Great Lakes Maritime Research Institute

A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

Ports and LNG as Maritime Fuel

Presented at the

The American Association of Port Authorities Maritime Economic Development Workshop

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UNIVERSITY of WISCONSIN Superior

UNIVERSITY OF MINNESOTA DULUTH

Chicago, IL

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If this was a 1953 AAPA conference we would be discussing -**Oil: The marine fuel of the future!**

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

Special built coal bunkering docks were common around the Great Lakes.

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

Rail was converting at the same time.

Challenges in moving from Coal to Oil as a primary marine fuel are much the same issues faced in moving from Oil to Natural Gas

- New fuel tanks, piping, safety, bunkering systems.
- Access to adequate quality fuel.
- Protecting from new hazards from accidental spills
- Increased capital costs.
- A need for greater crew training and an increased safety culture.
- Uncertainty about the cost of fuel in the future.
- Launching new coal (oil) fired ships even while converting to oil (natural gas)

In 2012-2013 the U.S. Maritime Administration (MARAD) funded a marine LNG study by GLMRI. Additional support in the form of access to vessels, expertise and data has been provided by the Lake Carriers Association members, the U.S. Coast Guard, the natural gas industry, and the Society of Naval Architects and Marine Engineers. During this AAPA conference I will touch on the research topics in red

- **Research the existing maritime usage of LNG**
- **Explore vessel suitability and owner interest**
- **Explore the conceptual designs for converting the remaining Great Lakes Steamships**
- **Evaluate the impact on emission of fuel conversion**
- **Regulatory issues impacting change**
- **Research LNG supply & distribution in the Great Lakes region**
- **Outreach for knowledge and technology transfer**

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Fueling Regulatory Analysis

Principal Investigator, Captain Randolph Helland, USCG, Ret.)

Multi faceted jurisdiction– Federal, State and Local

- IMO Interim Guidelines for LNG fueled ships
- US Army Corps of Engineers requires permitting for LNG tanks and liquefaction plants/construction
- Federal Energy Regulatory Commission and DOE over import/export of LNG
- National Fire Protection Association Code for production, storage and handling LNG

Regulatory Analysis (cont.)

- USCG has authority over LNG facilities that affect the safety and security of ports and navigable waters along with vessel safety and security.
  - Facility Security
  - Fuel Transfer
  - Personnel Training Requirements for Bunkering
- EPA has authority over emissions and discharges
- Cities of Ludington, MI and Manitowoc, WI – Local Fire Marshalls have input and are first responders
- Layup and repair–-hotwork issues?

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Supply Chain Study of regional gas availability, liquefaction facilities, capacity, and transportation gas supplies in the Great Lakes region.

