Life-Cycle Assessment of Jefferson Davis Parish Landfill Gas to Delivered CNG in California

October 9th, 2014

Submitted to:

Shell Energy North America

Prepared by

ICF International
75 E. Santa Clara St., Suite 300
San Jose, CA 95113

POC: Jeffrey Rosenfeld; Jeffrey.rosenfeld@icfi.com

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General Information

JDP Renewables LLC (JDP) operates a landfill gas (LFG) treatment facility to recover methane from the Jefferson David Parish Sanitary Landfill Commission landfill in Welsh, Louisiana.

The anaerobic decomposition of organic wastes in landfills results in the generation of a biogas commonly referred to as landfill gas (LFG). [redacted]. A landfill Gas Collection and Control System (GCCS) consisting of approximately 100 extraction wells feeding a series of lateral and header pipes routes raw LFG from the landfill and delivers it to the refinery located on the landfill site.

The JDP treatment facility purifies raw LFG via a series of cooling, filtering, and compressing processes using specifically designed equipment. The treatment facility utilizes a previously existing blower/flare at the site. JPD uses purified LFG routed upstream of the meter as pilot fuel for the flare and the thermal oxidizer and purchases electricity from Jeff Davis Electric Co-Op to serve the plant's electrical demand.

No permit limitation exists to the production of product gas at JDP. The maximum production capacity is the facility's equipment processing capacity and was determined through the EPA Registration process. The annual US EPA Actual Peak Capacity (calculated using the lower heating value of methane) is [redacted] million renewable fuel gallon equivalents of purified biogas production per year.

Pipeline grade LFG is transported via pipeline from Louisiana to California for compression and sale. The following pathway was produced using two (2) years (January 2012 – December 2013) of landfill gas production data[1] and two (2) years (2011-2012) of CNG compression data.[2]

Process Description

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

[redacted]

[1] Please see Annex 5 for JDP electric bills, and Annex 6 and 7 for the facility's gas sales

[2] Please see Annex 4 for CNG Station Electrical Efficiency Data

[3] Please see Annex 3 RSF Control Union Engineering Report for additional details

[redacted]

Data Collection and Process Results

To estimate GHG emissions, the energy and materials necessary for the following processes needs to be determined: LFG Production Plant, Transport of Gas to California (Pipeline), and Compression.

LFG Production Plant

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Two years (2012-2013) of plant modeling data show an average landfill gas inlet of [redacted] and open flares to combust off-gases generated during the regeneration steps and when plant is not operating.

TABLE 1 below shows the available data provided by JDP for input biogas, product biogas, biogas consumed on-site and imported electricity from January 2012 to December 2013. The balance of the biogas consumed in the thermal oxidizer and flare is calculated based on modeling data provided in the JDP Engineering Report (*Annex 3, pages 21 and 27*). The table also shows the provided data converted to GREET model inputs. The JDP pathway utilizes the CA-GREET default values for LFG recovery.

The value of [redacted] per hour in **TABLE 1** below is the average amount of product pipeline quality biogas produced. To determine combustion emissions from the consumed natural gas and landfill gas at the landfill gas plant, the GREET default values for natural gas combustion process for natural gas liquefaction (100% natural gas turbine) were chosen since they represent the processes more closely than natural gas compression (100% natural gas engine).

[4] Annex 3 RSF Control Union Engineering Report, page 51
[5] Annex 2, Summary, cell K32. 92% is the sales gas (43.02 mmbtu/hour) divided by the landfill gas (39.69 mmbtu/hour)
[6] Please see Annex 2, Summary tab, cell O25 for the calculation of this figure
[7] Please see Annex 2, Summary tab, cell I25 for the calculation of this figure
[8] Please see Annex 3 RSF Control Union Engineering Report, page 51. Gas sample analysis methane content is used in the energy flow calculations in Annex 2, Summary tab, cell E32

TABLE 1. JDP LFG PLANT OPERATING ENERGY AND FLARE CREDIT[9]
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

	Jan 2012 – Dec 2013 Hourly Data	Btu/MMBtu of Product Gas	Input Value	Changed Cells – NG Tab
[redacted]				

Below is a simplified process diagram of the facility that includes the estimated energy flow associated with each step of the LFG recovery process.

