

PERP Program – LNG Receiving Terminals

New Report Alert

February 2007

Nexant's *ChemSystems* Process Evaluation/Research Planning program has published a new report, ***LNG Receiving Terminals (05/06S12)***. To view the table of contents or order this report, please click on the link below:

http://www.nexant.com/products/csreports/index.asp?body=http://www.chemsystems.com/reports/show_cat.cfm?catID=2

INTRODUCTION

Natural gas is an efficient and clean burning fuel with a global demand of almost three trillion cubic meters per year. It is becoming more highly valued as both a fuel and a chemical feedstock throughout the world, and this interest has been sparked largely by the high prices that characterize today's energy market together with a strong drive for cleaner fuels.

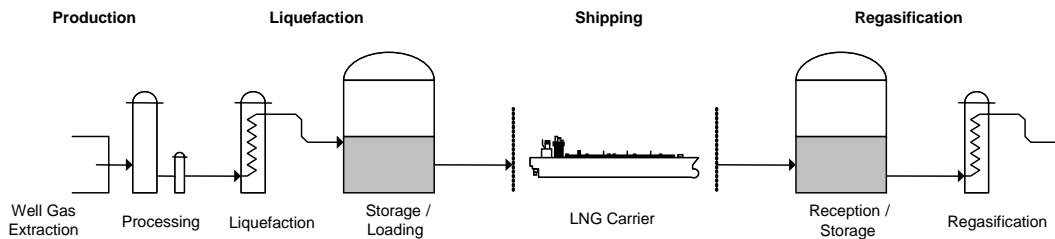
The main barrier to increasing gas utilization is the location of supplies; most gas reserves are not close to the major demand centers, the largest of which do not have sufficient indigenous supplies to meet demand and are so compelled to import it. There exist two principal methods of supply; via pipelines as natural gas, or marine transport using liquefied natural gas (LNG). Pipeline transport often becomes infeasible for economic reasons if the distance between the source and market are too great, and also for technical reasons, if modern pipeline technology is inadequate for certain sea routes. In these cases, the process of liquefaction, marine transportation, vaporization of LNG and subsequent pipeline transmission of gas becomes more competitive.

For these reasons and in order to help meet the worldwide gas demand, increasing volumes of LNG are being traded. Over the past 15 years, LNG trade as a proportion of global gas consumption has doubled from 3.5 percent in 1990 to around seven percent in 2005.

Scope of Report

The LNG value chain is made up of several different segments; from the upstream reservoirs, midstream liquefaction plants and tanker ships, to the downstream receiving terminals. Each of these business segments has its particular technical and commercial challenges that require close coordination, design and planning. The scope of this report is confined to the last part of the chain, the receiving terminal, where the LNG is unloaded from tankers, stored and then regasified before being piped out to the end-users.

Figure 1 LNG Value Chain



PP: 4120 Sec 1

The aim of this report is to identify and compare the different types of technology that comprise an LNG receiving terminal and also to discuss important trends and challenges that are faced by the players in this growing business.

LNG Receiving Terminals

The development of LNG receiving terminals involves large investment. In addition to the regasification equipment, the terminal includes berthing, unloading facilities and storage tanks. The total installed cost of an LNG receiving terminal is dependent on a number of factors including location and environmental considerations, access to deep water, prevailing sea conditions, dredging requirement, delivery capacity, and the distance between the ships berth and storage tanks.

There are 55 LNG receiving terminals currently operating worldwide. Of these, 64 percent are located in Asia and the remainder in Europe and the Americas. However, nearly 75 percent of the terminals that are planned, proposed and under construction are targeting the American and European markets. Because many of the proposed terminals are coming under intense scrutiny due to environmental and security concerns, it remains to be seen how many of the proposed terminals will actually be constructed.

Technology Considerations

The functions of an LNG receiving terminal are as follows: reception of the LNG cargo (Ship to Shore Interface), storage, pumping, vaporization, vapor handing, possible heat integration and finally gas metering and send-out. Although the utilization of onshore terminals has been the norm since the beginning of the LNG industry in the 1960s, stricter environmental and safety requirements and permitting processes have accelerated the development of offshore technologies. Both types of terminals consist of offloading installations, cryogenic storage tanks, pumps, regasification facilities and gas metering and send-out.

