

**CALIFORNIA
ENERGY
COMMISSION**

**LIQUEFIED NATURAL GAS
IN CALIFORNIA:
HISTORY, RISKS, AND SITING**

STAFF WHITE PAPER

JULY 2003
700-03-005



Gray Davis, *Governor*

CALIFORNIA ENERGY COMMISSION

Mignon Marks,
Principal Author

Susan Bakker
Mark DiGiovanna
Bob Haussler
Geoff Lesh
Monica Schwebs
Bob Strand
Chris Tooker
Rick Tyler
Contributors

Dave Maul
Manager
NATURAL GAS & SPECIAL
PROJECTS OFFICE

Terrence O'Brien,
Deputy Director
SYSTEMS ASSESMENTS &
FACILITIES DIVISION

Robert L. Therkelsen
Executive Director

James D. Boyd
*Commissioner and Leader of
the Governor's Natural Gas
Working Group*

DISCLAIMER

This paper was prepared as the result of work by a member of the staff of the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees, or the State of California. The Energy Commission, the State of California, its employees, contractors and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this paper; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This paper has not been approved or disapproved by the California Energy Commission nor has the California Energy Commission passed upon the accuracy or adequacy of the information in this paper.

LIQUEFIED NATURAL GAS IN CALIFORNIA: HISTORY, RISKS, AND SITING

INTRODUCTION

The United States, including California, needs to develop additional supplies of natural gas to meet its growing demand. Because North American supply basins are maturing, the U.S. will need to rely more on imported supplies, including liquefied natural gas (LNG). Currently, the U.S. has four LNG-receiving and regasification terminals, but no terminal is located on the West Coast. Recently, however, a number of companies have proposed to site LNG import facilities in California, in other locations in the U.S., and in Baja California, Mexico.

In the early 1970s, California's gas utilities were planning to build an LNG import facility and import LNG. They identified the Port of Los Angeles, Oxnard, and Point Conception as possible sites. However, the three agencies involved in site approval could not agree on a preferred site. To address the conflict, at least at the state level, the project proponents turned to the Legislature, which enacted the LNG Terminal Siting Act of 1977. Under this act, the California Public Utilities Commission (CPUC), with input from the California Coastal Commission (Coastal Commission) and California Energy Commission (Energy Commission), could approve one site. The CPUC chose Point Conception because of its remote location, but the proponents cancelled the project when LNG became uneconomical.

In 1987, the Legislature repealed the LNG siting act, and no company has attempted to site an LNG import facility on the West Coast until recently. The current process for siting such facilities is unclear as a result of that repeal.

This paper describes LNG import facilities and summarizes the key safety and environmental issues that need to be addressed during the siting process. It is organized into the following sections:

- Background
- History
- Current Projects
- Siting Processes

This paper does not discuss the front end of the LNG supply chain (i.e., the exploration, production, and liquefaction of gas from distant and isolated locations), LNG economics, or the features and permitting of small LNG facilities for vehicle fueling or peak-shaving purposes. It also does not discuss the regulation of LNG facility operations, gas pipeline construction and operation, gas quality, or gas prices.

BACKGROUND

Properties of LNG

LNG is essentially no different from the natural gas used in homes and businesses everyday, except that it has been refrigerated to minus 259 degrees Fahrenheit at which point it becomes a clear, colorless, and odorless liquid. As a liquid, natural gas occupies only one six-hundredth of its gaseous volume and can be transported economically between continents in special tankers.

LNG weighs slightly less than half as much as water, so it floats on fresh or sea water. However, when LNG comes in contact with any warmer surface such as water or air, it evaporates very rapidly (“boil”), returning to its original, gaseous volume. As the LNG vaporizes, a vapor cloud resembling ground fog will form under relatively calm atmospheric conditions. The vapor cloud is initially heavier than air since it is so cold, but as it absorbs more heat, it becomes lighter than air, rises, and can be carried away by the wind. An LNG vapor cloud cannot explode in the open atmosphere, but it could burn.

Safety Concerns

LNG is considered a hazardous material.¹ The primary safety concerns are the potential consequences of an LNG spill. LNG hazards result from three of its properties:

- Cryogenic temperatures
- Dispersion characteristics
- Flammability characteristics

The extreme cold of LNG can directly cause injury or damage. Although momentary contact on the skin can be harmless, extended contact will cause severe freeze burns. On contact with certain metals, such as ship decks, LNG can cause immediate cracking.

Although not poisonous, exposure to the center of a vapor cloud could cause asphyxiation due to the absence of oxygen.

LNG vapor clouds can ignite within the portion of the cloud where the concentration of natural gas is between a five and a 15 percent (by volume) mixture with air.² To catch fire, however, this portion of the vapor cloud must encounter an ignition source. Otherwise, the LNG vapor cloud will simply dissipate into the atmosphere.

An ignited LNG vapor cloud is very dangerous, because of its tremendous radiant heat output. Furthermore, as a vapor cloud continues to burn, the flame could burn back toward the evaporating pool of spilled liquid, ultimately burning the quickly evaporating natural gas immediately above the pool, giving the appearance of a “burning pool” or

“pool fire.” An ignited vapor cloud or a large LNG pool fire can cause extensive damage to life and property.³

Spilled LNG would disperse faster on the ocean than on land, because water spills provide very limited opportunity for containment. Furthermore, LNG vaporizes more quickly on water, because the ocean provides an enormous heat source. For these reasons, most analysts conclude that the risks associated with shipping, loading, and off-loading LNG are much greater than those associated with land-based storage facilities.

Facility Descriptions

Preventing spills and responding immediately to spills should they occur are major factors in the design of LNG facilities. The following descriptions emphasize the safety features of LNG facilities.

Tankers

Ocean-going tankers transport large amounts of LNG from distant natural gas fields. They are equipped with up to five LNG-cargo tanks housed inside a double-walled hull. Each cargo tank can store several thousand cubic feet of LNG. These ships are up to 1,000-feet long, and, when fully loaded, require a minimum water depth of 40 feet.

The cargo tanks function like Thermos bottles. LNG is injected into the cargo tanks where it is stored and transported under normal atmospheric pressure. The insulation surrounding the tank is the sole means by which the cargo is kept cold. Up to two feet of very efficient insulation surrounds each tank to minimize heat gain during the voyage from the liquefaction plant to the receiving terminal.

