

Changing Energy

Types, Sources, Demands and Policies

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AECOM National Ports & Marine Group
AAPA Maritime Economic Development Energy Projects Seminar
February 24, 2015

Agenda

- » Alternative Energy
- » Benefits of LNG
- » History of Marine Propulsion
- » Regulatory Drivers and Initiatives
- » Industry Response
- » LNG in Marine Vessels
- » Stakeholder Involvement
- » LNG Infrastructure
- » Summary

Solar-, Wind-, & Wave/Tidal-Power

» How ports are involved:

- » Ingenuity
- » Implementation
- » Operational support
- » Staging & Transportation



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LNG, a fuel for the future



Bit Viking: The First Tanker to Get its HFO System Replaced by LNG System



Kenworth T880 gets natural gas power



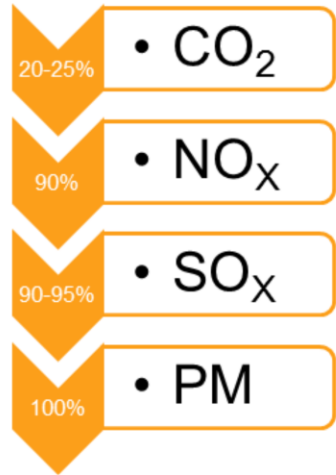
BNSF to Test LNG Locomotives, USA



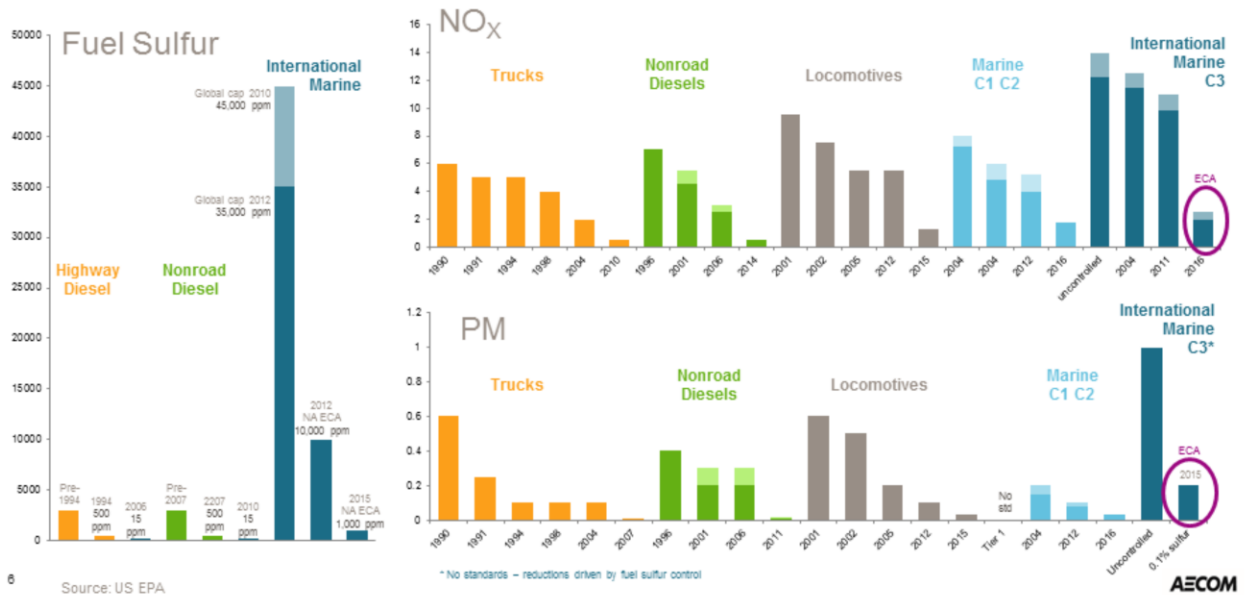
ULA, Blue Origin to fire LNG into space

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Benefits of LNG

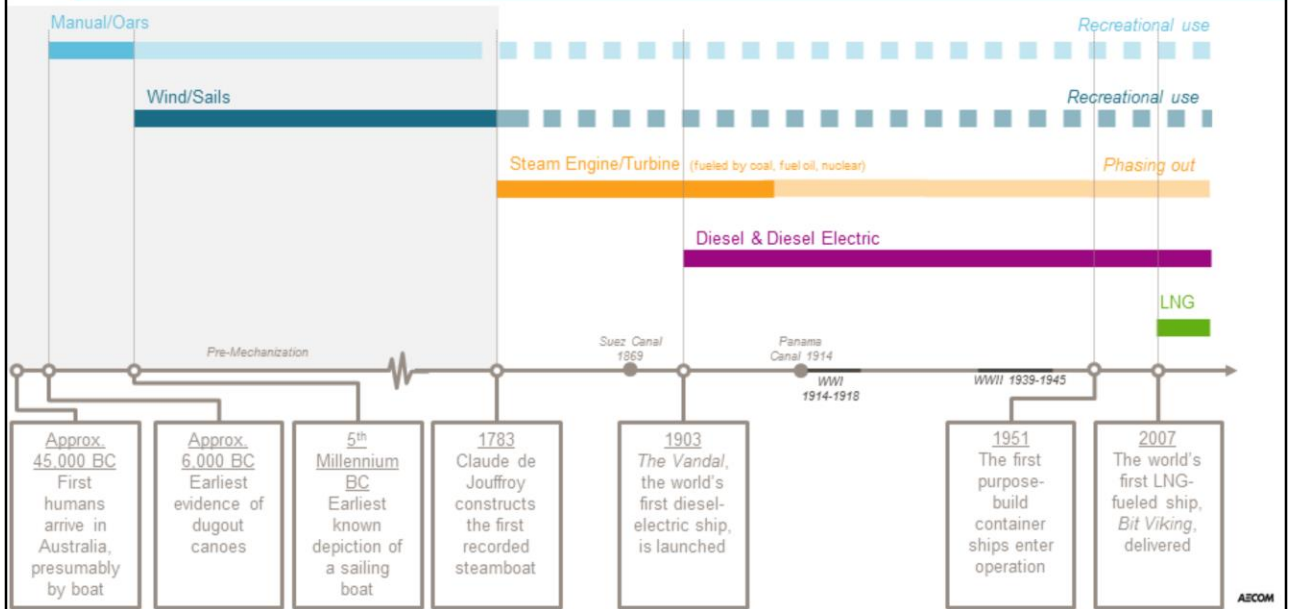


Emissions Standards in all Transportation Modes



And in fact, we have seen emissions reductions across all transportation modes through the EPA.

Brief History of Marine Propulsion



Regulatory Drivers and Initiatives

- » Emission Control Areas (ECAs) – MARPOL Annex VI
- » Energy Efficiency Design Index (EEDI) & Ship Energy Efficiency Management Plan (SEEMP) – MARPOL Annex VI



- » US MARAD: America's Marine Highway Program and Short Sea Shipping

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»Emission Control Areas (ECAs) – MARPOL Annex VI

»Designated areas where stricter controls on emissions for ships are enforced in jurisdictional waters.

»Current ECA are:

- »Baltic Sea – enforced since 2005
- »North Sea – 2006
