LIQUEFIED NATURAL GAS AS MARITIME FUEL ON THE OHIO RIVER:

A Case Study and Regulatory Evaluation

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Executive Summary

The Great Lakes Maritime Research Institute (GLMRI) entered into a cooperative agreement with the U.S. Maritime Administration to analyze the feasibility of implementing LNG as fuel on commercial vessels that operate on the Ohio River. It builds on the previous study that analyzed the use of LNG as fuel on commercial vessels operating on the Great Lakes. This study will address current federal, state and local regulations regarding LNG propulsion on commercial vessels and LNG fueling facilities and operations. Further, it will analyze mid-stream fueling as a bunkering option.

There are many federal, state and local government agencies in the U.S. that have jurisdiction over some aspect of LNG. Some agencies that have jurisdiction over the vessel (ship) and others have jurisdiction over the facility that stores and/or transfers LNG to the vessel. Facility types are further broken down into fixed facilities (storage tanks or liquefaction plant) and mobile facilities (LNG tank truck).

The International Maritime Organization (IMO) has continued work to develop international standards to address the safety and security of LNG bunkering operations, and the training and qualifications of personnel involved in those operations. International standards that address LNG fueled engines on ships are found in IMO Resolution MSC 285(86), Interim Guidelines For Gas-Fuelled Engine on Ships. Most of the classification societies around the world have adopted these standards. In 2011, Working Group 10 (WG 10) within the Technical Committee 67 (TC 67) of the International Organization for Standardization (ISO) drafted international guidelines for bunkering of gas-fueled vessels focusing on requirements for the LNG transfer system, the personnel involved and the related risk of the entire LNG bunkering process. A draft technical report was released in June 2013. The goal of the working group is that the standards will be finalized in 2014.

There are a myriad of federal, state and location government regulations that address LNG safety and security requirements at facilities. The Army Corps of Engineers requires a permit for construction of LNG facilities (tanks and liquefaction plants) that complies with the Rivers and Harbors Act. Other federal agencies regulate production facilities that handle large quantities of LNG. The smaller amounts of LNG for refueling vessels do not currently meet production regulatory requirements. Those agencies that have regulations for LNG but do not include the smaller amounts for bunkering include: the Federal Energy Regulatory Commission (FERC) and the Department of Energy (DOE). FERC has jurisdiction over import and export of LNG however there is a provision in their regulations that provides an exemption for those companies that use LNG for transportation. Similarly, DOE has jurisdiction over import and export of LNG, but they do not have regulations that address small amounts of LNG for transportation.

The Environmental Protection Agency (EPA) has authority over marine engine emissions, and facility emissions and discharges. On October 30, 2009, the EPA published a mandatory reporting requirement for Greenhouse Gases (GHG) from large GHG emissions sources in the United States. EPA has also published emission standards in Title 40 CFR Part 1042 for replacement engines with engine power levels over 250Kw installed on commercial vessels operating in the U.S. For any LNG project that involves the discharge of pollutants into waters

of the United States, EPA and, in some cases, a state, tribe or U.S. territory, administers applicable Clean Water Act (CWA) sections. EPA also evaluates whether the Marine Protection, Research, and Sanctuaries Act (MPRSA) applies to a project's activities

The Coast Guard exercises regulatory authority over LNG facilities that affect the safety and security of port areas and navigable waterways. The Coast Guard is responsible for matters related to navigation safety, vessel engineering and safety standards, and all matters pertaining to the safety of facilities or equipment located in or adjacent to navigable waters up to the last valve immediately before the receiving tanks. The Coast Guard also has authority for LNG facility security plan review, approval, and compliance verification as provided in 33 CFR Part 105, and siting as it pertains to the management of marine traffic in and around the LNG facility.

Coast Guard regulations in 33 CFR Part 127 (Waterfront facilities handling liquefied natural gas and liquefied hazardous gas) only applies to facilities that handle large quantities of LNG. However, there are no regulations that address LNG bunkering. Until regulations are developed and in order to address the increased interest and demand for using LNG as fuel the Coast Guard drafted several policy letters in 2013. The first addresses Vessels and Waterfront Facilities conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations and the other one addresses Liquefied Natural Gas fuel Transfer Operations and Training of Personnel using Natural Gas as Fuel.

There are state requirements pertaining to LNG fixed and mobile facilities. These requirements include permits for fixed facilities and compliance with the applicable National Fire Protection Association Code for mobile facilities.

The Coast Guard has the statutory responsibility to administer vessel inspection laws which ensure that both U.S. flag and foreign flag vessels are safe and well equipped for their intended service. Inspections of vessel safety systems include the following: hull inspections, main/auxiliary power inspections, electrical systems inspections, lifesaving system inspections, firefighting systems inspections, navigation equipment inspections and pollution prevention inspections.

The Coast Guard delegates this responsibility to the Officer in Charge, Marine Inspection. There are four basic categories of vessels subject to inspection. They are passenger vessels, tank vessels, cargo vessels and special use vessels such as offshore drilling units (MODU), offshore supply vessels, oceanographic research vessels, oil spill response vessels, nautical school vessels and sailing school vessels. Towing vessels are not currently included in the list of inspected vessels.

Ohio River Case Study

As discussed above, the international community and U.S. government are making strides in developing standards and regulations for LNG bunkering. Further, there is increased interest in the maritime industry for this technology. The study also analyzes the feasibility of implementing LNG as maritime fuel on vessels that operate on the Ohio River, and it addresses potential land-based and midstream refueling options.

The inland waters of the United States contain nearly 12,000 miles of water and approximately 192 locks. Every year, nearly 624 million tons of waterborne cargos transit the inland waterways. Waterways transport more than 60% of the nation's grain exports, approximately 22% of domestic petroleum and petroleum products and 20% of the coal used in electricity generation.

The Ohio River system contains 19 locks and dams that span the area from Pittsburgh, Pennsylvania to Cairo, Illinois The commercial industry that plies these waters include tow boats with barges and small passenger vessels. The tow boats vary in size and horsepower based on the location in the river and the size limitations of the locks.

Tow boats that operate on the Ohio River range in size from 100 to 200 feet long, 26 to 35 feet wide and 1,000 to 9,000 horsepower. Because there are no locks below St. Louis on the Mississippi River that serve as a limiting factor, tow boats are much larger (about 10,000 horsepower) and can accommodate larger tows.

Since tow boats that operate on the Ohio River are not Coast Guard inspected, they do not need to comply with the regulations governing inspected vessels. However, the Coast Guard has published a Notice of Proposed Rulemaking on August 11, 2011 which proposes safety regulations governing the inspection, standards, and safety management systems of towing vessels. The date that the new rules will be published is unknown. Until that time, tow boat owners desiring to either convert existing engines or build new vessels with LNG fueled engines need to obtain Commandant, U.S. Coast Guard approval. The design criteria listed in Coast Guard CG- 521 Policy letter number 01-12 dated April 19, 2012 would have to be followed for uninspected vessels.

While tow boats would be a natural fit for the application of LNG propulsion technology, there are several significant hurdles that need to be overcome. Below is a list of some of those challenges.

- Small tow boats bring space challenges for LNG engines and fuel tanks. An engineering study needs to be conducted on all tow boat sizes that operate on the Ohio River to determine the feasibility of adopting this technology. The study needs to include, but is not limited to the engineering requirements of an engine retrofit, determining the size and location of the LNG fuel tank, stability requirement and any operational requirements that may be placed on the vessel.
- The location of the LNG fuel tank on the boat may be a limiting factor. The current Coast Guard policy prohibits the placement of LNG fuel tanks above or below accommodation spaces. Working closely with the Coast Guard and applicable classification society early on in the process is critical to success.

Refueling Options: Establishing a supply system along the Ohio River that can provide LNG to tow boats is critical to the success of this effort. It can be accomplished by tank truck, fixed facility (LNG storage tank or liquefaction plane) or by tank barge. There are a number of options for refueling:

- Tank truck fueling at the dock

- Construction of designated facilities (either LNG storage tanks or liquefaction plants) along the Ohio River where the tow boat can refuel. This option would most likely require the tow boat to disconnect from their tow, conduct bunker operations then reconnect. This would cause an operational delay that would have to be assessed by the company.
- Refueling by an LNG tank barge at a dock, anchorage area, fleeting area or while underway in the river. If approved, there will most likely be operational restrictions required by the Coast Guard.

