# The Next Generation of LNG Carriers for Long Distance and Harsh Environments

By
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ConocoPhillips

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## ConocoPhillips Involvement in the LNG Industry

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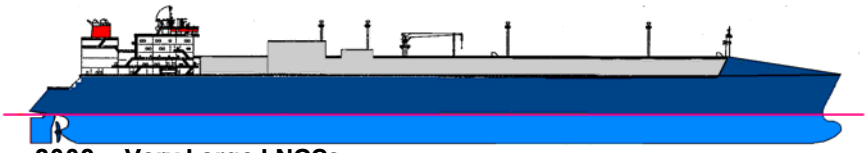
# CoP LNG Shipping Experience

**1959 – Methane Pioneer**

yesterday,
today and
tomorrow!

**1995 – Arctic Sun & Polar Eagle**

50 years of innovation
in LNG transportation!



**2009 – Very Large LNGCs**

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# ConocoPhillips - the LNG pioneer

- Continental Oil with partners built the world's first barge mounted LNG Plant and ocean going LNG Ship. On Jan 25, 1959 the ***Methane Pioneer*** left Louisiana with a cargo of LNG bound for the UK – 49 years ago. It was also the first diesel powered LNG vessel
- In 1968 the same ship was used to deliver the first inbound cargoes of LNG to the US, which were offloaded from the vessel offshore, again making history
- Phillips Petroleum built the world's 1st LNG plant to service Asian markets, providing Japan with almost 40 years of uninterrupted service since 1969
- In 1995 Phillips, with its partner Marathon built the world's first (and so far, only) LNG ships using independently prismatic tanks
- Licensed in-house technology, CoP Cascade, to projects in Trinidad and Egypt and using own technology for new equity supply projects in Australia/East Timor (Darwin LNG) and in Nigeria (Brass LNG)
- First new US LNG import terminal in 3 decades under construction in Freeport TX. – first gas 2008 and second Terminal on Texas coast, Golden Pass, being constructed jointly with Qatargas and ExxonMobil.
- In partnership with Qatargas, COP is constructing an 8mtpa LNG plant in Qatar which will supply the US using 10 very large LNGCs currently under construction in Korea

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# M.V Methane Pioneer

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# LNG Ship Loading at Kenai, Alaska


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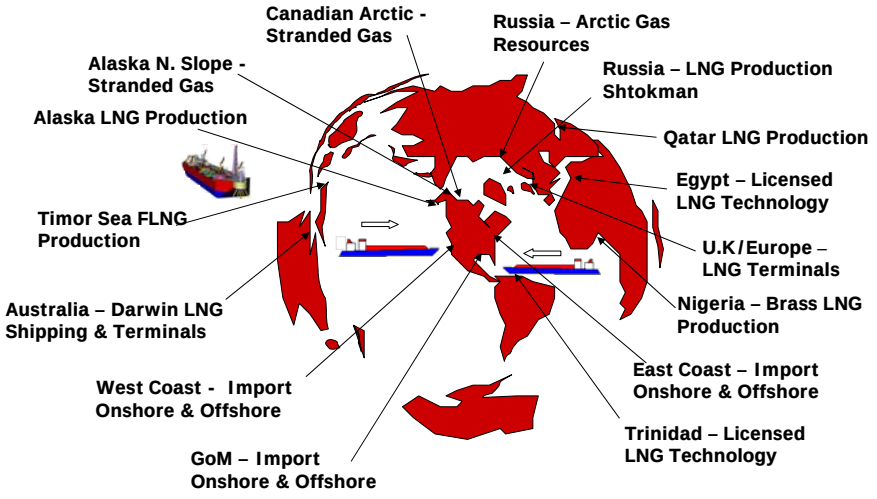
# Global LNG Prospects

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# Some Background on LNG Shipping Business

