NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Processing and Liquefaction of NG and Storage of LNG

Reference Flow: 1 kg of Stored LNG

Brief Description: This Unit Process includes the Pipeline gas input, energy requirements, emissions, losses, and boil-off gas associated with Processing, Liquefaction and Storage of Natural Gas before it is exported

Section I: Meta Data

Geographical Coverage: United States of America **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:

Energy_source_switch

Source of Energy at the facility.
0 for grid Electricity; 1 for Parasitic NG

Energy_requirement_MJ

Energy requirement for the entire process, depends on technology scenario

NG_loss_liquefaction

NG lost during the process

BOR_from_storage

Boil-off rate during storage of LNG

storage_time

LNG on-site storage time

Tracked Input Flows:

Upstream Pipeline gas

[Technosphere] Pipeline gas needed to store 1 kg of LNG after processing and liquefaction

Grid Electrcity required to re-liquefy BOG

[Technosphere] Energy required to re-liquefy the BOG generated during liquefaction process

Electricity

[Technosphere] Energy that is supplied through grid electricity

Natural gas, combusted

[Technosphere] Energy that is supplied through Parasitic NG

Tracked Output Flows:

Stored LNG

Reference flow

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_O_LNG_Liquefaction_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 processing Pipeline NG, liquefying it to LNG and storing it on liquefaction site before it is exported. Boil-off gas (BOG) from temporary onsite storage is assumed to be re-liquefied. The reference flow of this unit process is: 1 kg of Stored LNG

Boundary and Description

The pre-treatment, liquefaction, and storage UP accounts for the pre-treatment of the input pipeline quality gas, liquefaction of the pre-treated gas, and on-site temporary storage of LNG before it is loaded onto an ocean tanker. The pre-treatment processes include:

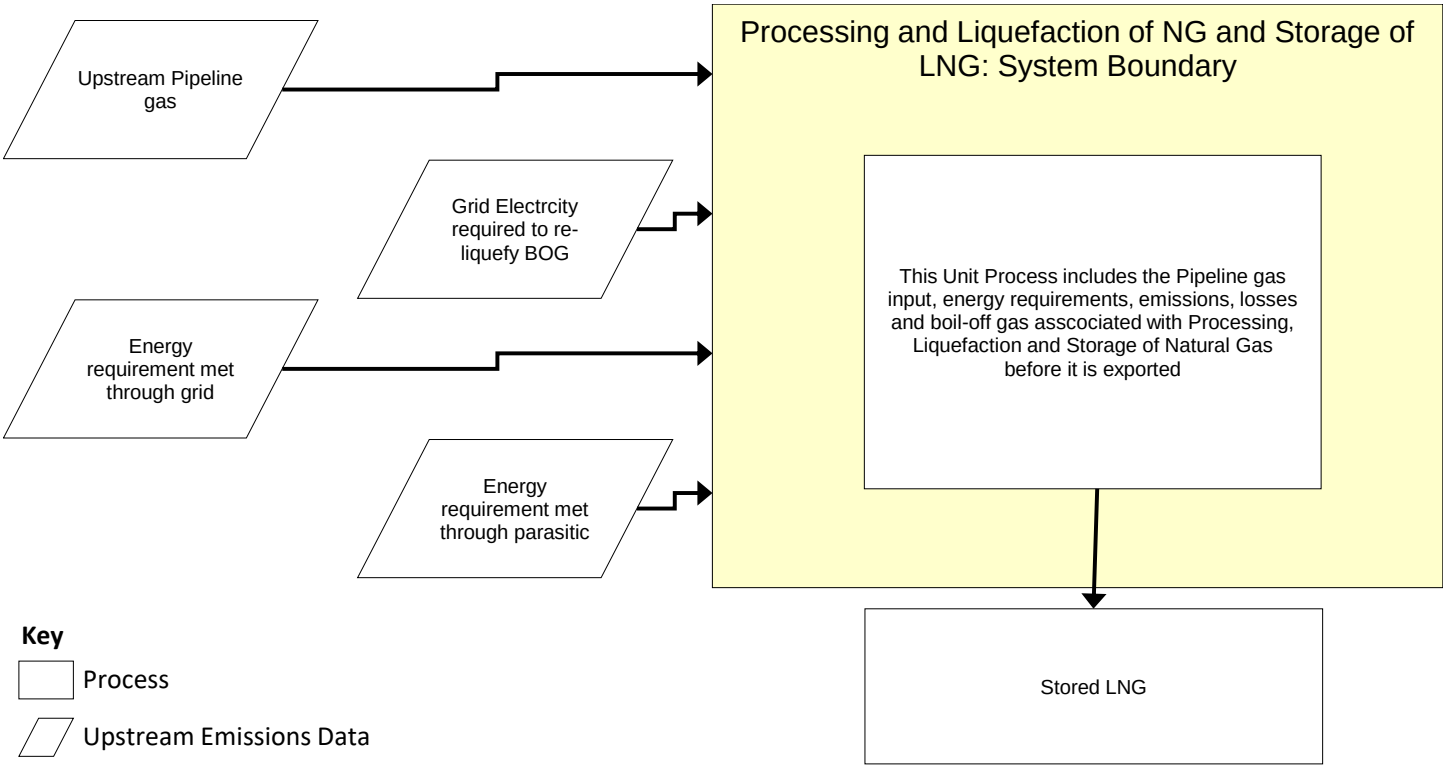
Acid gas removal (AGR): removal of CO2 and H2S from the pipeline feed gas, to avoid freezing and plugging in downstream units. (~7050 ppmv (EPA, 1996) to ~50 ppmv (Mallapragada et al., 2018) CO2)

