NATURAL GAS
facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Strategic Center for Natural Gas

06/2004

LIQUEFIED NATURAL GAS (LNG)

LNG – The Basics

LNG is natural gas that has been condensed to a liquid through a cooling process. The composition of natural gas, and hence the LNG that is formed from it, varies slightly according to its source and processing history, but it consists almost entirely of methane (CH_4), the simplest hydrocarbon compound. Typically, the composition of LNG is 85 to 95+ percent methane, along with a few percent ethane, even less propane and butane, and possibly trace amounts of nitrogen. Water is necessarily removed from the natural gas stream prior to its liquefaction. Like its primary constituent, LNG is odorless, colorless, non-corrosive, and non-toxic.

LNG is not formed by compressing natural gas nor is it maintained as a liquid through the use of high pressure. At atmospheric pressure [14.7 psi], methane will condense to a liquid when it is cooled to –259 °F (-161 °C). Cooling the gas to this temperature and keeping the resulting liquid cold allows the LNG to be transported and stored under normal [atmospheric] pressure as a cryogenic [very low temperature] liquid. The density of LNG is less than half that of water, so if LNG were to be accidentally spilled onto water it would float and then vaporize rapidly. An open container of LNG at room temperature and pressure would look and behave much like a container of boiling water.

The liquefaction process reduces the original volume of the natural gas being converted into LNG by a factor of more than 600, which allows for its efficient transport and storage. This shrinkage is roughly analogous to shrinking the gas volume in a large beach ball into a liquid volume the size of a ping-pong ball. Because of this dramatic reduction in volume, just one shipload (138,000 m^3) of LNG can deliver nearly 5 percent (~3 billion cubic feet) of the United States' average daily demand for natural gas.

Membrane type tanker transporting LNG

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STRATEGIC CENTER FOR NATURAL GAS WEBSITE

www.netl.doe.gov/scng

The LNG Value Chain

The global LNG business has been widely described as a "LNG Value Chain" having four links: (1) Exploration and Production, (2) Liquefaction, (3) Shipping, and (4) Storage and Revaporization. Each of these components has its own set of technological challenges and investment criteria, but each is linked to the others in the sense that no one component is a viable business investment without the others. The enormous investments required, particularly in the liquefaction and shipping components, have historically made the careful assembly of this chain a prerequisite for each LNG project; from the delineation and dedication of large natural gas reserves on the upstream end of the chain, to the guarantee of long-term markets on the downstream end.

Illustration of the LNG value chain

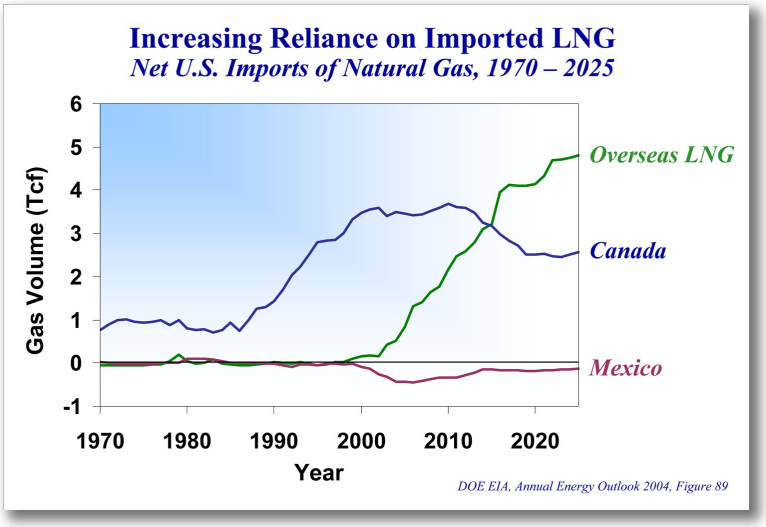
The worldwide community consumes about 90 trillion cubic feet (Tcf) of natural gas each year. Fortunately, natural gas is a resource found in significant volumes worldwide. At the beginning of 2003, the world's known natural gas reserves were estimated at about 5,500 Tcf, roughly 60 times the volume of gas consumed in that year and clear evidence that despite the world's appetite for natural gas, exploration and development efforts have more than met demand.

However, as with crude oil, the distribution of the world's supply of natural gas is not congruent with patterns of demand. Countries having large natural gas reserves and relatively low domestic gas consumption generally seek to monetize their gas resource [convert it from a natural resource into a saleable product]. If there are no high value gas markets within a reasonable pipeline distance, liquefaction of natural gas becomes one option for achieving this goal.

The Need for LNG Imports

LNG serves an economic purpose by providing a means for storing large volumes of natural gas in a relatively small space, either to be able to provide it to consumers on short notice [for peaking] or to facilitate its being transported across long distances when a pipeline is not feasible. This second reason is the primary motive behind the international LNG business: connecting natural gas that is "stranded" far from a market with the individuals and industries which need the energy.

