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Report to Congressional Committees

December 2015

MARITIME TRANSPORTATION

Implications of Using U.S. Liquefied-Natural-Gas Carriers for Exports

Accessible Version

GAO-16-104

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GAO Highlights

Highlights of GAO-16-104, a report to congressional committees

Why GAO Did This Study

More than 30 companies have received approval from DOE for large-scale exports of U.S. LNG—natural gas cooled for transportation—beginning in 2015 or 2016 via specialized LNG carriers.

Congress is considering whether to propose legislative language that would require U.S. LNG be exported via U.S.-built-and-flagged carriers with the goal of supporting U.S. shipbuilders and mariners. Congress included a provision in statute for GAO to review the number of vessel-construction and operating jobs that would be created in the U. S. maritime industry each year in 2015 through 2025 if exported LNG were required to be carried (1) before December 31, 2018, on vessels documented under the laws of the United States and (2) after such date, on vessels documented under the laws of and constructed in the United States. This report discusses (1) DOE and industry expectations for the market for U.S. LNG exports and (2) how the proposed requirement could affect jobs in the U.S. maritime industry and the broader U.S. economy.

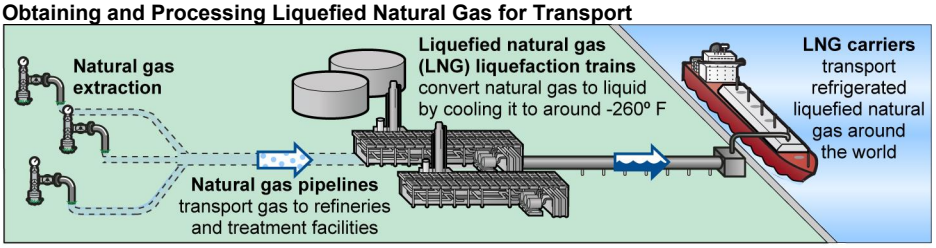
GAO reviewed and analyzed economic forecasts of the LNG market and interviewed relevant stakeholders including officials from DOD, DOE, the Department of Transportation, Coast Guard, and the U.S. Trade Representative; representatives of mariner groups, three U.S. shipyards that expressed interest in this market, the five U.S. liquefaction facilities that are under construction, and economic-research firms that have studied the LNG market.

View GAO-16-104. For more information, contact Susan A. Fleming at (202) 512-2834 or flemings@gao.gov.

What GAO Found

According to Department of Energy (DOE) and industry expectations, in the next few years the United States is expected to change from a net importer of natural gas to a net exporter, with those exports destined for different regions of the world, especially Asia. Five large-scale U.S. liquefaction facilities—necessary for conversion of natural gas to liquefied natural gas (LNG) (see fig. below)—are under construction with a projected capacity to export more than 12 percent of U.S. natural gas production in 2020. According to representatives from these five facilities, their liquefaction capacity has already been sold mainly through 20-year contracts and their customers are responsible for transporting the LNG to export markets. Based on estimates from these liquefaction facilities, transport of the full capacity of these liquefaction facilities will require about 100 or more LNG carriers. Currently operating LNG carriers are nearly all foreign built and operated. LNG carriers have not been built in the United States since before 1980, and no LNG carriers are currently registered under the U.S. flag.

Obtaining and Processing Liquefied Natural Gas for Transport



Source: GAO. | GAO-16-104

The proposed requirement to transport exports of LNG via U.S.-built-and-flagged carriers could expand employment for U.S. mariners and shipbuilders if it does not reduce the expected demand for U.S. LNG. According to representatives of U.S. mariner groups, between 4,000 and 5,200 mariners would be needed to operate the estimated 100 LNG carriers needed to transport the five U.S. facilities' full capacity of LNG once the five are fully operational. Based on the current capacity of U.S. shipyards we spoke with, building 100 carriers would likely take over 30 years, with employment in U.S. shipyards increasing somewhat or becoming more stable, according to shipyard representatives. Department of Defense (DOD) officials also indicated that any policy or requirement that increases and stabilizes jobs in the U.S. maritime industry could support military readiness. However, according to industry representatives, U.S. carriers would cost about two to three times as much as similar carriers built in Korean shipyards and would be more expensive to operate. Based on GAO analysis, these costs would increase the cost of transporting LNG from the United States, decrease the competitiveness of U.S. LNG in the world market, and may, in turn, reduce demand for U.S. LNG. The extent of these effects depends on customers' circumstances and business decisions. For example, several stakeholders told us implementing the proposed requirement may prompt customers to attempt to modify, renegotiate, or terminate their existing contracts for liquefaction. Additionally, limited availability of U.S. carriers in the early years of construction may decrease the amount of LNG that could be exported from the United States for a period of time, leading customers to seek alternate sources. Further, a reduction in the level of expected U.S. LNG exports could impact the broader U.S. economy, including potential job and profit losses in the oil and gas sector.

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Abbreviations

Act	Howard Coble Coast Guard and Maritime Transportation Act
bcf	billion cubic feet
BLS	Bureau of Labor Statistics
Btu	British thermal units
DOD	Department of Defense
DOE	Department of Energy
DOL	Department of Labor
DOT	Department of Transportation
EIA	Energy Information Administration
FERC	Federal Energy Regulatory Commission
LNG	liquefied natural gas
MARAD	Maritime Administration
MMBtu	million British thermal units
MSP	Maritime Security Program
NEPA	National Environmental Policy Act
NGA	Natural Gas Act
USCG	U.S. Coast Guard
VISA	Voluntary Intermodal Sealift Agreement

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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December 3, 2015

The Honorable John Thune
Chairman
The Honorable Bill Nelson
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Bill Shuster
Chairman
The Honorable Peter A. DeFazio
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

Worldwide, trade of liquefied natural gas (LNG)—that is, natural gas that has been liquefied for the purposes of storage and transportation—has the potential to increase from about 241-million tons annually in 2014 to about 424-million tons by 2020, according to the International Gas Union.[1] As advances in natural gas extraction technology have dramatically increased the amount of domestic gas extraction, the role of the United States in this market is poised to change from that of a net importer of natural gas to a net exporter. As of September 2015, more than 30 companies have applied to and been approved by the Department of Energy (DOE) to export U.S. LNG from large-scale liquefaction facilities, and exports are expected to begin in 2015 or 2016 via specialized LNG carriers.

There have long been questions about the health of the U.S. maritime industry, and its capacity to meet the needs of the U.S. military, including shipbuilding and mariner needs. To support the U.S. maritime industry

[1]International Gas Union, *World LNG Report—2015 Edition*, World Gas Conference Edition (Fornebu, Norway: 2015). The International Gas Union is a non-profit organization comprised of associations and corporations in the global gas market.

and better ensure its capacity to meet military needs, the Jones Act[2] and Cargo Preference laws[3] were enacted to help support a market for U.S. shipbuilding and mariners.[4] Currently, Congress is considering whether to propose legislative language that would require that U.S. LNG be exported via U.S.-built-and-flagged carriers with the goal of supporting U.S. shipbuilders and mariners and increasing jobs in those industries.[5] The Howard Coble Coast Guard and Maritime Transportation Act (Act) of 2014[6] included a provision for us to report on the number of positions that would be created in the U.S. maritime industry each year from 2015 through 2025 if LNG exported from the United States were required to be carried (1) before December 31, 2018, on carriers documented under the laws of the United States; and (2) after such date, on carriers documented under the laws of and constructed in, the United States. Currently, LNG carriers are nearly all foreign built and all are foreign flagged.[7] This report discusses:

- current industry and DOE expectations for the market for U.S. exports of LNG and how that market is expected to operate;
- stakeholders' views on how the proposed requirement to use U.S.-flagged-and-built carriers for LNG exports could affect jobs in the

[2]In general, the Jones Act requires that maritime transport of cargo between points in the United States be carried by vessels that are owned by U.S. citizens and registered under the U.S. flag with a coastwise endorsement, which in turn requires that such vessels be built in the United States. Section 27 of the Merchant Marine Act of 1920, Pub. L. No. 66-261, 41 Stat. 988, 999 (1920) (codified as amended at 46 U.S.C. § 55102).

[3]Three cargo preference laws identified by the Department of Transportation's Maritime Administration (MARAD) include what are commonly known as the Military Cargo Preference Act of 1904, Pub. L. No. 58-198, 33 Stat. 518 (1904) (codified as amended at 10 U.S.C. § 2631); Public Resolution 17, 73d Cong. 48 Stat. 500 (1934) (codified as amended at 46 U.S.C. § 55304); and the Cargo Preference Act of 1954, Pub. L. No. 83-664, 68 Stat. 832 (1954) (codified as amended at 46 U.S.C. § 55305).

[4]These laws require that certain cargoes or cargoes shipped to specific destinations be transported using U.S.-flagged and/or U.S.-built vessels.

[5]U.S.-flagged vessels are vessels registered in the United States, which must therefore meet U.S. Coast Guard requirements for safety, meet crew citizenship requirements, and abide by the laws of the United States.

[6]Pub. L. No. 113-281, § 308, 128 Stat. 3022.

[7]For the purposes of this report, LNG carriers refer specifically to vessels built for the purpose of transporting large amounts of LNG over long distances.

maritime, shipbuilding, and other related sectors; and

- potential effects of the proposed requirement on the market for U.S. LNG and the broader U.S. economy, including other industries.

