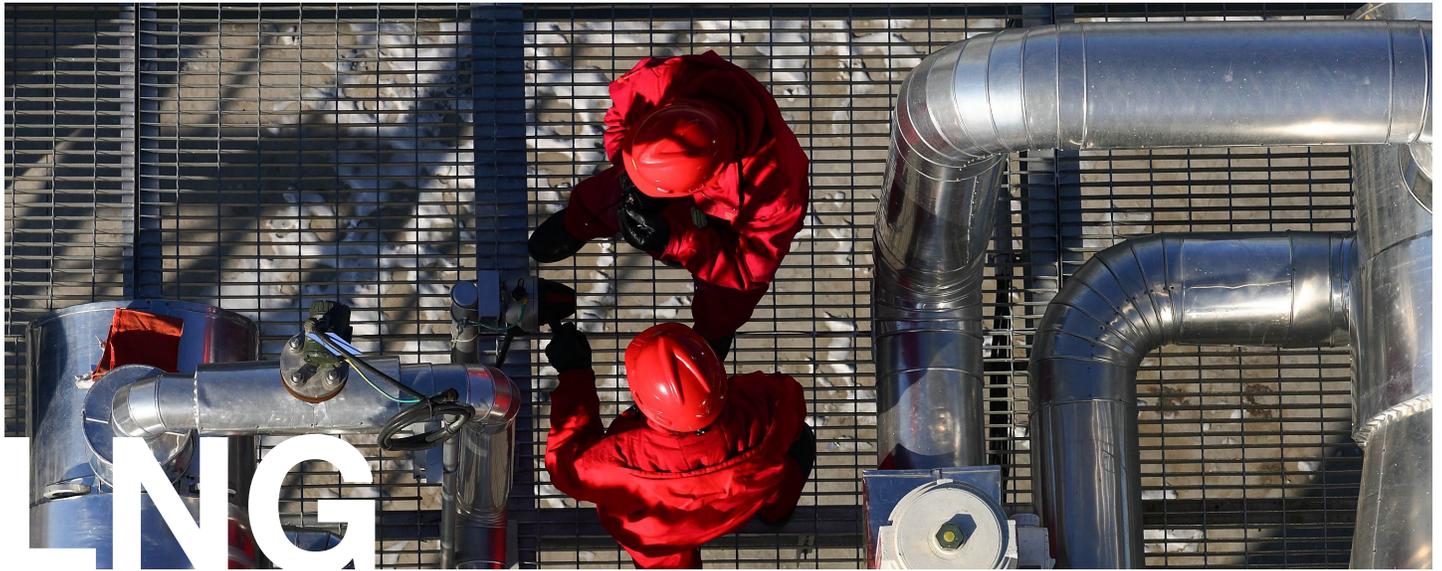


# Production and Transportation of Liquefied Natural Gas



# Production and Transportation of Liquefied Natural Gas



Source: Shell

## Natural gas in BC

British Columbia has significant natural gas resources. The BC government is seeking to develop its natural gas resources to support an export industry. Exporting natural gas to overseas markets will require turning it into liquefied natural gas, called LNG for short. Most of BC's natural gas is found in the northeast part of the province. Two of the most important areas where natural gas is found are the Horn River Basin and the adjacent Montney Basin, shown on the map here.

After being extracted from underground reservoirs or gas-bearing shales, natural gas is transported through pipelines to a processing plant. In the processing plant impurities are removed from the gas. Natural gas is composed mostly of methane. The refined natural gas is piped to consumers or to places where it can be turned into LNG for export.

In BC, the natural gas used in homes and businesses is delivered by pipelines in vapour form. But the natural gas destined for export to overseas markets will be liquefied at an LNG plant for shipping in specially designed ships. When we look at the LNG supply chain, BC will host only the first 3 stages. This information sheet describes the production and transportation of LNG.



Source: BCOGC

# Production and Transportation of Liquefied Natural Gas



LNG supply chain

Source: Wartsila

## Pipeline Construction and Operation

Pipelines are the most common way for moving gas over long distances on land. Natural gas pipelines are found across BC. They deliver gas from places of extraction and processing to cities and towns, and within communities to houses and businesses. Natural gas is also transported by truck, rail, barge, and ship.

