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Liquefied Natural Gas (LNG) Infrastructure Security: Issues for Congress

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Summary

Liquefied natural gas (LNG) is a hazardous fuel frequently shipped in large tankers from overseas to U.S. ports. LNG is also manufactured domestically and is often stored near population centers. Because LNG infrastructure is highly visible and easily identified, it can be vulnerable to terrorist attack. Since September 11, 2001, the U.S. LNG industry and federal agencies have put new measures in place to protect LNG infrastructure and respond to the possibility of terrorism. Nonetheless, public concerns about LNG risks continue to raise questions about LNG security. While LNG has historically made up a small part of U.S. natural gas supplies, rising gas prices and the possibility of domestic shortages are sharply increasing LNG demand. Faced with this growth in demand and public concerns, Congress is examining the adequacy of federal LNG security initiatives. Proposed legislation, including S. 684 and H.R. 173, would increase regulation of LNG security.

LNG infrastructure consists primarily of tankers, import terminals, and inland storage plants. There are seven active U.S. terminals and proposals for numerous others. Potentially catastrophic events could arise from a serious accident or attack on such facilities, such as pool or vapor cloud fires. But LNG has a record of relative safety for the last 40 years, and no LNG tanker or land-based facility has been attacked by terrorists. The likelihood and possible impacts from LNG attacks continue to be debated among experts.

Several federal agencies oversee the security of LNG infrastructure. The Coast Guard has lead responsibility for LNG shipping and marine terminal security, and has issued new maritime security rules under the Maritime Transportation Security Act of 2002 (P.L. 107-295). The Office of Pipeline Safety (OPS) and the Transportation Security Administration (TSA) both have security authority for LNG storage plants within gas utilities, as well as some security authority for LNG marine terminals. The Federal Energy Regulatory Commission (FERC) approves the siting, with some security oversight, of on-shore LNG marine terminals and certain utility LNG plants. The Coast Guard, OPS and FERC have agreed to cooperate in the siting approval of new LNG facilities, inspection and operational review of existing facilities, informal communication, and dispute resolution.

Federal initiatives to secure LNG are still evolving, but a variety of industry and agency representatives suggest they are reducing the vulnerability of LNG to terrorism. As Congress continues its oversight of LNG, it may consider whether future LNG security requirements will be appropriately funded, whether these requirements will be balanced against evolving risks, and whether the LNG industry is carrying its fair share of the security burden. Congress may also act to improve its understanding of LNG security risks. Costly "blanket" investments in LNG security might be avoided if more refined terror threat information were available to focus security spending on a narrower set of infrastructure vulnerabilities. Finally, Congress may initiate action to better understand the security implications of new LNG terminals offshore. This report will be updated as events warrant.

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Introduction

Liquefied natural gas (LNG) facilities are receiving a great deal of public attention due to their increasingly important role in the nation's energy infrastructure and their potential vulnerability to terrorist attack. LNG has long been important to U.S. natural gas markets, although energy economics and public perceptions about LNG risks have limited the industry's growth. Concerns about rising natural gas prices and the possibility of domestic gas shortages have been driving up demand for LNG imports. But LNG is a hazardous[1] liquid transported and stored in large quantities. Consequently, LNG infrastructure may directly impact the security of communities where this infrastructure is located. Faced with the widely perceived national need for greater LNG imports, and persistent public concerns about LNG risks, some in Congress are examining the adequacy of security provisions in federal LNG regulation.[2]

Measures before Congress would affect LNG infrastructure security. The Liquefied Natural Gas Safety and Security Act of 2005 (S. 684), among other provisions, would require the Federal Energy Regulatory Commission (FERC) to incorporate Coast Guard security recommendations and resource requirements into their review of new LNG terminal siting applications; would require LNG terminal developers to reimburse local government security costs; would require LNG developers to complete facility security plans before FERC issued siting application reviews; and would require federal standards to promote the remote siting of LNG facilities. The Anti-Terrorism and Port Security Act of 2005 (H.R. 173), among other provisions, would make it a crime to interfere with ships or maritime facilities; to put destructive devices in U.S. waters; or to knowingly discharge or release hazardous substances into U.S. navigable waters or the adjoining shoreline to endanger human life, health, or welfare.

This report provides an overview of recent industry and federal activities related to LNG security. The report describes U.S. LNG infrastructure, the industry's safety record and security risks, and the industry's security initiatives since September 11, 2001. It summarizes recent changes in federal LNG and maritime security law and related changes in the security roles of federal agencies. The report discusses several

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[1] 49 CFR 172.101. *List of Hazardous Materials.* Office of Hazardous Materials Safety, Department of Transportation.

[2] U.S. Representatives Edward J. Markey. "Markey, Other Key Lawmakers Asks GAO to Investigate LNG Security." Press release. Jan. 31, 2005.

policy concerns related to federal LNG security efforts: 1) public costs of marine security, 2) uncertainty regarding LNG terrorism risks, and 3) security implications of building offshore LNG facilities.

Scope and Limitations

This report focuses on industry and federal activities in LNG infrastructure security. The report includes some discussion of state and local agency activities as they relate to federal efforts, but does not address the full range of state and local issues of potential interest to policy makers. The report also focuses on shipping, marine terminals and land-based storage facilities within gas utilities; it does not address LNG trucking, special purpose LNG facilities, or LNG-fueled vehicles. The report discusses activities in LNG safety only as they relate to security. For further discussion of LNG terminal safety, see CRS Report RL32205, *Liquefied Natural Gas (LNG) Terminals: Siting, Safety and Regulation*, by Paul W. Parfomak and Aaron M. Flynn.

Background

What is LNG?

When natural gas is cooled to temperatures below minus 260°F it condenses into *liquefied* natural gas, or "LNG."[3] As a liquid, natural gas occupies only 1/600th the volume of its gaseous state, so it is stored more effectively in a limited space and is more readily transported by ship or truck. A single tanker ship, for example, can carry huge quantities of LNG–enough to supply the daily energy needs of over 10 million homes.[4] When LNG is warmed it "regasifies" and can be used for the same purposes as conventional natural gas such as heating, cooking and power generation.

In 2004, LNG imports to the United States originated primarily in Trinidad (75%), Algeria (16%), and Malaysia (3%). Some shipments also came from Qatar, Nigeria, Oman, Australia and other countries.[5] Brunei, Indonesia, Libya, and the United Arab Emirates also export LNG, and may be significant U.S. suppliers in the future. In addition to importing LNG to the lower 48 states, the United States exports Alaskan LNG to Japan.

Expectations for U.S. LNG Growth

The United States has used LNG commercially since the1940s. Initially, LNG facilities stored domestically produced natural gas to supplement pipeline supplies

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[3] Natural gas typically consists of at least 80% methane, although LNG is usually over 90% methane. It may also contain other hydrocarbon gases (e.g., propane) and nitrogen.

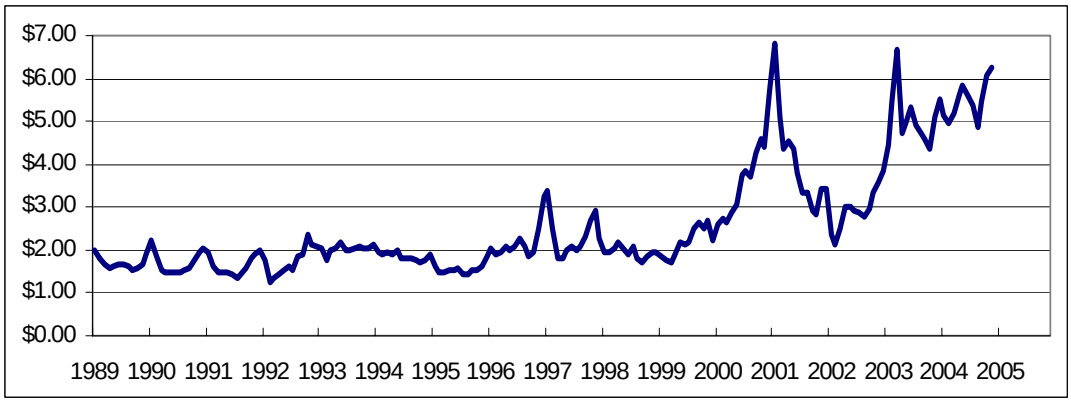
[4] Behr, P. "Higher Gas Price Sets Stage for LNG." *Washington Post*. Washington, D.C. July 5, 2003. pD10.

