NETL Life Cycle Inventory Data
Process Documentation File

Process Name: LNG Tanker, 130000 m3, Docking-Berthing-Deberthing

Reference Flow: 1 kg of LNG

Brief Description: Escort, berthing, and de-berthing operations for a 130,000 m^3 liquefied natural gas (LNG) ocean tanker.

Section I: Meta Data

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

Year Data Best Represents: 2003

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:

None.

Tracked Input Flows:

LNG Input	*LNG being transported in an LNG tanker*
Diesel	*Diesel expended as fuel for escorting the docking of an LNG tanker*
Residual oil	*Residual oil expended as fuel for escorting the docking of an 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_Docking_Berthing_Deberthing_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process accounts for the relevant input and output flows associated with the docking, berthing, and de-berthing of an ocean tanker that is transporting LNG. The docking/berthing/de-berthing process uses two tugs boats for escort, four tug boats for berthing, three tugboats for de-berthing, and one tugboat on standby. The LNG tanker also runs its engines during the process. Tug boats are assumed to run on diesel, while the LNG tanker is assumed to run on residual fuel oil. 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), diesel, and residual fuel oil; the upstream energy and material flows of LNG, diesel, and residual fuel oil 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 regasification of natural gas is the unit process that is immediately downstream of this unit process.

Boundary and Description

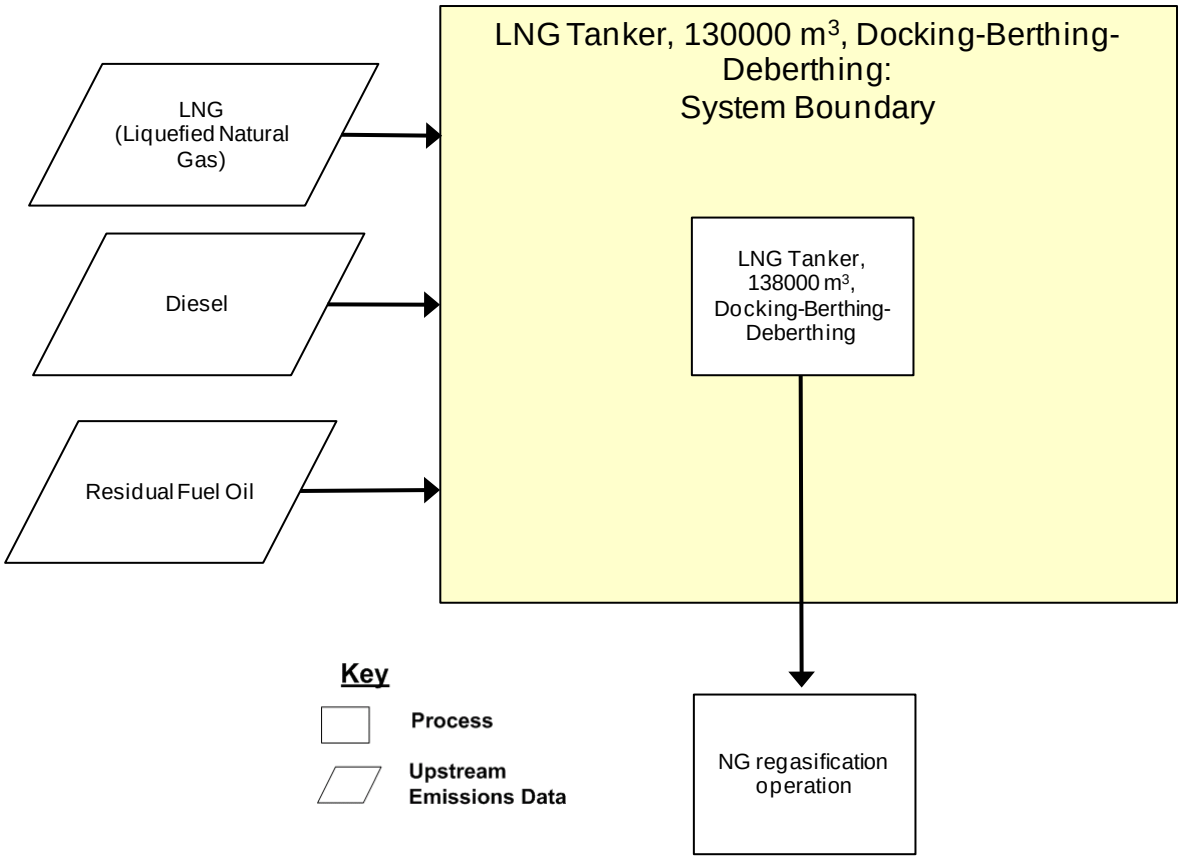
The emissions for LNG tanker escort, docking, and berthing/de-berthing are modeled using air emission estimates generated for a proposed power plant at Mare Island in Vallejo, California.