Canada has over 830,000 km networks in natural gas and oil pipelines. Long distance transmission pipelines are the major conduits of the pipeline network. Transmission pipelines deliver natural gas from producing regions across long distances at high pressures, typically 200 – 1500 psi (pounds per square inch, to markets throughout Canada and the US. These pipelines vary in size from 254 mm to 457 mm in diameter.

### Pipe, coating, and protection

Most natural gas pipelines are made out of high carbon steel. Pipe sections are fabricated in steel rolling mills and inspected to assure they meet government and industry safety standards. Transmission pipelines are designed specifically in terms of their sizes, strength, and wall thicknesses for their



Source: FORTISBC

### Preparing pipe for installation.

intended locations, soil environments, and geographic characteristics of the routes.

Coatings are used to protect the exterior of steel pipe from corrosion and rusting. In the past, pipelines were coated with coal tar enamel. The most common coatings used now are **fusion bonded epoxy** or **polyethylene heat-shrink sleeves**. Many coatings are applied in the factory, but field coating is done on the construction site when the pipes are welded together.

Pipe may rust if it sits in water, concrete, or even in some soils. To help prevent corrosion and rusting, **cathodic protection** is often used. This technique uses an electric current which makes a more active metal (called a sacrifice metal) become the anode which then corrodes, and the less active metal (the pipe becomes the cathode which means it is protected from corroding.



FortisBC's 2017 Coastal Transmission System Upgrade Project (Surrey to Coquitlam)

Source: FORTISBC

There are different types of pipeline construction methods. The most common is the open cut technique is known as traditional trench construction, where open trench is excavated and the pipeline is laid in the trench. The pipe is then covered with earth and the area is replanted with grasses and other plants, or possibly repaved if it is in an urban area. Open cut construction is used when there are loose soil conditions.

Other techniques include the conventional boring method, horizontal directional drilling, and the direct pipe installation method.

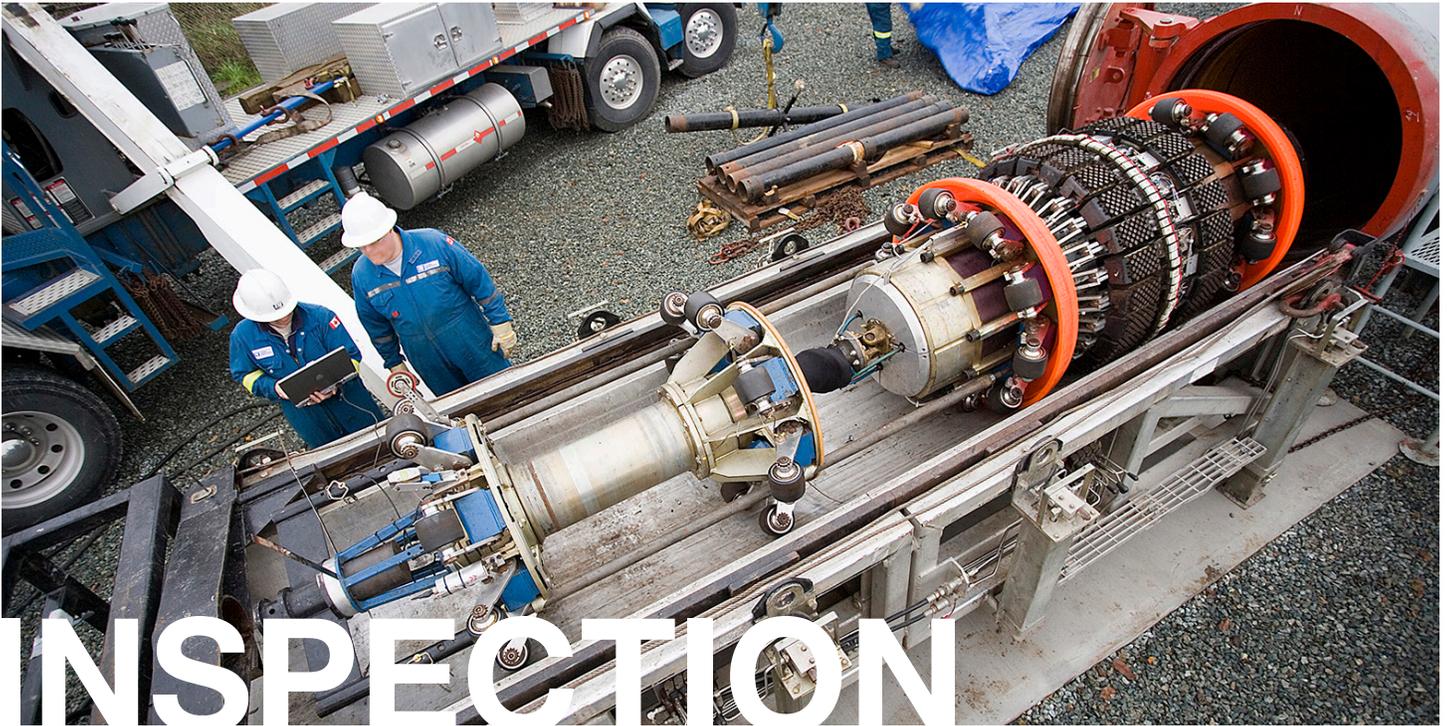
**In conventional boring**, a tunnel is created for pipe which is accomplished by first excavating a bore pit and a receiving pit. A boring machine is then lowered to the bottom of the bore pit to tunnel using a cutting head mounted on an auger. The auger rotates through a bore tube and is pushed forward as the hole is cut. The pipe is then installed. Conventional boring can deal with a length of 15-30 m pipe and requires minimum

