CHAPTER 7

World LNG shipping: dynamics in markets, ships and terminal projects

Siyuan WANG and Theo NOTTEBOOM

Abstract
The aim of this paper is to explore how world Liquefied Natural Gas (LNG) shipping has developed over the last decade given the growing usage of natural gas and increasing seaborne trade volume of LNG over the world. The paper presents current dynamics in the LNG shipping market focused on three aspects: the evolution of LNG short-term shipping and market structure, the growth of the LNG fleet and the development of terminal projects. It is found that with the liberalization of LNG trade, short-term shipping is rapidly growing, and that the size of LNG tankers and the scale of terminals are also extending accordingly in order to benefit from economies of scale.

1 | Introduction
Given its ease of use and environmentally-friendliness, Natural Gas is fast becoming one of the most attractive energy sources in the world. According to the latest report from EIA (The International Energy Outlook 2010), the total natural gas consumption worldwide is expected to increase by 44%, from 108 TCF\(^1\) in 2007 to 156 TCF in 2035. Although the global economic recession slowed down demand in 2009, once world economies begin to recover from the downturn, the demand will rebound. The consumption of natural gas, projected by EIA, is expected to grow at an average rate of 1.8% from 2007 to 2020. Figure 1 shows the outlook for world energy consumption by source. Nowadays, the transportation of Natural Gas is mainly done by pipeline and by shipment in the form of liquefied natural gas (LNG). LNG is natural gas that is stored and transported in liquid form at atmospheric pressure at a temperature of -161°C (-256°F). Liquefied gas occupies a volume corresponding of 1/600 of the gas in the gaseous form which eases the transportation process and allows to ship LNG in specialized LNG carriers. Most experts indicate that LNG shipping is more competitive in cases where pipeline transportation is not feasible due to geographic constraints or not economic, particularly for medium and long distances.

\(^1\) TCF: Trillion cubic feet, CM: Cubic meter, BCM: Billion cubic meter, BTU: British thermal unit, MMtpa: Million Metric ton per annum.
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Figure 1. World marketed energy use by fuel type, 1990-2035 (quadrillion BTU)

Source: EIA, International Energy Outlook 2010

Figure 2. Growth rates of marketed production, total natural gas trade and LNG trade

Source: GIIGNL, The LNG Industry 2009

Figure 3. Global gas consumption by LNG, regional pipelines and domestic production

Source: Shell
Figure 2 shows the growth rate of LNG trade up to 2009, versus the natural gas trade and marketed production. Figure 3 presents the gas consumption by types. The demand for LNG is expected to grow by an average of 10% per annum up to 2015.

With the increase of LNG international seaborne trade, world LNG shipping is booming, but so far it has received little attention compared to other stages of the gas chain. There are four key academic publications on LNG market dynamics.

Jensen (2004) made a study on the development of the LNG market with the aim to examine whether the global market would be shaped by the dynamics of the LNG trade of the past ten years. Although long-term contracts in LNG have been the vehicle for sharing the large up-front investment risks that characterize LNG projects, the paper demonstrates that short-term trading is growing fast in recent years. The study also shows that declining costs of delivering LNG, the growing diversity of supply sources and a loosening of the traditional rigid industry structure have created a system which can transmit price signals freely between isolated regional gas systems, therefore arbitrage trade is developed. However, as the author noted, the increase of physical flows between regions does not imply a global market. Since the long term contract still remains a mainstay of international trade, the growth of short-term trade volume and price arbitration are limited accordingly. Thus, a LNG global market may well not live up to expectations.

Through an analysis of recent developments in LNG shipping, Dorigoni et al. (2008) conclude that LNG shipping is intrinsically related to LNG sector dynamics, especially since the owners of tankers are companies controlled by gas producers and to a lesser extent by gas importers. This implies that long-term contracts are often used.

Gkonis and Psaraftis (2009) used a game theoretic approach to study competition in LNG shipping. The conclusions contain three key points for strategic decision-making by shipping lines. First, shipping companies must take into account the capacity each company supplies to the market. Second, the greater versatility and adaptability achieved by having smaller vessels in the fleet should be compared to the economies of scale advantages that a portfolio consisting of large scale vessels enjoys. Finally, non-cooperative collusion may exist in the LNG shipping business.

