

A Short History of LNG Shipping 1959-2009



By

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Introduction

- On January 25th 1959, the MV *Methane Pioneer* left the Calcasieu River on the Louisiana Gulf coast with the world's first ocean cargo of LNG and sailed to the UK where the LNG was delivered
- Subsequent expansion of that trade has brought us to today when giant LNG ships carrying up to 266,000 m³ of cargo are entering service.
- SNAME and SNAME members have been an integral part of this half century of development and this presentation will highlight some key events



M.V. Methane Pioneer Loading LNG



Canvey Island Receiving Terminal, UK



What is LNG

- **Liquefied natural gas** or **LNG** is natural gas (primarily methane, CH₄) that has been converted to liquid form for ease of storage or transport.
- When natural gas is cooled to below its liquefaction point of about minus 163 degrees Celsius at atmospheric pressure, it forms a liquid with a specific gravity in the 0.45 range.
- When liquefied there is a 600:1 reduction in volume
- LNG is normally stored in insulated tanks at atmospheric pressure and typically boils slowly giving off about 0.10% – 0.15% of volume per day in the form of Boil-Off Gas, BOG.
- Michael Faraday was the first to experiment with liquefaction of methane in the mid-nineteenth century.
- The first LNG plant built in West Virginia in 1912. It began operation in 1917
- The first commercial liquefaction plant was built in Cleveland, Ohio, in 1941 for storage of natural gas



Some Background Statistics on LNG Shipping Business



Current LNG Fleet Size

January 15th 2009

<i>Summary</i>											
<i>Type</i>	<i>Size Bracket</i>	<i>In Service</i>			<i>Building for Delivery in</i>						<i>Totals</i>
		<i>Pre-2009</i>	<i>2009</i>	<i>Total</i>	<i>2009</i>	<i>2010</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>Total</i>	
Q-Max	> 250,000 cm	4	0	4	8	2	0	0	0	10	14
Q-Flex	200-250,000 cm	20	0	20	6	4	0	0	0	10	30
Standard	100-200,000 cm	244	0	244	28	16	13	2	0	59	303
Small	<100,000 cm	30	0	30	0	0	0	0	0	0	30
Totals		298	0	298	42	22	13	2	0	79	377