[9] Please see Annex 2, JDP Energy Use & Gas Sales tab for the calculations of the figures presented in this table
[10] Please see Annex 6 and 7 for PDFs of gas sales invoices
[11] Please see Annex 5 for PDFs of facility electricity bills
[12] Please see Annex 1 for the Modified GREET model referred to in this report

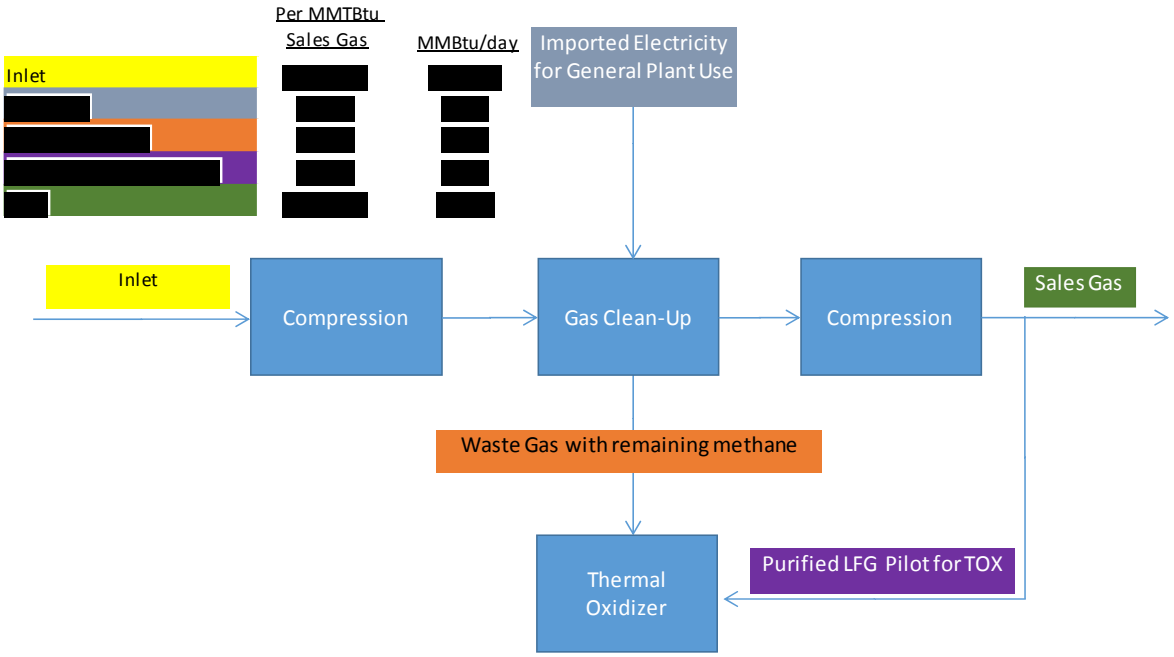

Figure 1. KC Process per MMBtu and MMBtu/day Energy Flows

The GREET model LFG pathway was then modified to adjust efficiency gas and process energy shares as listed in **TABLE 2**. The Southeast Asia region on the Regional LT tab was changed to the SERC Mississippi Valley (SRMV) Region to represent the 2012 eGRID data for year 2009 where JDP facility is located and this was used for the JDP Pathway. The ARB methodology of converting eGRID electricity mix to marginal mix was employed. This changed the electric mix cells of J83-J88 on the Region LT tab to those shown in **TABLE 2**. The remaining values from the Southeast Asia Region (now the SRMV region) were changed to match the US Average.

TABLE 2. SRMV ELECTRICITY GRID MIX

	eGRID CY 2009 Grid Mix	Marginal Grid Mix	CA-GREET Cell Regional LT Tab
Residual oil	2.31%	2.31%	J83
Natural gas	45.33%	73.03%	J84
Coal	22.73%	22.73%	J85
Nuclear	25.97%	0.00%	J86
Biomass	1.93%	1.93%	J87
Other (renewables)	1.73% (w/ hydro)	0.00% (w/o hydro)	J88

This produced the results for LFG to CNG shown in Table 3 below. These values are taken from the NG Tab of the Modified GREET model which can be found in Annex 2 of the supporting documents submitted in conjunction with this report. 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.