workspace of 15 x 30 m. The **workspace** is the size of area needed for the construction activity. Some techniques need more workspace than others.

**Horizontal directional drilling (HDD)** is used to install subsurface pipe over longer distances than conventional boring. Typical distance covered in HDD is in between 150-900 m. It is often used in stream and river crossings. It has a minimum required workspace of 61 x 76 m.

**Direct Pipe** is another trenchless method that combines the advantage of established pipeline installation methods; including micro tunnelling and HDD. Direct Pipe installations are for shorter and shallower installations. In this technique the excavation is continuously cased. This reduces the risk of a collapsed hole and ground settlement. The typical length covered in direct pipe method is in between 30-245 m. It is used in river crossings and highway crossing, it requires minimum workspace of 6 x 24 m.

# Production and Transportation of Liquefied Natural Gas



Preparing to launch a Smart Pig on FortisBC Coastal Transmission System.

Source: FORTISBC

Pipeline companies inspect their pipelines for corrosion and defects. This is done through the use of sophisticated pieces of equipment known as smart pigs. **Smart pigs** are robotic devices that move inside pipelines to look at the inside of the pipe. Smart pigs can test pipe thickness and roundness, check for signs of corrosion, and detect leaks or any other defects that may either block the flow of gas or pose a potential safety risk to the pipeline. Sending a smart pig down through a pipeline is called 'pigging' the pipeline.

Companies routinely inspect the right-of-way (photo below) along the pipeline route for evidence of damage, ground disturbances or other impacts.

**Compressor stations** are also monitored and inspected for any changes or problems.



Source: FORTISBC

FortisBC's Eagle Mountain Compressor Station

## KEEPING GAS MOVING

Compressor stations are placed along a pipeline route to make certain that the natural gas remains pressurized so that it flows. Compressors are located along a natural gas pipeline route about every 65 to 160 km, depending on the landscape.

Large compressors are similar to jet engines and move natural gas through the pipeline at around 40 km an hour.



Source: CEPA

# Production and Transportation of Liquefied Natural Gas



Receiving a Smart Pig on FortisBC's Interior Transmission System (Penticton)

Source: FORTISBC

Pipeline spills can be caused by corrosion, ground movement, flooding, or by activities that damage the pipeline or related facilities, such as being struck by a backhoe during excavation for a building.

In Canada, incidents and accidents are rare in natural gas pipeline operations. A pipeline incident can occur if a pipeline is disturbed. An incident might require an emergency shutdown. Not all incidents or accidents will result in a spill. The Transportation Safety Board of Canada provides data about pipeline occurrences.

