Natural Gas: A Transportation Fuel for the Future?

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Supply Chain Discussion

Great Lakes Maritime Research Institute
A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

UNIVERSITY of WISCONSIN Superior

Oil: The marine fuel of the future!

From 1880s until 1950s coal was the principal fuel for Great Lakes vessels.

Special built coal docks were common around the Great Lakes.

A fuel oil supply chain had to be developed to provide oil to the vessels.

Great Lakes Maritime Research Institute

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MARAD five year funding with Lake Carriers and industry support

- **A feasibility study to look at fuel alternatives (natural gas – primarily LNG, with considerations for CNG) for repowering the Great Lakes' vessels.**
- **A demonstration project to consider engineering design implications for a selected ship. (*S.S. Badger* – car and passenger ferry with service between Manitowoc, WI and Ludington, MI)**

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- Supply Chain Study of regional gas availability, and accessibility, liquefaction facilities and capacity, transportation and routing of gas supplies in the Great Lakes region.
- Research into the regulatory requirements for fueling vessels with LNG and CNG at terminals, docks and midstream.
- Education and Outreach with Industry-
  - Great Lakes Waterways Conference, hosted an LNG studies panel
  - Society of Naval Architects and Marine Engineers meeting, 2-day agenda
  - Twin Cities Transportation Club
  - Institute of Supply Management
  - MN Environmental Initiative

Do I use CNG or LNG????

- **Compressed natural gas – Unlikely for vessels**
  - Must be compressed – cost – initial and long term
  - High pressure containment – 4500 PSI
  - Lower BTU content for same volume
  - **High pressure, asphyxiant and flammability safety issues**
- **Liquefied natural gas**
  - Must be liquefied –cost- initial and long term
  - Cryogenic Stored at Minus 160 degrees centigrade
  - Stored at low pressure
  - Higher BTU content for same volume
  - **Cryogenic, asphyxiant, however non toxic not flammable as a liquid**
  - **The selection of CNG or LNG is very case specific!**

Short Haul Locomotive
Pacific Harbor Line Inc. Long Beach/LA

Why it worked well…

- LNG locomotive cost approximately 23% less to fuel on an energy-equivalent basis
  - LNG burned 72 diesel-equivalent gallons compared to 65 gallons of diesel burned by diesel locomotive (per day)
- Emitted an estimated 81% less oxides of nitrogen (NOx) & 57% less particulate matter (PM) compared to new Tier 2 locomotive

Why it didn't work so well…

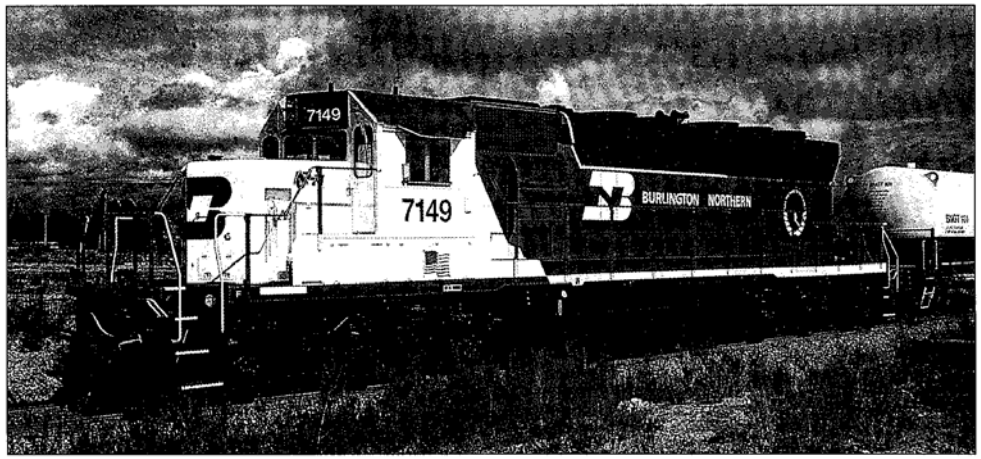
- **Logistics** & mechanical issues associated with fueling negatively impacted the locomotive's service capability
  - Needed to be refueled every 3 days compared to once a week
  - Lacked a reliable fuel gauge
  - Difficult requirements imposed by the local fire department
    - Extra labor during fueling
    - Fee paid to LAPD for fire inspector
  - Fuel slowly boil off over time
- Less reliable than diesel
  - Out of service approximately 15-20% more often than the diesel fleet
  - Low main air pressure, failed spark plug transformer

