Liquified Natural Gas—Overview of Prospectives

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ABSTRACT

This article provides an overview of different prospectives regarding manufacturing, handling, distribution, regulation, and investing in the liquefied natural gas (LNG) industry. As sources of energy are in increased demand, LNG becomes more and more important part of the natural gas supply in the world. Its main advantage is its ability to be converted into liquid form by cooling to -162ºC (-260ºF), thus occupying only a small portion (approximately one six-hundredth) the volume of its gaseous state, which makes it convenient for transportation to areas remote from natural gas wells by specially designed vehicles. Upon arrival at the final destination, LNG is re-gasified to return to its gaseous state and then delivered to the customers through local pipelines. As an environmentally friendly gas, it lures billions of euros in investments through cooperation between private enterprises on one side, and local and federal government on the other side, thus creating a more balanced energy future where competition is superior to monopoly.

Keywords
Liquefied natural gas, terminals, liquefaction, re-gasification, storage, transportation, safety, environment, regulation, investing.

HISTORY AND INTRODUCTION

LNG has been transported and used for more than 45 years. Delivering LNG from the well to the end user assumes three main steps [2]:

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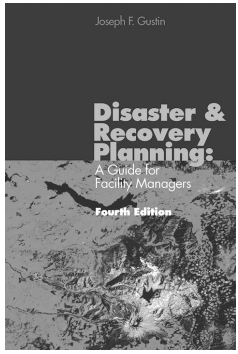

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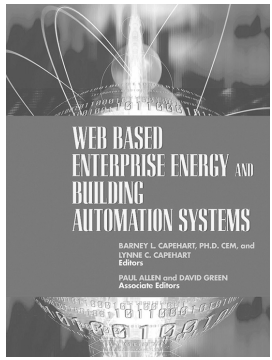

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1. Cooling the natural gas in the gaseous state at temperatures -162°C (-260°F) at normal pressure to convert it to liquid state, i.e. LNG; this process qualifies as cryogenic, since the temperatures are lower than -65.5°C (-85.9°F).

2. Storing LNG, or pumping it directly at only $1/614^{th}$ of the original (gaseous) state to specially designed vehicles (tankers, trains, and trucks) for transportation.

3. Finally, upon arrival to the final destination, LNG is pumped in the liquid form in storage. To be delivered to the customer, it has to be re-gasified by warming up in water-LNG or air-LNG heat exchangers.

LNG is odorless, non-toxic, non-corrosive, and less dense than water—0.41 to 0.50 kg/L (25.6 to 31.2 lbm/cf) [3], which is comparable to petrol and diesel fuels. LNG is a mixture of different gases, mostly methane—more than 90 percent. Oxygen, carbon dioxide, sulfur, and water can be removed during the process of liquefaction. It also contains small amounts of ethane, propane, butane, and some heavier alkanes. The heat value depends on the gas source—the location and process used for liquefaction is estimated at 24 MJ/L (86,100 Btu/gall). Liquid petroleum gas (LPG, sometimes called propane), is sometimes wrongly confused with LNG.

TRANSPORTATION AND STORAGE

Over 150 double-hulled tankers with extensive cargo safety systems transport LNG across the world oceans [9]. Tankers' crews must obey international ship and port security codes. Tankers are up to 300m (1000 ft) long. The most common tank types are: membrane (prismatic), Moss Rosenberg (spheres), and self-supporting prismatic type. LNG is kept until needed in steel alloy tanks, surrounded by a 0.25 m (2') thick concrete wall. Besides tankers, trains and trucks are used for transportation. Worldwide, there are 40 import terminals designed to receive LNG shipments, 17 LNG liquefaction export terminals, and more than 200 storage facilities owned mostly by the local utilities [10].

LNG can be stored above-ground and underground, meeting local regulations [11]. Tanks are pressurized at 5 to 250 psig (35 to 1700 MPa). Typical tank shape is cylindrical, due to even distribution of the

stress. Quantities up to 700 m^3 (190,000 gall) can be stored in either horizontal or vertical tanks, while larger quantities are always stored in horizontal tanks. LNG must be maintained below -83°C (-117°F) to remain a liquid. Due to a much warmer environment, a portion of LNG evaporates and is reused. Auto-refrigeration is the process when the temperature in the tank remains constant if the pressure is kept at the constant temperature.

