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LIQUEFIED NATURAL GAS: WHAT IS LNG? AND WHAT IS PROPOSED FOR CALIFORNIA?

The United States, including California, uses natural gas to heat homes and offices, cook food, and, most of all, fuel power plants generating electricity. Proposals are now under consideration that would bring additional natural gas supplies from the Rockies to the West Coast, including California, by 2010. In addition, numerous energy companies are exploring new natural gas sources overseas, most notably liquefied natural gas (LNG), and some would even like to deliver LNG just offshore of Southern California.

The federal Energy Information Administration estimates the global demand for natural gas will nearly double over the next two decades. One study shows that the global proliferation of LNG liquefaction (export) and regasification (import) terminals has made LNG a global commodity, much like oil is today.

Currently, there are 15 producers of LNG worldwide: Algeria, Australia, Brunei, Egypt, Equatorial Guinea, Indonesia, Libya, Malaysia, Nigeria, Norway, Oman, Qatar, Trinidad and Tobago, United Arab Emirates, and the United States. And there are now 60 LNG receiving terminals across the globe, with plans to build many more, including some in California, which currently has no LNG import or export facilities.

Transporting and Storing Liquefied Natural Gas

Natural gas is produced at oil and gas drilling and production sites and then is piped to a storage and processing facility. The natural gas is cooled to minus 259 degrees Fahrenheit, at which point it becomes liquefied. LNG can then be stored as a liquid in well-insulated tanks at atmospheric pressure or

An LNG Tanker Pulls Into Port
This specially designed double-hulled liquefied natural gas (LNG) carrier docks at a port linked to the liquefaction plant in the background.

What Is Liquefied Natural Gas?

Liquefied natural gas (LNG) is a natural gas, primarily methane, a fossil fuel. LNG, when regasified, is essentially like the natural gas used in homes and industries and its cost is now competitive with conventional supplies of natural gas. When natural gas is refrigerated it turns into a clear, colorless, odorless liquid called LNG and cannot ignite unless it's changed back into a gaseous form and encounters an ignition source.

Within North America, natural gas in its gaseous form is economically transported via underground pipelines. Yet natural gas developed on other continents or islands cannot be transported in its gaseous form to North America because it is too costly, given the relatively small volume that can be stored on a ship. As a liquid, however, natural gas occupies 1/600th of its gaseous volume, so the process of liquefying natural gas allows it to be transported around the world more efficiently.

loaded onto specially designed ocean-going LNG carriers, which are up to 1,000 feet long and are double-hulled and well-insulated, though not refrigerated. LNG ships typically carry 35 million gallons of LNG.

LNG can be transported to shore facilities in two ways: the tankers can be moored off a coastline (sometimes several miles offshore) and the LNG is regasified and then the natural gas is transferred to shore via pipelines, or the tankers can be docked at a facility adjacent to an onshore storage and regasification center.

At the onshore storage and regasification facilities, LNG generally is stored in liquid form. When the LNG is needed, it is warmed until it turns back into a gaseous form and then it is distributed through pipeline distribution systems designed to carry natural gas.

Loading LNG Onto an Ocean-Going LNG Tanker
Natural gas is refrigerated at liquefaction plants to minus 259 degrees Fahrenheit, which turns the gas into a clear liquid that can be transported via pipes for temporary storage onboard LNG carriers.

Proposed Projects for California

While there are no liquefied natural gas facilities in California at present, three offshore LNG receiving (import) terminals are being proposed for the state; two are now under consideration and another company expects to file an application soon:

- **Clearwater Port**
  Proposed location: 12.6 miles offshore of Oxnard.
- Status: An application was filed with the
- U.S. Coast Guard/MARAD and the California State Lands Commission on June 30, 2006.

- **OceanWay Secure Energy**
  Proposed location: 27 miles offshore of Los Angeles.
  Status: An application was filed with the City of Los Angeles and the U.S. Coast Guard/MARAD on August 18, 2006.

- **Port Esperanza**
  Proposed location: 15 miles seaward of the Port of Long Beach.
- Status: Esperanza Energy, LLC, announced in March 2007 that it will file an application in late 2008.

Other West Coast LNG Projects

One LNG facility, Energía Costa Azúl, was completed in Baja California, Mexico, in April 2008; the docking facility is expected to provide natural gas primarily to Mexico, followed by California and other western states, by early 2009. Six additional LNG projects have been proposed for other West Coast locations within Canada and Oregon.

The Permitting Process

While numerous state and federal agencies will be involved in the permitting process for any new LNG facilities, there are few lead agencies.