[5] Energy Information Administration (EIA). *Natural Gas Monthly*. Washington, D.C. Feb. 2005. Table 5.

during times of high gas demand. In the 1970's LNG imports began to supplement domestic production. Due primarily to low domestic gas prices, LNG imports stayed relatively small–accounting for only 1% of total U.S. gas consumption in 2002.[6] In countries with limited domestic gas supplies, however, LNG imports grew dramatically over the same period. Japan, for example, imported 97% of its natural gas supply as LNG in 2002, over 11 times as much LNG as the United States.[7] South Korea, France, Spain, and Taiwan also became heavy LNG importers.

Natural gas demand has accelerated in the U.S. over the last several years due to environmental concerns about other energy sources, growth in natural gas-fired electricity generation, and historically low gas prices. Supply has not been able to keep up with demand, however, so gas prices have recently become high and volatile. As **Figure 1** shows, gas prices at the wellhead have risen from between $1.50 and $2.50/Mcf through most of the 1990s to an average above $5.00/Mcf and a peak above $6.00/Mcf in 2004.[8] At the same time, international prices for LNG have fallen because of increased supplies and lower production and transportation costs, making LNG more competitive with domestic natural gas.[9] While cost estimation is speculative, some industry analysts believe that LNG can be economically delivered to U.S. pipelines for approximately $2.50 to $3.50/Mcf.[10]

Figure 1: U.S. Natural Gas Wellhead Price ($/Mcf)



Source: Energy Information Administration. *Natural Gas Weekly Update*. Feb. 3, 2005.

In 2003 testimony before the House Energy and Commerce Committee, the Federal Reserve Chairman, Alan Greenspan, called for a sharp increase in LNG

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[6] Park, G. "List of Planned LNG Ventures Grows." *Petroleum News*. Haines, AK. June 29, 2003.

[7] Energy Information Administration (EIA). "World LNG Imports by Origin, 2002." Washington, DC. Oct. 2003.

[8] Mcf = thousand cubic feet

[9] Sen. Colleen Taylor. "LNG Poised to Consolidate its Place in Global Trade." *Oil & Gas Journal*. Jun. 23, 2003. p73.

[10] Hughes, P. "Outlook for Global Gas Natural Markets." BP, Gas Power & Renewables Division. Presentation to the World Bank Energy Week 2004 Conference. Mar. 8, 2004.

imports to help avert a potential barrier to U.S. economic growth. According to Mr. Greenspan's testimony

> "...notable cost reductions for both liquefaction and transportation of LNG... and high gas prices projected in the American distant futures market have made us a potential very large importer... Access to world natural gas supplies will require a major expansion of LNG terminal import capacity."[11]

If current natural gas trends continue, the Energy Information Administration (EIA) projects U.S. LNG imports to account for approximately 21% of total U.S. gas supply in 2025.[12]

Overview of U.S. LNG Infrastructure

The physical infrastructure of LNG consists of interconnected transportation and storage facilities, each with distinct physical characteristics affecting operational risks and security needs. This overview focuses on the three major elements of this infrastructure: tanker ships, marine terminals, and storage facilities.

LNG Tanker Ships

LNG is transported to the United States in very large, specially designed tanker ships. LNG tankers are double hulled, containing several massive refrigerated tanks, each sealed and insulated to maintain safe LNG temperature and prevent leakage during transit. There are currently 176 tankers in service around the world, with a combined cargo capacity of over 21 million cubic meters of LNG, equivalent to over seven times the average daily U.S. natural gas consumption in 2004. Another 111 tankers with 17 million cubic meters of capacity are on order. There are no U.S.-flagged LNG tankers.[13]

LNG Marine Terminals

LNG tankers unload their cargo at dedicated marine terminals which store and regasify the LNG for distribution to domestic markets. These terminals typically consist of docks, LNG handling equipment, storage tanks, and interconnections to regional gas transmission pipelines. There are seven active U.S. LNG terminals:

- **Everett, Massachusetts.** The Everett terminal is located across the Mystic River from Boston; tankers must pass through Boston harbor to reach it. The first LNG import facility in the country, the Everett terminal began service in 1971. According to Tractebel, the Belgian company which owns the terminal,

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[11] Greenspan, Alan, Chairman, U.S. Federal Reserve Board. "Natural Gas Supply and Demand Issues." Testimony before the House Energy and Commerce Comm. June 10, 2003.

[12] EIA. DOE/EIA-0383(2005). Feb. 2005. Table A13. p159.

[13] LNG OneWorld. Internet home page. Drewry Shipping Consultants, Ltd. and Maritime Content, Ltd. London. March 7, 2005.

it "serves most of the gas utilities in New England and key power producers" altogether meeting "between 15-20% of New England's annual gas demand."[14] The terminal received 66 LNG shipments in 2004.[15]

- **Lake Charles, Louisiana.** The Lake Charles terminal is located approximately nine miles southwest of the city of Lake Charles near the Gulf of Mexico. The terminal began service in 1981 and is owned by CMS Energy.[16] The Lake Charles terminal received 59 LNG shipments in 2004, although it was closed for construction for part of the year.[17] After ongoing expansion, the terminal could receive up to 175 shipments per year by 2006.[18]

- **Cove Point, Maryland**. Cove Point is located on the Chesapeake Bay 60 miles southeast of Washington, DC. The Cove Point terminal, owned by Dominion Corporation, began service in 1978 but closed in 1980 because low domestic gas prices made imports uneconomic. In 1995, the terminal reopened to liquefy, store and distribute domestic natural gas in the Mid-Atlantic.[19] In July, 2003, the terminal reopened for LNG imports. The terminal received 77 LNG shipments in 2004.[20] Under current expansion plans, the terminal could receive up to 150 shipments per year by 2008.[21]

- **Elba Island, Georgia.** The Elba Island terminal, owned by El Paso Corporation, is located on a marsh island approximately five miles down the Savannah River from Savannah, Georgia and ten miles from the Atlantic coast. Like Cove Point, the Elba Island terminal began service in 1978 and closed in 1980, but reopened in late 2001.[22] The terminal received 41 LNG shipments in 2004.[23] After ongoing expansion the terminal could increase shipments to approximately 118 per year by 2006.[24]

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[14] Tractebel. "New LNG Vessel to Serve Tractebel's Atlantic Basin Customers." Press release. Brussells, Belgium. June 17, 2003.

[15] Dept. of Energy, Office of Fossil Energy (OFE). "Imports of Liquefied Natural Gas (LNG)." Unpublished data. Washington, D.C. Feb. 23, 2005.

[16] Panhandle Energy (CMS Energy Corp.). "Trunkline LNG Lake Charles Terminal." Internet web page. Houston. July 16,2003.

[17] OFE. Feb. 23, 2005.

[18] *Federal Register*. Vol 67 No34. Feb. 20, 2002. p7684.

[19] Dominion Corp. "History of Cove Point." Web page. Richmond, VA. July 17, 2003.

[20] OFE. Feb. 23, 2005.

[21] Martin, S.O. "Projections Not Promises." *Bay Weekly*. Deale, MD.. May 20, 2004.

[22] Energy Information Administration (EIA). "U.S. LNG Markets and Uses." Office of Oil and Gas. Washington, D.C. Jan. 2003. p3.

[23] OFE. Feb. 23, 2005.

[24] *Federal Register*. Vol 67 No181. Sept. 18, 2002. p58784.

- **Gulf Of Mexico, Louisiana.** The Gulf Gateways (Energy Bridge) terminal was completed in 2004 and received its first LNG shipment in March, 2005. The terminal, owned by Excelerate Energy, consists of an offshore gas pipeline buoy system and is served by specialized tankers which regasify their LNG cargoes on board. The terminal expects up to 60 LNG shipments per year by 2006.[25]

- **Peñuelas, Puerto Rico.** The Peñuelas terminal, located on the southern coast of Puerto Rico, began service in 2002. The terminal is dedicated to fueling an electric generation plant which supplies 20% of Puerto Rico's power.[26] Both the terminal and power plant are owned by EcoElectrica, a joint venture of Edison Mission Energy and Gas Natural, a Spanish company. The terminal received 14 LNG shipments in 2004.[27]

- **Kenai, Alaska.** Built in 1969, this is the oldest LNG marine terminal in the United States and the only one built for export (to Japan). The Kenai terminal, owned by Phillips Petroleum and Marathon Oil, is located in Nikiski near the Cook Inlet gas fields. Since 1969 the terminal has exported an average of approximately 34 LNG shipments each year.[28]

In addition to these active terminals, developers have proposed over 70 new LNG import terminals to serve the U.S. market. Many of these proposals are well-advanced, with recent or pending federal permit approvals. **Table 1** lists summary information for these proposed LNG terminals located in the United States. Additional LNG import terminals have been proposed in several of the states in **Table 1**, as well as in Alaska, Maine, Oregon, and Washington. Terminals to serve U.S. markets have also been proposed in Mexico, Canada and the Bahamas.