To describe current industry and DOE expectations for the market for U.S. exports of LNG, and how that market is expected to operate, we collected and analyzed information on economic forecasts of the LNG market, including the U.S. Energy Information Administration's (EIA) Annual Energy Outlook.[8] We interviewed DOE officials and representatives from four economic research and consulting firms that have published reports on the prospective market for U.S. LNG and LNG "liquefaction"[9] companies that have begun construction of U.S. liquefaction facilities to better understand DOE's estimates about expected U.S. LNG exports and the world LNG market and to assure ourselves that the estimates are sufficiently reliable for the purposes of this report. We identified economic research and consulting companies based on a literature review. We also interviewed the four companies associated with the five approved and under-construction domestic export facilities (as listed on the Federal Energy Regulatory Commission's list of approved import/export terminals in the continental U.S.) regarding their plans and expectations.[10] In addition, we interviewed representatives from the identified economic research and consulting firms and energy companies regarding expected export capacity, customer plans, and the number of LNG carriers needed to transport expected U.S. LNG capacity. We also analyzed this information to develop our own estimate of the needed carrier capacity.

The provision in the Act regarding this work specifies that GAO report on the number of positions that would be created in the United States' maritime industry each year beginning with 2015 through 2025 if the proposed requirement were implemented. As the proposed requirement had not been introduced as legislation as of October 2015, the dates referenced in the Act may change. As such, to describe stakeholder views on the potential effects of the proposed requirements on maritime

[8]The U.S. Energy Information Administration is the statistical and analytical agency within the U.S. Department of Energy.

[9]For the purposes of this report, "liquefaction" refers to the process of liquefying natural gas (see page 5 and fig.1).

[10]There is an LNG export facility that has been operating in Alaska since the 1980s, but this facility is responsible for a very small portion of expected U.S. exports.

jobs and the economy and to determine the potential effects of these requirements on the market for U.S. LNG and the broader U.S. economy, we have referenced timeframes more generally, rather than referring to specific dates. To describe stakeholder views on the extent to which the requirement of U.S.-flagged-and-built vessels for LNG exports could affect domestic jobs in the maritime, shipbuilding, and other related sectors, we obtained and analyzed the views of selected maritime-industry stakeholders, as well as related documents they provided on the capability and capacity of U.S. shipbuilders and estimated costs and requirements to build and operate LNG carriers. These stakeholders included representatives of three shipbuilding companies; shipping companies (one shipbroker and one LNG carrier operator); the four major marine officer and unlicensed mariner unions in the United States; and officials from DOE, Department of Transportation's (DOT) Maritime Administration (MARAD), and Department of Labor (DOL). We selected maritime stakeholders (including shipbuilders, mariner unions, and shipping companies) for interview based on recommendations from government and industry stakeholders and their capacity to provide services related to LNG carrier construction and operation. For instance, we selected the ship broker and ship operator based on the fact that they are currently involved in shipping LNG. We selected U.S. shipbuilders from a list of 11 large and active shipbuilding companies in the U.S. as of April 2015 based on their stated interest and capacity to build LNG carriers. We also interviewed MARAD, Department of Defense (DOD), and U.S. Coast Guard (USCG) officials to obtain their views on potential benefits for military readiness, including the U.S. maritime industry's capacity to meet military needs.

To identify the potential effects the proposed requirement may have on the broader U.S. economy, we collected and analyzed economic forecasts and testimonial evidence from industry stakeholders and economic research and consulting companies (as discussed earlier). We then assessed the resulting evidence using established economic theory and reasoning to describe potential effects of the proposal on world demand for U.S. LNG and jobs in other relevant U.S. industries. To illustrate the cost impact of a U.S.-flagged-and-built carrier requirement for LNG exports, if all other factors remain equal, we developed a set of hypothetical assumptions based on discussions with industry stakeholders, a 2011 MARAD report on the costs of operating U.S.-

flagged vessels,[11] and economic theory. For the purposes of estimating the potential costs of the proposed requirement, we made what we believe to be conservative estimates, including estimates of the cost of building LNG carriers in the United States and the costs of operating those carriers, in order to ensure that we do not overstate those potential cost effects. Due to the hypothetical nature of the proposed requirement as well as challenges related to predicting market outcomes, the estimated cost impacts are meant to be solely illustrative and should not be taken as a prediction. We interviewed U.S. Trade Representative officials and industry stakeholders regarding potential implications for U.S. trade. Additionally, we interviewed the U.S. Coast Guard and selected (as mentioned above) U.S. LNG liquefaction companies and shipping companies regarding potential security implications for LNG customers related to transporting LNG via U.S.-flagged-and-built carriers. See additional information on our scope and methodology in appendix I.

We conducted this performance audit from March 2015 to December 2015 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

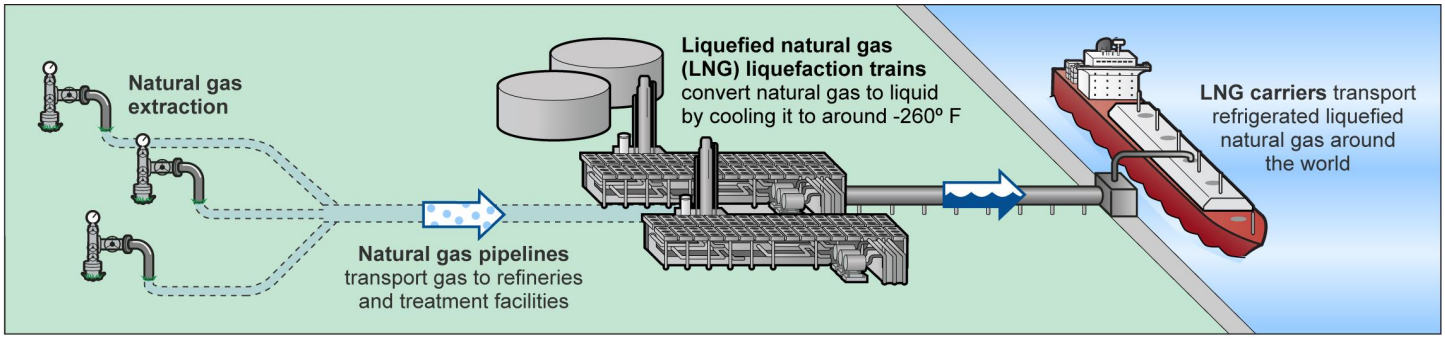
Liquefied Natural Gas

Natural gas is a fuel that can be used in many contexts, similar to gasoline, heating oil, and other crude-oil derivatives and is considered more environmentally friendly than oil derivatives. In its gaseous form, natural gas is transported by pipeline. LNG is natural gas cooled to -260 degrees Fahrenheit, at which point it becomes a liquid, and its volume is reduced by 600 times—allowing for ease of transportation via specialized

[11]Department of Transportation, Maritime Administration, *Comparison of U.S. and Foreign-Flag Operating Costs,* (Washington, D.C.: September 2011). While information on operating costs from MARAD is not specific to LNG carriers (or carriers of any kind), we determined that, as the only source of publicly available information comparing actual costs of U.S and foreign-flagged vessels, this report was sufficiently reliable for our limited purpose of developing an estimate of the potential costs of operating U.S. LNG carriers, in combination with additional estimates of potential costs provided by industry stakeholders.

LNG carriers over long distances. This cooling process takes place at liquefaction facilities. Figure 1 illustrates this process.

Figure 1: Process of Obtaining and Processing Liquefied Natural Gas (LNG) for Transport



Source: GAO. | GAO-16-104

Depending on the context, different units of measurement are used to describe volumes of natural gas and liquefied natural gas, as well as their respective energy content. For the purposes of this report, the conversions used are outlined in table 1.

Table 1: Conversion of Liquid, Gas, and Energy Equivalents of Natural Gas

	1 billion cubic feet (bcf) of natural gas	1 thousand cubic meters of LNG	1 million British thermal units (MMBtu)
1 billion cubic feet (bcf) of natural gas	1	47	1,100,000
1 thousand cubic meters of liquefied natural gas (LNG)	0.02189	1	23,308
1 million British thermal units (MMBtu)	0.0000011	4.29e-5	1

Source: GAO analysis of Department of Energy data. | GAO-16-104

Note: These conversions are based on those included in the Department of Energy's publication *Liquefied Natural Gas: Understanding the Basic Facts* (August 2005).

World Market for Natural Gas

Through 2015, the United States has been a net importer of natural gas, along with Japan, India, South Korea, Taiwan, and others. Ocean transport of LNG began in the late 1950s and early 1960s. According to the International Gas Union, Japan and South Korea are currently the largest importers of LNG, and as of 2014, the largest supplier/exporter of LNG was Qatar, followed by Malaysia, Australia, Nigeria, Indonesia, Trinidad, and Algeria.[12] As discussed in greater detail in the following section,

[12]International Gas Union, *World LNG Report.*

according to DOE, the market for LNG has changed recently due mainly to technology enhancements in the extraction of natural gas from shale formations and changes in energy needs.

Federal Role in Maritime and LNG Industries

Several federal agencies oversee or are involved in LNG exports or the U.S. maritime industry:

- **Department of Energy:** Under Section 3 of the Natural Gas Act (NGA), the import or export of LNG and the construction or expansion of LNG facilities requires authorization from DOE.[13] In 1984, DOE delegated the responsibility to approve or deny applications for LNG facilities to the Federal Energy Regulatory Commission (FERC).[14]

- **Federal Energy Regulatory Commission:** In keeping with its obligation to authorize LNG facility siting and construction under the NGA, FERC reviews applications to construct and operate LNG export facilities onshore or in state waters.[15] FERC's review is considered a federal action and subject to the National Environmental Policy Act (NEPA).[16]

- **Coast Guard:** Within the Department of Homeland Security, the U.S. Coast Guard is responsible for administering and enforcing requirements for U.S.-flag registry (e.g., determining whether vessels meet U.S.-owned-and-built requirements). USCG is also responsible for credentialing mariners and maintains records on all mariners who hold valid merchant mariner credentials, including data on mariners

[13]Pub. L. No. 75-688, § 3, 52 Stat. 822 (1938) (codified at 15 U.S.C. § 717b). For additional information about this process, see GAO-14-762.