Engelen and Dullaert (2010) examined transformations in gas shipping aimed at understanding the features of the gas shipping market, distinct with other main merchant markets (dry, tanker and container markets). They demonstrate that the LNG shipping market is transforming and evolving to a more competitive setting. The operational efficiency in the LNG market can be increased significantly when sellers take a more thorough stance towards contracting tonnage on the back of product supply. More flexible contracts will be used in a market with more dispersed sellers and buyers.
It is particularly interesting to analyze the LNG shipping market in view of understanding how it is linked to other stages of the chain, how it has developed and what the drivers behind this development are. This paper aims to find answers to these questions by presenting current dynamics in the LNG shipping market focused on three aspects: the evolution of LNG short-term shipping and market structure, the growth of the LNG fleet and the development of terminal projects. In this way, the paper tries to add value to existing literature in the field.

This paper is organized as follows: Section 2 discusses the LNG supply chain and provides a brief overview of world LNG trade. In Section 3, the development of the LNG shipping market, especially the growing short-term shipping market, and evolutions in the market structure are analysed in detail. Section 4 looks at the growth of the LNG fleet and ship distribution by type, age and size. Finally Section 5 provides more insight in global LNG export and import terminal projects.

2 | LNG trade and the LNG supply chain

2.1 World LNG trade

The dominant LNG consuming area is found in the Asia Pacific region where Japan, South Korea and Taiwan are the big importers. However, in recent years China and India are developing infrastructure to accommodate LNG imports. The European import volume is increasing slowly linked to the growth of pipeline transport capacity in this region. North America is witnessing a decrease in imports since 2007 as the US has significantly increased its own production in recent years through the exploration of unconventional gas (i.e. shale gas).

The main LNG producers and exporters are also situated in the Asia-pacific region, including Indonesia, Malaysia, Australia and Brunei. However, over the last ten years the total export volume from this region has remained rather stable. Indonesia and Malaysia are gradually losing their position to new rivals due to the maturity of gas fields in these countries. Meanwhile Middle East countries such as Qatar, Oman and UAE are becoming more important. Africa (Nigeria, Algeria, and Egypt) and America (Trinidad and Tobago) have also expanded their export capacities in recent years.

Figures 5 and 6 show the market shares of import and export countries in 2009. Note that Japan, South Korea and Spain are still the three biggest import countries. At the export side, Qatar extends its share to more than 20% (49.44 BCM) and delivers its cargo to 15 countries across three continents. Furthermore, the volume from Trinidad and Tobago accounts for 8.1% of total exports in 2009.
Figure 4. Overview of world LNG imports and exports (2000-2009)

Source: own elaboration based Poten & Partner (2010)
2.2 Overview of the LNG supply chain

Four distinct activities can be identified in the LNG supply chain (Figure 7): gas exploration, liquefaction, shipping and regasification. For each of these stages, advances in technology and design have led to significant cost savings and efficiency improvements, which have enhanced the competitiveness of LNG.

Figure 7. The LNG supply chain

Source: own elaboration based on Nikhalat and Zavitsas (2010)
Gas production is a capital intensive activity requiring large investments. However, the amount of investment varies depending on the characteristics of the gas reservoir. Normally gas production including gas processing and associated pipelines constitutes 15 to 20% of the cost of an entire LNG project. The largest cost component in the LNG value chain is the liquefaction plant (30 to 45% of total costs), which consists of one or more “trains” (production unit) to purify LNG by removing contaminants and liquefying gas by the use of refrigerants. LNG transport (10 to 30% of total cost) requires special tankers which are double hulled and insulated as to ship the cargo at a temperature of minus 161°C. Since an increasing number of shipyards is equipped to build LNG tankers, the price of purchasing an LNG tanker declined in the last decade. In addition, with the growth of ship size (from 138,000 CM to 260,000 CM) and technological advances in propulsion systems, the unit transport cost has been considerably decreased.

The final part of the LNG supply chain concerns storage and regasification at the receiving terminal (15 to 25% of total costs). Through the regasification process onshore, the liquid is transformed to natural gas and then pumped to grids for delivery to the end users. These users can be power plants (30% of global use in 2009), industries for plastics and fertilizers (27%) and residents for commercial use (21%) (EIA, 2010b).

