Advice on the Opportunity to Set up an Action Plan for the Promotion of LNG Chain Investments

- Economic, Market, and Financial Point of View -

FINAL REPORT

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Executive Summary

The task

1. This study discusses opportunities to set up an Action Plan at the EU level for the promotion of liquefied natural gas (LNG) chain investments. The study has been commissioned by MVV Consulting, the general contractor of DG TREN, on behalf of DG TREN (units C1, C2) to Professor Christian von Hirschhausen. The study also takes into account previous research in the joint EE^2-DIW program on "The Globalization of Natural Gas Markets", mainly from Dr. Anne Neumann and Sophia Ruester. The focus of the study is on the economic, market, and financial point of view.

Economic point of view

2. From an economic point of view, there seems to be no major problem that would justify an Action Plan. LNG plays an important role for the supply of Europe with natural gas, and it is also an essential building stone to promote the establishment of a global market for natural gas. Global natural gas supplies to Europe are sufficiently available for pipeline gas and LNG. The globalization of natural gas markets is beneficial to supply security; it also means, however, that Europe will compete with North America and Asia for natural gas "at the margin".
3. In the perspective of 2030, pressure on prices may cease due to declining demand for natural gas. Taking current climate policy goals serious natural gas must be considered as a "dirty" source of energy, since it emits about 350 g CO_2/kWh. In a world with predominant carbon capture, natural gas will not be competitive with clean coal. Indeed, recent forecasts of natural gas in the low carbon scenarios (IEA, WETO) forecast a demand decrease in the EU. Likewise, EIA forecasts of US natural gas demand have been significantly downgraded in recent years. The DG TREN "European Energy and Transport Trends 2030 – Update 2007" is likely to reflect this turnaround, too, in its upcoming scenario on the 2020 targets set by the 2007 European Council.
4. The value-added chain of LNG consists of 1) upstream natural gas production and transportation, 2) liquefaction, 3) shipping, 4) regasification, 5) storage, transmission and distribution. Steps 1) to 3) are generally outside the reach of the European Union. While shipping is a potentially competitive activity, natural gas production and liquefaction have come under the increased suspicion of oligopolistic behavior recently (danger of a "GasPEC"). Prices for LNG deliveries have increased since 2002. However, when compared to the regional (monopolistic) markets of the 1990s, there are now more market participants and a global market is emerging. It seems that there is little the European Union can or should do to affect the structure of the upstream LNG market beyond the activities it is already pursuing, i.e. strategic energy partnerships.

Market and regulatory point of view

5. From a market and fiscal federalist perspective, an Action Plan at the Community level is justified: i) if there is a significant market failure along the LNG chain, or in natural gas or energy supply at large, that can be remedied by public action without running the risk of state failure; and ii) if this action is implemented more efficiently at the Community level, rather than at the level of member states, or still at another constitutional level. Regarding the first aspect, market failure, we have identified three issues:
   - Supply security as a public good;
   - Quality asymmetry which may hinder market integration;
   - Regulatory issues towards the completion of the European internal market for natural gas that would favor supply security.
6. The main motivation to enquire about an Action Plan for LNG is to strengthen supply security of natural gas (see study outline). In this context it is important to note that supply security is not an objective state of the world that can or can not be attained. Rather, there are different levels of supply security, and each of these states is related to costs. A supply disruption induces damages to the economy, private businesses, and households. To avoid this or keep costs low, agents can diversify their energy supply. The optimal level of supply security is provided when the sum of expected damage costs, security costs, and administrative costs is minimized. In other words, options to diversify supplies determine the costs of supply security interruptions. For countries with a diversified LNG portfolio or diversified pipeline gas supplies (such as the UK or Spain), these costs are low. Exceptions are new EU member states in Central and Eastern Europe that depend on one country for natural gas supplies. In these countries, building an LNG regasification terminal may increase the resilience against supply disruptions. The price risk, however, remains. We conclude that security of supply with respect to natural gas (LNG and pipeline) is not really in danger provided the internal market works. A look at the regional level shows that the potential impact of an Action Plan varies significantly: thus, some of the new member countries of Central and Eastern Europe might benefit from specific action to increase their supply security. This might consist of LNG terminals, but also from inverting pipeline capacity to accommodate imports from the West.
7. Different quality specifications for LNG do exist, but the potential market disturbance is limited to the UK. The Wobbe Index of most of the LNG imported to Europe corresponds to the range defined in the European Association for the Streamlining of Energy Exchange (EASEE). In addition, the energy content can be modified at the receiving facilities at relatively low cost: the energy content can be decreased by adding nitrogen, and it can be increased by injecting propane. Some standardization of LNG qualities may make sense, but it is questionable whether an EU-wide Action Plan is the appropriate instrument to achieve this.
8. The downstream part of the LNG chain (regasification terminals, storage, transmission and distribution) is currently undergoing a major institutional change given the implementation of the

Acceleration Directive 2003/55/E, and the proposed 3rd Package. A long-term Action Plan needs to assume that both pieces of legislation to be implemented, which will relieve some of the inefficiencies currently hindering the development of an internal market for natural gas. This relates particularly to the vertical separation between natural gas trading and transmission pipelines, non-discriminatory access to the transmission grid, regulated access to storage, and the emergence of a truly functioning internal market. The separation of natural gas trading and natural gas transportation in the form of ownership unbundling is a requirement to create competitive wholesale markets. Access to storage should be regulated where it is in a dominant market position, and opened to merchant storage investment.

Financial point of view

9. Part 3 of the study finds that financing is no major obstacle to LNG regasification terminal developments in the EU. A case study of a representative LNG regasification project shows that as long as the appropriate institutional framework is in place, this investment is highly lucrative. Bilateral discussion with industry representatives have confirmed that financing is no barrier to the development of LNG receiving facilities in Europe. This is shown both by the large number of LNG regasification projects under way or planned in Europe, in particular in the UK and Spain. Therefore it does not seem to be necessary to extend the instruments of financial support by the EU beyond the existing framework. The main obstacle to the development of regasification terminals is resistance at the local level.
10. The case study of a commercial terminal (South Hook, UK) confirms that these projects have high rates of return, in particular if one included the real option value of building the terminal at a later point in time. The case study indicates that there should be no problem concerning investment incentives for European LNG regasification terminals. South Hook in the UK shows a positive net present value.
11. Employing the traditional net present value approach disregards a number of relevant factors. If the decision-maker has flexibility, and hence the opportunity to delay the investment in the regasification terminal, it is possible to broaden the scope. The real option value, i.e. the value of waiting, is highly positive for South Hook, so a delay of the investment decision is advisable to await higher natural gas prices.

Assessment

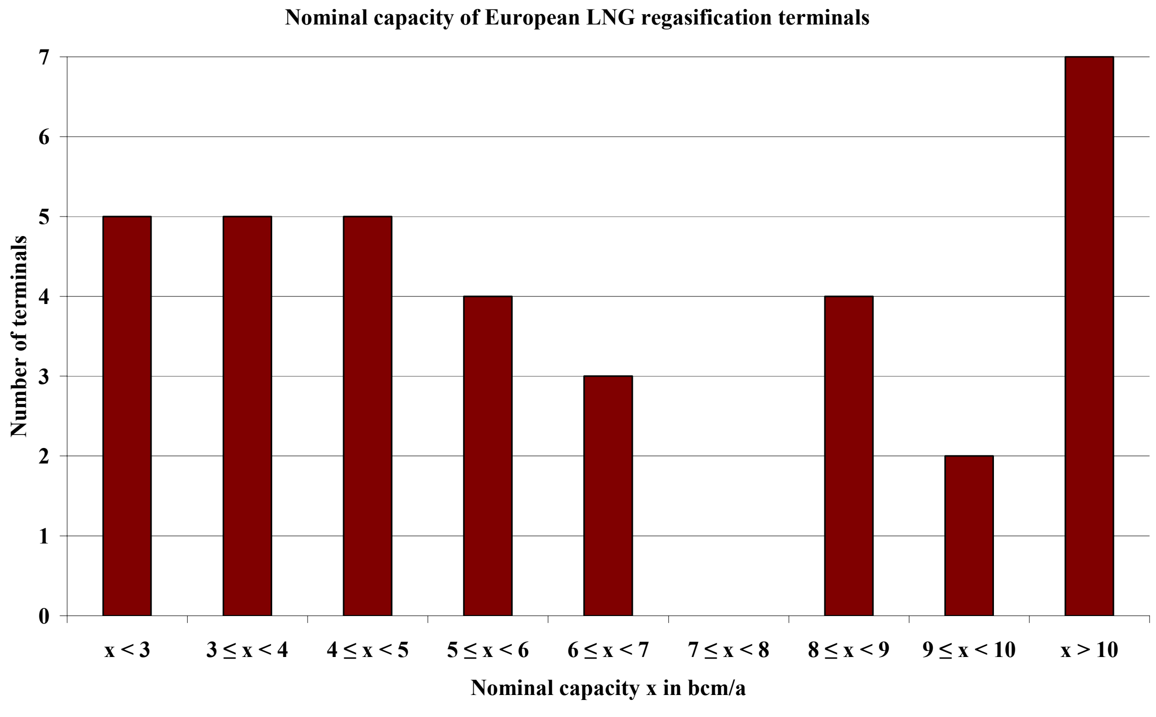
12. We conclude that from an economic, market, and financial point of view, there is a limited case for an LNG Action Plan at the EU level. If asked to provide a quantitative assessment on the need for an Action Plan, it would be located it in the range of 30%. In case an Action Plan is adopted, it should target the development of the internal market and European-wide competition, and specific problems of supply security in some of the new member countries of Central and Eastern Europe.