Offshore LNG terminals, such as the newly built Gulf Gateways and the proposed Cabrillo Port projects, connect to land only by underwater pipelines. These offshore terminal designs seek to avoid community opposition, permitting, and operating obstacles which have hindered the construction of new on-shore LNG terminal facilities.[29] Because offshore terminals would be located far from land, they also would present fewer security risks than on-shore LNG terminals. Offshore terminals do present environmental concerns, however, since they would use seawater for regasification. Such a process cools the waters in a terminal's vicinity with potential impacts on the local ecosystem due to the lower water temperatures.[30]

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[25] *Natural Gas Intelligence*. "Energy Bridge Terminal Prepares for First 3 Bcf LNG Delivery This Month." Intelligence Press, Inc. March 7, 2005.

[26] "Gas Natural Acquires Enron's 50% Stake in 540-MW Gas Plant in Puerto Rico." *Platt's Global Power Report*. McGraw-Hill. July 10, 2003. p11.

[27] OFE. Feb. 23, 2005.

[28] Marathon Oil Corporation. *2003 Annual Report*. Houston. March 8, 2004. p11.

[29] Zeus Development Corp. "Six New Offshore Terminal Designs May Expedite LNG Deliveries." Latin Petroleum Analytics. Houston, TX. June 11, 2003.

[30] O'Driscoll, M. "LNG: Shell's Gulf Landing Offshore Project Gets Green Light." (continued...)

Offshore LNG terminals also employ new engineering systems, so they may also need to overcome technical challenges associated with their floating designs.[31]

Table 1: Proposed U.S. LNG Terminals with Federal Permit Applications

Location	Name	Developer(s)	Type	Permit Status
Hackberry, LA	Cameron LNG	Sempra	Onshore	Approved 9/03
Gulf of Mexico, LA	Port Pelican	ChevronTexaco	Offshore	Approved 11/03
Freeport, TX	Freeport	Cheniere Energy	Onshore	Approved 6/04
Sabine Pass, LA	Sabine Pass	Cheniere Energy	Onshore	Approved 11/04
Gulf of Mexico, LA	Gulf Landing	Shell	Offshore	Approved 2/05
Sabine Pass, TX	Golden Pass	Exxon Mobil	Onshore	Applied 11/03
Fall River, MA	Weaver's Cove	Poten & Partners	Onshore	Applied 12/03
Corpus Christi, TX	Corpus Christi	Cheniere Energy	Onshore	Applied 12/03
Oxnard, CA	Clearwater Port	Crystal / Woodside	Offshore	Applied 1/04
Long Beach, CA	Long Beach	Mitsubishi / Conoco	Onshore	Applied 1/04
Oxnard, CA	Cabrillo Port	BHP Billiton	Offshore	Applied 1/04
Gulf of Mexico, LA	Main Pass	McMoran	Offshore	Applied 2/04
Mobile, AL	Compass Port	ConocoPhillips	Offshore	Applied 3/04
Ingleside, TX	Vista Del Sol	Exxon Mobil	Onshore	Applied 9/04
Providence, RI	Fields Point	KeySpan	Onshore	Applied 5/04
Logan Twp., NJ	Crown Landing	BP	Onshore	Applied 9/04
Ingleside, TX	Corpus Christi	Occidental Petrol.	Onshore	Applied 11/04
Gulf of Mexico, LA	Beacon Port	ConocoPhillips	Offshore	Applied 2/05
Gloucester, MA	Neptune	Distrigas	Offshore	Applied 2/05

Sources: Trade press; Company websites

LNG Peak Shaving Plants

Many gas distribution utilities rely on "peak shaving" LNG plants to supplement pipeline gas supplies during periods of peak demand during winter cold snaps. The LNG is stored in large refrigerated tanks integrated with the local gas pipeline network. The largest facilities usually liquefy natural gas drawn directly from the interstate pipeline grid, although many smaller facilities without such liquefaction capabilities receive LNG by truck. LNG tanks are generally surrounded by containment impoundments which limit the spread of an LNG spill and the potential size of a resulting vapor cloud.[32] LNG peak shaving plants are often located near the populations they serve, although many are in remote areas away from people.

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[30] (...continued)
Greenwire. E&E Publishing, LLC. Washington, D.C. Feb 18, 2005.

[31] Shook, B. "Environmental, Safety, Security Issues Add to Cost of Offshore LNG." *Oil Daily*. Energy Intelligence Group. Aug. 5, 2003.

[32] California Energy Commission (CEC). *Liquefied Natural Gas in California: History, Risks and Siting.* No.700-03-005. Sacramento, CA. p5.

According to the Energy Information Administration (EIA) there are 96 active LNG storage facilities in the United States distributed among approximately 55 utilities.[33] These facilities are mostly in the Northeast where pipeline capacity and underground gas storage have historically been constrained. **Figure 2** shows the locations of U.S. LNG storage facilities within utilities and on-shore terminals.[34]

Figure 2: LNG Storage Sites in Utilities and Marine Terminals

Source: Energy Information Administration

LNG Risks and Vulnerabilities

The safety hazards associated with LNG terminals have been debated for decades. A 1944 accident at one of the nation's first LNG facilities killed 128 people and initiated public fears about LNG hazards which persist today.[35] Technology improvements and standards since the 1940's have made LNG facilities much safer, but serious hazards remain since LNG is inherently volatile and is usually shipped and stored in large quantities. The January 2004 accident at Algeria's Skikda LNG terminal which killed or injured over 100 workers has added to the ongoing controversy over LNG facility safety.[36] Because LNG infrastructure is highly visible and easily identified, it is also potentially vulnerable to terrorist attack.

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[33] Gaul, D.and Young, L. Energy Information Administration (EIA). "U.S. LNG Markets and Uses." Washington, DC. Jan. 2003. pp1,11.

[34] Figure 2 excludes seven small sites associated with vehicular fuel or niche applications.

[35] Bureau of Mines (BOM). *Report on the Investigation of the Fire at the Liquefaction, Storage, and Regasification Plant of the East Ohio Gas Co., Cleveland, Ohio, October 20, 1944.* Feb. 1946.

[36] Junnola, J. *et al.* "Fatal Explosion Rocks Algeria's Skikda LNG Complex." *Oil Daily*. Jan. 21, 2004. p6.

Physical Hazards of LNG

Natural gas is combustible, so an uncontrolled release of LNG poses a serious hazard of explosion or fire. LNG also poses hazards because it is so cold. Experts have identified several potentially catastrophic events that could arise from an LNG release. The likelihood and severity of these events have been the subject of considerable research and testing. While open questions remain about the impacts of specific hazards in an actual accident, there appears to be consensus as to what the greatest LNG hazards are.

- **Pool fires.** If LNG spills near an ignition source, the evaporating gas in a combustible gas-air concentration will burn above the LNG pool.[37] The resulting "pool fire" would spread as the LNG pool expanded away from its source and continued evaporating. Such pool fires are intense, burning far more hotly and rapidly than oil or gasoline fires.[38] They cannot be extinguished–all the LNG must be consumed before they go out. Because LNG pool fires are so hot, their thermal radiation may injure people and damage property a considerable distance from the fire itself.[39] Many experts agree that a pool fire, especially on water, is the most serious LNG hazard.[40]

- **Flammable vapor clouds**. If LNG spills but does not immediately ignite, the evaporating natural gas will form a vapor cloud that may drift some distance from the spill site. If the cloud subsequently encounters an ignition source, those portions of the cloud with a combustible gas-air concentration will burn. Because only a fraction of such a cloud would have a combustible gas-air concentration, the cloud would not likely explode all at once, but the fire could still cause considerable damage.[41] An LNG vapor cloud fire would gradually burn its way back to the LNG spill where the vapors originated and would continue to burn as a pool fire.[42] If an LNG tank failed due to a collision or terror attack, experts believe the failure event itself would likely ignite the LNG pool before a large vapor cloud could form.[43] Consequently, they conclude that large vapor cloud fires are less likely than instantaneous pool fires.

- **Flameless explosion**. If LNG spills on water, it could theoretically heat up and regasify almost instantly in a "flameless explosion" (also called a "rapid phase

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[37] Methane, the main component of LNG, burns in gas-to-air ratios between 5% and 15%.

[38] Havens, J. "Ready to Blow?" *Bulletin of the Atomic Scientists*. July/Aug. 2003. p17.

[39] Fay, J.A. "Spills and Fires from LNG and Oil Tankers in Boston Harbor." Working paper. MIT. Dept. of Mechanical Engineering. Cambridge, MA. March 26, 2003.