Key to the successful implementation of LNG as fuel along the Ohio River is the supply chain. There is a significant supply of nature shale gas plays in the United States. The Marcellus play in the Pennsylvania area provides a huge supply that can be tapped for future use. An examination of the current supply chain on the Ohio River reveals no current infrastructure in place. There are a number of existing peak shaving plants, satellite peak shaving plants and import terminals around the U.S. The closest peak shaving plants to the Ohio River are located in the middle of Indiana (three locations) and Illinois (one location), and one location in the eastern portion of Pennsylvania. There are no LNG facilities in West Virginia and Kentucky.

Future Supply Chain: In the Gulf Coast Corridor, Shell Oil Company plans to install a small-scale liquefaction unit at its Shell Geismar Chemicals facility in Geismar, Louisiana. Once operational, this unit will supply LNG along the Mississippi River, the Intra-Coastal Waterway and to the offshore Gulf of Mexico and the onshore oil and gas exploration areas of Texas and Louisiana. In the Great Lakes Corridor, Shell plans to install a small-scale liquefaction unit at its Shell Sarnia Manufacturing Centre in Sarnia, Ontario, Canada along the St. Clair River. Once operational, this project will supply LNG fuel to all five Great Lakes, their bordering U.S. states and Canadian provinces and the St. Lawrence Seaway.

Midstream Refueling by LNG tank barge: Internationally, the first LNG bunker barge in the world services LNG fueled vessels in Stockholm, Sweden. The first bunker boat in the world, the *Seagas* will provide liquefied natural gas fuel to Viking Line's *Viking Grace,* a dual fuel passenger ferry, and possibly other vessels in Stockholm harbor. The benefit of transporting LNG by barge on the Ohio River is that it allows the product to be moved and delivered more efficiently on a small-scale basis to locations where large LNG infrastructure is not existent and is too costly and time consuming to construct. The barge can also serve as a floating storage facility, positioned to provide LNG fuel to tow boats.

While there are many benefits to midstream refueling, there are operational and regulatory issues that need to be addressed. In concert with the Coast Guard Captain of the Port, the location(s) of the midstream refueling area will need to be determined. A Waterways Suitability Assessment, while required for transportation of large quantities of LNG (as cargo) may be required by the Coast Guard Captain of the Port. A variety of waterway restrictions could be imposed from Safety or Security zones, Exclusion zones and operational restrictions including day time operations, escort vessels and security requirements.

Recommendations: This study has identified some potential roadblocks that could hinder the development of LNG fueled vessel technology and supply chain along the Ohio River. The roadblocks listed below are not limited to regulatory challenges, but also include a broader

context including stakeholder involvement and buy-in, the cost to implement this new technology and the current lack of LNG supply chain. The roadblocks include: stakeholder concern over LNG, cost to implement, delays in completing Federal, State and Local regulatory requirements, lack of LNG supply chain infrastructure, and tow boat design for LNG engines and fuel tanks. To overcome the potential roadblocks, industry representatives need to conduct outreach addressing facilities, mobile facilities and vessel construction.

Introduction

The interest in using Liquefied Natural Gas (LNG) as fuel for main propulsion on commercial vessels in the U.S. continues to grow. A number of companies in the Gulf and Great Lakes region have taken steps to either convert existing ships to engines fueled by LNG or have orders for new builds. Additionally, the infrastructure needed to support such a conversion is gaining traction. Shell Oil Company has announced they will be building small liquefaction plants in Geismar, Louisiana to service the Gulf coast, intra-coastal waterway, and lower Mississippi River, and a similar facility at their Sarnia Manufacturing Center in Sarnia, Ontario that will service the marine industry in the Great Lakes and St. Lawrence Seaway corridor.

In order to evaluate the potential for using LNG as fuel on vessels transiting the Ohio River, the Great Lakes Maritime Research Institute (GLMRI) entered into a cooperative agreement with the U.S. Maritime Administration to analyze the regulatory issues surrounding commercial vessels fueled by LNG, facilities that store or liquefy LNG and the feasibility of conducting midstream bunkering on the Ohio River. The commercial industry that plies these waters includes mostly tow boats with barges. The tow boats vary in size and horsepower based on the location in the river and the size limitations of the locks.

Phase I of the project addressed the regulatory issues and marine engineering analysis in converting the car ferry Badger to LNG propulsion. A summary of that study is discussed in the section below. Similarly, this study will address current federal and state regulations regarding LNG propulsion on commercial vessels and LNG fueling facilities and operations along the Ohio River. The analysis includes gaps in current regulations, roadblocks to moving ahead with this initiative and recommendations for successful implementation. Further, this study will examine the current and future supply chain, including midstream refueling that could support conversion of commercial vessels to LNG propulsion.

Phase I: Great Lakes Study Summary

The Great Lakes Maritime Research Institute (GLMRI) entered into a cooperative agreement with the U.S. Maritime Administration to analyze the feasibility of converting U.S. Great Lakes bulk carrier commercial ships (known as Lakers) to LNG propulsion. The Lake Michigan Carferry SS *Badger* was chosen as the demonstration project. The SS *Badger* is the only coal-fired steamship in operation in the United States.

The regulatory section of the study addressed current federal, state and local regulations regarding LNG propulsion on commercial vessels and LNG fueling facilities and operations. The engineering analysis modeled the Badger's consumption, routes, shore-fueling station(s) and viability of using natural gas. The analysis identified gaps in current regulations, roadblocks to moving ahead with this initiative and recommendations for successful implementation. Also**,** the

study examined the current supply chain availability that could support the SS *Badger* conversion.

The Phase I study also examined the LNG program in Norway, who for a decade, has operated natural gas powered ferries and are building other natural gas powered vessels. The GLMRI study team traveled to Norway and observed LNG propelled vessels, their bunkering operation, and met with Norwegian government officials to discuss the keys to successful implementation of this technology. The analysis also included an examination of Norway's Nitrogen Oxides (NOx) Fund which was established to encourage the maritime industry to invest in NOx reducing technology. This program has been very successful and the Phase I study recommended the U.S. government consider a similar type of initiative.

Federal, State and Local Regulatory Framework

With the expansion of the LNG industry as maritime fuel, the international community and U.S. government are making strides in developing standards and policy to address construction, operations, training and certification of personnel involved in LNG bunkering. That being said, final international standards established by the International Maritime Organization and regulations in the U.S. are still a year or so away.

Because there are so many federal, state and local government agencies in the U.S. that have jurisdiction over some aspect of LNG, the study was divided into functional areas that conform to the study parameters. There are agencies that have jurisdiction over the vessel (ship) and agencies that have jurisdiction over the facility that stores and/or transfers LNG to the vessel. Facility types are further broken down into fixed facilities (storage tanks or liquefaction plant) and mobile facilities (LNG tank truck). Refueling by bunker barge was also examined as part of this project. After identifying the agencies that have jurisdiction over LNG, the study examined whether the agency had regulations and/or policy in place or if they have they adopted an international or national standard. Tables 1, 2 and 3 summarize these results. A more detailed analysis of the regulatory requirements is in subsequent sections.

Facility Requirements

Agency/Organization	NFPA	Regulations	Policy	IMO
USCG	YES	NO*	YES	NO
Federal Energy Regulatory Commission	NO	NO	NO	NO
Environmental Protection Agency	NO	YES	YES	NO
State of Ohio	YES	YES	YES	NO
State of West Virginia	YES	YES	YES	NO
State of Kentucky	YES	YES	YES	NO
State of Pennsylvania	YES	YES	YES	NO
State of Indiana	YES	YES	YES	NO
State of Illinois	YES	YES	YES	
Army Corps Of Engineers	NO	YES	NO	NO
Federal Motor Carrier Administration	NO	NO	NO	NO
Pipeline and Hazardous Material Safety Admin	NO	YES	NO	NO
Federal Railroad Administration	NO	NO	NO	NO
Department Of Energy	NO	NO	NO	NO

Mobile (Tank Truck) Facility Requirements

Agency/Organization	NFPA	Regulations	Policy	IMO
USCG	YES	NO	YES	NO
Federal Energy Regulatory Commission	NO	NO	NO	NO
Environmental Protection Agency	NO	NO	NO	NO
State of Ohio	YES	NO**	NO	NO
State of West Virginia	YES	NO**	NO	NO
State of Kentucky	YES	NO**	NO	NO
State of Pennsylvania	YES	NO**	NO	NO
State of Indiana	YES	NO**	NO	NO
State of Illinois	YES	NO**	NO	NO
Army Corps Of Engineers	NO	NO	NO	NO
Federal Motor Carrier Administration	NO	YES	NO	NO
Pipeline and Hazardous Material Safety Admin	NO	NO	NO	NO
Federal Railroad Administration	NO	NO	NO	NO
Department Of Energy	NO	NO	NO	NO

