Natural Gas: A Viable Marine Fuel in the United States

Prevention First 2012

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- Historical Perspective for changing fuels
- Regulatory Developments
- Role LNG could play in the USA
- Emissions
- Cost
- LNG Marine Technology to make it all possible
- Macro benefits

Shift from Wind to Coal (1880’s)

	Cons	Pros	Motivated by
Wind to Coal (1880's)	High Investment Cost	Higher average speed	Economy
	Global Availability	Better flexibility and regularity	
	Crew Costs	Improved earnings	
	Technical Uncertainties		
	Loss of deadweight and cargo volume		

Shift from Coal to Oil (1920’s)

	Cons	Pros	Motivated by
Coal to Oil (1920's)	Lack of Bunkering Infrastructure	Improved Fuel Efficiency	Economy
	Global Availability	Improved Cargo Capacity	
	Crew costs	Reduced Crew	
	Technical Uncertainties	Improved Endurance	
		Less Harmful Emissions than coal	

Shift from Oil to LNG (NOW)

	Cons	Pros	Motivated by
Oil to LNG (NOW)	Lack of Bunkering Infrastructure	Improved Fuel Efficiency (Lean Burn Gas Engine Technology)	Economy
	Crew Costs	Reduction of harmful emissions - Nox, Sox, CO2, PM	Environment
	Technical Uncertainties	Lowest Cost in USA	
	Loss of Deadweight Cargo Volume	Simplistic Power Plant (no need for centrifuges, sludge and settling tanks ect)	
	Global Availability	Reduced lube oil consumption and component wear due to cleaner combustion.	

Regulatory Developments

- Formation of **International Standards Organization TC67 Committee, Work Group 10 Project Team 1**

- To develop Interim *Guidelines for Systems and Installations for Supply of LNG as Fuel to Ships* to be released in Spring 2013.

Regulatory Developments

- ABS – Guide for Gas Fueled Ships
- IMO – Interim Guidelines on Safety for Natural Gas Fuelled Engine Installations in Ships.
- IMO – Code of Safety for Ships Using Gas or Other Low flash-Point Fuels with Properties Similar to Liquefied Natural Gas (proposed at BLG 16)
- Guidance Document - IGC Code (New Revision)
- USCG CG-521 Policy Letter No. 01-12 (19 April 2012) establishes design criteria for natural gas fuel systems that provide a level of safety that is at least equivalent to that provided for traditional fuel systems by existing regulations.

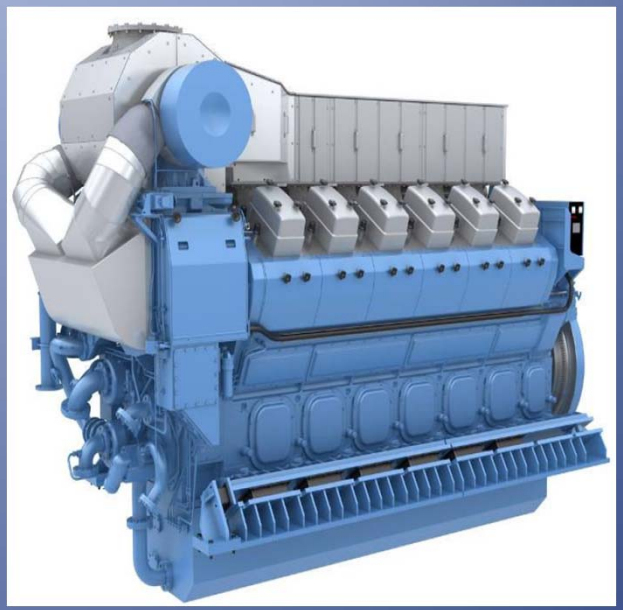
Regulatory Developments

- Gas Fuel Code
- A new mandatory Code is being developed to establish standards for gas fueled ships, other than vessels covered by the IGC Code, operating with gas or low flash point liquids as fuel. Mandatory criteria are provided for the arrangement, installation and operation of machinery, equipment and systems for such vessels to minimize the risk to the ship, its crew and the environment.