[14]DOE Delegation Order 0204-112, 49 Fed. Reg. 6684, 6690 (Feb. 22, 1984).

[15]For facilities located offshore beyond state waters, the Maritime Administration (MARAD) within the Department of Transportation authorizes construction pursuant to the Deepwater Port Act of 1974, as amended (Pub. L. No. 93-627, 88 Stat. 2126 (1975)).

[16]Enacted in 1970, NEPA has as its purpose, among others, to promote efforts to prevent or eliminate damage to the environment. NEPA requires an agency to prepare a detailed statement on the environmental effects of any "major federal action" significantly affecting the environment. Regulations promulgated by the Council on Environmental Quality implementing NEPA generally require an agency to prepare either an environmental assessment or an environmental impact statement depending on whether or not a proposed action could significantly affect the environment. For additional information about this process, see GAO-14-762.

who may serve on U.S.-flag vessels that support the DOD during times of war or national emergencies.

- **Maritime Administration:** MARAD's mission is to foster and promote the U.S. Merchant Marine and the American maritime industry to strengthen the maritime transportation system—including the shipbuilding and repair industry—to meet the economic and national-security needs of the nation. MARAD administers the Federal Ship Financing Program (commonly referred to as Title XI based on the part of the Merchant Marine Act of 1936 that established the program),[17] which provides a U.S. Government guarantee of private loans to (1) U.S. or foreign ship owners for the purpose of financing or refinancing either U.S. flag vessels or eligible export vessels constructed, reconstructed or reconditioned in U.S. shipyards and (2) U.S. shipyards for the purpose of financing advanced shipbuilding technology and modern shipbuilding technology of a privately owned, general shipyard facility located in the United States. In general, under the Federal Credit Reform Act of 1990, appropriations to cover the estimated subsidy costs[18] of a project must be obtained prior to the issuance of any letter of commitments for loan guarantees.[19]

- **Department of Defense:** As we have noted, the military strategy of the United States relies, in part, on the use of commercial U.S.-flagged ships and crews and the availability of a shipyard industrial base to support national defense needs.[20]

[17]Pub. L. No. 75-705, § 46, 52 Stat. 953, 969 (1936) (codified as amended at 46 U.S.C. Chapter 537).

[18]The credit subsidy costs for loans and loan guarantees is the net present value of expected lifetime cash flows to and from the government over the life of the loan, excluding administrative costs.

[19]Pub. L. No. 101-508, § 13201(a), 104 Stat. 1388-610 (1990) (codified as amended at 2 U.S.C. § 661c). More specifically, under 2 U.S.C. § 661c(b), new loan guarantee commitments may be made only to the extent that–(1) new budget authority to cover their costs is provided in advance in an appropriations act; (2) a limitation on the use of funds otherwise available for the cost of a direct loan or loan guarantee program has been provided in advance in an appropriations act; or (3) authority is otherwise provided in appropriations acts.

[20] GAO, *Puerto Rico: Characteristics of the Island's Maritime Trade and Potential Effects of Modifying the Jones Act*, GAO-13-260 (Washington, D.C.: Mar. 14, 2013).

In addition to the roles described above MARAD and DOD jointly manage programs intended to increase capacity for the military, including those related to sealift capacity. Sealift is the process of transporting DOD's and other federal agencies' equipment and supplies required during peacetime and war. First, the Voluntary Intermodal Sealift Agreement (VISA) program was established to provide DOD with "assured access" to commercial sealift and intermodal capacity to support the emergency deployment and sustainment of U.S. military forces.[21] To meet national defense or other security needs, DOD may use commercial sealift capacity, to the extent it is available, to meet ocean transportation requirements. This commercial sealift capacity includes U.S.-and-foreign-flagged vessels and/or intermodal capacity to support DOD's needs. In the event voluntary capacity does not meet DOD's contingency requirements, DOD may activate VISA as necessary.

A second program, the Maritime Security Program (MSP), is administered by MARAD and is intended to guarantee that certain kinds of militarily useful ships and their crews will be available to DOD in a military contingency.[22] Currently, MSP provides direct payment of $3.1 million per year for up to 60 militarily useful U.S.-flagged vessels participating in international trade to support DOD.[23] DOT determines the commercial viability and DOD determines the military usefulness of vessels that seek participation in MSP. According to MARAD, as of October 2015, there were 165 large oceangoing vessels operating under the U.S. flag, 139 of which have been categorized as militarily useful. If needed, vessels in MSP would be activated through the VISA program.

[21]Intermodal capacity includes dry cargo ships, equipment, terminal facilities and intermodal management services.

[22]Vessels in the voluntary MSP are also enrolled in VISA.

[23]As of October 1, 2015, there were 58 vessels that participate in MSP.

DOE and Industry Expect the United States to Play a Large Role in the LNG Market over the Next 10 Years

DOE and Industry Expect the United States to Become a Significant Exporter of LNG

According to DOE, due to advances in extraction technologies and growing worldwide demand for natural gas, the United States is expected to become a net exporter of natural gas in the next few years. For decades the United States has been a net importer of natural gas, and as recently as just a few years ago the prospects that the U.S. would become a net exporter in this market seemed doubtful. For example, EIA's *Annual Energy Outlook* 2011 did not have any projections for net exports of natural gas by the United States, but the next year's Energy Outlook did show projected exports and those projections in more recent years have risen.[24]

According to EIA, this evolution in the U.S. natural gas industry relates to the discovery of more energy resources as well as advances in hydraulic-fracturing and horizontal-drilling technologies. Moreover, studies we reviewed noted that the pricing of natural gas in many other regions of the world has traditionally been linked to oil prices, while in the U.S. prices are set based on supply and demand conditions in North America. Economic theory suggests that these differing price mechanisms in various regions of the world have encouraged some companies to invest in U.S. natural-gas liquefaction and export facilities with the intent to profitably sell U.S. natural gas in other regions where natural gas prices have generally been higher, particularly when oil prices are high. More recently, however, DOE officials told us that as the LNG export market has developed, oil-linked pricing is coming under pressure as buyers are benefiting from more options and demanding more flexibility in their

[24]Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011*, DOE/EIA-0383(2011) (Washington, D.C.: April 2011) and Department of Energy, Energy Information Administration, *Annual Energy Outlook 2012,* DOE/EIA-0383(2012) (Washington, D.C.: June 2012).

purchases. Nevertheless, demand for natural gas is expected to be strong with growing demand in the coming years.

Beyond the cost of natural gas, there are other key costs that are important in determining U.S. competitiveness in the LNG export market. Unlike the transport of natural gas by pipeline, the transport of LNG requires the product to be stored and transported at extremely low temperatures, necessitating LNG carriers to have expensive technology to accommodate such cold-storage transport. In terms of transportation costs, the United States does not have an advantage over some other sources of natural gas or LNG for the large importing countries in Europe and Asia. For example, according to a study we reviewed as of now, much of Europe is supplied with natural gas by pipeline. As a result, LNG from the United States is less likely to be an economical source of natural gas to that region under many possible market conditions. While some Asian markets—notably Japan and Korea—have little pipeline gas supply, exports from planned liquefaction facilities in Australia and East African countries will have a proximity advantage (that is, shorter and thus likely less expensive transportation) to Asian countries over the United States. As such, according to economic reasoning, the question of the extent to which a cost advantage in gas supply is offset by cost disadvantages in transport plays an important role in determining U.S. competitiveness in the world LNG market.

Recent investments in liquefaction facilities are an important indicator that market conditions are such that the United States is expected to be competitive in the market for LNG exports. Despite higher transportation costs for U.S. LNG as compared to LNG from other countries into key export markets in Asia, investors were willing to commit substantial resources to develop the liquefaction facilities needed for that trade, as evidenced by their construction. In particular, five large scale liquefaction facilities are currently under construction in the United States, with one facility expected to come online by the end of 2015 and all five facilities expected to be operational within about 3 years (see table 2).[25] The total

[25]According to DOE officials, "large-scale" facilities generally have a capacity to liquefy in excess of 0.1-billion cubic feet (bcf) per day of natural gas and generally intend to produce LNG for the purpose of exports via large LNG carriers. Conversely, small-scale facilities generally have a capacity of less than 0.1 bcf per day, and may produce LNG for various purposes including transport via intermodal containerized cargo aboard trucks or container ships. According to DOE officials, several of these small-scale facilities have applied to export LNG and some are currently operating.

daily capacity of these five facilities is nearly 10-billion cubic feet (bcf) of natural gas, which constitutes about 12.4 percent of expected U.S. natural gas production[26] and approximately 18.1 percent of the world's expected LNG capacity in 2020.[27] The business model used by the U.S. facilities currently under construction has helped to increase the business certainty of the liquefaction facilities, likely increasing their ability to obtain financing. In particular, according to representatives from the five facilities, the liquefaction capacity being built in the United States has been contracted out under 20-year contracts to buyers—mostly importers in Asian countries. Further, these contracts specify that buyers must pay for liquefaction services provided by the specific facility whether or not they choose to use all the capacity for which they contracted (that is, regardless of the amount of gas the customer chooses to have liquefied).

