NETL Life Cycle Inventory Data
Process Documentation File

Process Name: LNG Tanker, 138000 m3 Capacity, Operations

Reference Flow: 1 kg of LNG

Brief Description: Operation of a liquefied natural gas (LNG) ocean tanker, having a capacity of 138,000 cubic meters.

Section I: Meta Data

Geographical Coverage: Trinidad & Tobago; United States **Region:** N/A

Year Data Best Represents: 2005

Process Type: Transport Process (TP)

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:

One_Way_Dist — *One-way transport distance of LNG tanker*

Tracked Input Flows:

Natural gas — *Natural gas received from a liquefaction facility*

Diesel fuel — *Diesel used as a supplemental fuel for the LNG tanker*

Tracked Output Flows:

LNG — *Reference flow; 1 kg of liquefied natural gas (LNG)*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_LNG_Tanker_138000m3_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process accounts for the relevant energy and materials flows for the operation of an ocean tanker for the transport of LNG. The LNG tanker is fueled by a combination of natural gas from the boil-off of LNG and supplemental diesel. The boundaries of this unit process start with the loading of LNG onto the tanker, and end prior to de-berthing. All inputs and outputs are normalized to the reference flow (1 kg of LNG). The relevant flows of this unit process are described below and shown in **Figure 1.**

The inputs to this unit process are liquefied natural gas (LNG) loaded at a natural gas liquefaction facility and diesel fuel; the upstream energy and material flows of LNG and diesel are not included in this unit process but are accounted for by other unit processes. This unit process also accounts for environmental emissions that are directly released by the combustion of fuel by the LNG tanker. The de-berthing of the LNG tanker is the unit process that is immediately downstream of this unit process.

