Current Status and Perspectives for LNG in the UNECE Region

Introduction and Overview

Under the auspices of the United Nations Economic Commission for Europe (UNECE), a group of experts has developed this Study with the objective of providing a comprehensive and up-to-date picture of the Liquefied Natural Gas (LNG) industry. Drawing on the most recent publications, the authors have analyzed and organized existing information for the purpose of this Study. Each chapter stands alone, addressing related but specific topics. The four main chapters describe the LNG market (Chapter 1), the LNG value chain (Chapter 2), the regulatory frameworks (Chapter 3), and key interoperability and safety issues (Chapter 4).

The study reviews today's LNG market today, exploring current dynamics and trends as well as assessing potential developments in the market as a result of recent major events. In addition, the study includes "technical handbooks" on the LNG chain, a summary of different regulatory approaches adopted in the major LNG markets, and a comprehensive analysis of interoperability and interchangeability issues such as gas quality and quality adjustment, operational and safety issues of LNG facilities, ship-harbor interface, and so forth. A great deal of useful quantitative information is included in the tables and charts.

The overall objective of the study is to familiarize the readers with the LNG industry and market, and to present current drivers and potential obstacles for LNG to reach its full potential as an energy carrier.

LNG market, a very special subset of the gas market

In 1959, the Methane Pioneer carried the world's first-ever LNG cargo from Lake Charles in Louisiana (US) to Canvey Island (UK). Today one LNG tanker can transport 50 times more LNG than the Methane Pioneer did fifty years ago. The LNG industry operates more than 100 liquefaction trains with a production capacity close to 250 million tons a year, a fleet of more than 350 LNG tankers and 90 regasification LNG terminals.

Global gas demand was estimated by various sources to be 3,300 bcm in 2012. LNG comprises about 10% of the overall natural gas market and 32% of internationally-traded gas. It is growing faster than overall gas demand.

LNG means freedom of energy supply

A market with an LNG terminal can access many suppliers and enhance security of supply.

LNG access is not constrained by pipeline capacity availability or gas transit disputes.

LNG is ideal for isolated markets or markets with a single supply source.

LNG buyers do not necessarily need to commit to long term/high volume gas contracts.

LNG can be re-exported as market conditions evolve.

Regasification terminals respresent additional storage capacity.

LNG trade in spot and short-term transactions has increased significantly in the past few years. This development has been fuelled by increased quantities of flexible supplies from Qatari producers and from other global portfolio players competing in the market to take advantage of spot opportunities. LNG is usually more available than pipeline gas and can be supplied in smaller volumes. LNG gives buyers many options to secure gas supply without necessarily having to commit long term with a specific producer. LNG is a liquid and as such can be shipped similarly to oil. There are, however, important differences. LNG markets remain regional in nature because the availability of shipping does not match the fast growing LNG trade and because a fairly limited number of global operators control a substantial share of "free" LNG.

Electricity continues to be the final energy of preference and providing it is a priority objective in developing countries. Natural gas has been the preferred primary energy fuel for electric power generation, and LNG is well-placed to provide needed flexibility to power supply portfolios. Given its competitive costs and its flexibility, natural gas generally and LNG specifically can provide important support for renewable energy initiatives. In addition, the LNG market is a dynamic one: growing number of suppliers and buyers, breaks regional barriers to trade, helps to arbitrage gas price, shows capacity to innovate and has growth rates that surpassed those of pipeline gas for the last decades.

Spain leads in Europe in the massive use of LNG

LNG contributed to development of a gas market in Spain, a country fully dependent on gas imports and with limited connections to the European gas grid. More than 60% of Spain's annual gas demand of 34 bcm is met by LNG. Twelve different sources of LNG supply enhance both security of supply and competition. A novel "Please in My Back Yard" syndrome made it possible to build 6 LNG regasification terminals around the country. The LNG terminals have ample available capacity and access is granted to third parties by a fully independent operator. The LNG terminals procure the fuel that the country's combined cycle gas turbines need for baseload generation and to support major investments in renewable energy.