Answers to the questions in the Terms of References for Part II-C of the study

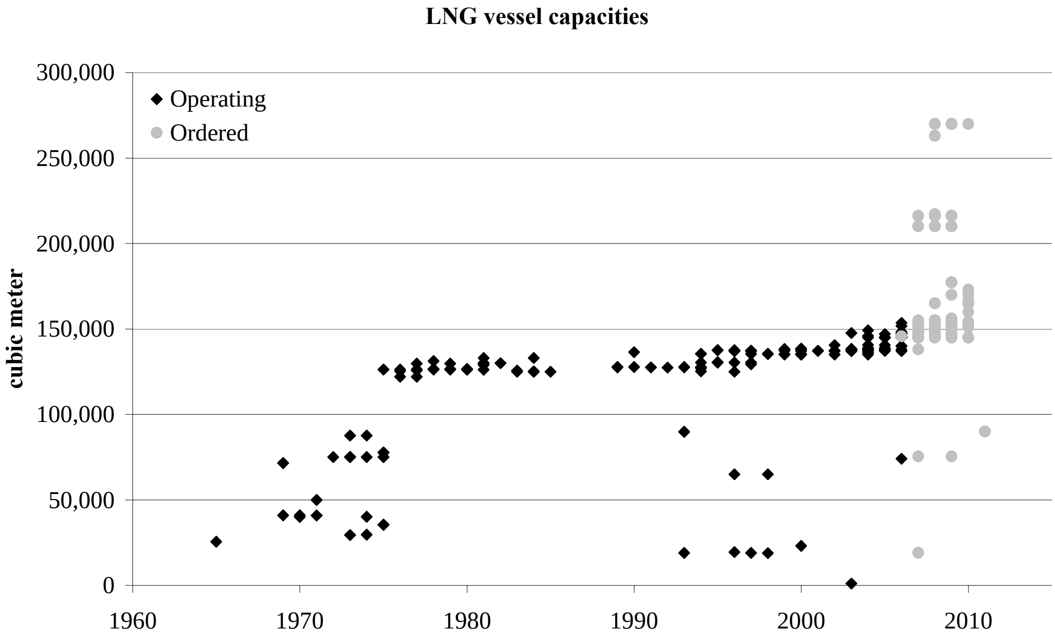
1, 2, 3) Growth of LNG demand in the next years and costs along the value chain

Long-term natural gas demand projections for the EU are shown in Figure 1 (page 11). The share of LNG in import demand is likely to rise significantly at the EU level. Due to the uncertainty to forecast private and public company behavior, it is not possible to predict a global investment figure. Figure 3 (page 13) shows the main costs foreseeable along the LNG value-added chain for different relations. Cost decreases realized during the 1990s, mainly due to economies of scale along the value added chain, have been partly absorbed in recent years owing to rising raw material prices and competition for skilled labor. Investors frequently announce cost-overruns and time delays (e.g. Snovhit project Norway).

The optimal size for an LNG regasification terminal depends on various region specific factors such as the structure of the downstream transmission network, the location of the terminal relative to demand centers, seasonality of demand, etc.. The Figure below shows the nominal capacities of European LNG regasification plants (including greenfield projects and existing/planned expansions). The capacities vary considerably and there seems to be no preferred "optimal" size by industry.



In midstream transportation we observe a trend towards two main types of vessels: Standard transportation ships have a capacity of 135,000 to 148,000 m³. Furthermore, a number of super size vessels are under construction (see Figure "LNG vessel capacities" below). These very large vessels (with a capacity of up to 270,000 m³) will serve e.g. for LNG deliveries from Qatar to the UK, an integrated project of ExxonMobil in cooperation with QatarPetroleum. However, these vessels will not be able to land at every LNG regasification terminal due to capacity constraints and port characteristics.



4) Competition between LNG and piped natural gas

See Figure 4 (page 14); it is generally estimated that the break-even point of LNG and piped gas has moved to the left in the last years, i.e. towards more competitive LNG for shorter distances.

5, 9) LNG investment decisions, appropriate margins

The main criteria which govern LNG investment decisions are the long-term rate of return and – in the case of an integrated company – the possibility to arbitrage between different supply options (be it LNG or pipeline natural gas). Long-term contracts play an important role for this decision, especially in order to secure capital intensive upstream greenfield investments. However, one observes increasing rates of capacity of LNG regasification terminals that can also accommodate shorter-term supplies ("flexible" LNG); on the exporting side for example, liquefaction projects such as Oman LNG reserve a part of the capacity for short-term deliveries.

There is a significant number of terminals under construction or planned, mainly by private investors. It seems as if the private sector is engaging in investment activity and no financial support beyond the existing framework seems to be required. The solvency of the companies involved is sufficient securing downstream investments; bilateral discussions with industry representatives have confirmed that financing is no barrier to the development of LNG receiving facilities in Europe.

6) Net regasification margins and optimal internal rate of return

There is no reliable information on this issue available.

7) Conditions to lead to a European natural gas price

Liquid trading places, secondary markets for transportation, and access to transportation and storage infrastructure are important. The completion of the European internal market for natural gas should lead to a European price. At present, this is not happening due to an insufficient implementation of the Directive 2003/55/EC, in particular with regard to cross-border trading, equal access to infrastructure capacity, and a lack of primary and secondary markets thereof.

8) LNG terminal connection to underground storage

It is important that LNG receiving terminals have flexibility in processing their natural gas. On-site storage in tanks is relatively expensive, so access to underground storage plays an important role in determining the financial structure of projects and to make use of arbitrage. A strong seasonality in demand further enhances the need for underground storage capacities. Storage can also ensure security of supply in times of severe crisis. Access to underground storage infrastructures should be regulated, since this is often an essential facility; where this is not the case, merchant storage should be allowed to develop freely.

10) LNG Action Plan justified?

We conclude that from an economic, market, and financial point of view, there is a limited case for an LNG Action Plan at the EU level. If asked to provide a quantitative assessment on the need for an Action Plan, it would be located it in the range of 30%. In case an Action Plan is adopted, it should target the development of the internal market and European-wide competition, and specific problems of supply security in some of the new member countries of Central and Eastern Europe.

1 Introduction

The increasing importance of LNG in the European natural gas supply portfolio in order i) to bring in additional natural gas volumes and ii) to diversify supply sources has led to considerations on the interoperability of LNG facilities and interchangeability of natural gas. Further, the study addresses the question whether there is a need for a European LNG Action Plan. This report investigates – as one of four expert opinions of the second part of the study – economic, market, and financial issues.

The study is structured in three main parts: in the Section 2 we address economic issues, focusing on supply and demand forecasts as well as the economics of LNG. Section 3 discusses potential market failures in the industry and the regulatory responses. Section 4 is dedicated to the financial point of view and a case study is calculated based on traditional net present value and real options approach. In particular, we ask whether investments into regasification capacities in the LNG chain are financially viable, and whether financial incentives should be provided by the Community, e.g. in the Priority Interconnection Plan, or EIB-credits. Section 5 concludes.

2 Economic Point of View

2.1 Supply and demand forecasts

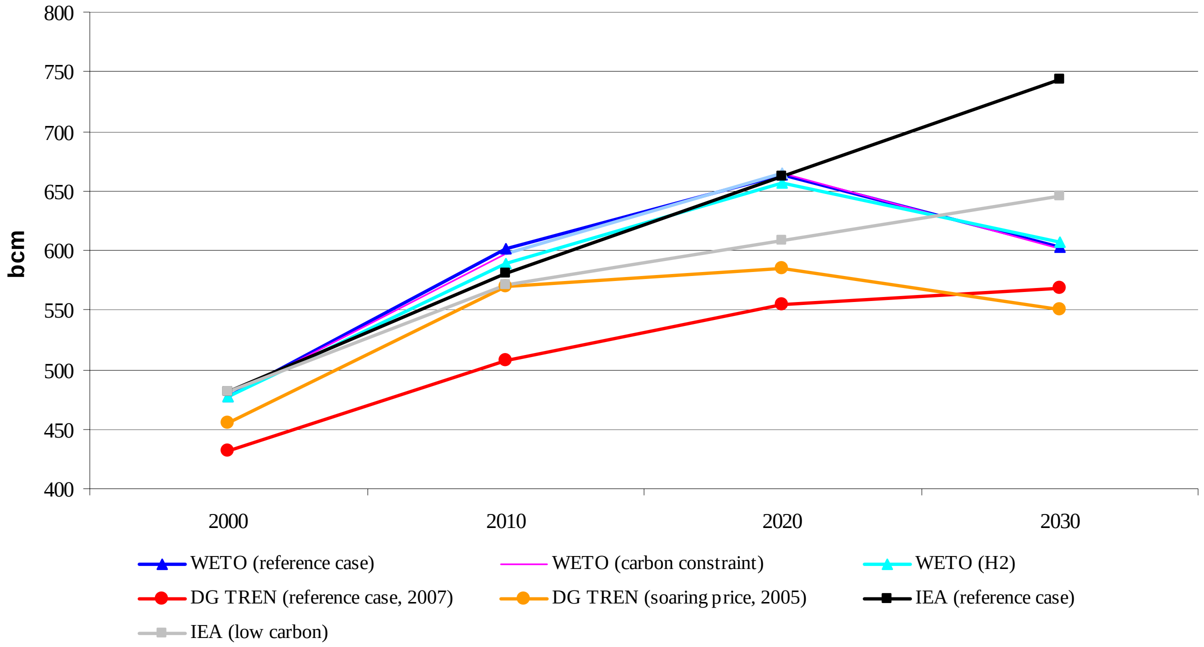
In a mid-term perspective up to 2030, increasing natural gas demand is facing declining domestic production. LNG plays a key role in order to fill the future gap in the supply-demand balance. Furthermore, an increase in diversification of energy sources and transit routes increases the security of supply.

2.1.1 Demand

EU-27 natural gas demand in 2006 accounted for 545 bcm. There is a high uncertainty about future demand development. Figure 1 compares different forecasts based on varying scenarios, including the updated "European Energy and Transport Trends to 2030" baseline scenario published by the European Commission in 2007. In the mid-term, until 2020, these forecasts remain relatively similar expecting a demand level between 550 and 670 bcm. However, things change in the longer-term. For the period up to 2030, the highest scenario (IEA reference case) and the lowest scenario (WETO carbon constraint case) differ by 200 bcm.