Regulatory Developments

WG 17 GE - Gas Engines

Aim	Chairman
This CIMAC WG should enhance the technical and scientific exchange of experience and should deal with some of the most urgent issues for gas engines like exhaust emissions, performance, safety and gas quality. Appropriate technical information will be elaborated and published in form of CIMAC Recommendations or as CIMAC Positions. Position paper About the influence of Ambient Conditions on Efficiency and Emissions of Gas Engines Position paper Information about the use of LNG as Engine Fuel Position paper Information about the Influence on Nox Emissions of Ammonia in the Fuel Gas Position paper on TRANSIENT RESPONSE BEHAVIOUR OF GAS ENGINES (April 2011)	Lars Magne Nerheim, siv ing Bergen University College Høgskolen i Bergen, HIB Nygårdsgaten 112 5020 Bergen Norway Phone: ++47 55 58 76 78 Fax: ++47 55 32 64 07 e-mail: lars.nerheim@hib.no



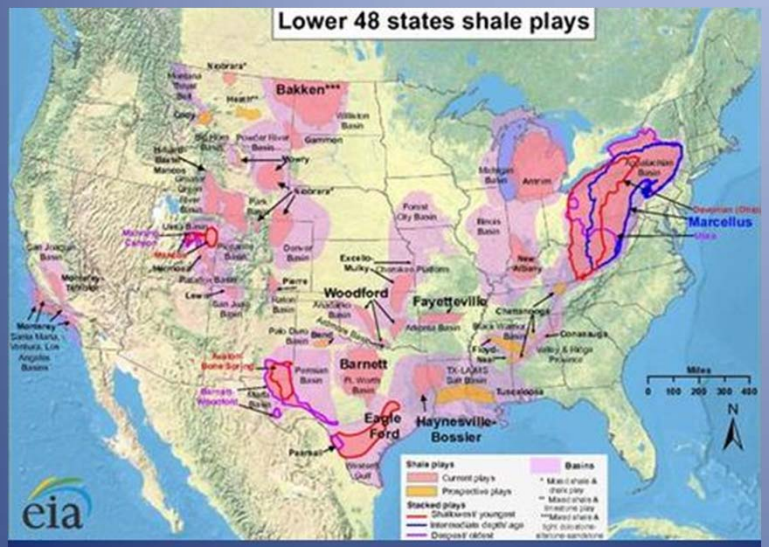
All CIMAC Working Groups

- WG 2 CS-D - Classification Societies
- WG 4 CD - Crankshaft Rules
- WG 5 EEC - Exhaust Emissions Control
- WG 7 F - Fuels
- WG 8 ML - Marine Lubricants
- WG 10 - Users
- *WG 13 TE - Turbocharger Efficiency (closed after publishing recommendation no. 27)*
- WG 14 UR - Unified Rules for Vibration Analysis and Measurement
- WG 15 ESS - Electronics and Software Systems
- WG 17 GE – Gas Engines

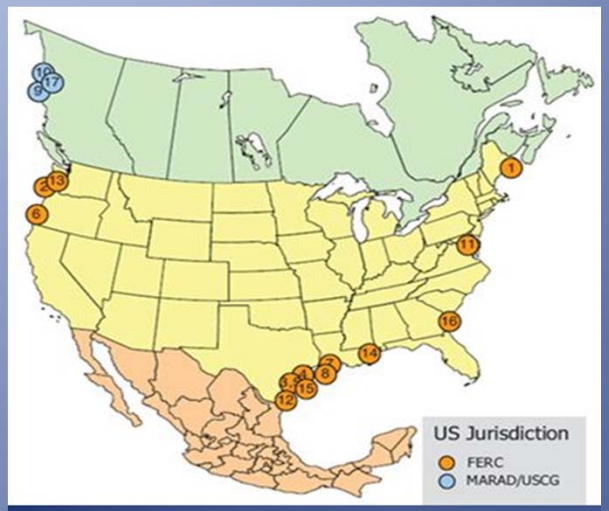
What is LNG?