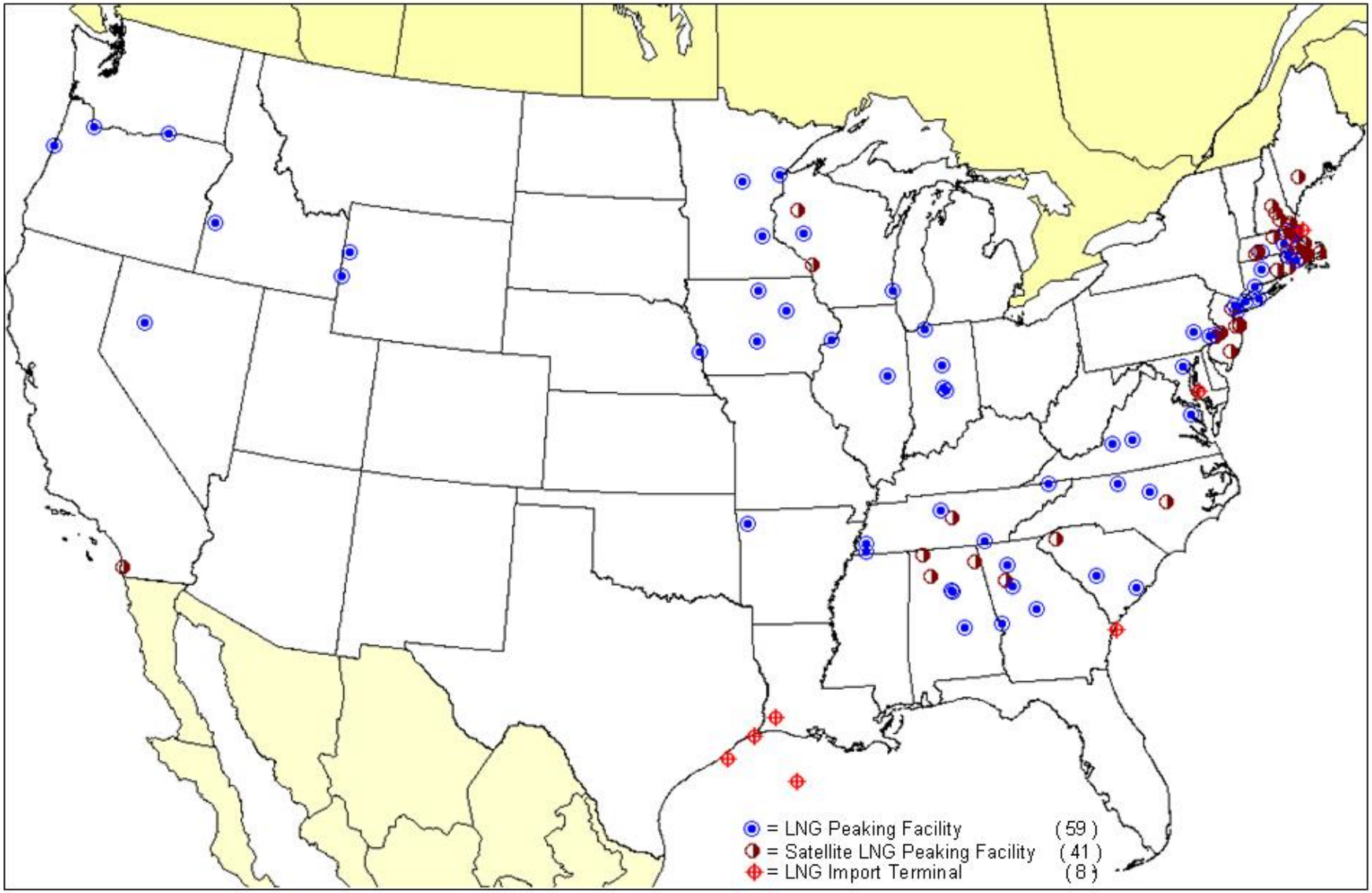
1. Modeled Supply Chains

2. Determined existing LNG supply and application for marine use.

3. Studied cost parameters in transporting LNG by truck.

4. Evaluated potential customer base for new liquefaction plants.

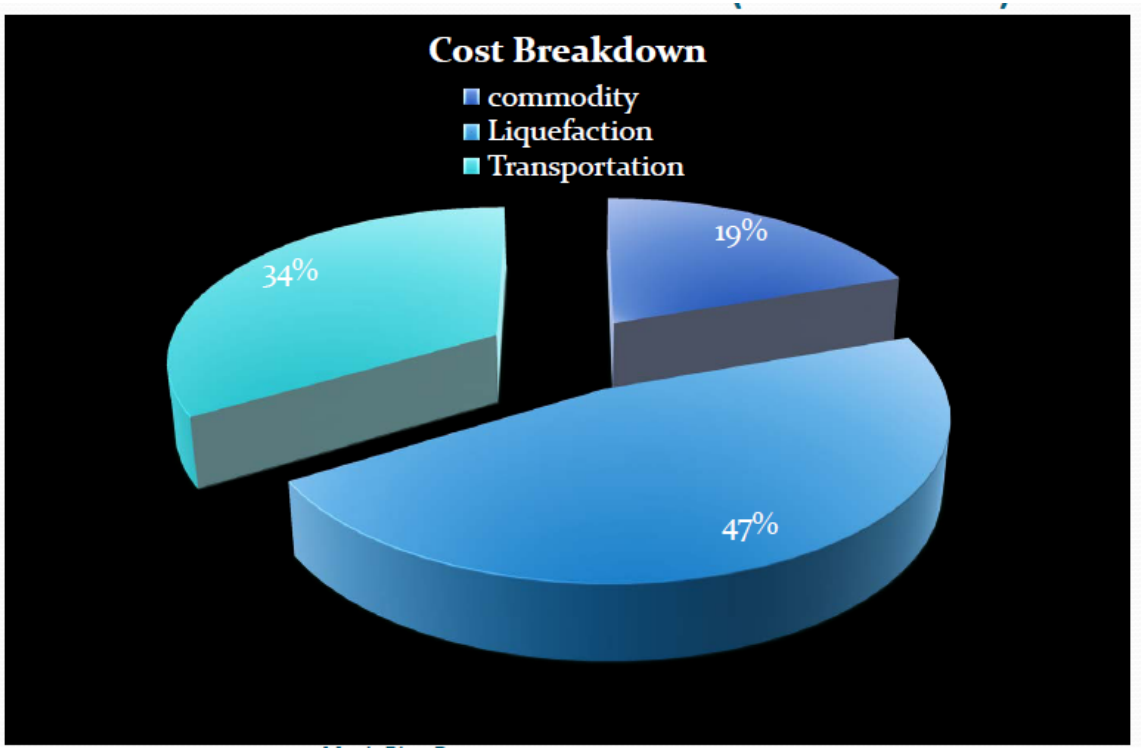
LNG Peak Shaving and Terminal locations



Note: Satellite LNG facilities have no liquefaction facilities. All supplies are transported to the site via tanker truck.
Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division Gas, Gas Transportation Information System, December 2008.

LNG Supply Chains

1. Peak Shaving Plants are usually regulated by public utility commissions and expansion to supply non-utility customers can be difficult.
2. Transportation of LNG is the second largest expense and 250 miles is about the maximum cost effective truck dray.
3. Liquefaction plants can be micro to macro but large scale reduces the cost of liquefaction



LNG Cost Breakdown (February 2012)

Building a Liquefaction Plant in the LNG Supply Chain

1. What is needed?
2. Who needs to be involved?
3. Not every port will need one!

Clean Energy's Boron, CA 160,000 gpd LNG Plant – Located on 15 acres

Liquefaction Plant Market Factors*

- **Conversion of existing high horse power users**
  - Marine, rail, mining, drilling, truck, off-grid power, agriculture
  - Conversion timetables must coincide with plant development
- **Anchor customer versus aggregated demand**
  - One customer with sufficient demand anchoring the project simplifies financing and timing
  - Aggregating multiple smaller off-takers to anchor plant complicates timing
- **Consistent versus variable LNG demand patterns**
  - Greater variability requires additional storage and flexible processing capability