However, the perspective changes once considering the recent evolution of forecasts, and once taking serious the engagement on climate change policies at the national and EU levels. Taking current climate policy goals serious natural gas must be considered as a "dirty" source of energy, since it emits about 350 g CO_2/kWh. In a world with predominant carbon capture, natural gas will not be competitive with clean coal. Indeed, recent forecasts of natural gas in the low carbon scenarios (IEA, WETO) forecast a demand decrease in the EU. Likewise, EIA forecasts for US natural gas demand are significantly downgraded in recent years. Therefore, the supposed gap between supply and demand may turn out to be much less significant than currently expected. Natural gas may turn out to become a "sunset"-industry, far from the "transition fuel" it was considered to become a decade ago. These projections concur with the majority of current studies of generation costs that find coal-fired plants to be the most competitive technology at current fuel and carbon prices (IEA, 2006).[1]

Figure 1: Long-term natural gas demand projections for the EU



Source: Based on data from DG TREN, IEA, WETO[2]

2.1.2 Supply

There is no serious concern about the long-term supply of natural gas, but prices may stay high. More than half (57%) of total EU-27 demand in 2006 has been imported from foreign suppliers.[3] Member states are unlikely to expand domestic production significantly, as major suppliers in North-western Europe report declining production rates (e.g. UK). Even though pipeline deliveries will continue to dominate, LNG plays an increasing role for EU natural gas supplies. In some African countries liquefaction capacities are extended; some countries have additional export potentials (such as Nigeria). However, these countries face increasing domestic demand, which in turn may influence future export volumes. Furthermore, political instability interferes with security of supplies. Large natural gas export potentials exist in the region of the Middle East; Qatar has been rapidly expanding

[1] Nevertheless, competition between gas and coal for electric generation is more complex than appears at first sight. Ellerman (1996) identifies sunk cost as one of the main drivers of fuel choice, while Johnson and Keith (2004) argue that investment decisions as mitigation options in an uncertain world are mainly driven by price volatility in natural gas and the price of emissions.

[2] Note that the WETO-figures also include the European countries that are not part of EU 27.

[3] Russia accounted for the largest share (130 bcm), followed by Norway (84 bcm), Algeria (56 bcm), Nigeria (11 bcm), Egypt (8.5 bcm), Libya (8.5 bcm), and the Middle East.

its liquefaction capacities, further expansions are planned; other countries (such as Iran) plan to enter the market.

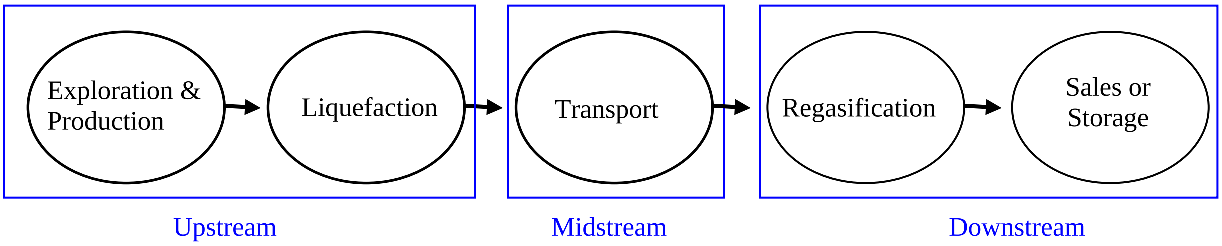
However, in times of increasing natural gas demand worldwide, we observe a global competition for world natural gas supplies. In the Atlantic Basin Europe competes with North America for African as well as South American supplies; the Middle East (accounting for more than 40% of worldwide proven natural gas reserves) is currently evolving to a swing producer; deliveries to European and Asian markets and even to North America are feasible without a significant difference in transportation cost. According to Stern (2007), it is difficult today to find any new large scale long-term contract which could start deliveries before 2015. In today's sellers' market new entrants have difficulties in finding an upstream contracting partner.

Recent discussions on a potential "GasPEC" further increase the debate on supply security. The Gas Exporting Countries Forum (GECF) mainly includes LNG exporters (Algeria, Qatar, Trinidad); since 2007 also Russia participates in the organization. Experts are split whether the GECF would have a cartel-power similar to OPEC. In any case, upstream market power is a problem for European natural gas supply. In this context, the intensification of energy dialogue is useful but it is unlikely to resolve the issue completely. As the history of OPEC shows, European and other consumers will need to live with imperfectly competitive commodity markets in natural gas, too.

2.2 Economics of LNG

Figure 2 depicts the five stages of the LNG value chain: after exploration and production (stage 1), natural gas is transported via pipeline to liquefaction facilities where it is cooled to -160°C (113K) under atmospheric pressure (stage 2) and shrinks to about 1/600 of its volume. Next, the liquefied gas is loaded into tankers containing a complex cooling system essential to keep the gas liquid during shipment to the destination countries (stage 3).[4] Upon arrival, tankers are off-loaded to terminals that reconvert the LNG to its original state of aggregation (stage 4). Finally, natural gas is fed into the destination country's pipeline grid, traded and sold to marketers, distributors, or power producers (stage 5), or stored for future demand.

Figure 2: LNG value chain



Source: Own illustration

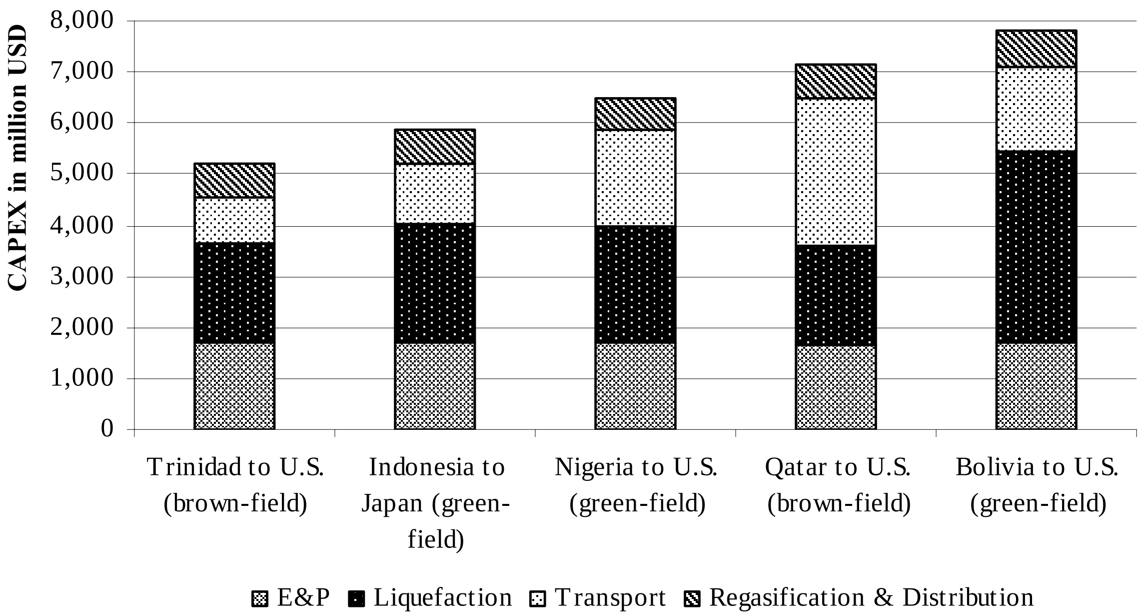
[4] Transportation infrastructure is a substantial element linking exporting and importing projects. In contrast to oil shipping, vessels for LNG transport remain dedicated assets for specific routes booked under extensive long-term contracts. However, an increasing number of vessels for uncommitted trade are now on the order books of shipyards and these will reduce dedicated asset specificity.

2.2.1 LNG versus pipeline transportation

Investment costs within the five stages vary significantly. Exploration and production account for 15-20% of the total costs of the LNG value chain; liquefaction for 30-45%; shipping for 10-30%; and regasification for 15-25%. Costs vary widely from one value chain to another; exact figures depend on factors such as distance, traded volumes, local conditions including construction costs, port configuration, and site conditions (see Figure 3).

Significant cost reductions could be realized during the last two decades along all stages of the value chain of LNG production due to technological innovations, economies of scale,[5] etc. and reached a level where LNG is able to compete for pipeline supplies. Recent price increases in raw materials and increasing investment activities led to a certain re-escalation of investment costs: whereas investment costs for liquefaction facilities where in the range of 400 million USD per mtpa in the 1990s, they decreased to about 200 million USD per mtpa and re-escalated to levels at 500-800 USD per mtpa recently according to industry experts.

Figure 3: Cost structure along LNG value chains



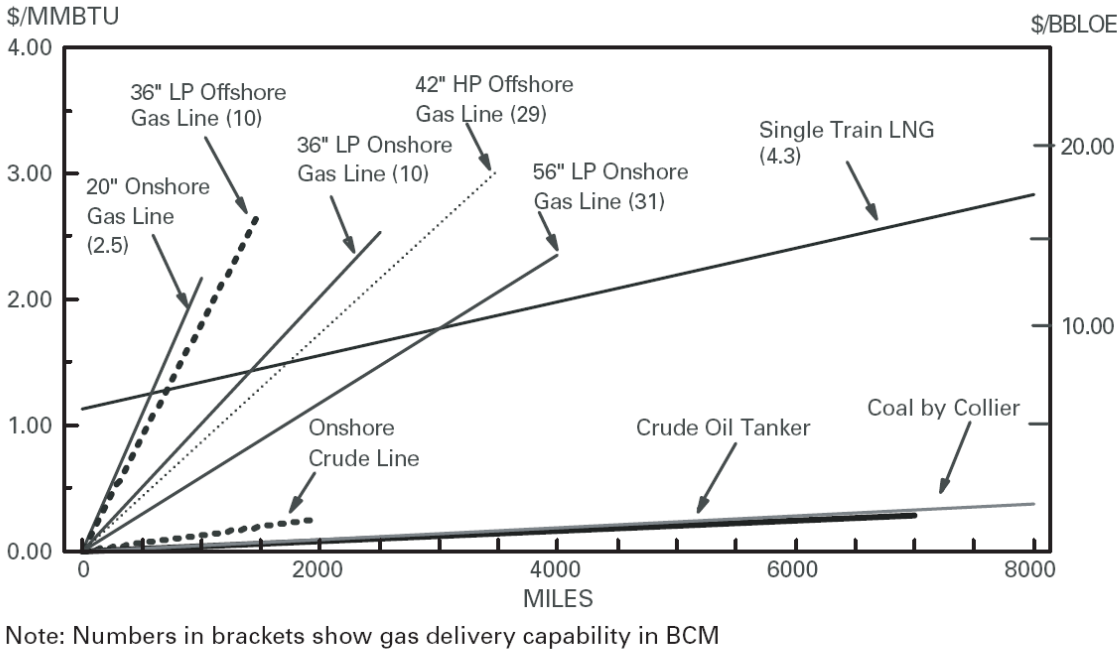
Source: Own calculation based on Jensen (2003), adaptation of cost levels according to recent cost developments
[Unfortunately, similar data on European relations is not readily available.]

