Congressional Briefing: LNG in the Great Lakes
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LNG in Great Lakes Transportation

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Great Lakes Maritime Research Institute
A University of Wisconsin - Superior and University of Minnesota Duluth Consortium
Emissions Reductions: A Driver of Change

0.1% Sulfur Limits in ECA effective 2015
European countries such as Norway are significantly more advanced in all areas of using NG as a marine fuel. Tapping into their expertise can reduce costs and time.

- Norwegian Ferry Terminal with LNG storage tanks
Natural Gas: A viable marine fuel option typical questions

- What is the difference between Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG)?
- How much does it cost to change?
  - Capital - initial
  - Ongoing – fuel and maintenance
- Where can I get CNG or LNG?
- What safety concerns are there?
- What regulations will need to be followed?
- Will conversion be economically viable and meet my operational requirements?
- What are the environmental pros and cons
Emission Advantages of LNG Fueled Vessels

Spark Ignited lean Burn Gas Engines:

- ~92% reduced NO\textsubscript{x} emission
- ~22% reduced GHG emission
- 100% reduced SO\textsubscript{x} emission
- Zero smoke
- Low unburnt fuel slip
- Low number of particles
- Low maintenance cost
NG Relative Price Stability

energy spot prices
2012 dollars per diesel gallon equivalent

History

Projections

Retail diesel
Retail LNG
Retail CNG

Source: EIA, Annual Energy Outlook 2014 Early Release
Nicholas Chase; used with permission
Great Lakes Maritime Research Institute
Natural Gas (NG) Study Overview

The U.S. Maritime Administration (MARAD) funded studies on conversion of the U.S. flag fleet to natural gas (NG) by GLMRI through a Cooperative Agreement established in August of 2011.

Additional support has been provided by the Lake Carriers Association members, the U.S. Coast Guard, the natural gas industry, local agencies and businesses.

Extensive literature review: Studies, presentations, websites, and video clips concerning the use of CNG & LNG for all modes and general information is available online at www glmri org
GLMRI Study: Topics

• Research existing maritime and other modal usage of CNG and LNG
• Developed designs for Great Lakes vessel conversion.
• Evaluated the air emissions of a variety of fuels.
• Researched CNG and LNG Supply & Distribution in the Great Lakes Region.
• Researched regulatory issues in using NG for ships.
• Engaged in outreach for knowledge dissemination and technology transfer.
General Study Findings for the Great Lakes Region

• The LNG and CNG supply chains are in their infancy.

• High Horsepower (over 500 BHP) users more likely to use LNG rather than CNG because of energy density.

• The NG industry is interested in expanding the supply chain. There is a lack of liquefaction plants to produce LNG.

• Adoption by multiple modes/user groups can further reduce costs.

    Marine, Rail, Trucking, Mining, Agriculture, Off-the grid are all starting to adopt natural gas as a fuel.
U.S. Marine Natural Gas Fuel Projects

- Interlake Steamship planning on converting Great Lakes vessels to LNG. Ohio
- Washington State Ferries study use of LNG as a primary fuel. Washington
- Staten Island Ferry exploring moving to LNG. NY
- Harvey Gulf Marine building four LNG offshore supply vessels. LA
- TOTE converting RO/RO vessels to LNG. WA & AK
- LNG fueled container vessels on order. FL & PR
- VanEnkevort Tug & Barge, Inc. planning on converting Great Lakes vessel to LNG. MI
Gaz Métro Transport Solutions will be supplying liquefied natural gas (LNG) to three new ferries ordered by the Société des traversiers du Québec.

The ferry crossings on the St. Lawrence Seaway will be served by the new LNG fueled ships in 2015.
Truck Conversions to CNG or LNG

PTI PAPER TRANSPORT, INC.

SCHNEIDER NATIONAL

Pilot FLYING J

U.S. Venture

La Crosse, WI
- **BNSF's First LNG Fueled Locomotives Placed Into Revenue Service September 18, 2014**
- At present, the four units are being utilized in pairs coupled with a LNG tender car, with GE and Caterpillar subsidiary Electro-Motive Diesel each having providing a pair.
- For fuel, the trains are relying on an existing 20,000 gallon tender built by Air Products and Chemicals, Inc.
- **CN Railroad retrofitted diesel engines in two 3,000-horsepower, Electro-Motive Diesel (EMD) SD40-2 locomotives to run on natural gas and are paired with a LNG fuel tender between them.**
Mining Industry Adopting NG Fueled Vehicles

