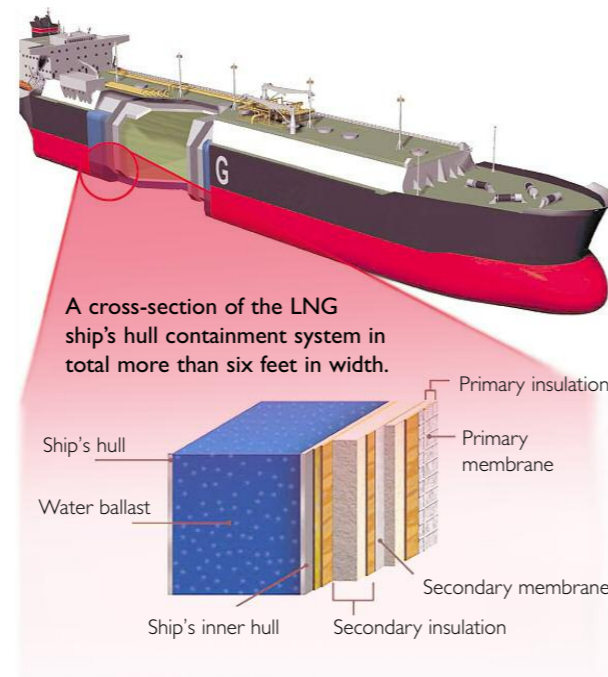


heated water. The vaporized gas is then regulated for pressure and enters a pipeline system as natural gas. Once the LNG is regasified and leaves the regasification terminal, it ceases to be 'LNG' and is indistinguishable from the conventional piped natural gas. Finally, residential and commercial consumers receive natural gas for daily use from local gas utilities or in the form of gas-powered electricity.



Double-hulled LNG vessel.

### LNG safety, security and the environment

Risks and potential hazards are well understood by industry, and safeguards and mitigation measures are firmly entrenched. The LNG industry has a proven safety record with 40+ years of shipping LNG across the world with no major incidents.

As a liquid, LNG cannot explode or burn. The lighter-than-air property of methane actually makes it less hazardous than some other fuels, such as propane or butane whose gases are heavier than air and tend to settle closer to the ground.

In gaseous form, LNG vapour can burn if it is within 5-15% natural gas in the air. If it is less than 5% natural gas in the air, the gas is too diluted to burn. If it is more than 15% natural gas in the air, there is not enough oxygen for it to burn.

Security measures for land-based LNG facilities include security patrols, protective enclosures, lighting and monitoring equipment. Safety and security zones around land-based facilities and ships are also common in some parts of the world.

Australia's Maritime Security is well established under the Maritime Transport Security Act 2003, which requires security risk assessments for ships and ports. The Joint Offshore Protection Command was established in March 2005 to link Australian Defence Force responsibilities

with existing civil maritime surveillance and regulatory roles that are undertaken or coordinated by the Australian Customs Service.

From an environmental perspective, natural gas is the cleanest burning fossil fuel and significantly reduces particulate and carbon dioxide (CO<sub>2</sub>) emissions by 30 – 60% in comparison with heavier hydrocarbon fuels. When spilled on water or land, LNG will not mix with the water or soil or leave a residue, but evaporates and dissipates into the air.

