An Overview of LNG Operations

Kelvin Wong, 28/09/2011
Allianz Risk Consulting

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About Allianz Risk Consulting

- Allianz Risk Consultants are an international network of more than 220 engineers providing a global risk consulting service for all our internal and external clients
- We are part of Allianz Global Corporate and Specialty Company
- We have 8 Risk Consultants located in LA, Houston, London, Moscow and Singapore specialising in Onshore and Offshore Energy risks
- We have 20 Risk Consultants in Asia Pacific covering various lines of businesses
- Our internal clients are our Underwriters and Claims Managers. While our external clients are the insured clients

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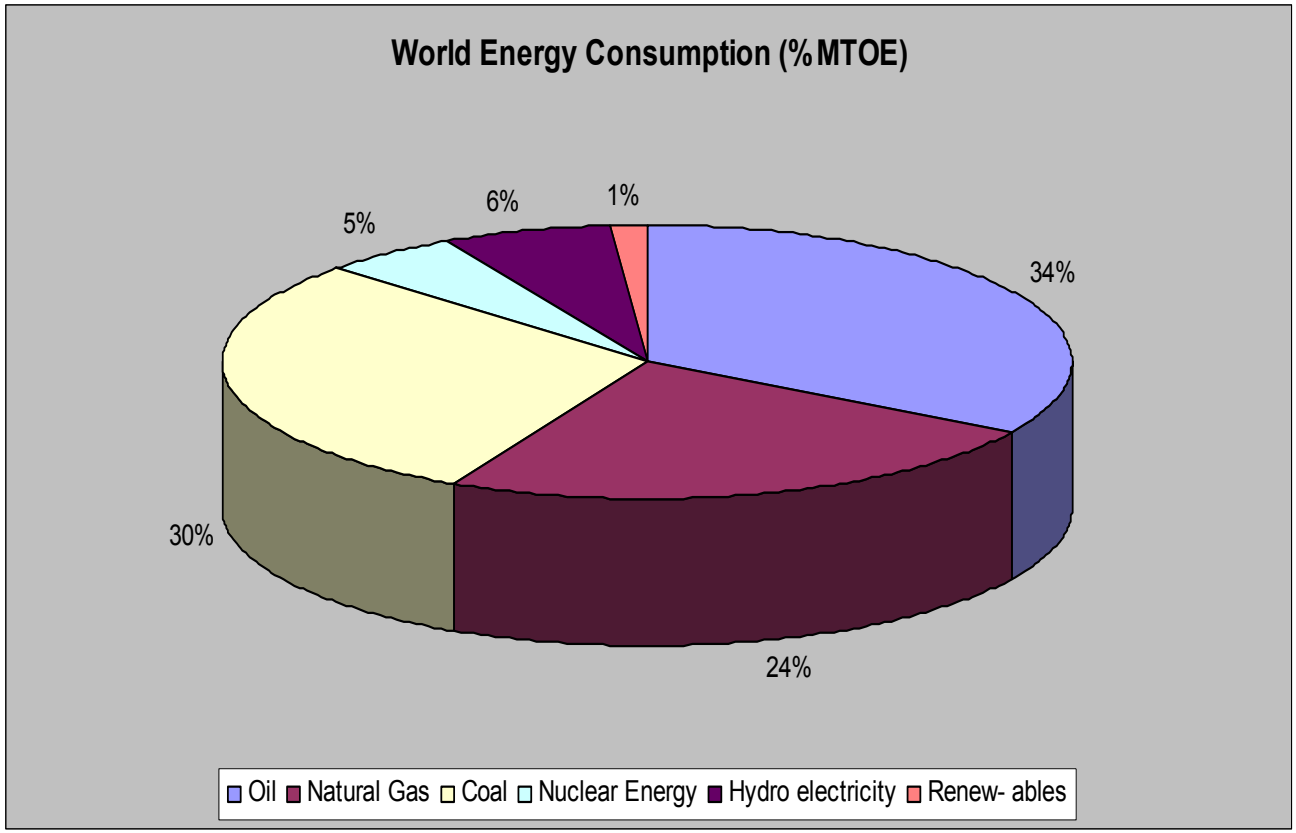
Introduction

What is LNG?