LNG tankers are equipped with specialized systems for handling the very low-temperature gas and for combating potential hazards associated with liquid spills and fire. The ship's safety systems are divided into ship handling and cargo system handling. The ship-handling safety features include sophisticated radar and positioning systems that alert the crew to other traffic and hazards around the ship. Also, distress systems and beacons automatically send out signals if the ship is in difficulty. The cargo-system safety features include an extensive instrumentation package that safely shuts down the system if it starts to operate out of predetermined parameters. Ships are also equipped with gas- and fire-detection systems.⁴

Onshore Receiving and Regasification Terminals

A shore-based LNG terminal — consisting of a docking facility, LNG-storage tanks, LNG-vaporization equipment, and vapor-handling systems — occupies approximately 25 to 40 acres of land. The location of a proposed LNG terminal would dictate the number and types of linear facilities, such as roads, electric transmission lines, and gas and water lines that would also be needed.

The docking facility is designed to accommodate the sizes of the anticipated LNG tankers. It normally consists of a pier about 1,800-feet long and 30-feet wide with

moorings and off-loading facilities. Moorings connect the tanker securely to the jetty so that the LNG can be transferred from the ship's tanks to the onshore piping.

In most respects, an LNG docking facility would be similar in size to those that currently handle supertankers delivering crude oil to California. One difference is that an LNG tanker has a much higher profile (125 feet). Therefore, when considering the placement of docking facilities, facility designers must account for the effect of prevailing winds on the maneuverability of those ships.

Despite peak flow rates of approximately 12,000 cubic meters per hour, unloading times for a full-sized LNG tanker average 12 to 15 hours. While unloading their cargoes, LNG tankers could be subject to substantial tidal and wave forces, which might jeopardize the integrity of the ship-to-shore interface. Therefore, LNG ports and jetties must have built-in safety features to prevent releases of LNG during ship-to-shore transfers.

A ship-to-shore emergency shutdown (ESD) system and associated shut-off valves allow rapid and safe shutdown of an LNG transfer. The ESD system will stop the ship's unloading pumps and close flow valves both on the ship and shore usually within 20 to 30 seconds. Quick-release couplings automatically disconnect the unloading arms during emergencies.

Transfer piping used to unload the cryogenic liquid from the ship's tanks can withstand a 200 degree Celsius temperature drop once LNG pump-out begins. Normally, the cryogenic piping is made of stainless steel, and one kilometer of stainless steel pipe, when cooled by 200 degrees C, will contract by nearly three meters. Expansion loops and expansion bellows are built-in safety features that compensate for this pipeline contraction.

LNG is normally held on land in one or more specially designed storage tanks while it awaits regasification. The failure of one or more tanks could release an enormous volume of LNG (e.g., 100,000 cubic meters) with potentially disastrous consequences due to the size of the resulting vapor cloud. However, the design of modern storage facilities has improved from earlier designs. "The design practices and metallurgy that caused earlier accidents are totally unacceptable by today's standards."⁵

The following three types of LNG storage tanks are used today:

- Single-containment tanks are double-walled. An interior tank is made of nine percent nickel, while the outer tank is made of carbon steel.
- Double-containment tanks have primary and secondary tanks. The secondary tank, typically a concrete wall, is located usually six meters or less from the primary tank. In the event of a leak, the secondary tank contains the cryogenic liquid and limits the surface area and vaporization of an LNG liquid pool.
- Full-containment tanks have a nine percent nickel inner tank, plus a pre-stressed concrete outer tank. The outer tank, which includes a reinforced concrete roof

lined with carbon steel, can be designed to withstand realistic impacts from missiles or flying objects.⁶

The Mexican government's new LNG siting regulations mandate the use of full-containment storage tanks.

Safety Features of LNG Storage Facilities

Modern storage tanks have no side or bottom penetrations. All penetrations, including those for LNG sendout, are through the roof. This design substantially reduces the amount of LNG spilled in the unlikely event of a rupture or leakage in the sendout piping.

If LNG stratifies into layers of different densities within a storage tank, a phenomenon called "rollover" could occur. With "rollover," pressures within the tank could rise to excessive levels, and, without properly operating safety-vent valves, pressures could rise to levels that would cause structural damage. To detect the development of "rollover" conditions, modern LNG storage tanks contain instruments to monitor the pressure, temperature, and density of the LNG along the entire height of the liquid column. Furthermore, tank designers provide for LNG recirculation.

In-tank cameras enable plant operators to assess tank damage in the event of an earthquake and to visually inspect the tank contents in the event of unusual instrument readouts.

Fire detection and response systems are in place wherever combustible gas is stored or handled. Facility operators use low-temperature, gas, fire, and smoke detectors, supplemented by closed-circuit television cameras that can identify potentially hazardous situations such as LNG spills and leaks.

On land, LNG spills are contained using a walled and bermed system that drains all LNG into a basin constructed of reinforced concrete that is sized to contain a specific design-spill. In addition, LNG storage tank impoundments are designed to contain at least 110 percent of a tank's volume in the event of a sudden, uncontrolled tank failure.

Impoundments not only limit the spread of an LNG spill, they reduce the surface area of the liquid pool, thereby decreasing and controlling the size of the vapor cloud.

When detector readings activate an alarm in the LNG operations control room, some fire-suppression responses are automatic. For example, high-expansion foam generators produce and deliver foam automatically to a spill or leak area. Initially, the foam helps to disperse LNG vapors upwards and away from potential ignition sources. "Since potential sources of ignition are more likely found close to ground level, the upward dispersion substantially reduces the chances of ignition."⁷

In addition, if a "pool fire" develops at an LNG facility, foam provides some control over the rate of burning. Essentially, the foam blankets the liquid surface to limit heat

transfer from the air to the liquid, thereby reducing the rate of vaporization. Consequently, the rate of burn is limited since only the vapor will burn after it mixes with adequate oxygen. Foam will be applied repeatedly until all LNG has been burned in a controlled manner.

Water is ineffective in fighting LNG fires because it provides a heat source for vaporization. Instead, firefighters apply dry powder (e.g., sodium bicarbonate or potassium bicarbonate) to extinguish LNG fires in the open air. However, water sprinklers *are* used to cool building surfaces and protect fire-fighting and other equipment from thermal-radiation damage. Fireproofing of structures and equipment are additional mandatory safety features within LNG facilities.

Safety Features of LNG Facility Layout

LNG facilities are designed to assure adequate distances between the following parts of the terminal facility:

- Two or more LNG storage tanks
- The storage area and the jetty
- The vaporization process area and the other parts of the facility

In addition, LNG facilities must have exclusion zones — the area surrounding an LNG facility in which an operator legally controls all activities. These zones assure that public activities and structures outside the immediate LNG facility boundary are not at risk in the event of an on-site LNG fire or a release of a flammable vapor cloud.

Federal regulations identify two types of exclusion zones: thermal-radiation protection (from LNG fires) and flammable vapor-dispersion protection (from LNG clouds that have not ignited but could migrate to an ignition source).