[40] Havens. 2003. p17.

[41] West, H.H. and Mannan, M.S. "LNG Safety Practices and Regulations." Prepared for the American Institute of Chemical Engineering Conference on Natural Gas Utilization and LNG Transportation. Houston, TX. April, 2001. p2.

[42] Quillen, D. ChevronTexaco Corp. "LNG Safety Myths and Legends." Presentation to the Natural Gas Technology Conference. Houston, TX. May 14-15, 2002. p18.

[43] Havens. 2003. p17.

transition"). While the effects of tanker-scale spills have not been studied extensively, Shell Corporation experiments with smaller LNG spills in 1980 did not cause flameless explosions. Based on a review of these experiments, a U.S. national laboratory concluded that "transitions caused by mixing of LNG and water are not violent."[44] Even if there were a flameless explosion of LNG, experts believe the hazard zones around such an event "would not be as large as either vapor cloud or pool fire hazard zones."[45]

In addition to these catastrophic hazards, an LNG spill poses hazards on a smaller scale. An LNG vapor cloud is not toxic, but could cause asphyxiation by displacing breathable air.[46] Such clouds rise in air as they warm, however, diminishing the threat to people on the ground. Alternatively, extremely cold LNG could injure people or damage equipment through direct contact.[47] The extent of such contact would likely be limited, however, as a major spill would likely result in a more serious fire. The environmental damage associated with an LNG spill would be confined to fire and freezing impacts near the spill since LNG dissipates completely and leaves no residue (as crude oil does).[48]

Safety Record of LNG

The LNG tanker industry claims a record of relative safety over the last 45 years; since international LNG shipping began in 1959, tankers have carried 40,000 LNG cargoes without a serious accident at sea or in port.[49] LNG tankers have experienced groundings and collisions during this period, but none has resulted in a major spill.[50] The LNG marine safety record is partly due to the double-hulled design of LNG tankers. This design makes them more robust and less prone to accidental spills than single-hulled oil, fuel, and chemical tankers like the *Exxon Valdez*, which caused a major Alaskan oil spill after grounding in 1989.[51] LNG tankers also carry radar, global positioning systems, automatic distress systems and beacons to signal

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[44] Siu, N. *et al*. *Qualitative Risk Assessment for an LNG Refueling Station and Review of Relevant Safety Issues*. Idaho National Engineering Laboratory. INEEL/EXT-97-00827 rev2. Idaho Falls, ID. Feb. 1998. p71.

[45] Havens. 2003. p17.

[46] Siu. 1998. p62.

[47] Siu. 1998. p63.

[48] Quillen. 2002. p28.

[49] Verberg, G. "The Role of IGU in the Promotion of LNG." Presentation to the *Groupe International des Importateurs de Gaz Natural Liquefie*. Korea. Oct. 17, 2004.

[50] CH-IV International. *Safety History of International LNG Operations*. TD-02109. Millersville, MD. July, 2004. pp13-18.

[51] Society of International Gas Tanker & Terminal Operators Ltd. (SIGTTO). "Safe Havens for Disabled Gas Carriers." Third Edition. London. Feb. 2003. pp1-2.

if they are in trouble. Cargo safety systems include instruments that can shut operations if they deviate from normal as well as gas and fire detection systems.[52]

The safety record of onshore LNG terminals is more mixed. There are approximately 40 LNG terminals (and more than 150 other LNG storage facilities) worldwide. Since 1944, there have been approximately 13 serious accidents at these facilities directly related to LNG. Two of these accidents caused single fatalities of facility workers — one in Algeria in 1977, and another at Cove Point, Maryland, in 1979. On January 19, 2004, a fire at the LNG processing facility in Skikda, Algeria killed an estimated 27 workers and injured 74 others. The Skikda fire completely destroyed a processing plant and damaged a marine berth, although it did not damage a second processing plant or three large LNG storage tanks also located at the terminal.[53] The Skikda accident did not injure the rest of the 12,000 workers at the complex, but it was considered the worst petrochemical plant fire in Algeria in over 40 years.[54] According to press reports, the accident resulted from poor maintenance rather than a facility design flaw.[55] Another three accidents at worldwide LNG plants since 1944 have also caused fatalities, but these were construction or maintenance accidents in which LNG was not present.[56]

LNG Security Risks

LNG tankers and land-based facilities may be vulnerable to terrorism. Tankers could be physically attacked to destroy their cargo—or commandeered for use as weapons against coastal targets. Land-based LNG facilities could also be physically attacked with explosives or through other means. Alternatively, computer control systems could be "cyber-attacked," or both physical and cyber attack could happen at the same time. Some LNG facilities could also be indirectly disrupted by other types of terror strikes, such as attacks on regional electricity grids or communications networks, which could in turn affect dependent LNG control and safety systems.[57] Since LNG is fuel for power plants, heating, military bases, and other uses, disruption of LNG shipping or storage poses additional "downstream" risks, especially in more LNG-dependent regions like New England.

LNG Tanker Vulnerability. LNG tankers cause the most concern among security analysts because they are potentially more accessible than fixed terminal facilities, because they may transit nearer to populated areas, and because LNG spills from tankers could be more difficult to control. According to a December 2004

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[52] Petroplus International, N.V. "Energy for Wales: LNG Frequently Asked Questions." Internet home page. Amsterdam, Netherlands. Aug. 4, 2003.

[53] Junnola, J. *et al*. Jan. 21, 2004. p6.

[54] Hunter, C. "Algerian LNG Plant Explosion Sets Back Industry Development." *World Markets Analysis*. Jan. 21, 2004. p1.

[55] Antosh, N. "Vast Site Devastated." *Houston Chronicle*. Jan. 21, 2004. pB1.

[56] CH-IV International. pp6-12.

[57] Skolnik, S. "Local Sites Potential Targets for Cyberterror." *Seattle Post-Intelligencer*. Seattle, WA. Sept. 2, 2002.

report by Sandia National Laboratories, an intentional LNG spill and resulting fire could cause "major" injuries to people and "significant" damage to structures within approximately 500 meters (0.3 mile) of the spill site, more moderate injuries and structural damage up to 1,600 meters (1.0 mile) from the spill site, and lower impacts out to 2,500 meters (1.5 miles).[58]

A 2002 Lloyd's Register report specifically assessed the impacts of a hand-held missile attack and a bomb attack from a small boat on tankers serving the Everett LNG terminal. The study found that under certain circumstances "loss of containment may occur through shock mechanisms caused by small amounts of explosive."[59] The study concluded that "a deliberate attack on an LNG carrier can result in a ... threat to both the ship, its crew and members of the public."[60] However, the study also concluded that the fire hazard from an LNG tanker would be less than that from a gasoline or liquefied petroleum gas (LPG) tanker, both of which are more common on US waterways.[61] Other LNG hazard studies have reached somewhat different conclusions. Because such studies rely upon engineering models, however, with distinct input assumptions and methodological limitations, their projections are only approximate. Substantial uncertainty remains about how dangerous a real LNG tanker attack could be.[62]

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[58] Sandia National Laboratories (SNL). *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*. SAND2004-6258. Albuquerque, NM. Dec. 2004. p54.

[59] Waryas, E. Lloyd's Register America's, Inc. "Major Disaster Planning: Understanding and Managing Your Risk." Presented to the Fourth National Harbor Safety Committee Conference. Galveston, TX. March 4, 2002. p11

[60] Waryas. March 4, 2002. p24.

[61] Waryas. March 4, 2002. p12.

[62] For further discussion of LNG hazard models, see CRS Report RL32205, *Liquefied Natural Gas (LNG) Terminals: Siting, Safety and Regulation*, by Paul W. Parfomak.