- LNG is Liquefied Natural Gas
- It is a form of fossil fuel
- It is considered as the ‘cleanest’ form of fossil fuel
- Its composition consists of:
    - 83% - 99% methane
    - 1% - 13% ethane
    - 0.1% - 3% propane
    - 0.2% - 1% butane
- Natural Gas (NG) is extracted from offshore and onshore gas fields
- Natural Gas (NG) that is liquefied at – 162 degrees C in a processing plant is called LNG
- LNG is 600 times more dense than NG. Hence It is more efficient to ship LNG than NG

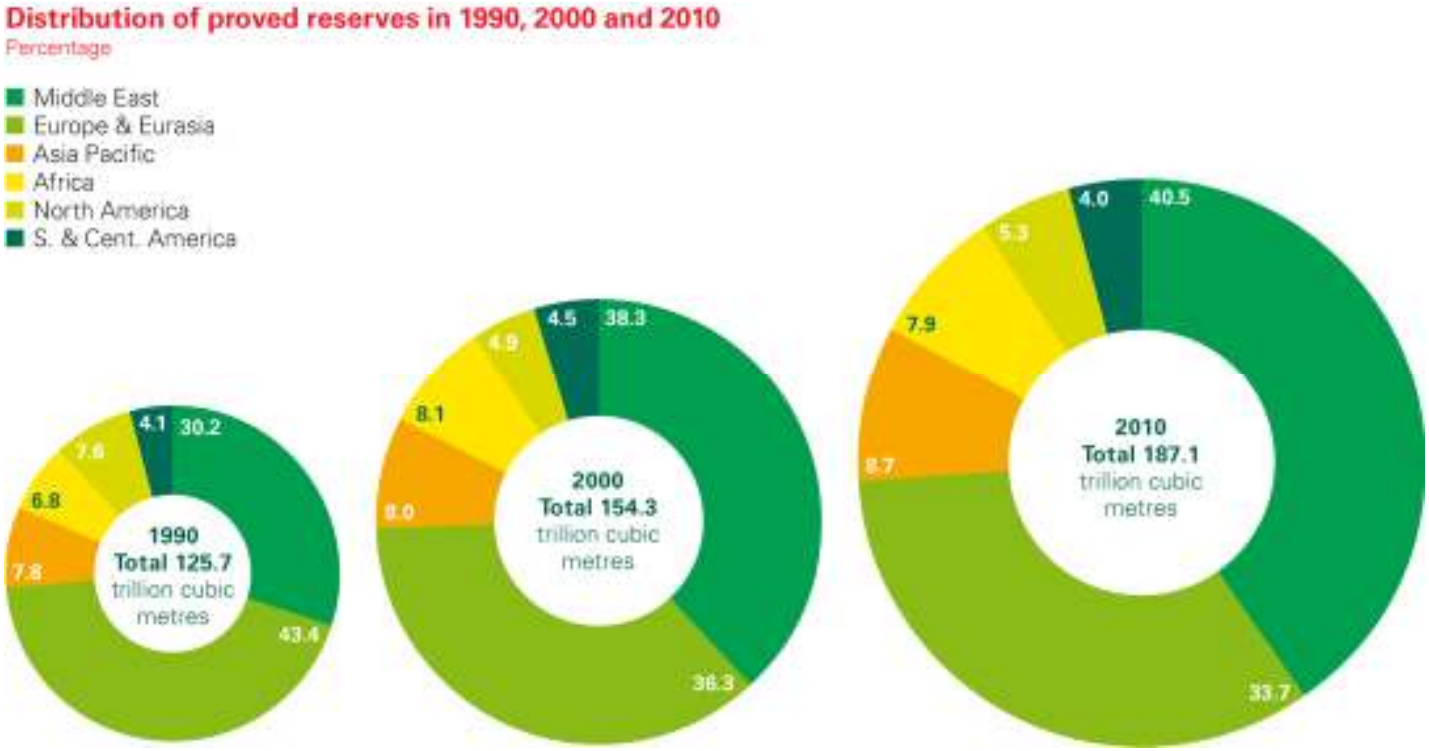
Why is Natural Gas Important?