Thermal-radiation exclusion distances are determined by using the National Fire Protection Association (NFPA) standard for the production, storage, and handling of LNG, or by using a computer model that accounts for facility-specific and site-specific factors, including wind speeds, ambient temperature, and relative humidity. For example, the thermal-exclusion zone around the Cove Point LNG facility in Maryland is 1,600 feet.⁸ The required distances assure that heat from an LNG fire inside the dikes, for example, would not be severe enough at the property line to cause death or third-degree burns.

Safe distances from dispersing LNG vapor clouds are determined by the same NFPA standards or by a computer model that considers average gas concentration in air, weather conditions, and terrain roughness. The exclusion zones for the LNG facility in Cove Point cover 1,017 acres, and the exclusion zones for the Elba Island, Georgia facility cover 840 acres.⁹ The permitting authority, in cooperation with the DOT-Office of Pipeline Safety and the Coast Guard, would determine the exclusion zones for LNG tankers and port facilities.

HISTORY

LNG Receiving Terminals in the U.S.

In the late 1960s, the U.S. faced declining natural gas production as a result of federal price controls on interstate gas transactions. Because of these controls, producers withheld natural gas from interstate markets to avoid federal regulation. Since price controls did not apply to intrastate transactions, however, producers could sell gas in the state within which it was produced at prices above federal controls. These circumstances led to a perception that domestic natural gas reserves were declining, which, in turn, led some firms to explore LNG imports as an alternative source of natural gas.

In 1969, Distrigas Corporation started constructing the first U.S. LNG receiving terminal in Boston Harbor. In 1971, Distrigas's Everett, Massachusetts facility received its first delivery of LNG from Algeria. Two additional marine import and regasification facilities went into service during the 1970s, one at Elba Island, Georgia, owned by Columbia LNG Corporation and Consolidated Systems LNG Company, and one at Cove Point, Maryland, owned by Southern Natural Gas Company. These three companies purchased LNG from El Paso Algeria Corporation, operating under the title El Paso I LNG Project. In 1975, Trunkline LNG Company signed a long-term supply contract with Algeria's national oil and gas company for delivery of LNG to its planned Lake Charles, Louisiana facility.

In 1978, Congress passed the Natural Gas Policy Act lifting price controls on all domestic natural gas discovered after 1977. With price controls lifted, natural gas exploration and drilling expanded, and producers began to make domestic natural gas available to the interstate market. This change in federal policy diminished the cost advantage of imported LNG. As a consequence, U.S. imports of LNG declined after reaching an all-time peak of 253 billion cubic feet (Bcf) in 1979.

Around the same time, the El Paso I Project companies began to dispute the prices their Algerian LNG supplier, Sonatrach, was charging them pursuant to the terms of long-term contracts originally signed in 1969. These disputes were never resolved, and, in 1980, Algeria ceased deliveries to Elba Island, Georgia, and Cove Point, Maryland, leading to the closure of both facilities.

Trunkline suspended its LNG imports and shut down its Lake Charles facility in 1983 because, it claimed, the high price of the LNG made it unmarketable. Trunkline eventually resumed LNG imports during the late 1980s, in part, because of Algeria's willingness to enter into more flexible long-term contracts. In 1984, Distrigas became the sole importer of LNG in the U.S.¹⁰

LNG imports to the U.S. have rebounded significantly over the past seven years, increasing each year from the decade-low volume of 18 Bcf in 1995, to the second highest volume of LNG ever imported into the U.S. of 238 Bcf in 2001.¹¹ The increase is attributable to both increasing natural gas demand in the U.S., about 14 percent from

1990 to 2001, and declining prices for imported LNG as a result of substantially lower capital and operating costs over all segments of the LNG supply chain.¹² In 2000, the annual average price of imported LNG was actually lower than the price of pipeline gas.^{13, 14}

Lower prices led the owners of the remaining two LNG import facilities in the U.S. to resume operations. The Elba Island LNG facility, currently owned by El Paso, Inc., reopened in 2001 and, in October of that year, received its first LNG shipment in more than 20 years.¹⁵

In early October 2001, the Federal Energy Regulatory Commission (FERC) authorized Williams Companies, Inc.¹⁶, then owner of the Cove Point facility, to reactivate its LNG receiving terminal and expand storage capacity. Following the terrorist attack of September 2001, however, FERC reconsidered its order, because the facility is within four miles of a nuclear power plant.¹⁷ Based on confidential evidence submitted by the FBI, Coast Guard, Nuclear Regulatory Commission, and Department of Transportation - Office of Pipeline Safety, FERC reaffirmed its finding that the proximity of the nuclear power plant to the Cove Point LNG facility does not raise a specific national-security concern.¹⁸ Restart of the facility is now scheduled for the end of 2003.¹⁹

In 2002, FERC also granted final approval for expanding the Trunkline LNG terminal in Louisiana.²⁰

Global demand for LNG has been on the rise, growing ten percent annually during 1999 and 2000. LNG demand continued to increase during 2001, albeit at a slower rate (4.5 percent) because of a weak global economy.²¹ The Energy Information Administration estimates that global natural gas demand will nearly double over the next two decades.²² A study released in July 2002 by the energy research firm DRI-WEFA concluded that the global proliferation of LNG liquefaction and regasification terminals will make natural gas a global commodity by 2025, much like oil is today.

Safety Record

The most notable safety incident occurred in Cleveland, Ohio in 1944 at a peak-shaving plant. The East Ohio Gas Company had built the plant in 1941 and its owners decided to add a new tank in 1944. Because certain stainless steel alloys were scarce during World War II, East Ohio built the new tank with a steel alloy that had low-nickel content (3.5 percent). Shortly after going into service, the tank failed, spilling its contents into the street and storm-sewer system. A disastrous explosion and fire within the confined space of the storm-sewer system killed 128 people.

The last death involving LNG in the U.S. occurred at the Cove Point, Maryland terminal in 1979. From the spring of 1978, when it began to operate, until the accident, more than 80 LNG ships had unloaded at Cove Point. The accident began when LNG leaked through an inadequately tightened electrical-penetration seal on an LNG pump. The LNG vaporized, passed through 200 feet of underground electrical conduit, and entered a substation building. The normal arcing contacts of a circuit breaker ignited the gas-air

mixture causing an explosion within the confined space of the substation building. The explosion killed one operator in the building, seriously injured a second, and caused \$3 million in damages.

From 1952 to the present, LNG ships have made more than 33,000 voyages worldwide and transported over three billion cubic meters of LNG. Of these voyages, more than 2,400 have been to or from U.S. ports. **Types of tanker accidents include engine room fires, collisions, groundings, loss of containment, and temperature embrittlement from cargo spillage. There have been no cargo explosions, fires, or shipboard deaths.**²³

LNG Terminal Development in California: The Point Conception Project²⁴

By 1972, several public utilities in California had announced plans to import LNG. Western LNG Terminal Company (Western), a subsidiary of Pacific Lighting Corporation (the parent company of Southern California Gas Company) and Pacific Gas and Electric Company planned to build three LNG import facilities: one at the Port of Los Angeles, one in Oxnard, and one at Point Conception. Western was proposing the Point Conception project on behalf of the El Paso Natural Gas Company, whose policy was to avoid siting an LNG facility within ten miles of a populated area.