Spain has been the largest EU LNG importer in Europe for many years, although UK has unloaded more quantities in recent years. More than 45,000 LNG trucks a year are loaded at the regasification terminals and sent to approximately 400 satellite plants close to industrial and residential customers' sites around the country.

Conversely, there are certain disadvantages associated with natural gas and LNG. Gas prices are notoriously volatile, which can have an immediate and significant impact in short term LNG contracts. Regarding competitive costs, it is not clear that LNG is the most competitive gas option as Asian demand is driving up global LNG prices. LNG shipping also contributes to price variations – the current tight LNG shipping market is a consequence of longer trips to premium LNG markets, and tightness led to peak charter rates in both 2011 and 2012. Given the huge and rising capital investments required to develop an integrated LNG project, prices for LNG are not expected to decline in the future, even if the number of supply sources continues growing as expected.

LNG market moving events

Global liquefaction capacity amounted to approximately 350 bcm in 2011, and expectations are for liquefaction capacity to reach up to 450 bcm in as soon as 2015. Regasification appears not to be an obstacle to the forecast expansion of worldwide LNG trade as current capacity is, and it is planned to remain, two times the liquefaction capacity.

The nuclear outages in Japan changed LNG demand not only domestically but throughout the Asia Pacific region and, increasingly, in other gas markets as well. While LNG demand for power generation in Japan increased by around 30% in fiscal year 2011, the accident in Fukushima also reduced operations at nuclear plants in Europe and has led some countries to reconsider their nuclear policies altogether. The immediately-available alternative is gas-fuelled power, and it remains to be seen what the longer-term consequences of Fukushima will be.

Developments to monitor

- Fukushima's nuclear accident as driver of gas-fired generation in Japan and beyond.
- Economic growth in Asia: new buyers soak up growing volumes of LNG.
- Uncertainty about future European energy requirements.
- The long-term impact of the Arab Spring on the region's LNG export/import balance.
- Shale gas developments that change traditional LNG trade flows.

In addition, growing demand from emerging economies and attractive prices for LNG suppliers to Asia are shifting LNG trade to Asia, a region that already represents 60% of global LNG supply. China and India will be especially important in future LNG market dynamics: together they added more than 25 mtpa of regasification capacity between 2011 and 2012. Any future supply gap in Asia could be covered mainly by new supplies from Australia and North America (utilizing the expanded Panama Canal to reach Pacific Basin markets).

Perspectives for LNG in Europe are less clear than in Asia, although decreasing domestic gas production and efforts to diversify supply sources are drivers for European LNG growth. Recent studies issued by the IEA, BP, Cedigaz and others all anticipate that LNG demand will increase further in Europe. LNG's market share is forecast to move up from 15% in 2010 to 24% in 2020 according to the BP Outlook. Threats to these positive perspectives are the lasting economic crisis and the strong policy push of the European Union for energy efficiency and "decarbonization" of the energy system that could curtail energy demand growth.

Here comes shale gas!

US shale gas deliveries grew from about 20 BCM in 2005 to an estimated 280 BCM in 2013, 40% of total US gas production. Gas production in the Marcellus Shale formation alone rose ten-fold from 2008 to 9.5 bcf per day by May 2013. Its production surpassed the total gas production of Algeria at year-end 2012, and is more than twice Nigeria's total gas production. Rising shale gas production steadily reduced expectations for LNG imports into the US and, by 2010, domestic US gas markets were unable to absorb the additional volumes. In the expectation of continued increases in shale gas production in North America, applications have been filed with authorities in the US and Canada to export surplus natural gas as LNG from 10 terminals. LNG exports from U.S. and Canadian terminals are economically competitive in all major markets, including Europe and Asia Pacific, based on forward gas price differentials. Comfortable margins can be demonstrated to 2015 based on current forward prices.

Europe may need to reconsider its gas portfolio amidst upheavals taking place where some traditional suppliers may no longer act predictably. High potential suppliers may not fulfil development plans in a timely way while others may need to restrain their LNG exportation plans to cope with quickly increasing domestic demands.