In the last six years, the total number of recorded natural gas pipeline incidents was around 40. There were no natural gas pipeline accidents reported in 2015 and 2016. In 2017 there were 5 reported accidents. Less than half of pipeline accidents from 2007 to 2016, occurred at compressor stations and gas processing plants.

In the fall of 2018, a pipeline explosion north of Prince George interrupted a major natural gas supply line. The time needed to repair the pipeline led to possible supply problems for many parts of BC.

## WHAT IS AN INCIDENT?

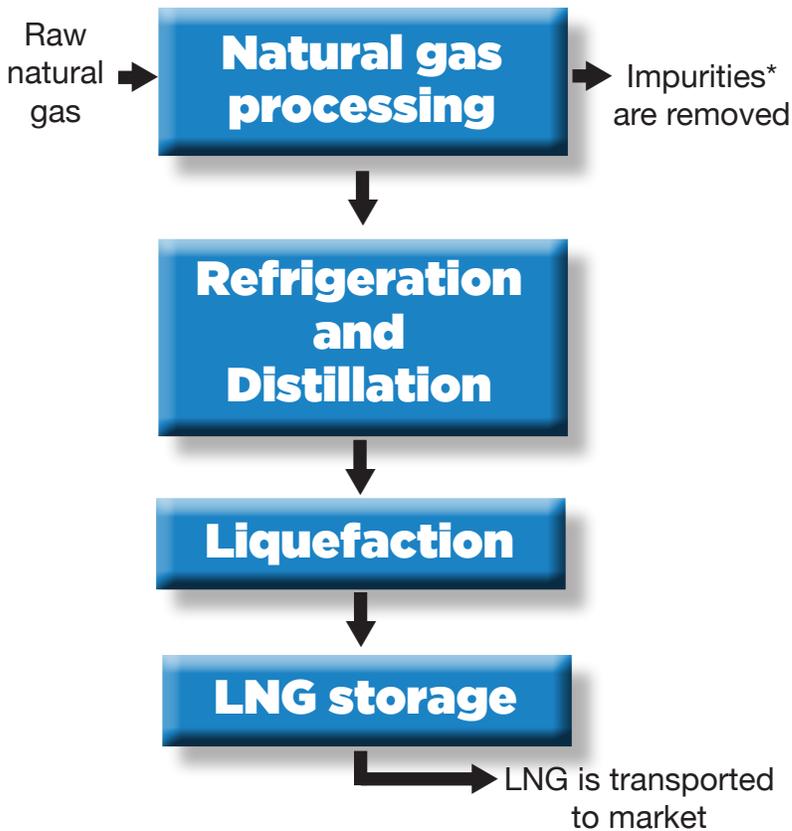
An incident and an accident are not the same thing. An incident is a sequence of actions or events; an accident is the result of an incident. But while an incident may occur, if there is no consequence or harm, then there is no accident. Incidents can be classified based on the magnitude of their impact.

**1 - High consequence:** An incident has a significant impact on people or the environment. This may include significant damage to property or the environment, injury to people or even loss of life.

**2 - Medium consequence:** A moderate impact on people or the environment. Some damage may occur to the environment, or there may be some disruption to people's daily activities.

**3 - Low consequence:** Little to no impact on people or the environment or on people's daily activities.

# Production and Transportation of Liquefied Natural Gas



\* Impurities include raw natural gas condensate, water, hydrogen sulfide, mercury, carbon dioxide

## Producing LNG

Natural gas is first processed to remove contaminants and heavy hydrocarbons. After this it moves through the LNG facility begin the liquefaction process. At this stage the natural gas being liquefied is almost entirely methane.

The gas is liquefied through by using refrigeration technology. After is has been cooled to a very low temperature (-160°C) it turns from a vapour into a liquid. This is done to allow natural gas to be stored in a much smaller space when it is being exported by carrier ship to overseas markets.

## Producing LNG

Accidents at LNG facilities are rare. But there are specific hazards associated with the production of LNG:

### 1 - Explosion

An explosion may occur when a substance rapidly changes its chemical state. This would likely happen due to structural failure of containment system. But if LNG is leaked a properly constructed containment system can prevent ignition. LNG is stored at atmospheric pressure and a breach in a container will not create an immediate explosion.