Each of the regasification technologies has their own specific advantages and disadvantages and their use will be highly dependent on various environmental and economical factors. This report describes each of the onshore and offshore technologies that are employed and those that are emerging. Because permitting issues are currently impacting future onshore terminals, emphasis

will be given to environmental and regulatory issues and on the new and emerging offshore technologies, defined by the following categories:

- Offshore Gravity Based Structures (GBS)
- Floating Storage Regasification Units (FSRU)
- Regasification Vessels
- Platform Based Import Terminals

This report focuses on all the main functions of an LNG receiving terminal, as described above, and will cover the various technologies available to regasify LNG (e.g., Submerged Combustion Vaporizer, Open Rack Vaporizer (ORV), Natural Draft Ambient Air Vaporizers (AAV) and Forced Draft Air Heater Vaporizers (AHV); various methods for recovering boil off gas and possible heat integration in order to use the cold potential of LNG. The issue of gas interchangeability and the processes available to meet pipeline specification is also covered in this report.

Commercial Considerations

New LNG terminals are being proposed all over the world, however, the selection of acceptable sites has proved, in some cases, very controversial. In order to minimize potential barriers to construction and operation of new LNG receiving terminals, close coordination must be achieved across multiple government agencies at the local, state and federal levels in a variety of activities. Among the many considerations that can impede the expansion of existing terminals, or the construction of new ones, are siting, permitting and regulatory issues.

Site Selection

When selecting a particular terminal site, the factors to be considered include:

- Size of natural gas market
- Accessibility for large LNG tankers (harbor depth, channel width, etc)
- Proximity to market demand centers
- Capacity of existing pipeline networks
- Cost of land acquisition and land use characteristics
- Public sentiment regarding the facility
- Availability of public infrastructure (roads, electricity, housing, etc.) and of skilled labor
- Environmental sensitivities.

In those cases where there has been local resistance to the construction of an LNG terminal, the main reasons have been concerns over the danger of fire and explosion, environmental and visual disruptions and damage to local tourism and fishing economies. As a result of the opposition, many developers now consider offshore terminals as an alternative, thus minimizing land-based facility impacts and accelerating the permitting process.

Permitting Issues

In many countries, the potential for adverse public opinion make for significant hurdles that if not dealt with in an appropriate and timely manner could become insurmountable roadblocks leading to the abandonment of projects with corresponding financial losses. The need for conditions precedent to cover terminal permitting processes is now considered a key element of future LNG contracts, meaning that developers should condition the effectiveness of key contracts on the successful procurement of appropriate authorization.

Like any other industry, the LNG business employs risk mitigation systems to reduce the likelihood of occupational hazards and to protect workers, local communities and the environment. These systems include primary and secondary containment systems, exclusion zones, security requirements, operational procedures, and emergency response protocols.

Constraining Factors

Possible constraining factors to the growth of future LNG markets can be identified as follows:

- Gas Quality and Interchangeability issues which means that not all supplies will be able to meet end-users specifications and that not all LNG supplies are interchangeable with local supply sources
- Supply Bottlenecks which could cause shortages of gas to critical end-users such as residential heating or regional electric power plants, and
- Market Concentration due to the limited number of players involved with international LNG trade.

Contract Procurement

The huge investment costs associated with the realization and development of an LNG terminal are such that long term supply contracts, often for between 15 and 20 years and ensuring a reliable and adequate supply, are utilized for securing financing of the project. The small proportion of LNG supplies that are not predetermined in long term contracts are based on expensive spot prices, meaning that short-term supplies are generally significantly more costly than those procured under long term contracts. About ten percent of the total traded volume was sold on a spot or short-term basis in 2005.

ECONOMIC ANALYSIS

Due to the number of LNG regasification technologies that are available and the variety of combination for their application, many possibilities exist for comparing the costs associated with LNG regasification. The composition of the LNG delivered as well as economic and environmental restrictions and requirements all influence the choice of the technology and facilities employed. The analysis presented in this report is based on the regasification of a lean LNG stream produced in the Middle East and delivered to the Asian market. This basic terminal comprises LNG reception facilities, which include LNG berth and jetty, utilities, BOG compression, LNG storage, LNG pumping, LNG vaporization and send-out facilities. The cost of production associated with the use

of an open rack vaporizer (ORV) and a submerged combustion vaporizer (SCV) are analyzed for a range of natural gas prices, using Nexant's *ChemSystems* methodology for the assessment of project economics, i.e., cost of production (COP).

Whereas, the comparative economic analysis is based on a stand-alone LNG receiving terminal employing the most commonly used re-vaporization technology, in order to deliver gas to market, an integrated LNG producer first needs to identify a potential market and identify the most economic means for delivering this gas to the market (e.g. pipeline or LNG) and thereafter develop sufficient gas reserves to meet the projected demand of the targeted market.

In the case where LNG is chosen as the preferred means of transporting natural gas to markets, the major elements that make up the supply chain are gas exploration and production, base load liquefaction, LNG shipping in specially designed LNG tankers and finally import to a receiving terminal with storage, regasification and gas send-out facilities.