On the supply side the boom has a name: shale gas (see box on previous page). The most relevant event is the fast development of shale gas resources in North America. Shale gas now comprises an incredible 40% of total US gas production, up from 4% a decade ago. The US Department of Energy has authorized exports of 25 mtpa (35 bcm) of surplus natural gas in the form of LNG in 2016, and further projects have been submitted for approval. Overall US exports could reach around 50 mtpa (70 bcm) by the mid-2020s. A key question is to what extent ample availability of LNG for export from the US could threaten planned Australian LNG projects. LNG trade has also been stimulated by recent discoveries of conventional gas in locations such as East Africa where maritime transport would appear more competitive than pipelines.

Could increasing LNG liquidity push towards a global LNG price?

The Gas Exporting Countries Forum (GECF), an association gathering a good number of major gas producing countries, advocates maintaining the oil price link for gas though market fundamentals work against this position. The current LNG price at Henry Hub (Louisiana) is less than half the price at European hubs and less than one-fourth the average price paid in Asian markets. LNG transport costs alone do not justify such differences. A dual pricing mechanism (oil indexation and hub pricing) is in place in Europe, which prompts constant comparisons and pricing debates. New import contracts in Europe have been indexed at least partly to spot prices at the European hubs.

Power generation is the major driver of gas demand today, but most electricity utilities have alternative primary fuel options to meet their generation needs. Some European utilities have urged Gazprom, supplier of ~~30~~24% of European gas demand, to switch to spot indexation, arguing they are being squeezed between low electricity revenues and gas prices indexed to a basket of oil product prices.

With new LNG export capacities in the US and Australia (neither of which are GECF member countries) expected to be in operation within this decade, together with parallel development of the LNG carrier fleet, the prospect is that the LNG market will enjoy a fair degree of liquidity by or before 2020. In a liquid LNG market it may be even more challenging maintain an oil price link going forward.

The LNG value chain

Chapter 2 assesses the LNG value chain, the way it is structured and operates, and includes a thorough description of risks and LNG contract terms. The chapter sets out up-to-date information on all liquefaction plants (with a summary of liquefaction technology), LNG tanker fleets, and regasification terminals. Several technical graphics illustrate the different processes.

Emerging issues in the LNG chain

• LNG by truck: most LNG is converted to gas and compressed into long distance pipelines but it can also be delivered directly to customer sites ("virtual pipeline") when low populated areas do not justify underground pipelines or when construction lead-times are too long to meet growing gas demand.
• Bi-directional projects: liquefaction added to regasification terminals with lower construction costs and timelines than greenfield liquefaction projects.
• Floating Storage and Regasification Units (FSRUs), hailed as a low-cost revolution with the potential to become the terminal of choice.
• Floating Liquefied Natural Gas facilities (FLNG): small scale projects with production capacities ranging between 1.5–3.0 MMtpa but mobile and quick to construct can provide a suitable solution to meet gas shortfalls.
• Reloading at regasification terminals and ship to ship transfer: the progressive disappearance of destination clauses is giving new life to LNG terminals which not only deliver gas to the local distribution grids but also load methane tankers to trade LNG. Terminals also provide support to transfer cargoes for re-export LNG before off-loading and from ice-breakers to classic methane carriers.

An integrated LNG project typically takes about a decade to put into place. High upfront capital investment and lengthy development periods are unavoidable features of these projects and make it necessary to have a strong commitment among the partners, including the financial participants. The requisite level of commitment has instigated a number of different formulae or partnership structures that have evolved along the years. Some of these approaches set forth in this study involve:

- Traditional structure with a selling consortium contracting with one or more energy utilities;
- Integrated project structure controlling all the links of the LNG chain;
- Aggregators holding a portfolio of LNG supply sources for onward sale to downstream markets and their own (or chartered) fleets of LNG carriers; and
- Tolling model where the "toller" enters into a lease contract with the infrastructure owner under a fixed charge.

