Attachment A

Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources

Version 1.0 – July 20, 2009

Sempra Energy Comments – North American Natural Gas Sources

Appendix A1 (Scenario 1)

Section 3. Natural Gas Transportation and Distribution

3.1 Energy Use for NG Transport to LNG Plants in California

The pathway document utilizes values for energy intensity (405 Btu/ton-mile) and pipeline leak rate (0.08%) that are substantially understated and not supported by publically available information. Both of these values require revision to rectify errors made in their derivation(NA NG to CNG Pathway, Page 30)

Information is publicly available from the EIA and EPA that can be utilized to calculate the average fuel consumption rate and methane emissions rate for gas transportation in the US. Additional information from interstate gas pipelines must be used to adjust the average US rates to the specific situation described in the pathway document.

The energy intensity value utilized for the pipeline transportation equates to a fuel consumption rate of less than 1% for the 750 mile pipeline. This is far lower than the existing interstate pipelines serving Southern California. This understated value was primarily the result of assuming the pipeline required only a single compressor station. A review of actual operating pipelines would show a 750 mile pipeline requires multiple gas compressor stations for proper operation. Based on the published tariff data the 750 mile pipeline would have a fuel consumption rate of 3.0%. The energy intensity value used for pipeline transportation should be increased to 1654 Btu/ton-mile to be more reflective of actual pipelines.

The pathway document utilizes a fugitive methane emissions rate of 0.08% based on information from an AB 1007 analysis. That analysis incorrectly applied the methane leakage rate for the California utility pipeline system alone to represent the entire 750 mile pipeline. Based on publically available data, a more appropriate rate for the pipeline would be 0.53% which is very similar to the original CA-GREET default value 0.56% before modification.

The following provides additional information regarding the derivation of appropriate values for energy intensity and fugitive methane emissions rate.

Information from the Kern River, Transwestern and El Paso pipeline tariffs was evaluated to determine appropriate fuel consumption rates for natural gas transportation. [1,2,3]

Pipeline	2007 Volume, MMcfd[7]	Usage Rate	Distance, Miles	Usage Rate per 100 Miles
El Paso	1673	2.56%	450	0.57%
Transwestern	825	2.90%	450	0.64%
Kern River	1629	1.67%	600	0.28%

Weighted Average				0.47%

The tariff information generated a weighted average gas usage rate of 0.47% per 100 miles for natural gas transportation. Because this total usage rate addresses both natural gas consumed as fuel and fugitive methane emissions, the rate must be allocated between the two categories. Data from the EIA for 2006 was utilized to cal culate the average fuel gas consumption rate for the US associated with natural gas transportation by pipeline.

2006 Gas Volume Data – EIA Natural Gas Annual 2007 – Table 1[4]
Pipeline & Distribution Fuel – 584,213 MMscf
Total Natural Gas Delivered to Consumers - 19,958,451 MMscf

The fuel gas consumption rate should be calculated by dividing pipeline and distribution fuel by the total natural gas delivered to consumers. Using the EIA 2006 actual gas volume data described above, the fuel gas consumption rate is 2.93% (584213 ÷ 19958451) for 2006.

The average fugitive methane emission rate for the US associated with natural gas transportation by pipeline should be calculated using the following EPA actual data for natural gas transmission in 2006:

2006 Fugitive Methane Data – Table 3-35, Page 3-45[5]
Transmission & Storage Fugitive Methane – 1,817 Gigagrams or 1,817,000 tonnes

In order to use this fugitive emissions data for transmission in the GREET model, it has to be converted to a gas volume equivalent. This conversion is calculated below:

Methane density - 23.654 Scf/lb or 0.05215 MMscf/tonne
1,817,000 tonnes * 0.05215 MMscf/tonne = 94,757 MMscf

The actual transmission fugitive emission rate should be calculated on the basis of the total fugitive emissions above (94,757 MMscf), by dividing these total fugitive emissions by the same total volume of natural gas delivered to consumers that has been used to calculate the transmission fuel gas consumption rate above. On this basis, the actual fugitive methane emission rate for natural gas transmission is 0.48% (94757 ÷ 19958451) for 2006

Now the US average rates derived above for fuel consumption and fugitive methane emissions can be utilized to allocate the gas usage rate between the two categories. The transmission fuel consumption is calculated by multiplying the total usage rate for gas transportation by the US average fuel consumption rate divided by the total of the US fuel consumption rate and US fugitive methane emission rate. The transmission fugitive methane rate is calculated in a similar manner. These calculations are set forth below:

Transmission fuel consumption - 0.47% * 2.93%/(2.93% + 0.48%) = 0.40% per 100 miles
Transmission fugitive methane - 0.47% * 0.48%/(2.93% + 0.48%) = 0.07% per 100 miles

The transmission fuel consumption rate must be converted to an energy intensity value for input in the GREET Model based on the parameters from the model set forth below. This should be done by multiplying the fuel consumption rate by the grams per ton by the natural gas lower heating value, divided by the product of natural gas density and 100 miles. This calculation is set forth below:

Natural Gas Lower Heating Value (LHV) – 930 Btu/Scf
Natural Gas Density – 20.40 grams/Scf
Fuel Consumption – 0.40% per 100 miles
907,200 grams per ton
0.40% * 907200 * 930 ÷ (20.40 * 100) = 1654 Btu/ton-mile

The pipeline leak rate calculated above of 0.07% per 100 miles is utilized to calculate the appropriate value for the gas transmission pipeline to the liquefaction plant in California. The fugitive methane leak rate for the 750 mile pipeline should be 0.53% (0.07 * 7.5).