Source: www.coltoncompany.com



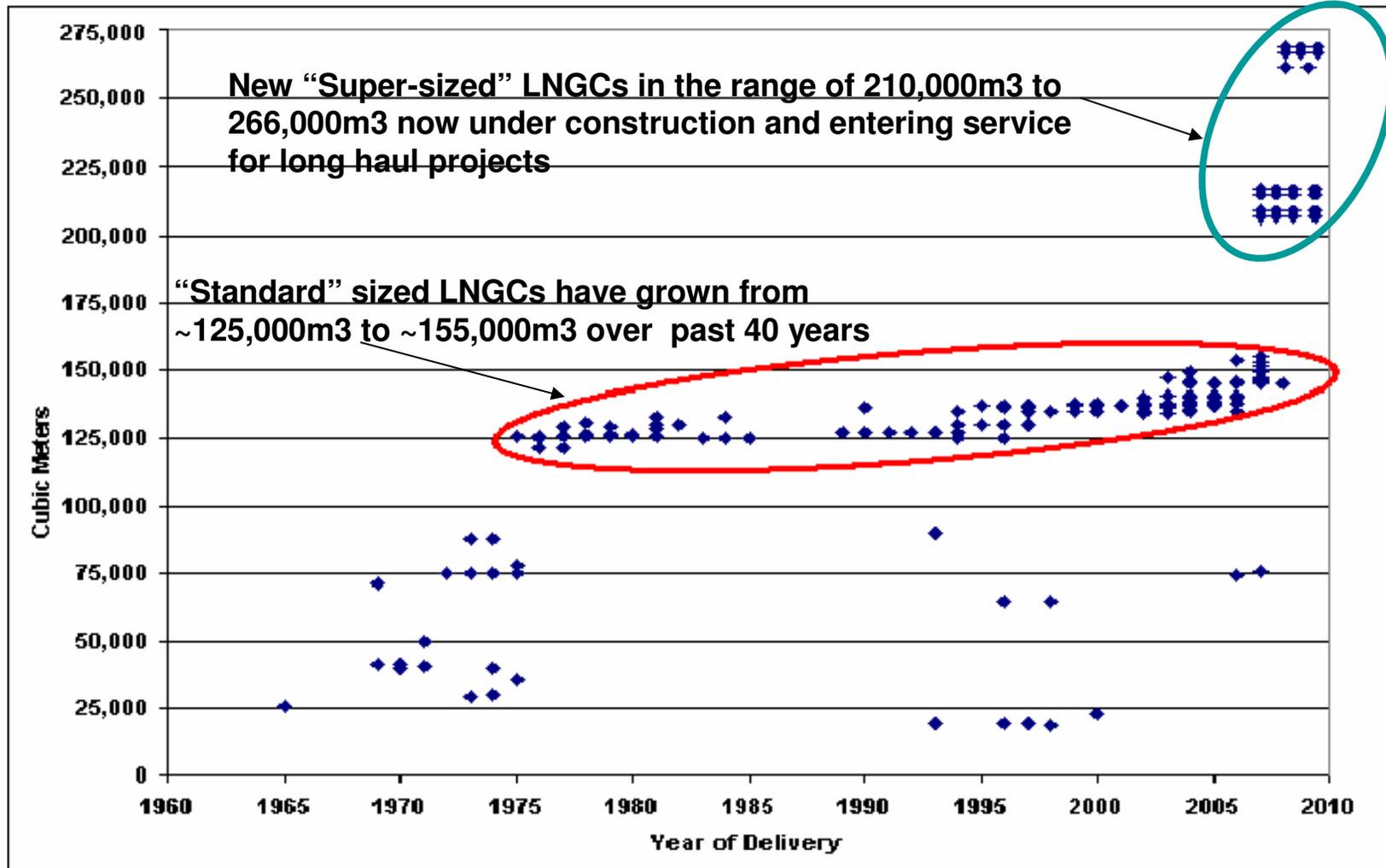
LNG Ships withdrawn from service

January 15, 2009

<i>Name of Ship</i>	<i>Operator</i>	<i>Shipbuilder</i>	<i>Year Built or Rebuilt</i>	<i># of Voyages</i>	<i>Year With-drawn</i>	<i>Cargo Capacity (cu.m.)</i>	<i>Cargo System</i>	<i>Disposition</i>
Methane (barge)	Chicago Stockyards	Ingalls	1955	0	1955	5,550	Morrison	Converted to an oil barge
Beauvais	Gaz de France	Atlantique	1962	0	1962	640	Mixed	Scrapped
Pythagore	Gazocean	Le Havre	1964	1	1964	610	TZM	Converted to a fish carrier
Aristotle (ex Methane Pioneer)	Stephenson, Clarke	Alabama	1958	30	1972	5,000	Morrison	Converted to LPG storage
Euclides	Gazocean	Le Havre	1971	14	1973	4,000	TZM	Converted to an LPG carrier
Sanko Ethylene Maru	Hitachi Zosen	Hitachi	1974	0	1974	1,100	Hitachi	Disposition unknown
Massachusetts (barge)	Unknown	Todd Houston	1974	7	1974	4,000	Unknown	Converted to LPG storage
Sant Jordi	Unknown	Bilbao	1975	0	1975	5,000	Sener	Sank off Spain in 1995
El Paso Columbia	El Paso Tankers	Avondale	1979	0	1979	130,000	Conch	Converted to OBO, scrapped in 2000
El Paso Savannah	El Paso Tankers	Avondale	1979	0	1979	130,000	Conch	Converted to OBO, now an FPSO
El Paso Cove Point	El Paso Tankers	Avondale	1979	0	1979	130,000	Conch	Wrecked and scrapped in 1987
Ben Franklin	SNTM-Hyproc	La Ciotat	1975	5	1980	120,000	TZM	Scrapped in 1980
El Paso Paul Keyser	El Paso Tankers	Dunkerque	1976	12	1980	129,500	GT	Scrapped in 1985
El Paso Sonatrach	El Paso Tankers	Dunkerque	1977	26	1980	129,500	GT	Scrapped in 1985
El Paso Consolidated	El Paso Tankers	Dunkerque	1977	15	1980	129,500	GT	Scrapped in 1987
Esso Portovenere	SNAM	Italcantieri	1971	335	1984	40,000	Esso	Scrapped in 1984
Methane Progress	British Gas	Harland & Wolff	1964	467	1992	27,400	Conch	Scrapped in 1992
Methane Princess	British Gas	Vickers-Armstrong	1964	500+	1998	27,400	Conch	Scrapped in 1998
Havfru	BW Gas	Moss Verft	1973		7-May	29,388	Moss	Scrapped in 2007
Laieta	Maritima del Norte	Astano	1970		8-Jun	40,000	Esso	Scrapped in 2008
Cinderella	TMT Co. Ltd.	Le Trait	1965		8-Jul	25,500	Worms	Scrapped in 2008
Charm Junior	TMT Co. Ltd.	Atlantique	1971		8-Jul	50,000	TZ Mk. 1	Scrapped in 2008
Century	BW Gas	Moss Verft	1974		8-Nov	29,588	Moss	Scrapped in 2008