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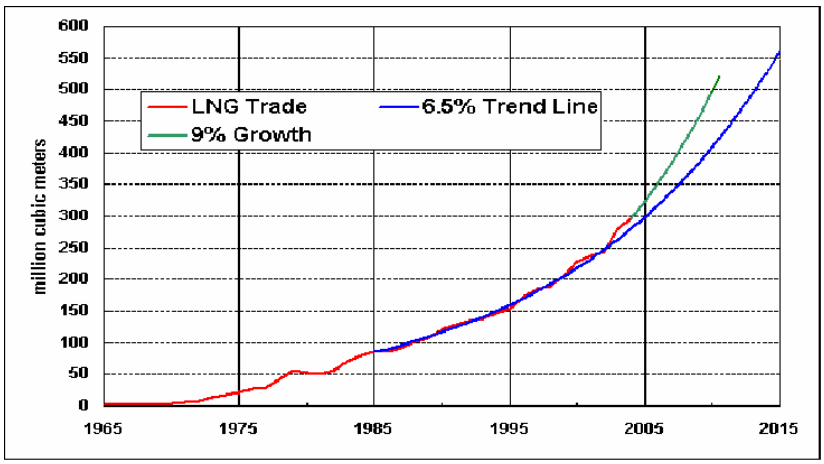
# Growth in World Wide Production and Ocean Trade in LNG

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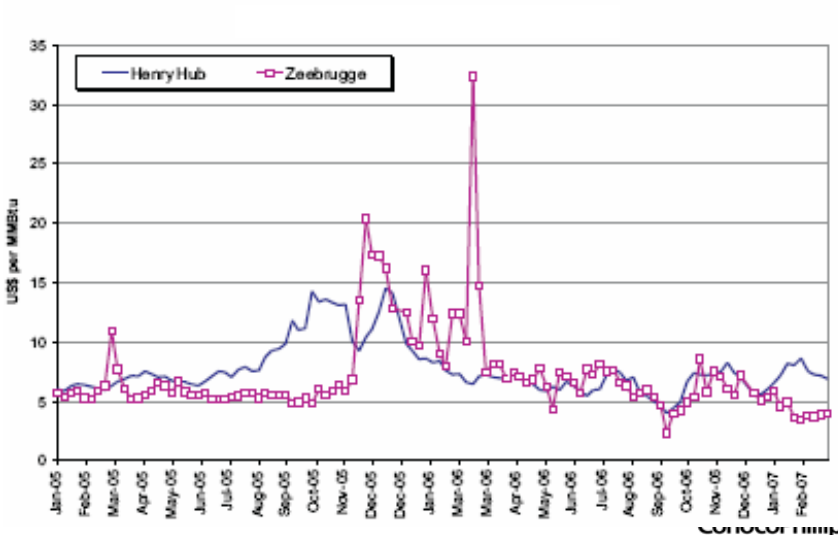
# Natural Gas Price US & Europe

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# Current LNG Fleet Size as of December 2006

| ACTIVE LNGC FLEET | | | |
|---|---|---|---|
| | # of Ships | Cubic Meters | Capacity/Ship |
| Active Fleet on 1/1/06 | 194 | 23,001,978 | 118,567 |
| Additions | 28 | 3,976,200 | 142,007 |
| Deletions | 0 | 0 | |
| Active Fleet on 12/31/06 | 222 | 26,978,178 | 121,523 |
| **LNGC ORDERBOOK** | | | |
| | # of Ships | Cubic Meters | Capacity/Ship |
| Ships on Order on 1/1/06 | 134 | 20,822,400 | 155,391 |
| New Orders | 28 | 5,762,500 | 205,804 |
| Deliveries | 28 | 3,976,200 | 142,007 |
| Ships on Order on 12/31/06 | 134 | 22,608,700 | 168,722 |

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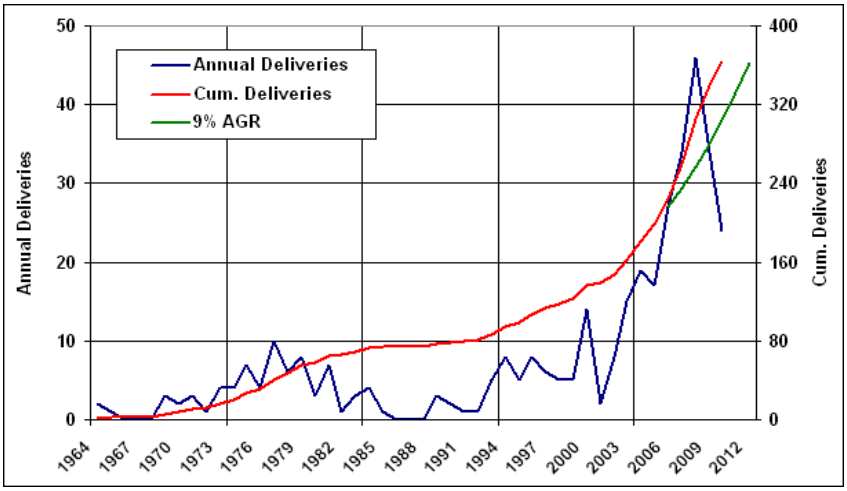
# Delivery of New LNG Ships and Growth in the Fleet