- **LNG is liquefied natural gas**
- Liquefied by cooling to -260˚F
- Stored at ‘low pressure’ (<150 psig)
- Liquefaction increases the purity – almost pure methane (CH4)
- **LNG is 618 times more dense than natural gas**
- LNG requires 1.7 times the volume of diesel for the same energy value.

The Role LNG Could Play



Shale Gas Locations in the U.S.



LNG Inport/Export Terminals

Marine Highway Corridors

Emission Control Areas

EPA Marine Emissions Summary

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel % Sulfur content outside ECA's	3.50%								0.50%
Fuel % Sulfur inside ECA	1%			0.10%					
Category 1,2 Engines	Tier 2		Tier 3		Tier 4				
Category 3 Engines	Tier 2				Tier 3				

- **Sulfur content of fuel will be reduced both inside and outside the ECA's.**
- **CARB more stringent (only recognize distillate fuel).**
- **EPA regulates HC, PM for Category 1,2 engines with 90% reductions for Tier 4.**
- **Tier 3 and 4 will require After Treatment for distillate and residual fuel users.**
- **Category 3 emissions requirements are less stringent (only look at Nox). EPA and IMO are same here only.**

Diesel vs Natural Gas Emissions Comparison

25-30% CO2 reduction

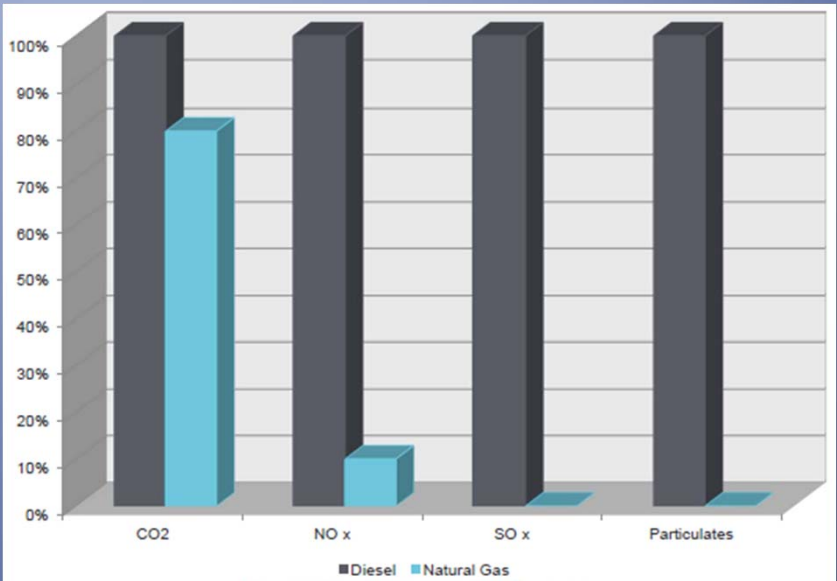
80-92% Reduced NOx emissions

98-100% reduced SOx emissions.

92-98% Reduced Particulates

Long-term compliance with local port, IMO and EPA regulations.

Potential tax benefits.