The recovery energy and emissions are based on ARB LFG pathway defaults of 4621.25 Btu of electricity/MMBtu of landfill gas.[13]

TABLE 3. JDP LFG PLANT GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

	Recovery Emissions	JDP LFG Plant	CA-GREET Cell NG Tab
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]
[redacted]		[redacted]	[redacted]

Transportation to California by Pipeline

Clean Energy owns, operates or supplies natural gas and biomethane to [redacted] (*JDP Pathways Annex 4 – CNG Station Electrical Efficiency Data.xls),* [redacted] single representative transport distance (and carbon intensity) was chosen for all of Clean Energy's stations to allow for fungibility of JDP's biomethane between the CNG stations and require the approval of only one pathway [redacted] The distances were determined by the using the driving route most similar to the pipeline map. Google Maps was used to determine the driving routes with the I-10W route most similar to the pipeline map to Los Angeles and I-10W to I-5N the most similar to the pipeline map to San Francisco.[14] The emissions were determined by linked cell E148 on the NG tab to cell F479 on the T&D_Flowcharts tab for LFG to CNG, and this same distance will be used for LFG and LNG. The table below shows the pipeline transport emissions from cells F151-F157 on the NG Tab.

[13] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf; page 9.
[14] Please see Annex 3 RSF Control Union Engineering Report, pipeline map on page 75

TABLE 4. JDP LFG TRANSPORT GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Transport Emissions	JDP LFG Transport
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Compression

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Based on the submitted Confidential Business Information from Clean Energy Fuels, Clean Energy will be submitting for one pathway for their CNG Stations based on two (2) years of data (2011-2012). The weighted average energy consumption is [redacted] and has been previously approved in Pathway CNG009_1. Table 5 and Table 6 below show the calculation from kWh/GGE to process efficiency and the cells that were changed and the results from cells G151- G157.

TABLE 5. CNG STATION PLANT OPERATING EFFICIENCY
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

All Units in Btus per GGE	Compression	Input Value	Changed Cells – NG Tab
[redacted]	[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

TABLE 6. CNG COMPRESSION GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Recovery and Processing Emissions	Compression
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[15] Please see Annex 8 for the CNG station Electrical Efficiency Data
[16] 109,772 Btu/GGE default CA-GREET value

JDP Fuel Pathway Results

When the CA-GREET model is run completely with the modifications listed above, the table below shows the complete pathway results. The WTT pathway gCO2e/MJ results were taken from cell H158 which is the sum of cells E158 – G185 on the "NG" tab for CNG. The TTW gCO2e/MJ was taken from the Detailed California-Modified GREET Pathway for Compressed Natural Gas (CNG) from Landfill Gas[17].

TABLE 7. PATHWAY RESULTS

GHG Emissions (gCO2e/MJ)	JDP LFG Plant to CNG
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
gCO2e/MJ WTW	24.03

[17] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf

Appendix A: Summary of CA-GREET Inputs

Parameter	Unit	Value	CA-GREET Cell Changed
LFG Recovery and Transport			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[18] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf, pages 9-10.

Appendix B: List of Supporting Annexes

Annex 1 - Modified GREET model_LFG to CNG

Annex 2 - Facility Energy Data & Analysis

Annex 3 - RSF Control Union Engineering Report

Annex 4 - Clean Energy – CNG Station Electrical Efficiency Data

Annex 5 - Electric Bills 2012-2013

Annex 6 - Gas Sales 2012

Annex 7 - Gas Sales 2013

Life-Cycle Assessment of Jefferson Davis Parish Landfill Gas to Delivered LNG and LCNG in California

October 9th, 2014; Revised August 24th, 2015

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General Information

JDP Renewables LLC (JDP) operates a landfill gas (LFG) treatment facility to recover methane from the Jefferson David Parish Sanitary Landfill Commission landfill in Welsh, Louisiana.

The anaerobic decomposition of organic wastes in landfills results in the generation of a biogas commonly referred to as landfill gas (LFG). Raw LFG consists primarily of about [redacted] methane and [redacted] carbon dioxide, [redacted]N2, and trace components. A landfill Gas Collection and Control System (GCCS) consisting of approximately 100 extraction wells feeding a series of lateral and header pipes routes raw LFG from the landfill and delivers it to the refinery located on the landfill site.

The JDP treatment facility purifies raw LFG via a series of cooling, filtering, and compressing processes using specifically designed equipment. The treatment facility utilizes a previously existing blower/flare at the site. JPD uses purified LFG routed upstream of the meter as pilot fuel for the flare and the thermal oxidizer and purchases electricity from Jeff Davis Electric Co-Op to serve the plant's electrical demand.

No permit limitation exists to the production of product gas at JDP. The maximum production capacity is the facility's equipment processing capacity and was determined through the EPA Registration process. The annual US EPA Actual Peak Capacity (calculated using the lower heating value of methane) is [redacted] million renewable fuel gallon equivalents of purified biogas production per year.