LNG transportation generally is favorable to pipeline transportation for distances larger than 1,500 km for large offshore pipelines (42''; 29 bcm/a) and larger than about 3,000 km for large onshore transmission lines (56''; 31 bcm/a) as shown in Figure 4.

[5] For example, the first liquefaction trains (Arzew in Algeria) had a capacity of 1.1 mtpa; today, trains with a capacity of 4 mtpa are common, and Qatar recently announced plans to construct units with 7.8 mtpa. Economies of scale of two 4 mtpa trains reduce the liquefaction cost of an 8 mtpa greenfield project with four 2 mtpa units by nearly 30%; an increase of one 7.8 mtpa unit leads to an additional 20% cost reduction (Jensen, 2003).

Despite recent price increases and the higher costs for LNG transportation for shorter distances compared to pipelines, LNG is an attractive technology; on the one hand natural gas prices are at high levels, too, allowing for adequate profits in the natural gas industry; and on the other hand LNG contributes to diversification of energy sources and transit routes, hence, supporting supply security. It is generally estimated that the break-even point of LNG and piped gas has moved to the left in the last years, i.e. towards more competitive LNG for shorter distances.

Figure 4: Break-even of LNG and pipeline transportation



Source: Jensen (2004)

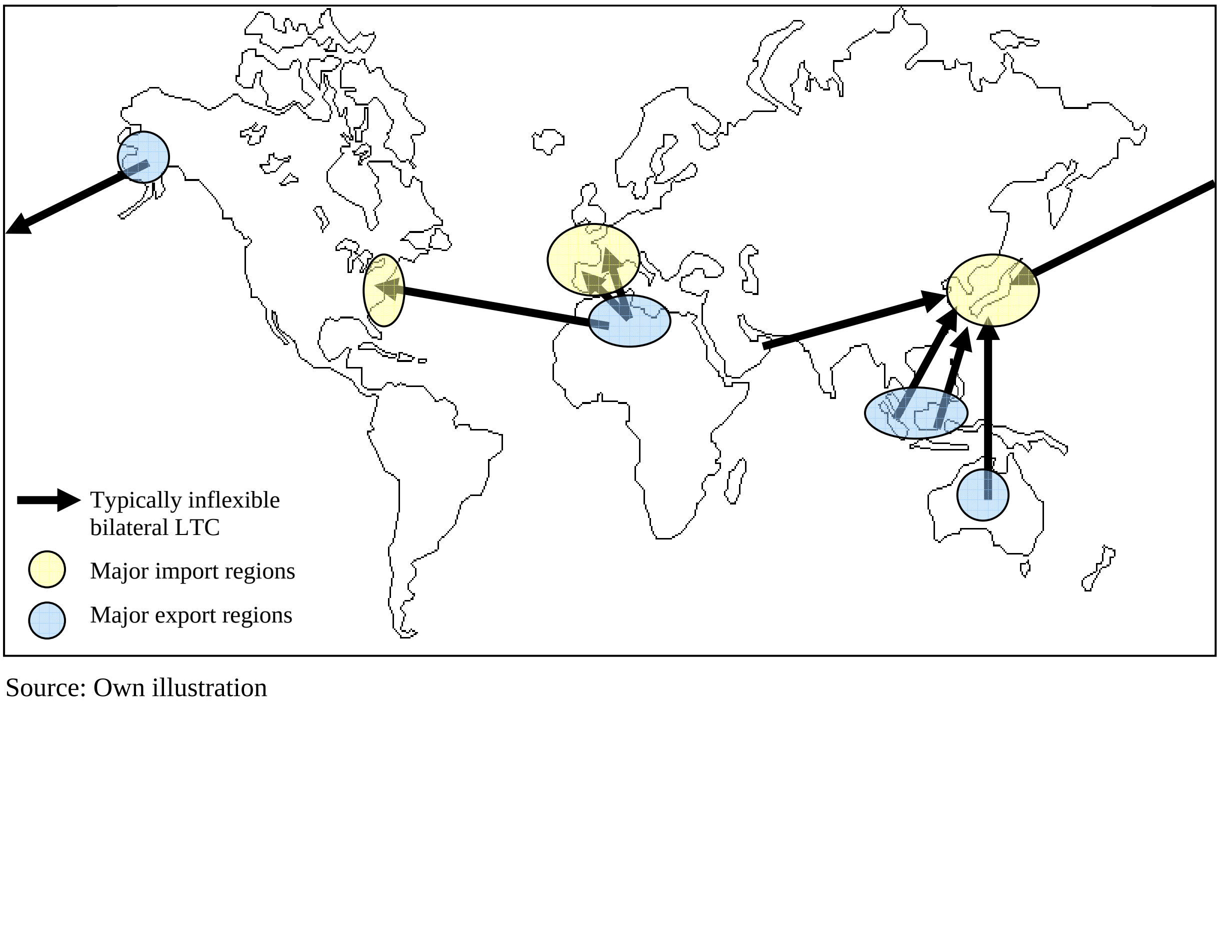
2.2.2 Globalization of natural gas markets

The globalization of natural gas markets favors security of supply, but also introduces competition between previously separated regions. Converting natural gas to LNG for transportation by tanker has been utilized for more than 40 years, but the industry achieved a remarkable level of global trade only recently. Markets stayed regional in nature until the 1990s, Inflexible bilateral long-term contracts with take-or-pay and destination clauses allocated price risks to the seller and volume risks to the buyer (see Figure 5). During the last two decades, large investments along all stages of the value chain have been realized; new players – countries as well as companies – entered the industry and the LNG technology supports the globalization of formerly regional markets (i.e. Europe; North America; Asia Pacific). Contracts gain in flexibility, contract duration decreases (Neumann and Hirschhausen, in print) and spot markets gain in liquidity.

Today, LNG is responsible for supplying the US, the UK, Spain, South Korea, India, and China among others. The Middle East accounts for more than 40% of worldwide proven natural gas reserves and is expected to become the largest regional exporter of LNG.

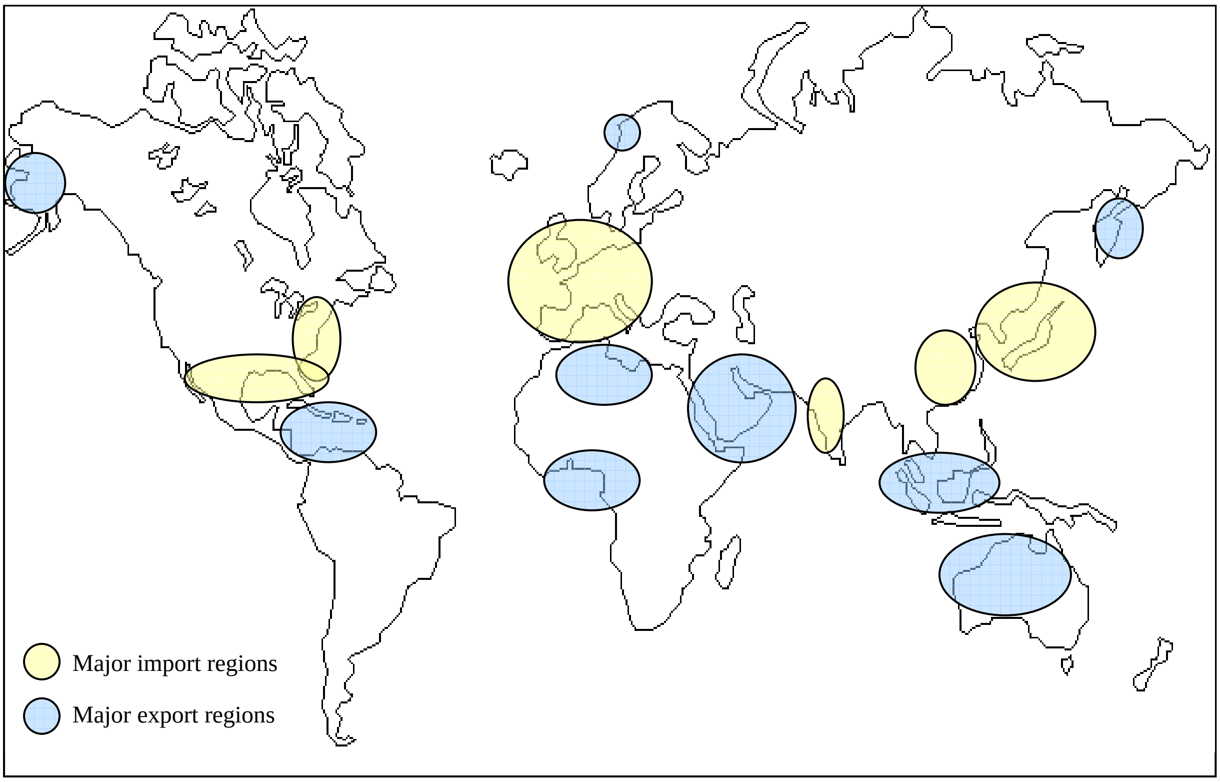
Changes in the institutional framework (from monopolistic structures to competition) in turn require fundamental changes in the organizational behavior of market participants. Global mergers and acquisitions, vertical and horizontal integration, and strategic partnerships have become routine today (Ruester and Neumann, 2006). Global oil and natural gas producers and distributors are frequently engaged in all stages of the LNG value chain. In addition, export projects are increasingly financed and developed by private (and foreign) interests. Former downstream monopolists of natural gas are finding their traditional markets challenged by the intrusion of oil and gas majors integrating into import markets. Vertical integration in response to market deregulation features various drivers: Upstream producers aiming to benefit from downstream margins, ownership of transportation capacities to exploit arbitraging possibilities, distribution and power companies moving upstream to ensure margins and supply security in a period of increasing global demand. Furthermore, non-integrated merchants enter the industry and use their infrastructures as “tolling facilities” (particularly in the US).