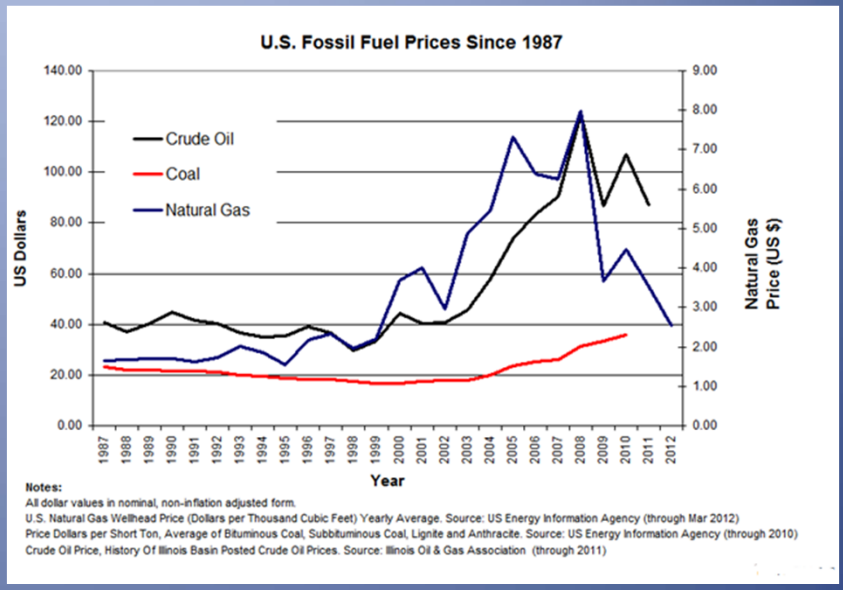
Fossil Fuel Emission Levels
- Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Source: EIA - Natural Gas Issues and Trends 1998

Natural Gas Cost Analysis

Wellhead price comparison for natural gas and crude oil in the USA. Natural Gas and Coal pricing are similar but Natural Gas has the edge with regard to emissions.



International wellhead cost comparison shows USA with lowest pricing.

What does this mean for the Ship Owner?

- Burn Ultra Low Sulfur distillate and install after treatment by 2015

- Or switch to LNG

What is needed to develop Small Scale LNG infrastructure in the United States?

Bulk Storage tanks and LNG Liquifaction plant in close proximity of US Ports. (Halhjem Norway)

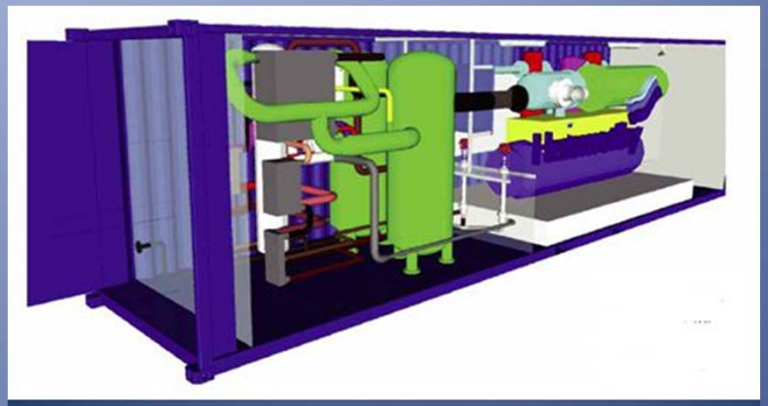
Carbon Pricing - The World Business Council for Sustainable Development has provided a vision for 2050: Secure and Sufficient Supply of Low Carbon Energy.

ISO 40' Cryogenic Container for LNG Transport

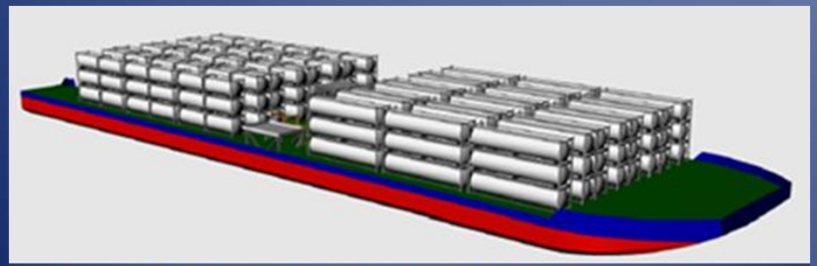
Small Scale LNG Tank Vessels such as the "Norgas Innovation" are dedicated to the mini-LNG business in Scandinavia.

What is needed to develop Small Scale LNG infrastructure in the United States?

LNG Hybrid Power Barge (Becker Marine Systems). In port power solutions with ultra low emissions.



Mini LNG liquefaction plant that comes in standard 40' ISO container. (Hamworthy)



Intermodal LNG Barge Concept (Argent Marine)

A well organized LNG company working closely with a port authority such as Risavika harbor in Norway. Similar relationships need to develop in the USA.