- NG provides 24% of world energy consumption



NG will continue to be a important energy source in the foreseeable future

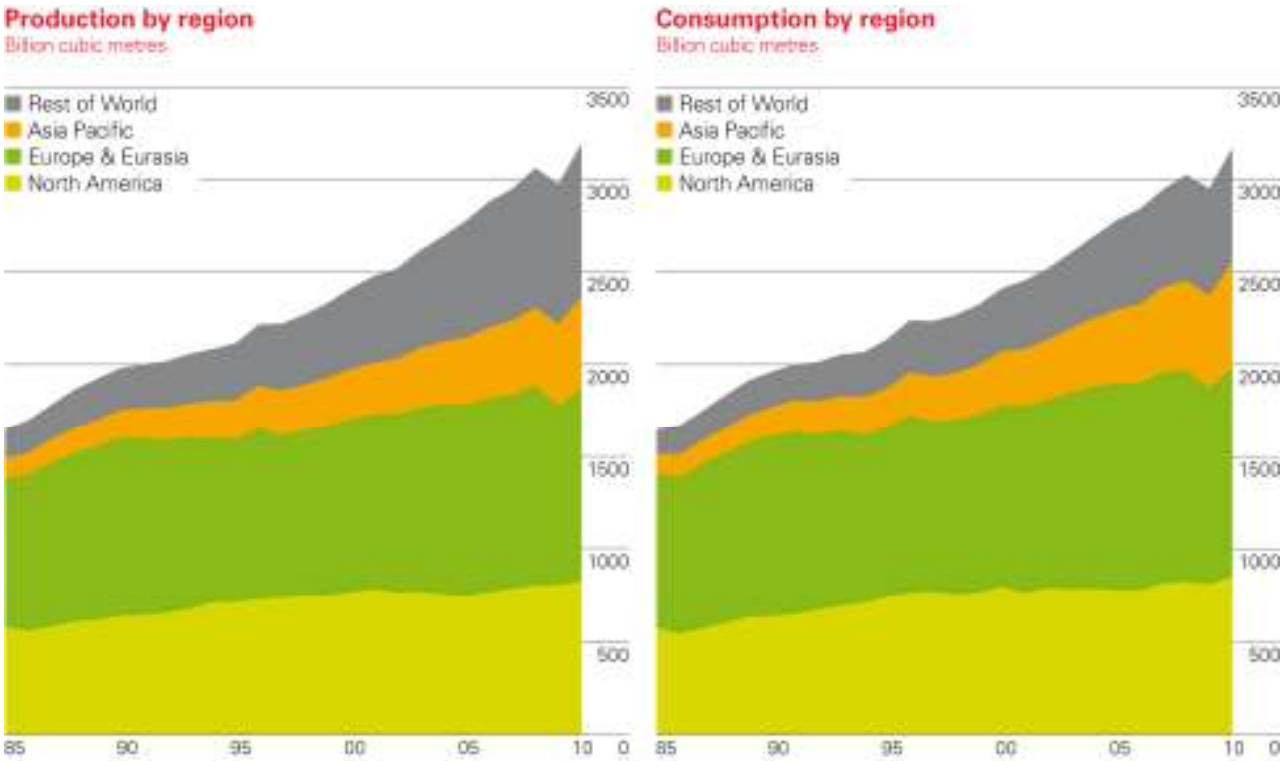
Global Distribution of Proved Gas Reserves