### 2 - Vapor Clouds

When LNG is released from a temperature-controlled container, it warms up and returns to being a gas. This creates a vapor cloud that could in turn be exposed to an ignition source. LNG facilities use safety procedures and features to reduce the likelihood of a vapor cloud release.

### 3 - Freezing liquid

If a person comes into contact with LNG it could result in a freezing injury (a cryogenic burn where they were touched by the liquid. LNG containment systems are separated from other equipment to prevent the interaction of cold and warm systems and equipment. Workers are provided with personal protective equipment for their protection from possible contact with a freezing liquid, and for working in any hazardous areas.

### 4 - Sloshing

Sloshing is when LNG is carried in a partially filled tank. It is the motion of the fluid which in turn increases pressure of LNG tank walls. Sloshing of cargo has been identified as a cause of damage during some LNG operations. LNG operators use different engineering techniques to reduce the risk of sloshing.

## Accidents at LNG plants

Globally, accidents at LNG facilities have been rare. The design of LNG facilities has been improved over the years as operators learn from previous incidents, and the technology of production and safety systems has advanced. In the last 30 years only two major accidents were reported.

One happened in 2004 at a facility in Algeria, where there was a gas leakage. There was no automatic shutdown or hazard detection system at the facility, and there was an explosion.

After that accident an automatic shutdown system was installed.

In 2014, leakage at an LNG facility in Washington State occurred when flying debris from an explosion penetrated the walls of an LNG tank. The blast injured five workers. People within a two-mile radius of the site were evacuated. To avoid putting workers at risk, a robot was deployed to snap photos of the damaged tank. Some who did approach the site were reportedly affected by fumes.



In 1959, the first LNG ship transported LNG from the US to Britain. Today, there are around 500 LNG carriers in operation worldwide, with over 100,000 delivery cargoes.

The average LNG load per ship is around 2.5 million tonnes, but carriers have different capacities. The global LNG fleet delivers more than 110 million metric tons (tonnes) of LNG annually around the world. The global LNG trade has set a record by reaching 258 million tonnes for three consecutive years.

On an LNG carrier, the most severe accident that may realistically occur is the breach of one or more storage tanks, resulting in the leakage of LNG. Globally, from 1944 to 2007 there were 52 reported incidents; 41 involved no injuries.

Information about these events can be limited, but there have been no on-board fatalities attributable to cargo operations. There have been no major cargo losses in the history of LNG ship operations.

The safety record is at least partially due to the double-hulled construction of LNG tankers. There have been LNG ship groundings and engine room fires, incidents typical in maritime transportation, but none of the incidents have ever caused LNG tank failures or spills.

LNG shipping is considered to have fewer spill risks than comparable crude oil shipping. Insurance rates are generally 25% less for LNG shipping than for crude oil shipping. Insurance coverage is focused on fire and damage and not on environmental pollution.

# Production and Transportation of Liquefied Natural Gas

## Ships

A LNG carrier is designed to transport liquefied natural gas in tanks. Since natural gas is transported in its liquid form, conditions such as high pressure, very low temperatures, or the combination of the two have to be met in order to keep the natural gas in a liquid form. LNG ships are classified in three ways:

**1 Fully pressurized:** These are the smallest type of carrier. Most such ships have two or three horizontal, cylindrical or spherical cargo tanks and have typical capacities between 3,500 and 7,500 m<sup>3</sup>. They carry LNG at ambient temperatures in steel pressure tanks designed to work at a pressure of 17.5 kg/cm<sup>2</sup>. They are not fitted with re-liquefaction plant and are a simple cost-effective means of transporting LNG.

**2 Semi-pressurized & refrigerated:** These ships carry LNG in a semi-pressurized/semi-refrigerated state offer high flexibility in cargo handling. These ships are fitted with a refrigeration plant and have a high design pressure for the cargo tanks, but below the pressure required for fully pressurized carriage. The tanks are cylindrical in shape and of a thinner construction than the fully pressurized ships. Their construction is based on carrying LNG at a pressure of 8.5 kg/cm<sup>2</sup> and a temperature of -10 °C. Semi-pressurized and refrigerated ships generally range up to 15,000 m<sup>3</sup>. These carriers, incorporating tanks either cylindrical, spherical or bi-lobe in shape, are able to load or discharge LNG at both refrigerated and pressurized storage facilities.