Vessel Requirements

Agency/Organization	NFPA	Regulations	Policy	IMO
USCG	YES	NO***	YES	NO
Federal Energy Regulatory Commission	NO	NO	NO	NO
Environmental Protection Agency	NO	YES	YES	NO
State of Ohio	NO	NO	NO	NO
State of West Virginia	NO	NO	NO	NO
State of Kentucky	NO	NO	NO	NO
State of Pennsylvania	NO	NO	NO	NO
State of Indiana	NO	NO	NO	NO
State of Illinois	NO	NO	NO	NO
Army Corps Of Engineers	NO	NO	NO	NO
Federal Motor Carrier Administration	NO	NO	NO	NO
Pipeline and Hazardous Material Safety Admin	NO	NO	NO	NO
Federal Railroad Administration	NO	NO	NO	NO
Department Of Energy	NO	NO	NO	NO

*The Coast Guard does not have regulations that apply to the transfer of small quantities of LNG from a storage facility to a vessel. The Coast Guard applies NFPA standards to their policy and regulatory efforts. The regulations in 33 CFR Part 127 applies to facilities that handle large quantities of LNG. They have drafted policy letters that are discussed below.

**The states of Pennsylvania, West Virginia, Ohio, Indiana, Kentucky and Illinois have no regulations that apply to the transfer of LNG from a tank truck to a vessel or facility. They do regulate the transportation of LNG over the roads of their respective states.

*** The Coast Guard does apply NFPA and IMO standards to their policy and regulatory efforts for inspected vessels. On the Ohio River, there are numerous tow boats and they are not inspected by the Coast Guard, however they would require Coast Guard approval for conversion to LNG fuel engines.

Facility Requirements (Storage Tanks/Liquefaction Plants)

There are still a myriad of federal and state government regulations that address LNG safety and security requirements at facilities. The Army Corps of Engineers requires a permit for construction of LNG facilities (tanks and liquefaction plants) that complies with the Rivers and Harbors Act. Other federal agencies regulate production facilities that handle large quantities of LNG. The smaller amounts of LNG for refueling vessels do not currently meet production regulatory requirements. Those agencies that have regulations for LNG but do not include the smaller amounts for bunkering include: the Federal Energy Regulatory Commission (FERC) and the Department of Energy (DOE). FERC has jurisdiction over import and export of LNG, however there is a provision in their regulations that provides an exemption for those companies that use LNG for transportation. Similarly, DOE has jurisdiction over import and export of

LNG, but they do not have regulations that address small amounts of LNG for transportation. While facility safety requirements vary between federal, state and local government agencies, fixed facilities will need to comply with applicable security requirements in the Maritime Transportation Security Act and the accompanying regulations in 33 CFR Part 105 (Maritime Security: Facilities). Compliance with these requirements will be to the satisfaction of the cognizant Coast Guard Captain of the Port.

For onshore LNG projects, as well as those located in state waters, the states or local air control agencies issue the applicable Clean Air Act permits (if EPA approves the State's program). The number of required permits will vary, depending on the design of the project, the air quality status of the area, and the amounts of different air pollutants to be emitted. States and local control agencies with authority for issuing federally-required construction and operating permits would also be responsible for issuing any air permits that might be needed to authorize construction and operation of associated pipelines in areas of state jurisdiction.

For any LNG project that involves the discharge of pollutants into waters of the United States, EPA and, in some cases, a state, tribe or U.S. territory, administers applicable Clean Water Act (CWA) sections. EPA also evaluates whether the Marine Protection, Research, and Sanctuaries Act (MPRSA) applies to a project's activities. EPA's jurisdictional authority for LNG projects varies based upon the location and design of an individual LNG project. Under the CWA, the dischargers of pollutants from any point source into waters of the United States are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit.[1]

The Coast Guard exercises regulatory authority over LNG facilities that affect the safety and security of port areas and navigable waterways. The agency is responsible for matters related to navigation safety, vessel engineering and safety standards, and all matters pertaining to the safety of facilities or equipment located in or adjacent to navigable waters up to the last valve immediately before the receiving tanks. The Coast Guard also has authority for LNG facility security plan review, approval, and compliance verification as provided in 33 CFR Part 105, and siting as it pertains to the management of marine traffic in and around the LNG facility.

Coast Guard regulations in 33 CFR Part 127 (Waterfront facilities handling liquefied natural gas and liquefied hazardous gas) only applies to facilities that handle large quantities of LNG. Similarly, Coast Guard Navigation and Vessel Inspection Circular 01-2011 (Guidance Related to Waterfront LNG Facilities) and Commandant Instruction (COMDTINST 16010.3 Risk Based Decision-Making Guidelines) typically apply to LNG facilities and tank ships that transport LNG as cargo. There are no regulations that cover LNG bunkering and storage facilities handling LNG in small quantities (i.e., storage tanks, mobile tank trucks, rail cars).

Until regulations are developed and in order to address the increased interest and demand for using LNG as fuel the Coast Guard crafted several DRAFT policy letters in 2013. The first addresses Liquefied Natural Gas fuel transfer operations and personnel training, and the other

[1] EPA: EPA's Liquefied Natural Gas Regulatory Roadmap, EPA230-B-06-001, July 2006

one addresses waterfront facilities conducting Liquefied Natural Gas (LNG) marine fuel transfer (bunkering) operations. Details related to those draft policy letters are outlined below.

Draft Coast Guard OES Policy letter 1-13: Guidelines For Liquefied Natural Gas Fuel Transfer Operations And Training Of Personnel Using Natural Gas As Fuel. This draft policy letter addresses fuel transfer operations and the training of personnel who will be conducting LNG fuel transfer operations in the U.S. It provides guidance to the U.S. Coast Guard Captain of the Port on operations involving LNG fueled vessels and waterfront facilities that handle LNG as a marine fuel source. The draft policy letter also:

- Provides guidelines for transfer operations
- Provides additional guidelines for LNG systems used by vessels
- Promotes the conduct of safe fuel transfer operations between regulated sources and vessels using LNG as fuel.
- Outlines recommendations for operations, maintenance, equipment and personnel training in the use of LNG as fuel.

The draft policy letter also addresses the training criteria and qualifications for those personnel involved in LNG bunkering operations. The Coast Guard considers the training criteria in Chapter 8 of IMO Resolution MSC.285(86), Chapter 8, Interim Guidelines on Safety for Natural Gas-Fueled Engine Installations in Ships, provides a level of competence necessary for the safe operation of natural gas fuel systems. However, mariners will still be required to receive company and vessel specific training before assuming their duties. Further, tabletop and functional exercises are required to ensure that personnel are trained to perform their duties during fueling and contingency response.

The training on gas-fueled ships is divided into the following categories:

Category A: Basic training for the crew

Category B: Supplementary training for deck officers

Category C: Supplementary training for engineer officers

Mariners working on board a natural gas fueled vessel who hold a Merchant Mariner's Credential (MMC) endorsed as Tankerman PIC (LG) will be considered as meeting Categories A, B and C.

Tank truck and/or railcar operator training: The federal requirements for carriage of hazardous materials by highway and railway are outlined in 49 CFR Parts 172, 173, 174, 177 and 179. Operators of tank trucks and/or railcars are required to meet the applicable state and/or federal requirements for training along with other requirements which may be imposed for persons in charge of a shoreside transfer operation.

Draft Coast Guard Policy Letter No 02-13: Guidance Related To Vessels And Waterfront Facilities Conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations. This draft policy letter provides guidance to both vessel owners and operators intending to conduct LNG fueling operations as well as Coast Guard Captains of the Port who

will be approving those operations. The guidelines in the draft policy document are intended to identify the minimum level of safety and security required for a LNG fueling operation. It addresses transfers from tank ships and barges, waterfront facilities handling LNG including storage tanks, mobile tank trucks and rail cars, and portable tanks containing LNG which are transferred to vessels for use as fuel.