Table 2: U.S. Liquefaction Facility Construction Expected Capacity in Billion Cubic Feet (bcf) per day and Timelines

Site	Location	Total capacity	First liquefaction
Sabine Pass	Louisiana	3.5 bcf/day	2015[a]
Corpus Christi	Texas	1.8 bcf/day	2018
Cameron	Louisiana	1.7 bcf/day	2018
Freeport	Texas	2 bcf/day	2018
Cove Point	Maryland	0.77 bcf/day	2017[a]
Total	**n/a**	**9.77 bcf/day**	**n/a**

Source: GAO Analysis of Industry Documents | GAO-16-104

[a]These facilities are expected to begin liquefaction late in the year.

Investments in facility construction, and the contracting of the associated capacity, have helped to position the United States as an emerging LNG exporter. Based on discussions with DOE officials, liquefaction facilities, and economic consulting firms, the expected level of U.S. exports over the next several years is tied, among other things, to the amount of liquefaction capacity of these five facilities. However, the fact that, according to liquefaction facility representatives, the liquefaction capacity is already under contract and liquefaction facilities are expected to

[26]Based on estimates in EIA's Annual Energy Outlook 2015.

[27] Based on estimates in a report issued by the International Gas Union: International Gas Union, *World LNG Report – 2015 Edition*, World Gas Conference Edition (Fornebu, Norway: 2015).

receive payments for their full capacity does not mean that the capacity will necessarily be fully used all the time. Volatility in world market conditions may at times cause capacity to be underutilized due, for example, to periods of reduced demand such as during a recession. Moreover, other world suppliers are expected to enter the market over the next several years, and this could reduce the relative attractiveness of U.S. LNG. Even customers that have already purchased liquefaction capacity may choose not to use all the capacity for which they contracted from U.S. liquefaction facilities if new supply sources are more economical. As a result, some market uncertainty exists as to whether the full U.S. LNG capacity from the five facilities will, in fact, be exported over the next 20 years, even though liquefaction facility representatives stated that capacity is already under contract.

Additional uncertainties regarding U.S. exports of LNG relate to whether more capacity for liquefaction is likely to be developed beyond the capacity currently under construction. A number of additional liquefaction facilities have applied for approval from DOE and FERC in the past few years, and, as of September 2015, DOE has approved more than 30 companies to export LNG from large-scale liquefaction facilities. However, based on current demand, representatives from liquefaction facilities told us that it is unlikely that some of those additional facilities will ever be built. Thus, while confidence regarding U.S. exports in the next few years under expected market conditions is driven primarily by the capacity commitments in liquefaction capability, longer-term forecasts are more uncertain due to unknowns regarding macroeconomic conditions, increased exports by other countries, as well as whether additional liquefaction capacity will be profitable to develop.

Customers of U.S. LNG Have Responsibility for Transporting LNG from Liquefaction Facilities

According to representatives from the liquefaction facilities we spoke with, under current business models and contracts, the costs associated with importing LNG (including, for example, feed gas, liquefaction services, and transportation) are separate, and U.S. liquefaction facilities have no responsibility for shipping LNG. According to representatives at all five U.S. liquefaction facilities, customers take possession of the LNG at each facility's loading terminal, and customers arrange for LNG carriers to transport the LNG at their own expense. For example, representatives from one liquefaction facility explained that their customers may contract for the services of existing LNG carriers on long-term charters or may contract for construction of new carriers to transport U.S. LNG exports. See figure 2 for pictures of two styles of LNG carriers. A representative from another liquefaction facility told us that its customers have already

contracted to build new LNG carriers to serve their needs in the new U.S. export market.

Figure 2: Image of Moss and Membrane Style Liquefied Natural Gas Carriers

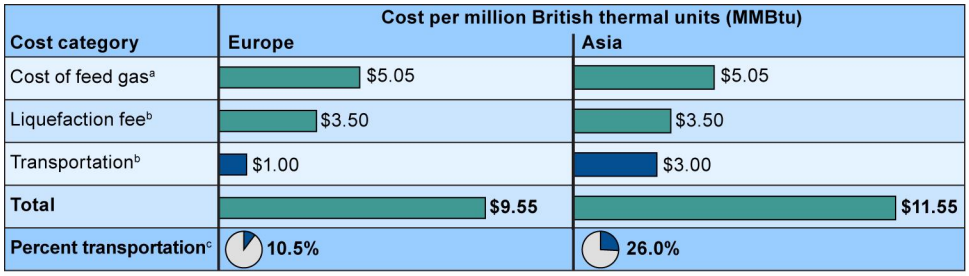
Moss style liquefied natural gas (LNG) carrier

Membrane style LNG carrier

Source: Society of International Gas Tanker and Terminal Operators (SIGTTO). | GAO-16-104

Transportation costs borne by contracted overseas customers include vessel operating costs, such as fuel and labor, and capital costs, such as the purchase and financing of LNG carriers. Costs for transporting U.S. LNG vary depending on the destination. Thus, transportation costs affect the total delivered price of LNG to customers. Figure 3 shows an example from two liquefaction facilities of the costs that, combined, represent the total “landed” price of LNG for customers in Europe and Asia. According to representatives of the five liquefaction facilities, U.S. LNG customers are primarily from Asian countries, but some cargos are contracted to companies in Europe and would likely incur lower shipping costs.

Figure 3: Estimated Costs Associated with Acquiring Liquefied Natural Gas from the United States, U.S. Dollars



Source: GAO analysis of Department of Energy data and statements from liquefaction company representatives. | GAO-16-104

Note: The costs of feed gas and transportation are highly variable; these examples are provided for illustrative purposes only. Costs for liquefaction, natural gas supply, and transportation are generally discussed per MMBtu (energy content) rather than gas or liquid volume. One bcf of natural gas is equivalent to roughly 1,100,000 MMBtu.

[a]Calculated as 115 percent of average 2014 Henry Hub price per MMBtu. The Henry Hub is a major gas trading center in the Gulf of Mexico and the delivery point for natural gas futures contracts on the New York Mercantile Exchange.

[b]Transportation cost estimates and liquefaction fee were provided by a company associated with 2 U.S. liquefaction facilities. Representatives from the three other U.S. facilities generally agreed with these estimates.

[c]Estimated transportation costs as a percentage of estimated costs associated with acquiring LNG from the United States.

About 100 or More LNG Carriers May Be Needed to Transport Expected U.S. LNG Exports in the Coming Years

Estimates of the number of LNG carriers necessary for transporting U.S. LNG vary, but based on estimates of representatives from the five liquefaction facilities with whom we spoke, about 100 or more LNG carriers will be needed to transport U.S. exports once liquefaction facilities are fully operational. Stakeholders, including DOE officials and shipbuilder representatives, estimated the number of needed carriers to be as low as 25 and as high as 200. However, based on their knowledge of the contracted liquefaction capacity, representatives from liquefaction facilities, one shipbuilder, and an international association of LNG importers told us that about 100 LNG carriers will be needed for transporting U.S. exports and that most of these carriers have already been ordered or are under construction. This estimate is generally in line with our analysis of the needed carrier capacity to transport roughly 9.77 bcf per day (the currently contracted capacity of U.S. facilities) based on the factors below (see app. I for more information on this analysis):

- Most modern LNG carriers have a cargo volume of between 160,000 to 170,000 cubic meters.[28]
- Most U.S. liquefaction capacity has been contracted to customers in Asia.
- According to a ship-building company we spoke with, a one-way voyage for an LNG carrier from the U.S. Gulf Coast to Japan can take approximately 30 days (or about 60 days, roundtrip) through the Panama Canal.

According to the shipbroker and other maritime stakeholders we spoke with, the current world LNG carrier fleet includes over 400 carriers, with another 160 new carriers scheduled for delivery by the end of 2018. Maritime stakeholders we spoke with said there is currently an overabundance of LNG carriers available in the world's LNG shipping market relative to current demand, due in part to a speculative rush of orders. However, these stakeholders expect this to change in the next few years as increased LNG capacity from the United States and Australia begins to come online and older LNG carriers are taken out of service, at which point additional carriers may be needed.

As mentioned previously, currently operating LNG carriers are nearly all foreign built and flagged. For example, a ship broker we spoke with estimated that Korean shipyards have built about 250 of the 350 LNG carriers delivered in the last 20 years and also have the largest share of LNG carriers under construction. According to MARAD officials and a shipbuilder representative, LNG carriers have not been built in the United States since 1980, and no LNG carriers are currently registered under U.S. flag.[29]

[28]To put this into context, 170,000 cubic meters of LNG is equal to about 3.7 bcf of natural gas.

[29]Sixteen LNG vessels were built in the U.S. in the 1970s and are either operated under foreign flag for use in international trade, have been repurposed, or have been decommissioned. Congress has authorized the Coast Guard to issue coastwise endorsements for three specified U.S.-built LNG vessels, which would make them eligible for use in transport of LNG for domestic shipping under the Jones Act. The ship operator noted that these 3 vessels are not well-suited to global trade because of their relatively small size (125,000 cubic meter capacity).