Figure 23. Close-up of LNG fuel tanks in CAT 793 dual-fuel haul truck at Belle Ayr Mine

![Close-up of LNG fuel tanks in CAT 793 dual-fuel haul truck at Belle Ayr Mine](Source: Gladstein, Neandross & Associates)

![CAT 793 dual-fuel haul truck at Belle Ayr Mine](Source: Gladstein, Neandross & Associates)

Table 17. Estimated Net Present Value of converting one mine haul truck to dual-fuel LNG operation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Baseline Diesel Use (diesel gal/yr)</td>
<td>274,000</td>
</tr>
<tr>
<td>Estimated Incremental Capital Cost (CapEX)</td>
<td>$200,000</td>
</tr>
<tr>
<td>Diesel Displaced (diesel gal/yr)</td>
<td>109,600</td>
</tr>
<tr>
<td>LNG Required (LNG gal/yr)</td>
<td>184,000</td>
</tr>
<tr>
<td>Annual Fuel Cost Savings</td>
<td>$164,400</td>
</tr>
<tr>
<td>Simple Payback Timeframe</td>
<td>1.2 years</td>
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<tr>
<td>NPV of Natural Gas Option vs. Baseline Diesel</td>
<td>$1,542,000</td>
</tr>
</tbody>
</table>

Assumptions: $1.50 per DGE fuel price spread, 40% fuel substitution rate, 20 year life, 7% discount rate, 100% engine efficiency compared to baseline diesel truck
What is a LNG Supply Chain?

• Similar to a Refinery Distribution Model
• Large high pressure pipeline connection from bulk NG sources to Liquefaction plant is best.
• Distribution from Liquefaction plant to end users by:
  – Rail
  – Truck
  – Marine
Supply Chain Study

- Modeled LNG supply chains in U.S. & overseas
- Studied cost parameters in transporting LNG by truck.
- Evaluated potential customer base for new liquefaction plants

New Liquefaction Plant Location Drivers: Access to a Supply of NG, suitable location, and physical distribution system to meet growing market demand.
LNG Cost Breakdown

Cost-effective one way trucking range (drayage) in U.S. is 250 Miles (402 Kilometers).

These percentages can vary depending on location and volume.
Case study of 18th Largest Port in U.S.
Duluth/Superior

Potential NG/LNG customer base: 250 mile (402 Kilometer) radius is cost-effective one-way truck drayage.

- Marine – Great Lakes and Inland rivers
- Rail
- Transit
- Mining
- Trucking
- Agriculture
- Other industries using diesel, heavy fuel or propane and are off the gas pipeline grid.
- Delivery to other users by container, truck, rail or water.
Twin Ports LNG Liquefaction Plant Marketing Region
250 mile (402 Kilometer) drayage

4.3 Million People

Mining
Agriculture
Rail
Trucking
Pipeline
Transit
Marine Transportation

250-Mile Radius of Duluth and Chicago
Potential Liquefaction Plant Locations with a 250 mile (402 Kilometer) dray radius
Topics For Consideration

• There is a significant price differential between Diesel and NG.

• There is a large supply of U.S. natural gas.
  – Gas wells and Oil/gas wells
  – Methane from landfills and composting
  – Methane from Shale Gas deposits

• The supply chain for LNG as a transportation fuel is undeveloped.

• Adoption by multiple user groups will expand the supply chain and realize economies of scale.
Topics For Consideration

• Building the NG supply chain will take time, capital and a public private partnership.

• Transportation companies that use NG will need a safety culture.

• The selection of LNG or CNG will be on a case by case basis driven by fuel availability and economics.

• Diesel will still be used as a primary fuel by all modes. There will not be 100% conversion.
Topics For Consideration

• Emissions are less with NG than diesel but NG is not the only option to reduce air emissions.
  – Scrubber technology for diesel engines – costly & disposal issues
  – Low Sulfur distillate fuel – expensive & needed by trucks

• There are environmental concerns expressed about using NG as a transportation fuel.
  – Methane slip
  – Potential environmental impacts from the Fracking process
  – Emission life cycle comparison to other fuels
  – Micro-particles

• There is concern about transportation NG use raising residential NG fuel costs.
State and Multi-State plans for Adoption of Natural Gas as a Transportation fuel

**Wyoming LNG Roadmap**
Prepared by GNA with support from state of Wyoming

- The State of Wyoming has played an important role in the development of LNG as a fuel for HHP
- The Roadmap characterizes the many choices, considerations, opportunities, challenges and barriers for wide-scale use of natural gas in Wyoming’s HHP vehicle and equipment sectors, and it lays out initial steps in the process to attain that vision.