The Middle East is a major supplier of NG

Source: BP Statistical Review of World Energy 2011

Gas Production/Consumption by Region

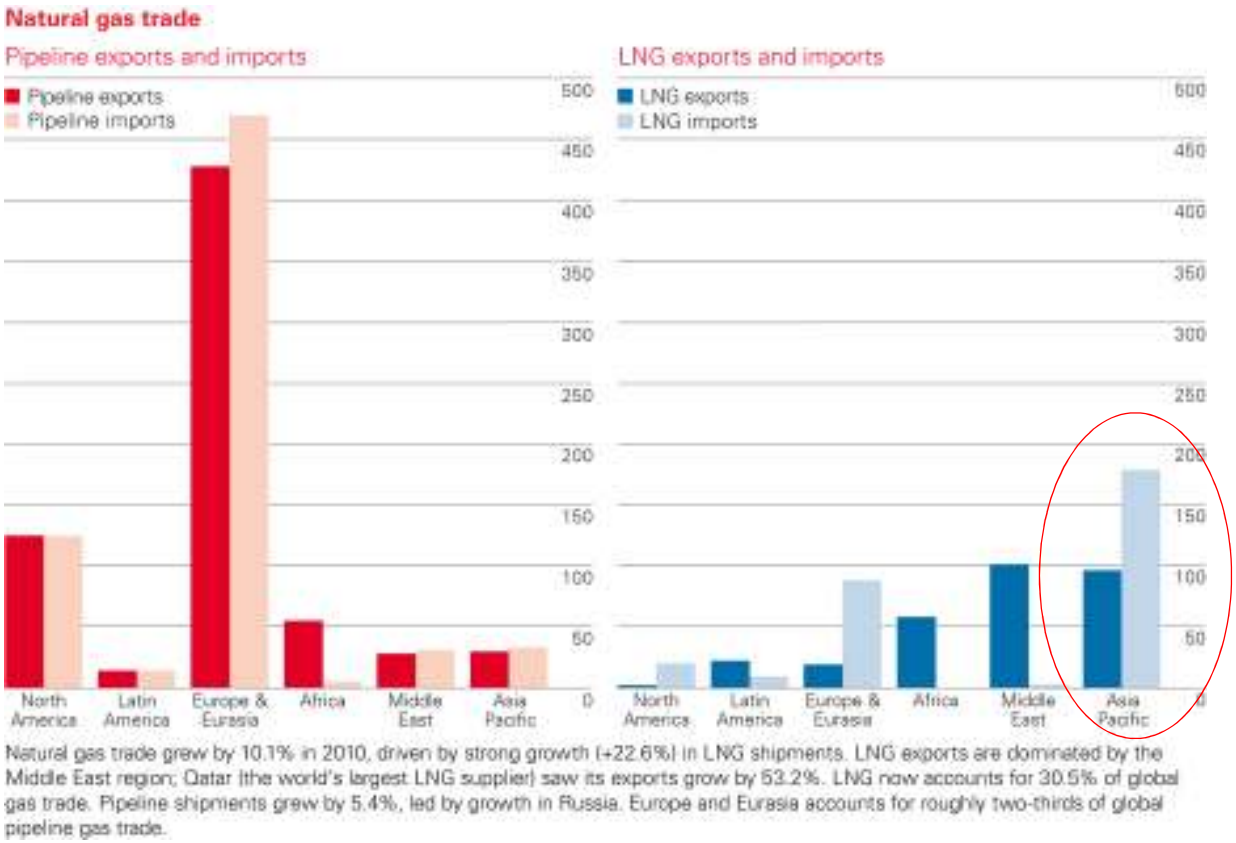


World natural gas production increased by 7.3%, the largest increase since 1984. Growth was above average in all regions; Russia recorded the largest production increment. Natural gas consumption increased by 7.4%, with above-average growth in all regions but the Middle East. The US recorded the world's largest gas consumption increment.