The different approaches seek to reconcile investment needs with market requirements while complying with changing regulatory frameworks that seek to protect customers and encourage competitive markets. The challenge is how to make business models suited to attract investment compatible with competition-seeking rules such as the unbundling of commercial activities and infrastructure management, or with the skepticism of authorities about long-term contracts.

Liquefaction

Liquefaction is the most capital and energy intensive component of the LNG value chain. It consists of chilling natural gas to the point where it becomes liquid, at an average temperature of –160° C (–260° F), which is an energy-intensive process: 275-400 kWh/ton LNG. This step represents more than half of the total capital investment and more than half of LNG production costs. Investment costs for a liquefaction plant have increased dramatically during the last decade, from about $400 per ton of capacity in 2004 to $1,000 per ton in 2008. The main reasons for the increase have been the shortage of key EPC (Engineering, Procurement and Construction) contractors, challenges in finding a skilled workforce, and rising costs of steel. Costs moderated after 2008 due to the global financial crises but further reductions are not expected.

Regasification

Regasification (or vaporization) consists of returning LNG to its regular gaseous phase at about 5º C using heat exchangers. Typically, regasification represents 10% of total investment in the LNG value chain and 8% of gas production cost. More than 75% of the world's regasification capacity is located in five countries: Japan 30%, US, 20%, South Korea, 12%; Spain, 8%, and UK, 6%, and total regasification capacity is much higher than liquefaction capacity. Storage tanks represent nearly 50% of the total cost of a regasification terminal. Currently, the largest LNG storage tanks have a capacity of 200,000 m^3.

Shipping

The global fleet has expanded in the past decade to a total of more than 358 vessels, with a combined capacity of about 52 million m^3 of LNG. Shipbuilding is rising again in response to major demand growth in the Asia Pacific region as economies recover and as LNG demand grows in Japan following the Fukushima disaster. Shipping can represent between 8 and 12% of total investment in the LNG value chain and around 15% of gas costs.

Qatar has driven the increase in ship sizes as Rasgas and Qatargas projects have ordered 45 ships bigger than 200,000 m3 (14 Qmax (263,000-266,000 m^3 and 31 Qflex 209, 200-217,300 m^3). The rationale has been to enable further destinations and improved efficiency in LNG transport. Though most LNG transport has been carried out in large-scale LNG carriers to ensure economic delivery, small LNG carriers are emerging as a way to address constraints and restrictions at smaller ports closer to final customers. The capacity of small LNG carriers ranges between 500 cubic meters and 12,000 cubic meters.

Other than enlarging the capacity of LNG ships, development has focused on new propulsion systems, containment, and winterization/ice class (ships ordered by the Snohvit and Sakhalin projects). Prevailing containment technologies are membrane systems installed in around 70% of ships, and spherical Moss (30% of the fleet, approximately).

The high price of diesel compared to boil-off gas since 2010 has been a strong incentive to modify vessels to accept boil-off gas as their fuel. On board re-liquefaction allows an operator to arbitrage between LNG and HFO/diesel. Today, most LNG carriers use boil-off from their cargo as fuel for steam boilers and propulsion but there is an opportunity to broaden maritime use of LNG if the industry and regional governmental and port authorities develop the infrastructure to store and supply LNG more widely than at present.

Is there an ideal regulatory framework for LNG?

Chapter 3 deals with Regulation and presents the approach to regulate the LNG industry in such major importing regions or countries as Europe, US and Japan. The chapter explores the strategic and societal rationales underpinning each kind of regulation. There is consensus that no single system of regulation is valid for different markets, for different institutional arrangements and for different political priorities. Each case requires careful assessment and even a mix of different regulatory models may be appropriate. Nevertheless, a comparative analysis of existing regulatory frameworks can help anticipate how certain rules might attain or impede attainment of desired objectives.