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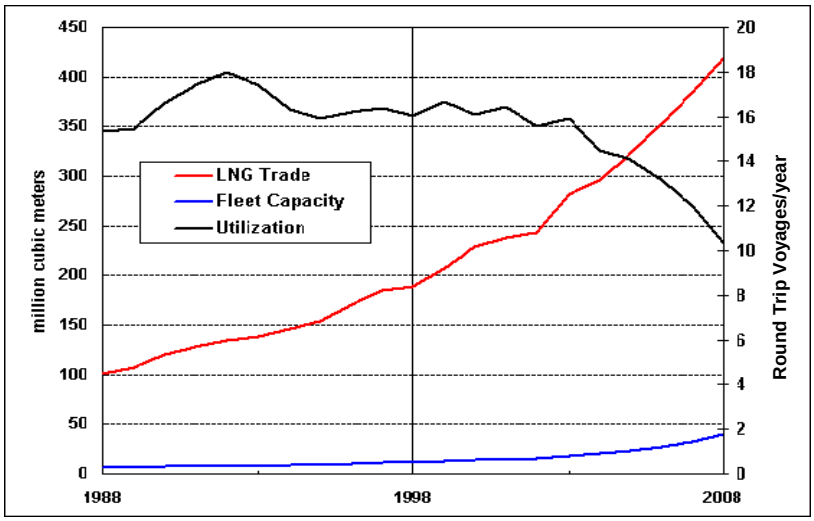
# Utilization of the LNG Fleet

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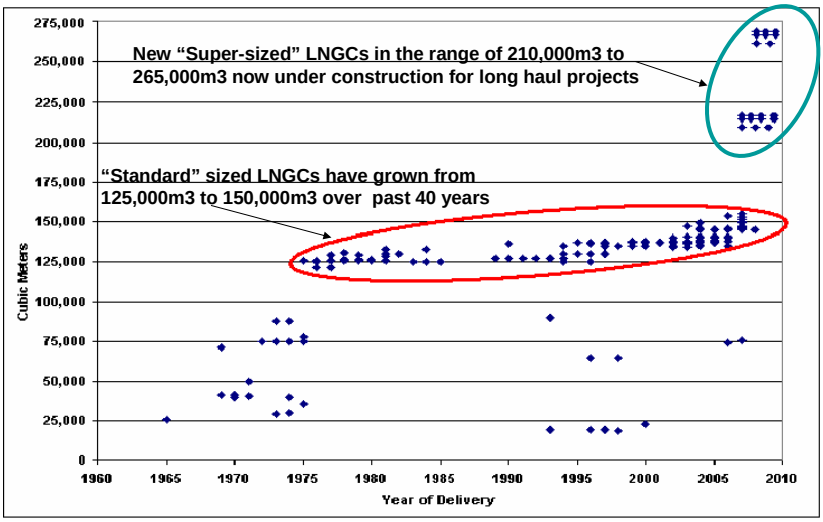
# Growth in Capacity of LNG Carriers

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# The Driver and Opportunities for Innovation