**Multi-State Compact for supporting the adoption of CNG**

**FIRST STEP- STATES VEHICLE CONVERSION**

On Nov. 9, 2011, Gov. Mary Fallin pledging to use CNG vehicles in the vehicles of 11 other states and working with the Big 3 Automakers

*States In Compact:*
- Oklahoma
- Colorado
- Wyoming
- Pennsylvania
- Utah
- Maine
- New Mexico
- West Virginia
- Kentucky
- Texas
- Ohio
- Mississippi
- Louisiana
GLMRI’s Continuing LNG Research

• Research foreign LNG supply chains
  – Canadian Ferry LNG supply chain
  – European marine LNG Supply chain

• Research containerized transport of LNG
  – Marine transportation options
  – Rail movement of containerized LNG
  – Japanese containerized LNG system

• Supply chain options for Upper Mississippi (north of Vicksburg, MS) and the Ohio Rivers
  – Build on GLMRI and GNA studies
  – Potential location of liquefaction plants
  – Outreach to inland rivers fleets to support adoption
Questions...
ABUNDANCE AND OPPORTUNITY: U.S. Shale Revolution

Amy Farrell
VP of Market Development
America’s Natural Gas Alliance
Driving Demand for Natural Gas
Supply for the Long Run

U.S Production (TCF)

Source: EIA AEO, Historical Production
Fewer Rigs, More Production

Source: EIA - 12 Month Rolling Average of Production and Demand,
Baker Hughes - 12 month Rolling Average of Rig Count
Natural Gas & Methane Emissions

**Total US GHG Emissions in 2012**

- Carbon Dioxide: 82%
- Methane: 9%
- Nitrous Oxide: 6%
- Fluorinated Gases: 3%


**Natural Gas Gross Production & Natural Gas Systems Methane Emissions**

*Source: EIA, EPA 2014*
ANGA Market Segments

- POWER
- TRANSPORTATION
- INDUSTRIAL
- EXPORTS
Transportation
Great Lakes Potential

![Map of Great Lakes Ports]

**Great Lakes Ports**
(annual fuel use in mmBtu)

<table>
<thead>
<tr>
<th>PORT NAME</th>
<th>Fuel Use by Vessel</th>
<th>Switcher Rail Facilities</th>
</tr>
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<tbody>
<tr>
<td>5,000,000 – 20,000,000</td>
<td>Articulated tug barge</td>
<td>25,000 – 50,000</td>
</tr>
<tr>
<td>Port Name</td>
<td>Bulk carrier</td>
<td>50,000 – 100,000</td>
</tr>
<tr>
<td>1,000,000 – 5,000,000</td>
<td>General cargo</td>
<td>100,000 – 800,000</td>
</tr>
<tr>
<td>Port Name</td>
<td>Offshore support vessel</td>
<td></td>
</tr>
<tr>
<td>500,000 – 1,000,000</td>
<td>Passenger</td>
<td></td>
</tr>
<tr>
<td>Port Name</td>
<td>Pushboat</td>
<td></td>
</tr>
<tr>
<td>125,000 – 500,000</td>
<td>Tanker</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tug</td>
<td></td>
</tr>
</tbody>
</table>

**LNG Supply**

- Peak shaver
- Import-Export terminal
- Production plant
- Planned production plant
Key Findings

• No single location
• Coordination is key
• Interest is real
• 62.6 million gallons
Resources

ANGA LNG Opportunities for Maritime and Rail Report
www.anga.us/marinerail

ANGA’s “Moving America” Video
www.anga.us/lng

Moving America: Liquefied Natural Gas

As liquefied natural gas (LNG) is being put to use in a growing number of applications, individuals, regulators and potential customers are asking a number of questions:

- What is LNG?
- How is LNG produced, stored and transported?
- How is LNG ultimately used?

The video “Moving America” takes viewers across the country to answer these questions and explain how greater use of LNG can benefit our nation.

Is LNG New?

No, LNG isn’t new. For more than 50 years, companies have used LNG to generate electricity and deliver natural gas to homes and businesses. But as supplies of natural gas have grown, so have the potential applications of LNG. Trucks, ships, trains and other high-horsepower equipment are capable of running on LNG, and fleet managers of all kinds are turning to this fuel to reduce emissions and operating costs.