NETL Life Cycle Inventory Data
Process Documentation File

Process Name: NG Regasification, Operation

Reference Flow: 1 kg of natural gas

Brief Description: Energy consumption and emissions to air for the operation of Trunkline LNG facility for regasification of LNG and injection into the transmission/distribution network.

Section I: Meta Data

Geographical Coverage: United States **Region:** N/A

Year Data Best Represents: 2007

Process Type: Basic Process (BP)

Process Scope: Gate-to-Gate (GG)

Allocation Applied: No

Completeness: Individual Relevant Flows Captured

Flows Aggregated in Data Set:

☒ Process ☒ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☒ Greenhouse Gases	☒ Criteria Air Pollutants	☒ Other
Releases to Water:	☐ Inorganic Emissions	☐ Organic Emissions	☐ Other
Water Usage:	☒ Water Consumption	☒ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

None.

Tracked Input Flows:

Natural gas	*Natural gas received from the offloading of an LNG ocean tanker*
Diesel fuel	*Diesel used as fuel for regasification process equipment*
Electricity	*Electricity used as fuel for regasification process equipment*

Tracked Output Flows:

Natural gas	*Reference flow; 1 kg of natural gas*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NG_Regasification_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process accounts for all relevant input and output flows associated with operation of a regasification facility, wherein liquefied natural gas (LNG) is returned to the gas state. The boundaries start with the input of LNG received from the offloading of an LNG ocean freighter and end with natural gas ready for injection into a pipeline.

The inputs to this unit process are LNG (received from the offloading of an LNG tanker), diesel, and electricity. The energy and emissions for the upstream production of LNG, diesel, and electricity are not included in this unit process but are accounted for by other unit process. The output of this unit process is natural gas that is suitable for pipeline transport. The unit process that immediately follows this unit process is the operation of a natural gas pipeline. The unit process is based on the reference flow of 1 kg of re-gasified natural gas. The relevant flows of this unit process are described below and shown in **Figure 1.**

Boundary and Description

The data sources for this unit process include mass balance and equipment data as reported by the Trunkline LNG facility to the federal energy regulatory commission (FERC) (Trunkline LNG 2006, Trunkline LNG 2008, and Trunkline LNG 2007), emission factors for the combustion of natural gas and diesel (EIA 2007), and criteria pollutants provided by Trunkline LNG (Louisiana DEQ 2007). Other data sources include energy conversion factors provided by EIA (EIA 2007) and the average density of natural gas (API 2004); these factors were necessary to translate data from a mass basis to an energy basis.

The LNG regasification facility uses a small portion of LNG input as fuel for a turbine and vaporizers. According to FERC documentation (Trunkline LNG 2008), natural gas is consumed at an average rate of 1.61% of the regasified natural gas product. Thus, for the production of 1 kg of re-gasified natural gas, 0.016 kg of natural gas is used for onsite energy generation, which translates to a total of 1.016 kg of LNG input.

The combustion of natural gas for onsite energy results in air emissions of CO_2, methane (CH_4), and nitrous oxide (N_2O). These air emissions were calculated by applying the amount of natural gas combusted (0.016 kg) to generic emission factors for natural gas combustion in stationary equipment (EIA 2007). In order to perform this calculation, it was necessary to convert natural gas from a mass basis to an energy basis; a heating value of 1,027 BTU/scf (EIA 2007) and density of 0.042 lbs/scf (API 2004) were used to complete this calculation.

In addition to the natural gas that is used for onsite energy, diesel is used for pumps and backup generators. The amount of diesel required per unit of production was determined from an equipment list provided by Trunkline LNG to FERC (Trunkline LNG 2006). This equipment list itemizes the fuel consumption per hour and annual hours of operation for each piece of diesel equipment used at the LNG regasification facility. This data was used to calculate annual diesel fuel consumption. The diesel fuel consumption is then divided by Trunkline's output to determine diesel usage per kg of re-gasified natural gas.