Pipeline grade LFG is transported via pipeline from Louisiana to California for liquefaction and sale. The following pathway was produced using two (2) years (January 2012 – December 2013) of landfill gas production data[1] and two years (2011-2012) of liquefaction data.[2]

Process Description

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

The following steps outline the process train for the production of pipeline quality natural gas from [redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted].

[1] Please see Annex 5 for JDP electric bills, and Annex 6 and 7 for the facility's gas sales

[2] Please see Annex 8 for LNG station electrical efficiency data

[3] Please see Annex 3 RSF Control Union Engineering Report for additional details

[redacted]

Data Collection and Process Results

To estimate GHG emissions, the energy and materials necessary for the following processes needs to be determined: LFG Production Plant, Transport of Gas to California (Pipeline), Liquefaction, and Transportation & Distribution.

LFG Production Plant

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Two years (2012-2013) of plant modeling data show an average landfill gas inlet of [redacted] The JDP facility imports the necessary electricity to purify the landfill gas and uses an onsite thermal oxidizer and open flares to combust off-gases generated during the regeneration steps and when plant is not operating.

Table 1 below shows the available data provided by JDP for input biogas, product biogas, biogas consumed on-site and imported electricity from January 2012 to December 2013. The balance of the biogas consumed in the thermal oxidizer and flare is calculated based on modeling data provided in the JDP Engineering Report. The table also shows the provided data converted to GREET model inputs. The JDP pathway utilizes the CA-GREET default values for LFG recovery.

The value of [redacted] per hour in Table 1 below is the average amount of product pipeline quality biogas produced. To determine combustion emissions from the consumed natural gas and landfill gas at the landfill gas plant, the GREET default values for natural gas combustion process for natural gas liquefaction (100% natural gas turbine) were chosen since they represent the processes more closely than natural gas compression (100% natural gas engine).

[4] Annex 3 RSF Control Union Engineering Report, page 51
[5] Annex 2, Summary, cell K32. 92% is the sales gas (43.02 mmbtu/hour) divided by the landfill gas (39.69 mmbtu/hour)
[6] Please see Annex 2, Summary tab, cell O25 for the calculation of this figure
[7] Please see Annex 2, Summary tab, cell I25 for the calculation of this figure
[8] Please see Annex 3 RSF Control Union Engineering Report, page 51. Gas sample analysis methane content is used in the energy flow calculations in Annex 2, Summary tab, cell E32

TABLE 1. JDP LFG PLANT OPERATING ENERGY AND FLARE CREDIT[9]
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

	Jan 2012 – Dec 2013 Hourly Data	Btu/MMBtu of Product Gas	Input Value	Changed Cells – NG Tab
[redacted]	[redacted]	[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	Calculated w/in GREET[12]	

[9] Please see Annex 2, JDP Energy Use & Gas Sales tab for the calculations of the figures presented in this table
[10] Please see Annex 6 and 7 for PDFs of gas sales invoices
[11] Please see Annex 5 for PDFs of facility electricity bills
[12] Please see Annex 1 for the Modified GREET model referred to in this report

Below is a simplified process diagram of the facility that includes the estimated energy flow associated with each step of the LFG recovery process.