Growth in Capacity of LNG Carriers



History of LNG Transport at Sea



Beginnings of Waterborne LNG

- In the mid 1950s, an early concept for the transportation and use of LNG was explored, by Union Stockyards, Chicago and Continental Oil through a joint venture named Constock.
- The plan was to buy gas on the Gulf Coast, liquefy it, transport by water to Chicago, and vaporize it in the food processing industry, using the cold for refrigeration and making the gas available for industrial use.
- As part of this venture a barge, the *Methane* with a cargo capacity of 5,550 cubic meters, was built at Ingalls Shipyard to operate on the Mississippi hauling LNG north to Chicago.
- The initial economics looked good, however the FDA refused to permit the concept down due to the fear of contaminating the food product.
- The failure to obtain approval from FDA caused Union Stockyards to withdraw from the venture. .



LNG Ocean Shipping - The Start

- Continental chose to continue the LNG operation and found that gas could be liquefied on the Gulf coast, transported to the east Coast by water, vaporized and put into the gas mains competitively with pipelining.
- In the late 1950's an opportunity to sell LNG to the UK developed and Constock aligned itself with the British Gas Council to develop the world's first ocean shipping system for LNG



M.V. *Methane Pioneer* - 1959

- On January 25th 1959, the MV *Methane Pioneer* left the Calcasieu River on the Louisiana Gulf coast with the world's first ocean cargo of LNG and sailed to the UK where the LNG was delivered
- In 1968 the *Methane Pioneer* became the first LNG ship to import cargoes into the US, when its cargo was offloaded in Boston Harbor into LNG trucks positioned on a barge.
- The *Methane Pioneer* became the first LNG ship to be diesel powered and the first to offload at sea – innovations which we will see are of current interest.

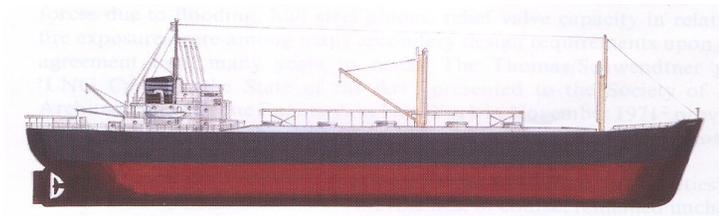


Outline Specifications *MV Methane Pioneer*

- Ship was originally built as a US Government cargo ship, a C1-M-AV1 design, at end of WWII.
- The *M.V. Marline Hitch* was built in Duluth, MN and delivered in July 1945
- The vessel was converted to carry LNG in 1958.
- *MV Methane Pioneer* Specifications
 - Length O.A 338.5 ft
 - Beam 50.0 ft
 - Draft 18.0 ft
 - Deadweight. 5034 tons
 - LNG Cargo Capacity ~5000 m³
 - Power (diesel) 1750 h.p



M.V. Marline Hitch – C1-M-AV1



M.V. Methane Pioneer Conversion



First purpose built LNG ship - *Methane Princess*

- The success of the *Methane Pioneer* caused Shell to order two purpose built LNG carriers to be constructed in the UK;
 - the *Methane Princess* at Vickers Armstrong and
 - the *Methane Progress* at Harland and Wolff
- The ships were fitted with Conch independent aluminum cargo tanks and entered the Algerian LNG trade in 1964.
- These ships had a capacity of ~27,000 cubic meters of cargo and between them made ~1,000 voyages before being scrapped in the mid 1990s