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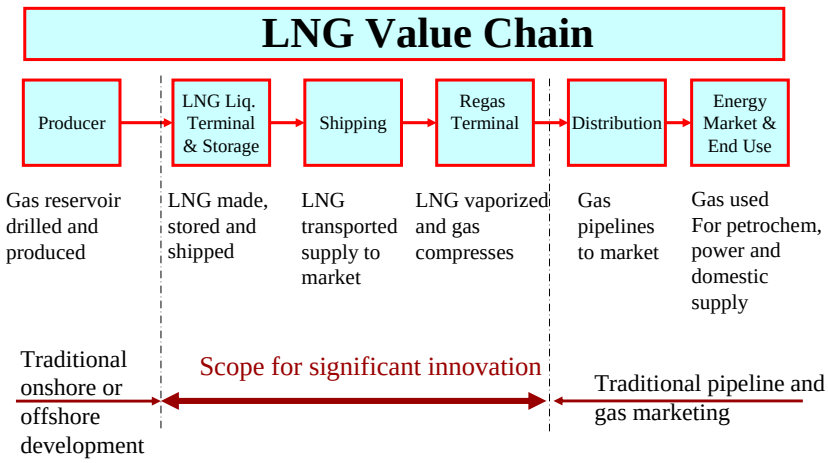
# The LNG Value Chain

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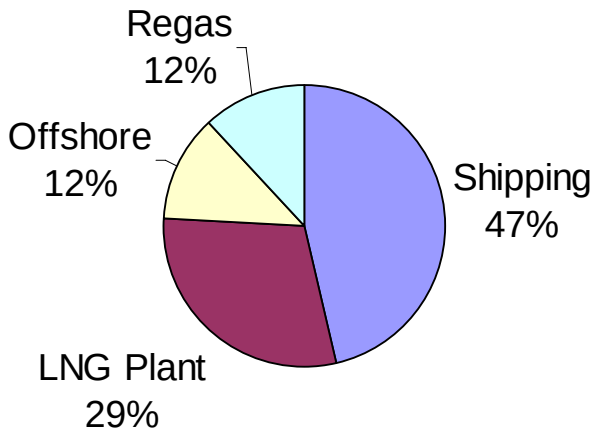
# Large LNG Project Relative CapEx

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# Innovation in LNG Loading and Discharge Terminals

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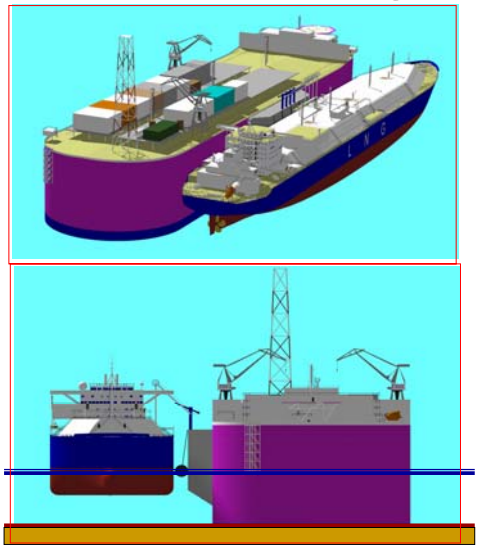
# Offshore LNG Receiving Terminal



- **Gravity Based Structure (concrete,steel or hybrid) 20 miles offshore in ~60 ft water.**
- **Subsea pipeline to existing offshore trunk line.**
- **Criteria:**
  - 7 BCF ( 300,000 $M^3$ ) Storage
  - Initial delivery 0.75 bcfd
  - Capacity expandable
  - Operating Reliability
    - Gas Send out 99.9%
    - Marine Ops > 97%
  - Serve existing LNG Ships
  - Serve future ships to
  - 250,000 $M^3$

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# Compass Port

Compass Port

**Project description**

- 1.0 bcfd capacity
- $1.0 billion CapEx
- 11 miles offshore Alabama
- ~ 250,000 cubic meter ships
- 300,000 cubic meters total storage
- Interconnection with Transco, Gulfstream and Gulf South Interstate Pipelines

**Status**

- Deepwater Port Application submitted to US Coast Guard
- Proposed Open Rack Vaporization technology facing significant stakeholder challenges

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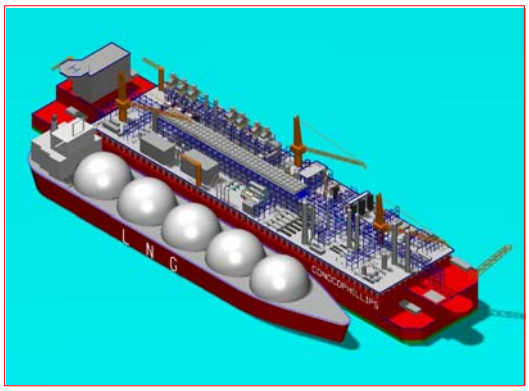
# Floating LNG using CoP Cascade Process