Western commissioned risk assessments for the Los Angeles and Oxnard sites. Both studies found extremely low safety risk, based on the probabilities of marine and onshore LNG accidents and bad weather conditions. The Oxnard City Council, however, did its own study, which considered safety risks under worst-case scenarios. Oxnard's citizens opposed the project after the City's study showed up to 70,000 casualties from an LNG accident there. None of the risk assessments considered acts of sabotage.

Western needed local, state, and federal approvals. At that time, the California Coastal Commission had siting authority at the state level, and appeared unlikely to approve either the Oxnard or the Los Angeles site due to public-safety concerns. The remote Point Conception site also faced permitting problems because of potential environmental impacts on marine life, surfing breaks, and spectacular views, which were the very resources the Commission had been created to protect.

At the federal level, the Federal Power Commission (FPC), the forerunner of FERC, had oversight. While the FPC favored the Oxnard site over the others, the National Energy Plan called for LNG terminals to be sited remotely. The FPC appeared likely to deny the Port of Los Angeles site because of its proximity to an earthquake fault, even though the Los Angeles City Council supported the project for economic-development reasons.

Because these different governmental agencies favored different sites, project proponents turned to the California Legislature for help in averting a siting stalemate. They sought to remove siting authority from local authorities and from the California Coastal Commission, and to place it with the CPUC.

Western, together with business and labor-union interests, supported legislation that became the LNG Terminal Siting Act of 1977. In a concession to environmental interests, the new law mandated that the California Coastal Commission identify and rank possible sites — including whichever site Western proposed — and to pass on those rankings to the CPUC. The California Coastal Commission evaluated 82 sites, 18 of which were nominated by the public. Of the 82 sites, only four, including the Western-proposed Point Conception site, met the strict population-density standards and other criteria then established by the California Coastal Commission, including wind and wave conditions, earthquake hazards, and soil conditions.

During the screening process, adjacent landowners — the Bixby and Hollister Ranch Associations — presented evidence of earthquake faults at Point Conception. Nevertheless, the CPUC conditionally approved the site, subject to Western's ability to demonstrate that the faults were an acceptable risk.

FERC (formerly the FPC) also approved the Point Conception site. However, project opponents appealed FERC's approval to the United States Court of Appeals for the District of Columbia, and the Court remanded the case back to FERC for reconsideration of the seismic-risk data. FERC and the CPUC held concurrent hearings on seismic risk, and the CPUC ruled that the risk was sufficiently low to permit construction. By the time FERC reaffirmed its approval, however, increasing domestic natural gas supplies had rendered the project uneconomic.

CURRENT PROJECTS

Project developers have renewed their interest in LNG terminals in North America. The following reasons explain the growing interest in LNG-receiving capacity in the U.S.:

- LNG prices now appear to be competitive with conventional supplies of natural gas.
- Analysts expect global LNG production to increase by 50 to 100 percent in the next 10 years.²⁵

On May 30, 2002, Dynegy, Inc. announced that one of its subsidiaries had filed an application with FERC for a permit to construct and operate an LNG terminal in Hackberry, Louisiana, with a production capacity of 1.5 Bcf per day (in comparison, all of California's natural gas wells produce about 1.0 Bcf per day). Dynegy sold its interest in the project to Sempra Energy LNG Corporation in April, 2003. If the project receives all required approvals, it could begin commercial operation in late 2006, making the Hackberry facility the first new LNG import terminal to commence operation in the U.S. since 1982. This project is one of many onshore and offshore LNG proposals along the eastern seaboard.

Some developers have also expressed interest in building LNG import terminals in California and Baja California, Mexico. Below is a table summarizing the current proposals for LNG terminals on the West Coast.

Project (Updated July 2002)	Location	Capacity (MMcfd)	Projected On-Line Date
Baja California, Mexico El Paso & Phillips Co. Marathon Oil Co. Shell Group Sempra/CMS	Rosarito Tijuana Ensenada Ensenada	600 750 1,300 800	(on hold) 2005 2006 2006
Sound Energy Solutions Crystal Energy, Small Ventures, et. al.	Long Beach Harbor Offshore near Oxnard	750 550	~2007 2006

These proposed facilities are comparable in size to existing LNG facilities in the U.S., as indicated in the table below. Owners of the Everett and Lake Charles facilities plan to expand output capacities to 1 Bcf per day.

Facility Owner	Location	Capacity (MMcfd)
Distrigas of Massachusetts	Everett, Massachusetts	435 (expanding to 1,000)
Southern Energy Company	Elba Island, Georgia	430 (expanding to 806)
CMS Energy/ Trunkline	Lake Charles, Louisiana	600 (expanding to 1,200)
Dominion Resources	Cove Point, Maryland	750 (expanding to 1,000)

Bechtel/Shell LNG Facility—A Case Study

Beginning in Spring 2001, Bechtel Enterprises and Shell Gas and Power initiated discussions with the City of Vallejo staff about building an LNG import terminal, storage facility, and power plant on 100 acres of land on Mare Island. The land, owned by the U.S. Navy, had been used for a shipyard, which closed in 1994.

In May 2002, the city council authorized its city manager to enter into an exclusive right to negotiate for a project feasibility study. On August 20, however, the council delayed the feasibility study until an independent health and safety study was conducted.

The city's new LNG Health and Safety Committee evaluated the likelihood of events which could damage the LNG facility sufficiently to release a large amount of LNG, causing a fire of sufficient radiant heat to harm residential areas, or to form a flammable vapor cloud extending into residential areas before igniting. Possible initiating events considered were earthquake, maritime accident, operational error, and acts of terrorism.

According to the *San Francisco Chronicle*, "...the study raised serious concerns about building the terminal in the middle of a densely populated area." The executive summary of the LNG safety study, however, contained the following conclusions:

- An earthquake is likely to occur, but the chance that a spill would create a flammable plume capable of reaching developed parts of Vallejo is unlikely.
- A maritime accident is unlikely, but an accident at the [tanker] turning basin could result in radiant heat from a pool fire affecting developed parts of Vallejo.
- An operational accident resulting in a plume or radiant heat reaching developed areas of Vallejo is very unlikely.
- A terrorist action is unlikely to result in a large plume or dangerous levels of radiant heat reaching developed areas of Vallejo, unless it involves a carrier in the turning basin.