Natural gas production increased by 7.3%, highest since 1984

Source: BP Statistical Review of World Energy 2011

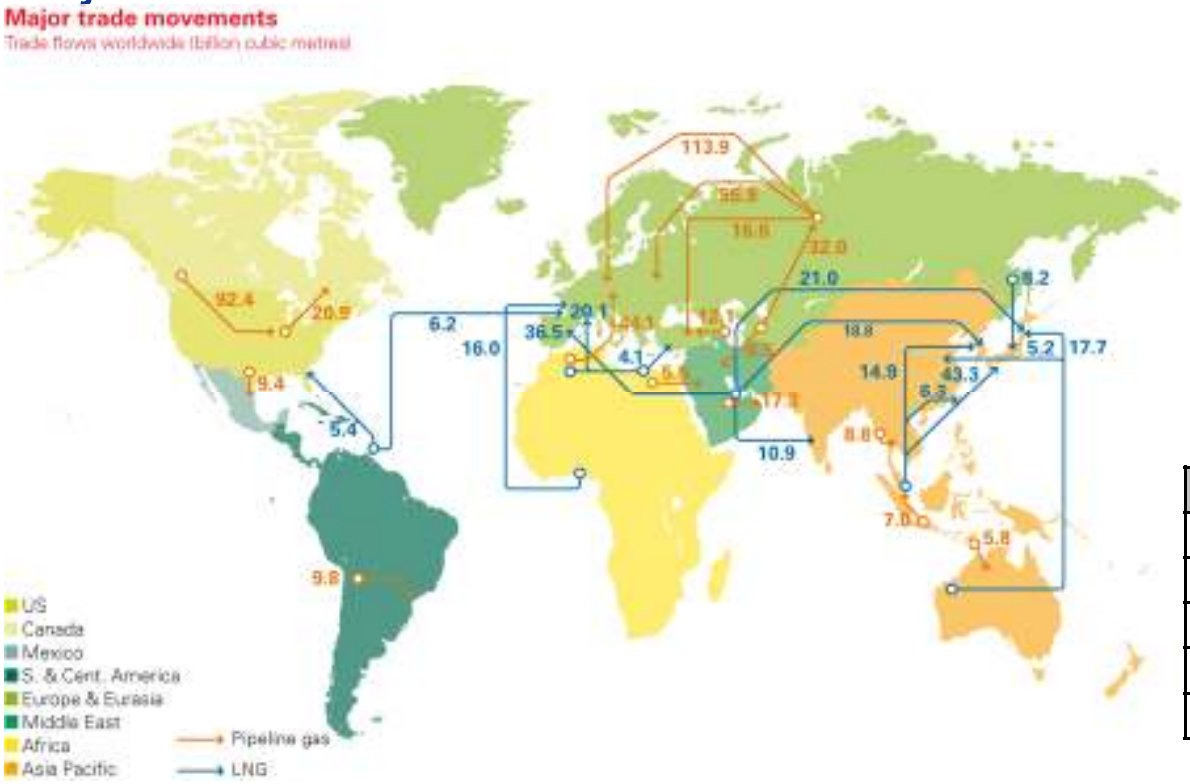
Chart of natural gas trade



- Asia is the biggest gross and net importer of LNG
- Middle East is the biggest exporter of LNG
- Qatar is the world's largest LNG supplier
- LNG accounts for 30.5% of world gas trade

Source: BP Statistical Review of World Energy 2011

Major Gas Trade Movements



Billion cubic metres

Asia Pacific	Total LNG imports
China	**12.80**
India	**12.15**
Japan	**93.48**
South Korea	**44.44**
Taiwan	**14.90**

- Japan, South Korea, Taiwan, China and India are the main LNG importers in Asia
- Australia, Indonesia, Malaysia, Russia and Qatar are the main suppliers
- Papua New Guinea is a potential major LNG exporter
- Mainly used as fuel for power generation
- More demand for LNG in future as replacement for nuclear fuel post Japan Tohoku Earthquake?