What is needed to develop Small Scale LNG infrastructure in the United States?

More Floating Liquid Regassification and Storage Units (FLRSU) in the GOM?

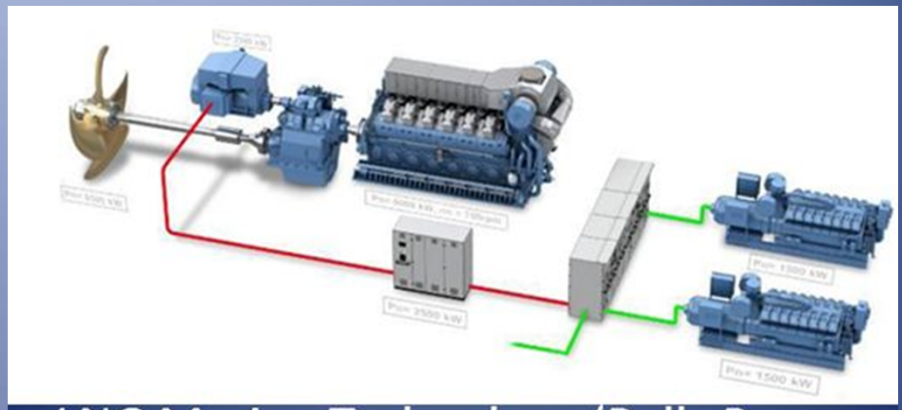
More Floating Production Storage and offloading units (FPSO) in the GOM?

More Floating Liquid Natural Gas Units (FLNG) in the GOM?

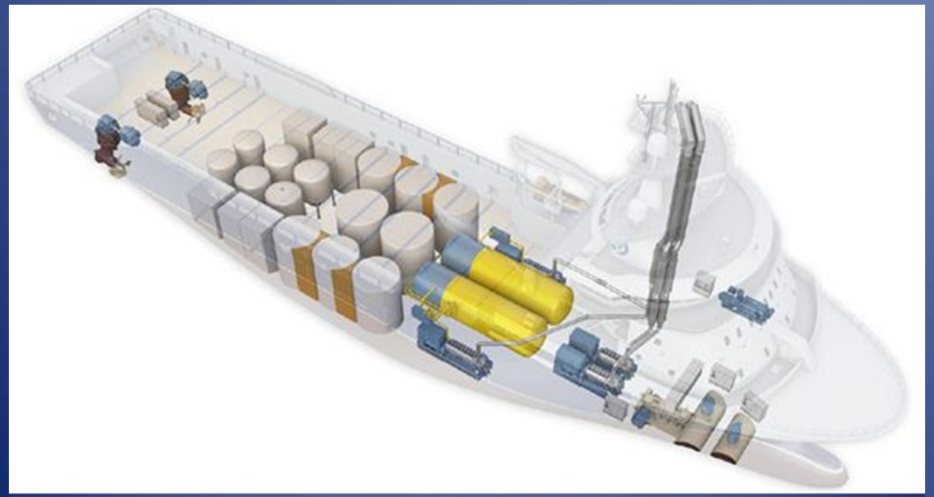
More Floating Storage and Re-gasification Units (FSRU) in the GOM?

LNG Marine Technology

TGE Marine New Construction or Conversion Concept



LNG Marine Technology (Rolls Royce Gas Hybrid)



Rolls Royce Lean Burn Gas Powered Supply Vessel UT776 CDG

Wartsila 50DF

Signs of the Times ?