- »North American (US and Canadian coasts) – 2012
- »US Caribbean (including Puerto Rico, US Virgin Islands) - 2014

»Energy Efficiency Design Index (EEDI) & Ship Energy Efficiency Management Plan (SEEMP) – MARPOL Annex VI

»Regulations on energy efficiency for ships, both existing and newbuilds

»US MARAD: America's Marine Highway Program

»Encourages the use of the Nation's navigable waters for commerce

Cost Advantages and Environmental Regulations will Motivate Marine Operators to Use LNG

- » Operators with routes within ECA zones are the best candidates for early adoption of LNG
- » U.S. flagship carriers on the Gulf Coast are excellent candidates for being early adopters:
 - » Pasha (beginning 2015):
Manatee – Veracruz - Altamira - Manatee
 - » Intermarine:
U.S. Flagged Charters for U.S. Ocean
- » Emerging Markets
 - » Cruise Lines
 - » Passenger Ferry Services
 - » Tug Operations
 - » Offshore Oil Services
 - » Short Sea Shipping with Mexico/Caribbean Basin
 - » Cuba



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Industry's Response

» Technologies and operational strategies used to be compliant

"Tremendous Potential" for LNG Conversions, but There Are Challenges shganduniar.com



Clean Marine Wins Contract for Scrubber Installation shganduniar.com



First Installation for Bunker Saving Solar Energy System shganduniar.com



SCR Scrubber System for Marine Engines First to Receive Approval from MAN shganduniar.com



10 more CMA CGM ships to get bow retrofits shganduniar.com



Cruise Ship to Get Scrubber Ahead of Schedule shganduniar.com



Construction Begins on Crowley's New LNG-Powered ConRo Ships shganduniar.com

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- »Technologies and operational strategies used to be ECA compliant
 - »Pre-Treatment Technologies
 - »After-Treatment Technologies
 - »Alternative Fuels