If the Proposed Requirement Does Not Reduce the Expected Demand for U.S. LNG, It Could Expand Employment for U.S. Mariners and Shipbuilders

If Demand Is Not Reduced, Maritime Stakeholders Say the Proposed Requirement Could Expand Employment for U.S. Mariners, Though Time Would Be Needed for Training

While we cannot reliably estimate the total number of U.S. mariner jobs that would be created due to the possibility that the proposed requirement could reduce demand for U.S. LNG (discussed in the next section), Coast Guard officials and representatives from four mariner unions estimated that each U.S.-flagged LNG carrier would likely employ a crew of between 40 and 52 mariners, as discussed below. According to Coast Guard officials and representatives from mariner unions we spoke with, LNG carriers typically require about 20 to 26 mariners to operate, depending on the type of propulsion system used in the vessel. According to representatives from mariner unions, this number is a fairly average crew size for a large ship; in comparison, the average container ship requires about 20 mariners. A ship's crew is comprised of officers and unlicensed mariners. For example, according to representatives from one mariner union, a typical LNG carrier may be operated by 11 officers (including deck and engineering officers) and 15 unlicensed mariners (7 deck crew, 5 engine crew, and 3 stewards). To estimate the total number of mariner jobs each LNG carrier would support, mariner groups told us that this number should be doubled to 40 to 52 to account for vacation time, other types of leave, and training. Assuming that demand for U.S. LNG is not decreased and that 100 LNG carriers would be needed to transport the five U.S. facilities' full capacity of LNG once they are fully operational, approximately 4,000 to 5,200 mariners could potentially be employed on U.S.-flagged LNG carriers. However, as discussed in the next section, implementation of the proposed requirement would likely lead to decreased demand for LNG.

All currently operating LNG carriers are foreign-flagged (as discussed previously) and, according to mariner unions we spoke with, employ few U.S. officers and no unlicensed U.S. mariners.[30] According to representatives from the mariner groups we contacted, about 180 active U.S. officers have the training and experience to work on LNG carriers, but the last time any U.S. unlicensed mariners worked on LNG carriers may have been over a decade ago. While all U.S. flagged vessels are required to hire predominantly U.S. citizen mariners,[31] maritime stakeholders told us that foreign-flagged vessels may be able to hire the least expensive crews available with the necessary skills.

U.S. mariners may not be immediately available to operate LNG carriers due to training and experience requirements and expectations from carrier operators. In the shipping industry, there are minimum experience requirements for working on LNG carriers, as discussed below. Representatives from mariner unions we spoke with stated that the U.S. maritime industry has the capacity to accommodate the potential demand for LNG carrier crews and recruiting mariners would not be an issue. However, based on requirements for obtaining necessary credentials, ensuring officers and unlicensed mariners have sufficient experience and training could take years. According to a representative from one mariner union we spoke with, unlicensed mariners need to complete a one-week LNG-carrier training class. However, qualification for employment on LNG carriers also requires experience working on an LNG carrier. For example, Coast Guard requirements for a "tankerman" credential (certification required to work on a tank vessel, including LNG carriers) include at least 90 days of experience as well as at least 10 loadings or unloadings of liquid cargo while working on the tanker.[32] According to Coast Guard officials, currently there about 300 U.S. mariners holding a national endorsement as Tankerman-PIC (person in charge) that is valid for liquefied gas tank vessels. For an LNG carrier, the latter requirement

[30]"Unlicensed mariner" is the term used to refer to more entry-level/non-officers of a vessel crew, though they are subject to Coast Guard and international training and credential requirements.

[31]U.S. regulations for manning are in 46 C.F.R. Part 15 and are further explained in Coast Guard Policy contained in the USCG Marine Safety Manual Volume III Part B.

[32]See 46 C.F.R. § 13.203. National tankerman endorsements are issued for either liquefied gases (including LNG) or dangerous liquids (oil and chemical) and mariners must have the endorsement appropriate to the cargo of the vessel on which they will serve.

could take 10 months or more to satisfy. According to representatives from a shipping brokerage company we spoke with, it could also be difficult for U.S. mariners to gain the necessary experience aboard a foreign-flagged LNG carrier (necessary due to the current lack of U.S.-flagged LNG carriers) because of the relatively higher costs associated with U.S. unlicensed mariners—discussed later in this report—compared with available foreign mariner crews competing for those jobs.

Increased employment opportunities for U.S. mariners, if they did occur, could have benefits related to military readiness. DOD and MARAD officials told us that any action that increases the number of U.S. mariners available to operate the reserve sealift fleet is beneficial. However, we found in August 2015 that while MARAD has stated that there is a need for additional mariners for military purposes DOD has had a sufficient number of mariners to meet its past needs.[33] In fact, we found that according to Coast Guard data, the number of mariners potentially qualified to operate the reserve sealift fleet has increased, from 37,702 in 2008 to 54,953 in 2014. While MARAD estimates that only 11,280 of those mariners are available, we found that MARAD had not fully analyzed the availability of mariners for a prolonged activation, and we recommended MARAD conduct a full analysis.[34] As such, it is unclear to what extent the additional mariner capacity possible under the proposed requirement would provide a benefit to military sealift capacity.

A Few U.S. Shipyards Expressed Interest in Building LNG Carriers, but a Number of Challenges Exist

Representatives from 3 of 11 companies we contacted operating large and active U.S. shipyards expressed interest in building LNG carriers.[35] However, the shipyards would need to acquire the equipment and technology to build specialized LNG-containment systems that store LNG at minus 260 degrees Fahrenheit.[36] In order to license this technology, shipyards must pay a licensing fee and successfully complete a qualification process, which includes building a mock-up of the containment system, to be certified to build the

[33]GAO, *International Food Assistance: Cargo Preference Increases Food Aid Shipping Costs, and Benefits Are Unclear*, GAO-15-666 (Washington, D.C.; August 2015).

[34]DOT concurred with our recommendation.

[35]The three shipyards are National Steel and Shipbuilding Company, Aker Philadelphia, and VT Halter Marine.

[36]According to shipbuilders we spoke with, most LNG vessels use a containment system designed and licensed by a French company.

containment system. Although some U.S. shipyards are currently gaining experience building LNG-powered vessels, shipbuilders and others we spoke with stated that this experience is not comparable to building the large containment systems required for transporting LNG for trade. Specifically, LNG-powered vessels use containment systems with a capacity of about 900 cubic meters. These systems are generally purchased overseas and welded onto the vessel. Conversely, according to shipbuilders, LNG carriers have larger containment systems, with approximately 170,000 cubic meter capacity, that must be constructed within the carrier.

Based on information from shipbuilders, we found that construction of LNG carriers in U.S. shipyards presents several challenges that could likely mean higher costs and longer lead and construction times than those for Korean shipyards, which currently build most LNG carriers:

- **Shipyard infrastructure:** Only two of the three shipyards in our review currently have docks long enough to accommodate construction of the LNG carriers necessary for international trade (approximately 1,000 feet long) without substantial capital improvements.[37]

- **Availability:** The two shipyards with docks large enough to build these LNG carriers currently have vessel orders that take up their shipbuilding capacity through approximately 2018, after which representatives stated they may be available for building LNG carriers. However, we believe that given the limited dock space, orders they may receive in the near term for other types of vessels may delay future construction of LNG carriers.

- **Timeline:** Representatives from those two shipyards with docks long enough to build LNG carriers estimated that it would take about 4 to 5 years to build an LNG carrier from the time of initial contact with a buyer. According to one representative, the process of building capacity, preparing for construction, and constructing the first LNG carrier would include:

[37]It is unclear whether, or the extent to which, U.S. shipyards would expand to create additional capacity for this potential market. According to representatives from one shipyard, anything may be possible given a market and enough funding.

- development of carrier specifications,
- contract negotiations,
- qualification to build the LNG containment system,
- detailed design of the carrier,
- construction of the carrier,
- installation of the containment system, and
- final testing of the carrier and containment system.

- **Productivity:** Representatives from those two shipyards stated their shipyard can produce one and two large vessels a year, respectively. Based on these rates, we estimate it would take over 30 years to build the 100-carrier fleet potentially needed for U.S. exports. These shipyard representatives stated that as more carriers are built, efficiency may increase and construction may gain speed. Increased efficiency might somewhat reduce the number of years it would take to provide an adequate fleet for this trade. In comparison, according to representatives from a ship brokerage, major Asian shipyards may be capable of delivering between 50 and 80 large ships in 1 year, for reasons discussed below.

As a result of U.S. shipyards' capacity constraints, as well as their anticipated lower productivity than foreign shipyards, LNG carriers built in U.S. shipyards would likely cost more than those currently built in foreign shipyards. According to industry representatives we spoke with, new LNG carriers built in Korean shipyards, where the majority of LNG carriers are currently built, are generally priced from $200 to $225 million. Currently, no U.S. shipyards build LNG carriers, so there are no actual carrier prices for comparison. However, representatives from the three U.S. shipyards we spoke with estimated that U.S.-built carriers would cost about two to three times as much as similar carriers built in Korean shipyards, depending on factors such as volume.[38] Based on this range cited by U.S.

[38]Additionally, the definition of what constitutes a U.S.-built LNG carrier under any proposed requirement—meaning the amount of foreign-built components allowed or the extent of assembly required in U.S. shipyards under the requirement—would also affect costs.

shipyards, the cost of U.S.-built LNG carriers could range from $400 to $675 million. Another factor that contributes to cost differences between U.S. and Korean shipyards, according to representatives from a shipping brokerage company we spoke with, is that Korean shipyards have made capital investments in equipment that increases efficiency such as cranes that can lift 2,000-4,000 tons, compared to cranes in U.S. shipyards that can lift 600 tons.