SAFETY AND ENVIRONMENTAL IMPACT

The LNG industry has made more than 33,000 carrier trips since early 1960s, traveling over 111 million kilometers (60 million nautical miles) without major incident; Japan has 25 LNG import terminals and has not had any major incidents during a 35-year history (Chevron Corp., 2006). Extensive safety systems on the tankers include: radar, global positioning system (GPS), alarm systems, etc., while ground terminals are monitored around the clock, have fences with sensors, closed-circuit television, electricity generators, etc.

In the case of leakage from the storage tank to the atmosphere, LNG would evaporate into a cloud. It is unlikely to be ignited due to narrow flammability ratio of gas (5 to 15 percent) and air. Since it evaporates, it would not leave residues in the ground. If spilled on water, LNG is insoluble and would rapidly evaporate. Although a clean burning fuel, effects of LNG on environment are carefully followed, especially in the light of Kyoto Protocol and the European Union's Emissions Trading Scheme.

INVESTING IN LNG INDUSTRY

Demand for energy is constantly rising. China and India, with combined populations of over two billion, consume significantly more energy than just few years ago, due to economic growth. A part of the globalization process is having access to more clean energy. By 2030, 14 billion euros (17 billion U.S. dollars) is projected to be invested in the oil, gas, and electric power sector [8] through replacing existing and building new infrastructure. Major factors affecting the supply in the future may be divided into two segments ([4], [5]):

1. General Barriers to Increasing Supply:
   —Land access,
   —Pipeline infrastructure,
   —The financial environment,
   —Political aspect.

2. Short-term Supply Barriers:
   —Availability of skilled workers,
   —Natural gas prices and drilling rig operation,
   —Availability of equipment,
   —Obtaining permits,
   —Weather and delivery disruptions.

Obtaining permits, between the location of natural gas deposits and the beginning of production, can range from as little as a few months to as much as ten years. LNG terminals are sometimes viewed as displeasing to local residents and businesses, causing noise, pollution, and wildlife endangerment. Therefore, all the "non-energy" aspects of LNG need to be handled sensibly. People need to be educated about advancements in technologies that are making this source of energy more and more feasible, as well as strict regulatory provisions ensuring safety and minimal environmental impact. LNG facilities are built with long-term supply commitments, thus making the price more stable than rather volatile natural gas prices.

In today's market, where competition is superior to monopoly, a complex array of conditions has to be met for an estimated 3 billion euros (4 billion dollars) to be invested in one LNG facility infrastructure and equipment. Two non-operational risks closely related to building new terminals and infrastructure are [4]:

1. Terrorism and accident risk, and
2. Government risk.

CONCLUSION

World economies are in need of additional natural gas sources based on forward fundamental supply/demand and price expectations. LNG is a very viable choice. The real advantage is that

LNG allows countries to import natural gas from other countries around the world, thus expanding and diversifying natural gas supplies and contributing to energy security. However, political, sovereign, and regulatory risk can impede the progress of such beneficial projects. It is becoming more apparent that energy companies, governments, and regulatory commissions need to work together to determine a pragmatic goal to satisfy projected gas demand growth. The solutions need to be prudently pursued by private enterprise and supported by local and federal government legislation to create a more balanced energy future with LNG as an integral component.

References

[1] Fundamentals of the Global LNG Industry (2001). *Petroleum Economist*.
[2] Jones, C.A., Leonard, J.J., and Sofranko, J.A. (1987). Fuels for the Future: Remote Gas conversion. *Energy & Fuels*.
[3] LNG—A Glossary of Terms (2001). *Petroleum Economist*.
[4] *Encyclopedia of LNG* (2006). Petroleum Economist.
[5] Shively, B. & Ferrare J. Understanding Today's Global LNG Business. Enerdynamics.
[6] Stoppard, M. (2006). *Liquefied Natural Gas—Opening up a Global Gas Market*. CERA.
[7] Adorjan, A. (1990). *Heat Transfer in LNG Engineering*. Taylor & Francis.
[8] International Energy Agency official web site.
[9] American Petroleum Institute official web site.
[10] U.S. Federal Energy Regulatory Commission official web site.
[11] *World Energy Magazine*, Vol. 7, No. 1 & 4 (2006).