The draft policy letter also provides guidance regarding tank truck and railcar operations. The Coast Guard requires that these operations also incorporate the operational requirements of 33 CFR 127 including emergency response planning and fuel transfer operations. It considers any location where LNG tank trucks or railcars are used to transfer LNG to vessels for use as a marine fuel must be viewed as a waterfront facility handling LNG. Owners and operators of facilities using tank trucks and/or rail cars are required to include the emergency response information, training, and safety and security items when developing operations and emergency manuals, and evaluating security risks associated with their LNG transfer operations. Listed below are the various safety and security issues:

- Vessels moored to shore based structures used to transfer LNG
- Mobile LNG tank trucks forming part of a vessel's fuel supply system
- LNG delivered in portable tanks
- LNG transfer operations from waterfront facilities handling LNG

The Coast Guard draft policy letter also provides guidance related to LNG storage tanks along the waterfront. Storage tanks on shore with pipelines leading to a manifold at a pier are another type of waterfront facility. Design requirements for the storage tanks, associated equipment, and piping systems outside the marine transfer area will be subject to local, state, or federal requirements depending on the details of the design. Unlike LNG import and export facilities which have direct federal oversight from the Federal Energy Regulatory Commission (FERC), permitting of the siting, construction, and operation of smaller LNG bunkering facilities may be shared between a variety of federal, state, and local agencies.

Waterfront facilities that handle large quantities of LNG from tank ships to facilities (importing or exporting of LNG) are required to complete a Waterway Suitability Assessment (WSA). The draft guidance indicates that facilities handling small quantities of LNG used in bunkering operations may not be required to complete a WSA. However, they would be required to complete a safety and security assessment which considers the scope and particulars of the proposed operation.

The safety and security risk assessment should cover physical and operational hazards, and the suitability and compatibility of equipment used in the transfer. The assessment requirements are based on recommendations established by the Society of International Gas Tanker and Terminal Operator's Ltd (SIGTTO), in their LNG Ship to Ship Transfer Guidelines, 1st Ed., 2011.

The draft policy also provides guidance on equipment that is used in LNG bunkering operations. It includes firefighting equipment, emergency shutdown systems, LNG fuel transfer hoses, LNG bunkering manifold designs, radio and communication equipment, deck lighting, personnel protection equipment, and portable gas detection requirements.

LNG bunkering with passengers onboard the vessel: At this time, due to the concern for passenger safety and lack of experience with LNG fueling aboard passenger vessels, any requests for conducting passenger operations during LNG fueling operations would require a heightened level of scrutiny. Until national and/or international standards are developed, it is presumed that LNG fueling operations should not occur at times when passengers are onboard or embarking/disembarking the vessel. In the event the COTP receives a specific request to conduct an LNG transfer operation with passengers onboard, the Coast Guard will make a determination on a case by case basis.

As of the date of this research paper, the Coast Guard policy letters are still in draft form and not yet published. Additionally, until such time that regulations are promulgated, LNG projects identified in this paper will be evaluated on a case by case basis.

The states of Pennsylvania, West Virginia, Ohio, Indiana, Kentucky and Illinois require various permits to build a facility (storage tanks or liquefaction plants). They range from construction, air emission, storm, water/sewer, and NPDES permits. Facilities also need to comply with EPA's Spill Prevention Contingency and Countermeasures rules, if applicable.

Vessels (Ships or Barges)

Most of the federal, state and local agencies defer vessel inspection requirements/responsibilities to the Coast Guard. Coast Guard CG-521 policy letter of April 19, 2012 entitled Equivalency Determination and Design Criteria for Natural Gas Fuel Systems still applies to certificated vessels. It establishes the design criteria for natural gas fuel systems that provide a level of safety that is equivalent to traditional fuel systems. Since tow boats that operate on the Ohio River are not Coast Guard inspected vessels, they would not need to comply with the regulations governing inspected vessels. However, the Coast Guard has published a Notice of Proposed Rulemaking on August 11, 2011 which proposes safety regulations governing the inspection, standards, and safety management systems of towing vessels. Specifically, it addresses the electrical and machinery requirements for new and existing towing vessels, the use and approval of third party auditors and surveyors, and the procedures for obtaining certificates of inspection. Until the time regulations are published, tow boat owners desiring to either convert existing engines or build new vessels with LNG fueled engines need to obtain Commandant, U.S. Coast Guard approval. The design criteria listed in Coast Guard CG- 521 Policy letter number 01-12 dated April 19, 2012 would have to be adhered to for uninspected vessels. Barges that are constructed for LNG bunkering need to be inspected by the Coast Guard, and are subject to the regulatory requirements for transporting gases.

The Environmental Protection Agency is the only other federal agency that has regulations that cover vessels with marine engines powered by natural gas. In April 2010, EPA published rules on engines installed on U.S. commercial vessels as well as marine diesel fuels produced and distributed in the United States. The regulations also implemented Annex VI to MARPOL in the United States, which includes engine and fuel sulfur limits, and extends the Emission Control

Area (ECA) engine and fuel requirements to U.S. internal waters. Regulations in Title 40 CFR Part 1042 detail emission requirements for replacement engines with engine power levels over 250Kw and replacement fuel systems. Further, there are two new tiers of engine standards for marine engines: Tier 2 standards that began in 2011 and Tier 3 standards that will begin in 2016.

Mobile Facility Requirements (Tank Trucks)

There are several federal agencies that have jurisdiction over tank trucks transporting LNG. The Federal Hazardous Materials Transportation Law (Federal hazmat law), 49 U.S.C. § 5101 et seq., is the basic statute regulating hazardous materials intrastate, interstate, and foreign commerce transportation in the United States. The Federal Motor Carrier Safety Administration has authority over the transportation or shipment of hazardous materials by highway. It requires that carriers be registered, trucks need DOT and motor carrier operating authority (MC) numbers, and drivers need to be qualified to transfer LNG. The Pipeline and Hazardous Material Safety Administration (PHMSA) is responsible for regulating and ensuring the safe and secure movement of hazardous materials to industry and consumers by all modes of transportation, including pipelines.

The Coast Guard does not currently have regulations that apply to LNG transfers from mobile facilities. The transfer regulations found in 33 CFR Parts 154, 155 and 156 apply to oil and hazardous material transfers. The Coast Guard has drafted policy that addresses mobile facilities including tank trucks and rail cars (discussed above). The states that border the Ohio River also do not have regulations that apply to the transfer of LNG from a tank truck to a vessel, however all tank trucks must comply with state requirements for transporting LNG over the roads of the respective states. Cities in which LNG operations are performed from mobile facilities would have to be queried as to the requirements for transfer operations.

International Standards

The International Maritime Organization (IMO) has continued work to develop international standards to address the safety and security of LNG bunkering operations, and the training and qualifications of personnel involved in those operations. It developed Interim Guidelines on Safety for Natural Gas Fuelled Engine Installations in Ships in 2009, however there were no international standards for operations, training and licensing requirements. Resolution MSC 285 (86) provides Interim Guidelines for the arrangement and installation of machinery for propulsion and auxiliary purposes, using natural gas as fuel. Resolution MSC 285(86) covers:

- General hazards, applications and survey requirements for gas-fuelled engines
- Ship arrangements and system design
- Fire safety
- Electrical systems and hazard zones
- Control, monitoring and safety systems
- Compressors and gas engines
- Manufacture, workmanship and testing

In 2011, Working Group 10 (WG 10) within the Technical Committee 67 (TC 67) of the International Organization for Standardization (ISO) drafted international guidelines for bunkering of gas-fueled vessels focusing on requirements for the LNG transfer system, the personnel involved and the related risk of the entire LNG bunkering process. A draft technical report was released in June 2013. The working group would like the standards finalized in 2014.

The regulatory framework for seagoing vessels covered by the International Maritime Organization (IMO) above is supplemented by standards and best practices published by organizations like the International Association of Oil and Gas Producers (OGP), the Society of International Gas Tankers and Terminal Operators (SIGTTO), and the Oil Companies' International Maritime Forum (OCIMF).

OGP is a global organization which identifies and shares best practices in areas of health, safety, the environment, security, social responsibility, engineering and operations in the oil and gas industry. Recognizing the world-wide interest and growth in LNG fueling, OGP drafted a document in February 2013 entitled Guidelines for Systems and Installations for Supply of LNG as Fuel to Ships (draft document 118683). The purpose of the document is to provide a prospective standard and provisional application until international standards are approved by ISO. The document addresses the bunkering facility, ship/shore interface, connection and disconnection procedures, emergency shutdown interface and the LNG bunkering process control. It provides guidance for systems, equipment, procedures and training for personnel involved in transferring LNG as fuel to ships. [2]

SIGTTO is an organization formed to promote high operating standards and best practices in gas tankers and terminals throughout the world. It drafted LNG Ship to Ship Transfer Guidelines in 2011 that pertains to vessels undertaking side-by-side ship to ship (STS) transfer or lightering of LNG. The guidelines apply to the transfer of large amounts of LNG from ship to ship. It does not cover the bunkering process.