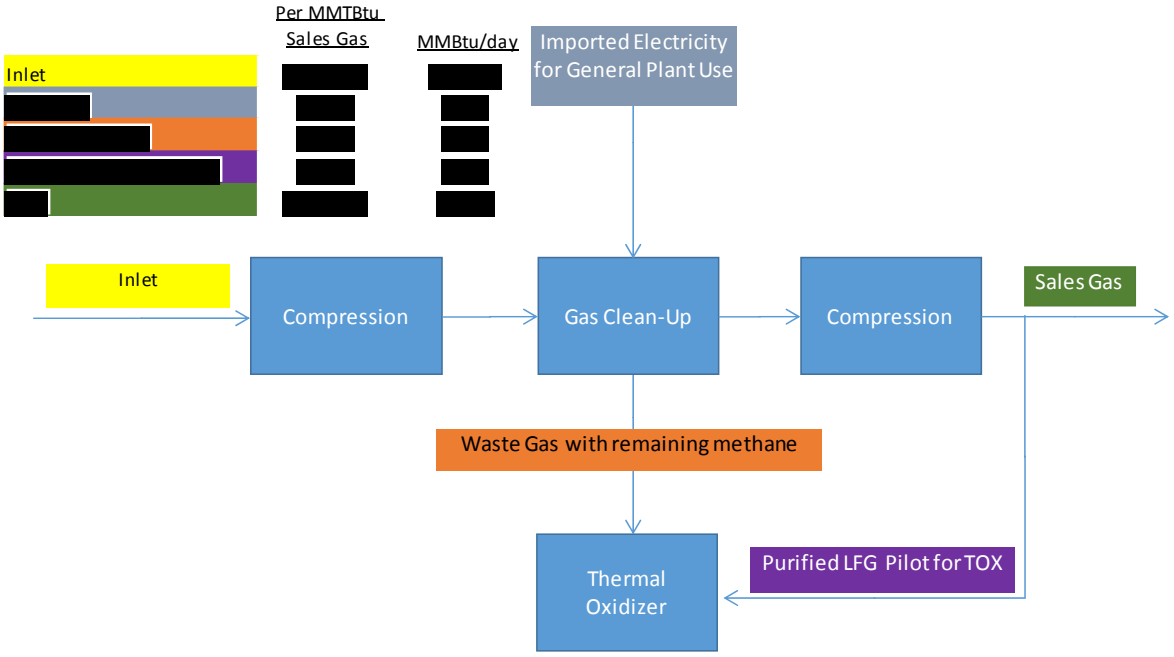

Figure 1. KC Process per MMBtu and MMBtu/day Energy Flows

The GREET model LFG pathway was then modified to adjust efficiency gas and process energy shares as listed in Table 2. The Southeast Asia region on the Regional LT tab was changed to the SERC Mississippi Valley (SRMV) Region to represent the 2012 eGRID data for year 2009 where JDP facility is located and this was used for the JDP Pathway. The ARB methodology of converting eGRID electricity mix to marginal mix was employed. This changed the electric mix cells of J83-J88 on the Region LT tab to those shown in Table 2. The remaining values from the Southeast Asia Region (now the SPSO region) were changed to match the US Average.

TABLE 2. SMRV ELECTRICITY GRID MIX

	eGRID CY2009 Grid Mix	Marginal Grid Mix	CA-GREET Cell Regional LT Tab
Residual oil	2.31%	2.31%	J83
Natural gas	45.33%	73.03%	J84
Coal	22.73%	22.73%	J85
Nuclear	25.97%	0.00%	J86
Biomass	1.93%	1.93%	J87
Other (renewables)	1.73% (w/ hydro)	0.00% (w/o hydro)	J88

This produced the results for LFG to CNG shown in Table 3 below. These values are taken from the NG Tab of the Modifed GREET model which can be found in Annex 2 of the supporting documents

submitted in conjunction with this report. 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.

The recovery energy and emissions are based on ARB LFG pathway defaults of 4621.25 Btu of electricity/MMBtu of landfill gas.[13] The default LFG transport distance of one mile was used since the distance between JDP and the JDP Landfill is less than 1 mile, as can be seen in Figure 2 below.

Figure 2. Proximity between JDP (identified location) and the JDP Landfill

TABLE 3. JDP LFG PLANT GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

	Recovery Emissions	JDP LFG Plant	CA-GREET Cell NG Tab
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]
[redacted]		[redacted]	[redacted]

[13] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf; page 9.

Transportation to California by Pipeline

The pipeline transport distance was modified to 1,733 miles from Welsh, LA to Boron, CA where the gas will be liquefied. The distance was determined by the using the driving route most similar to the pipeline map. Google Maps was used to determine the driving routes with the I-10 route most similar to the pipeline map. [14]The emissions were determined by linked cell E148 on the NG tab to cell F479 on the T&D_Flowcharts tab for LFG to CNG, and this same distance will be used for LFG and LNG. The table below shows the pipeline transport emissions from cells F151-F157 on the NG Tab.

TABLE 4. JDP LFG TRANSPORT GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Transport Emissions	JDP LFG Transport
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Liquefaction

(THIS SECTION CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Based on the submitted Confidential Business Information from Clean Energy Fuels fo [redacted] For the Boron LNG facility, the feed gas is the same as the product LNG gas during that time period. 80,968 Btu is the energy content of one gallon of LNG. All excess gas that is not converted to LNG is sent to the neighboring natural gas power plant.

Table 5 and

Table 6 below show the calculation from kWh/GGE to process efficiency and the cells that were changed and the results from cells G163- G169.