If LNG Customers Contract to Purchase U.S.-Built Carriers, Construction of Those LNG Carriers Could Provide Employment in U.S. Shipyards, according to Shipyard Representatives

Officials from the two U.S. shipyards with sufficient dock space stated that hiring of U.S. shipyard workers would depend on the number of LNG carriers ordered and would rely in part on foreign workers. Representatives from one shipyard roughly estimated that for an order of one large LNG carrier they might hire about 1,000 short-term U.S. workers and hire an additional 250 to 300 skilled Korean workers for the duration of the build time to ensure the work is done correctly. However, if they had contracts for a larger number of carriers, they would likely hire fewer Korean workers, who would gradually be transitioned out as U.S. workers were trained to complete the work. A representative from the second shipyard stated that the skills needed to build the LNG containment system do not exist in their current workforce, so for an order of two LNG carriers, they would likely hire skilled foreign shipyard workers to do the work in order to mitigate risk and increase schedule predictability, even if the costs of employing a foreign workforce may be slightly higher than using U.S. workers. Representatives also stated that they would be unlikely to increase capacity by opening another shipyard to build LNG carriers alongside other vessels, so they might not hire any additional new workers. Nonetheless, they noted that this LNG work would add to the stability of the shipyard's current 1,100 shipbuilding jobs, and lead to a more skilled workforce.

This shipyard employment estimate is roughly comparable to estimates using Bureau of Labor Statistics (BLS) estimates on job creation. Based on employment estimating tools from BLS, construction of a $450-million ship (as noted above, a conservative estimate of the cost to build an LNG carrier in the United States) is associated with 1,675 jobs in the shipbuilding industry. However there are a number of caveats associated with this estimate. For example, the numbers in BLS's estimates represent averages for all types of ship and boat building, and are not specific to LNG carriers. Additionally, the number of shipbuilding workers would likely remain steady across the production of multiple ships over time, so it would not provide new jobs for every additional carrier ordered. For example, the estimated need for 100 LNG carriers to serve the U.S.

LNG export market will not result in 167,500 jobs. And finally, while jobs may be created in the shipbuilding sector, a certain number of the jobs would likely be taken by people who are currently working in other construction or related industries, such as welders or other skilled trade workers. As such, while shipbuilding jobs might increase, not all of that increase necessarily represents net new jobs for the overall economy.

Increasing or stabilizing jobs in the shipbuilding industry for a period of time, if it occurred, could have additional benefits for military readiness. DOD officials told us that there is no military use for LNG carriers because the carriers are too specialized for current military needs. However, in addition to offering stability for U.S. shipbuilder jobs, as long as a market for U.S. LNG is at or near currently expected levels, the proposed requirement could help maintain shipbuilding capacity in the event it is needed for military purposes. Officials from DOD and MARAD stated that any actions that increase the capacity of U.S. shipyards as an industrial base would be indirectly beneficial for the Navy and military readiness in general.

U.S.-Built Carriers Would Increase Transportation Costs and Would Likely Reduce Demand for U.S. LNG

The proposed requirement would increase the cost of transporting LNG from the United States, which would decrease the competitiveness of U.S. LNG as compared to other sources. This decreased competitiveness may in turn reduce demand for U.S LNG. The extent of this reduction is unclear. Additionally, any reduction in demand for U.S. exports due to the proposed requirements and resulting changes to the LNG market may decrease jobs in other U.S. industries such as the liquefaction and the oil and gas industries.

The Proposed Requirement Would Increase Transportation Costs For U.S. LNG Exports

As we have noted, transportation costs for LNG are a fairly significant portion of the overall cost of the product in import markets. Based on information shared with us by representatives from U.S. liquefaction companies regarding current expected costs of the key phases for the LNG export supply chain—gas supply, liquefaction, and transportation—shipping costs are expected to make up about 26-percent of total costs for U.S. LNG delivered to an Asian market. Representatives from liquefaction companies, shipping companies, and an economic consulting company we spoke with currently expect U.S. LNG exports from the United States over the coming years to be transported on carriers built in foreign countries—primarily Korea and Japan. If these exports were required to be transported on U.S.-built and U.S.-flagged carriers, the costs associated with transport would be higher, as described below.

The requirement to ship U.S. LNG on U.S.-built-and-flagged carriers would affect both the cost of carrier construction, as noted above, as well as carrier operation. Our conversations with the 3 shipbuilders and 2 shipping companies have suggested that the purchase price of a U.S.-built LNG carrier is likely to be at least double—and could be significantly more—the cost of an LNG carrier constructed in South Korea. In addition, operating costs for U.S.-flagged carriers would be higher than for internationally flagged carriers. According to a 2011 MARAD study, U.S. crews are generally more highly paid than international crews and certain other operating costs associated with U.S. flagging requirements, such as insurance costs, are also higher. The study found that operations costs of U.S.-flagged vessels of various types were, on average, about 2.7 times that of foreign-flagged carriers.[39] However, based on our discussions with one mariner union, the differential for the costs of crewing U.S-flagged LNG carriers compared to international carriers may be less than the cost differential for the types of vessels MARAD surveyed. This is because, according to three mariner unions we spoke with, LNG carriers require more highly skilled mariners, so crew costs for international LNG carriers are generally higher than crew costs on other types of ocean-going vessels.

The higher costs of building and operating U.S. LNG carriers may make it more challenging for shippers to obtain financing for construction of U.S.-built carriers than for carriers built in other countries. A critical question regarding any large capital project is whether potential investors believe that the asset will be profitable enough to warrant the investment, particularly if financial returns carry substantial risk. To better understand the cost implications of a requirement that U.S. LNG exports be carried on U.S.-built-and-flagged carriers, we conducted an analysis designed to develop a general estimate of the additional shipping revenues that investors must believe will be earned over the life of the investment to provide reasonable certainty that the investment is financially viable.[40]

[39]Department of Transportation, Maritime Administration, *Comparison of U.S. and Foreign-Flag Operating Costs* (Washington, D.C.; September 2011).

[40]While shipping rates may vary substantially over the course of time given global macroeconomic conditions, our analysis focuses solely on the amount of revenues gained through shipping rates that are necessary to cover the investment in building and operating an LNG vessel. In other words, at times shipping rates may far exceed that needed for full cost recovery, and at other times rates may be low enough that carriers may not fully recover costs for a period of time. Our focus is solely on the *additional* revenues required, on average, over the 25-year period to cover the higher costs associated with the U.S. build and operations.

Although we do not have data to conduct a detailed estimate,[41] by making some hypothetical assumptions we are able to provide an illustration of the potential cost impact of a U.S.-built-and-flagged carrier requirement for LNG exports, if all other factors remain equal. [42] These assumptions include:

- The U.S.-built carriers would be financed through 25-year debt at a 4 percent rate of interest.[43]
- A U.S.-built LNG carrier of approximately 170,000 cubic meter capacity will be priced at $450 million, about twice that of such carriers being constructed for this trade in Korea.[44]
- Operating costs of the U.S.-flagged LNG carriers would be 50-percent higher than an internationally flagged LNG carrier (likely a conservative estimate, compared to the MARAD study cited above).
- A U.S. carrier would make six deliveries of LNG each year to an Asian destination.[45] This suggests an annual capacity of over 23-trillion British thermal units (Btu) of energy per LNG export carrier.

We found that, under these assumptions, the additional transportation costs associated with a U.S.-built-and-flagged LNG carrier would be roughly $0.73 per MMBtu of delivered energy product. Based on our discussions with U.S. liquefaction companies, we understand that an estimated shipping rate for LNG from the U.S. to market destinations in

[41]Data on the costs to build LNG carriers in the United States is not available because carriers of this size and type have never been built in the United States.

[42]For additional information on this analysis, see Appendix I.

[43]This interest rate assumes that investors in LNG carriers are able to participate in the MARAD loan guarantee programs at rates comparable to those prevailing recently. However, if investors are not able to obtain these loan guarantees and/or if future interest rates rise, the appropriate interest rate assumption would be higher.

[44]According to a shipbroker we spoke with, the current market price of a Korean-built LNG carrier is based on the achievement of substantial economies of scale in construction. While the average cost of a carrier built in the United States would decrease over time, the extent to which economies of scale and increased efficiency would contribute to cost reduction is unclear. Nevertheless based on our discussions with shipbuilding industry officials, we believe this to be a conservative estimate of the average cost of a U.S.-built LNG carrier.

[45]This estimate is based on discussions with several industry stakeholders who told us that transit time for an LNG vessel from the United States to Asia is roughly 30 days each way.

Asia is roughly $3.00 per MMBtu under the status quo market environment, suggesting that a requirement for U.S.-built-and-flagged carriers to transport U.S. LNG would be associated with about 24-percent higher shipping rates if all of the additional cost were passed on to the buyer.[46]

Increased Transportation Costs Would Reduce U.S. Competitiveness in the LNG Market

Higher shipping rates likely associated with U.S.-built-and-flagged carriers would decrease the competitiveness of U.S. LNG, but the extent to which this would occur and its effects are uncertain. As we have noted, world supply and demand conditions determine the extent to which there is a market for U.S. LNG exports, and those conditions would be affected by higher shipping costs for U.S. LNG exports. The increase in shipping costs may increase the delivered price for U.S. LNG relative to non-US LNG and other energy sources. A higher relative price may in turn reduce demand for U.S LNG. However, it is difficult to know the extent to which these added costs would affect U.S. LNG exports because of the variety of additional supply and demand factors that may also affect purchasers' decisions.

