
# Floating Liquefied Natural Gas (FLNG)

## (Mooring systems and Transfer methods)

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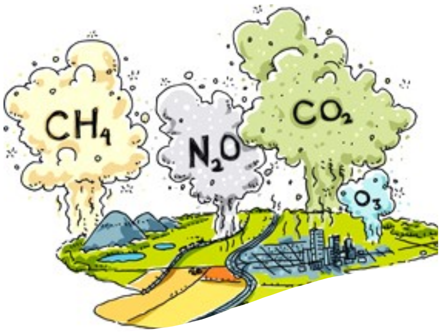
## Liquefied Natural Gas

LNG or Liquefied Natural Gas is natural gas that has been super cooled to a temperature around –162°C (-260 F), whereby it condenses into a liquid form. It is a non-toxic, non-corrosive, colourless and odourless fuel. The process of conversion is not new, having been established in 1917 and was first used in the United States over 60 years ago. The main purpose of cooling is to reduce the LNG to around 1/600th of its volume as a gas, drastically decreasing its weight to about 45% as much as an equivalent amount of water. This has very evident merits in terms of transportation from natural gas rich areas.

Under normal operations and even in the occurrence of an accident, vessels which run on LNG maintain an environmentally friendly profile and this serves as a major reason why they are built. Using LNG instead of diesel poses more environmentally friendly advantages, such as:




- A reduction in emission of greenhouse gases (CO2 and Hydrocarbons) as a result of the higher hydrogen ratio in LNG compared to diesel or HFO.
- Remarkable decrease in the release of NOX, SOX and other particulate matter (82-84 %, 100% and 67 %, respectively). The reductions are dependent on engine size and type. (TrainMosII)

At an onshore plant, the natural gas is treated so that it can be fed into a gas pipeline network and/or liquefied for export via an LNG carrier. Installing pipelines between the point of extraction and the shore makes it very expensive, and sometimes impossible to develop offshore fields that are far from land and hard to access. To avoid building such complex networks and costly infrastructure, the Floating Liquefied Natural Gas (FLNG) facility was invented and developed to combine an extraction unit with a natural gas liquefaction plant. The pay-off is steep savings and the protection of coastal areas that can be environmentally sensitive. (Gervais, Grovel, & Jones, 2020)

## What is an FLNG?

Floating Liquefied Natural Gas (FLNG) systems are entire facilities that allow the offshore storage, processing and transport of LNG. These massive facilities use the same systems as land-based LNG plants, which means that gas can be processed closer to the source without having to lay miles of pipelines to get the gas to the nearest coastal facility. This unveils massive new potential sources, miles out to sea, that would previously have been too difficult or costly to take advantage of.

Since LNG is produced continuously and there is a limited storage capacity, the gas must be regularly transferred to LNG carriers, every five to six days, using cryogenic loading arms that can tolerate a temperature of up to-—163°C (- 261.4 F). A lack of weather windows may disrupt this schedule. If bad conditions persist for days, the FLNG’s production has to be halted, triggering a series of measures to protect the subsea production system and the liquefaction trains. The latter must be kept cold to minimize the amount of time needed to start back up again. (Gervais, Grovel, & Jones, 2020)