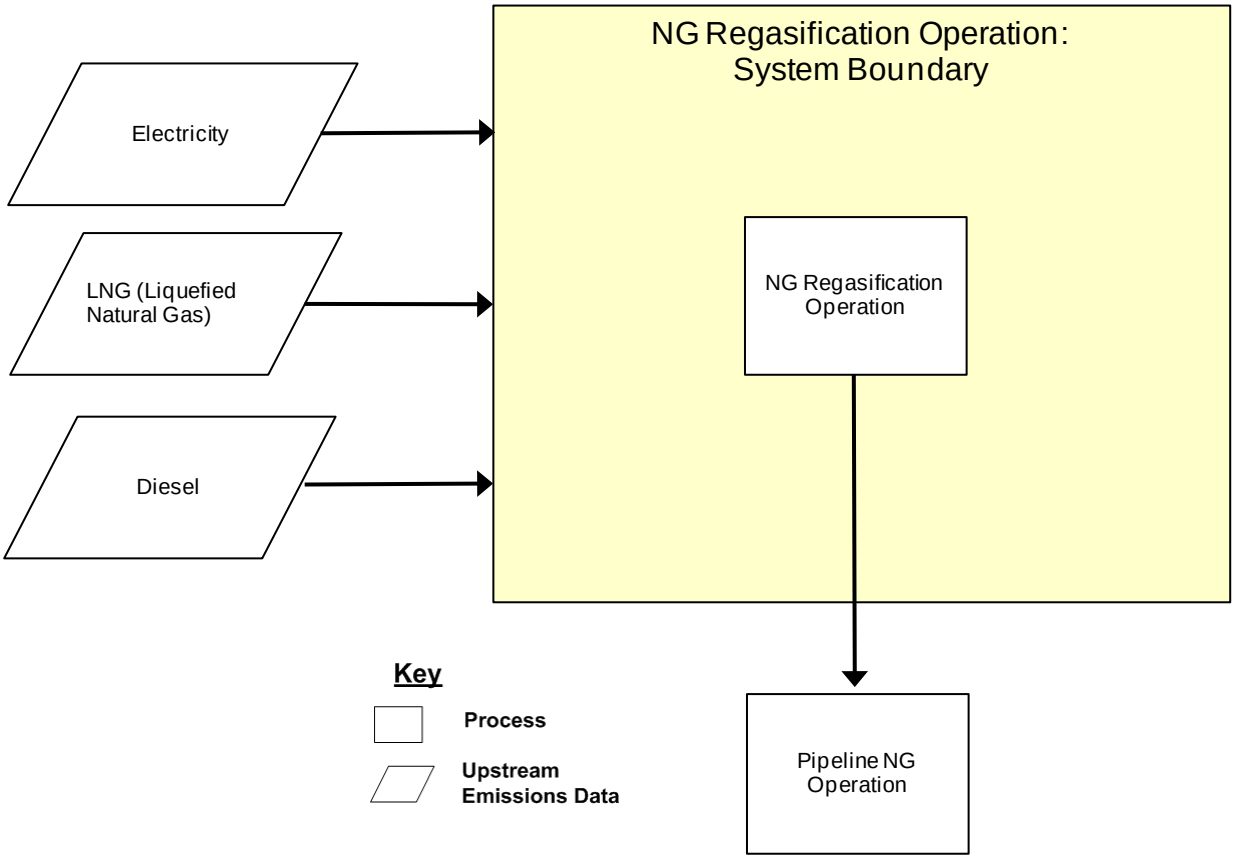
The CO_2 emissions from diesel combustion were calculated using emission factors for diesel combustion in diesel equipment (EIA 2007). This calculation was similar to the calculation used for CO_2 emissions from natural gas combustion as described above. Generic emission factors for diesel combustion were used to calculate methane and nitrous oxide emissions from diesel combustion in construction equipment (EIA 2007).