The City also commissioned a preliminary economic assessment of the proposed project. The study estimated that the facility would have:

- Created 79 permanent, on-site jobs
- Generated an estimated \$1.4 million in property tax annually, along with another \$3,600 in yearly sales tax revenue.

Local citizens organized to oppose the project and communicated their concerns to elected city officials. Furthermore, local opposition groups gathered more than 11,000 signatures on petitions against the LNG proposal. Opponents feared that the project could pose a risk of explosion, fire, or environmental contamination. They preferred an alternative land-use plan for the site, which included light industrial and recreational development.

The Vallejo City Council never voted to conduct a feasibility study. On January 16, 2003, Shell Gas and Power announced it was leaving its partnership with Bechtel and on January 30, Bechtel decided to suspend further work on the project.²⁶

SITING PROCESSES

Project developers must obtain federal, state, and local government permits to build an LNG receiving and regasification terminal in California. Developers of the Cove Point, Maryland LNG terminal had to secure more than 140 permits or approvals from federal, state, and local agencies.²⁷ The Puerto Rican LNG terminal, built by EcoElectrica L.P. in the late 1990s, required more than 60.²⁸ The Energy Commission staff believes, based on recent power plant licensing experience, that approximately 100 permits could be required for an LNG import facility in California.

During the permitting process, one federal agency becomes the lead agency for environmental review under the National Environmental Policy Act (NEPA), and one state or local government agency serves as lead agency under California Environmental Quality Act (CEQA). During this joint environmental review process, the LNG facility's potential public safety and environmental impacts are identified and all significant impacts must be mitigated before the project can be permitted.

Site Selection

The first step in the siting process is site selection. Currently, the company or consortium proposing to build a new LNG receiving terminal selects the site and initiates the site approval process. LNG facility developers consider such factors as accessibility for large tankers, proximity of the existing gas pipeline network, costs of land acquisition, availability of skilled labor, and availability of public infrastructure, such as roads, electricity, and sewers. Other considerations include land-use characteristics, public sentiment regarding the facility, and environmental sensitivities.

Public opposition to on-shore LNG facilities has led some project developers to consider off-shore LNG receiving terminals. Locating LNG receiving facilities offshore would avoid or reduce certain land-based facility impacts, possibly making offshore facilities easier to permit. Oil tankers have been making deliveries at some near-shore mooring stations in California for many years. However, making deliveries miles offshore, totally unprotected from wind and storm conditions, would pose a different set of problems. The Coast Guard and U.S. Army Corps of Engineers must determine whether moored ships and their moorings present navigation hazards.

Safety Risk Assessment

LNG project developers perform detailed risk assessments to design the facility and to develop a risk management plan. Their work involves extensive modeling of potentially hazardous situations, such as ship movements, vapor cloud dispersions, pool fires, and deliberate attacks.

A risk assessment typically follows a four-step process including hazards assessment, hazard-probability assessment, worst-case assessment, and worst-case probability assessment

Hazards assessments for LNG facilities identify both shipping-related and land-based risks. In the second step, the probability assessment attempts to determine the likelihood of an event happening at a facility based on the history of mechanical failures, accident rates, and other factors. For the most part, these events are assumed to occur at random and most are not site specific. In the third step, worst-case events are evaluated to determine the potential for severe consequences such as loss of life, injury, and property. Severe consequences have included confined-space explosions, deflagration²⁹, and pool fires. The magnitude of potential loss is very site specific.

Finally, worst-case events are evaluated in terms of their probability of occurrence. In practice, significant potential risks are justified as acceptable, because the likelihood of

these risks occurring is so small (e.g., one in one million) as to be considered almost implausible.

Shipping-related events which could result in LNG spills include collisions, groundings, navigational errors, and mechanical failures. Spills are most likely to occur, however, during the connection and disconnection process between the ship and the on-shore unloading arms, leakage from swivel joints, emergency disconnection of unloading arms, or a rupture in the cargo ship's containment system. Land-based events which could result in an LNG spill include equipment failure and site-specific events such as earthquakes. Terrorist attacks against LNG ships or storage tanks could release a large amount of LNG at once.

The potential for earthquakes and related geologic hazards to occur will significantly influence the location and design of LNG facilities, especially in California. Typical earthquake and geologic hazards include potential for fault-related, ground-surface rupture; intense ground shaking; adverse foundational conditions, such as soil liquefaction and settlement; slope instability; and tsunamis. Although an LNG facility cannot be sited in a major fault zone because of potential damage from surface rupture, designing storage tanks and other facilities appropriately can mitigate against other geologic hazards.

The U.S. Department of Transportation (DOT) uses stringent design criteria for LNG facilities to ensure adequate safety from earthquakes and adverse geologic conditions.³⁰ DOT regulations require that LNG facilities be designed and built to withstand earthquake ground motion with a 1-in-10,000-year exceedance without loss of structural or functional integrity. The regulations also specify the methods and studies that the developer must use to determine the earthquake forces that will govern the design of the facility. They are comprehensive and conservative.

In addition to the forces of nature, man-made forces can create hazardous situations that could lead to an LNG spill, fire or confined-space explosion. After the September 11, 2001 terrorist attacks, the Coast Guard imposed a month-long ban on LNG tankers in Boston Harbor and issued a temporary rule expanding the size of buffer zones around stationary and moving tankers carrying LNG.³¹ The Coast Guard now also deploys sea marshals to oversee so-called high-interest vessels such as LNG tankers. Furthermore, the Coast Guard now requires arriving LNG ships to provide a 96-hour advance notice of their arrival so that the Coast Guard can conduct a terrorism risk assessment and put in place appropriate mitigation before the ship reaches the shipping channel.

Risk assessments of LNG facilities conducted prior to the September 11, 2001 terrorist attack focused on accidental-release scenarios. In these scenarios, the events that lead to a predicted outcome are assumed to be random. The Hackberry, Louisiana LNG facility's draft environmental impact statement, however, includes terrorism as a potential risk. In the EIS, FERC concluded, "[T]he likelihood of future acts of terrorism or sabotage occurring at the proposed Hackberry Terminal, or at any of the myriad

natural gas pipeline or energy facilities throughout the United States, is unpredictable given the disparate motives and abilities of terrorist groups...Moreover, the unpredictable possibility of such acts does not support a finding that this particular LNG terminal should not be constructed."³²

The Energy Commission staff will conduct further research on LNG safety issues and risk assessment studies. It also intends to evaluate appropriate risk-assessment methodologies (e.g. probabilistic versus deterministic approaches) for analyzing terrorist risks for LNG facilities.

Environmental Impact Assessment

As a rule, an LNG facility has environmental impacts related to air emissions, cold-water discharge, land use, and various other aspects of its operations. These potential impacts, however, have not been a major obstacle to developing LNG facilities.