Ocean Going Vessels are Moving to LNG



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Tugs, Ferries and Cruise Lines are Operating on LNG

AIDA Duel-Fuel Newbuilds



MS Viking Grace, LNG Ferry



LNG Powered Tugs (Sanmar/Rolls Royce)



Incat, LNG Powered Fast Ferry (58 knots)



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LNG also Provides Benefits for Container Handling Equipment



Kalmar LNG Reach Stacker



LNG Yard Tractor

- »Technologies and operational strategies used to be ECA compliant
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LNG is Being Evaluated and Adopted in Long-Haul Land-Based Transportation

GE LNG Locomotives
2014 Pilot Program with CSX



Kenworth T800 LNG Trucks

- Operating range of 300-500 mi
- Dash-mounted display to monitor the LNG fuel level
- LNG fuel tanks can be configured to suit a range of customer requirements
- Qualify for up to \$28,800 in IRS tax credits

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- »Technologies and operational strategies used to be ECA compliant
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Significant Investments in LNG

Baltic Ports Organization initiates LNG bunkering project lngworldnews.com



LNG Emerging As Fuel Of Choice For Vessels, Ferries aqr.com



TOTE finalizes charter for LNG-powered containerships lngworldnews.com



AIDA: LNG Bunkers are the Future for the Cruise Ship Sector lngworldnews.com

Deltamarin scores LNG icebreaker deal lngworldnews.com



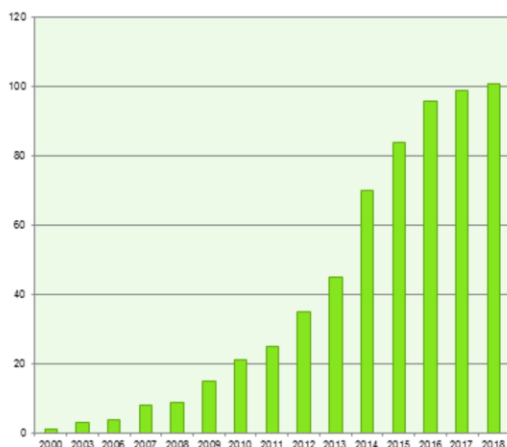
LNG Transport Applications Abound; Offer Environmental Benefits breakingenergy.com

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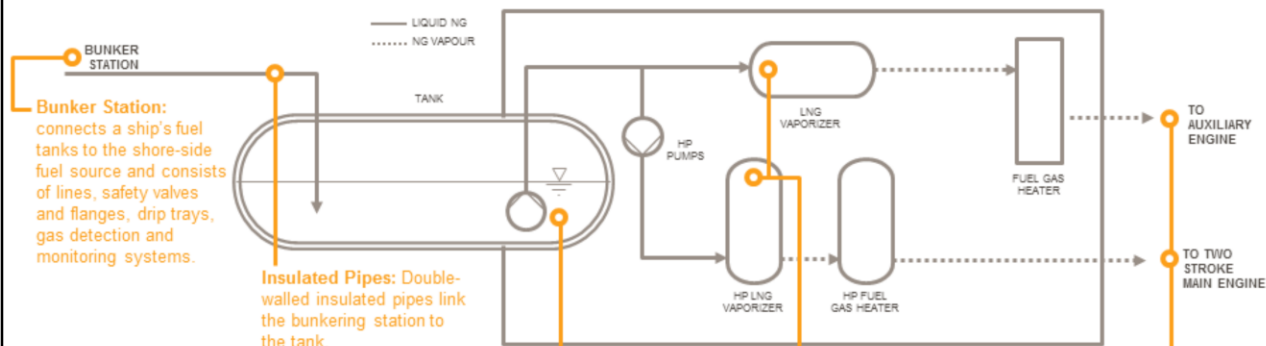
LNG as a propulsion fuel will be an historic change akin to the conversion of sail to steam or from steam to internal combustion

- **63 ships will use LNG this year,** out of approximately 55,000 merchant ships operating worldwide, according to Norwegian classification society Det Norske Veritas.
- In the container sector the numbers are smaller still, however, **newbuilds are currently under construction.**



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LNG in Marine Fuels



Storage Tanks: Shape, barriers, and pressure dictates the construction of tanks for the bulk storage of liquefied natural gas. Due to the lower energy density and the necessary low storage temperature of LNG (-162°C), storage tanks must be larger to provide the same operating range as the diesel counterparts and to accommodate the need for vacuum or foam insulation. Three tank types suitable for fuel tank storage of liquefied natural gas for gas-fuelled ships:

- Type A
- Type B
- Type C

Vaporizer: The pressure building unit vaporizer is used to convert the liquefied gas into a gaseous state in preparation for the delivery to the engine.