First, leaving aside the higher cost of U.S. LNG to purchasers, the shipyard capacity in the United States could present a major limiting factor for accommodating U.S. exports under a U.S.-built-and-flagged requirement. As we noted earlier, the U.S. shipbuilding industry does not have the capacity to build the carriers needed for the expected level of this trade in the near term so it will take many years for enough carriers to be built to service the expected level of exports. As such, the manner in which any U.S.-built requirement is implemented would be a critical element in the market consequence of this requirement. If U.S.-built carriers were required within, for example, 5 years of the requirement's passage, total carrier capacity available to ship LNG would itself be a major limiting factor for exports. Because capacity would likely only be able to come online gradually over more than 3 decades, limited LNG

[46]Note that the $0.73 per MMBtu cost differential estimate is based on increases to only the capital and operating cost portions of total shipping costs that would be different for U.S. flagged versus foreign vessels. The market shipping rate (which, according to liquefaction facility officials, is expected to be roughly $3.00 per MMBtu for voyages to Asia) also reflects other cost elements, such as fuel costs and other voyage costs—such as port and canal costs—which would not be higher for U.S. vessels. Thus, the increase in capital and operating costs that we hypothesize for U.S. vessels, when taken as a percentage of estimated shipping rates, represent only a 24-percent increase.

would likely be exported for some period of time, requiring purchasers to import from other sources in the early and intermediate years. This reduction in the currently planned exports of U.S. LNG may cause the U.S. export industry to not develop as currently planned—particularly if liquefaction facilities were unable to enforce provisions of their contracts that require them to pay regardless of services used (see further discussion below). Moreover, in the interim years, importers may be developing new sources for their product and contracting for long-term purchases from these other suppliers. Such circumstances would likely undermine any substantial development of U.S. exports. However, the ability to reflag international carriers to the U.S. flag might be able to occur in a more timely fashion such that this ability to reflag could mitigate a substantial impact on exports related to LNG carrier availability if the requirement for U.S.-built carriers were phased in over a longer term.

A second factor that may influence the market effect of this requirement relates to customers' existing financial commitments. As discussed previously, according to representatives of liquefaction facilities, all of the LNG liquefaction capacity for U.S. exports is already committed under 20-year contracts—that is, customers have already agreed to pay for liquefaction services for a long period of time whether they fully use the service or not. Additionally, according to liquefaction companies we spoke with, some of these customers have contracted to lease foreign-built carriers on a long-term basis and/or have contracted for the construction of new carriers in foreign shipyards for the transport of U.S. LNG. These existing financial commitments may constrain the manner in which these purchasers can adjust their business plans in response to a U.S. carrier requirement.

Several stakeholders told us that implementation of the proposed requirement and associated increases in transportation costs could prompt customers to attempt to modify, renegotiate, or terminate their liquefaction contracts. Specifically, according to two liquefaction companies and a representative from an economic research and consulting company, customers might try to excuse their contractual obligations by invoking contract law doctrines such as force majeure (generally defined as unforeseeable circumstances outside the control of the contract parties that prevent compliance with a contract) or impracticability (generally defined as where contract performance of an act [such as contractual duty] can only be rendered at excessive or unreasonable difficulty). While the outcome of such potential litigation is uncertain, any litigation could create delays and add to market uncertainty, which may, in turn, reduce the market for U.S. LNG. If

customers are able to modify, renegotiate, or terminate these contracts, the liquefaction facilities would likely experience reduced profits, which might adversely affect their operations.

Similarly, purchasers would need to be able to finance the U.S.-built LNG carriers to be able to continue their plans to purchase U.S. LNG. As we noted, the increased cost of U.S.-built vessels could make it more challenging to finance these vessels. Moreover, existing commitments to lease or contract for foreign-built tankers could add an additional obstacle. If customers are not able to modify, renegotiate, or terminate contracts for leased tankers or for the building of new tankers in foreign shipyards, customers' ability to purchase U.S. LNG may be constrained because they may not be able to finance additional tankers built in the United States. In that case, whether or not they must pay for liquefaction capacity they have contracted for (without receiving any LNG), purchasing U.S. LNG might no longer be a financially viable option.

Proposed Requirement and Changes in U.S. LNG Exports May Have Ripple Effects through the LNG Supply Chain

A reduction in the level of expected U.S. LNG exports due to higher shipping costs could have effects on sectors of the economy involved with the LNG export supply chain. Reduced or eliminated exports would render some or all of the capacity in liquefaction facilities unnecessary, so some jobs that have been or are expected to be created in these facilities would be lost. For example, representatives from one facility stated that they expect to employ more than 200 individuals once the facility becomes operational. Further, if contracts for the purchase of liquefaction were modified, renegotiated, or terminated by customers (for example, through the litigation process or through default), these facilities could be less profitable, which could lead to financial implications for their investors. Further, as discussed above, the potential gain in jobs in the shipbuilding and mariner occupations that the carrier requirement would be designed to promote might not be fully realized if U.S. LNG exports were reduced. If, for example, the market for U.S. LNG were eliminated, no LNG carriers would need to be built in the United States.

In addition, in the gas extraction industry, any reduction in exports would likely cause a small loss in the number of jobs, since there would be reduced demand for natural gas supplies.[47] Another possible effect of

[47]If the requirement were also imposed on exports of LNG from Alaska, that trade may also be affected.

reduced U.S. exports would be reduced revenues for oil and gas companies involved in energy extraction, which could have a further effect of reduced investments by these companies. Finally, reduced exports could lead to a small decrease in the price of natural gas in the domestic market, since more of the supply of the product would be maintained for domestic use.

Stakeholders Expressed Concerns about Potential Trade Implications

Representatives from economic forecasting firms, one shipbuilder, and one liquefaction company we spoke with stated concerns that the proposed requirement may have implications under existing trade agreements, including:

- potential legal action to challenge the requirement brought in various forums,
- potential adverse effects on current or future trade negotiations, and
- potential retaliatory trade practices, such as foreign government action to protect one or more industries within their respective countries.

Few Stakeholders Cited Safety and Reliability Benefits

A few stakeholders have proposed that the requirement may also have some safety and security benefits beyond military readiness. For example, one mariner union raised the possibility of U.S. carriers being perceived as safer than those built and/or flagged in other countries. However, other stakeholders, including the Coast Guard, stated there is no reason to believe U.S.-built-and-flagged carriers would be any safer than foreign LNG carriers. According to industry reports, as of February 2015, there have been no major accidents involving LNG carriers. Similarly, Coast Guard officials stated that they have protocols/procedures in place to help ensure safety of the United States from ships coming into U.S. port and that they saw no security benefit associated with reducing the number of foreign shippers entering U.S. waterways and ports.

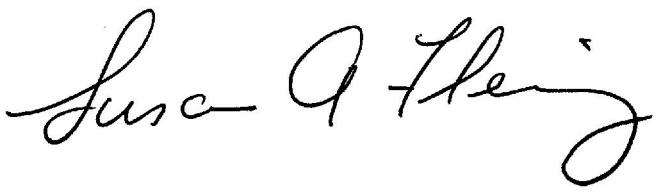
Agency Comments

We provided a draft of this report to the Departments of Defense, Energy, Homeland Security, and Transportation and the U.S. Trade Representative for their review and comment. We also provided a draft of this report to DOL for informational purposes. DOE and DOT provided technical comments, which we incorporated as appropriate. DOD provided technical comments, which we incorporated as appropriate, as

well as formal comments. In its comments, which are reprinted in full in appendix II, DOD stated that it appreciated that we noted that U.S. national security plans and strategies rely, in part, on the ability to draw on U.S. commercial ships and mariners as well as the existence of a domestic shipbuilding industrial base. USTR and DHS had no comments.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Secretary of Energy, the Secretary of Homeland Security, the Secretary of Labor, the Secretary of Transportation, and the U.S. Trade Representative. This report is also available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-2834 or FlemingS@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix III.



Susan A. Fleming
Director, Physical Infrastructure Issues

Appendix I: Objectives, Scope, and Methodology

The Howard Coble Coast Guard and Maritime Transportation Act of 2014[1] includes a provision for GAO to report on the number of positions that would be created in the United States maritime industry each year in 2015 through 2025 if liquefied natural gas (LNG) exported from the United States were required to be carried: (1) before December 31, 2018, on vessels documented under the laws of the United States; and (2) after such date, on vessels documented under the laws of the United States and constructed in the U.S. This report discusses: (1) current industry and Department of Energy (DOE) expectations for the market for U.S. exports of LNG, and how that market is expected to operate, (2) stakeholders' views on how the proposed requirement to use U.S.-flagged-and-built carriers for LNG exports could affect jobs in the maritime, shipbuilding, and other related sectors, and (3) potential effects of the proposed requirement on the market for U.S. LNG and the broader U.S. economy, including the market for U.S. LNG and other industries.

To describe current industry and DOE expectations for the market for U.S. exports of LNG, and how that market is expected to operate, we collected and analyzed information on economic forecasts of the LNG market including the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook* for several years, including 2015.[2] We interviewed DOE officials and representatives from four economic research and consulting firms who have published reports on the prospective market for U.S. LNG and LNG liquefaction companies that have begun construction on U.S. liquefaction facilities to better understand DOE's estimates about expected U.S. LNG exports and the world LNG market and to assure ourselves that the estimates were sufficiently reliable for the purposes of this report. We identified economic research and consulting firms for interviews based on work they performed relevant to this topic. We determined that reports issued by those companies were reliable for our purposes based on our reading of the methods and analysis used as described in their published reports. We also interviewed the four companies associated with the five approved and under-construction export facilities (as listed on the Federal Energy Regulatory Commission's list of approved import/export terminals in the continental U.S. as of July

[1]Pub. L. No. 113-281, § 308, 128 Stat. 3022.

[2]Department of Energy, U.S. Energy Information Administration, *Annual Energy Outlook,* (Washington, D.C.: September 2015). The U.S. Energy Information Administration is the statistical and analytical agency within the U.S. Department of Energy.