S.T. *Methane Princess*

Principle Dimensions

Length:	621 ft (189 m)
Beam:	82 ft (25 m)
Installed power:	13750 shp
Propulsion:	Steam
Speed:	17.5 knots



Kenai, Alaska LNG Export

- In the late 1960s and opportunity arose to export LNG from Alaska to Japan and in 1969 that trade was initiated.
- Two ships, each with a capacity of 71,500 cubic meters were built at the Kockums yard in Sweden. While the shipyard is long gone, these ships remain in service with SovComFlot as the *SCF Polar* and *SCF Arctic* and are currently in the Trinidad to Spain trade



LNG Ship - *SCF Arctic*



LNG Ship - *SCF Polar*



US LNGC Shipbuilding

- In the early 1970's the US Government encouraged US shipyards to build LNGCs by providing loan guarantees through MarAd Title XI
- Three shipyards took up this challenge with varying degrees of success
- A total of 16 LNG ships were built
 - General Dynamics, Quincy – 10 ships using the Moss spherical tank system
 - Newport News, VA – 3 ships using the TZ Mk 1 system
 - Avondale, LA – 3 ships using a modified Conch System



Energy Transport Corp.

- Energy Transportation Corporation took delivery of 8 of the 125,000 m³ GD built ships and placed them into long term charter with Burmah Oil Company delivering LNG from Indonesia to Japan.
- The ships were originally US Flag with US crews, but recently have transferred to Marshall Islands Flag. They remain in the Indonesian LNG trade.
 - Delivered Sept 1978
 - Cargo Capacity 126,300 m³
 - Power (steam) 43,000 s.h.p.
 - Service Speed 20.4 knots



LNG ship *Gemini*

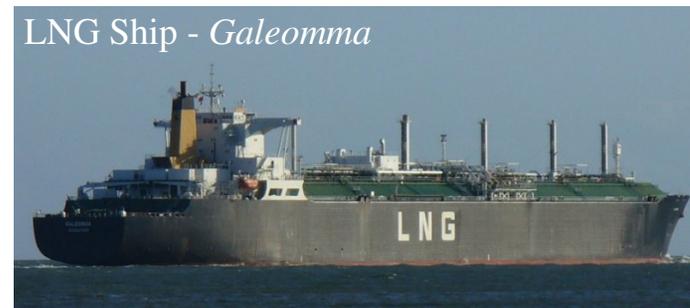


LNG ship *Aquarius*



El Paso - Newport News Ships

- Newport News delivered 3 membrane LNG ships to El Paso in 1978-79.
- These ships are still in service with the following operators and trades:
 - *LNG Delta* – Operator, Shell STASCO – Service Nigeria-Europe
 - *Galeomma* – Operator, Shell STASCO – Service, Oman-Spain
 - *Suez Mathew* – Operator, Hoegh LNG– Service, Trinidad - US



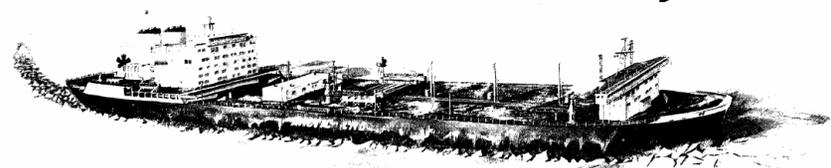
El Paso – Avondale Ships

- The El Paso ship project at Avondale turned into a fiasco.
- The ships were built with a modified Conch system using independent aluminum tanks with a novel insulation system
- The ships had a length of 931.5 ft; a beam of 140.5 ft; and a draft of 36 ft. Cargo tank capacity was 125,000 cubic meter and the single screw steam turbine plant developed 41,000 shaft horsepower..
- When undergoing builder's trials the cargo tank insulation failed and when it was determined that repairs could not be effectively made, the ships were declared total constructive losses.
- The disposition of the ships was as follows
 - *El Paso Columbia* – converted to OBO ship, scrapped in 2000
 - *El Paso Savannah* – converted to OBO, then converted to double hulled FSO for N. Sea. Still in service
 - *El Paso Cove Point* – wrecked and scrapped in 1987

