



NETL Life Cycle Inventory Data

Process Documentation File

Process Name: LNG Unloading
Reference Flow: 1 kg of LNG unloaded
Brief Description: This Unit Process includes energy requirements, losses, boil-off gas generation and GHG emissions associated with unloading LNG from tanker/ship after importing

Section I: Meta Data

Geographical Coverage: Europe and Asia **Region:** N/A
Year Data Best Represents: 2016
Process Type: Basic Process (BP)
Process Scope: Gate-to-Gate Process (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:

Std_unloading_rate

Standard unloading rate of LNG from the tanker

Boil_off_rate

Boil-off rate i.e. the rate at which Boil-off Gas is generated

BOG_recondensor_power_consumption_kW

Power consumption of the recondensor used to re-liquefy the BOG

BOG_recondensor_handling_capacity

Handling capacity of the recondensor used to re-liquefy the BOG

Tracked Input Flows:**LNG feed**

[Technosphere] LNG that needs to be transported to be able to unload 1 kg of LNG from the ship after losses

Diesel, combusted

[Technosphere] Energy requirement for the unloading process met by diesel combustion

Electricity

[Technosphere] Energy requirement for re-liquefaction of BOG generated during unloading

Tracked Output Flows:**LNG unloaded**

Reference flow

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_O_LNG_Unloading_2018.01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