LNG facilities do not flare natural gas except during emergencies. Instead, every effort is made to capture boil-off gas and use it productively either onboard the LNG tanker or within a receiving facility's operations. The primary source of air emissions associated with LNG facilities comes from diesel-fired generators. As emergency equipment, these generators (usually no more than about 2 megawatts) would only operate if electricity from the grid were interrupted. Because emergency generators would operate infrequently, air emissions would be minimal, and thus air emissions and possible public health impacts would also be minimal.

Coast Guard regulations, however, require that LNG ships generate their own electric power when in port. For this reason, docked LNG ships will emit air pollution from their diesel generators. In addition to these diesel emission sources, the tug boats which must escort LNG tankers into port are typically equipped with diesel-fired engines. The air quality analysis conducted for the proposed Bechtel/Shell LNG facility found that tug boats were the largest source of air pollution associated with the proposed facility.³³

Although LNG facilities do not consume significant amounts of water or produce significant amounts of waste, cold-water discharges associated with the heat-exchanger regasification systems could adversely affect aquatic environments if the discharge plume were significantly colder than the ocean water into which the discharge was flowing.³⁴ Again, these facilities can be designed to meet different operating requirements, depending upon the site specific needs.

Dredging and filling activities to accommodate the large tankers in coastal waters could cause significant marine water-quality and biological impacts. The exact effects on wildlife, however, are site specific. Nevertheless, a preferable site would be one that avoids any significant disturbance of habitat, particularly habitat important in sustaining wetlands, listed species, and other areas designated for protection.

LNG tankers do not discharge ship-ballast water after arriving at a receiving terminal. For this reason, there is no concern that LNG shipping might introduce non-native

marine organisms into local waters. However, LNG tankers returning to their home bases do take on ballast water as they unload LNG, and they might, therefore, introduce non-native marine organisms into waters at their home ports.

Noise, visual impacts, and traffic impacts could also occur. During normal operations, an LNG facility poses no unique noise concerns. Visual impacts would be an issue in sensitive view sheds.³⁵ Traffic impacts often require site-specific mitigation.

The following is a brief summary of the key federal and state agencies that would be involved in reviewing and approving proposed LNG import facilities.

Federal Permitting Processes³⁶

Federal agencies that would potentially be involved include: the Departments of Energy, Transportation, Defense, and Interior; FERC; the Maritime Administration; the Army Corps of Engineers; the Coast Guard; the Occupational Safety and Health Administration; and the Environmental Protection Agency.

Before the 1990s, the U.S. Department of Energy (DOE) approved LNG-import agreements after considering the competitiveness of the import, the need for the natural gas, and the security of the supply. Congress simplified the review of LNG-import agreements in the Energy Policy Act of 1992, and by 1995, the Department of Energy had quit reviewing LNG-import agreements entirely. While DOE must still approve LNG imports, it generally provides blanket certifications that permit receiving LNG supplied by any source.

As part of the Maritime Transportation Security Act of 2002, Congress has recently given the Secretary of the Department of Transportation regulatory authority over LNG facilities constructed offshore in federal waters.³⁷ Primary responsibility for regulating offshore LNG facilities is now shared by the Coast Guard and the Maritime Administration.

FERC would most likely have federal authority over permitting of onshore LNG terminals although the law is ambiguous. In 2001, Dynegy asked FERC to issue a declaratory order which would disclaim jurisdiction to grant approval for the new LNG terminal facility it proposed to build in Hackberry, Louisiana. Dynegy argued that, as a result of changes made to the Natural Gas Act in the Energy Policy Act of 1992, FERC no longer has jurisdiction to issue any approvals for LNG terminal facilities. FERC declined the request to disclaim jurisdiction, finding that doing so would create a "regulatory gap."³⁸ But, in further proceedings regarding this proposed new terminal facility, FERC has modified its position regarding what approvals are required. FERC has indicated that it will continue to grant approvals for importation under Section 3 of the Natural Gas Act unless importation is not consistent with the public interest, but will not require approvals under Section 7 of the Natural Gas Act.³⁹ Section 7 requires project proponents to obtain certificates of public convenience and necessity before constructing new *interstate* natural gas facilities, but does not expressly grant FERC authority over LNG terminal facilities. FERC has indicated that it will not require

approval under Section 7 for terminal facilities in order to put LNG on the same competitive position as other sources of natural gas.

It is not yet clear what the impact of FERC's new position regarding required approvals will be. On one hand, it has been argued that the new position will encourage development of LNG supplies since facilities approved under Section 7 must meet open season and open access requirements that do not give developers assured access to terminal facilities. But, on the other hand, without a Section 7 certificate of public convenience and necessity, applicants would not be entitled to assert eminent domain to build the facilities.⁴⁰

Even before Dynegy's petition resulted in FERC's new position regarding the need for Section 7 approvals, there was reason to doubt that Section 7 approval would be required for LNG terminal facilities in California. Section 7 requires approval for *interstate* pipelines. But in California, most major natural gas pipelines are *intrastate* facilities, and Section 1(c)⁴¹ exempts intrastate pipelines from the Natural Gas Act. If FERC has a role in permitting LNG facilities connected to intrastate pipelines, this role arises only from an internal Department of Energy delegation order, which requires FERC to oversee the siting and construction of facilities used to import LNG.

Regardless of whether FERC issues an approval to import LNG under Section 7 of the Natural Gas Act, the approval required from FERC under Section 3 would likely make FERC the lead agency for review under the National Environmental Policy Act. FERC would work jointly with other federal agencies to produce an Environmental Impact Statement.

Two organizations have responsibility for setting safety standards for onshore LNG facilities: the U.S. Department of Transportation's Office of Pipeline Safety and the Coast Guard, which has recently been placed within the Department of Homeland Security. Under the Natural Gas Pipeline Safety Act, the Office of Pipeline Safety has authority to set and enforce safety standards for all but the marine transfer areas at LNG facilities. Under the Ports and Waterways Safety Act of 1972, the Coast Guard has authority to set safety standards for the marine transfer facilities at LNG terminals.

The Office of Pipeline Safety has issued minimum safety standards,⁴² and federal law specifically permits state governments to assume responsibility for assuring compliance with these federal minimum standards for those intrastate facilities not regulated by FERC under the Natural Gas Act. A state can assume this responsibility either by certifying that it has met the eligibility requirements set forth in the statute or by executing an agreement with the Office of Pipeline Safety expressly authorizing it to take necessary action. In California, the CPUC has issued a General Order indicating that it will enforce Office of Pipeline Safety rules for LNG facilities.