Experiments on 1200 HP Switch Engine 2008-2009

BNSF Main Line LNG Powered Engines 1991-1996

Conversions worked 1600 mile coal route - 800 mile range

1. **Economical**
    1. BN determined that natural gas to provide a 10% to 20% cost savings over DO
    2. Estimated it could save $200 million a year in fuel if it converted its entire locomotive fleet of engines
    3. Using natural gas reduces engine maintenance costs
    4. It is estimated that engine life cycle can be improved by as much as 40 percent
    5. “engines can go 2 to 3 times as long between lubrications, oil, and filter changes.”
2. **Not adopted because LNG supply chain not mature**
3. **Experiments done prior to current discovery of natural gas reserves**



Burlington Northern 7149 is the second SD40-2 converted to use natural gas as a fuel source, but the third locomotive in BN's history. In 1983, GP9 1961 was converted to burn natural gas.

Mining Industry Conversion of Trucks

GFS CORP™

Converts CAT 777C to 60% Liquefied Natural Gas – 2010

Bi-Fuel conversion system

Operates in coal mines Harlan County, KY

Preparing to convert fleet for KY and WV

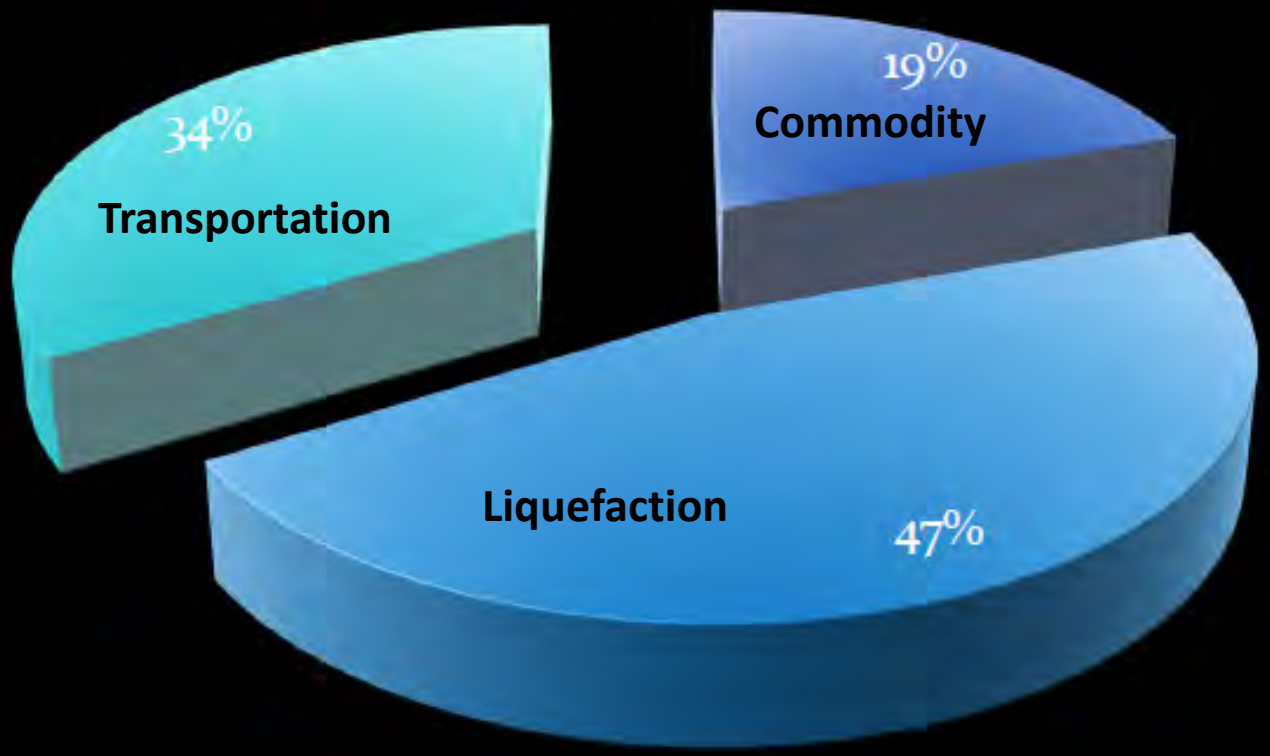
US Flag LNG Powered Offshore Supply Vessels