MARKET ANALYSIS

LNG Demand

A market that was once dominated by state-owned buyers from Japan and Korea is changing rapidly as new players and markets come into force in India, China, the UK and the US.

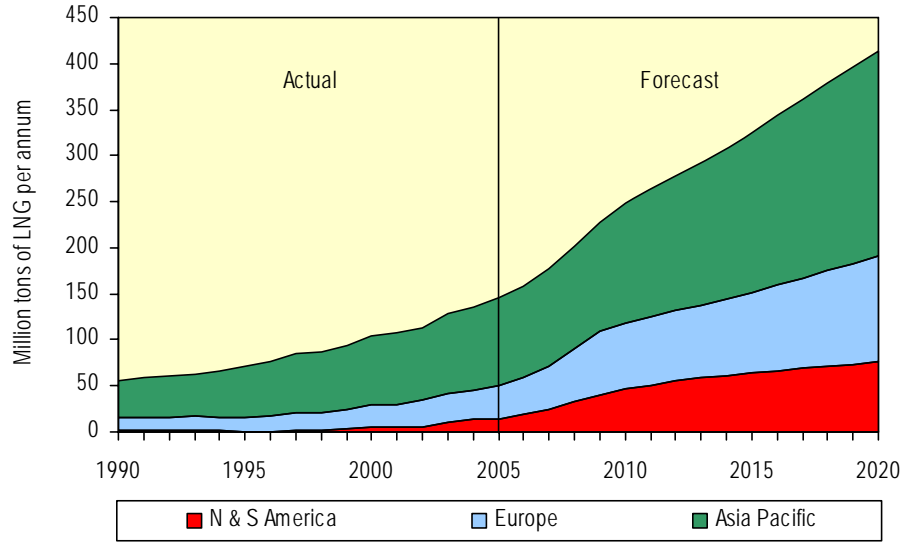
The Asia Pacific region is currently the largest market for LNG and includes the emerging markets of India and China, where the developments of significant import capacity are being planned. In Continental Europe, LNG has historically played a minor role in a market dominated by pipeline gas supplies. However, in a number of countries LNG is becoming an ever more important complementary source of supply. The UK could become one of Europe's leading LNG importers by 2010 as its indigenous North Sea gas supplies continue to decline.

In the US, declining domestic gas production and increasing demand from the electric power sector have been a major factor for increased gas prices over recent years, making LNG imports more competitive. As a result existing plants are experiencing higher utilization, capacity expansions are in progress, and numerous new terminal projects are in the planning stage.

In the Mexico, Central America and Caribbean region, LNG receiving terminals have recently been constructed in the Dominican Republic and Puerto Rico and new terminal projects have been completed and are under development in Mexico. In South America, there are no countries currently importing LNG, although Brazil and Chile have plans in place for new receiving terminals.

Nexant's future market projections of regional LNG trade are illustrated in Figure 2.

Figure 2
Historical and Projected LNG Market



XL: 4120/Sec_1

LNG Supply

There is a significant new liquefaction capacity that is due to come on stream over the coming decade in the Middle East, Africa and Asia Pacific regions. Major projects include Qatar’s RasGas and Qatargas, Indonesia’s Tangguh LNG, Russia’s Sakhalin II LNG, a number of new Australian LNG projects, several new projects in Nigeria, and capacity additions in Algeria and Egypt. LNG supply is projected to reach around 250 million tons per annum by 2010 and around 505 million tons per annum by 2025.

=====
Copyright© by Nexant, Inc. 2007. All Rights Reserved.

Nexant, Inc. (www.nexant.com) is a leading management consultancy to the global energy, chemical, and related industries. For over 38 years, Nexant’s *ChemSystems Solutions* has helped clients increase business value through assistance in all aspects of business strategy, including business intelligence, project feasibility and implementation, operational improvement, portfolio planning, and growth through M&A activities. Nexant has its main offices in San Francisco (California), White Plains (New York), and London (UK), and satellite offices worldwide.

These reports are for the exclusive use of the purchasing company or its subsidiaries, from Nexant, Inc., 44 South Broadway, 5th Floor, White Plains, New York 10601-4425 U.S.A. For further information about these reports contact Dr. Jeffrey S. Plotkin, Vice President and Global Director, PERP Program, phone: 1-914-609-0315; fax: 1-914-609-0399; e-mail: jplotkin@nexant.com; or Heidi Junker Coleman, phone: 1-914-609-0381, e-mail address: hcoleman@nexant.com, Website: <http://www.nexant.com>.