The federal Coastal Zone Management Act (CZMA) requires that LNG project developers who seek federal approvals, such as FERC approvals under Sections 3 and 7 of the Natural Gas Act also seek certification from the state agency responsible for

ensuring land-use compliance with the CZMA. In California, either the California Coastal Commission or the San Francisco Bay Conservation and Development Commission are responsible for granting this certification, depending on the location of the proposed facility. The CZMA specifically requires Coastal Zone Management Plans to incorporate planning provisions relating to energy facilities and the term “energy facilities” expressly includes both LNG facilities and pipelines.

The U.S. Environmental Protection Agency might also need to issue a Prevention of Significant Deterioration (PSD) permit for air emissions emanating from some projects.

State Permitting Processes⁴³

The actual state agencies involved in a specific project also depend upon the project’s location and the point of interconnection to the natural gas pipeline network.

Since the California Legislature repealed the LNG Terminal Act of 1977 (Act), the state no longer has a clear siting process for LNG-import facilities. However, a review of this Act is helpful to understand how California might approach the future siting of an LNG facility.

The Act sought to assure adequate and reliable natural gas supplies in light of natural gas shortages predicted to occur in the early 1980s. The statute only allowed the LNG facility to receive imports from southern Alaska and Indonesia. In addition, the statute:

- Authorized the CPUC to site a single, on-shore, multi-company LNG terminal facility and directed it to regulate the safety and construction of the terminal.
- Established population-density criteria (persons per square mile⁴⁴) for use in siting the LNG facility.
- Required the Energy Commission to assess California’s natural gas supply and demand and to forecast when significant curtailments would occur.
- Required the California Coastal Commission to study and rank alternative sites from which the CPUC was to select the highest-ranking site for the terminal, but could choose a lower-ranking one if that alternative facility could be built faster to prevent curtailments.
- Bestowed the power of eminent domain upon the LNG facility licensee.
- Declared that applying for or receiving a permit to construct an LNG facility would not make the applicant a public utility subject to CPUC rate regulation.

Since no LNG terminal facilities have been constructed in California, many of the legal issues posed by construction of LNG terminal facilities are not yet settled. The following are some tentative conclusions, however, about siting jurisdiction:

- For the land-based LNG terminal facilities built to serve the intrastate market, it is clear that DOE and FERC would have to authorize importation of the LNG, while it is not clear whether FERC would have authority over the siting, construction, and operation of the LNG terminal facilities since facilities built to serve the intrastate

market are exempt from the Natural Gas Act. The CPUC would be the most likely state agency to issue a certificate of public convenience and necessity to site, build and operate an LNG terminal facility if the LNG would supply gas only within California.

- For the new pipelines used to transport gas from land-based terminal facilities to the intrastate gas pipeline system, the CPUC would be the most likely agency to have jurisdiction to grant a certificate of public convenience and necessity.
- If land-based LNG terminal facilities and associated pipelines were built in California to serve the markets outside of California, FERC may have exclusive authority to decide whether a certificate of public convenience and necessity would be required and, if so, whether to issue such a certificate.
- While the Energy Commission would be able to assume siting jurisdiction over any thermal power plant more than 50 megawatts in size that is proposed in conjunction with the LNG facilities, the Energy Commission's jurisdiction does not appear to extend to the LNG terminal facilities or new pipelines used to transport gas directly to customers or to the intrastate pipeline system.
- Agencies that issue approvals for the project will have to comply with CEQA. The CEQA review should be for the whole of the project and could be done in conjunction with the NEPA review. Lead agency designation would depend on the nature of the project proposed.
- The California Coastal Commission would have to review plans for any LNG terminal facilities and associated pipelines to assure they are consistent with the state's CZMP. Under this state plan, an LNG terminal facility and associated pipeline could not be constructed in the coastal zone unless alternative locations are infeasible or more environmentally damaging.
- Construction of an offshore LNG terminal facility in state waters, i.e., within three miles of the coast, would require approvals from the State Lands Commission, which has jurisdiction over the lands underneath such waters. Applicants would have to obtain approvals for leases to use such lands and for permits to construct offshore gas pipelines.
- Construction of an offshore LNG terminal facility in federal waters, i.e., from three to 12 miles offshore, would require approval of the Coast Guard and other federal agencies as well as approval by the Governor.
- For both land-based and offshore-based terminal facilities, since the state does not have a one-stop siting process for LNG projects, many environmental permits and approvals would have to be obtained from state and local agencies.

Possible environmental and land-use permits may include the following:

- Project developers would need to secure an Authority to Construct permit from the local air pollution control district for air emissions emanating from the project and use permits for the LNG facility from the city or county government with land-use

authority for the site. A wastewater discharge permit would also be required from the regional water quality control board.

- If the project would affect endangered or threatened species, it would also require permits from the California Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service. It would also need dredge and fill permits from the Army Corps of Engineers to construct the terminal facilities.
- If the project is proposed within a port, it must obtain a harbor development permit from the local port authority. The port authority must conduct a CEQA review prior to issuing its permit. Decisions by the port authority to issue harbor development permits may be appealed to the California Coastal Commission.

The actual federal, state, and local agencies involved in a specific project depend upon the project's location (land-based on military reservation, other land-based, offshore but within three miles of the shore, and offshore between three and 12 miles of the shore), and interconnection to the natural gas pipeline network (interstate or intrastate).