**3 Fully refrigerated:** These are built to carry liquefied gases at a very low temperature and atmospheric pressure between terminals equipped with fully refrigerated storage tanks. The cargo tanks are prismatic-shaped and fabricated from nickel steel, allowing the shipping of LNG at temperatures as low as -160 °C. Prismatic tanks enable the ship's cargo carrying capacity to be maximized, thus making these ships highly suitable for carrying large



volumes of LNG. Fully refrigerated ships range in capacity from 20,000 to 100,000 m<sup>3</sup>. Ships in the size range of 50,000 to 80,000 m<sup>3</sup> are often referred to VLGCs (Very Large Gas Carriers).

## Ship design and construction

LNG ships are built using a double hulled construction, with four or five large tanks to hold the LNG. These tanks are generally composed of several layers of material to prevent leaks and maintain the low temperature needed to keep natural gas in its liquid form.

The tanks are also heavily insulated, minimizing the amount of liquefied gas that boils off or evaporates during the transportation. Some ships actually utilize the boil off to fuel their engines.

The tanks themselves are generally made of aluminum or with an alloy of 9% nickel steel. The materials used for the hull of the ship are designed to accommodate a wide range of temperatures. However, if the material in the hull gets too cold (at temperatures as low as -160°C it will become brittle, thus it is important that the tanks are insulated to protect the hull from the effects of the low temperature.

The insulated tanks are located within the inner hull of the double-hulled construction. There is a space between the inner and outer hull to reduce the transfer of heat and protect cargo tanks in the event of some emergency. The cargo tanks are separated from each other and other components of the ship by dry compartments.

In addition to being advanced in the way that they hold LNG, the ships are also equipped with advanced gas and fire detection and suppression systems to ensure that even a small leak would trigger a response. This makes a catastrophic fire on an LNG carrier very unlikely.



Coastline of Gulf Islands of BC.

Source: Kevin Hanna

## What happens if an LNG spill occurs at sea or on land?

The potential hazards of a large LNG spill include suffocation, cryogenic (which means extreme low temperatures) burns, and cryogenic damage to a ship, fires, and explosions. A LNG spill can happen during transport and storage at sea or on land.

LNG is cryogenically liquefied natural gas. This is done to reduce the volume for shipping and storage. If it spills on the ground or water, it evaporates quickly and leaves behind no residues. The short residence time of a LNG spill suggests that it is unlikely to cause harm to aquatic life or damage waterways. However, contact with LNG chilled to around  $-160\text{ }^{\circ}\text{C}$  will damage living tissue. At these temperatures most metals lose their ductility (meaning the ability to bend or stretch). If an LNG spill happens on a ship the low temperature might result in the fracture of metal.

As LNG vaporizes, the methane vapor will condense water vapor out of the air, making the cloud visible and causing it to hang close to the ground until it warms up and disperses. If an ignition source is present, the cloud can burn back to the source, which is a fire hazard. An ignition can result in rapid burn off of natural gas vapors, or even cause explosions. Explosions may cause secondary damage that could lead to spilling more LNG.

If a spill occurs and the vapor does not ignite, it would build to higher concentrations. At higher concentrations, the vaporized gas creates a suffocation hazard for people in the area.

If a spill or leak followed by vaporization occurs in or near water, then water in contact with the spilled LNG can hurry the vaporization process and increase the concentration of vapor.

# Production and Transportation of Liquefied Natural Gas

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# Production and Transportation of Liquefied Natural Gas

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The Information Series is produced by the First Nations LNG Alliance in collaboration with the Centre for Environmental Assessment Research at UBC. The series provides information for individuals and communities interested in learning about the nature, structure, operation and impacts of the LNG industry and natural gas resource development in British Columbia. Where possible the information sheets are developed using sources available online. This is so readers can more easily access the sources used by the author. Information sheets may be updated periodically. Please check the date of issue for the most current version.

October 2018

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Natural Gas  
Unconventional Gas Production  
Liquefied Natural Gas Industry in BC  
First Nations Issues and the Development of BC's LNG Industry  
The Review and Assessment of LNG Projects  
Understanding and Managing Risk  
Production and Transportation of Liquefied Natural Gas



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