About LNG

WHAT IS LNG?

LNG is made from natural gas, which is a clean-burning source of heat energy with many applications including as fuel for power generation, industrial and home heating and as a chemical feedstock. Natural gas is composed primarily of methane (typically, 85 - 90%), but also typically contains ethane, propane and heavier hydrocarbons (butane, pentane, hexane etc.). Small quantities of nitrogen, oxygen, carbon dioxide and sulphur compounds are also found in most sources of natural gas, but the composition can vary markedly with the geological conditions.

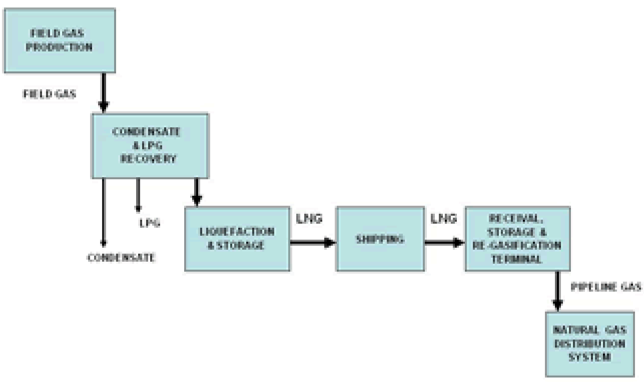
Natural gas is transported by pipeline to its consumers, but when the distance between source and consumption is great (~1,500km by sea or 5,000km over land) then liquefaction of the gas to reduce its volume by a factor of 600 becomes economic. The gas in liquid form can then be carried economically by ships equipped with well-insulated tanks made from special steel.

Liquefied natural gas (LNG) is formed when natural gas is cooled by a refrigeration process to temperatures of between -159 to -162°C at atmospheric pressure and the gas condenses to a liquid. Before natural gas can be liquefied in this way, the impurities, including carbon dioxide, sulphur compounds, heavier hydrocarbons and water must be removed by various processes. If nitrogen is present in the natural gas at high levels it may be removed at the end of the process as it condenses at an even lower temperature than pure methane (-196°C).

The liquefaction process can be designed to purify the LNG to almost 100% methane, or leave in more ethane and some LPGs (propane and butane) to match the pipeline gas specifications in the receiving gas system or country. Most gas distribution systems specify limits in terms of the heating (calorific) value of the gas to maintain safe conditions in combustion equipment. As it happens the specifications are quite different in Japan (the dominant LNG import market over the past 30 years) and the USA, the major emerging LNG import market.
LNG is about 47% as dense as water and is odourless, colourless, non-corrosive and non-toxic. When vaporized it burns only in concentrations of 5% to 15% when mixed with air. Neither LNG nor its vapour can explode in an unconfined environment.

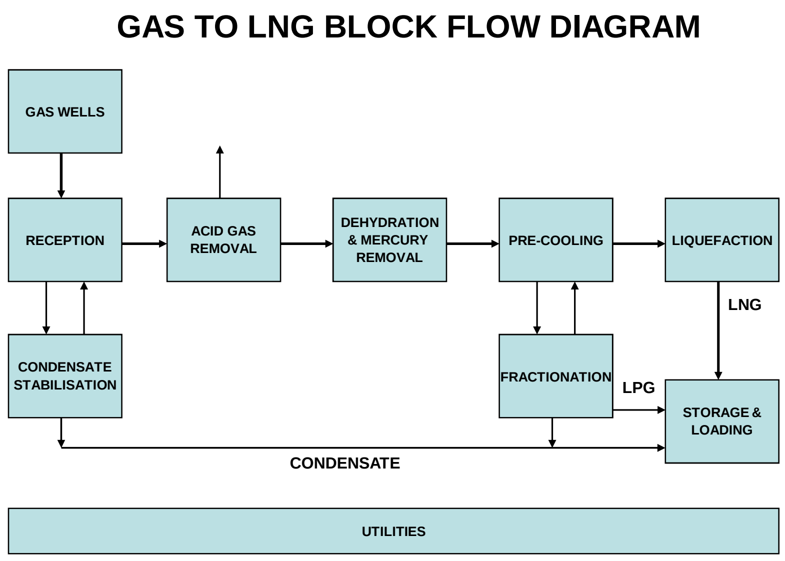
The LNG value chain from field production to pipeline gas consumers across oceans is as follows:

LNG VALUE CHAIN



How is LNG made?