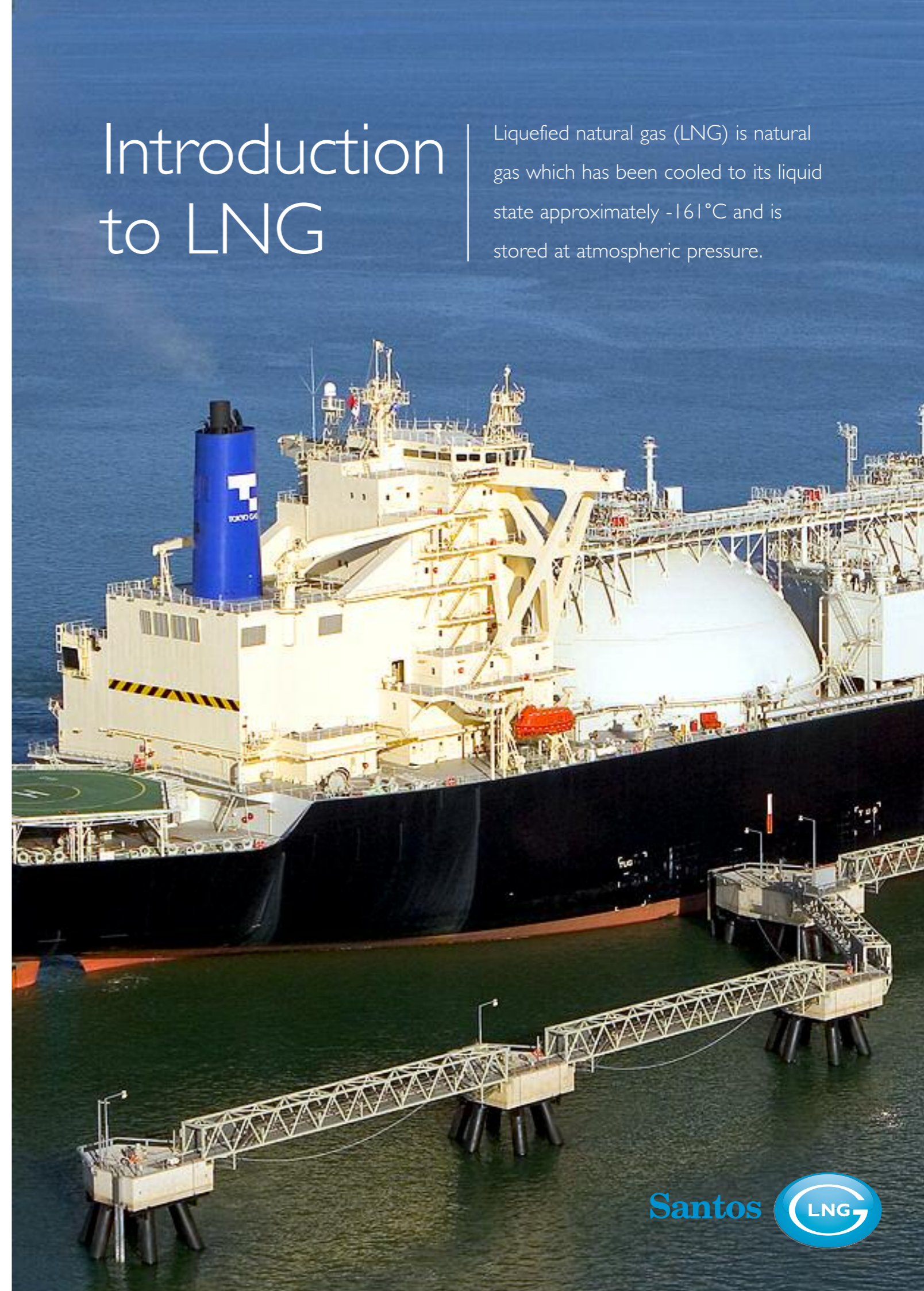
Administration of the environmental regulatory regime is managed under the cooperative arrangements of the Commonwealth and the States/Northern Territory. Processes for environmental assessments are well established and provide for public consultation.

#### References:

1. Center for Energy Economics, "Introduction to LNG", January 2003.
2. Department of Energy, "LNG Safety & Security".
3. Australian Government, Department of Industry, Tourism, and Resources, "Australian Liquefied Natural Gas (LNG) – Clean Energy for a Secure Future", 2005.
4. Center for Liquefied Natural Gas
5. Federal Energy Regulatory Commission (FERC)
6. International LNG
7. U.S. Department of Energy, Office of Fossil Energy (DOE)

# Introduction to LNG

Liquefied natural gas (LNG) is natural gas which has been cooled to its liquid state approximately -161°C and is stored at atmospheric pressure.



## What is LNG?

Liquefied natural gas (LNG) is natural gas which has been cooled to its liquid state at approximately  $-161^{\circ}\text{C}$  and atmospheric pressure. Liquefaction reduces the volume by approximately 600 times, thus enabling it to be economically transported between continents in specially-designed ships. LNG is used for long distance transport of natural gas where traditional pipeline transportation systems operating at high pressure are technically, economically or politically infeasible. LNG technology enables natural gas to be available throughout the world.

Some relevant properties of LNG include the following:

- It is mostly methane gas, with typically small concentrations of ethane, propane, butane.
- It is a cryogenic liquid (liquid cooled to approximately  $-161^{\circ}\text{C}$ ).
- LNG is colourless, odourless, non-toxic and non-persistent (does not linger in the environment).
- Methane is lighter than air.
- LNG is stored and transported at atmospheric pressure (1 atm).

## Who produces and uses LNG?

Leading exporters of LNG include Qatar, Indonesia, Algeria, Malaysia, Trinidad, Egypt and Australia. Australia entered the LNG market in 1989 and is the third largest LNG producer in the Asia-Pacific region and the fifth largest LNG producer in the world, exporting approximately 13+ million tonnes in 2006. Australia has a track record as a competitive, reliable and stable LNG supplier, as well as an enviable record for safety and reliability. Over 1700 shipments have been despatched without incident.