Figure 5: „Old world of LNG“ – bilateral relationships



Source: Own illustration

Figure 6: „New world of LNG“ – globalization of natural gas markets



Source: Own illustration

2.2.3 Prices, wholesale markets, and the emergence of a global natural gas market

The development towards more international trading of natural gas has direct repercussions with the pricing of the commodity. The increase in LNG trade provides the missing link allowing market integration across regions, in particular across the Atlantic Ocean. The analysis of international spot trading prices at Henry Hub (US) and NBP (UK) suggests an increasing convergence of spot prices on either side of the Atlantic Basin (see Neumann, 2007). In addition, traditional pricing schemes are being reviewed moving from long-term, often oil-price indexed natural gas prices towards prices based on market mechanisms providing a better indicator of a gas-to-gas competitive market. The restructured industry in Europe and North America features an increasing proportion of spot trading. Transparent information on the market is provided by trade press and trading platforms for natural gas thus favoring competition. Active arbitrage is observed in the Atlantic Basin, where LNG shipments from Trinidad and Nigeria have been diverted either to the US or Europe depending on spot prices. Arbitraging possibilities occur in cases when the price differential of a homogeneous commodity exceeds transportation costs. The impact of these swaps and diverting activities on spot price in countries where cargoes have been sent to has been modest. Nevertheless, underutilization of US facilities during the main part of 2007 indicates the power of short term trading on the flow direction of LNG vessels.

Curiously, though, there has not yet been a convergence towards a single European price for natural gas. Quite on the contrary, even physically close regions such as Zeebrugge and Bunde have featured wide price dispersion (see Neumann, et al., 2006). An increasing number of trading places in

Continental Europe (such as France, Spain, Italy, and Germany) would facilitate the management of price risk. A liquid market is required to provide a standardized trading environment in which market participants have full information. Introducing futures and options would deliver substantial certainty under else volatile prices. Independent, commercial users along the value chain might thus achieve planning certainty provided by futures and options markets. Regulatory reform in this direction is urgent.

3 Market and Regulatory Point of View

There are two market failures that apply to the LNG industry: the public good character of supply security, and diverging quality standards. Neither seems to be sufficiently important to require an Action Plan at the EU-level.

3.1 Security of supply issues

The discussion on supply security entails two very different aspects: Firstly, the supply of a country or a region with energy resources, and its resilience against unexpected supply disruptions. This will be the focus of our analysis here; and second the reliable supply of network infrastructure and services, such as electricity generation and transmission or natural gas infrastructure. The supply uncertainty problem represents a market failure of the externality type where the true social costs of non-secure supplies are not reflected by the price.

The European discussion on supply security is fostered by various aspects, among them the effort to finalize new contracts with upstream suppliers in a market where major consumers worldwide compete for (the same) supplies, the peaking of domestic production in several countries (i.e. UK, Netherlands), current record high energy prices (LNG spot cargoes to Japan have been delivered at prices above the 19$/MBTU level in January 2008), or discussions about a GECF cartel.

The ongoing liberalization process of natural gas and electricity markets in Continental Europe is one issue enhancing the discussion concerning supply security. We argue that liberalization is conducive to supply security. A more competitive structure in the European natural gas market will not undermine supply security of the EU, because competitive markets will provide efficient investment signals. Ample availability of pipeline gas and the emergence of new LNG markets will lead to a more diversified, rather than a more constrained, supply structure. There is no inherent conflict between market liberalization and supply security as long as an appropriate regulatory framework is implemented; spot trading and ("modern") long-term contracts should be seen as complementary.

Box 1: Aspects of supply security

Supply security has something to do with two main components of concern: volumes and prices. Concerning reliable supplies people fear potential supply disruptions due to upstream, midstream, or downstream breakdowns. High levels of import dependency and the political instability of many major suppliers support this fear; furthermore, national oil companies control a huge share of world natural gas reserves (e.g. Gazprom, Sonatrach, Nigerian NPC, QatarPetroleum). Concerning prices the risks lie in the very low short-term price elasticity facing highly volatile prices.

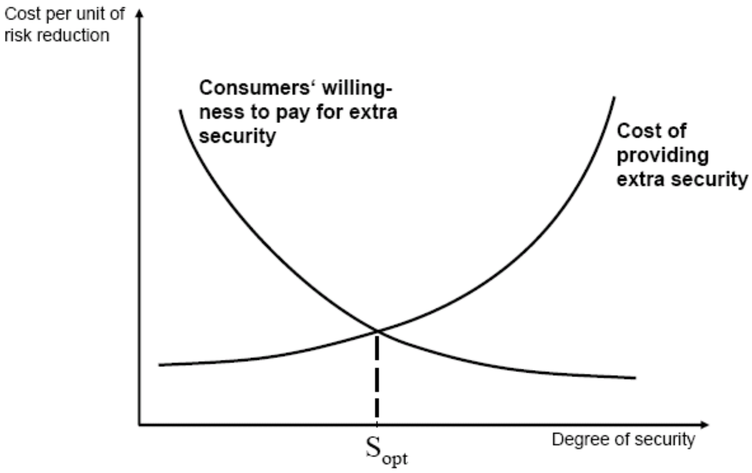
The concept of supply security should be understood as a concept of risk management. There may be technical risks (such as a shortfall of infrastructure), political risks (such as a supply disruption by a transit country), regulatory risks (instable institutional framework), physical risks (exhaustion of resources), or economic risks (such as a lack of investment in capacities or excessive prices for pipeline access).

Supply security can be regarded and evaluated from a number of perspectives: i) short-term reliability of the system from long-term adequacy of investments; ii) regional levels: sub-national vs. national vs. regional vs. world level; iii) economic perspective (costs of supply security; welfare, …) versus from a (geo-) political perspective; iv) supply side versus demand side perspective; v) ex post versus ex ante analysis.

3.1.1 The "optimal" level of supply security

If you asked an engineer what the optimal level of supply security was, he or she would most probably answer "such that never constrains operation". This line of reasoning neglects the fact that supply security has a benefit – it allows the smooth production and consumption process – but that it also has a cost. From an economic or a social welfare perspective, it is the optimal relation between the two that determines the "optimal" level of supply security. More precisely: we want to equate "marginal social benefit" and "marginal social cost". The theoretically optimal level of supply security can be determined by equaling the consumers' marginal willingness to pay for extra supply and the social costs of providing this extra security (see Figure 7). The marginal cost curve is flat over a wide area and then rising steeply when remaining risks are expensive to deal with.

Figure 7: Optimal level of supply security

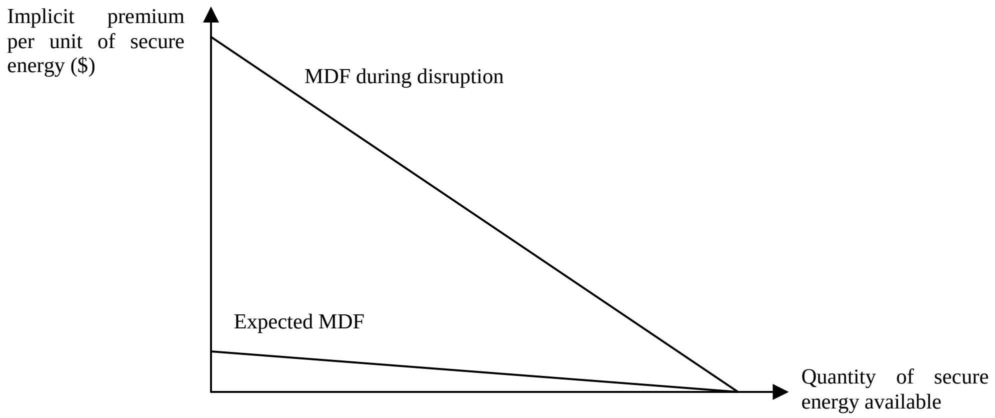


Source: Own illustration based on Nera (2002, 10)

Energy supplies subject to political, economic, or regulatory risks should receive a lower social valuation than secure energy supplies. However, market prices are not able to reflect any security premium. In order to address the question about a justifiable price premium for secure energy supplies we will discuss a theoretical model dealing with optimal import dependence reduction programs (for an application to the US oil market see Griffin and Steele, 1986, 221 ff.). This analysis is based on the minimization of the sum of expected damage costs (due to a supply disruption), security costs (due to the provision of extra supplies), and administrative costs such that social welfare is maximized.

Social costs are defined by the area under the marginal damage function (MDF) of a supply interruption of a strategic commodity (e.g. oil or natural gas). The marginal damage function is sloped downward; the marginal effect of the first unit of energy not delivered is less than the loss of the last unit: low quantities of the resource can easily be replaced by another energy source, or by energy efficiency measures, whereas these costs increase with the amount of natural gas withheld. The MDF equals zero if all demand is satisfied by secure supply sources. In order to obtain an expected marginal damage function, the absolute marginal damage has to be weighted with the probability corresponding to the various durations of potential supply disruptions, leading to the expected MDF function (see Figure 8).

Figure 8: Marginal damage function at various levels of supply disruption

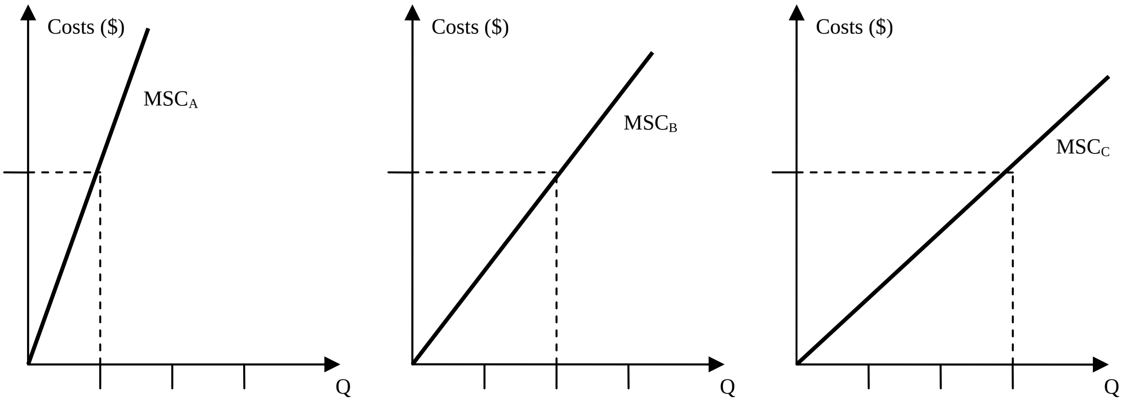


Source: Own illustration based on Griffin/Steele (1986)

A country generally has several options to respond to a supply disruption (it can use strategic storage in which it has invested previously, and can increase its domestic production of natural gas or of other close substitutes).[6] These measures are depicted by the marginal social cost curves (MSC) in Figure 9: We define strategy A as the use of emergency storage, marginal security costs MSC_A are rising in quantity. Strategy B is defined as the increase of domestic production (e.g. the use of standby capacities), with MSC_B rising again. We further define strategy C as the combined use of both measures and denote it MSC_C.