The *Gaz Fountain* Attack

Although there have been no terrorist attacks on LNG tankers, there is at least one documented case of a gas tanker of similar construction being attacked in wartime. During the Iran-Iraq War in the 1990s, the double-hulled LPG tanker *Gaz Fountain* was fired upon by an Iranian aircraft using three air-to-ground, armor-piercing Maverick missiles. Two of the missiles exploded on or above the ship's deck, causing relatively minor damage. The third missile penetrated the deck and exploded above a butane storage tank, opening a 6 square-meter (65 square-foot) hole in the roof of the tank. The escaping gas ignited, establishing a large fire on deck above the missile entry hole. The fire aboard the *Gaz Fountain* was successfully extinguished by a salvage ship, her remaining cargo was successfully unloaded to another tanker, and she was eventually repaired.[63]

The *Gaz Fountain* attack and salvage provides some evidence as to the robustness of double-hulled gas tankers like those that carry LNG. But the relatively benign outcome in the *Gaz Fountain* attack does not necessarily demonstrate that attacks on LNG tankers would have similarly limited impacts. The *Gaz Fountain* was fortunate that its storage tank was breached only at the top. If missiles had been targeted at the hull of the ship rather than its deck, one might have penetrated the side of a storage tank, causing a major spill on water and an inextinguishable pool fire. Furthermore, if the gas involved had been LNG rather than butane, the *Gaz Fountain* might have been subject to cryogenic damage since LNG is transported at a much lower temperature than butane (-260°F vs. +25°F). According to the Sandia report, such a combination could lead to cascading failure of adjacent storage tanks and, presumably, an even larger fire.[64]

Recent LNG Security Initiatives

Operators of LNG infrastructure had security programs in place prior to September 11, 2001, but these programs mostly focused on personnel safety and preventing vandalism. The terror attacks of September 11 focused attention on the vulnerability of LNG infrastructure to different threats, such as systematic attacks on LNG facilities by foreign terrorists. Consequently, both government and industry have taken new initiatives to secure LNG infrastructure in response to new threats.

Several federal agencies oversee the security of LNG infrastructure. The Coast Guard has lead responsibility for LNG shipping and marine terminal security. The Department of Transportation's Office of Pipeline Safety and the Department of Homeland Security's Transportation Security Administration have security authority

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[63] Carter, J.A. "Salvage of Cargo from the War-Damaged *Gaz Fountain*." Proceedings of the Gastech 85 LNG/LPG Conference. Nice, France. Nov. 12-15, 1985.

[64] SNL. December 2004. p151.

for peak-shaving plants within gas utilities, as well as some security authority for LNG marine terminals. FERC has siting approval responsibility, with some security oversight, for land-based LNG marine terminals and certain peak-shaving plants. In addition to federal agencies, state and local authorities, like police and fire departments, also help to secure LNG.

Coast Guard Maritime Security Activities

The Coast Guard is the lead federal agency for U.S. maritime security, including port security. Among other duties, the Coast Guard tracks, boards, and inspects commercial ships approaching U.S. waters. A senior Coast Guard officer in each port oversees the security and safety of vessels, waterways, and many shore facilities in his geographic area.[65] The Coast Guard derives its security responsibilities under the Ports and Waterways Safety Act of 1972 (P.L. 92-340) and the Maritime Transportation Security Act of 2002 (P.L. 107-295). Maritime security regulations mandated by P.L.107-295 are discussed below. Under P.L.107-295 the Coast Guard and the Maritime Administration share siting approval authority for offshore LNG terminals.

Shortly after September 11, 2001, the Coast Guard began to systematically prioritize protection of ships and facilities, including those handling LNG, based on vulnerability assessments and the potential consequences of security incidents. The Coast Guard evaluated the overall susceptibility of marine targets, their use to transport terrorists or terror materials, and their use as potential weapons. In particular, the Coast Guard evaluated the vulnerability of tankers to "a boat loaded with explosives" or "being commandeered and intentionally damaged."[66] While the assessments focused on Coast Guard jurisdictional vessels and facilities, some scenarios involved other vital port infrastructure like bridges, channels, and tunnels.[67] The Coast Guard used these assessments in augmenting security of key maritime assets and in developing the agency's new maritime security standards.

The Coast Guard began increasing LNG tanker and port security immediately after September 11, 2001. For example, the Coast Guard suspended LNG shipments to Everett for several weeks after the terror attacks to conduct a security review and revise security plans.[68] The Coast Guard also worked with state, environmental and police marine units to establish 24-hour patrols in Boston harbor.[69] In July 2002, the Coast Guard imposed a 1,000-yard security zone around the Kenai LNG terminal–and subsequently imposed similar zones around other U.S. LNG

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[65] See CRS Report RL31733, *Port and Maritime Security*, for more information about maritime and port security.

[66] 68FR126. July 1, 2003. p39244

[67] 68FR126. July 1, 2003. p39246

[68] McElhenny, J. "Coast Guard Lifts Ban of Natural Gas Tankers in Boston Harbor." Associated Press. Oct. 16, 2001.

[69] Crittenden, J. "Vigilance: Holiday Puts Spotlight on Harbor Security." *Boston Herald*. Boston, MA. June 30, 2002. p1.

terminals.[70] The Coast Guard also reassessed security at the Cove Point terminal before allowing LNG shipments to resume there for the first time since 1980.[71]

The most heavily secured LNG shipments are those bound for the Everett terminal because they pass through Boston harbor. The Coast Guard and local law enforcement agencies have numerous security provisions in place for these shipments, including:

- Inspection of security and tanker loading at the port of origin in Trinidad.
- Occasional on-board escort to Boston by Coast Guard "sea marshals."
- 96-hour advanced notice of arrival of an LNG tanker.
- Advance notification of local police, fire, and emergency agencies, as well as the Federal Aviation Administration and the U.S. Navy.
- Boarding of the LNG tanker for inspection prior to entering Boston harbor.
- Harbor escort by armed patrol boats, cutters, or auxiliary vessels.
- Enforcement of a security zone closed to other vessels two miles ahead and one mile to each side of the LNG tanker.
- Suspension of overflights by commercial aircraft at Logan airport.
- Inspection of adjacent piers for bombs by police divers.
- Posting of sharpshooters on nearby rooftops.
- Additional security measures which cannot be disclosed publicly.[72]

According to the Coast Guard, many of these security provisions are in place for the other U.S. LNG terminals as well, depending upon local assessments of security risk and the unique characteristics of each marine area.[73] Similar security measures would also likely be put in place for new on-shore LNG terminals.

On October 22, 2003, the Coast Guard issued final rules to implement the new security requirements mandated by P.L. 107-295. The rules are codified in Title 33 of the Code of Federal Regulations, Chapter 1, Subchapter H. Among other provisions, the rules establish Coast Guard port officers as maritime security coordinators and set requirements for maritime area security plans and committees. The rules require certain owners or operators of marine assets to designate security officers, perform security assessments, develop and implement security plans, and comply with maritime security alert levels. The vessel rules apply to all LNG tankers entering U.S. ports. Facility rules apply to all land-based U.S. LNG terminals or proposed offshore LNG terminals. Finally, the rules require certain vessels, including LNG tankers, to carry an automatic identification system.

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[70] "LNG Security in Boston to Be Permanent." *Platt's Oilgram News*. New York, NY. Aug. 1, 2002.

[71] "Coast Guard, Mikulski Clear Plan to Reactivate Cove Point LNG Plant." *Platt's Inside FERC*. Washington, DC. Jan. 6, 2003. p5.

[72] Greenway, H.D.S. "Is it Safe?" *The Boston Globe Magazine*. July, 27, 2003; Lin, J. and Fifield, A. "Risky Business?" *The Philadelphia Enquirer*. Feb. 20, 2005. p1.

[73] U.S. Coast Guard, Port Security Directorate. Personal communication. Aug. 12, 2003.

The marine security rules required that U.S. ships and facilities subject to the rules be operating in compliance with approved plans by July 1, 2004. Foreign vessels were required to have security plans by July 1, 2004 as well, although the Coast Guard has been relying on countries of origin to approve the security plans of foreign vessels. As of November, 2004, the Coast Guard had received "over 99 percent" of the vessel and facility security plans required under P.L. 107-295.[74] Security plans specifically for the existing U.S. LNG terminals were completed on schedule and the terminals' compliance with the plans was verified by Coast Guard port security personnel through scheduled on-site examinations.[75]

The Coast Guard has also led the International Maritime Organization (IMO) in developing maritime security standards outside U.S. jurisdiction.[76] These standards, the International Ship and Port Facility Security Code (ISPS Code) contain detailed mandatory security requirements for governments, port authorities and shipping companies, as well as recommended guidelines for meeting those requirements. The ISPS Code is intended to provide a standardized, consistent framework for governments to evaluate risk and to "offset changes in threat with changes in vulnerability."[77] The Coast Guard considers the new ISPS Code "to reflect the current industry, public and agency concerns."[78]

Federal Pipeline Safety and Security Agencies

The Office of Pipeline Safety (OPS) within the Department of Transportation has statutory authority to regulate the safety and security of LNG peak-shaving plants under the Natural Gas Pipeline Safety Act of 1968 (P.L. 90-481). The OPS security regulations for LNG peak-shaving facilities are found in 49 CFR 193, *Liquefied Natural Gas Facilities: Federal Safety Standards* (Subpart J-Security). These regulations govern security procedures, protective enclosures, communications, monitoring, lighting, power sources, and warning signs. Federal LNG *safety* regulations (33 CFR 127) and National Fire Protection Association standards for LNG also include provisions addressing security, such as requirements for monitoring facilities and preparing emergency response plans.[79] According to the OPS, the agency enforces the LNG security regulations in 49 CFR 193 as part of its broader safety mission.[80]

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[74] Dep. Sec. James Loy, Dept. of Homeland Security. Remarks at the Maritime and Port Security Summit . Washington, DC. Nov. 16, 2004.

