_1.<sup>3</sup> The conversion of the LNG to L-CNG for use in CNG-powered vehicles requires that the energy and emissions associated with these additional steps be included in the L-CNG pathway CI. The resulting well-to-wheels pathway CIs are 40.91 gCO<sub>2</sub>e/MJ, and 41.68 gCO<sub>2</sub>e/MJ for ANGF's LNG and L-CNG pathways, respectively.

ANGF currently sells fuel in California under the following certified LCFS pathways:

1. LNG011\_1 and CNG015: North American natural gas to LNG and L-CNG<sup>4</sup>
2. LNG016 and CNG013: Pennsylvania LFG to LNG<sup>5</sup>
3. LNG017 and CNG014: Michigan LFG to LNG and L-CNG<sup>6</sup>

Because the biomethane supplied under the LNG and L-CNG pathways described in this Summary is commingled with fossil natural gas both when it is injected into the interstate pipeline system and when it is liquefied at ANGF's liquefaction plant, ANGF must maintain an accounting system that will enable it to demonstrate unequivocally at any time that every unit of transportation fuel sold and reported under each pathway can be associated with an equal unit of biomethane purchased.

ANGF's LNG and L-CNG pathways would cover the production of biomethane from landfill gas anywhere in North America. The biomethane produced under each pathway would be conveyed by pipeline to Topock, Arizona for liquefaction, and transported by heavy duty diesel truck to wholesale customers in California, and to two vehicle refueling distribution centers. The distribution centers—one in Barstow and one in Ontario—dispense both LNG and L-CNG.

The inputs for the upstream phases of ANGF's LFG-to-LNG and LNG to L-CNG pathways are the same as those used in the existing North American LFG to CNG pathway (see footnote 2 for information on pathway CNG006):

- A pipeline transport distance of 3,600 miles;
- An electrical energy generation mix of 100 percent coal for the LFG recovery and processing phases<sup>7</sup>.
- An LFG capture and processing efficiency of 77.2 percent—5.5 percent lower than the efficiency calculated for the original California LFG-to-CNG pathway (CNG001).<sup>8</sup>

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<sup>3</sup> LNG011\_1 and CNG015: North American natural gas to LNG and L-CNG:  
<http://www.arb.ca.gov/fuels/lcfs/2a2b/apps/angf-101813.pdf>

<sup>4</sup> LNG011\_1 and CNG015: North American natural gas to LNG and L-CNG:  
<http://www.arb.ca.gov/fuels/lcfs/2a2b/apps/angf-101813.pdf>

<sup>5</sup> LNG016 and CNG013: Pennsylvania LFG to LNG and L-CNG:  
<http://www.arb.ca.gov/fuels/lcfs/2a2b/apps/jre-angf-sum-101813.pdf>

<sup>6</sup> LNG017 and CNG014: Michigan LFG to LNG and L-CNG:  
<http://www.arb.ca.gov/fuels/lcfs/2a2b/apps/bse-angf-101813.pdf>

<sup>7</sup> The California marginal mix was used for the electricity consumed within California. This was also true of the original California LFG-to-CNG pathway (CNG001).

- Fuel shares of 76.8 percent thermal and 26.2 percent electrical for LFG processing
- A natural gas leak fraction of 0.15 percent

The downstream phases of the pathway (LNG production, including liquefaction efficiency and energy usage) are the same as those used to prepare ANGF's fossil-NG-to-LNG pathway (Pathway LNG011\_1)<sup>9</sup>.

### **Carbon Intensity of the Fuel Produced**

The inputs described above were entered into CA-GREET using three different electrical generation energy mixes: 100 percent coal for biomethane production, the CA-GREET 1.8b default U.S. average mix for LNG production at the Topock plant, and the California marginal mix for electricity consumed within California for L-CNG compression. As shown in the following table, the resulting CIs are 40.91 gCO<sub>2</sub>e/MJ for LNG and 41.68 gCO<sub>2</sub>e/MJ for L-CNG.

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<sup>8</sup> The LFG processing efficiencies used in the ANGF (LNG012) and CNG001 pathways are calculated from all but one identical parameter: membrane efficiency. The extracted LFG is forced through a membrane to separate the methane from the other constituents. CNG001 assumed a membrane efficiency of 90 percent, while LNG012 assumed a membrane efficiency of 84 percent. Both efficiencies correspond to measured efficiencies of actual membranes currently in use.

<sup>9</sup> Applied Natural Gas Fuels Inc. October 3, 2012. LCFS Life Cycle Fuel Pathway Report: Method 2B Application, Topock LNG Plant. <http://www.arb.ca.gov/fuels/lcfs/2a2b/apps/angf-090612.pdf>

**Proposed Lookup Table Entries**

Fuel/ Feedstock	Pathway Identifier	Pathway Description	Carbon Intensity in gCO <sub>2</sub> e/MJ (Including Indirect Effects)		
			Direct Emissions	Land Use or Other Indirect Effects	Total
LFG to LNG	LNG012_1	2B Application*: North American landfill gas to pipeline-quality biomethane; delivered via pipeline; liquefied in Topock, AZ; transported by truck to CA	40.91	0	40.91
LFG to CNG	CNG008_1	2B Application*: North American landfill gas to pipeline-quality biomethane; delivered via pipeline; liquefied in Topock, AZ; transported by truck to CA; re-gasified and compressed to L-CNG	41.68	0	41.68

\*Specific Conditions Apply

**Operating Conditions**

1. Actual pathway energy consumption values shall remain at or below the levels specified in ANGF's application. In contrast, the liquefaction efficiency shall remain at or above the values in the ANGF's application. These conditions apply to the LNG liquefaction plant in Topock, Arizona, and the LNG and L-CNG dispensing stations in Barstow and Ontario, California. Energy consumption values for these facilities are classified by the applicant as confidential business information.
2. Because ANGF purchases, liquefies, and sells into the California transportation fuels market both fossil natural gas and biomethane produced from landfill gas, and because gas from these two sources is commingled in the fuel that ANGF sells, ANGF must maintain an accounting system that will enable it to demonstrate unequivocally at any time that every unit of biomethane and fossil

natural gas reported under the LCFS can be associated with equal amounts of each fuel type purchased.

3. ANGF must be able to demonstrate the LFG it purchases from any landfill for the purpose of producing biomethane to be sold in California under either pathway described in this Summary does not cause the maximum LFG yield of that landfill to be exceeded. This demonstration must account for all LFG sold to all customers. ANGF's purchases, in combination with all other LFG sales, must not exceed the maximum LFG yield.

### **Staff Analysis and Recommendation**

The North American LFG-to-LNG pathways summarized in this document were modified using two existing LCFS pathways: the North American LFG to LNG and CNG pathways published in June 2013 (LNG0012 and CNG008). Staff has reviewed and replicated, using CA-GREET 1.8b, the CIs calculated by ANGF.

On the basis of these findings, staff recommends that pathways LNG012\_1 and CNG008\_1 for North American LFG to LNG and L-CNG be certified.