For onshore LNG projects, the Federal Energy Regulatory Commission (FERC) had asserted itself as the lead agency (FERC regulates natural gas transmission and maintains it has the final authority over LNG terminals as well). The state of California had contested FERC's authority in federal court but the federal Energy Policy Act of 2005 gave exclusive authority to FERC to decide on LNG import facilities. For offshore LNG facilities (which includes the

An LNG Crewman Conducts Safety Checks
The odorless liquefied natural gas is unloaded from an LNG carrier during a nighttime operation, while a safety worker checks on the progress of the routine procedure.

Importing LNG Into the United States: How It All Began

> **In the late 1960s,** natural gas production in the United States experienced a decline due to federal price controls on interstate gas transactions. This prompted some energy companies to explore importing LNG from overseas as an alternative source of natural gas.

> **The first LNG receiving facility in the United States** was built in 1969 in Boston Harbor. Two additional marine import and regasification facilities went into service in the 1970s at Elba Island in Georgia and at Cove Point near Lusby, Maryland. Together these three facilities purchased LNG from Algeria's national oil and gas company.

> **In 1978 the federal government** lifted price controls on all domestic natural gas discovered after 1977. As a result, additional natural gas flowed into the interstate market, which dramatically decreased LNG imports to the United States. LNG imports have rebounded in the last 13 years, from a low of 18 billion cubic feet in 1995 to about 540 billion cubic feet in 2003, which is approximately 2 percent of the United States' natural gas consumption.

The California Connection

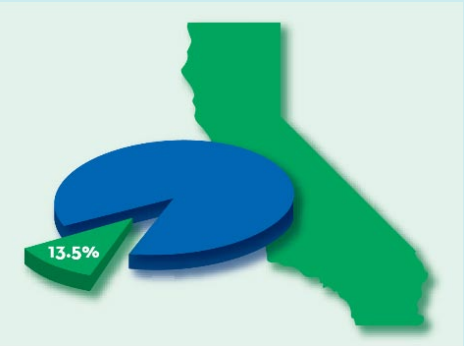
> **California has no LNG facilities.** In 1977 the Legislature passed the LNG Terminal Act (repealed in 1987), which required the California Coastal Commission to identify and rank possible LNG sites and provide the information to the Public Utilities Commission.

> **In 2002 an LNG facility** was proposed for Mare Island, a former naval shipyard in San Francisco Bay. Considerable citizen opposition prompted the withdrawal of this project.

> **In 2004 the Cabrillo Deepwater Port LNG facility** was proposed off the coast of Malibu. The facility was denied in a letter from the Governor and other state agencies.

> **Also in 2004 a Long Beach onshore LNG facility** was proposed, however, the California Supreme Court upheld the City of Long Beach's decision not to review this project.

> **Today, three LNG facilities** are being proposed for California (see the preceding page).



California Produces 13.5 Percent of the Natural Gas It Currently Consumes
Natural gas is used to heat homes and businesses, cook food, and fuel power plants generating electricity. Most of the natural gas consumed by California is imported from other states and Canada.

three proposed projects for California), the U.S. Coast Guard, the U.S. Department of Transportation's Maritime Administration (MARAD), and, in some cases, the California State Lands Commission, oversee the permitting process.

In both cases, a joint state and federal Environmental Impact Statement (EIS)/ Environmental Impact Report (EIR) is submitted under the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).

Safety Issues

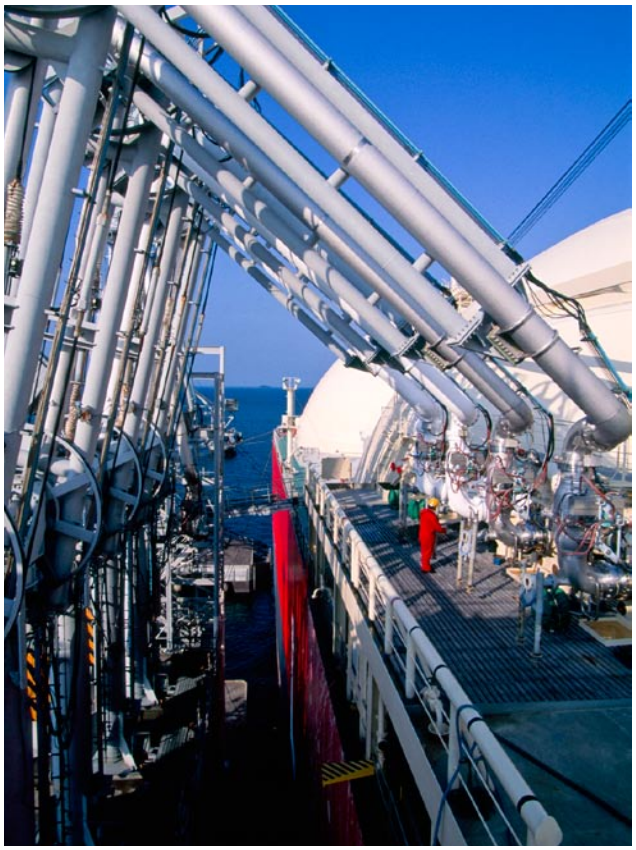
LNG in its liquid form cannot ignite. However, if released into the air or water, it warms rapidly, then vaporizes and turns into a gaseous vapor cloud that can be flammable. This vapor cloud is lighter than air, so it rises and can travel downwind. It will dissipate unless it encounters an ignition source when the vapor cloud is between approximately 5 to 15 percent of the surrounding air.