- Floating LNGC may be useful for development of remote gas fields
- Very large floating vessels
- Turret moored
- Side by Side loading
- Storage Tanks in hull for LNG, LPG and condensate

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# Cargo Containment Systems

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# Current LNG Tank Technology

- Current LNG Containment Tanks of LNGCs are of two types
  - Self Supporting Tanks, Moss and IHI-SPB tanks
  - Prismatic Hull Tanks with inner Membrane Systems – GTT Systems
- Some problems with moving to larger vessels i.e. 145k cbm – 200+k cbm ships
  - Spherical tanks are heavy and expensive to build
  - Because of hull arrangement ships with spherical tanks pay higher Suez Canal dues than other types of LNG ships - $100k per one way trip
  - Membrane Systems as susceptible to damage from sloshing loads from large free-surface in tanks and this is exacerbated when vessels size increase

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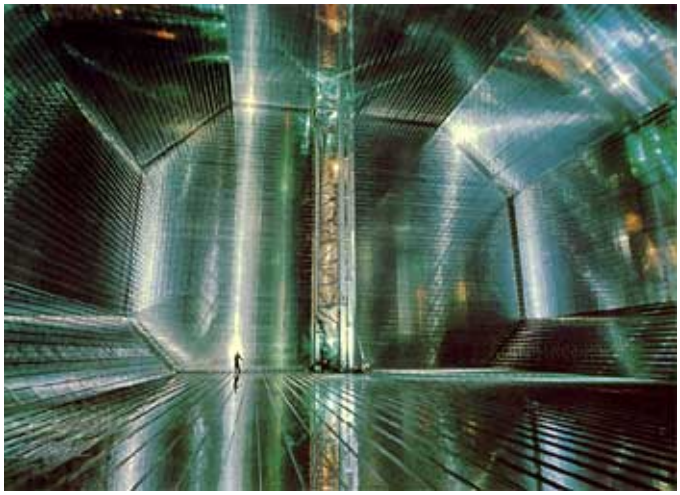
# Typical membrane LNG tank in 145,000m3 vessel



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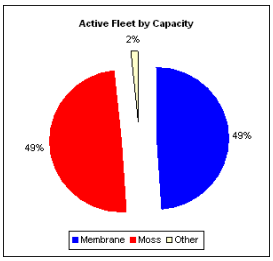
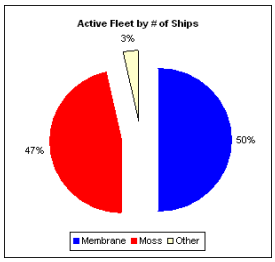
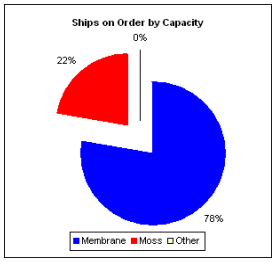
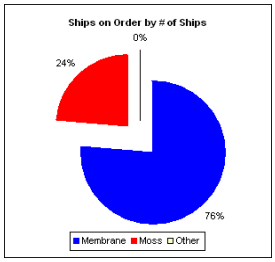
# Cargo Containment System Usage

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# Pyramid Tank Concept for LNGCs