OCIMF is a voluntary association of oil companies with an interest in the shipment and terminal operation of crude oil, oil products, petrochemicals and gas. The OCIMF aims to facilitate safe and environmentally responsible operations of oil ships and terminals by promoting continuous improvement in design and operation standards.

Ohio River Case Study

As discussed above, the international community and U.S. government are making strides in developing standards and regulations for LNG bunkering. Further, there is increased interest in the maritime industry for this technology. This part of the study analyzes the feasibility of implementing LNG as maritime fuel on vessels that operate on the Ohio River, and it addresses potential land-based and midstream refueling options.

The inland waters of the United States contain nearly 12,000 miles of water and approximately 192 locks. (See figure 1 below) A study conducted by the Texas Transportation Institute entitled

[2] OGP draft document: Guidelines for Systems and Installations for Supply of LNG as Fuel to Ships (draft document 118683), February 2013

A Modal Comparison of Freight Transportation Effects on the General Public stated the inland waterways move commerce to and from 38 states throughout the nation's heartland and Pacific Northwest, serve industrial and agricultural centers, and facilitate imports and exports at gateway ports on the Gulf Coast. Waterways transport more than 60% of the nation's grain exports, about 22% of domestic petroleum and petroleum products and 20% of the coal used in electricity generation.[3] These commodities are transported by tug and barge**.**

Source: http://www.vtn.iwr.usace.army.mil/docs/VTNInlan dNavBro_loresprd.pdf

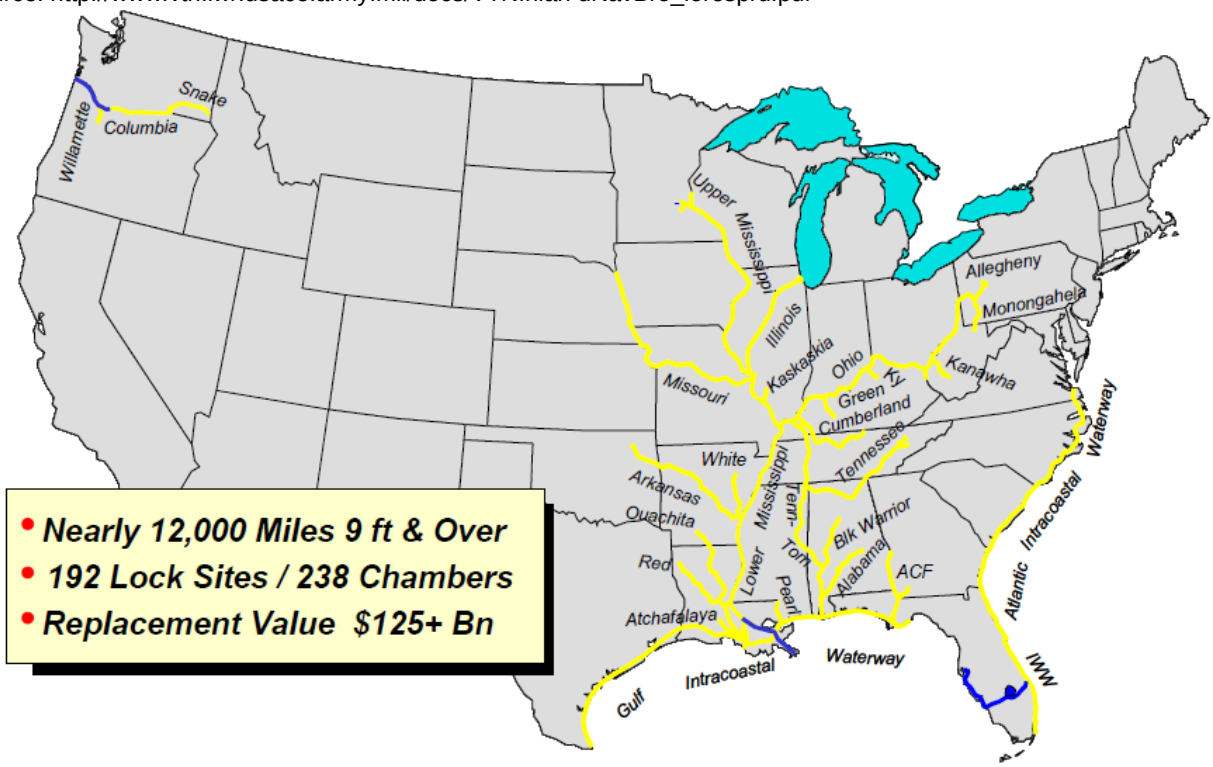


Figure 1: Army Corps of Engineers Inland River Figures For the U.S.

"The Ohio River is 981 miles long, starting at the confluence of the Allegheny and the Monongahela Rivers in Pittsburgh, Pennsylvania, and ending in Cairo, Illinois, where it flows into the Mississippi River. The Ohio River flows through or borders six states: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia. In addition, water from parts of New York, Virginia, North Carolina, Tennessee and Alabama drain into tributaries that empty into the Ohio. The Ohio River is the source of drinking water for more than three million people. Over 25 million people, almost 10 percent of the U.S. population, live in the Ohio River Basin." [4]

[3] Texas Transportation Institute, A modal comparison of domestic freight transportation effects on the General Public: 2001–2009, The Texas A&M University System College Station, Texas February 2011

[4] Ohio River Foundation Fact Sheet: The River and Its Watershed

The Ohio River system contains 19 locks and dams that span the area from Pittsburgh, Pennsylvania to Cairo, Illinois (See figure 2 below). While the Ohio River is home to almost 10 percent of the U.S. population, there are large sections of the river that are extremely remote.