The docking facility is sized to service a 70,000 dead weight ton (DWT) LNG tanker with an LNG storage capacity of 130,000 cubic meters (URS 2003). The LNG tanker is propelled by steam boiler/steam turbine systems. The inbound voyage relies on LNG vapors as a fuel source. Vessel maintenance during LNG offloading requires on 0.5% sulfur fuel oil. The outgoing voyage uses 1.5% sulfur heavy fuel oil (URS 2003). Round trip fuel consumption (pilot on to pilot off, including offloading of cargo) requires 120 metric tons equivalent of fuel oil (URS 2003).

An LNG tanker is escorted by tug boats. Each tug boat is has a 4,200 horsepower (hp) diesel engine. Two tug boats are required to escort an LNG tanker (2 hours each way/tug or 8 tug-hours total/visit). Four tug boats are used to assist berthing (2 hours/tug or 8 tug-hours total/visit) and three tugs are used for deberthing (1 hours/tug or 3 tug-hours total/visit). An additional tug boat is on standby duty for approximately 15 hours per LNG tanker visit (URS 2003).

Future emission regulations will mandate a lower sulfur content for marine diesel powered vessels. Operations with a lower fuel sulfur content have not been modeled and is considered a data limitation. Emissions of CO_2, CH_4, and N_2O were estimated using fuel emission factors (EIA 2007). A mercury emission factor for heavy fuel oil was not readily available for inclusion in the modeling and is considered a data limitation. Ammonia emissions were estimated using emission factors for combustion sources (Battye 1994). Mercury emissions from diesel fuel were estimated using a mercury concentration in fuel study (Conaway 2005). Fuel density was obtained from a reference source (URS 2004).

Figure 1: Unit Process Scope and Boundary



Key properties of the unit 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 Docking, Berthing, and Deberthing

Property	Value	Source
Number of escort tugboats	2	URS 2003
Number of berthing tugboats	4	URS 2003
Number of deberthing tugboats	3	URS 2003
Number of standby tugboats	1	URS 2003
Tugboat engine rating (horsepower/engine)	4,200	URS 2003

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
LNG Input	1.00	kg
Diesel [Crude oil products]	2.52E-04	kg
Residual Fuel Oil [Crude Oil products]	2.14E-03	kg
Outputs		
Liquefied Natural Gas	1.00	kg
Carbon dioxide [Inorganic emissions to air]	8.19E-03	kg
Methane [Organic emissions to air (group VOC)]	5.97E-07	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	2.08E-07	kg
Nitrogen oxides [Inorganic emissions to air]	3.42E-05	kg
Sulphur dioxide [Inorganic emissions to air]	2.26E-05	kg
Carbon monoxide [Inorganic emissions to air]	2.79E-06	kg
NMVOC (unspecified) [Group NMVOC to air]	1.35E-06	kg
Dust (PM10) [Particles to air]	6.29E-06	kg
Mercury (+II) [Heavy metals to air]	3.52E-13	kg
Ammonia [Inorganic emissions to air]	2.64E-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

URS Corporation. Preliminary Evaluation of Air Quality Impacts for the Proposed Mare Island Energy Center. January 2003.

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).

Battye R, Battye W, Overcash C, Fudge S. 1994. Development and Selection of Ammonia Emissions Factors, Final Report. USEPA, Washington, D.C.

Conaway C H, Mason R P, Steding D J, Flegal A R. 2005. Estimate of mercury emission from gasoline and diesel consumption, San Francisco Bay area, California. Atmospheric Environment 39:101-105.

URS Corporation. 2004. Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry. Prepared for the American Petroleum Institute. http://www.api.org/ehs/climate/new/upload/2004_COMPENDIUM.pdf (accessed March 10, 2009).

Section III: Document Control Information

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