Criteria air pollutants for the LNG regasification facilities were based on emission data reported by the Trunkline LNG facility (Louisiana DEQ 2007). These emissions include VOC, NO_x, SO_2, PM, and CO. Trunkline LNG did not report any ammonia, lead, or mercury emissions.

Trunkline LNG combusts natural gas (primarily methane) and uses the combustion heat to re-gasify LNG. During this process, the cooled exhaust stream results in condensed water discharge. The amount of water discharged is estimated by assuming all the natural gas burned is methane. (For larger organic molecules (ethane, propane, etc), larger quantities of water would be produced for each molecule combusted.) Water production was estimated based on the amount of water produced from complete combustion of the amount of gas used for fuel. This quantity was then determined per kg of NG regasified.

Estimation of electricity requirements was based on FERC data (EIA 2008) reporting the operational power costs for Trunkline LNG activities. Electricity price data obtained from EIA was used to complete the estimate of the electrical energy consumed. The energy requirement was then expressed on the basis of kg of NG re-gasified.

Figure 1: Unit Process Scope and Boundary



Key properties of the natural gas regasification process are summarized in **Table 1.** The inputs and outputs of this unit process are summarized in **Table 2.**

Table 1: Properties of Natural Gas Regasification Operations

Property	Value	Units	Source
Annual natural gas output of regasification facility	4.8 E+09	kg/yr	Trunkline LNG 2008
Electricity requirements	0.0236	kWh/kg of natural gas output	Trunkline LNG 2007; EIA 2008
Natural gas input that is used for process fuel	1.61%	%	Trunkline LNG 2008
Diesel fuel requirements	1.38E-05	liters/kg of natural gas output	Trunkline LNG 2006

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Natural gas	1.016	kg
Diesel fuel	1.38E-05	kg
Electricity	2.36E-02	kg
Outputs		
Natural gas	1.00	kg
Carbon dioxide [Inorganic emissions to air]	3.79E-02	kg
Methane [Organic emissions to air (group VOC)]	3.13E-03	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	7.26E-08	kg
Nitrogen oxides [Inorganic emissions to air]	1.69E-05	kg
Sulphur dioxide [Inorganic emissions to air]	1.39E-07	kg
Carbon monoxide [Inorganic emissions to air]	9.30E-06	kg
NMVOC (unspecified) [Group NMVOC to air]	1.25E-06	kg
Dust (unspecified) [Particles to air]	1.56E-06	kg
Lead (+II) [Heavy metals to air]	0.00E+00	kg
Mercury (+II) [Heavy metals to air]	0.00E+00	kg
Ammonia [Inorganic emissions to air]	0.00E+00	kg
Water (wastewater) [Water]	2.99E-02	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using GaBi modeling software, as shown in Figure 2.

Embedded Unit Processes

None.

References

API (2004). American Petroleum Institute. Compendium of Greenhouse Gas Emissions Methodologies in the Oil and Gas Industry. 2004.

EIA (2007). Fuel Emission Factors (From Appendix H of the instructions to Form EIA-1605). http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls (accessed April 29, 2009).

EIA (2008). Table 5.6.B. Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State, Year-to-Date through December 2008 and 2007. http://www.eia.doe.gov/cneaf/electricity/epm/epmxlfile5_6_b.xls (Accessed May 14, 2010).

Louisiana DEQ (2007). 2007 Certified Totals of Criteria Pollutants for Louisiana (ERIC). http://www.deq.louisiana.gov/portal/LinkClick.aspx?fileticket=KvqcnDz%2fj4w%3d&tabid=1758

Trunkline LNG (2006). Trunkline LNG. Response to FERC's Environmental Information Request. Federal Energy Regulatory Commision Docket # CP06-102-000. 2006.

Trunkline LNG (2007). Trunkline LNG Tariff Revision 2007. Internet link to FERC website not available.

Trunkline LNG (2008). Michael Langston. Response to FERC Concerning Fuel Reimbursement Adjustment and Electric Power Cost Adjustment. 2008.

Section III: Document Control Information

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