Source: BP Statistical Review of World Energy 2011

Chart of Gas Prices

Gas prices are trending upwards in tandem with economic growth

Source: BP Statistical Review of World Energy 2011

The LNG Supply Chain

Overview

1. Upstream
2. Liquefaction
3. Shipping
4. Terminal
5. Gas sales

1. Upstream

- Each Offshore gas platform costs hundreds of millions
- Weighs 10,000 tons

Above: Goodwyn A gas platform, North West Shelf Project, Western Australia

Right: Angel gas platform, North West Shelf Project, Western Australia

Pictures from Woodside website

2. Liquefaction

Major processes in a LNG liquefaction plant:

- Impurities removal
  - Acid gas removal
  - Dehydration
  - Mercury removal
- Chilling
- Liquefaction
- LNG storage
- LNG shipment

Left: Woodside Karratha Plant

Above: Woodside LNG V module being transported to site during construction

3. Shipping – Example of New LNG Carrier, Arctic Voyager

- Overall length of Arctic Voyager is 289.50 m
- Length between perpendiculars is 277.00 m
- The beam of the vessel is 48.40 m and the depth is 26.50 m
- Vessel deadweight of 75,434 metric tons
- Gross Tonnage is 118,571 gross tons.
- Cargo tank capacity is over 140,000 cubic meters

Left: Artic Voyager

4. Terminal

LNG terminal and re-gasification plant:

- Unload from LNG ship
- LNG storage
- LNG re-gasification
- NG transfer through pipelines

Below: in-ground LNG tank in terminal

Pictures from Tokyo Gas

5. Gas Sales

- Gas transfer through pipeline
- Applications
  - Fuel for power plants
  - Feedstock for ammonia and fertilizer plants
  - Fuel for homes
  - Feedstock for Gas to liquids for making oil products
  - Fuel for process heaters in Oil Refineries and Petrochemical Plants
  - Feedstock for Hydrogen production
  - Fuel for steam boilers

Hazards in LNG facilities

Overview of Hazards

- Explosion from hydrocarbon vapour cloud
- Jet fires as a result of hydrocarbon releases under high pressure
- Damage from knock-on fires resulting from a major machinery breakdown incident
- LNG tank explosion when it is taken out of service for maintenance
- Pool fires (e.g. LNG, diesel or lube oil)
- Ship or aircraft impact

1.1 Loss in Offshore Platform – P-36 Semi-sub (2001)

- In the early hours of March 15, 2001 there were two explosions in the aft starboard column at the emergency drain tank
- The first explosion was caused by an overpressure event
- The second by ignition of leaking hydrocarbon vapor
- At the time there were 175 people on the rig, 11 were killed
- Following the explosions, the rig developed a 16° list
- Teams tried over the weekend to save the platform by pumping nitrogen and compressed air into the tanks to expel the water. They abandoned the rig after bad weather
- The platform sank 5 days after the explosions in 1,200 m (3,940 ft) of water

1.2 Loss in Offshore Platform – P-36 Semi-sub (2001)

2.1 Loss in LNG Processing Plant – Skikda, Algeria

- The loss occurred on 20th January 2004
- Explosion in LNG plant killed more than 20 people
- It was reported that a boiler at one of the gas units was the origin of the blast
- The blast destroyed three of the refinery's LNG plants and one maintenance building
- The blast was so extensive, with metal, glass and concrete debris spread across the 92 ha site

2.2 Loss in LNG Processing Plant – Skikda, Algeria

2.3 Loss in LNG Processing Plant – Skikda, Algeria

The Future - Floating LNG Ships

Shell Prelude FLNG – World's first FLNG

- Stationed out some 200 kilometres off the Western Australian coast, Shell's Prelude FLNG facility will produce gas from offshore fields and liquefy it onboard by cooling