U.S. demand for natural gas is increasing and this increase is forecast to continue; natural gas demand is projected to grow by nearly 40% by 2025, to over 31 Tcf in 2025. Abundant, affordable energy is foundational to our economic wellbeing. The U.S. however, cannot meet its natural gas requirements. Historically, natural gas imports – mostly from Canada via pipeline – have made up the deficit. By all accounts, increases in Canadian imports are not viable. Options for meaningfully increasing imports are (1) accessing arctic natural gas via large diameter pipeline, and (2) securing LNG from multiple overseas sources. The arctic pipeline alternative is a capital intensive, long lead time, relatively high risk endeavor. LNG can impact U.S. supplies in the nearer term, and tap vast global natural gas resources at competitive costs.



Recent forecast of U.S. LNG imports

How Safe is LNG?

Every day millions of Americans fill their cars and trucks with gasoline, use propane in their backyard grills, and cook and heat in their homes with natural gas with little thought to the safety of these fuel products. Yet, with projected increases in U.S. imports, storage, and use of LNG, many are asking, "just how safe is LNG?" To answer this question, one must first understand the properties of LNG and the conditions for which LNG becomes a hazard. If we compare the properties of LNG to gasoline and fuel oil we see that like these other hydrocarbon fuels, LNG is flammable under certain limited circumstances. Because of its physical and chemical properties however, the risk of an LNG fire is significantly lower than for other commonly used hydrocarbon fuels. Unconfined, LNG will not explode.

The LNG industry, like most industries, is subject to routine safety and health hazards. While accidents have occurred, overall the LNG industry has enjoyed an enviable history of safe operations. As with any industry, the LNG industry has risk mitigation systems in place to reduce the likelihood of occupational hazards and to ensure protection to the environment, workers, and the surrounding community in the unlikely event of an accidental LNG release. The industry adheres to multi-layer protection requirements to ensure the safety and security of LNG facilities and their operation. These safeguards include:

LNG storage tanks at marine terminal – Photo Credit: Dominion

- Primary containment
- Secondary containment
- Exclusion zones
- Security requirements
- Operational procedures
- Incident/emergency response protocols.

Typical LNG facility for baseload and peaking needs. – Photo Credit: Northstar Industries

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 for peak-shaving plants as well as some authority for LNG marine terminals. The Federal Energy Regulatory Commission has siting approval responsibility, with some security oversight, for land-based LNG terminals and certain peak-shaving plants. The Energy Department is responsible for authorizing the import/export of LNG. In addition to federal agencies, state and local authorities, like police and fire departments, also establish requirements to ensure the safe and secure transport and storage of LNG.

DOE Actions

While LNG is a viable option for increasing supplies, myriad issues may delay and/or limit the expansion of existing facilities and construction of critically needed new storage and regasification facilities. These issues include: safety, security, siting, stakeholder knowledge and acceptance, gas quality, permitting, and other regulatory issues. The U.S. Department of Energy [Office of Fossil Energy (FE)/National Energy Technology Laboratory (NETL)] coordinates across multiple federal and state agencies in a variety of activities to eliminate/minimize potential impediments to LNG facilities/ operations. These activities are varied and include technology, education, modeling and simulation, and interagency liaise.

Specifically, NETL is developing novel regasification and storage technologies, e.g., the Bishop process, which may substantially lower revaporization/storage costs, and minimize safety and security concerns as well. The laboratory is also funding the demonstration of an integrated, satellite LNG system for peaking applications. This activity is designed to demonstrate the versatility of the concept, gain additional public acceptance [of small scale units], and lower the capital & operational costs of the system. NETL is proactively addressing the safety and security issues of most concern relative to LNG. Activities include modeling the behavior of vapor [LNG] dispersion, broad based risk assessments including consequence analysis, and scenarios evaluation involving hypothetical LNG releases/spills.

DOE has also established an effective dialog across multiple federal and state agencies to facilitate the siting and permitting of import terminals, and to minimize environmental impacts of the facilities. As part of this educational/ technology transfer objective, NETL is implementing the DOE/National Association of Regulatory Utility Commissioners LNG partnership. The partnership focuses on providing state regulators and other affected stakeholder groups with science-based information via effective formats in order to facilitate productive discussion and debate. NETL is planning a LNG Technology Roadmapping activity during FY 2005 in order to identify remaining R&D needs and establish priorities to enhance LNG safety and security, and to advance the integrity and reliability of LNG facilities and operations.

SOURCES OF ADDITIONAL INFORMATION

American Petroleum Institute
http://lngfacts.org/

Atlantic LNG Company of Trinidad and Tobago
http://www.atlanticlng.com/

California Energy Commission
http://www.energy.ca.gov/lng/

CH-IV International
http://www.ch-iv.com

Dominion Cove Point LNG, LP
http://www.dom.com/about/gas-transmission/covepoint/index.jsp

Federal Energy Regulatory Commission
http://www.ferc.gov/industries/gas/indus-act/lng-what.asp

Gas Technology Institute
http://www.gastechnology.org

LNG Express
http://www.lngexpress.com/

National Association of Regulatory Utility Commissioners
http://www.naruc.org

University of Houston Law Center Institute for Energy, Law & Enterprise
http://www.energy.uh.edu/lng/

For additional information click here

"QUICK" CONVERSIONS

1 metric ton LNG ~ 2.2 m^3 LNG

1 m^3 LNG ~ 610 m^3 natural gas

1 m^3 LNG ~ 21.5 Mcf natural gas

1 metric ton LNG ~ 47.4 Mcf natural gas

A short video on LNG is available from British Petroleum p.l.c.
http://www.bplng.com/environment/video.asp