TABLE 5. BORON LNG PLANT OPERATING EFFICIENCY[15]
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

All Units in Btus per Gal of LNG	Boron LNG Plant	Input Value	Changed Cells – NG Tab
[redacted]	[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[14] Please see Annex 3 RSF Control Union Engineering Report, pipeline map on page 75
[15] Please see Annex 8 – Boron LNG Electricity Consumption Data for the calculations of the figures presented in this table

[redacted]	[redacted]	[redacted]	AD66 (via C175)

TABLE 6. BORON LNG PLANT GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Recovery & Processing Emissions	Boron LNG Plant - Liquefaction
[redacted]	[redacted]

LNG Transport to Refueling Station

In addition the CA-GREET default LNG transport distance of 50 miles was used but the fuel shares were modified to utilize the Westport HPDI trucks consuming 90% LNG and 10% diesel with an EER of 1.0. The numbers were inputted in cells CD95 (% diesel consumption) and CD97 (% LNG consumption) on the "T&D" tab and the results were taken from cells H163-H169 on the "NG" tab. The LNG trucks also have 100% boil-off capture, adjusting "Inputs" Tab cell D179 to 100%.

TABLE 7. LNG TRANSPORT GREENHOUSE GAS EMISSIONS
(THIS TABLE CONTAINS CONFIDENTIAL BUSINESS INFORMATION)

Recovery & Processing Emissions	Boron LNG Plant – Transport
gVOC/MMBTU	0.15
gCO/MMBTU	0.40
gCH4/MMBTU	0.71
gN2O/MMBTU	0.01
gCO2/MMBTU	289.99
gCO2e/MMBTU	311.62
gCO2e/MJ	**0.30**

LNG Storage

In addition the CA-GREET default for LNG storage was used. The default values are listed in Table 8 below (the results were taken from cells I163-I169 on the "NG" tab).

TABLE 8. LNG STORAGE CA-GREET DEFAULT VALUES

	Bulk Terminal Storage	CA-GREET Cells Inputs Tab	Distribution	CA-GREET Cells Inputs Tab
Boil-Off Rate: % per Day	0.05	E171	0.1	F171
Duration of Storage or Transit: Days	5	E174	0.1	F174
Recovery Rate for Boil-Off Gas	80%	E179	80%	F179

TABLE 9. LNG STORAGE GREENHOUSE GAS EMISSIONS

	LNG Storage
gVOC/MMBTU	
gCO/MMBTU	
gCH4/MMBTU	11.10
gN2O/MMBTU	
gCO2/MMBTU	
gCO2e/MMBTU	277.47
gCO2e/MJ	**0.26**

L/CNG Conversion

To convert from LNG to CNG, LNG is re-vaporized and then compressed to cylinder pressure (at about 3000psi). According to ARB default LNG and CNG pathways (as sent to Clean Energy and ICF by ARB Staff):

- Re-gasified to LNG: + 0.75 gCO2e/MJ[16]
- Compressed to CNG: +2.14 gCO2e/MJ[17]
- Total: 2.89 gCO2e/MJ

[16] http://www.arb.ca.gov/fuels/lcfs/092309lcfs_lng.pdf
[17] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_cng.pdf

JDP Fuel Pathway Results

When the CA-GREET model is run completely with the modifications listed above, the table below shows the complete pathway results. The WTT pathway gCO2e/MJ results were taken from cell J170 which is the sum of cells E170 – I170 on the "NG" tab for CNG. The TTW gCO2e/MJ was taken from the Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from Landfill Gas[18].

TABLE 10. PATHWAY RESULTS

GHG Emissions (gCO2e/MJ)	JDP LFG Plant to LNG	JDP LFG Plant to L/CNG
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]		[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
gCO2e/MJ WTW	28.60	30.72

[18] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf

Appendix A: Summary of CA-GREET Inputs

Parameter	Unit	Value	CA-GREET Cell Changed
LFG Recovery and Transport			
[redacted]			

[19] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_lfg.pdf, pages 9-10.

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
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Appendix B: List of Supporting Annexes

Annex 2 - Facility Energy Data & Analysis_070214

Annex 3 - RSF Control Union Eng Report

Annex 5 - Electric Bills 2012-2013

Annex 6 - Gas Sales 2012

Annex 7 - Gas Sales 2013

Annex 8 - Boron LNG Electricity Consumption Data

Annex 9 - Modified GREET model LFG to LNG and LCNG