2.3 Effects of technology on cost reduction

LNG projects are highly capital intensive, most projects costing several billion dollars. However, economies of scale are significant. The reduction of unit costs of liquefaction plants is not only achieved by increasing the size of each processing train (from 3.5 MMtpa in 2005 to 7.8 MMtpa (Qatar Projects) in 2010), but by setting up new trains as well. Adding a second train once a plant is built can reduce the unit cost of a liquefaction train by 20 to 30% (Cornot-Gandolphe 2005). In addition, technological progress over the past four decades has led to a sharp decrease in investment and operating costs of liquefaction plants. The average unit cost for a liquefaction plant dropped from $350 per ton per year of capacity in the mid 1990s to approximately $200 in 2010 (Figure 8).

Transport costs are largely a function of the distance between the liquefaction and regasification terminals. Using a larger number of smaller carriers offers more flexibility and reduces storage requirements but raises unit shipping costs. The largest LNG carriers today have a maximum capacity of 220,000-266,000 CM. Substantial cost reductions have been achieved in recent decades thanks to economies of scale. Regasification plant construction costs depend on throughput capacity, land development and labor costs (which vary considerably according to location), and storage capacity. Economies of scale are most significant for storage. Tanks with a storage capacity of about 480,000 CM (the largest feasible at present) are currently the optimal size.
2.4 Advantages of LNG compared to transport by pipeline

Gas producers have to consider which transport method they will use for delivery to the markets: LNG shipping or pipelines. But where such a choice exists there is a marked difference in cost build-up versus distance to market. Research by ENI shows that an LNG project, along the chain from production to the market, has a high cost threshold, but distance to the market is not as crucial as for pipeline delivery. The costs of a gas pipeline are highly sensitive to scale and the distance to the market. Figure 9 demonstrates that LNG shipping is more competitive than pipeline on long distances. The LNG project break-even distance versus a 42-inch onshore pipeline is 2,500 miles (4,000 km) and 1,240 miles (2,000 km) for an offshore pipeline (Ndao 2004).

Source: ENI
However, costs are not the only determinant for the choice between LNG and pipeline supply. Pipelines may have to cross many counties, whereas LNG trade normally only involves an end-to-end route from port of loading to port of discharge. The absence of transit negotiations and treaties (and possibly high transit costs) simplifies the project development process in the case of LNG and makes for shorter development times (and may offer an additional cost advantage). ‘Security’ aspects are also a major concern. An extended pipeline system transiting many countries poses supply security issues. For LNG these are more contained as transit through other countries is limited. Moreover, with regards to safety performance, LNG has a very good track record. The effect of a shipping accident at sea would not be catastrophic and would only have a limited environmental impact (Clingendeal 2003).

Diversity of supply is yet another aspect of ‘security’. For a number of markets LNG offers a realistic alternative to a single dominant supply source. As the LNG market grows, so does its ability to offer flexibility of supply between markets: if a market cannot take delivery of a cargo, the ship can be redirected to another market. If a supply source experiences a problem, the cargo can be shipped to the market from another source. In addition, such flexibility also encourages gas sellers to do arbitrage trade taking advantage of a price difference between the markets to maximize their profit (Clingendeal 2003). Hence, it can be concluded that the flexibility of LNG supplies and arbitrage opportunities between different consuming areas are among the biggest advantages of LNG over pipelines.

3 | Dynamics in the LNG shipping market

3.1 Evolution of the short-term shipping market

The LNG industry originally developed as a niche business where a relatively small number of sellers supplied specific regional markets, using a traditional approach with tankers dedicated to bilateral trades for long-term contracts (normally more than 20 years), and there is little in the way of spot/short-term trade (less than 3 years) or cargo diversions from the originally intended destination. In the early of 1990s, the LNG world was firmly divided between the Atlantic Basin and Asia Pacific markets (Figure 10). There was minimal trade between these two regions, and consequently little or no market or price interaction (Thompson et al, 2009). The capital-intensive LNG projects obliged the investors to conclude long-term commitments with customers in order to minimize risks and secure their return on investment.