The Australian LNG industry has made enormous contributions to the Australian economy. Exports are currently worth more than \$3.2 billion a year and there is potential for the industry to deliver even greater wealth and export income worth billions of dollars each year for decades to come.

The major stages of the LNG value chain, excluding pipeline operations between the stages, consist of the following.

- **Exploration** to find natural gas in the earth's crust and production of the gas for delivery to gas users.
- **Liquefaction and storage** to convert natural gas into a liquid state so that it can be transported in ships.

- **Shipping** the LNG in special-purpose ships.
- **Regasification** to convert the LNG stored in specially-made storage tanks from the liquefied phase to the gaseous phase, ready to be moved to the final destination through the natural gas pipeline system.

## Exploration and production

Most natural gas is stranded a long way from market in countries that do not need large quantities of additional energy.

Australia has an abundance of coal seam and conventional natural gas supplies.



Australia's natural gas production has increased steadily over the past two decades at an average annual growth of approximately 6.5% since 1980. Australia produced around 1.3% of the world's natural gas as of 2004.

## LNG liquefaction and storage

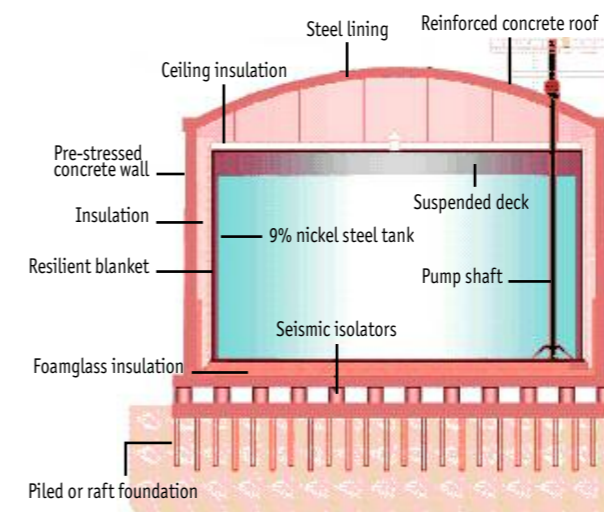
Feed gas to the liquefaction plant comes from the production field. The carbon dioxide and water found in produced natural gas are removed to avoid freezing up and damaging equipment when the gas is cooled and to meet pipeline specifications at the delivery point. The liquefaction process can be designed to purify the LNG to almost 100% methane.



The liquefaction process entails cooling the clean feed gas by using refrigerants. The liquefaction plant may consist of several parallel units (commonly known as "trains"). The natural gas is liquefied at atmospheric pressure.

LNG is a cryogenic liquid. The term "cryogenic" means low temperature, generally below  $-73^{\circ}\text{C}$ . LNG is a clear liquid, with a density of about 45% that of water.

The LNG is typically stored in double-walled tanks at atmospheric pressure. The storage tank is actually a tank within a tank. The annular space between the two tank walls is filled with insulation. The inner tank, in contact with the LNG, is made of 9% nickel steel, suitable for cryogenic service and structural loading of LNG. The outer tank is generally made of carbon steel or pre-stressed concrete.



*Onshore storage tank design.*

## LNG shipping

LNG tankers are double-hulled ships specially designed and insulated to prevent leakage or rupture in an accident. The LNG is stored in a special containment system within the inner hull where it is kept at atmospheric pressure and  $-161^{\circ}\text{C}$ .

Three types of cargo containment systems have evolved as modern standards. These are the:

- spherical (Moss) design
- membrane design
- structural prismatic design.



Most of the current LNG ships use spherical (Moss) tanks, and they are easily identifiable as LNG ships because the top half of the spherical tanks are visible above the deck. The typical LNG carrier can transport about 90,000–160,000 cubic metres of LNG, which will provide about 54–96 million cubic metres of natural gas. The typical carrier measures some 275 metres in length, about 43 metres in width and 11 metres in water draft.

The ship size is similar to that of a large coal ship but significantly smaller than that of a Very Large Crude oil Carrier. LNG tankers are generally more environmentally 'friendly' than other shipping vessels because they burn natural gas in addition to fuel oil as a fuel source for propulsion.

## LNG regasification

To return LNG to a gaseous state, it is fed into a regasification plant. On arrival at the receiving terminal in its liquid state, LNG is first pumped to a storage tank, similar to those used in the liquefaction plant, at atmospheric pressure. When it is required for consumption, it is pumped at high pressure through various terminal components where it is warmed in a manner by passing it through pipes heated by direct-fired heaters, seawater or through pipes that are in