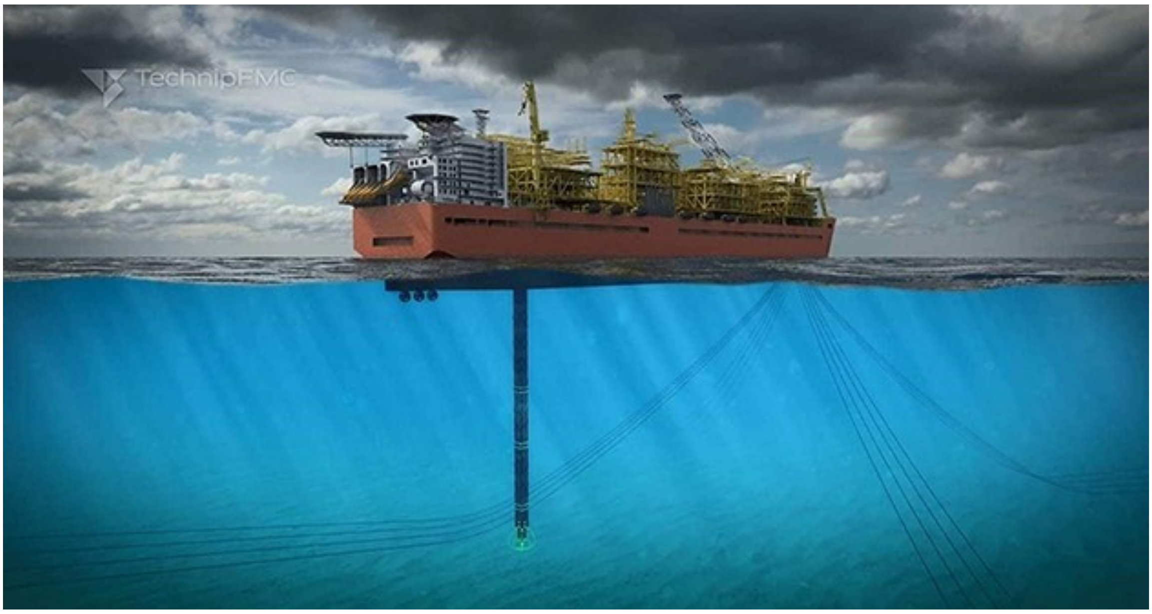



**Figure:**

**(TechnipFMC, 2018)**

## Mooring

The FLNG has to be moored to maintain some level of stability and reduce the risk of collision during operations with the LNG carriers. Environmental factors determine the configuration and which materials make up the mooring system. Spread mooring and Single Point Mooring systems are most commonly used with floating vessels. For the single point mooring (SPM) system, the moored floating structure always keeps a favourable alignment to the prevailing wind, wave or current loads because the floating object is deliberately left free to move around the SPM terminal. (Schellin, 2003)

Internal turret mooring system allows the vessel to weathervane, i.e., to rotate freely with the changing winds, waves and currents without halting, to reduce environmental loads and motion. However, does not do very well in waters with strong directional waves that do not vary much (± 15° from the median direction) and thus, can be replaced with a conventional spread mooring at the FLNG's four corners. The turret is a fragile FLNG structural component that adds a hefty $100 million-plus to the price tag, so, the spread mooring presents a much cheaper option that keeps the FLNG in the desired direction and position.

Likely problems that can occur during mooring or LNG transfer include too much rolling of the LNG carrier, high mooring-cable tension, compression of the buoys buffering the ships and forces that cause the articulated loading arms to stretch, damaging the hoses. Such incidents can be fatal for personnel and damage installations. The only way to control the risks is a preventive shutdown of the transfer to separate the two ships before an accident happens. The inherent complexity of ship-to-ship (STS) LNG transfer is thus a major obstacle to ramping up FLNG use. (Gervais, Grovel, & Jones, 2020)

There are currently three STS transfer methods:

- **Side by side**: The two vessels are brought alongside one another so that the LNG carrier can moor itself to the FLNG and offload the cargo.


- **Tandem**: The FLNG unit and LNG carrier are lined up one behind the other. This requires an LNG carrier that can work with the loading system, including a reliable propulsion and dynamic positioning system to maintain the correct distance.
- **Parallel positioning**: Similar to the tandem system, but the FLNG and the LNG carrier are positioned parallel to one another. This system is suitable for standard LNG carriers.


**Figure: (TechnipFMC, 2018)**

Currently, the use of Side-by-side offloading with articulated rigid arms is the reference solution for floating liquefied natural gas facilities. The technology and procedures used are quite similar to exposed jetties and it is a cost-effective solution.

Despite the FLNG’s close proximity to the LNG carrier moored beside it and the 2.5-meters significant wave height usually present, side-by-side mooring provides sufficient offloading uptime for FLNG projects sanctioned to date. Side-by-side offloading may no longer be a workable solution especially for harsher environments.

The industry has proposed several tandem LNG offloading systems that provide a significantly safe distance between the vessels and high environmental thresholds. However, a dedicated LNG carrier fleet with bow loading systems or long and large-diameter floating flexible LNG lines to reach the midship manifold of conventional LNG carriers is still required.

In late 2014, TechnipFMC and HiLoad LNG AS began the development of the HiLoad® LNG parallel loading system, an offloading solution that jointly use the best of both side-by-side and tandem solutions. The HiLoad system make use of a dynamically positioned, semi-submersible, L-shaped vessel that can dock onto any tanker vessel and provide dynamic positioning station-keeping. (TechnipFMC, 2018)

The HiLoad system is operational in the following;

- It has the ability to Support loading of any LNG carrier, or for full trading pliability and minimum shipping costs.
- High environmental thresholds for typically above 4 meters significant wave height could be accommodated.
- Improvement of offloading uptime and regularity.

- Fluid transfer line length for high flow and reduced pressure drops can be minimized.
- The technologies are highly qualified and proven.

Movement of the LNGC midship manifold significantly closer to the FLNG in comparison to the tandem arrangement to shorten the LNG transfer lines is the absolute motivation behind the development of Hiload System. With the midship manifold in line with about 100 meters away from the stern of the FLNG, the arrangement keeps the LNG carrier parallel to the starboard side of the FLNG; which is in line with the overall goal.

## References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