- Despite some of the higher initial costs and design challenges, LNG fueled vessels are still a very attractive option.
- Harvey Gulf believes that the use of LNG fueled vessel will continue to provide company growth by continuing to meet customer demands.
- Harvey Gulf anticipates that LNG fueled vessels will maintain and enhance its competitive advantage.

Building four U.S. flag vessels:

2- 2,700KW Internal Combustion Engines: Total LNG fueled engines 7,500 KW
LOA 302',
Draft 20' 4.5"
Beam 64'

LNG Cost Breakdown (February 2012)

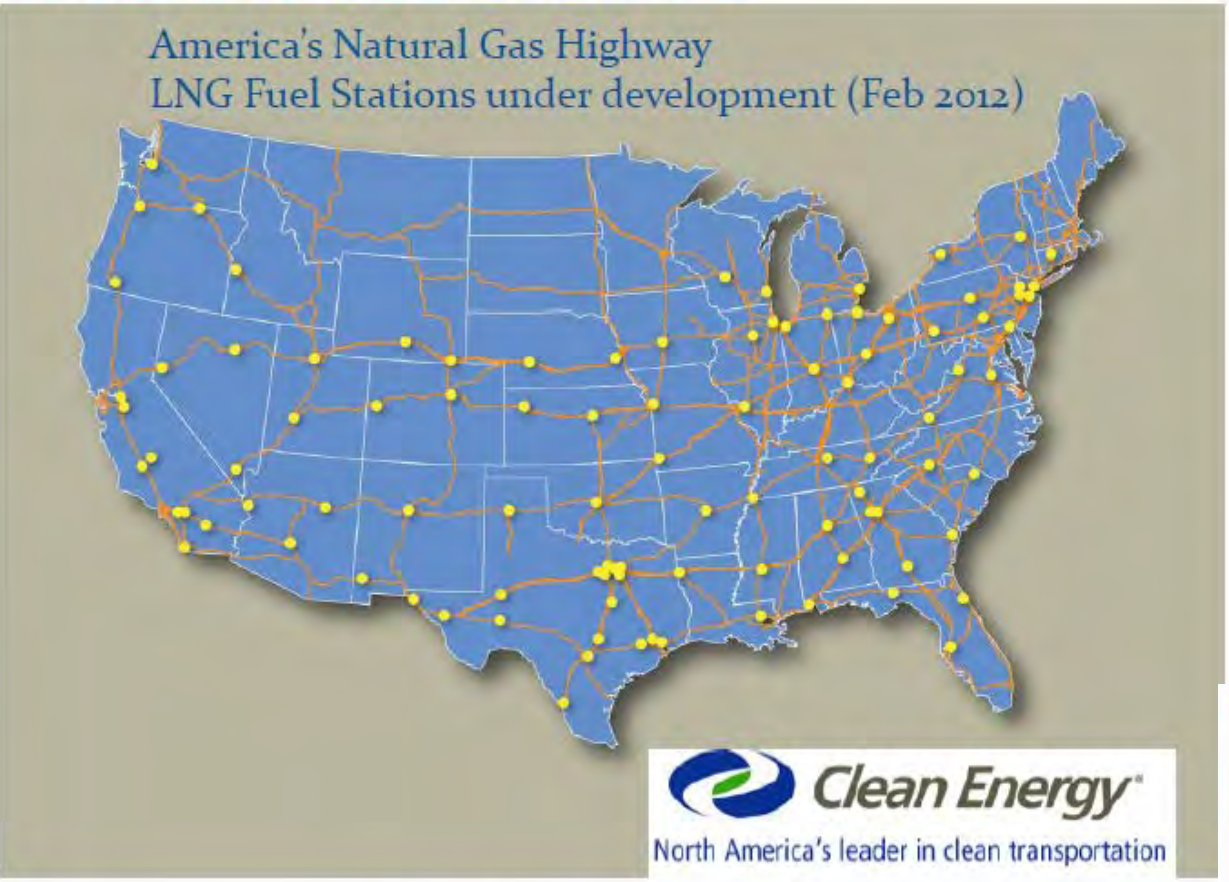


These percentages can vary depending on location and volume .

What is an LNG supply chain like?

- Liquid Cargo Distribution
- Similar to Distillate Distribution
- Liquefaction Terminal to End User
  - Ports/Vessel Fueling
  - Fleet Yards
  - Refueling Stations
  - Other
- Independent of Pipeline
  - Complement
  - Alternative

LNG AVAILABILITY



c Mystic River Partners 2012

LNG Truck station Seville, OH
Partially funded by OH grants

Clean Energy Investing $150 Million in LNG stations in the US.

Fueling a truck http://www.youtube.com/watch?v=s-8zCUPoxu0&feature=related

Europe has been using LNG fueled ships for a decade!

Natural Gas as Fuel for Future Vessels

- 35 daily port calls 51000/year
- Engines have run more than 35.000 hrs since Jan 2007
- NOX reduction = 160,000 cars running for 1 year

Lets see her underway!

Baltic using marine LNG supply chain

Bunkring Ship to Ship (STS)

Bunkring Ship to Ship (STS)