Because of the possibility of flammable vapor clouds, there are safety concerns associated with LNG liquefaction, transport, and regasification processes. Accidental or intentional releases of LNG can have disastrous consequences. The release of radiant heat energy can occur under two circumstances:
(1) if LNG is spilled, it produces a vapor cloud above the pool of LNG, which, when the correct percentage of air and gas is combined and ignited (known as a pool fire), produces tremendous radiant heat energy;
(2) if a vapor cloud travels downwind and is ignited, it will also release a great amount of radiant heat energy.

Deliberate sabotage of an LNG tanker or LNG storage terminal is a possibility. In fact, after the September 11, 2001, World Trade Center attack, Boston Harbor was closed to LNG tanker traffic as a safety precaution.

Since the increased demand for natural gas in the U.S. could significantly increase the number and frequency of marine LNG imports, many LNG import terminals around the world are being designed to handle larger capacity LNG carriers. As a result, the U.S. Department of Energy (DOE) requested Sandia National Laboratories to assess the potential hazards and consequences of a significant LNG spill from these larger carriers. Sandia's report, released in May 2008, concluded that the larger LNG tankers have a greater potential for accidental or intentional spills.

This DOE-sponsored report also notes that planned offshore facilities, such as the three currently proposed for California, are sufficiently far enough from the shore that potential casualties at the facilities would unlikely directly affect anyone on shore.



Unloading LNG From a Double-Hulled LNG Tanker
Liquefied natural gas (LNG) tankers typically measure up to 1,000 feet in length and carry about 35 million gallons of LNG.

Historically there have been relatively few LNG accidents, though a few are notable:

- **In 1944 in Cleveland, Ohio,** an LNG tank failed, spilling its contents onto the street and into the storm-sewer system. An explosion and fire within the storm-sewer system killed 128 people.
- **In 1979 in Lusby, Maryland,** at the Cove Point LNG facility, LNG leaked through an electrical-prevention seal on an LNG pump. The LNG vaporized, passed through 200 feet of electrical conduit, and entered a substation building. Normal arcing of a circuit breaker ignited the gas-air mixture, killing one operator and seriously injuring a second, and it caused extensive damage to the structure.
- **In January 2004 in Algeria,** a steam boiler that was part of an LNG production plant exploded, triggering a second, even larger, vapor-cloud explosion and fire that took many hours to extinguish; 27 people were killed, 56 were injured, and a portion of the LNG plant was destroyed.

The Required Infrastructure

If construction were to proceed on an LNG facility in California, several types of structures would need to be built:

- **The first would be offloading facilities:** either onshore facilities with shore-side piers and offloading equipment, or offshore facilities with offloading equipment, which can include moorings, islands, platforms, and associated pipelines.
- **Once an LNG tanker arrives** at its destination, its LNG cargo is typically regasified (returned to its vaporous state) at the terminal or an adjacent facility, and the resulting natural gas is then piped into the existing intrastate natural-gas distribution system.

  Regasification can occur immediately or the liquefied natural gas can be stored at the terminal for regasification at a later time. At most onshore terminals, the LNG is transferred to insulated storage tanks designed to specifically hold LNG. These storage tanks can be either above or below ground and are built to keep the liquid at a low temperature to minimize evaporation. When natural gas is needed, the LNG is warmed (using a regasification process involving heat exchangers) until it converts back to its gaseous state.
- **Natural gas pipelines** may need to be built to connect regasification facilities to the existing intrastate natural-gas

Will LNG Carriers Someday Pull Into an LNG Terminal in California?
California currently has no LNG facilities, though three LNG import projects have been proposed for the state several miles offshore of Los Angeles, Oxnard, and the Port of Long Beach.

distribution system. The location of an onshore LNG terminal typically dictates the number and types of linear facilities (such as gas and water lines, electric transmission lines, and roads) that would be needed.