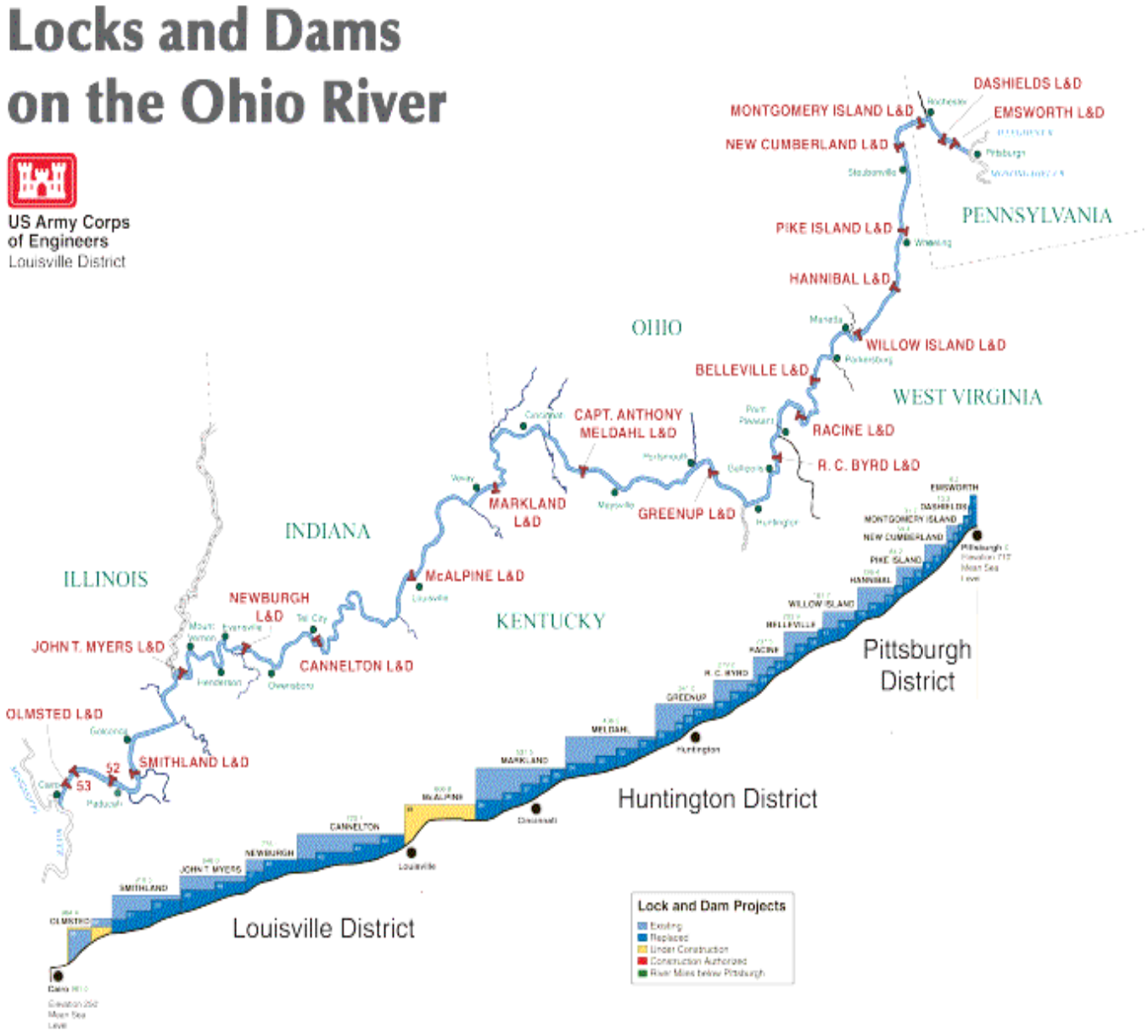


Figure 2: Army Corps of Engineers, Louisville District, Ohio River Locks and Dams

Tug and Barge industry

The commercial industry that operates on these waters includes mostly tow boats with barges along with a few small passenger vessels. The tow boats vary in size and horsepower based on the location in the river and the size limitations of the locks.

Tow boats that operate on the Ohio River range in size from 100 to 200 feet long, 26 to 35 feet wide and 1,000 to 9,000 horsepower. Because there are no locks below St. Louis, Missouri that serve as a limiting factor, tow boats on that part of the Mississippi River are much larger (about 10,000 horsepower) and can accommodate larger tows.

The U.S. Coast Guard has the statutory responsibility to administer vessel inspection laws which ensure that both U.S. flag and foreign flag vessels are safe and well equipped for their intended service. Inspections of vessel safety systems include the following: hull inspections, main/auxiliary power inspections, electrical systems inspections, lifesaving system inspections, firefighting systems inspections, navigation equipment inspections and pollution prevention inspections.

The U.S. Coast Guard delegates this responsibility to the Officer in Charge, Marine Inspection. There are four basic categories of vessels subject to inspection. They are passenger vessels, tank vessels, cargo vessels and special use vessels such as offshore drilling units (MODU), offshore supply vessels, oceanographic research vessels, oil spill response vessels, nautical school vessels and sailing school vessels. Towing vessels are not currently included in the list of inspected vessels. However, as noted above, the Coast Guard has published a Notice of Proposed Rulemaking on August 11, 2011 which proposes safety regulations governing the inspection, standards, and safety management systems of towing vessels. Until that time, the Coast Guard implemented a Towing Vessel Bridging Program (TVBP) to ease the transition and ensure that both the Coast Guard and the towing vessel industry are informed and prepared to meet the new requirements. This is accomplished through an extensive outreach, education and voluntary uninspected towing vessel examination program.

The U.S. Coast Guard command responsible for the Ohio River is Sector Ohio Valley. Sector Ohio Valley includes three Marine Safety Units: Pittsburgh, Pennsylvania.; Huntington, West Virginia.; Paducah, Kentucky and two Marine Safety Detachments: Cincinnati, Ohio and Nashville, Tennessee. According to Coast Guard data, the tow boat fleet of responsibility for Coast Guard Sector Ohio River Valley is approximately 976. Even though MSD Nashville is not on the Ohio River, tow boats from that area transit the river system, including the Ohio River. The breakdown by Coast Guard office within that Sector is highlighted is figure 3.

Figure 3 Source: Coast Guard data for tow boat fleet of responsibility for Sector Ohio Valley

Tow Boat Challenges

While tow boats would be a natural fit for the application of LNG propulsion technology, there are several significant hurdles that need to be overcome. Below is a list of some of those challenges.

- Small tow boats bring space challenges for LNG engines and fuel tanks. An engineering study needs to be conducted on all tow boat sizes that operate on the Ohio River to determine the feasibility of adopting this technology. The study needs to include, but is not limited to the engineering requirements of an engine retrofit, determining the size and location of the LNG fuel tank, stability requirement and any operational requirements that may be placed on the vessel.

- The location of the LNG fuel tank on the boat may be a limiting factor. The current Coast Guard policy prohibits the placement of LNG fuel tanks above or below accommodation spaces. Working closely with the Coast Guard an applicable classification society early on in the process is critical to success.

Refueling Options:

Establishing a supply system along the Ohio River that can provide LNG to tow boats is critical to the success of this effort. This can be accomplished by tank truck, fixed facility (LNG storage tank or liquefaction plant) or by tank barge. A discussion of the LNG supply chain is detailed in the section below. There are a number of options for refueling:

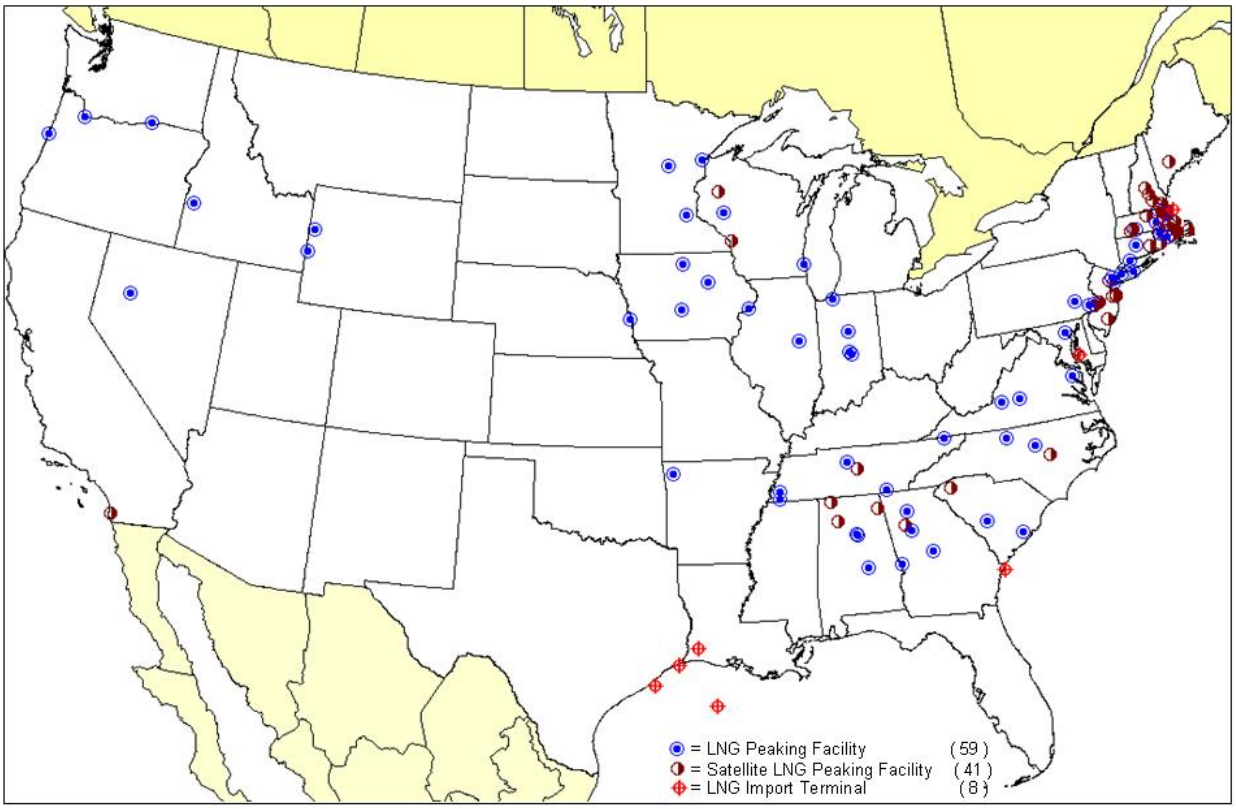
- Tank truck fueling at the dock.
- Construction of designated facilities (either LNG storage tanks or liquefaction plants) along the Ohio River that the tow boat can refuel. This option would most likely require the tow boat to disconnect from their tow, conduct bunker operations then reconnect. This would most likely cause an operational delay. A cost/benefit analysis would need to be completed by the company before making a determination.
- Refueling by a LNG tank barge at a dock, anchorage area, fleeting area or while underway in the river. If approved, there will most likely be operational restrictions required by the Coast Guard.