  - Greater storage capacity required to offset near term demand variability
    - **Tankage can represent greater than 50% of plant cost**

***Examples from Industry**

Liquefaction Plant Physical Factors*

- **Plant Size**
  - Capital is major component of liquefaction cost and capital efficiency improves with larger plant size
- **Natural Gas Supply**
  - Sufficient Supply - 100,000 gpd plant requires ~9,000 Mcf/d of gas
  - Quality – Processing steps added to clean gas impurities prior to liquefaction
  - Pipeline pressure – Higher pressure can reduce plant compressor costs
  - Right of way permitting for installing feed pipe to plant
  - Interconnection, lateral pipe ownership and distance to plant
- **Electrical Power Access**
  - 100,000 gpd plant requires between 4-6 MW, depending on refrigerant cycle
  - Interconnection, substation and distance from existing power lines

*Examples from Industry

Liquefaction Plant Physical Factors*

- **Access to Multi-model transportation options to maximize market reach and plant efficiency**
  - **Marine, Rail, Truck- Note: ISO containers may be used on all modes**
- **Exclusion zone required to allow for vapor dispersion in the event of an LNG spill/release**
  - **Best if kept within property boundaries**
  - **Impacted by weather patterns**
- **Footprint – relatively small based on plant and and tank capacity.**
- **Suitable subsurface geotechnical load bearing capacity to support LNG tank**

***Examples from Industry**

Liquefaction Plant Geo-Political Factors*

- Favorable political climate
- Regulatory requirements drive development cost
- Industrial zoned area
- State & federal tax regimes
- Willing local populous – stakeholder outreach program is critical
- Support of local business community
- Local & state tax incentives, grants & loans