[6] Note that energy "conservation" is not an alternative, since the expected MDF curve already measures the costs of "forced" conservation.

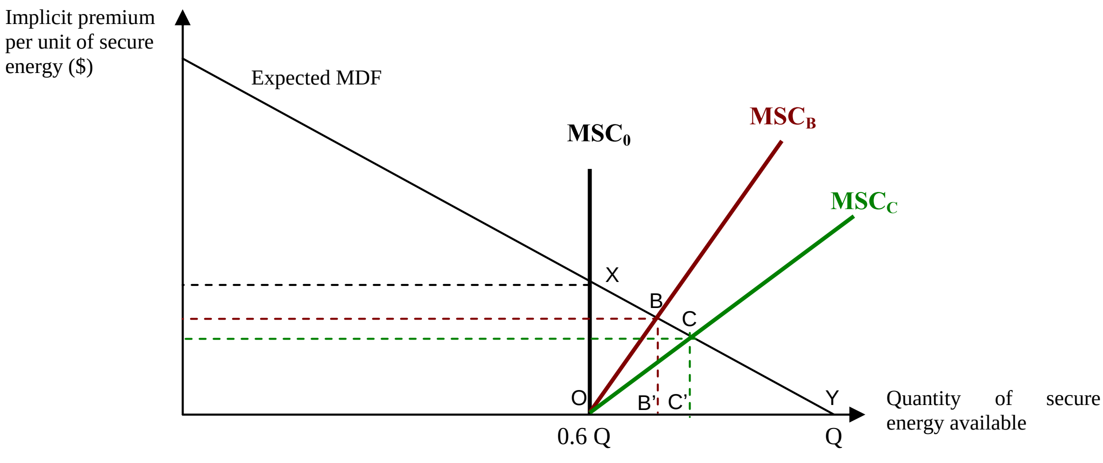
Figure 9: Combination of emergency supply strategies



Soure: Own depiction following Griffin and Steele (1986, 224)

The first case to be investigated is the one importer – one exporter case, hence in the case of a supply disruption no alternative imports are available. In Figure 10, Q is the total demand of the region under investigation. A domestic production of 60% of total energy needs is assumed (0.6 Q). MSC_0 indicates a situation without any supply security strategy, a disruption of imports would reduce total supply to the level of 60%. Total costs will equal damage costs (area OXY). Strategy C is the most preferable strategy since employing both measures (storage as well as an increase in domestic production) yields the lowest marginal costs for additional volumes of secure energy. Damage costs would be reduced to the area (CC'Y), the costs for additional supplies account for the area (CC'O). MSC_B indicates a situation in which only domestic production is increased; this strategy is inferior to MSC_C since the remaining damage equals the area (BB'Y); security costs equal the area (BB'O).

Figure 10: One importer – one exporter case

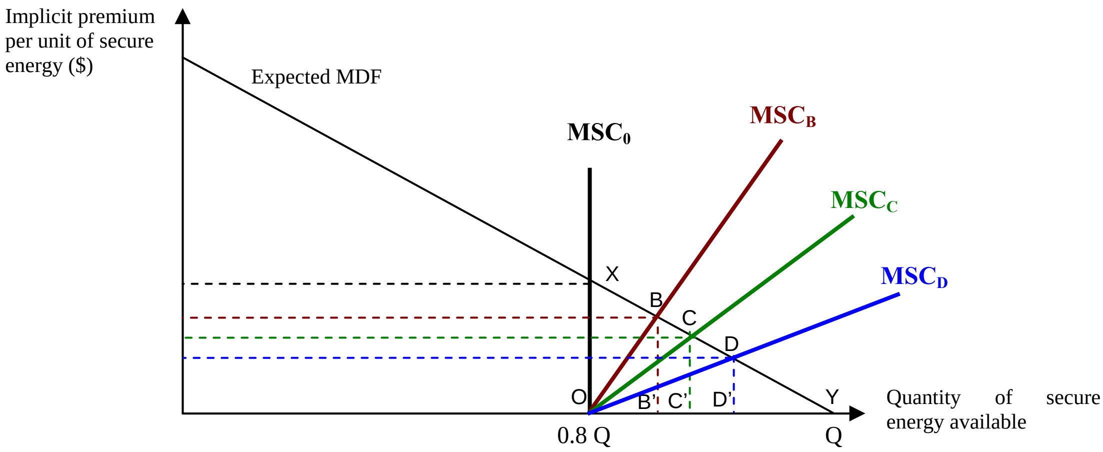


Source: Own illustration based on Griffin/Steele (1986)

Things get slightly more involved when two exporters deliver to one importer. One exporter is assumed to be reliable and always supplying energy at market prices, whereas the other is unreliable and supply disruptions have a certain probability. In that case, the expected MDF does not change, but the MSC does: First, it is shifted to the right by the amount that the reliable exporter provides in the base case; and second, additional supplies can be purchased from the reliable supplier, albeit once again at higher marginal costs than the non-emergency supplies. The aggregate MSC-function lowers the social costs of a disruption (see MSC_D in Figure 11).

We assume again 60% of total demand being produced domestically; and each supplier delivering another 20%. A potential supply disruption of one supplier therefore would lead to a decline by only 20% of total supplies. MSC_0 indicates a situation without any supply security strategy, a disruption of imports would reduce total supply to the level of 80%. Total costs will equal the damage costs (area OXY). MSC_B indicates a situation in which only domestic production is raised; under MSC_C storage capacities are used and domestic supply is increased. MSC_D indicates the case where an even more extensive supply security strategy is followed: storage is used, domestic supply is increased and furthermore, additional volumes are imported from the importer without disruption. Due to a further decreasing marginal cost of extra supplies, this last strategy is the most efficient solution. Remaining damage is reduced to the area (DD'Y); total security costs in this case equal area (DD'O).

Figure 11: One importer – two exporters case

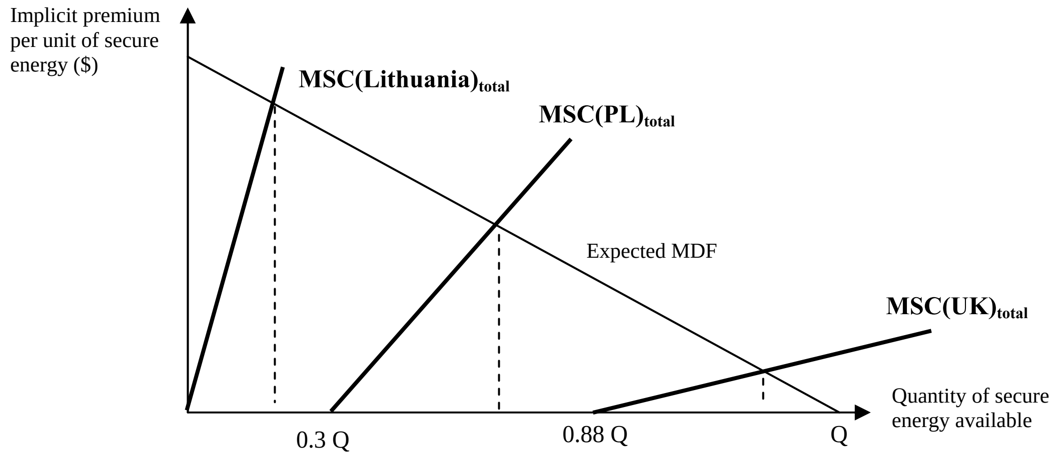


Source: Own illustration based on Griffin/Steele (1986)

3.1.2 Applications

For countries with varying natural gas supply portfolios the marginal security cost curves have significantly varying shapes. The UK, with a domestic production of 88% of total demand in 2006 and a well diversified supply portfolio including pipeline as well as LNG deliveries, faces a quite low total marginal security cost curve (MSC_D=MSC_{total}). In contrast, for a country like Lithuania (no domestic production, total foreign deliveries originating from Russia) or Poland (only 30% domestic production, major supplier Russia) the slope of MSC_{total} will be much steeper (for a graphical illustration see Figure 12). Lithuania's only possibility to react to a supply disruption from the single supplier is the use of storage whereas the UK would have a broad portfolio of possibilities reducing significantly total security costs.

Figure 12: UK versus Poland versus Lithuania



Source: Own illustration

We conclude that supply security is a relative concept; the degree to which it is a critical issue varies widely between countries. There are major differences in the supply portfolio of European countries. Typically, Western European countries like the UK, Spain, or Italy have a significant share of domestic production or at least a well diversified supply portfolio including pipeline as well as LNG deliveries. In contrast, most Eastern European states, such as Lithuania, do not have the opportunity to diversify there supply today, they heavily rely on one strong supplier.

3.2 Quality issues

The changing nature of the global natural gas market inhibits a trend towards globalization of formerly regional markets, increasing importance of spot trade, and companies following a strategy of investments in a portfolio of LNG export and import facilities. This is mainly to act more flexible and to benefit from arbitrage possibilities. As a result, interchangeability and adaptation to varying natural gas qualities and standards, in particular for the regasification terminals are required.