The regasification terminal is the step of the whole LNG value chain that tends to attract the most interest from a regulatory perspective because it is an important means of access to gas markets. The regulatory framework that applies to a regasification terminal would be a prominent factor in the attractiveness of investment or the number and kinds of players who may access a particular market.

Extensive and detailed attention has been given in Chapter 3 to the main pieces of regulation on LNG in the European Union, Directive 2009/73/EC and Regulation 715/2009, which are integral part of the so-called "Third Energy Package". The chapter also assesses how European LNG terminals are operated: services offered, access rules, booking procedures, congestion management and capacity allocation mechanisms, programming and nominations, tariff and contracts, and so forth.

In addition to specific operational issues, there are abstract matters of general interest and with a significant impact on the regulatory approach to LNG terminals such as access regimes, secondary markets, and construction permits.

Access regimes

European legislation enshrines the principle of regulated third party access (TPA) to all essential infrastructure. However, the objectives of encouraging investment in LNG terminals, diversifying supply sources and overcoming limitations caused by insufficient pipeline connections, have triggered several exceptions to this principle. Regulated and non-regulated access regimes coexist in Europe, and can even be applied to the same terminal. It is difficult to talk about a common European approach to TPA to LNG terminals.

Japan imports most of the gas it consumes and all imported gas enters as LNG. There is not a nationwide interconnected pipeline system and each of the 27 LNG terminals operating in Japan is dedicated to supply specific power plants or neighboring gas markets. Construction of a new LNG terminal is as possible so existing LNG terminals are not categorized as essential facilities. For this reason, there is not regulated but negotiated TPA to LNG terminals and, in practice, there is no TPA access. In other parts of Asia TPA is not even considered.

In the US, the three LNG terminals in operation were authorized under open access regulation (similar to TPA) but the "Hackberry decision" of 2002 represented a major policy shift in the regulatory approach. This decision and subsequent codifying legislation waived open access requirements for import terminals (subject to demonstrating lack of market power) and treated them instead much like gas wells, which are not subject to price regulation in the US. This step was intended to foster investment in LNG import terminals within a context of uncertain future natural gas production in North America and a perceived need to import significant quantities.

The Hackberry decision affected not only the US but also fostered lively debate in Europe and other parts of the world about the type of regulation needed encourage investment in LNG import terminals.

The key question behind the access regime for LNG regasification terminals is whether these facilities are regarded as part of the downstream or of the upstream business. If they are part of the downstream business, then the argument could be made that LNG terminals should be considered essential infrastructure and, therefore, must be regulated just like other transmission infrastructure. If they are part of the upstream business then they could be considered part of the production portfolio and subject to a more light-handed regulatory approach. Countries that have opted for negotiated access have had poorer results in terms of third party-access to LNG terminals, but terminals not subject to a regulated regime have generally enjoyed more stability and predictability in rate of returns, which is a means of attracting investments. Therefore, the choice of regulated or negotiated access as the access regime will depend on policy priorities.

Unbundling of LNG terminals is an issue linked to and with a clear influence on access conditions. Where LNG terminals are considered part of the downstream gas infrastructure unbundling requirements are usually applied. Under some regulatory regimes an effective separation of commercial and infrastructure interests is deemed to be a requisite to ensure the independence of LNG operators but even under these regimes there are LNG terminals that are not subject to unbundling requirements. In Europe, the unbundling of LNG operators has not been imposed by regulation but has been the consequence of unbundling transmission companies that also operate LNG terminals.

Secondary markets

An effective secondary market at LNG terminals is a valuable tool to increase market liquidity, minimize contractual congestions and prevent capacity hoarding. Primary holders of capacity can be required to place back on the market all the capacity they do not intend to use through bilateral deals or through a formal secondary market. European regulators in particular are keen on eliminating barriers to the creation of secondary markets for the above reasons but also to facilitate access to short-term capacity for spot cargos so taking into account the needs and constraints of small players. Even LNG terminals exempted from TPA in the US and the UK (Isle of Grain, South Hook and Dragon LNG) have secondary markets in place.