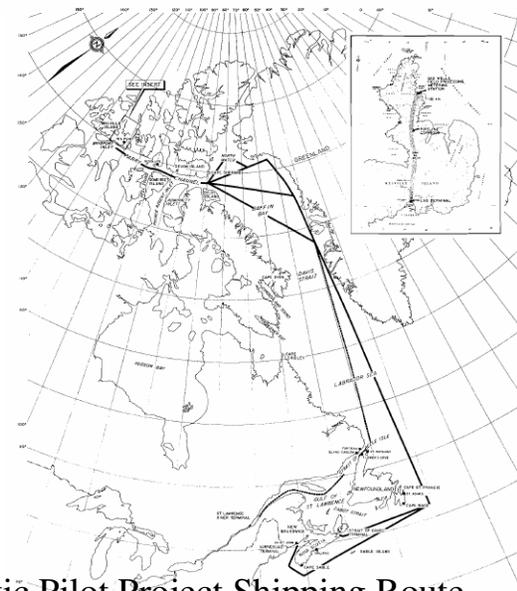


Arctic Pilot Program – LNG

- The late 1970s and early 1980's brought the prospect of Arctic LNG ships with a number of projects being studied.
- The Arctic Pilot Program led by PetroCanada was one of the leading projects with plans to build a liquefaction plant at Bridport Inlet on the south coast of Melville Island in the Canadian Arctic islands and to ship LNG in icebreaking LNGCs through the N.W. Passage to eastern Canada.
- Significant work was done on this project before the lower energy prices of the mid 1980s put the project on the shelf.



Artist's Impression – Icebreaking LNG ship



Arctic Pilot Project Shipping Route



New Ships for Kenai Trade - 1995

- In 1995, the Kenai LNG project replaced the original Swedish built ships with two somewhat larger capacity ships, (89,880 cubic meters) built by IHI in Japan.
- The ships are steam turbine driven with and installed power of 21,000 h.p. giving a service speed of 18.5 knots
- The ships, the *Polar Eagle* and *Arctic Sun*, are unique in that they employ free-standing prismatic cargo tanks - so far the only ships in service with this arrangement.

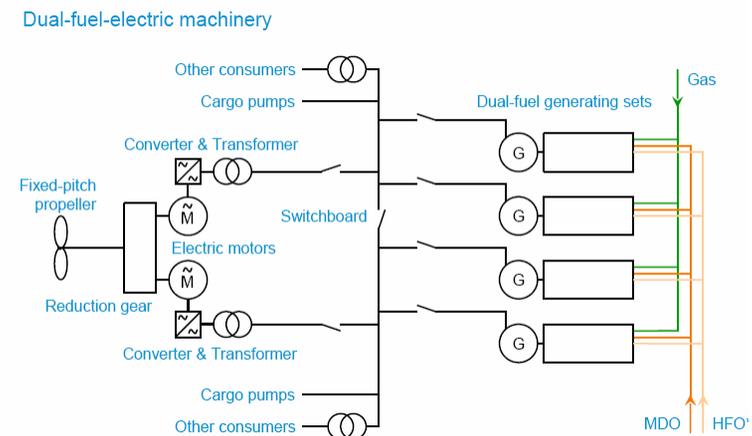


Dual Fuel Diesel Electric LNG Ships

- Traditional LNG ships have had steam turbine plant installed and have used the boil of gas, BOG as a fuel source for the boilers along with heavy fuel as required.
- In recent years medium speed diesel engine technology has been advanced so that these units can now run on dual fuels – gas or liquid.
- The schematic shows a typical arrangement for a DFDE ship with 4 diesel generator sets, feeding two motors connected to a single propeller through a gearbox.
- Depending on the service it is possible to use prime movers of different size to optimize performance, both in terms of fuel consumption and air emissions



DFDE LNG Ship *British Emerald*



Re-Gas Ships

- Another relative new development has been the Regas Transport LNG ship, promoted by Excellerate Energy and using the APL submerged turret loading systems
- In addition to their cargo tanks these ships are fitted with vaporization equipment and submerged turret loading such that LNG cargo can be turned back into natural gas and then exported to new or existing offshore pipelines for onward transport to market.
- It is also possible to use these type of ships as offshore storage units with ship-to-ship transfer taking place between the transport ship and the storage ship