End Notes

- ¹ LNG is not the only hazardous cargo transported in the U.S. today. Other cargoes posing hazards when transported in large volumes include liquefied petroleum gas and gasoline.
- ² Vapor clouds are not flammable at the edge of the cloud, where the greatest mixing with ambient air occurs, because the concentration of gas is too low at the outer border. Conversely, the interior of the LNG vapor cloud will not ignite due to the lack of oxygen.
- ³ Delayed ignition will in general have greater consequences than immediate ignition because the vapor cloud increases in size as it travels downwind, according to *Risk Analysis and Decision Processes*, by Howard C. Kunreuther and Joanne Linnerooth et. al., page 162.
- ⁴ "LNG Frequently Asked Questions," Dominion Cove Point LNG, LP, <http://www.dom.com/about/gas-transmission/covepoint/faq.jsp>.
- ⁵ "Safety and Security Zones; LNG Carrier Transits and Anchorage Operations, Boston, Maine Inspection Zone and Captain of the Port Zone," Department of Transportation, Coast Guard, 33 CFR Part 165. Rule effective from November 13, 2001 to June 15, 2002.
- ⁶ *LNG Receiving and Regasification Terminals: An Overview of Design, Operation and Project Development Considerations*, Ram R. Tarakad, Zeus Development Corporation, 2000, Page 7-5.
- ⁷ "Safety and Security Zones; LNG Carrier Transits and Anchorage Operations, Boston, Maine Inspection Zone and Captain of the Port Zone," Department of Transportation, Coast Guard, 33 CFR Part 165. Rule effective from November 13, 2001 to June 15, 2002.
- ⁸ "Foreign tankers seen as security concern," by Paul Owens, Associated Press, November 12, 2001 <<http://www.washingtontimes.com/metro/20011112-11794072.html>>.
- ⁹ "Environmental & Safety Alert" regarding the proposed LNG facility by El Paso on Radio Island, North Carolina from <www.c-cape.org/alert.html>.
- ¹⁰ U.S. Department of Energy, Office of Fossil Energy, *Quarterly Focus – LNG Trade: Past Present, Future (?)*, December 1995.
- ¹¹ U.S. Department of Energy, Office of Fossil Energy, *1995: Year in Review*, March 1996 <http://www.fossil.energy.gov/oil_gas/im_ex/analyses/focus/4th95foc.pdf> and *2001: Year in Review*, March 2002 <http://www.fossil.energy.gov/oil_gas/im_ex/analyses/focus/4th01foc.pdf>
- ¹² U.S. Department of Energy, Energy Information Administration, *United States Country Analysis Brief*, May 2002 <<http://www.eia.doe.gov/emeu/cabs/usa.html>>
- ¹³ U.S. Department of Energy, Energy Information Administration, *Natural Gas Monthly*, "U.S. Natural Gas Imports and Exports – 2000", August 2001 <http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_monthly/historical/2001/2001_08/pdf/fa082001.pdf>
- ¹⁴ Energy Information Administration, *Natural Gas Annual 2000*, "Table 6. Wellhead Value and Marketed Production of Natural Gas, by State, 1996-2000," November 2001 <http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/natural_gas_annual/nga.html>
- ¹⁵ U.S. Department of Energy, Office of Fossil Energy, *2001: Year in Review*, March 2002 <http://www.fossil.energy.gov/oil_gas/im_ex/analyses/focus/4th01foc.pdf>
- ¹⁶ Williams sold this facility to Dominion Resources on September 15, 2002. Energy Commission natural gas expert, Bill Wood, believes Williams sold the facility to improve its financial standing, and not because the facility is losing money or is a bad investment.
- ¹⁷ "FERC gives Cove Point LNG terminal green light to reopen", *Oil & Gas Journal*, December 20, 2001
- ¹⁸ "FERC Affirms Decision to Reactivate Cove Point LNG Facility," FERC News Release, December 19, 2001.

-
- ¹⁹ Personal conversation with Dan Donovan, Manager of Media Relations, Dominion Gas Companies, on May 19, 2003.
- ²⁰ CMS Trunkline LNG Company, LLC, 100 FERC ¶ 61,217 (Aug. 27, 2002), reh'g denied, 101 FERC ¶ 61,300 (Dec. 18, 2002).
- ²¹ "Market access remains key for LNG producers" by Andy Flower, *Oil & Gas Journal*, April 22, 2002.
- ²² U.S. Department of Energy, Energy Information Administration, *International Energy Outlook 2002*, "Natural Gas", March 26, 2002 <http://www.eia.doe.gov/oiaf/ieo/nat_gas.html>
- ²³ *Safety History of International LNG Operations*, Revision 2, CH IV International, 11/2002 <http://www.ch-iv.com/>.
- ²⁴ This summary was excerpted and condensed from *Risk Analysis and Decision Processes: The Siting of Liquefied Energy Gas Facilities in Four Countries* by Howard C. Kunreuther and Joanne Linnerooth et al., 1983.
- ²⁵ "Industry Profile: Liquefied Natural Gas," Chenier, <http://www.cheniere.com/LNGIndustryProfile.htm>.
- ²⁶ "Bechtel pulls out of gas plant project: Yields to Mounting Opposition in Vallejo," article by George Rain, San Francisco Chronicle, January 31, 2003, Pages 23 and 27.
- ²⁷ "Implications of the U.S. – Algerian Liquefied Natural Gas Price Dispute and LNG Imports," Report by the Comptroller General of the United States, Report No. EMD-81-34, December 16, 1980, Appendix II, page 15.
- ²⁸ "EcoElectrica LNG import Terminal and Cogeneration Project – Final Environmental Impact Statement," FERC and Puerto Rico Planning Board, FERC? EIS-0099F and PRPB/EIS94-62-1219JPU, April 1996.
- ²⁹ "Deflagration" means rapid burning with intense heat and dazzling light.
- ³⁰ Both the National Fire Protection Association and the U.S. Department of Transportation have regulations, which provide criteria and methods for the siting and design of LNG facilities in areas with potential earthquake and geologic hazards. CPUC General Order 112-E, Subpart D, LNG, requires that LNG facilities comply with both NFPA Standard No. 59A and 49 CFR part 193.
- ³¹ "Safety and Security Zones; LNG Carrier Transits and Anchorage Operations, Boston, Maine Inspection Zone and Captain of the Port Zone," Department of Transportation, Coast Guard, 33 CFR Part 165. Rule effective from November 13, 2001 to June 15, 2002.
- ³² *Draft Environmental Impact Statement: Hackberry LNG Project*, Federal Energy Regulatory Commission, Office of Energy Project, March, 2003, pages 4-80 – 4-81.
- ³³ Personal conversation with the City of Vallejo Fire Chief.
- ³⁴ Typically, seawater exits the vaporizers about 4 to 5 degrees C colder than it enters, according to *LNG Receiving and Regasification Terminals: An Overview of Design, Operation and Project Development Considerations*, Ram R. Tarakad, Zeus Development Corporation, 2000, Page 10-2.
- ³⁵ It is worth noting that the Japanese have built LNG tanks underground, in part, to address visual impacts.
- ³⁶ This summary of federal siting processes was based on legal research by Monica Schwebs of the Energy Commission's Office of the Chief Counsel.
- ³⁷ Maritime Transportation Security Act of 2002, P.L. No. 107-295.
- ³⁸ Dynegy LNG Production Terminal, 97 FERC ¶ 61,231 (2001).
- ³⁹ Hackberry LNG Terminal, 101 FERC ¶ 61,294 (2002).
- ⁴⁰ "Natural Gas Sector Wrestles with New Dilemma," by Ken Silverstein, UtiliPoint International, December 23, 2002.
- ⁴¹ This is the "Hinshaw amendment."

⁴² 49 C.F.R. Part 193.

⁴³ This summary of state siting processes was based on legal research performed by Monica Schwebs of the Energy Commission's Office of the Chief Counsel.

⁴⁴ The LNG Terminal Act of 1977 required the one certified LNG terminal be located at a site remote from human population and prescribed the following population densities: for the zone one mile from the offloading, regasification and storage facilities – no more than 10 people per square mile; for the zone four miles from these facilities – no more than 60 people per square mile.