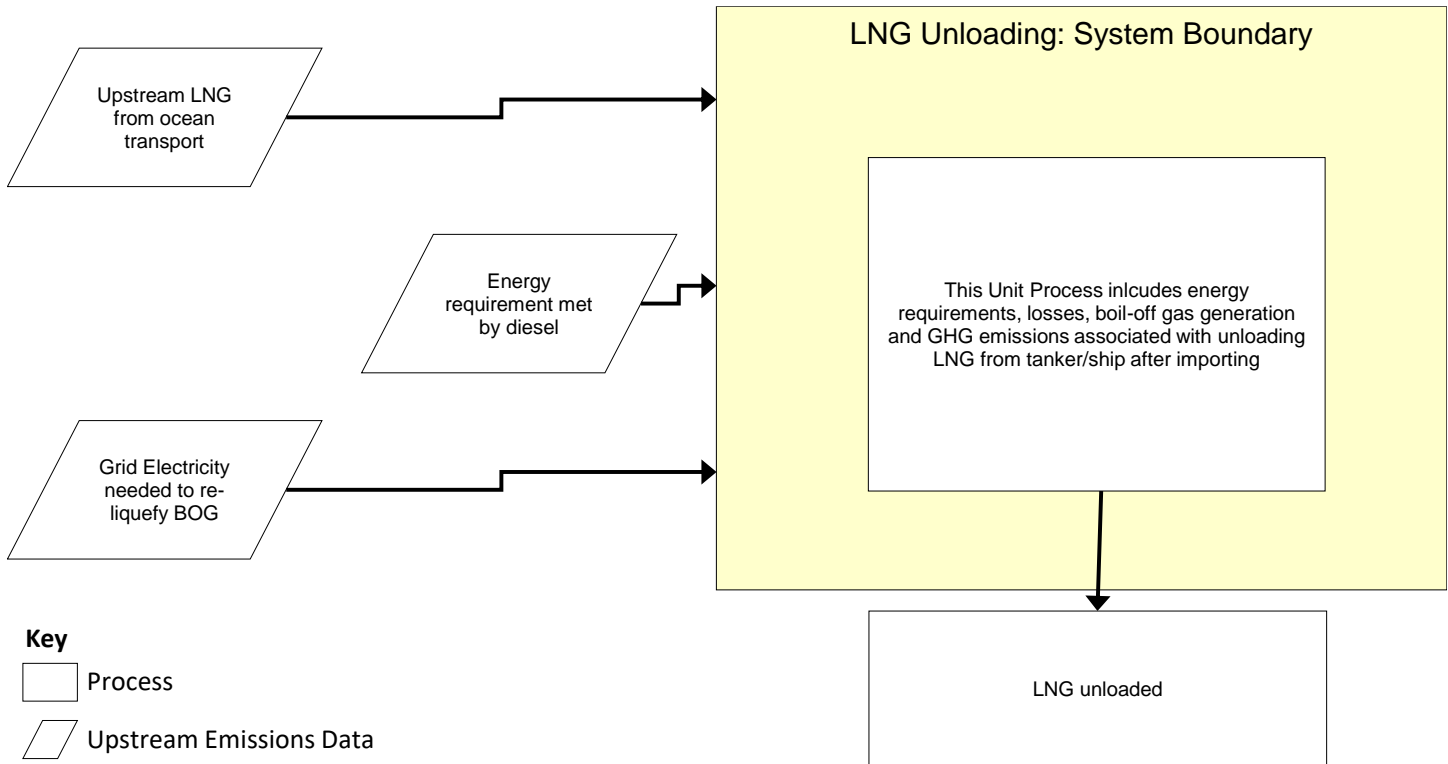
Goal and Scope

This unit process provides a summary of relevant input and output flows associated with unloading 1 kg of LNG from a tanker/ship imported from the US. The equipment used to unload the LNG is assumed to be operating on Diesel. The Boil-off Gas generated during the process is also re-liquefied and unloaded. The reference flow of this unit process is: 1 kg of LNG unloaded

Boundary and Description

The unloading UP represents the process of unloading the LNG from the ocean tanker into a regasification storage facility after transportation. This UP assumes the ship capacity to be in the range of 150,000 m³ to 180,000 m³ (IGU, 2017). The boil-off gas (BOG) generated during unloading is assumed to be re-liquefied and directed back into the supply chain, so the net loss of LNG during unloading is assumed to be zero. Based on literature, a standard unloading rate of 10,000-12,000 m³/hour and a boil-off rate (BOR) of 20,000 kg/hour is assumed (Dobrota, Lalic, & Komar, 2013). It is assumed that in any journey only 98% of the total ship capacity is utilized. During unloading, it is assumed that 2.5% of the capacity is to be left behind as heel for the ballast voyage. The average time at sea for the scenarios investigated in this analysis is 22.67 days (Sea-Distances.org, 2016) and assuming the BOR to be 0.001 kg/day during transportation (IGU, 2017), it is calculated that approximately 93.23% ($98\% - 2.5\% - 0.001 \times 22.67 \times 100$) of the ship will have to be unloaded on arrival at the port. The unloading equipment is assumed to be diesel based and the total diesel consumption is estimated by back-calculating from a literature based CO₂ emission data point (PACE Global, 2015). It is assumed that the BOG re-liquefaction compressor operates on purchased grid mix electricity. Compressor specifications from literature are used to estimate the energy requirement to re-liquefy 1 kg of BOG (Li & Wen, 2016). The functional unit of this process is the mass of LNG unloaded from the ocean tanker.

Figure 1: Unit Process Scope and Boundary



Embedded Unit Processes

None.

References

- Dobrota, D., Lalic, B., & Komar, I. (2013). Problem of Boil-off in LNG Supply Chain *Transactions in Maritime Science*, 2, 91-100. doi: 10.7225/toms.v02.n02.001
- IGU. (2017). *2017 World LNG Report*. IGU Website: Retrieved November 20, 2018, from https://www.igu.org/sites/default/files/103419-World_IGU_Report_no%20crops.pdf
- Li, Y., & Wen, M. (2016). Boil-Off Gas Two-Stage Compression and Recondensation Process at a Liquefied Natural gas Receiving Terminal *Chemical Engineering & Technology*, 40, 18-27. doi: 10.1002/ceat.201500751
- PACE Global, A. S. B. (2015). *LNG and Coal Life Cycle Assessment of Greenhouse Gas Emissions*. Retrieved September 26, 2018, from <http://www.paceglobal.com/wp-content/uploads/2015/10/LNG-and-Coal-Life-Cycle-Assessment-of-Greenhouse-Gas-Emissions.pdf>
- Sea-Distances.org. (2016). Sea-Distances Retrieved September, 27, 2018, 2018, from <https://sea-distances.org/contact>

Section III: Document Control Information

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