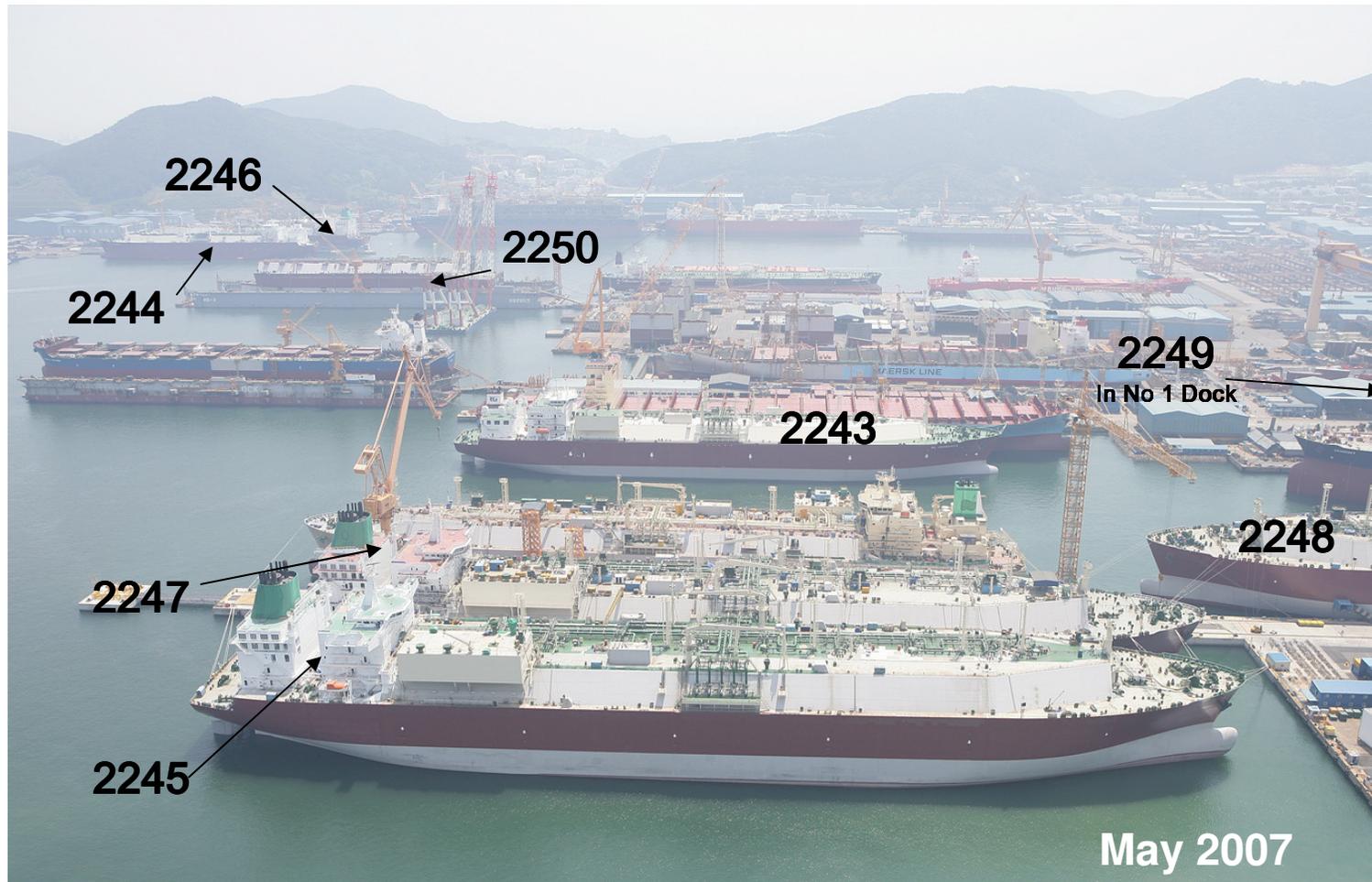


Q-Flex & Q-Max LNGCs

- Qatargas has pioneered the development of two new classes of Liquefied Natural Gas (LNG) tankers. Referred to as Q-Flex and Q-Max. Each ship has a cargo capacity of between 210,000 and 266,000 cubic meters.
- These new vessels have many innovative features to maximize cargo deliveries and to ensure the highest levels of safety and reliability, some of which include:
 - Twin engines and shafts to ensure maximum propulsion safety and reliability, with reduced environmental footprint and twin rudders to ensure safety of navigation and maneuverability in confined waters.
 - Slow speed diesel engines which are more thermally efficient than steam turbines and therefore burn less fuel, which will produce 30% lower overall emissions compared to traditional existing LNG carriers.