[75] Capt. David Scott, U.S. Coast Guard. Testimony before the Senate Committee on Energy and Natural Resources, Subcommittee on Energy. Feb. 15, 2005.

[76] 68FR126. July 1, 2003. p39241.

[77] International Maritime Organization (IMO). "IMO Adopts Comprehensive Maritime Security Measures." Press release. London. Dec. 17, 2002.

[78] 68FR126. July 1, 2003. p39241

[79] National Fire Protection Association (NFPA). *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG).* NFPA 59A. Quincy, MA.

[80] Office of Pipeline Safety (OPS). Personal communication. Aug. 22, 2003.

The Transportation Security Administration (TSA) is the lead federal authority for the security of the interstate gas pipeline network under the Natural Gas Pipeline Safety Act of 1968 (P.L. 90-481). This security authority was transferred to TSA from the Transportation Department's Office of Pipeline Safety (OPS) under the Aviation and Transportation Security Act of 2001(P.L. 107-71). The TSA has also asserted its security authority over land-based LNG facilities that are considered an integral part of the interstate pipeline network.[81] Prior to February 2005, the TSA exercised its pipeline and LNG security oversight through the Pipelines Branch of its Office of Maritime and Land Security. In this capacity, the TSA expected pipeline and jurisdictional LNG facility operators to maintain security plans based on the OPS/industry consensus security guidance circulated in 2002. In 2003 and 2004 TSA visited the largest 25-30 pipeline operators, including some with LNG plants, to review their security plans. Because all land-based LNG plants were not considered "nationally critical," however, TSA did not plan to inspect all plants.[82] On February 7, 2005, TSA disbanded its Office of Maritime and Land Security, reassigning its employees to other jobs within the agency.[83] TSA has not publicly released specific information about its pipeline and LNG security activities following this reorganization.

Federal Energy Regulatory Commission (FERC) Oversight

The FERC is responsible for permitting new land-based LNG facilities, and for ensuring the safe operation of these facilities through subsequent inspections.[84] The initial permitting process requires approval of safety and security provisions in facility design, such as hazard detectors, security cameras, and vapor cloud exclusion zones. Every two years, FERC staff inspect LNG facilities to monitor the condition of the physical plant and inspect changes from the originally approved facility design or operations.[85] The FERC derives its LNG siting authority under the Natural Gas Act of 1938 (15 USC 717). The agency has jurisdiction over all on-shore LNG marine terminals and 15 peak-shaving plants involved in interstate gas trade.[86]

In response to public concern about LNG plant security since September 11, 2001, FERC has emphasized the importance of security at LNG facilities. According to the commission, FERC staff played key roles at inter-agency technical conferences regarding security at the Everett and Cove Point LNG terminals. As part of its biennial inspection program, FERC also inspected 17 jurisdictional LNG sites in 2002 and 2003 "placing increased emphasis on plant security measures and

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[81] TSA. Personal communication. Aug. 18, 2003.

[82] TSA. Personal communication. Jan. 12, 2004.

[83] Dickey, B. "TSA Dismantles Maritime Unit, Reassigns Employees." *GovExec.com*. Feb. 25, 2005.

[84] U.S. Code of Federal Regulations. 18 CFR 157.

[85] Foley, R. Federal Energy Regulatory Commission (FERC), Office of Energy Projects. "Liquefied Natural Gas Imports." Slide presentation. Jan. 2003. p17.

[86] FERC. Personal communication. Aug. 13, 2003.

improvements."[87] According FERC staff, the commission has added a security chapter to its LNG site inspection manuals which consolidates previous requirements and adds new ones.[88]

Federal Interagency Cooperation in LNG Security

The Coast Guard, TSA, and FERC all have potentially overlapping security jurisdiction over certain facilities at onshore LNG terminals. For example, FERC's biennial LNG site visits explicitly include security inspections, and TSA oversees on-site pipeline security–but the Coast Guard asserts lead security authority over the entire terminal in its new maritime security regulations.[89] Under current authority, both the Coast Guard and TSA could both require their own facility security assessments for pipelines and LNG storage at LNG marine terminals. Among oil refiners, with marine terminals similar to those in LNG and also regulated by TSA and the Coast Guard, confusion did emerge over which federal agency had jurisdiction over certain security rules.[90] LNG peak-shaving plant operators reportedly expressed similar concerns about potentially overlapping OPS and TSA security rules for their facilities.[91]

To avoid jurisdictional confusion, the Coast Guard, OPS and FERC have entered into an interagency agreement to ensure that they

> work in a coordinated manner to address issues regarding safety and security at waterfront LNG facilities, including the terminal facilities and tanker operations, to avoid duplication of effort, and to maximize the exchange of relevant information related to the safety and security aspects of LNG facilities and the related marine concerns.[92]

According to the agreement, the agencies will cooperate in the siting approval of new LNG facilities, inspection and operational review of existing facilities, informal communication, and dispute resolution.[93]

According to FERC, the agency's security review for new LNG terminal applications is conducted in consultation with the US Coast Guard. Security assessments of individual terminal proposals are conducted by Coast Guard field

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[87] Federal Energy Regulatory Commission (FERC). *2002 Annual Report* and *2003 Annual Report.* Washington, DC. p21.

[88] FERC. Personal communication. Aug. 13, 2003.

[89] U.S. Coast Guard, Port Security Directorate. Personal communication. Aug. 12, 2003.

[90] "Industry Trends." *Oil and Gas Journal.* Aug. 11, 2003. p7.

[91] Dominion Resources. Personal communication. Aug. 21, 2003.

[92] Federal Energy Regulatory Commission (FERC). "Interagency Agreement Among the Federal Energy Regulatory Commission United States Coast Guard and Research and Special Programs Administration for the Safety and Security Review of Waterfront Import/Export Liquefied Natural Gas Facilities." Feb. 11, 2004. p1.

[93] FERC. Feb. 11, 2004. pp2-4.

units through security workshops involving federal, state and local law enforcement officials as well as port stakeholders. FERC engineers provide technical assistance on marine spill issues. FERC and the Coast Guard require LNG terminal applicants to also submit a navigational suitability review under 33 CFR 127, and begin a security assessment of their proposal in accordance with 33 CFR 105. According to FERC, where site-specific security concerns have been raised, the agencies have conducted non-public technical workshops with "all relevant stakeholders and federal, state and local expert agencies" to resolve those security concerns.[94]

Industry Initiatives for Land-Based LNG Security

After the September 11 attacks, gas infrastructure operators, many with LNG facilities, immediately increased security against the newly perceived terrorist threat. The operators strengthened emergency plans; increased liaison with law enforcement; increased monitoring of visitors and vehicles on utility property; increased employee security awareness; and deployed more security guards.[95] In cooperation with the OPS, the Interstate Natural Gas Association of America (INGAA) formed a task force to develop and oversee industry-wide security standards "for critical onshore and offshore pipelines and related facilities, as well as liquefied natural gas (LNG) facilities."[96] The task force also included representatives from the Department of Energy (DOE), the American Gas Association (AGA), and non-member pipeline operators. With the endorsement of the OPS, the INGAA task force issued security guidelines for natural gas infrastructure, including LNG facilities, in September 2002.[97] The task force also worked with federal agencies, including Homeland Security, on a common government threat notification system.[98]

Key Policy Issues in LNG Security

Government and industry have taken significant steps to secure the nation's LNG infrastructure. But continued progress in implementing and sustaining LNG infrastructure protection activities may face several challenges. As discussed in detail in the following sections, members of Congress and federal officials are concerned about the growing public costs of LNG security, the uncertainty of terrorist threats against LNG, and the security implications of offshore terminal siting.

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[94] Robinson, M., Federal Energy Regulatory Commission (FERC). Testimony before the Senate Committee on Energy and Natural Resources, Subcommittee on Energy. Feb. 15, 2005.

[95] American Gas Association (AGA) *Natural Gas Distribution Industry Critical Infrastructure Security.* 2002. and AGA. *Natural Gas Infrastructure Security–Frequently Asked Questions.* April 30, 2003.

[96] Haener, W.J., CMS Energy Corp. Testimony on behalf of the Interstate Natural Gas Association of America (INGAA) before the House Transportation and Infrastructure Subcommittee on Highways and Transit. Feb. 13, 2002. p4.