However, with debottlenecking and the expansion of liquefaction plants, more surplus volume was offered which either effectively rolled into long-term contracts and sold to the same buyers or flowed into the alternative markets. As a result of the latter a short-term market started to emerge and regionalization of the industry began to
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break down. Other drivers favouring the short-term market include:

- Flexibility of supply: once the long-term buyers couldn’t absorb the contracted volume, with more flexible contract terms (i.e. no destination restriction clause), the sellers can divert the cargo to alternative buyers in order to arbitrage prices between the markets.

- Quick response to gas demand: once natural events occurred upon buyers (i.e. pipeline supply is curtailed or a sudden increase of seasonal demand), the buyers can search for gas from other supplies.

Figure 10 shows that there are far more short-term trading routes (indicated by thin lines) in 2008 than in 1990. Most of these routes are cross regional, i.e. from North Africa and South America to the Asia-Pacific region.

Figure 10. Changes in LNG Trading Routes for last two decades

Source: Poten & Partner
While a very small short-term LNG market has been in existence for nearly a decade, it has grown rapidly in the past several years. In 1997, short-term LNG transactions accounted for only 1.5% of international LNG trade. In the following four years the volume of short term transactions increased six fold and in 2001 accounted for 7.8% of international trade. In late 2008 the share amounted to 17.8%. As estimated by Thompson et al (2009), short-term trade volumes will increase at an average rate of about 11% per annum between 2008 and 2015, with most of the growth occurring between 2011 and 2014. This short-term growth rate is faster than total growth in the LNG market, causing the share of the short-term trade in total trade to increase from 20 to 25% during this period.

Although it is envisioned that the short-term market is continuously growing, “the long-term contracts would be still alive and well” (Jensen, 2004) since no supplier has yet undertaken to build a new facility on a speculative basis without a contracted outlet. But for short-term markets, suppliers in different regions have their own strategies to balance short-term and long-term contract volumes. Suppliers in the Atlantic and the Mid-East region are more active in the short-term market with a growing offering up to 2015 (Figure 11). However, the Asia-Pacific basin (Malaysia and Indonesia) still prefers firm long-term commitments.

Figure 11. Short-term LNG demand and supply by region, 2008-2015

Source: Poten & Partner

On the demand side of the short-term market, importers of the Atlantic basin are more important than Asian-Pacific buyers. Asian importers rely almost exclusively on LNG as their gas source, making them more sensitive to supply risks. The import volume for this region will also go up in the following years, since Korean and China are major growth markets for short-term trade. With the growth of the short-term trade, the liberalisation of the gas market, a new global and competitive market is in the making.
3.2 The structure of the LNG Shipping Market

The LNG market developed for a long time as an oligopoly market which was dominated by a few big state-controlled or regulated oil and gas companies and a few independent shipowners. As part of the global trend towards privatization of the energy markets, the transformations taking place in the LNG market are heavily influenced by deregulation and liberalization in both the upstream and downstream gas markets. Figure 12 indicates that the ongoing changes have recently resulted in more cooperation agreements and the setting up of creative consortiums between market players. Nowadays, it can be found that some independent shipowners cooperate with upstream gas sellers by investing in liquefaction projects (i.e. in 2004, Golar LNG had a corporation with the BG group). Some other shipping companies invest with downstream buyers in import terminals or even take over the role of refrigeration terminals by converting ships to floating gas production or regasification units (Engelen & Dullaert, 2010).

![Figure 12. Evolution of LNG market structure](attachment:image)

Source: own representation based on Engelen & Dullaert (2010)

The dominance of a few large state monopolies is decreasing although the key gas-rich countries in the Middle East, like Qatar, still hold a national LNG fleet and control most of the upstream and downstream business. Qatar gas, the national gas company of Qatar is holding the largest LNG shipping capacity in the world by fully owning 24 tankers and 30 other units in joint venture with independent shipping companies or downstream buyers.
Among the top nine shipowners there are four independent shipowners (NYK, MOL, Teekay and K-line). Of the 57 owners around thirty are shipping companies. More individual shipping companies are entering the market, but a portion of the ship capacity of these independent shipping companies is jointly owned by upstream sellers or downstream buyers. Roughly 74% of the current fleet is under joint venture and only 26% is wholly owned by single owners.