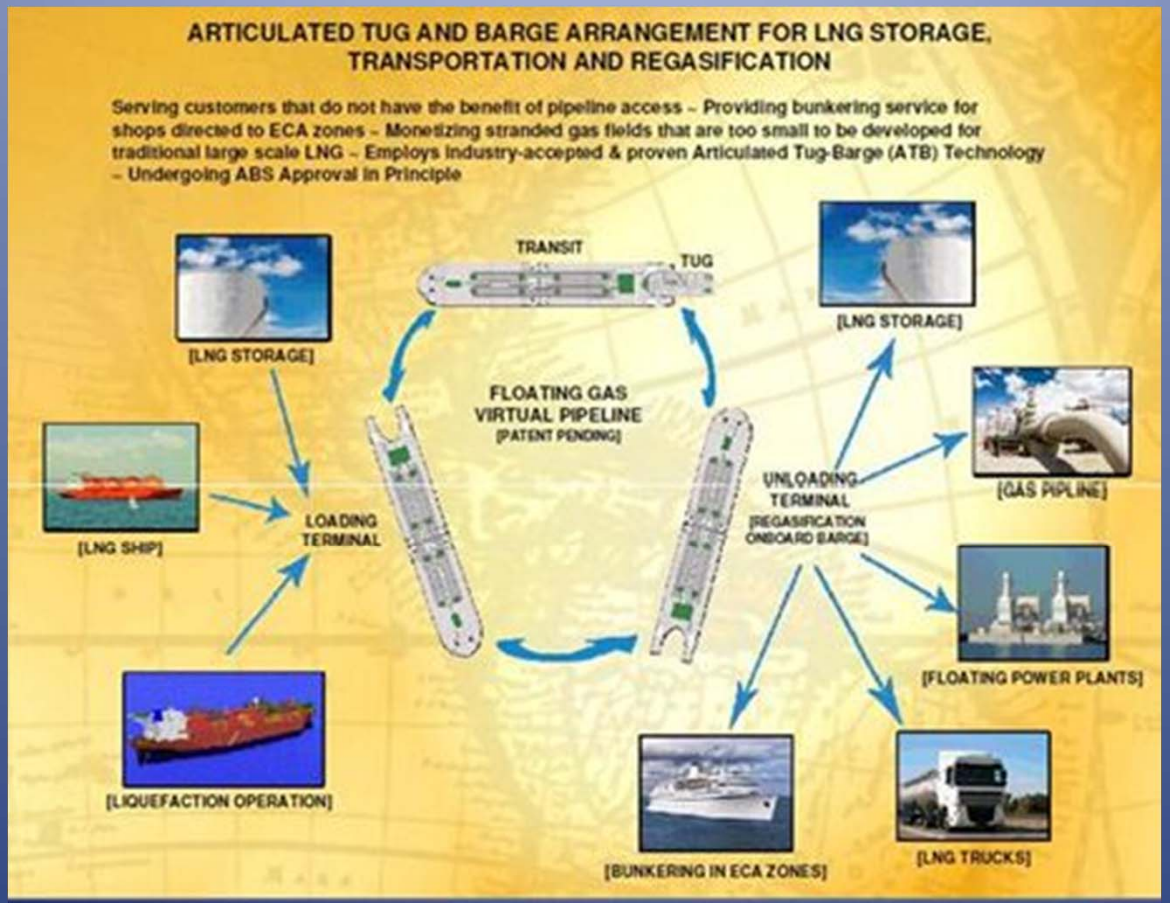
Harvey Gulf Charters 6 LNG Fueled OSV's

Shell to Charter Barges Powered Soley by LNG

Staten Island Ferry to run on LNG

The Staten Island Ferry will receive $2,340,000 in federal funding for a pilot program for conversion from diesel fuel to liquefied natural gas, U.S. Sens. Charles Schumer and Kirsten Gillibrand announced last week.

Signs of the Times ?



Articulated Tug Barge Concept from Waller Marine

Macro Benefits of Switching to Natural Gas as a Marine Fuel in the USA

- Energy Independence and energy infrastructure here at home.
- A possible revitalization of our industrial base.
- Transportation Independence (i.e. Rebuilding the Jones Act Fleet)
- Improved Efficiency of the U.S. Intermodal Transportation System by utilization of the U.S. Marine Highways.
- Reduction of Greenhouse Gas Emissions
- Provide a bridge to other gaseous fossil and renewable fuels.

Thank You

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