[97] Interstate Natural Gas Association of America (INGAA) et al. *Security Guidelines Natural Gas Industry Transmission and Distribution*. Washington, DC. Sept. 6, 2002.

[98] Haener. Feb. 13, 2002. p4.

Public Costs of LNG Marine Security

Some policymakers are concerned about the public cost and sustainability of securing LNG shipments. Overall cost data for LNG security are unavailable, but estimates have been made for Everett shipments. The Coast Guard Program Office has estimated that it costs the Coast Guard approximately $40,000 to $50,000 to "shepherd" an LNG tanker through a delivery to the Everett terminal, depending on the duration of the delivery, the nature of the security escort, and other factors.[99] State and local authorities also incur costs for overtime police, fire and security personnel overseeing LNG tanker deliveries. The state of Massachusetts and the cities of Boston and Chelsea estimated they spent a combined $37,500 to safeguard the first LNG shipment to Everett after September 11, 2001.[100] Based on these figures, the public cost of security for an LNG tanker shipment to Everett is on the order of $80,000, excluding costs incurred by the terminal owner.

Marine security costs at other LNG terminals could be lower than for Everett because they are farther from dense populations and may face fewer vulnerabilities. But these terminals expect more shipments. Altogether, the six active onshore U.S. LNG terminals, including Everett, expect to have enough capacity for nearly 600 shipments per year by 2008. Further increasing LNG imports to meet 21% of total U.S. gas supply by 2025 as projected by the EIA could require over 3,700 LNG shipments to LNG terminals serving the United States. Assuming an average security cost only half that for Everett, or $40,000 per shipment, annual costs to the public for marine LNG security could exceed $24 million by 2008 and $148 million by 2025.[101]

The potential increase in security costs from growing U.S. LNG imports, and the potential diversion of Coast Guard and safety agency resources from other activities have been a concern to policy makers.[102] According to Coast Guard officials, the service's LNG security expenditures are not all incremental, since they are part of the Coast Guard's general mission to protect the nation's waters and coasts. Nonetheless, Coast Guard staff have acknowledged that resources dedicated to securing maritime LNG might be otherwise deployed for boating safety, search

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[99] U.S. Coast Guard, Program Office. Personal communication. August 12, 2003. This estimate is based on boat, staff and administrative costs for an assumed 20-hour mission.

[100] McElhenny, J. "State Says LNG Tanker Security Cost $20,500." Associated Press. Nov. 2, 2001. p1.

[101] Note that security costs associated with LNG terminals in Canada, Mexico and the Bahamas (built primarily to serve U.S. markets) would not be a direct U.S. responsibility, although such costs might still be priced into LNG supplied from those terminals.

[102] See, for example: Government Accountability Office (GAO). *COAST GUARD: Station Readiness Improving, but Resource Challenges and Management Concerns Remain.* GAO-05-161. Jan. 2005; U.S. Senator Jack Reed at the Senate Energy and Natural Resources Committee, Subcommittee on Energy Hearing on Liquified Natural Gas. Feb 15, 2005.

and rescue, drug interdiction, or other security missions.[103] LNG security is funded from the Coast Guard's general maritime security budget, so it is not a line item in the FY2006 DHS budget request. However, the Coast Guard's FY2006 budget does request an additional $11 million in funding over FY2005 levels for "Increased Port Presence and LNG Transport Security," specifically including "additional boat crews and screening personnel at key LNG hubs."[104]

State and local agencies are also seeking more funding to offset the costs of LNG security. Otherwise, they believe that LNG security needs may force them to divert limited local resources from other important public services.[105] Acknowledging these concerns, FERC officials have recommended that new LNG terminal operators pay the costs of any additional security or safety needed for their facilities.[106] The FERC has also recommended that LNG terminal operators provide private security staff to supplement Coast Guard and local government security forces.[107] Nonetheless, because the accounting of these security costs is unclear, and cost recovery may be partly tied to uncertain sources of federal funding, such as DHS security grants, some local government officials continue to voice concern over LNG security costs.[108] Furthermore, some LNG companies have resisted suggestions that they pay more for public security, reasoning that the millions of dollars in federal, state, and local taxes they pay should cover public law enforcement and emergency services.[109] Others have expressed a willingness to pay for "excess" security only if it exceeds the level of security agency service ordinarily commensurate with corporate tax payments.[110]

The public costs of LNG security may decline as federally mandated security systems and plans are implemented. New security technology, more specific threat intelligence, and changing threat assessments may all help to lower LNG security costs in the future. Nonetheless, the potential increase in security costs from growing U.S. LNG shipments may warrant a review of these costs and associated recovery mechanisms.

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[103] U.S. Coast Guard, Port Security Directorate. Personal communication. Aug. 12, 2003.

[104] Dept. of Homeland Security (DHS). *Budget-in-Brief, Fiscal Year 2006*.

[105] McElhenny, J. Nov. 2, 2001. p1.

[106] Baldor, L.C. "Federal Agency, R.I. Officials Meet over LNG Terminal." *Associated Press*. March 17, 2005.

[107] Federal Energy Regulatory Commission (FERC). "Response to Senator Jack Reed's 2/1/05 letter regarding the proposed Weaver's Cove LNG Project in Fall River, MA & the proposed KeySpanLNG Facility Upgrade Project in Providence, RI under CP04-293 et al." March 3, 2005. p2.

[108] U.S. Sen. Jack Reed. Remarks at the Senate Energy and Natural Resources Committee, Energy Subcommittee hearing on Liquefied Natural Gas. Feb. 15, 2005.

[109] McElhenny, J. Nov. 2, 2001. p1.

[110] Dominion Resources, Corporate Security. Personal communication. Richmond, VA. Aug. 19, 2003.

Uncertainty About LNG Threats

The likelihood of a terrorist attack on U.S. LNG infrastructure has been the subject of debate since September 11, 2001. To date, no LNG tanker or land-based LNG facility in the world has been attacked by terrorists. However, similar natural gas and oil facilities have been favored terror targets internationally. For example, since 2001, gas and oil pipelines have been attacked in at least half a dozen countries.[111] In June 2002, Moroccan authorities foiled an Al-Qaeda plot to attack U.S. and British warships, and possibly commercial vessels, in the Straits of Gibraltar.[112] LNG tankers from Algeria *en route* to the United States pass through the same waters. In October 2002, the French oil tanker *Limburg* was attacked off the Yemeni coast by a bomb-laden fishing boat.[113] In the United States, federal warnings about Al Qaeda threats have repeatedly mentioned energy infrastructure.[114] In June 2003, U.S. intelligence agencies warned about possible Al Qaeda attacks on energy facilities in Texas.[115] The Homeland Security Council included terrorist attacks on "cargo ships" carrying "flammable liquids" among the fifteen hazards scenarios it developed in 2004 as the basis for U.S. homeland security "national preparedness standards."[116]

In addition to warnings of a terrorist threat to energy facilities in general, federal agencies have identified LNG infrastructure in particular as a potential terrorist target. The Department of Homeland Security (DHS) specifically included LNG assets among a list of potential terrorist targets in a security alert late in 2003.[117] The DHS also reported that "in early 2001 there was some suspicion of possible associations between stowaways on Algerian flagged LNG tankers arriving in Boston and persons connected with the so-called 'Millennium Plot'" to bomb targets in the United States. While these suspicions could not be proved, DHS stated that "the risks associated with LNG shipments are real, and they can never be entirely eliminated."[118] The 2004 report by Sandia National Laboratories concluded that potential terrorist attacks on LNG tankers, could be considered "credible and

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[111] See CRS Report RL31990, *Pipeline Security*, for specific examples.

[112] Sawer, P. "Terror Plot to Blow Up Navy Warships is Foiled." *The Evening Standard*. London. June 11, 2002. p4.

[113] "Ships as Terrorist Targets." *American Shipper*. November, 2002. p59.

[114] Federal Bureau of Investigation (FBI). *The Terrorist Threat Confronting the United States*. Statement of Dale L. Watson, Exec. Dir. for Counterterrorism and Counterintelligence before the Senate Select Committee on Intelligence. Washington, DC. Feb. 6, 2002.

[115] Hedges, M. "Terrorists Possibly Targeting Texas." *Houston Chronicle*. June 24, 2003.

[116] Homeland Security Council. *Planning Scenarios: Executive Summaries*. July 2004. p 6-1.

[117] Office of Congressman Edward J. Markey. Personal communication. Jan. 5, 2004.