Figure 13. Distribution of the LNG tanker capacity by shipowners

Source: own elaboration based on Clarkson data 2010

4 | Dynamics in the LNG Fleet

4.1 The development of the LNG fleet

The first LNG cargo was shipped in 1959 by Methane Pioneer. The construction of the first large-scale liquefaction plant took place in 1964 in Algeria. The LNG trade started from North Africa to Europe and the USA, and from South East Asia to Japan. The 1973 oil crisis intervened and the uncertainty this created, especially over future gas export prices, resulted in projects being deferred or abandoned altogether. Investor confidence only revived in the early 1990s. Trade quadrupled from 48 BCM in 1984 to 242 BCM in 2009.

The development of the LNG fleet followed the LNG trade climate. Shipowners are sensitive to the volatility in the market. They order more ships when the market goes well and try to reduce capacity when the market is weak. The time-lag between new orders and deliveries creates cycles in the LNG shipping market of roughly 3-4 years (Figure 14).
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Figure 14. Market cycles in LNG shipping

Source: own elaboration based on Clarkson data

Growth in the world LNG fleet peaked in 2008 with an increase of 29% compared to the previous year (i.e. 49 new tankers delivered of which 19 large units). In July 2010 there were 353 LNG tankers with a joint capacity of 50 million CM. Some 30 vessels were on order with a total capacity of 4 million CM. In the first half of 2010 two ships were sold for scrapping and five tankers were converted to FSRU (Floating, Storage and Regasification Unit). According to the economic research by Platou in 2009, the supply of the LNG shipping capacity outweighed demand during 2009, which would explain why no more new orders occurred in 2010 leading to a strongly decline in the growth rate of the fleet until 2012 (Figure 16).

Figure 15. Growth rate of world fleet by type (LNG ships vs bulk carriers, tankers and container ships)

Source: authors’ elaboration on Clarkson data 2010
The study of Platou (Figure 17) also revealed that the slow growth of shipping demand in 2009 contributed to a reduction in vessel speed. The average speed of the LNG fleet is estimated to have fallen due to continued high bunker prices and also as a result of oversupply. Another driver behind demand was storage as a number of the idle Qatari vessels were used for storage purposes. Moreover, a negative factor to the demand in 2009 was a six percent decline in average traded distance. After the demand collapsed in Japan and Korea following the financial crisis in the autumn of 2008, prices fell and the arbitrage trade between the Atlantic and Pacific basins plummeted to one third of what was recorded in 2008. Consequently the utilization rate of the LNG fleet fell by nine percentage points to 75% in 2009 and thus pushed the average short-term charter rate down.

**Figure 17. Supply, demand and utilization rate of the LNG fleet, 2000-2009**

*Source: Platou Economic Research (2009)*
In 2010, the situation improved. On the demand side, volumes from the new LNG projects and an increase in average distances contributed to a marginally higher growth in demand compared to supply. This led to a small improvement in the utilization rate and thus spot rates. An increase in arbitrage trade or storage may improve the utilization rate.

4.2 Ship distribution by type, size and age

LNG carriers are constructed according to the double-hull concept. The ship’s bottom is protected against ship grounding incidents. Furthermore, the gas must be carried according to the so-called “cargo containment system” principle, i.e. the cargo tanks are installed separately in the ship’s holds, and are not part of the ship’s structure. According to the types of containment system, LNG carriers can be classified in two types: Membrane and Moss (spherical). The Membrane system, introduced in 1969, is rectangular and fully integrated into the hull and relies on the strength of the ship’s hull. This system is based on a very thin primary steel barrier (0.7-1.5 mm membrane of stainless steel alloy) supported by insulation. Therefore, cargo tanks of this type are not self-supporting, but only a relatively small amount of steel has to be cooled. However, the Moss system, introduced in 1971, uses distinctive self-supporting spherical tanks, with a single insulation layer, not integral with the hull, but propped up by a cylindrical supporting structure (Figure 18).