LNG involves the purification, chilling and liquefaction of natural gas by various processes including refrigeration using hydrocarbon refrigerants. The first step is removal of carbon dioxide and other acid gases such as hydrogen sulphide by a recirculating amine process. This is a very common process in natural gas treatment plants producing pipeline gas and in petroleum refining and petrochemical plants. The carbon dioxide is normally vented to the atmosphere. Carbon dioxide, if not removed would freeze to solid in the heat exchangers involved in the liquefaction process and cause blockages. Water would do the same, so it is removed using molecular sieve driers as commonly used in natural gas treatment plants producing pipeline gas. Traces of mercury sometimes occur in natural gas and this is a potential problem for LNG plant as mercury corrodes aluminium which is used in some of the equipment. Mercury removal facilities are usually incorporated into LNG plants as a result.



The chilling of the gas to moderately low temperatures causes at first the condensation of heavy hydrocarbons, which might also freeze and cause blockages of equipment at lower temperatures. These components of the gas are removed in a 'scrub' column along with some of the LPG (propane and butane) as the gas is cooled to about -35°C.

Chilling and then liquefaction is accomplished by a refrigeration process powered by a large compressor typically driven directly by a gas turbine or a steam turbine. In principle, the refrigeration process is no different from that in a domestic refrigerator or air conditioner, but the difference in scale is immense.
Cooling and condensation of the high pressure refrigerant gas is accomplished in air coolers or water-cooled heat exchangers. When the high pressure liquid refrigerant is depressured through an expansion valve, the drop in temperature is used to extract heat energy from the process gas through a heat exchanger. Usually there are at least two main compressors with multiple stages of heat exchangers for maximum efficiency in liquefying the methane and ethane in the purified natural gas to make LNG.

How is it stored?

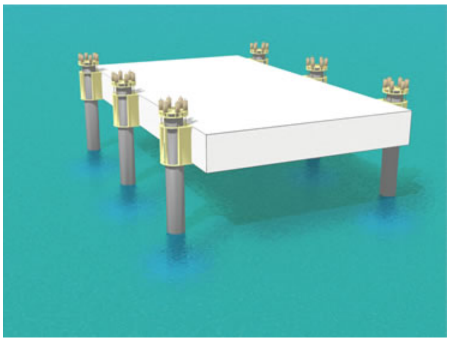
LNG is stored in shore tanks at both ends of its sea voyage to accumulate sufficient volumes for economic shipping. The tanks are of double-wall construction with extremely efficient insulation between the walls. Large tanks tend to have a low aspect ratio (height to width) and are cylindrical in design with a domed roof. Storage pressures in these tanks are very low, less than 5 psig. The outer walls are made of reinforced concrete and are designed to safely contain the contents of the inner tank in the extremely unlikely event of it developing a leak.

How is it kept cold?

The shore tank or ship tank's insulation, as efficient as it may be, will not keep the LNG cold enough to remain as a liquid by itself. LNG is stored as a "boiling cryogen", that is, it is a very cold liquid at its boiling point for the pressure at which it is being stored. Storage of LNG utilizes a phenomenon called "auto-refrigeration" where the LNG stays at near constant temperature if kept at constant pressure. This constant temperature occurs as long as the LNG vapour boil off is allowed to leave the storage tank. The vapour is either removed and used as fuel or re-liquefied and returned to the tank.

LNG Tank Design

In the 3D CAD image and design drawing shown below of the tank planned for the Timor Sea LNG Project, a conventional LNG on-shore tank is constructed on and integrated with a concrete gravity base structure (CGS) which acts as a transport barge and then a foundation when ballasted on the shoal with seawater.

Is LNG safe?

It is important to remember that LNG is a form of energy and must be respected as such. Today LNG is transported and stored as safely as any other liquid fuel. Before the storage of cryogenic liquids was fully understood, there was a serious incident involving a LNG storage tank failure killing 128 people in Cleveland, Ohio in 1944. This incident virtually stopped all development of the LNG industry for 20 years.

The race to the Moon led to a much better understanding of cryogenics and cryogenic storage with the expanded use of liquid hydrogen (-252°C) and liquid oxygen (-182°C). LNG technology grew from the advancements developed by NASA for the space programme.

In addition to Cleveland, there have been two other incidents in the USA sometimes attributed to LNG. A construction accident on Staten Island in 1973 has been cited by some parties as an "LNG accident" because the construction crew was working inside an (empty, warm) LNG tank. In another case, the failure of an electrical seal on an LNG pump in 1979 permitted gas (not LNG) to enter an enclosed building. A spark of indeterminate origin caused the building to explode. As a result of this incident, the electrical code has been revised for the design of electrical seals used with all flammable fluids under pressure.

Today the LNG industry maintains an excellent safety record by incorporating many years of experience and engineering solutions and safety codes into the design and operation of LNG liquefaction, storage and re-gasification plants around the world.