Figure 4: Shale Play Locations: Source EIA

Supply Chain

Key to the successful implementation of LNG as fuel along the Ohio River is the supply chain. There is a significant supply of nature gas shale plays in the United States. The Marcellus play in the Pennsylvania area provides a huge supply that can be tapped for future use (See Figure 4). An examination of the current supply chain on the Ohio River reveals no current infrastructure in place. There are a number of existing peak shaving plants, satellite peak shaving plants and import terminals around the U.S. The closest peak shaving plants to the Ohio River are located in the middle of Indiana (three locations) and Illinois (one location), and one location in the eastern portion of Pennsylvania. There are no LNG facilities in West Virginia and Kentucky (see figure 5).

Further, Figure 6 is a map provided by the Department of Transportation's Office of Pipeline and Hazardous Materials Administration that shows the location of LNG Peak Shaving facilities that are connected to natural gas pipelines. Those locations are consistent with the locations of the liquefaction plants that are supplied by tank trucks.



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.

Figure 5: LNG Peak Shaving Facilities and LNG Import Terminals

Future Supply Chain: In the Gulf Coast Corridor, Shell Oil Company plans to install a small-scale liquefaction unit at its Shell Geismar Chemicals facility in Geismar, Louisiana. Once operational, this unit will supply LNG along the Mississippi River, the Intra-Coastal Waterway and to the offshore Gulf of Mexico and the onshore oil and gas exploration areas of Texas and Louisiana.

This facility will supply LNG fuel to marine vessels that operate in the Gulf of Mexico and provide what is anticipated to be the first LNG barging and bunkering operation in North America at Port Fourchon, Louisiana. The LNG transport barges will move the fuel from the Geismar production site to Port Fourchon, Louisiana. Their Gulf Coast Corridor will provide LNG along the Gulf coast from Pensacola, Florida to Houston, Texas. It will also serve the marine industry along the lower Mississippi River, Intra-Coastal Waterway and the offshore oil and gas industry in the Gulf of Mexico.[5]

[5] Shell Press Release, LNG Tomorrow's Fuel Today, Gulf Coast Corridor, March 2013

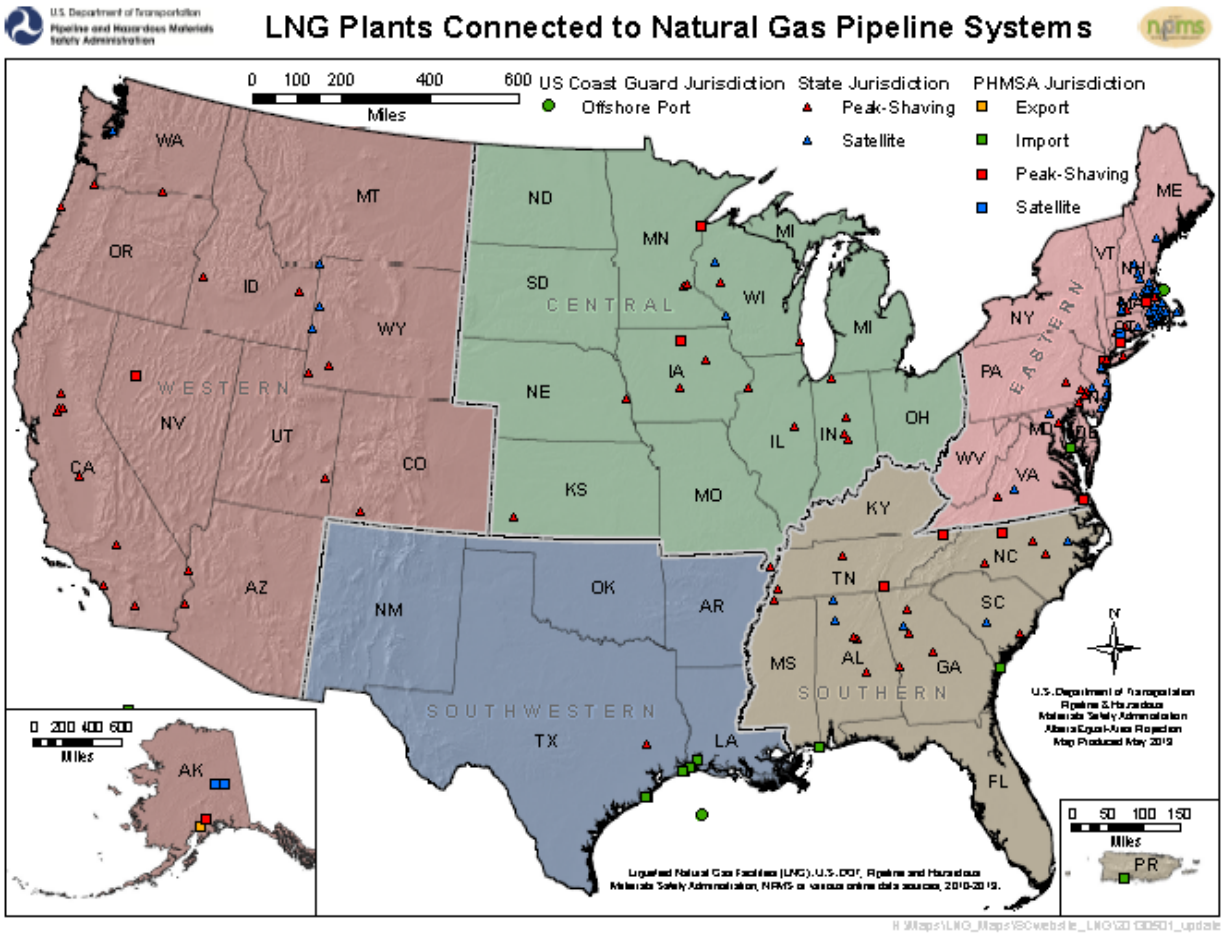


Figure 6: DOT Pipeline and Hazardous Material Safety Administration Gas Systems

In the Great Lakes corridor, Shell plans to install a small-scale liquefaction unit at its Shell Sarnia Manufacturing Centre in Sarnia, Ontario, Canada along the St. Clair River. Once operational, this project will supply LNG fuel to all five Great Lakes, their bordering U.S. states and Canadian provinces and the St. Lawrence Seaway. Shell signed an MOU with Travel Centers of America to supply LNG fuel from their Sarnia facility to long-haul truck stops between Chicago, Detroit and Louisville. The Great Lakes corridor LNG availability zone from the Sarnia Manufacturing Centre would include Detroit, Chicago, Indianapolis, Louisville, Washington D.C. and New York City and serve marine, truck and possible rail transportation.[6]

Both of these locations may have the capability of providing LNG to the Ohio River region sometime in the future.

[6] Shell Press Release, LNG Tomorrow's Fuel Today, Great Lakes Corridor, March 2013

Midstream refueling by LNG tank barge:

Internationally, the first LNG tank barge in the world services LNG fueled vessels in Stockholm, Sweden. The LNG bunker boat *Seagas* will provide liquefied natural gas fuel to Viking Line's *Viking Grace*. The *Seagas* is a converted ferry from Norway, originally built in 1974, is 157 feet and can transport about 70 tons (50,000 gallons) of LNG. (See Figure 7)

Figure 7: Source: LNG bunker boat *Seagas*

In the U.S. several companies have initiated construction of LNG fueled Off-Shore Supply Vessels (OSV) that support the off-shore oil and gas industry. The only current project for building an LNG bunker barge is for Waller Marine. The company was granted an Approval in Principal in October 2012 from the American Bureau of Shipping for the Articulated Tug Barge (ATB) LNG and regasification barge concept. Waller Marine intends to build an LNG and regasification ATB with capacities from 15,000 to 50,000 m^3 and small ATBs with capacities from 2,000 to 10,000 m^3 designed for the lower Mississippi River and coastwise trade.[7]

The vessel has the ability to load LNG from LNG terminals, liquefaction facilities or traditional LNG carriers and transport product to existing storage tanks or other facilities, trucks or marine

[7] Waller Marine Presentation at LNG For Marine Transportation Conference, Houston, Texas, June 11-13, 2013

vessels using LNG as a fuel. The barge also is equipped for regasification of LNG directly to a pipeline or to a power plant.