 - Cargo re-liquefaction plants will return cargo boil off to the cargo tanks and therefore maximize the cargo delivery at the discharge port.
- The vessels are currently being constructed at three shipyards in South Korea: Hyundai Heavy Industries (HHI) at Ulsan, Samsung Heavy Industries (SHI) on Geoje Island and Daewoo Shipbuilding & Marine Engineering (DSME), also on Geoje Island.



QatarGas LNG Ships at DSME, Korea



QatarGas LNG Ships at DSME, Korea

Comparison of “standard” sized LNG ~145,000m³ with
“super-sized” LNG ~210,000+ m³



Lead Ship Q-Max Class 266,000m³

Lead Q-Max “MOZAH”
alongside outfit berth,
Samsung Heavy Industries.
Geoje Island, Korea

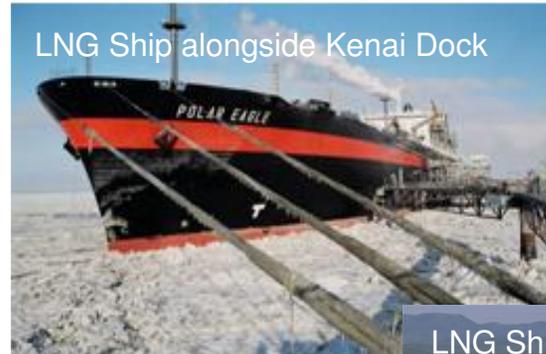


Lead Q-Max “MOZAH”
returning from Sea Trails

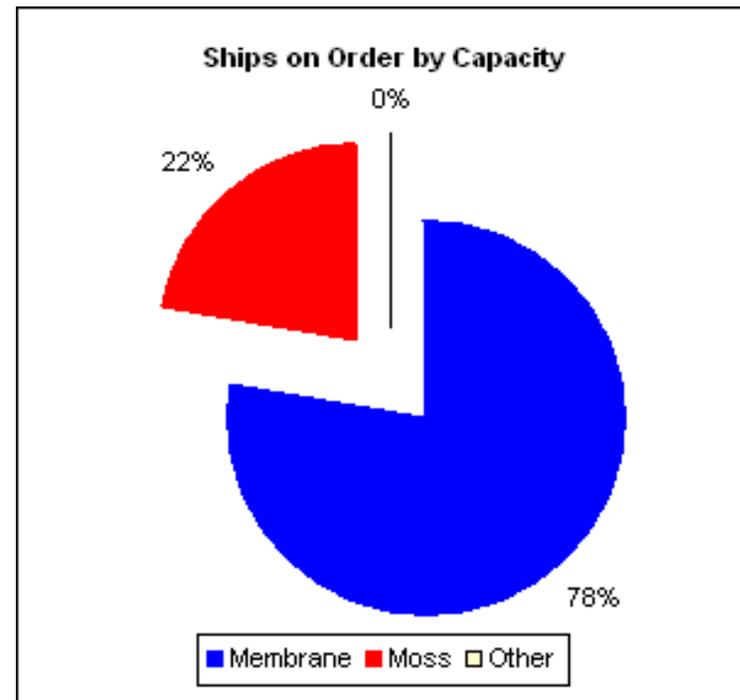
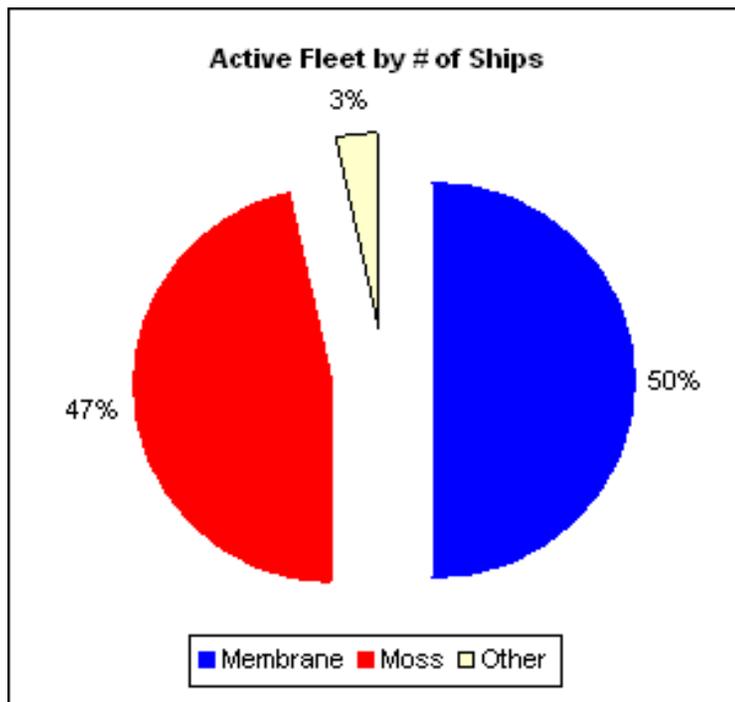