An explanation of the Concept

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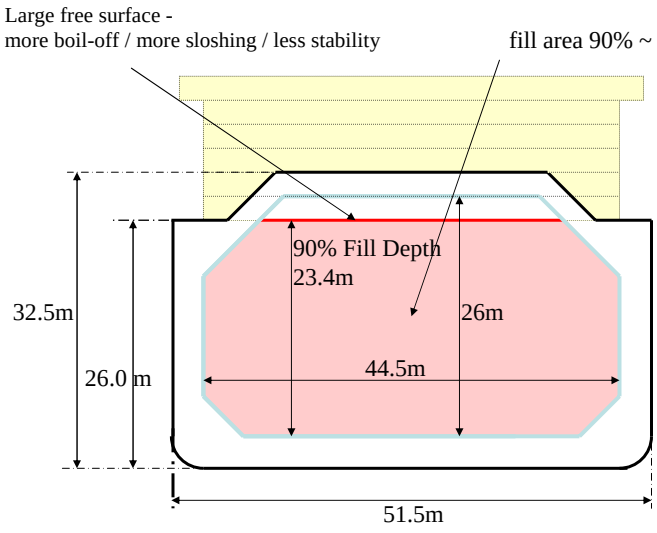
# Typical Midship Section of a 225k cu.m. LNGC

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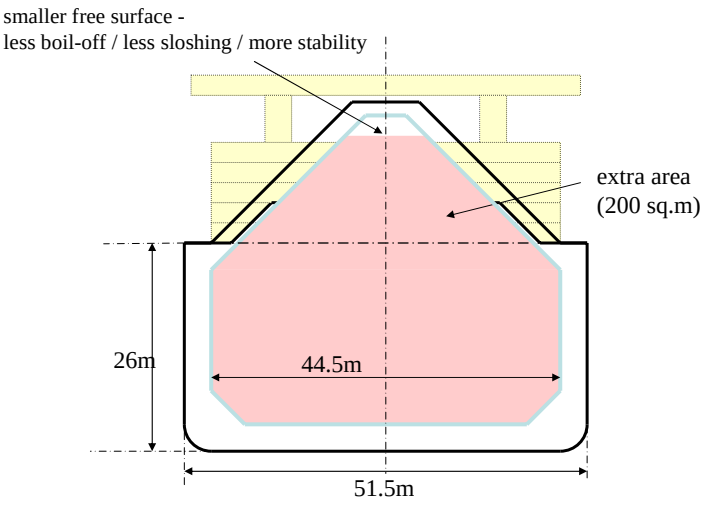
# Midship section of a 225k cu.m. LNGC with Pyramid Tanks

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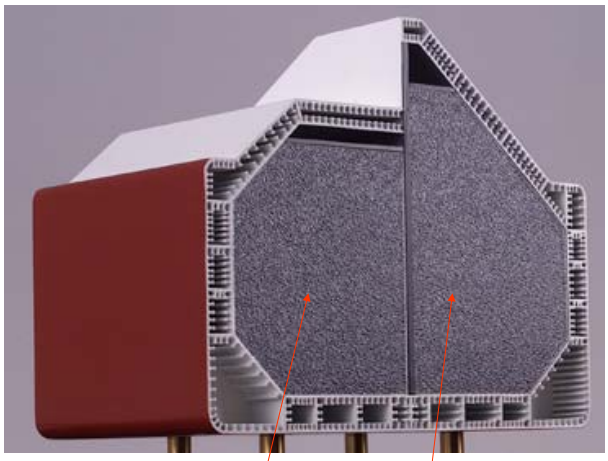
# Side by Side Tank Model



**Existing Membrane Tank Design**

**Pyramid Tank Design**

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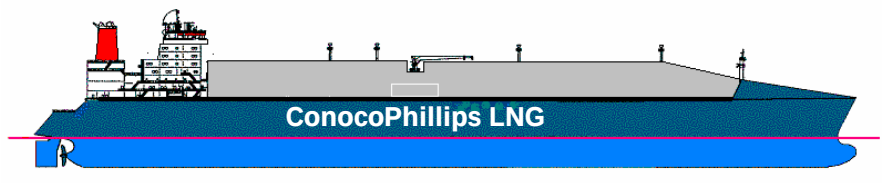
# *SuperFlex LNGC*

## Typical Concept Development




| | | | |
|---|---|---|---|
| • LBP | 315m | • Cargo | 224,000 $m^3$ |
| • Beam | 50.8m | • Power | 2 x 26,700hp |
| • Depth | 27.6m | • Propulsion | Twin Screw |
| • Draft | 11.9m | • Boil Off | 0% |
| • Service Speed | 19.7 kts | • Crew | 26 +6 |

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# Propulsion Systems for LNGCs