- The cost of the Prelude FLNG facility is around US$10.5 billion to US$13 billion

- And come 2017, the FLNG is expected to commence production of up to 3.6 million tonnes of liquefied natural gas (LNG) a year. The Prelude gas field has around 3 trillion cubic feet equivalent of resources

- Shell has tied up with Samsung Heavy Industries to assemble the world's first and largest FLNG in South Korea. After which, the FLNG will be moored in a gas field off Western Australia for 25 years

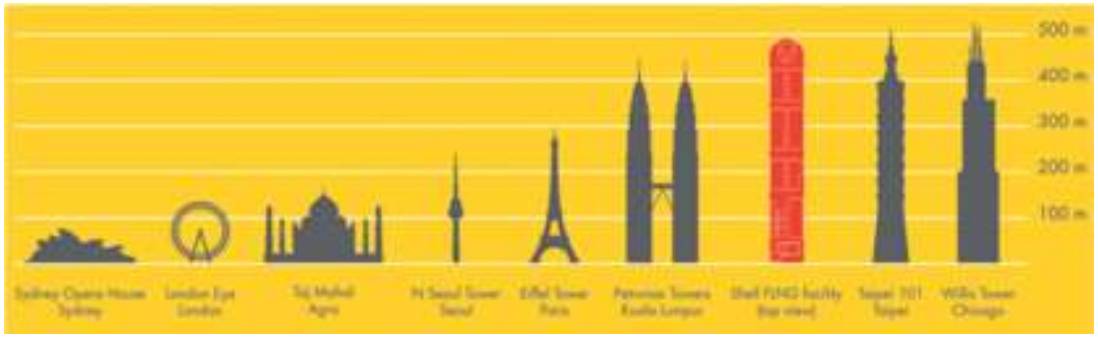
Source: Shell website

Specifications of Prelude FLNG

- Its deck measures 488 X 74 metres, the length of more than four soccer fields
- 260,000 tons of Steel
- Fully ballasted it will weigh roughly six times as much as the largest aircraft carrier
- The facility is one-quarter the size of an equivalent plant on land. Engineers have designed components that will stack vertically to save space:
  - The operating plant will be placed above LNG storage tanks
  - Tapping the cold of the ocean depths by pumping water to help cool the gas, avoiding the need to for extra equipment on deck.
  - An assembly of eight one-metre diameter pipes will extend from the facility to about 150 m below the ocean's surface. It will deliver around 50,000 m^3 of cold seawater each hour. This helps to cool the gas from below the facility, saving deck space
- The sheer size of the full-scale facility will help it to withstand very high winds and giant waves
- It will be secured in place by one of the largest mooring systems in the world. A 105-metre high turret, spacious enough to house the Arc de Triomphe, will run through the facility. Four groups of mooring lines will anchor it to the seabed
- The system allows the facility to turn slowly in the wind – absorbing the impact of strong weather conditions while remaining moored over the gas field. It can stay safely moored at sea even during the most powerful cyclones. This saves valuable production days that would otherwise be lost on disconnecting the facility and moving it off the field
- Three 6,700-horsepower engines will sit in the rear of the facility. Two of these will operate at any one time to turn the facility out of the wind and allow LNG carriers to pull safely alongside to load. The facility's storage tanks will be below deck. They can store up to 220,000 m^3 of LNG, 90,000 m^3 of LPG, and 126,000 m^3 of condensate. The total storage capacity is equivalent to around 175 Olympic swimming pools

Source: Shell website

Artist Impression and Size of Prelude FLNG



Left: Prelude is longer than the Petronas Tower

Value Proposition of FLNG

- Cost
- Less infrastructure required (platforms, onshore plants, docks, jetties and pipelines)
- Portable (can move when fields are depleted, economics change and political events)
- Less permitting problems compared to land based LNG