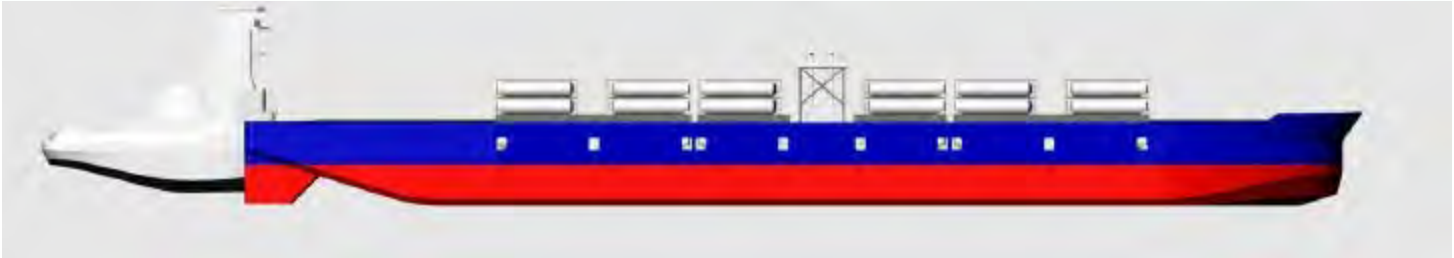
Intermodal LNG System

Containerized LNG supply chain

ISO Tanktainers: efficient storage, loading and transport

Trucking

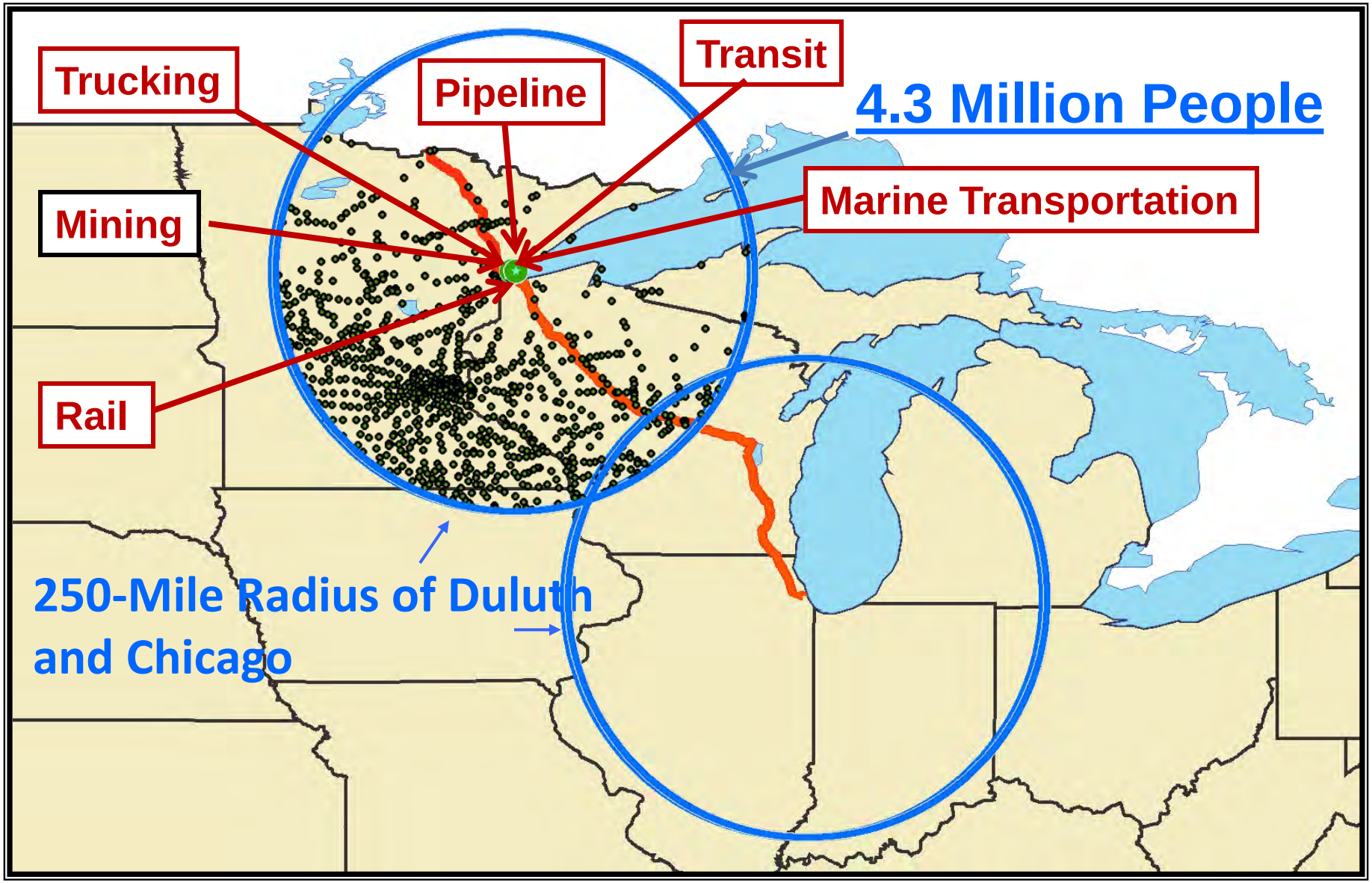
Rail



Liquefaction Plant in the Twin Ports

- Community open to industry
- Existing Peakshaving liquefaction plant within miles in Wrenshall, MN
- Natural gas pipelines in place
- Transportation hub
- Skilled workforce and industrial base
- Market of 4.3 million people within 250 miles

Twin Ports LNG Terminal Marketing Region



Liquefaction Plant in the Twin Ports

- **Potential customer base:**

1. **Marine fueling**
2. **Rail yards – switch engines**
3. **City busses**
4. **Mining industry**
5. **Trucking industry**
6. **Delivery to other communities by truck, rail or water**
7. **Agriculture**

Program Agenda…

Photo by Chris J. Benson