Engine: From the tank room, gas is fed by the main gas valve to the engine. LNG engines are currently available in three schemes based on the ignition process used:

- spark ignited
- dual fuel
- gas diesel

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LNG Trends “the debate is on”

- LNG as a marine fuel has heightened as deadlines approach to reduce sulfur emissions globally.
- Reduction in fuel sulfur content estimated to cost the container sector alone \$75 billion or more per year.
- Lloyd's Register survey revealed that by 2020, ports expect 13 percent of bunkers will be LNG, and by 2025, 24 percent of the bunker fuel will be LNG.
- Some maritime industry thought believe LNG can become a viable alternative to fuel oil as a bunker fuel.
- Others argue that from a design and logistics standpoint, LNG will never come into widespread use.

LNG Operations in the Gulf

Carib Energy is Now a Crowley Company



Working closely, Carib Energy allows Crowley to now offer a comprehensive and diverse suite of LNG services that including vessel design and construction; transportation; product sales and distribution, and full-scale, project management solutions throughout the U.S., Caribbean and Central America.

Carib Energy is the first company to receive a small scale, 25-year, LNG export license from the U.S. Department of Energy (DOE) for LNG transportation from the U.S. into Free Trade Agreement (FTA) countries, and a small-scale, 20-year LNG export license from the DOE from the U.S. into Non-Free Trade Agreement (NFTA) countries

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Port LNG Facilities - Examples

Port Freeport



- Port Freeport (TX) - one of the first LNG import and regasification facilities in U.S.
 - Recent approval of a natural gas liquefaction project (for export) on Quintana Island for three trains – each with annual capacity of 4.4 million metric tons
- Port of Corpus Christi - Cheniere Energy
 - Pending FERC approval for an \$11 billion natural gas liquefaction facility and LNG export terminal on La Quinta

Port LNG Facilities - Examples

- Port of Jacksonville – Clean Energy Fuels
 - Construction to be completed of LNG facility for maritime, heavy-duty trucking and rail industries
- Port Manatee – Air Products
 - Exports of Air Products LNG heat exchangers, a major component of LNG facilities



Global ports are gearing up for a gas-fueled future for shipping

- » “Major ports around the world are either planning for, or are anticipating, the wide-scale development of LNG bunkering,” Lloyd’s Register concluded from a recent 2014 survey of 22 ports globally.
- » It said, compared to its previous survey in 2011, availability of LNG infrastructure rose from being considered a low priority to the second most important driver after demand.



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LNG Creates a Fuel Hedge

- Currently crude oil derivatives such as diesel have no true competition
- Need national recognition that access to reliable and affordable energy is the basis for economic expansion — and global competitiveness



National and International Efforts to Support LNG as Marine Fuel

The draft International Code of Safety for Ships using Gases or other Low flashpoint Fuels (IGF Code) and proposed amendments to make the code mandatory under SOLAS have been approved by the inaugural meeting of the IMO's Sub-Committee on Carriage of Cargoes and Containers (CCC 1).

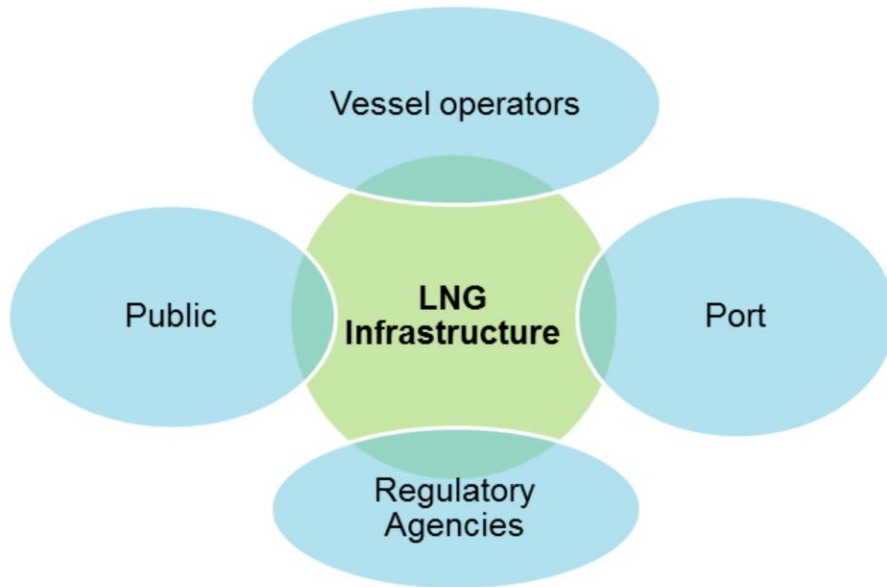
What is needed for LNG Bunkering:

- Infrastructure
- Safety
- Regulatory gaps
- Operations/Training needs



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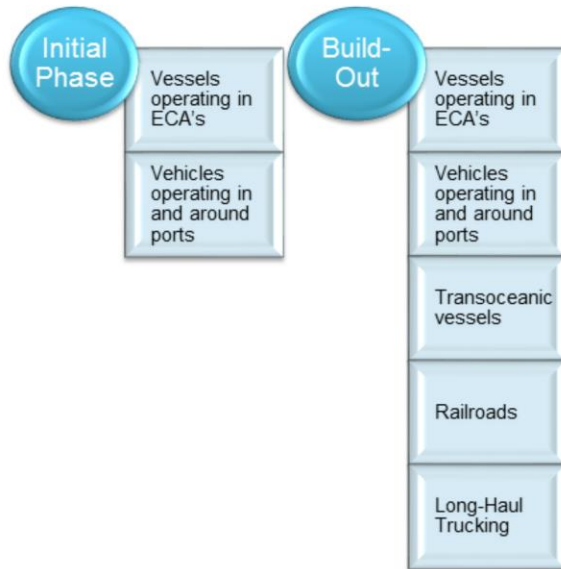
Stakeholders Must All Say “YES”



Stakeholder Drivers & Concerns

Stakeholder	Needs
Vessel Operator	<ul style="list-style-type: none"> • Financial incentive • Technology and infrastructure availability • Regulatory certainty
Ports	<ul style="list-style-type: none"> • Critical customer mass • Facilitate a confluence of space and utilities • Public support • Regulatory certainty
Regulatory Agencies	<ul style="list-style-type: none"> • Lead agency identification
Public	<ul style="list-style-type: none"> • Environmental benefits • Education and safety assurance
Infrastructure Providers	<ul style="list-style-type: none"> • Ample customer base • Long-term fuel contracts • Approval from ports to operate on premise • Adequate space and utilities • Regulatory certainty

LNG Infrastructure to Grow with LNG Demand



What will be the LNG fueling distribution network?

- The scarcity of accessible fueling stations is a major roadblock to expanding the use of CNG and LNG as over-the-road truck fuels.
- There are only 716 [public CNG fueling stations](#) and 54 LNG stations in the U.S., according to the Energy Information Administration.
- U.S. Department of Energy/Energy Efficiency & Renewable Energy "Alternative Fuels Data Center"
- http://www.afdc.energy.gov/fuels/natural_gas_locations.html

LNG Infrastructure Considerations

- Land: Zoned Industrial with rail and deep water access in close proximity to a natural gas pipeline
 - Preferable location: Waterfront with dock
 - Alternative location: Inland, with accessible highway and rail transportation network for port delivery
- Site quality: brownfield vs. greenfield
- Plant Configuration: Footprint, delivery access, dispersion area
- Utilities: Sufficient gas and electricity

Summary

- Europe and East Asia have embraced the transition to LNG
- Only a few U.S. Ports have embraced LNG, but that is changing
- Environmental benefits of LNG
 - New ECAs and the IMO global sulfur standard may be drivers
- LNG has a price advantage
 - Price of oil is low today, but typically a large difference
- Significant LNG investment in N. America

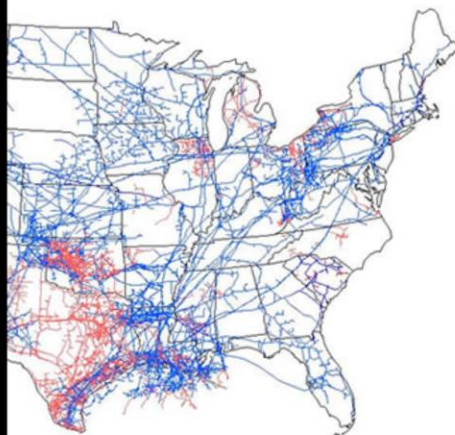
Natural Gas – North American Supply?

- 80, 90, 100,...150,...200 years,...300+ years?

United States Shale Gas Plays



200 years, at current use/current supply
300+ years? - Monterey Shale basin in California



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