*Examples from Industry

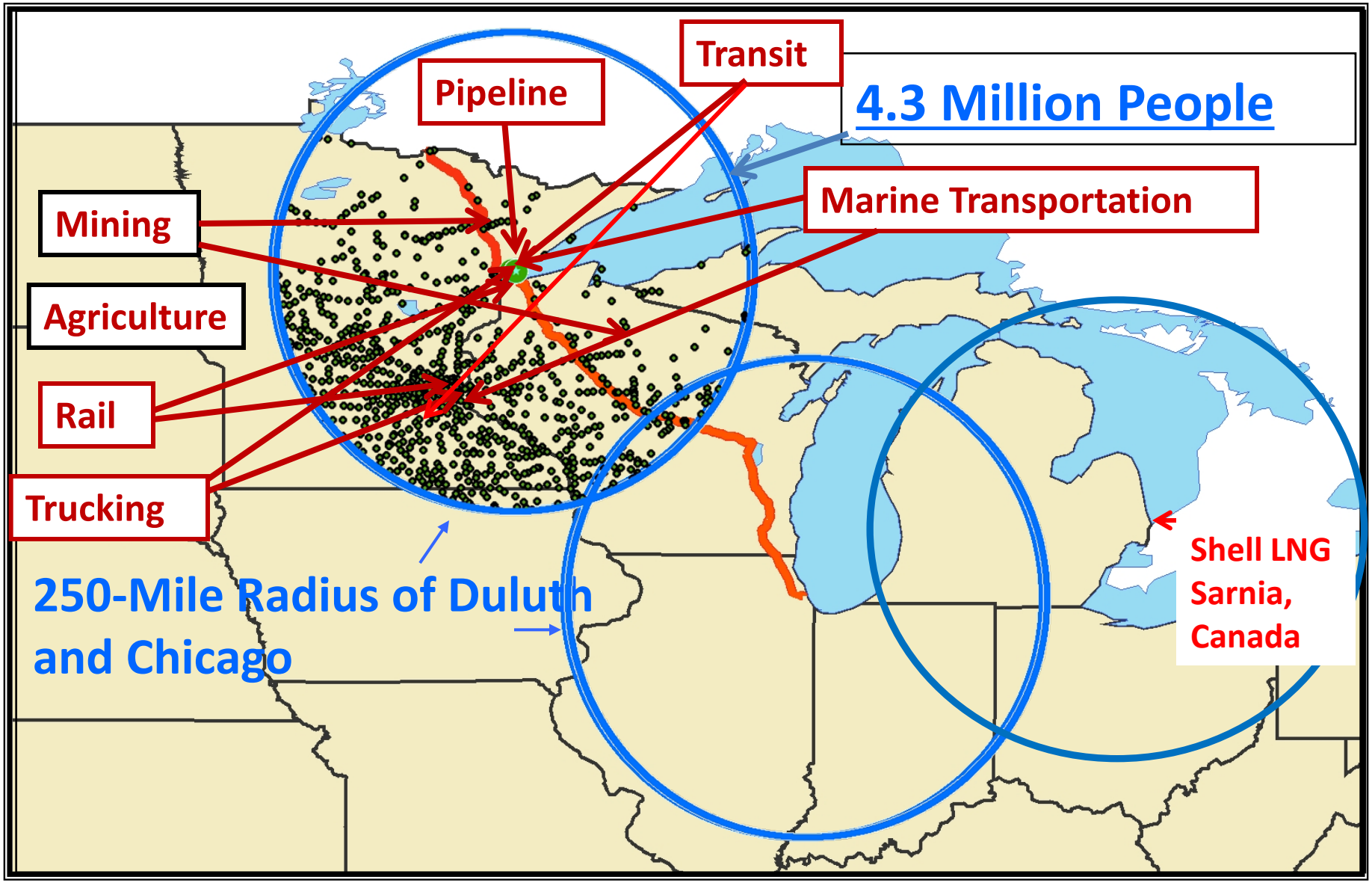
Liquefaction Plant in the Twin Ports of Duluth, MN and Superior, WI

Meetings June 19, 2012 and May 21, 2013 users, suppliers and government

- **Potential customer base within 250 miles**

1. **Marine fueling** **(18 million gallons annually = 49K GPD**
   Note: not all vessels will switch)
2. **Rail yards – switch engines – main line**
3. **City Transit**
4. **Mining industry**
5. **Trucking industry – long haul, local, regional**
6. **Agriculture**
7. **Off-grid power units for remote industries**
8. **Delivery to other communities by truck, rail or water**

Twin Ports LNG Liquefaction Plant Marketing Region
250 mile drayage



Summary

- The LNG supply chain for all modes of transportation is in its infancy.

- Regulations are being drafted and may be case specific.

- Adoption of LNG by multiple user groups is essential for cost effective operations.

- Participation or leadership by Port Authorities essential if marine use is expected in the future.

- Lead times of 5 to 10 years.

- Not all ports will have liquefaction plant – only where it is cost effective.

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Questions and Discussion…

Photo by Chris J. Benson