The benefit of the transporting LNG by barge on the Ohio River is that it allows the product to be moved and delivered more efficiently on a small-scale basis to locations where large LNG infrastructure is not existent and is too costly and time consuming to construct. A barge can also serve as a floating storage facility, positioned to provide LNG fuel to tow boats. There are several locations along the Ohio River that serve as connecting/disconnecting and fleeting areas. The Paducah, Kentucky to South Point, Ohio serves as an interchange area and Pittsburgh, Pennsylvania to South Point with Pittsburgh serving as a fleeting area. These would be potential areas for midstream refueling.

While there are many benefits to midstream refueling, there are operational and regulatory issues that need to be addressed. In concert with the Coast Guard Captain of the Port, the location(s) of the midstream refueling area will need to be determined. A Waterways Suitability Assessment, while required for transportation of large quantities of LNG (as cargo) may also be required by the Coast Guard Captain of the Port for a LNG bunker barge. A variety of waterway restrictions could be imposed from safety or security zones, exclusion zones and operational restrictions including day time operations, escort vessels and security requirements.

Roadblocks to Success

This study has identified some potential roadblocks that could hinder the development of LNG fueled vessel technology and supply chain along the Ohio River. The roadblocks listed below are not limited to regulatory challenges, but also include a broader context including stakeholder involvement and buy-in, the cost to implement this new technology and the current lack of an LNG supply chain.

Stakeholder concern over LNG: Similar to the Great Lakes area, this process must include outreach to stakeholders. Depending on the location of LNG storage tanks, liquefaction plants or refueling by tank truck, the Ohio River area encompasses six states. Assuming that there is some type of facility in each of those states, the stakeholder outreach effort must include every state. This process must include an outreach and education effort on the properties of LNG, as well as addressing any concerns over its handling and storage. There are misconceptions regarding its safety, and those issues need to be addressed before the project can be successful.

Cost to implement: The cost to repower a vessel with either a replacement engine or repowering using LNG is expensive. There could be significant capital investment in the design of tow boats to accommodate the engine and LNG fuel tank. Companies may not have the capital to invest unless there are federal grant programs that encourage investment in this technology. Norway's NOx fund continues to be an excellent example of the government approving the establishment of a private fund that is used to reimburse a portion of the purchase of NOx reducing technology.

Delays in completing Federal, State and Local regulatory requirements: The Coast Guard has made significant progress in developing draft guidance documents that address operational requirements for LNG bunkering as well as the training and qualifications of personnel

conducting those operations. Additionally, the Coast Guard has published a Notice of Proposed Rulemaking on August 11, 2011 which proposes safety regulations governing the inspection, standards, and safety management systems of towing vessels. However, until regulations are published that address these issues, each project will be evaluated on a case by case basis. If the desire is to pursue fixed facilities (storage tanks or liquefaction plants), there are numerous federal, state and local government permits required prior to construction. Depending on the speed of that process, there could be delays in beginning this effort.

Lack of LNG supply chain infrastructure: The availability of LNG as fuel is limited due to the lack of infrastructure along the Ohio River. There are no Peak Shaving plants in close proximity nor are there plans to build any in the near future. If the intent is to fuel the vessel by tank truck, this will also be a challenge due to the extensive travel distance from the LNG facility to the tow boat. This will have an impact on supplying LNG to tow boats. Supply trucks will have to travel large distances and fueling locations will have to be identified. The other option is the fueling of tow boats by an LNG tank barge that can conduct midstream transfers or bunkering operations alongside the tow boat while moored at a dock. Fueling by tank barge is a longer term option as there are currently no barges being built to service the commercial industry operating in the Ohio River.

It is recommended that a supply chain study be undertaken to develop a LNG supply implementation plan that would include LNG supply tank truck, tank barge and/or LNG liquefaction plant.

Tow boat design for LNG engines and fuel tanks: Current tow boats that operate on portions of the Ohio River are smaller and may not have the space to accommodate LNG engines and fuel tanks. An additional complicating factor is the current Coast Guard policy which prohibits the placement of LNG tanks below accommodation spaces. Larger tow boats may have the space to accomplish the modification of an existing engine or installation for new builds. While tow boats would be a natural fit for the application of LNG propulsion technology, there are several significant hurdles that need to be overcome. Below is a list of some of those challenges

- Small tow boats bring space challenges for LNG engines and fuel tanks. An engineering study needs to be conducted on all tow boat sizes that operate on the Ohio River to determine the feasibility of adopting this technology. The study needs to include, but is not limited to the engineering requirements of an engine retrofit, determining the size and location of the LNG fuel tank, stability requirement and any operational requirements that may be placed on the vessel.
- The location of the LNG fuel tank on the boat may be a limiting factor. The current Coast Guard policy prohibits the placement of LNG fuel tanks above or below accommodation spaces. Working closely with the Coast Guard an applicable classification society early on in the process is critical to success. Even though tow boats are not inspected vessels by the Coast Guard, LNG repowering and new builds require approval from Commandant, U.S. Coast Guard.

Recommendations

The U.S. regulatory and policy framework is being developed and the supply chain infrastructure is also moving forward. In order to move forward and make this technology a reality, the following recommendations are offered. They are divided into those involving outreach and others that address facility and vessel compliance, and supply chain requirements. Both areas are critical to make this effort successful.

Outreach

Outreach to all stakeholders, including but not limited to local citizens, environmental groups, federal, state and local agencies and is critical in any project that may be controversial. The Ohio River encompasses six states and numerous county and local governments. There must be a significant outreach plan regardless of the LNG facility location. The location can include land-based storage or liquefaction plants or designated anchorage or fleeting areas along the river. Therefore, it is recommended that maritime companies and organizations:

- Work closely with federal, state and local officials in planning and implementation of LNG operations along the Ohio River (i.e., fueling procedures, fire fighting training, transfer requirements, licensing qualifications, etc). Specifically, companies intending to implement LNG fueled technology need to reach out to Coast Guard Sector Ohio Valley, applicable states and local governments in complying with transfer operation requirements (regulatory and NFPA) for fixed and/or mobile facilities.
- Develop an outreach plan to obtain buy-in and support from local and regional stakeholders. Failure to obtain buy-in and support from this group could result in significant delays or possibly cancellation of the project. This effort needs to be started as soon as possible.

Facilities (Fixed and Mobile)

The Ohio River area is not unlike other areas of the U.S. The technology is new and the infrastructure is not yet available to support this initiative. Additionally, the areas along the river often are remote and access can be difficult. Therefore, the following is the recommended approach should towing companies and LNG suppliers decide to pursue this initiative:

- Initiate a phased-in approach by starting with LNG bunkering by tank truck. At the same time, develop plans and obtain approvals/permits from applicable federal, state and local agencies for LNG storage tanks or liquefaction plants, if desired.
- Continue to develop the LNG supply chain along the Ohio River.
- Further research is needed to analyze the supply chain and LNG availability, including potential fueling locations along the Ohio River. An evaluation of the best option for LNG fueling should be conducted which includes LNG storage tanks, liquefaction plants, tank trucks and tank barges.

Vessels

- Work closely with the U.S. Coast Guard (Marine Safety Center, Coast Guard Headquarters and Sector Ohio Valley) to obtain plan approval for a LNG conversion on tow boats operating on the Ohio River. The requirements for obtaining plan approval are detailed in the Coast Guard policy letter CG 521 (01-12).
- Implement Coast Guard mandates for transfer procedure requirement, training and licensing, when applicable. The Coast Guard has drafted policy for these areas and there is an opportunity, through MERPAC and other professional organizations to be involved in the process.

Nitrogen Oxides (NOx) Fund

Norway has been very successful in encouraging the maritime industry to invest in NOx reducing technology. They have established a federal tax on NOx emissions. As an option, they also approved the establishment of a private NOx fund that companies can voluntarily contribute monies (through a tax). If companies sign up and contribute, then 80 percent of differential costs between the LNG and non-LNG engine plants can be recouped from the fund by companies who upgrade their technology with NOx reducing equipment. This program applies to Norwegian flag vessels that transit strictly on Norwegian territorial waters. The NOx fund has been extremely successful and has contributed in furthering the LNG fueled ships initiative. The U.S. should consider developing a similar program that supports the implementation of this technology.

Disclaimers

The opinions expressed here are those of the author only and do not represent the opinions, conclusions, or plans of any of the companies or agencies that have provided assistance to this study.

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