Harsh Environment LNG Shipping

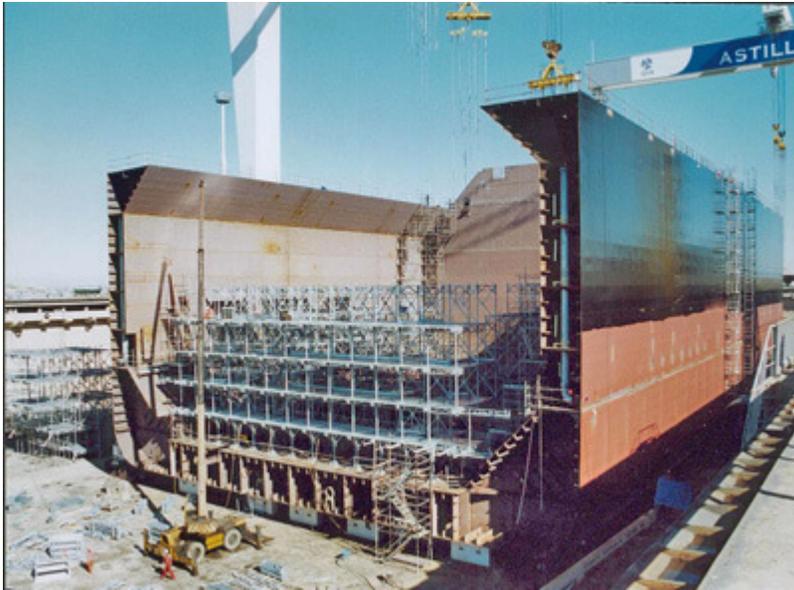
- An number of high latitude – harsh environment LNG projects are already underway and more will come in the future
 - Kenai – started shipping in 1969
 - Snohvit – started shipping in 2007
 - Sakhalin – will start shipping in 2009



Cargo Containment System Usage



Membrane Tank Construction



Build a double hulled ship mid-body and start to scaffold the tanks



Complete scaffolding of the cargo holds to access the whole inner surface of the tank



Membrane Tank Construction continued



Complete installation of membrane system and install cantilevered pump mast



Completed tank with pump mast installed



Conclusions

- Natural gas is the fuel of choice for many applications and its increasing popularity will keep the demand for efficient shipping high.
- Large LNG ships are here to stay, although the increasing size of LNG ships may have already reached a natural limit, at least for the time being based on current infrastructure and markets.
- We will continue to see developments in improved LNG containment systems, and propulsion systems.
- New projects with particularly challenging conditions such as shipping LNG from the Russian and Canadian Arctic will provide exciting challenges for naval architects, marine engineers and shipbuilders in the years ahead.



Questions?



Methane Pioneer in Louisiana, loading first cargo of LNG bound for UK, January 1959