Risk Hazards of FLNG from Insurer's Point of View

FLNG is has a MUCH higher inherent risk compared to an onshore LNG plant

1. Severity of fire and explosion:

- At ¼ the footprint of an equivalent plant on land, fire load will be 4 times higher
- Unlike conventional onshore plant where LNG storage tanks are located at a distance from process units, process units in FLNG will be located on top of storage tanks
- Location of flare in FLNG
- Fire fighting access is severely limited
- Consequence of fire and vapour cloud explosion is severe due to the congestion

2. Design limitations

- Onshore LNG storage tanks can have the safest full containment concrete design. Not possible for FLNG due to dead weight
- Limitation on fireproofing of structures

Source: Shell website

Risk Hazards of FLNG from Insurer's Point of View (continue)

3. Environmental
- Corrosive environment
- Risk from vessel and helicopter impact
- Conseuqence of cyclone

4. Hull Risk
- Unlike onshore plant, FLNG is also a hull risk
- FLNG will sink if hull integrity is compromised

Source: Shell website

Risk Mitigation in FLNG

Loss PREVENTION is more important than protection. i.e. more emphasis on:

- Process Safety Management
- Equipment integrity
- Corrosion management

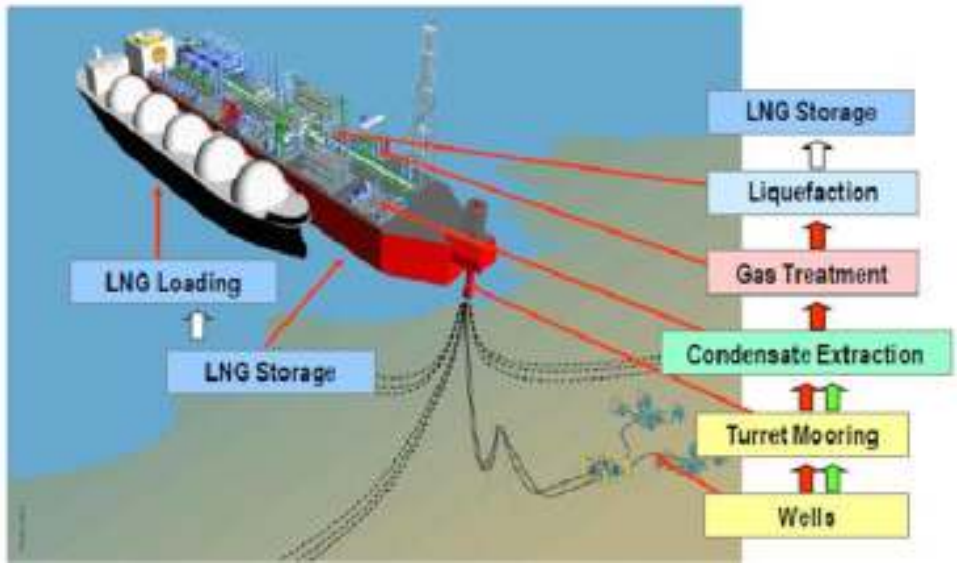
To prevent an incident from escalating, platform must have:

- Excellent inherent design to incorporate multiple layers of protection
- Comprehensive fire and gas detection/alarm coverage
- Robust fixed fire protection to extinguish incipient fire

Source: Shell website

Sum Insured Value

- **Average cost to build a FLNG is US$ 3.5 billion per 1 million tons/year LNG capacity**
- A FLNG the size of Prelude will easily cost more than US$ 10 billion
- EML of FLNG is more than US$ 10 billion (?)



Source: Shell website

Conclusion

- LNG is going to be a important source of energy for Asian countries
- More LNG facilities will be build to meet growing demands
- FLNG ships will be a technological and insurance challenge

THANK YOU

Please send your comments to

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