Figure 18. Examples of LNG carriers based on Membrane and Moss types

138,000 m³ LNG carrier of the membrane type

138,000 m³ LNG carrier of the spherical (Moss) type

Nowadays, membrane tanks are most common because of their higher utilization of the hull volume for cargo capacity (i.e. for the same cargo capacity, the ship dimensions are smaller than for a similar spherical (Moss) type LNG carrier). However, the boil-off gas amount is higher for the membrane tank type compared to that of the spherical tank type. Prismatic membrane tanks have been introduced which largely reduce the amount of boil-off gas. In addition, spherical tanks are more expensive (20 to 30% more than ships with membrane tanks) and require a longer construction period.

*Figure 19. Distribution of containment systems*

![Distribution of containment systems](image)

*Source: own elaboration based on Clarkson data*

Another notable characteristic of an LNG carrier is its propulsion system based on steam turbines, a technique no longer applied to other ship types. An LNG carrier can burn its boil-off gas in the ship’s boilers. Some 273 ships (77%) of the current fleet use steam turbines. However, diesel engines and dual-fuel diesel-electric engines are more and more applied to newer tankers in view of improving fuel efficiency.

LNG carriers can be classified according to ship dimensions, as shown in Table 1. The LNG fleet may be the youngest fleet in the shipping industry. Figure 20 illustrates that more than 50% of the fleet is under the age of four years. All large ships (Q-Flex and Q-Max) are within this class.

*Table 1. LNG carrier classes by size*

<table>
<thead>
<tr>
<th>LNG carrier classes</th>
<th>Ship size - LNG capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>up to 90,000 CM</td>
</tr>
<tr>
<td>Small Conventional</td>
<td>120,000 - 149,999 CM</td>
</tr>
<tr>
<td>Large Conventional</td>
<td>150,000 - 180,000 CM</td>
</tr>
<tr>
<td>Q-flex</td>
<td>200,000 - 220,000 CM</td>
</tr>
<tr>
<td>Q-max</td>
<td>More than 260,000 CM</td>
</tr>
</tbody>
</table>
Figure 20. The current LNG fleet age profile (situation on July 31, 2010)

Source: own elaboration based on Clarkson data

Figure 21. Average size of fleet vs. average size of delivery

Source: own elaboration based on Clarkson data

Figure 22. Ship size distribution by year of delivery
The average size of the LNG fleet has been continuously growing for the last decade, from 112,649 CM in 1998 to 136,367 CM in 2008. The average size of the current fleet (353 ships in total) is 142,092 CM and it is expected to remain the same for next two years (Figure 21). Figure 22 illustrates the distribution of ship size by year of delivery. Several large ships owned by Qatar gas were delivered in the last couple of years (16 Q-flex and 4 Q-Max).

From 2008, more large ships have been delivered. However, the growth in ship size is restricted by the scale of loading and unloading terminals, especially for LNG carriers purpose-built for special projects. An analysis of the distribution in ship size distribution (Figure 23) shows that capacity class of 100,000-150,000 CM accounted for 64% of the current fleet (average age of 10 years). Most of these vessels were built ten years ago when this size represented the technological standard and just few regasification terminals could receive ships bigger than this size. However, with the delivery of larger ships, receiving terminals are getting bigger. In October 2010 there were 34 import terminals in operation all over the world that can accommodate ships over 200,000 CM. This represents 40% of all terminals in operation. Fifteen terminals able to accommodate ships of over 200,000 CM are under construction, accounting for 67% of all terminals under construction. It can be foreseen that more large size tankers will be ordered in the future.

![Figure 23. Ship size frequency distribution](image)

The distribution of ship size by sailing distance is presented in Figure 24. There are still some small ships operational on regional trades, e.g. Algeria-France (515 miles) and Malaysia-Japan (2208 miles). However, the most common vessel size (100,000-150,000 CM) is deployed on a wide distance range from 1500 miles to 6000 miles, some serving regional and others cross-regional trades (e.g. Qatar to Japan - 12 ships and Korea - 8
The newest classes of large ships, Q-Flex and Q-Max, are deployed on the routes between Qatar and Europe/US. Qatar has become the biggest LNG exporter in the world despite its location far away from the markets: the average distance to Europe amounts to 5,737 miles, Japan is 6,508 miles away and the US 9,680 miles. Qatar Gas uses large ships to reduce unit transport costs and to keep its competitive position.