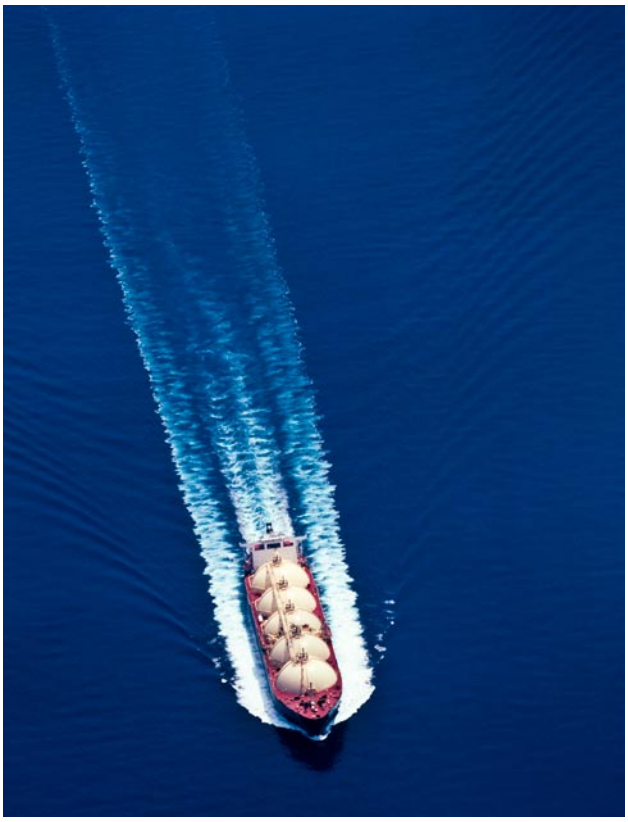
The three current proposals for California-based LNG receiving terminals are all for offshore facilities.

The cost to build an LNG receiving terminal is approximately $1 billion and construction can take many years. For instance, the Energía Costa Azúl project in Baja California received its environmental permit from the Mexican government in April 2003 and construction was completed five years later.

LNG in the Future

The U.S. Energy Information Agency (EIA) says the domestic production of natural gas may increase significantly due to the discovery of new natural-gas shale fields. These discoveries are expected to reduce the need for LNG imports to the U.S. for at least the next couple of years, yet the EIA says the U.S. still needs to consider developing additional supplies of natural gas for the future.

Worldwide demands for natural gas are expected to increase dramatically in the years ahead and currently some countries overseas, including many in Asia and Europe, are willing to pay a much higher price for LNG, which means already tight supplies are being diverted from the U.S. to those who are willing to pay premium rates. Furthermore, export supplies from existing liquefaction facilities have



Demands for Natural Gas Continue to Grow in California—and Worldwide
Now that China, India, and other largely populated countries have entered the global LNG market, the pressure to discover additional natural-gas reserves has increased, prompting international territorial disputes over hydrocarbon-rich land and maritime regions. The United States and Canada, for example, are disputing rights over the Beaufort Sea, an outlying sea of the Arctic Ocean.

An LNG Carrier Navigates Tokyo Bay
Sixty LNG import (or regasification) terminals are spread across 18 countries, including the United States. In contrast, only 26 LNG export (or liquefaction) terminals are located in 15 countries, which also includes the United States. Worldwide, numerous LNG export and import terminals are now either under construction or have been proposed as viable projects, including the proposed terminals offshore of Southern California.

been limited due to repair and maintenance issues, and rising construction costs have plagued the progress of new LNG liquefaction (export) projects around the world, further limiting LNG availability.

California currently imports 86.5 percent of its natural gas supply and the state's demand for natural gas—with LNG potentially being a viable long-term option—is growing. Whether a permit will be granted to build any of the LNG receiving terminals now proposed for California is not yet known, but the debate over the potential construction of such LNG facilities in this state continues. In the meanwhile, California—and, indeed, the rest of the world—also continues its mission to seek new ways to address energy shortage concerns for the years to come.

Written by Kip Wiley. The California Senate Office of Research is a nonpartisan office charged with serving the research needs of the California State Senate and assisting Senate members and committees with the development of effective public policy. It was established by the Senate Rules Committee in 1969. For more information and copies of this report, please visit **www.sen.ca.gov/sor** or call **(916) 651-1500.**

Sources: The California Energy Commission; Center for Liquefied Natural Gas; Clearwater Port; U.S. Energy Information Administration (EIA), Official Energy Statistics From the U.S. Government; The Federal Energy Regulatory Commission (FERC); OceanWay Secure Energy.