Construction permits

Finally, there is an issue not directly related to the way existing LNG terminals are managed but on how new terminals are permitted and built.

Developing new infrastructure in an increasingly environmental-sensitive world involves time-consuming procedures and complex negotiation with different government levels and agencies to the point that a wrongly-designed regulation on authorizations may neutralize the positive effects of good regulation in other areas. This complexity, often related to the NIMBY syndrome (unlike the PIMBY syndrome observed in Spain, is particularly relevant in some countries like Italy. IT has been a driver for the emergence of new and creative alternatives such as offshore LNG receiving facilities (FSRU, FLNG).

Interoperability and safety in international LNG trade.

Chapter 4 analyzes LNG quality issues and initiatives to harmonize LNG specifications in order to obtain full interchangeability and appropriateness to new gas uses. The chapter also explores quality adjustments that can be performed at the different steps of the value chain. In addition, the chapter addresses the physical engineering compatibility of liquefaction plants and regasification terminals and the requisites of LNG tankers or ship-shore interface. Chapter 4 contains appendices detailing useful information on specific topics such as gas quality requirements in LNG importing countries, LNG quality average in exporting countries, vessel approval procedures at regasification terminals and a complete list of international associations involved in LNG quality.

The chapter draws three broad conclusions:

- The LNG industry has achieved the high level of safety throughout its 50-year history.
- The operational safety standards and their compatibility throughout the LNG chain have been a result of industry commitment. Regulations have typically followed or complemented the industry initiatives.
- Though there is room for improvement, existing differences in LNG specifications, liquefaction plants, receiving facilities, local operation procedures, LNG tanker designs, and so forth have not been a barrier for development of global LNG trade.

Despite these achievements, the industry needs to maintain the initiative and anticipate the challenges inherent in a rapidly growing business. New supply sources and an expanding number of LNG facilities and users pose challenges which can be grouped in two broad categories, LNG quality and information sharing.

LNG quality

The issues of LNG quality and interchangeability are of common interest to producers and purchasers of LNG due to increased liquidity in the LNG market. Gas quality concerns involve sulphur and mercury content, as well as calorific value. Gas interchangeability is the ability to substitute one gaseous fuel for another in a combustion application without materially changing operational safety, efficiency, performance or materially increasing air pollutant emissions. At the moment the world is split into three areas where different specifications predominate:

- the Asian market with rich gas requirement (high calorific value, high Wobbe number),
- the Atlantic Basin with preference for leaner gas, and
- the European Union that is trying to harmonize specifications among member states to make acceptable a wide range of lean and rich LNGs.

Full harmonization of traded LNG quality is unlikely because different gas fields have different compositions and the liquefaction process influences its quality. Some degree of harmonization of LNG specifications is necessary to acceptance at all LNG terminals and by a majority of end users. This issue is especially important for electricity generation using combined cycle gas turbines, which currently are the fastest growing and largest potential gas users.

The impact of different qualities of gas on the performance of domestic appliances is under study by many organisations with the objective to assess the impact of a wider range of heating values and Wobbe Index on their safety, operations and efficiency. Blending, mixing of LNG during offloading, mixing of LNG during send out and ballasting are all methods of controlling the quality of LNG to conform to contractual conditions and end-use requirements. A final objective is to ensure that all LNG importing countries and end users have access to all sources of supply.

Standardization and sharing of information

There is presently a huge body of knowledge on operational issues of the LNG chain. The information comes from a range of sources, is located in a multitude of reports, and is growing rapidly. For LNG to become a truly global industry, important efforts are needed to normalize the information and to make it widely available and understood. Dialogue that has always existed among players in the LNG chain, even players from distant regions, must be encouraged and focused on the standardization and exchange of information. Regulatory bodies should be part of this dialogue as well. Such efforts would contribute to increasing compatibility, added operational efficiencies and improved safety throughout the whole LNG chain.

A main conclusion of this study could be that if natural gas is an essential energy source for a sustainable future, **LNG is the gateway to a global gas market.**