Figure 24. LNG tanker size and distance covered

Source: own elaboration based on data of World LNG Journal (Aug, 2010)

5 | Overview of terminal projects

LNG terminals both in export countries and import countries play an important role for LNG seaborne trade. Once an LNG project is launched, the project developers have to finance and construct liquefaction or regasification facilities along the quay side. Export terminals typically consist of pipelines, liquefaction plants, storage tankers and loading facilities. Pipelines convey the natural gas from the gas fields to the liquefaction plant. After the liquefying process the liquids are transferred to storage tanks, and then finally loaded in an LNG carrier.

In October 2010 there were 56 export terminal projects in operation in 18 countries. The aggregate capacity of all liquefaction plants amounted to 274.2 Million ton per year (Table 2). There are a number of projects under construction and others are planned. The Pacific region has a lot of projects under construction or planned. Australia is also important in this respect. Currently, there are three terminal projects under construction in Australia. By 2014, the maximum loading volume will reach 47.85 million ton per year, overtaking Indonesia to become the biggest LNG exporter in the Pacific region. Moreover, nine projects are planned in Australia which could make Australia the biggest LNG exporter in the world. Iran and Papua New Guinea will join the list of LNG exporters in 2012. Canada and Brazil might be potential exporters since
they already plan to develop liquefaction facilities.

Table 2. Overview of export terminal projects in operation in 2010

<table>
<thead>
<tr>
<th>Region</th>
<th>Export Country</th>
<th>No. of projects</th>
<th>No. of trains</th>
<th>Total Liquefaction Capacity (MMt/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic</td>
<td>Algeria</td>
<td>6</td>
<td>21</td>
<td>28.4</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>4</td>
<td>6</td>
<td>21.9</td>
</tr>
<tr>
<td></td>
<td>Trinidad Tobago</td>
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<td>4</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>Egypt</td>
<td>3</td>
<td>3</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td>1</td>
<td>1</td>
<td>4.3</td>
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<tr>
<td></td>
<td>Equatorial Guinea</td>
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<td></td>
<td>Libya</td>
<td>1</td>
<td>4</td>
<td>0.4</td>
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<td>Middle East</td>
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<tr>
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<td>Abu Dhabi</td>
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<td>3</td>
<td>5.8</td>
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<td></td>
<td>Yemen</td>
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<td>Pacific</td>
<td>Indonesia</td>
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<td>Australia</td>
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<td>Total</td>
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<td>99</td>
</tr>
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</table>

Source: Poten & Partner

Figure 25. Annual liquefaction capacity of export terminals projects by status (situation in October 2010)

Source: authors’ elaboration on Poten & Partner
The number of import terminals is steadily increasing. So far, there are 90 import terminals in 20 countries with a total storage capacity of 36.65 million CM (see Table 3). There are several terminals under construction and some potential importers have ambitions to enter the market. The big LNG importers, i.e. Japan, South Korea and the US, established terminals to meet their domestic demand. Not only the number and size of storage tanks are increasing, but the maximum ship size that terminals can accommodate is also rising. There are 11 importing counties so far that can berth large LNG carriers of more than 200,000 CM.

China has six import terminal projects along its coastal line to be completed by 2013. Meanwhile, there are three new importers (i.e. the Netherlands, Thailand and Sweden) with terminals under construction and expected to commence operations in 2011. Also other countries such as Germany, Croatia, Romania and Singapore are planning LNG terminals in view of diversifying their energy supply.