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# LNGC Propulsion Systems

- Traditionally LNGCs have used steam turbine propulsion systems since that allows easy disposal of cargo Boil Off. These systems are not very thermally efficient and do required trained steam engineers, who are becoming scarce
- There has been a move in recent years to use both dual-fuel diesel electric, DFDE, propulsion systems and slow speed diesel systems with onboard reliquefaction, DRL, systems
- DFDE systems allow the use of BOG as fuel while DRL systems deliver all the cargo to market that was loaded at the export terminal

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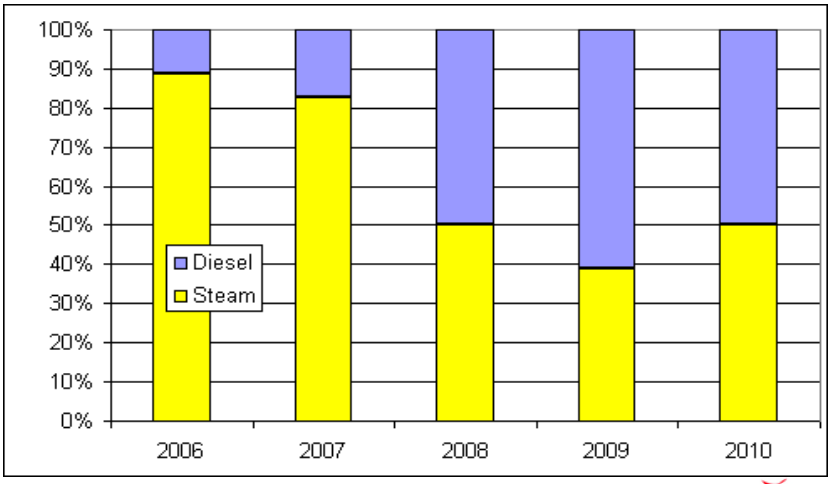
# LNG Carrier Propulsion Systems Order Book

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# New Hull-form Developments

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# New Shallow Draft Hull Forms

- The move to larger LNGCs has not been matched by LNG terminals permitting deep draft so nearly all new LNG ships are still restricted to a maximum draft of 12.0m
- This leads to the requirement for twin screw arrangements for large (200,000m3 +) LNGCs
- Significant work has been done in recent years on the development of efficient, high block, relatively high speed, shallow draft ships

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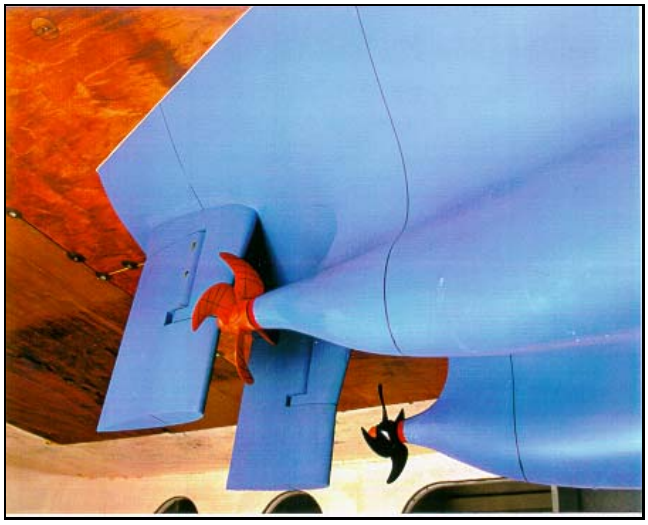
# Twin Screw LNGC Model



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# Large LNGC General Arrangement

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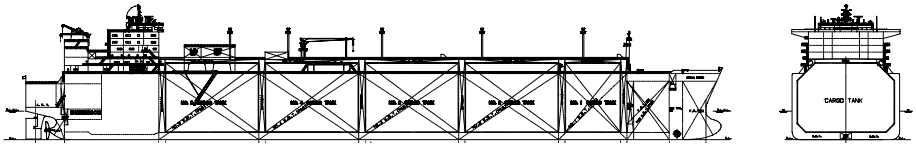
# Typical 228k $m^3$ LNGC



| | | | |
|---|---|---|---|
| • LBP | 322m | • Cargo | 228,000 $m^3$ |
| • Beam | 50m | • Power | 2 x 26,700hp |
| • Depth | 27.6m | • Propulsion | Twin Screw |
| • Draft | 11.9m | • Boil Off | <0.00%/day |
| • Service Speed | 19.5 kts | • Crew | 28 |