[118] Turner, P.J., Assistant Secretary for Legislative Affairs, Department of Homeland Security (DHS). Letter to U.S. Representative Edward Markey. April 15, 2004. p1.

possible."[119] The Sandia report identified LNG tankers as vulnerable to ramming, pre-placed explosives, insider takeover, hijacking, or external terrorist actions (such as a *Limburg*-type, missile or airplane attack).[120]

Although they acknowledge the threat information put forth by federal agencies, many experts believe that public concern about threats to LNG is overstated and should not impede increased LNG imports.[121] The head of one university research consortium remarked, for example, "from all the information we have ... we don't see LNG as likely or credible terrorist targets."[122] Likewise, based in part on consultations with the Federal Bureau of Investigation, NFPA's LNG standards committee has not seen a need to update the 59A standard for onshore LNG facilities in light of the September 11, 2001 terror attacks.[123] Industry representatives argue that deliberately causing an LNG catastrophe to injure people might be possible, perhaps, but would be extremely difficult. They cite the safety record of the LNG industry and the *Gaz Fountain* incident to support this conclusion.

LNG proponents also believe that LNG facilities are relatively secure compared to other hazardous chemical infrastructures which receives less public attention. In a December 2004 report, the FERC stated that

> for a new LNG terminal proposal ... the perceived threat of a terrorist attack may be considered as highly probable to the local population. However, at the national level, potential terrorist targets are plentiful.... Many of these pose a similar or greater hazard to that of LNG.[124]

Based on data from the U.S. Office of Hazardous Materials Safety, 600 LNG tanker shipments would account for less than 1% of total annual U.S. shipments of hazardous marine cargo such as ammonia, crude oil, liquefied petroleum gases, and other volatile chemicals.[125] Considering these other potential terrorist targets, LNG industry representatives argue that some LNG opponents greatly overestimate the relative risk of an LNG attack.[126]

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[119] Sandia National Laboratories (SNL). *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*. SAND2004-6258. Albuquerque, NM. Dec. 2004. pp49-50.

[120] SNL. Dec. 2004. pp61-62.

[121] McLuaghlin, J. "LNG is Nowhere Near as Dangerous as People Are Making it Out to Be." *Lloyd's List*. Feb. 8, 2005. p5.

[122] Behr, P. "Higher Gas Price Sets Stage for LNG." *Washington Post*. July 5, 2003. pD10.

[123] National Fire Protection Assoc. (NFPA). Technical Committee on Liquefied Natural Gas. Personal communication. Quincy, MA. Dec. 15, 2003.

[124] Federal Energy Regulatory Commission (FERC). *Vista del Dol LNG Terminal Project, Draft Environmental Impact Statement*. FERC/EIS-0176D. Dec. 2004. p4-162.

[125] Office of Hazardous Materials Safety, Department of Transportation. *Hazardous Materials Shipments*. Washington, DC. Oct. 1998. Table 2. p2.

[126] Grant. R., President, Distrigas. Testimony before the Senate Committee on Energy and (continued...)

It may be impossible for federal and industry officials to ever prove that LNG infrastructure will *not* be targeted by terrorists. As the FERC has remarked, "unlike accidental causes, historical experience provides little guidance in estimating the probability of a terrorist attack on an LNG vessel or onshore storage facility."[127] Because the probability of a terrorist attack on LNG cannot be known with certainty, policy makers and community leaders must ultimately rely on their judgment to decide whether LNG security measures for a specific facility will adequately protect the public.

Security Implications of Offshore LNG Facilities

Some policy makers have proposed that new LNG import terminals should be built only offshore to keep associated terrorism hazards away from populated areas. Such a strategy may indeed reduce terrorism risks to ports and coastal communities, but it may also increase the risks to the terminals themselves. Because offshore oil and gas facilities are remote, isolated, and often lightly manned, some experts believe they are more vulnerable to terror attacks than land-based facilities.[128] Offshore oil and gas facilities have not been frequent terror targets, but they have been attacked in the past during wartime and in territorial disputes.[129] Since September 11, 2001, international concern about terrorist attacks on these platforms has grown.[130] Some experts believe terrorist attacks against offshore platforms have been on the rise recently in countries with a history of terror activity like Nigeria, Colombia, and Indonesia–although many of these attacks may be economically, rather than politically, motivated.[131] Disruption of any single offshore LNG terminal would not likely have a great impact on U.S. natural gas supplies, but if several new offshore terminals were attacked in the future, the effects on natural gas availability and prices could have serious consequences for U.S. energy markets. On-shore versus offshore siting alternatives should therefore be considered in the context of both local public security and the security of national energy supplies.

Conclusions

The U.S. LNG industry is growing quickly. While rising LNG imports may offer economic benefits, they also pose risks. LNG infrastructure is inherently hazardous and it is potentially attractive to terrorists. Both lawmakers and the

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[126] (...continued)
Natural Resources, Subcommittee on Energy. Feb. 15, 2005.

[127] FERC. FERC/EIS-0176D. Dec. 2004. p4-162.

[128] Daughdrill, W. H., Ecology & Environment, Inc. Lancaster, NY. Personal communication. Aug. 7, 2003.

[129] George, D. "Piracy on Increase, Presents Threat to Offshore Structures, Vessels." *Offshore*. Oct. 1993. p25.

[130] McKenzie, S. "Submarine Terror Fear for North Sea Oil Rigs." *Scottish Sunday Mail*. Aug. 10, 2003.

[131] Adams, N. "Terrorism in the Offshore Oil Field." *Underwater*. March/April 2003.

general public are concerned about these risks, although the LNG industry has a long history of relatively safe operations and has taken steps to secure its assets against terrorist attack. No LNG tanker or land-based facility has been attacked by terrorists, and federal, state and local governments have put in place security measures intended to safeguard LNG against newly perceived terrorist threats. These measures are evolving, but a variety of industry and agency representatives suggest that these federal initiatives are reducing the vulnerability of U.S. LNG to terrorism.

The ongoing debate about LNG infrastructure security in the United States has often been contentious. Local officials and community groups have challenged numerous LNG infrastructure proposals on the grounds that they may represent an unacceptable risk to the public. Heightened public scrutiny of LNG facilities has made it difficult to site new LNG terminals near major gas markets and has increased the cost and complexity of LNG terminal siting approval. Nonetheless, both industry and government officials acknowledge that enough new LNG infrastructure will likely be approved to meet long-term U.S. import requirements. Indeed, as of March 2005, federal agencies had approved the construction of six new U.S. import terminals, three of them onshore. Numerous additional terminal proposals await federal approval. Together with the expansion of the existing U.S. import terminals and the construction of two recently approved LNG terminals in Canada and Mexico, the approved U.S. facilities would provide enough added capacity to meet the bulk of U.S. LNG demand for the next twenty years.

New U.S. LNG terminals may not be ideally located so as to minimize the cost of natural gas, but building them in these locations may be better than not building them at all.[132] Furthermore, because their security has been subject to intense public scrutiny, new LNG terminal and tanker operations may be safer than they might have been without such scrutiny and their siting may be less likely to be challenged at a later time when construction is already underway. The construction and subsequent closure of the Shoreham nuclear power plant in the 1980's due to new public opposition offers an example of the need to resolve safety and security concerns before capital is invested. From a purely economic perspective, therefore, the added costs associated with building more heavily protected LNG terminals potentially farther from their primary markets may represent the U.S. public's willingness to pay for LNG security. Whether this implicit price of LNG security is reasonable is an open question, but the continued interest of private companies to invest billions of dollars in U.S. LNG terminals suggests that it will not prevent needed LNG development.

As Congress continues its oversight of LNG, it may decide to examine the public costs and resource requirements of LNG security, especially in light of dramatically increasing LNG imports. In particular, Congress may consider whether future LNG security requirements will be appropriately funded, whether these requirements will be balanced against evolving risks, and whether the LNG industry is carrying its fair share of the security burden. Congress may also act to improve its understanding of LNG security risks. Costly "blanket" investments in LNG security

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[132] For further discussion, see CRS Report RL32386, *Liquefied Natural Gas in U.S. Energy Policy: Infrastructure and Market Issues*, by Paul W. Parfomak.

might be avoided if more refined terror threat information were available to focus security spending on a narrower set of infrastructure vulnerabilities. Finally, Congress may initiate action to better understand the security implications of new LNG terminals offshore.

In addition to these specific issues, Congress might consider how the various elements of U.S. LNG security activity fit together in the nation's overall strategy to protect critical infrastructure. Maintaining high levels of security around LNG tankers, for example, may be of limited benefit if other hazardous marine cargoes are less well-protected. U.S. LNG security also requires coordination among many groups: international treaty organizations, federal agencies, state and local agencies, trade associations and LNG infrastructure operators. Reviewing how these groups work together to achieve common security goals could be an oversight challenge for Congress.