**Table 3. Overview of import terminal projects in operation in 2010**

<table>
<thead>
<tr>
<th>Region</th>
<th>Import Country</th>
<th>No. of terminal project</th>
<th>No. of Storage tanks</th>
<th>Total Storage Capacity (million CM)</th>
<th>Maximum Ship Size (CM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic</td>
<td>USA</td>
<td>15</td>
<td>30</td>
<td>3.79</td>
<td>277,000</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>2</td>
<td>4</td>
<td>0.78</td>
<td>138,000</td>
</tr>
<tr>
<td></td>
<td>Mexico</td>
<td>2</td>
<td>4</td>
<td>0.62</td>
<td>217,000</td>
</tr>
<tr>
<td></td>
<td>Dominican Republic</td>
<td>1</td>
<td>1</td>
<td>0.16</td>
<td>145,000</td>
</tr>
<tr>
<td></td>
<td>Puerto Rico</td>
<td>1</td>
<td>1</td>
<td>0.16</td>
<td>125,000</td>
</tr>
<tr>
<td></td>
<td>Canada</td>
<td>1</td>
<td>3</td>
<td>0.48</td>
<td>250,000</td>
</tr>
<tr>
<td>Pacific</td>
<td>Japan</td>
<td>28</td>
<td>137</td>
<td>15.29</td>
<td>260,000</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>5</td>
<td>10</td>
<td>1.07</td>
<td>200,000</td>
</tr>
<tr>
<td></td>
<td>South Korea</td>
<td>4</td>
<td>48</td>
<td>6.32</td>
<td>266,000</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>3</td>
<td>6</td>
<td>0.96</td>
<td>260,000</td>
</tr>
<tr>
<td></td>
<td>Chili</td>
<td>2</td>
<td>3</td>
<td>0.48</td>
<td>163,000</td>
</tr>
<tr>
<td></td>
<td>Taiwan</td>
<td>2</td>
<td>3</td>
<td>0.48</td>
<td>145,000</td>
</tr>
<tr>
<td>Europe</td>
<td>UK</td>
<td>6</td>
<td>14</td>
<td>1.88</td>
<td>265,000</td>
</tr>
<tr>
<td></td>
<td>Spain</td>
<td>6</td>
<td>19</td>
<td>2.30</td>
<td>263,000</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>3</td>
<td>9</td>
<td>0.84</td>
<td>216,000</td>
</tr>
<tr>
<td></td>
<td>Turkey</td>
<td>2</td>
<td>5</td>
<td>0.54</td>
<td>140,000</td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>2</td>
<td>4</td>
<td>0.35</td>
<td>152,000</td>
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<tr>
<td></td>
<td>Belgium</td>
<td>2</td>
<td>4</td>
<td>0.40</td>
<td>217,000</td>
</tr>
<tr>
<td></td>
<td>Portugal</td>
<td>1</td>
<td>2</td>
<td>0.24</td>
<td>165,000</td>
</tr>
<tr>
<td></td>
<td>Greece</td>
<td>1</td>
<td>2</td>
<td>0.13</td>
<td>135,000</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>90</td>
<td>309</td>
<td>36.65</td>
<td>/</td>
</tr>
</tbody>
</table>

*Source: Poten & Partner*
Natural gas is becoming more important as a clean energy source. LNG shipping can be economically operated on medium and long distances. Cost reductions in all segments of the LNG supply chains and a changing world geography in LNG trade have triggered a lot of new investments in LNG shipping and terminal projects. The LNG shipping market was initially based on dedicated long-term contracts and regionally based trade flows. With the debottlenecking and expansion of liquefaction plants, gas sellers were urged to find alternative markets to absorb their surplus. The emergence of the short-term/spot trade was one of the outcomes. With the current fluctuations in gas supply, the short-term market is expanding. Still, long-term contracts will continue to be dominant as project investors have to secure their return on investment for the capital intensive facilities.

The LNG market structure initially was characterized by an oligopoly formed by a few large state-controlled or regulated oil and gas companies and a few independent shipowners. The liberalization trends in both the upstream and downstream gas markets resulted in the emergence of more independent shipping companies who cooperate with upstream gas sellers in liquefaction projects or with downstream buyers in import terminals. In some cases, they even take over the role of refrigeration terminals by converting ships to floating gas production or regasification units.

The LNG shipping market cycles are roughly 3-4 years. The LNG fleet is one of the youngest fleets with average age of 9 years. More than half of the ships are less than 5
years old. The ship size distribution of the current fleet clearly shows that the average size is growing with the delivery of large tankers from Qatar gas (Q-flex, Q-Max). However, the most common ship size is still in the range between 100,000 and 150,000 CM. The large Q-Flex and Q-Max units are deployed on LNG routes between Qatar and Europe/US. LNG terminal size is rising in line with the increase in average ship sizes. The number of terminals is growing, not only in existing export or import countries, but also in countries who have the ambition to enter the market.

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