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# LNG Shipping in High Latitudes & Harsh Environments

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# LNG at High Latitudes

- There are considerable gas reserves in high latitudes in Alaska, Canada, Norway and Russia, with active front-end projects in all these areas.
- In Alaska, the Kenai project has been exporting LNG for almost 40 years and in Norway, the Snohvit project is coming on-stream
- To be successful in these areas will require significant innovation and will require special attention to icebreaking, operations in total darkness and low temperatures, operations far from supporting infrastructure etc.

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## Arctic Oil Transport as an Analog

- ConocoPhillips in partnership with LukOil has chartered 3 – 70,000 dwt icebreaking tankers which will be used to export oil from the Pechora Sea area.
- COP has been actively involved in the design and construction of these ships and believes that much of the experience which has been gained in this activity will be useful in future Arctic LNG projects

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## 70,000 tdwt icebreaking Arctic tanker – delivery 2008

Full icebreaking bow for independent ice-breaking in 1.5m thick ice

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# 70,000 tdwt icebreaking Arctic tanker – delivery 2008

Twin 10mw Azipod drives for good maneuvering performance in level ice and ridges

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# Comparison of Membrane, Moss and SPB Harsh Environment Ships

| Ship Type/ Item | 217k MK III | 216k SSPB | 216k Moss | Remarks |
|---|---|---|---|---|
| Dimension (LBP/B/Td) | 302/50/11.6 | 312/51/11.6 | 320/51/11.5 | Arrival draught basis |
| Depth | 27.0 m | 28.6 m | - | |
| No. of Tank | 5 | 4 | 5 | |
| Cargo Capacity | Appx. 217,000 m3 | Appx. 216,100 m3 | Appx. 216,000 m3 | 100% full |
| Cargo S.G | 0.442 | 0.442 | 0.440 | |
| M/E Type | 6S70ME-C x 2 | 6S70ME-C x 2 | - | |
| Speed | 19.5 Knots | 19.5 Knots | - | |

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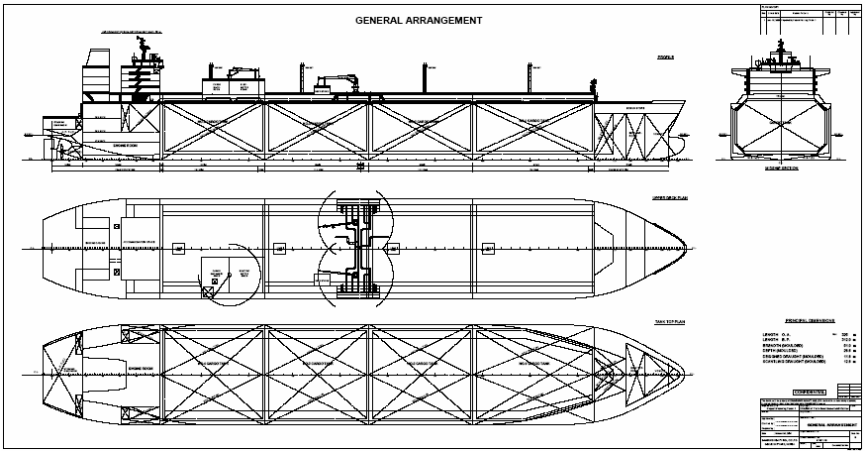
# 216,000m3 SPB LNG Ship for Harsh Environments

(non-icebreaking)

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# Conclusions

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# Conclusions

- There is good opportunity for innovation to reduce costs and increase efficiency in LNG Transportation
- There is rapid expansion taking place in the LNG shipping sector right now, but even with this expansion LNG shipping will remain a small specialized part of the tanker market
- LNG ships will largely be employed in long term trades through multi-year time charters with only very limited opportunities for spot market activities
- National Oil Companies such as Qatar Petroleum, Gazprom, Nigerian National Petroleum Corporation, etc. will play an increasingly active role in LNG shipping projects

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