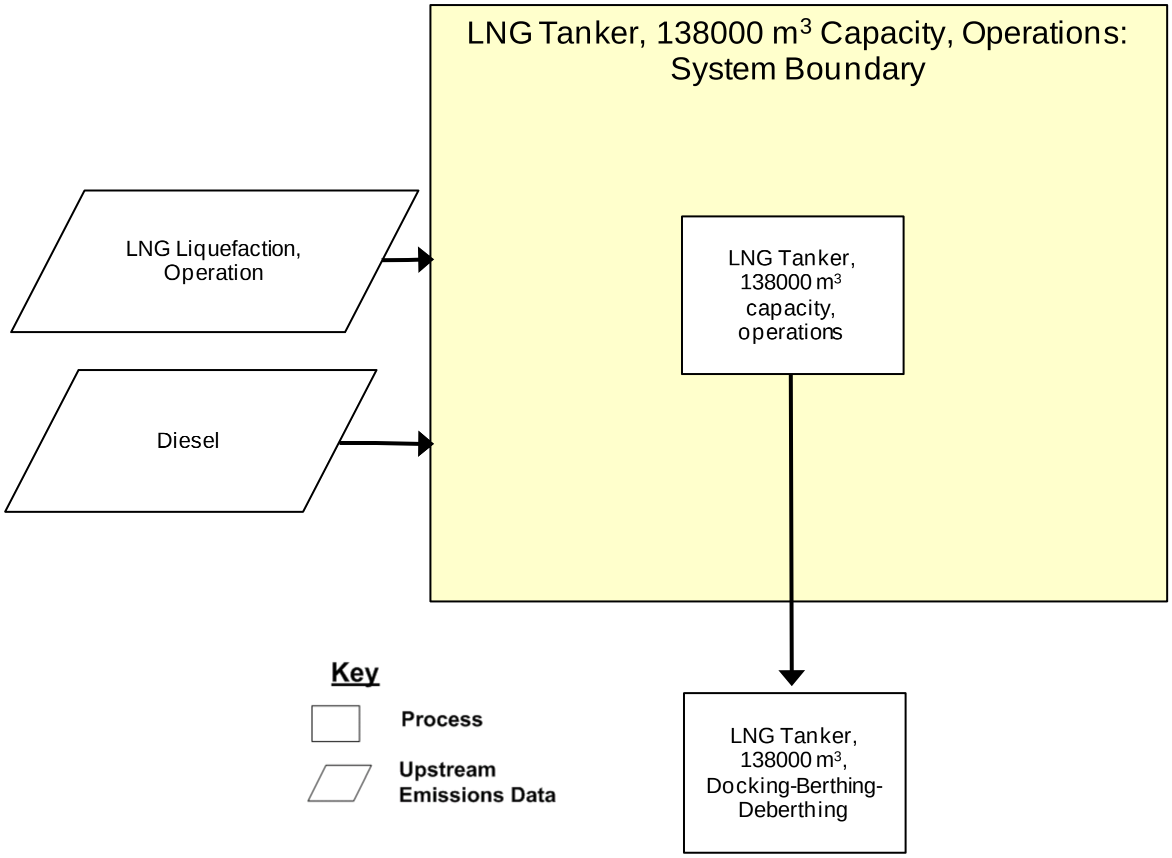
Boundary and Description

This unit process calculates the amount of natural gas and diesel fuel used to transport LNG from a foreign source to the US. The default parameters for this unit process describe LNG that is transported from Atlantic LNG in Trinidad and Tobago to Trunkline LNG in Lake Charles, Lousiana (Panhandle Energy 2006). This transport scenario can be modified by adjusting the distance parameter of this unit process.

The LNG tanker is a 138,000 cubic meter carrier (Colton Company 2006, Namba 2006). It is fueled by combusting the natural gas that boils off from the LNG product. Diesel is a supplemental fuel. The LNG tanker has dual-fuel engines (Wärtsilä Corporation 2005). The amount of natural gas boil-off is variable for both the laden and ballast voyages (Hasan. 2009). The percentages of cargo LNG used as fuel and heel (the percentage of initial volume remaining for fuel for the return trip) are also variable. After accounting for the quantity of LNG used for fuel and heel (Colton Company 2006, DOE 2005, Hasan. 2009, Namba 2006, Panhandle Energy 2006), the actual delivered quantity of LNG is 127,000 cubic meters. This value is the basis for the emissions from the tanker.

Carbon dioxide and NO_x emissions are calculated from engine manufacturer specifications (Wärtsilä Corporation 2005), assuming that the engines are running at 75% load (higher emissions than for 100% load). Remaining air pollutant emissions were estimated by applying EPA AP-42 emission factors for Large Stationary Diesel and All Stationary Dual-Fuel Engines (EPA. 1996). Emission factors were not available for ammonia, mercury, or lead and this is noted as an insignificant data limitation. Emissions are for the round-trip voyage.

Figure 1: Unit Process Scope and Boundary



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

Table 1: Properties of LNG Tanker Operations

Property	Value	Source
Capacity	138,000 m^3 natural gas	Colton Company 2006; Namba 2006
One-way transport distance (from Trinidad & Tobago to the U.S.)	2,600 miles	Study Assumption
Baseload natural gas consumption as fuel	172 kg/mile	Colton Company 2006; Namba 2006
Supplemental diesel consumption as fuel	15.0 kg/mile	Colton Company 2006; Wärtsilä Corporation 2005

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
LNG	1.015	**kg**
Diesel Fuel	1.28E-03	**kg**
Outputs		
Liquefied Natural Gas	1.00	kg
Carbon dioxide [Inorganic emissions to air]	4.69E-02	kg
Methane [Organic emissions to air (group VOC)]	2.29E-04	kg
Nitrogen oxides [Inorganic emissions to air]	2.71E-04	kg
Sulphur oxides [Inorganic emissions to air]	3.26E-07	kg
Carbon monoxide [Inorganic emissions to air]	4.55E-04	kg
NMVOC (unspecified) [Group NMVOC to air]	7.87E-05	kg
Dust (unspecified) [Particles to air]	2.89E-06	kg
Mercury (+II) [Heavy metals to air]	2.00E-13	kg
Ammonia [Inorganic emissions to air]	1.67E-07	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

Colton Company. 2006. Colton Company. The World Fleet of LNG Carriers. (Internet link no longer active)

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Hasan. 2009. ACS Publications. Minimizing Boil-Off Losses in Liquefied Natural Gas Transportation (abstract). http://pubs.acs.org/doi/abs/10.1021/ie801975q (accessed April 16, 2009)

Namba, N. 2006. Mitsubishi. Transportation of clean energy at sea--Mitsubishi LNG carrier, at present and in future. Mitsubishi Heavy Industries, Ltd. Volume 40. Issue 1. (Internet link no longer active)

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Wärtsilä Corporation. 2005. Wärtsilä Corporation. Wärtsilä 50DF. (Internet link no longer active)

Section III: Document Control Information

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Section IV: Disclaimer