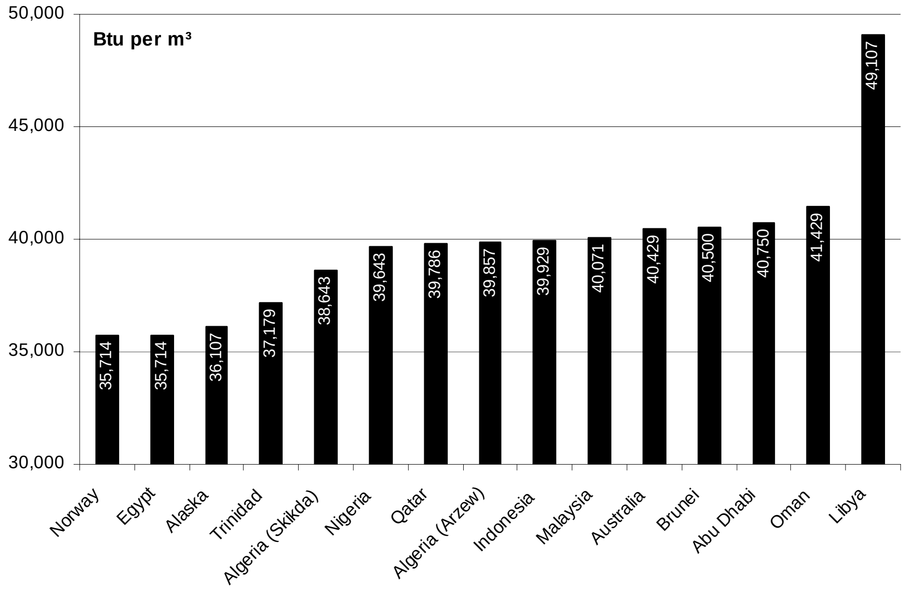
3.2.1 Different qualities as a market barrier

The Wobbe-Index is the single most important interchangeability parameter; in combination with a secondary parameter (e.g. the High Heating Value) it ensures interchangeability of different gases. The traditional three main importing regions can be classified by the quality of the imported LNG (according to HHV and Wobbe-Index): Asian traditional importers (i.e. Japan and South Korea) import rich LNG with high HHV (> 1090 BTU/scf); the US and UK networks contain natural gas with a low HHV (< 1075 BTU/scf); Continental European terminals typically are able to accept LNG with intermediate HHV (990 BTU/scf < HHV < 1160 BTU/scf).

In 2002, the European Association for the Streamlining of Energy Exchange (EASEE) has been founded in order to develop and promote the simplification and streamlining of both the physical transfer and the trading of natural gas across Europe. A common business practice has been passed in 2005, determining parameter standards for Wobbe-Index, sulphur-, oxygen-, and carbon dioxide content, and relative density amongst others.

Figure 14 provides an overview on natural gas qualities in major natural gas importing regions (i.e. Japan, North America, and EU) as well as the HHV for a number of major supplier countries.[7]

Figure 13: Heat content of LNG suppliers



Source: Lukens (2003)

Box 2: Wobbe Index

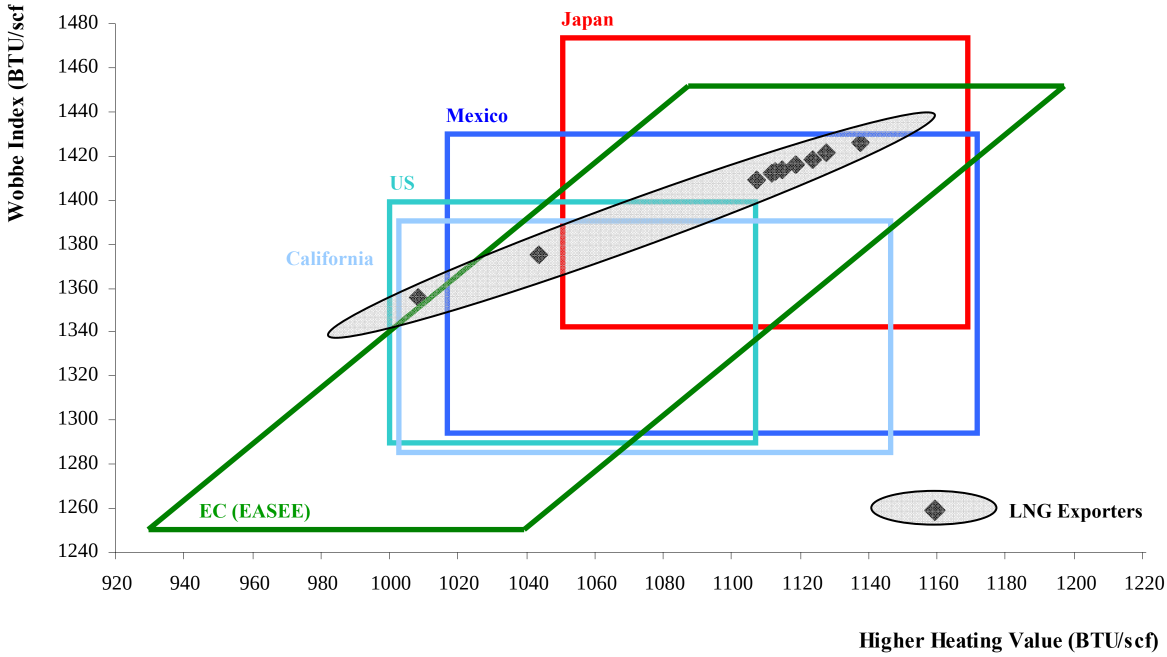
The Wobbe Index (WI) is the main indicator of the interchangeability of fuel gases. If HHV is the higher heating value (or calorific value) and G_s the specific gravity, the Wobbe Index is defined as

$$WI = \frac{HHV}{\sqrt{G_s}}.$$

The index is used to compare the combustion energy output of different fuel gases. For an identical Wobbe Index and given pressure the energy output of two fuel gases will be identical.

[7] These include (from the lowest values to the highest) Alaska, Trinidad and Tobago, Qatar, Indonesia (Bontang and Arun), Malaysia, Abu Dhabi, Algeria, Brunei, and Australia.

Figure 14: Wobbe-Index and HHV of various importing and exporting regions



Source: Own illustration based on Simmons (2005) and Kuipers (2007)

The first US LNG import terminals (i.e. Cove Point and Everett) have been constructed dedicated to special suppliers (originally Algeria, later they also received deliveries from Nigeria and Trinidad). It is relatively easy to equip facilities with special natural gas adaptation technology allowing for a decrease (mainly necessary in the UK and the US) or increase (mainly Asian importers) of natural gas quality in order to meet grid requirements; in the UK Grain LNG terminal, this is already the case: adaptation of gas quality technically is feasible in both, liquefaction[8] and regasification facilities: At liquefaction terminals the heaviest components (LPGs = propane, butane) can be extracted making complex LPG plants necessary. Even if these LPGs can be fully extracted, the remaining ethane content may lead to a HHV above the acceptable value. The decrease of energy content at regasification terminals is based on nitrogen injection (with air separation process needed). The nitrogen content is limited to an upper value by the downstream natural gas network specifications (5% UK, in general 3% US). In order to increase the energy content, propane can be injected.

Quality issues do play a role in the deployment of LNG in Europe, but that they can be resolved at relatively modest cost. In countries that still have specific standards, such as the UK (appliances) the quality issue is likely to be resolved "naturally" over time.

[8] Due to increasing demand also in low HHV areas (namely UK, US) the adaptation at liquefaction facilities becomes necessary.

3.3 Regulatory issues

The European regulatory framework for LNG regasification facilities plays an important role to facilitate efficient and sufficient investment in infrastructure. The 3rd Package from the European Commission acknowledges the need to develop a competitive and efficient natural gas market which is far from complete. The proposal for amending existing legislation includes several measures that will contribute to further achievements in this direction. Third party access to LNG facilities plays an important role in achieving this goal. Clearly defined rules and a sustainable regulatory environment for the use of these terminals are key to create an internal market.

A short-term supply disruption in a functioning internal market for natural gas will provide market-based signals in a liquid wholesale market. Prices at these trading places will direct the flow of natural gas to consumption centers where it achieves the highest value. The role of emergency procedures and financial compensation thereof remains to be analyzed. Underground and LNG storage facilities can provide additional flexible instruments to respond to short-term delivery disruptions. The long-term adequacy of infrastructure investment, in particular importing, underlines the importance of additional LNG regasification facilities.

In order to achieve diversification of imports and thereby reducing the risk of import dependence initially requires substantial upfront investments. A well-developed competitive wholesale market defines the timing and level of investment. Competitive, transparent markets deliver sufficient information about supply and demand and therefore increase the resilience of the system. Information on future market conditions supports investors in making economically rational decisions; more and better information makes more efficient investments in infrastructure feasible. Competitive (wholesale) markets and secondary trading support efficient reactions of market participants to price movements. Taken together, these arguments indicate a positive relation between competitive markets and supply security. Competition leads to a higher number of market participants, more diversification of infrastructure, and attracts new investment thus improving supply security.

4 Financial Point of View

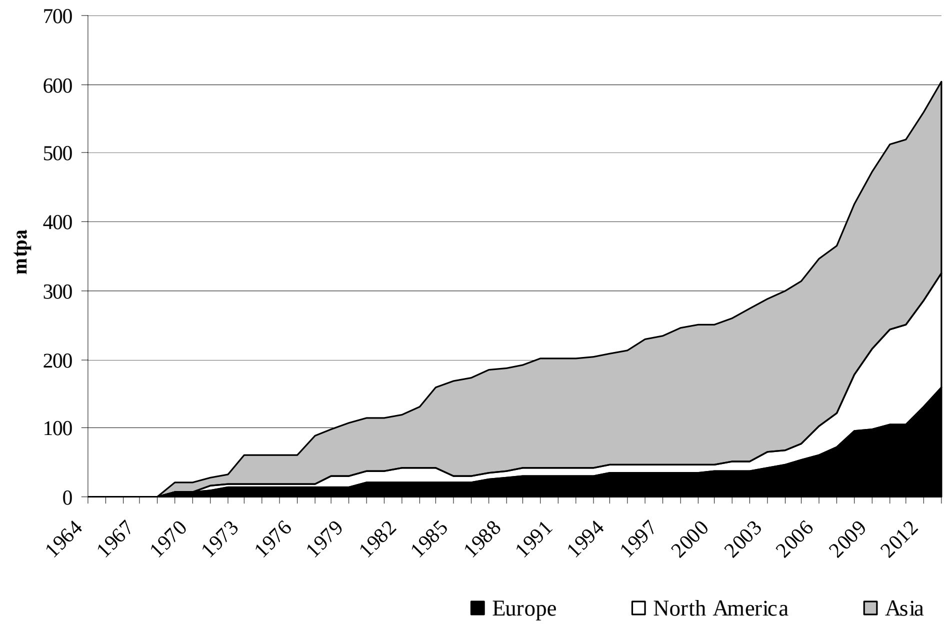
4.1 Overview: investment in LNG regasification terminals is forthcoming

Investments in LNG import capacity are forthcoming in all three importing regions worldwide, i.e. Europe, North America, and Asia. European nominal regasification capacity nearly doubled from 2000 (37 mtpa) to 2007 (72 mtpa), with capacity additions mainly in Spain and the UK. Further facilities are under discussion: Expansions at existing sites and in countries, not participating in the LNG business yet such as Germany, Croatia, and Poland.