Section 1. Natural Gas Recovery

1.1 Energy Use for Natural Gas Recovery
The pathway includes a recovery efficiency of 97.2% for NA natural gas based on the GREET default value. (Page 40). This value should be revised to reflect more current information.

All natural gas consumed (fuel, vented or flared) during the production operations would be included in the determination of recovery efficiency (total gas consumption). Dividing total natural gas consumed by the total produced gas volume gives the fuel consumption percentage. Because it is the most recent actual data available, the following data from the EIA for 2006 should be utilized to calculate the average fuel gas consumption rate for the US associated with natural gas production:

2006 Gas Volume Data – EIA Natural Gas Annual 2007 – Table 1[4]
Vented & Flared - 129,469 MMscf
Lease Fuel - 782,992 MMscf
Total Dry Production - 18,503,605 MMscf

The fuel gas consumption rate should be calculated by dividing the total of the lease fuel and vented & flared volume by total dry production. Therefore the fuel gas consumption rate is (129469 + 782992) ÷ 18503605 or 4.93% for 2006. The natural gas efficiency value can then be calculated by subtracting the fuel gas consumption rate from 100% as follows:

100% - 4.93% = 95.07%

The NA natural gas recovery efficiency in the pathway document and GREET Model should be revised to incorporate this 95.07% value.

Section 2. Natural Gas Processing

2.1 Energy Use for Natural Gas Processing

The pathway document includes a processing efficiency of 97.2% for NA natural gas based on the GREET default value (Page 40). . This value should be revised to reflect more current information from EIA for 2006 regarding the average fuel gas consumption rate for the US associated with natural gas production:

2006 Gas Volume Data – EIA Natural Gas Annual 2007 – Table 1[4]
Plant Fuel – 358,985 MMscf
Total Dry Production - 18,503,605 MMscf

The fuel gas consumption rate should then be calculated by dividing plant fuel by total dry production. Using the forgoing more recent data, the fuel gas consumption rate is 1.94% (358985 ÷ 18503605) for 2006. Using this fuel gas consumption rate, North American gas processing efficiency can be calculated by deducting this consumption rate from 100% as follows:

100% - 1.94% = 98.06%

The NA natural gas processing efficiency in the pathway document and GREET Model should be revised to incorporate the 98.06% value reflected in more recent data.

2.2 GHG Emissions from Natural Gas Processing

The pathway document includes an emissions rate of 1,237 gram CO2/MMBtu for vented CO2 associated with NA natural gas based on the GREET default value(NA NG to CNG, Page 27). This value should be revised to reflect more current information.

Any CO2 removed from natural gas and vented during the production or processing operations should be included in the determination of the vented CO2 rate. An accurate vented CO2 rate can be calculated by dividing total vented CO2 weight by the net energy content of natural gas produced. Produced gas volumes can then be converted to energy content using the average lower heating value. Source data for vented CO2 should be based on the Environmental Protection Agency's 2008 Inventory of Greenhouse Gas Emissions and Sinks and EIA data should be used as the basis for total dry production. The EPA and EIA data for 2006 necessary to calculate an accurate average vented CO2 rate for the US is set forth below:

2006 Vented CO2 – Table 3-37, Page 3-45[6]
Field Production - 7,203 Gigagrams (10^9 grams)
Processing – 21,204 Gigagrams (10^9 grams)

2006 Gas Volume Data – EIA Natural Gas Annual 2007 – Table 1[4]
Dry Production - 18,503,605 MMscf

On the basis of the forgoing, as well as the Lower Heating Value (LHV) of 930 Btu/Scf (930 MMBtu/MMscf) from the GREET Model, the vented CO2 rate for North American natural gas processing should be calculated as follows:

$$(7203 + 21204) * 10^9 \div (18503605 * 930) = 1,653 \text{ gram } CO_2 \text{ per MMBtu}$$

The vented CO_2 rate for NA natural gas processing in the pathway document and GREET Model should be revised to incorporate the 1653 gram CO_2/MMBtu value reflected above.

Section 5. LNG Transport, Distribution and Storage

5.2 LNG Truck Transport Energy Consumption

The pathway document includes a distance of 50 miles for the LNG truck transport from the liquefaction plant in California to the LNG station. Existing plants that liquefy pipeline gas are located near the California border or outside Los Angeles. A value of 100 to 150 miles would be more appropriate for the typical distance for trucked LNG.

References

[1]Kern River Pipeline - http://www.kernrivergas.com/InternetPortal/FrontDesktop.aspx?

[2]Transwestern Pipeline - https://twtransfer.energytransfer.com/index.jsp?companyName=TW&pg=IP&frames=none

[3]El Paso Pipeline - http://passportebb.elpaso.com/ebbEPG/ebbmain.asp?sPipelineCode=EPNG

[4]Energy Information Administration / Natural Gas Annual 2007, Table 1. Summary Statistics for Natural Gas in the United States, 2003-2007; http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/natural_gas_annual/nga.html

[5]Environmental Protection Agency 2008 Inventory of Greenhouse Gas Emissions and Sinks, 2006 Fugitive Methane - Table 3-35, Page 3-45

[6]Environmental Protection Agency 2008 Inventory of Greenhouse Gas Emissions and Sinks, 2006 Vented CO2 - Table 3-37, Page 3-45