Molecular sieve dehydration: removal of water to avoid freeze-up and unplanned shut downs, costly repairs and hazardous working conditions (ensure <0.5 ppmv water (Mallapragada, et al., 2018))

Heavy hydrocarbon (HHC) removal: to protect the main heat exchanger from freezing and plugging. This can be done by either Adsorption or Cryogenic Distillation (≈75 ppmv (EPA, 1996) to <10 ppmv C5+ (Smith & Doong, 2016))

The liquefaction facilities in the U.S. predominantly employ two technologies, Propane Pre-cooled Mixed Refrigerant (C3MR) process and Optimized Cascade process. This model represents the C3MR technology in combination with different pre-treatment technologies, represented through four different scenarios. The energy requirement for all scenarios is estimated based on literature (Mallapragada, et al., 2018). Based on the publicly available data on plant export capacities (EIA, 2017) and ship capacity assumptions (IGU, 2017), the residence time of LNG on site is estimated, which is treated as the LNG storage time on site. This value is estimated to be between 1.58 days to 1.90 days. During storage, Boil-off Gas (BOG) is generated at an estimated Boil-off Rate (BOR) of 0.02% to 0.1% (Dobrota, Lalic, & Komar, 2013). It is assumed that the BOG generated during storage is re-liquefied, which then enters back into the supply-chain. Literature suggests that the temporary onsite storage unit does not require energy to maintain the LNG in its liquid stage because it uses the concept of auto-refrigeration. The pre-treatment and liquefaction energy requirement is assumed to be met through combusting parasitic NG as it leaves the pre-treatment facility and before it enters the liquefaction facility. The functional unit of this unit process is the mass of LNG that is stored after being treated and liquefied.

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

EIA. (2017). U.S. liquefied natural gas exports have increased as new facilities come online. EIA Retrieved November 20, 2018, from https://www.eia.gov/todayinenergy/detail.php?id=34032

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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

Mallapragada, D. S., Reyes-Bastida, E., Roberto, F., McElroy, E. M., Veskovic, D., & Laurenzi, I. J. (2018). Life cycle greenhouse gas emissions and freshwater consumption of liquefied Marcellus shale gas used for international power generation. *Journal of Cleaner Production, 205*, 672-680. doi: 10.1016/j.jclepro.2018.09.111

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Section III: Document Control Information

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