2015) regarding their plans and expectations.[3] We interviewed representatives from the identified economic research and consulting firms and energy companies regarding expected export capacity, customer plans, and the number of LNG carriers needed to transport expected U.S. LNG capacity. We also analyzed this information to develop our own estimate of the needed carrier capacity. To estimate the necessary number of carriers needed to transport U.S. LNG capacity, we made the following assumptions:

- U.S. liquefaction capacity of 9.77 bcf per day, based on information from the five under-construction U.S. facilities;
- 330 liquefaction days per year, assuming that liquefaction facilities would operate at 90 percent productivity;
- carrier capacity of 170,000 cubic meters LNG, based on information from industry stakeholders; and
- six round-trip voyages per carrier, per year, based on:
    - Information from the five liquefaction facilities that a majority of U.S. LNG capacity is contracted to customers in Asia, and
    - Statements from stakeholders that a round trip voyage to Asia would take about 60 days.

Under these assumptions, we calculated a need for approximately 870 carrier voyages per year to transport U.S. LNG exports, or about 145 carriers total. However, depending on destination (some U.S. capacity has been contracted to customers in Europe, which would require less time per round trip), expected productivity of liquefaction facilities (at least one liquefaction facility we spoke with expects to operate at about 80 percent efficiency), and the amount of gas customers eventually purchase and liquefy (customers may, at one time or another, choose not to use their entire contracted capacity), we believe 100 carriers, as estimated by the liquefaction companies we spoke with, is a reasonable estimate of projected need.

[3]There is a LNG export facility that has been operating in Alaska since the 1980s, but this facility is responsible for a very small portion of expected US exports. We were unable to interview officials from this facility.

The provision in the Act regarding this work specifies that GAO report on the number of positions that would be created in the U.S. maritime industry each year in 2015 through 2025 if the proposed requirement were implemented. As the proposed requirement has not been introduced as legislation as of October, 2015, the dates referenced in the Act may change. As such, to describe stakeholder views on the potential effects of the proposed requirements on maritime jobs and the economy and to determine the potential effects of these requirements on the market for U.S. LNG and the broader U.S. economy, we have referenced timeframes more generally, rather than referring to specific dates. To describe stakeholder views on the extent to which the requirement of U.S.-flagged-and-built carriers for LNG exports would affect jobs in the maritime, shipbuilding, and other related sectors, we collected and analyzed information on the capability and capacity of U.S. shipbuilders and estimated costs and requirements to build and operate LNG carriers based on documentary and testimonial evidence from selected maritime industry stakeholders. These stakeholders include representatives of three shipbuilding companies; two shipping companies (one shipbroker and one LNG carrier operator); the four major marine officer and unlicensed mariner unions in the United States; and officials from DOE, Department of Transportation's (DOT) Maritime Administration (MARAD), Department of Homeland Security's U.S Coast Guard, and Department of Labor (DOL). We selected maritime stakeholders (including shipbuilders, mariner unions, and shipping companies) for interview based on recommendations from government and industry stakeholders and capacity to provide services related to LNG carrier construction and operation. For instance, we selected the shipping companies based on the fact that they are currently involved in shipping LNG. We selected U.S. shipbuilders from a list of 11 large and active shipbuilding companies in the United States as of April 2015 based on their stated interest and capacity to build LNG carriers. To estimate the employment required to support a given level of ship-building, we relied on the Bureau of Labor Statistics' Employment Requirements Table (ERT), which is a commonly used methodology. However, this type of analysis has limitations:

- Estimates for the ERT are based on the ship and boat-building industry as a whole, using the Domestic Nominal ERT. According to BLS, it is not possible to obtain more precise estimates of the job supported in the construction of LNG carriers specifically.

- The ERT is based on a snapshot of the economy at a given time and does not take into account changes in productivity based on increases

in production (for example, economies of scale).

- All estimates refer to jobs, but not necessarily full-time.
- These estimates include the effect of inputs into production, but not the additional impact of spending by these employees on consumer goods. If these effects were included, (sometimes called multiplier effects) this would induce additional employment gains outside the shipbuilding industry.
- We relied on the most recent ERT available, which was 2012, so the table does not take more recent changes into account.

We also interviewed MARAD, Department of Defense, and U.S. Coast Guard officials to obtain their views on potential benefits for military readiness, including U.S. maritime-industry capacity to meet military needs.

To identify the potential effects of the proposed requirement on the market for U.S. LNG and the broader U.S. economy, we collected and analyzed economic data and forecasts and testimonial evidence from the industry stakeholders and economic research and consulting companies we spoke to (discussed earlier) and assessed the resulting evidence using established economic theory and reasoning to describe potential effects on world demand for U.S. LNG and jobs in other relevant U.S. industries. To illustrate the cost impact of a U.S.-flagged-and-built carrier requirement for LNG exports, if all other factors remain equal, we developed a set of hypothetical assumptions based on statements from industry stakeholders, a 2011 MARAD report on the costs of operating U.S.-flagged carriers,[4] and economic theory. These assumptions include:

[4]Department of Transportation, Maritime Administration, *Comparison of U.S. and Foreign-Flag Operating Costs* (Washington, D.C.: September 2011). While information on operating costs from MARAD is not specific to LNG carriers (or carriers of any kind), we determined that, as the only source of publicly available information comparing actual costs of U.S. and foreign-flagged vessels, this report was sufficiently reliable for our limited purpose of developing an estimate of the potential costs of operating U.S. LNG carriers, in combination with estimates of potential costs provided by industry stakeholders.

- The U.S.-built carriers would be fully funded through 25-year debt at a 4 percent rate of interest.[5]
- A U.S.-built LNG carrier of approximately 170,000 cubic meter capacity will be priced at $450 million, about twice that of such carriers being constructed for this trade in Korea (a conservative estimate of construction costs, based on statements from shipyard representatives, and others).
- Operating costs of the U.S.-flagged LNG carriers would be 50-percent higher than an internationally flagged LNG carrier (likely a conservative estimate, compared to the MARAD report, based on statements from stakeholders that the different in cost might not be as large for LNG carriers and in an effort to ensure our analysis does not overestimate the potential costs of operating U.S.-flagged LNG carriers).
- A U.S. carrier would make six deliveries of LNG each year to an Asian destination.[6] This suggests an annual capacity of just over 23 million MMBtu of energy per LNG export carrier.

For the purposes of estimating the potential costs of the proposed requirement, we made what we believe to be conservative estimates, including estimates of the cost of building LNG carriers in the United States and the costs of operating those carriers, in order to ensure that we do not overstate those potential cost effects. Due to the hypothetical nature of the proposed requirement as well as challenges related to predicting market outcomes, the estimated cost impacts are meant to be solely illustrative and should not be taken as a prediction. We interviewed U.S. Trade Representative officials and industry stakeholders regarding potential implications for U.S. trade. Additionally, we interviewed the U.S. Coast Guard and selected (as described above) U.S. LNG liquefaction companies and shipping companies regarding potential security implications for LNG customers related to transporting LNG via U.S.-flagged-and-built carriers.

[5]This interest rate assumes that investors in LNG carriers are able to participate in the MARAD loan guarantee programs at rates comparable to those prevailing recently. However, if investors are not able to obtain these loan guarantees and/or if future interest rates rise, the appropriate interest rate assumption would be higher.

[6]This estimate is based on discussions with industry stakeholders who told us that transit time for an LNG vessel from the United States to Asia is roughly 30 days each way.

We conducted this performance audit from March 2015 to December 2015 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Comments from the Department of Defense

ASSISTANT SECRETARY OF DEFENSE
3500 DEFENSE PENTAGON
WASHINGTON, DC 20301-3500

LOGISTICS AND
MATERIEL READINESS

NOV 18 2015

Ms. Susan A. Fleming
Director, Physical Infrastructure Issues
U.S. Government Accountability Office
441 G Street, N.W.
Washington, DC 20548

Dear Ms. Fleming:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-16-104, "MARITIME TRANSPORTATION: Implications of Using U.S. Liquefied Natural Gas Carriers for Exports" dated December 2015 (GAO Code 541130). The Department acknowledges receipt of the draft report. The Department also notes that the report includes no recommendation but appreciates the GAO noting that U.S. national security plans and strategies rely, in part, on the ability to draw on U.S. commercial ships and mariners as well as the existence of a domestic shipbuilding industrial base. Thank you for the opportunity to review and provide input to this draft.

Sincerely,

David J. Berteau

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Susan Fleming, (202) 512-2834 or FlemingS@gao.gov

Acknowledgments

In addition to the contact above, Catherine Colwell, Assistant Director; Amy Abramowitz; Pedro Almoguera; Ben Bolitzer; Ken Bombara; Brian Chung; Katie Hamer; Geoff Hamilton; Delwen Jones; Sara Ann Moessbauer; Josh Ormond; and Oliver Richard made key contributions to this report.

Appendix IV: Accessible Data

Agency Comment Letter

Text of Appendix II: Comments from the Department of Defense

Page 1

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LOGISTICS AND MATERIEL READINESS

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Sincerely,

David J. Berteau

Data Tables

Data Table for Figure 3: Estimated Costs Associated with Acquiring Liquefied Natural Gas from the United States, U.S. Dollars

	Cost per million British thermal units (MMBtu)	
Cost category	**Europe**	**Asia**
Cost of feed gas[a]	$5.05	$5.05
Liquefaction fee[b]	$3.50	$3.50
Transportation[b]	$1.00	$3.00
Total	$9.55	$11.55
Percent transportation[c]	10.5%	26%