Figure 15 illustrates the development of regasification capacities worldwide.

Table 1 provides data on LNG import capacity expansions in Spain and the UK, two countries facing huge investments.

Figure 15: Development of regasification capacities



Source: Own depiction

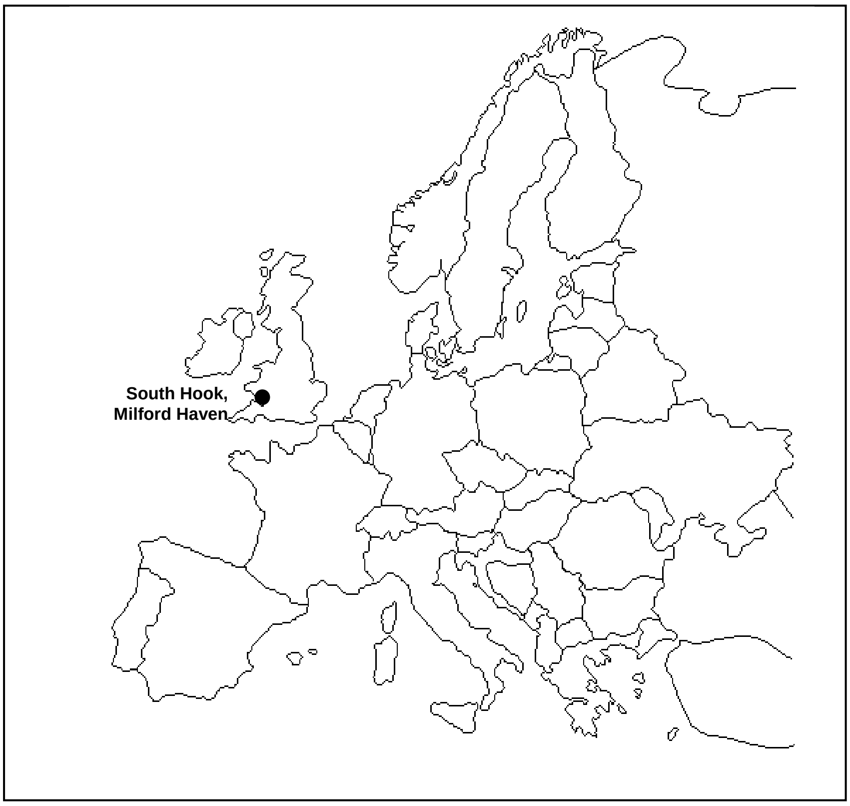
Table 1: Development of regasification capacities in Spain and the UK

Terminal	MS	Start up	Nominal capacity (mtpa)	Storage (m³)	Operator
Huelva Phase I	ES	1988	2.6	160,000	Enagas
Huelva Phase II		2004	1	150,000	Enagas
Huelva Phase III		2006	2.8	150,000	Enagas
Cartagena Phase I		1989	3.8	160,000	Enagas
Cartagena Phase II		2004	2	135,000	Enagas
Cartagena Phase III		2007	1.1	135,000	Enagas
Barcelona Phase I		1969	7.6	240,000	Enagas
Barcelona Phase II		2005	2.9	150,000	Enagas
Bilbao		2003	2.2	300,000	Bahia de Bizkaia Gas
El Ferrol		2007	2.7	300,000	Regasificadora del Noreste SA
Sagunto		2006	4.8	300,000	Planta de Regasification de Sagunto
Dragon/ Milford Haven	UK	2008	4.5	336,000	Dragon LNG Ltd.
Isle of Grain Phase I		2005	3.5	200,000	Grain LNG Ltd.
Isle of Grain Phase II		2010	7	500,000	Grain LNG Ltd.
Teeside (offshore)		2007	tba	tba	Excelerate
South Hook Phase I		2008	7.8	465,000	South Hook Terminal Company Ltd.
South Hook Phase II		2010	7.8	310,000	South Hook Terminal Company Ltd.
Canvey Island		Under study	tba	tba	Calor Gas

4.2 Case study: data

In this section we sketch out a methodology to assess the financial viability of LNG regasification terminals. We assume that these terminals are managed commercially. Based on an assessment of the profitability, we show that there should be no problem concerning investment incentives for European LNG regasification terminals. Rather, these investments reach a high internal rate of return. Our case study – South Hook currently under construction in the UK (see Figure 16) – is based on publicly available sources (e.g. IEA Energy Prices and Taxes) and own data research.

Figure 16: Location of the considered LNG terminal



Calculating the Net Present Value (NPV) and the Internal Rate of Return (IRR), requires several parameters. Some of these input factors are published in publicly available studies and surveys, others are based on own estimations or assumptions. Table 2 summarizes input parameters and sources.

Investment costs account for 750 million USD for South Hook, equaling 535 million EUR (based on an exchange rate of EUR/USD = 1.40). South Hook has a capacity of 10.5 bcm (378,000,000 MBtu); in order to account for realistic capacity utilization, we work with an average capacity utilization of 150,000,000 MBtu.

The wholesale price for natural gas is used as benchmark for the feed-in price from the terminal into the pipeline system. The natural gas price is 4.88 EUR/MBtu for the UK in the base year. LNG import price as of August 2007 averaged 4.20 EUR/MBtu (UK). The spread between natural gas price and

LNG import price represents the profit margin of the LNG terminal. Both prices are assumed to increase over time.[9]

Variable costs are included as follows: During the regasification process about 1% of the processed gas is lost; hence 1% of natural gas import price represents these losses. Labor costs are calculated for an estimated 15 workers per terminal. Wages are estimated at 40,000 EUR (UK), and the tax rate is 30%.

The cost-accounting interest rate has to be estimated. Due to the dependence on unknown financial leverage of the companies we assume an equity ratio of one. To allow for the higher yield, the equity yield rate is set up to 10% for the terminal.

Table 2: Input parameters case studies

	South Hook, UK	**Sources**
Investment costs	535 million EUR	South Hook LNG Terminal Company Ltd., own data
Volume p.a.	150,000,000 MBtu	South Hook LNG Terminal Company Ltd., own data
Price for natural gas	4.88 EUR/MBtu	IEA Energy Prices and Taxes, 4Q2007
Price for LNG	4.20 EUR/MBtu	IEA Energy Prices and Taxes, 4Q2007, August 2007 average
Price increase natural gas	0.96% p.a.	EWI/Prognos: Die Entwicklung der Energiemärkte bis zum Jahr 2030
Variable costs	Regasification requires 1% of processed gas	IEA, Natural Gas Transportation, 1998
Staff	15 employees; wages: 40,000 EUR/a	Own assumption, based on BP information
Tax rate	30%	Tax rate for companies, survey of federal government
Calculatory interest rate	10%	Depends on financial leverage, assumed for equity ratio 1

[9] EWI/Prognos (2007) report in their study “ Die Entwicklung der Energiemärkte bis zum Jahr 2030“ an annual rise of 0.96% per year.

4.3 Traditional NPV approach

The model determines cash flows over a running period of 40 years. We use the Discounted Cash Flow (DCF) method to calculate the NPV and internal rate of return. Depreciations are linearly split over running time. Furthermore, the possibility of tax shields is ignored, i.e. there is no refunding of taxes in case of a negative fiscal assessment basis. Cash flows are discounted by the assumed interest rate and added up; these cumulated cash flows are offset by the investment costs for NPV calculation. The internal rate of return equates to the interest rate resulting in a NPV of zero.

South Hook shows a positive NPV. With a value of 166 million EUR, it is highly economical and legitimates the investment decision.

4.4 Real options approach

When employing the traditional NPV approach a number of relevant factors are disregarded. Due to the static approach of determining cash flows, the decision-maker has to reach a now-or-never decision. If the NPV of a considered project is positive, the investment will be carried out, otherwise it will be discarded.

Flexibility of a decision-maker, hence the opportunity to delay the investment, broadens the scope. He can await future developments, e.g. on prices or investment costs, to obtain more certainty related to input parameters of the cost effectiveness study. Therefore, the now-or-never decision turns into a wait-and-see decision of the project. The investment is delayed under the prospect of favorable developments of prices or costs. This proceeding is represented by the real option approach (Dixit and Pindyck, 1994).

To estimate this option value of waiting (delaying the investment decision), we develop several scenarios concerning future natural gas price developments. With a certain probability (p=50%) the natural gas price is assumed to rise with a given volatility of 20%; the price will decrease with a probability of 25% (same volatility). With a probability of 25%, there is no additional change in natural gas prices. The decision period is set at 5 years, so investments may occur in the base year 2005, in 2010, or in 2015. After 2015, the natural gas price is assumed to remain at the same level, under consideration of annual price increases.

For estimating the potential value of postponing the investment and the value of the delay option, it is necessary to calculate the NPVs of the five scenarios. These are compared to the NPV of the base case. If the NPV of the new developed scenario is higher than the NPV of the base case the differential expresses the value of the delay option and consequently the value of waiting. Therefore, in case of a positive differential the option is exercised and the investment delayed for a certain number of periods. We compute these option values for both terminals and each scenario. Results are summarized in

Figure 17.

Figure 17: Real option values in million EUR

	Traditional NPV	2010 high	2015 high high	2015 high medium	2015 high low	2015 medium high
South Hook, UK	165.6	509.5	676.5	338.0	-0.4	338.0
Value of the real option	n/a	343.9	510.9	172.4	0	172.4

For South Hook the real option value in later periods is highly positive, so a delay of the investment decision is advisable to await higher natural gas prices.

This case study should be considered as representative, but not fully reflecting reality. Expert discussions have confirmed the idea that financing does not constitute a major obstacle to the investments in the LNG chain.

5 Conclusion

We conclude that from an economic, market, and financial point of view, there is a limited case for an LNG Action Plan at the EU level. If asked to provide a quantitative assessment on the need for an Action Plan, it would be located it in the range of 30%. In case an Action Plan is adopted, it should target the development of the internal market and European-wide competition, and specific problems of supply security in some of the new member countries of Central and Eastern Europe.

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