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Market-based Options for Security of Energy Supply

Insuring against Disruptions of Energy Supply

# Investments in Gas Pipelines and Liquefied Natural Gas Infrastructure

## What is the Impact on the Security of Supply?

**Patrick Cayrade**

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## *INDES WORKING PAPER NO. 3/MARCH 2004*

**PATRICK CAYRADE***


### Executive Summary

This paper addresses the question of the infrastructure investment required for gas pipeline and liquefied natural gas (LNG) connections to meet growing gas demand in an enlarged EU over the next 20 years. Several issues are presented, bearing in mind the major objective of the security of supply for EU countries.

- First, to set the scene, recent projections of gas demand in an enlarged EU are presented along with the corresponding need for additional imports.
- Then a scenario is developed showing possible supply routes to meet the import gap, relying on increasingly remote routes. An impressive bill of $150 to 200 billion will have to be paid for extending and building the required infrastructure in pipeline links and LNG-receiving facilities.
- The expected major development of LNG markets is subject to a particular discussion, as far as the progressive globalisation of this market and its inherent flexibility provide major advantages in terms of the security of supply, despite more costly infrastructure than pipeline links.
- The impact of technological progress is expected to reduce both capital investment and unit transport costs, offering access to new supply opportunities.
- Finally, the question of major obstacles to the realisation of the required huge investments in gas infrastructure over the next 20 years is addressed, opening hot debate on the subjects of future gas price, market liberalisation and financing issues.


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## WHAT IS THE IMPACT ON THE SECURITY OF SUPPLY?

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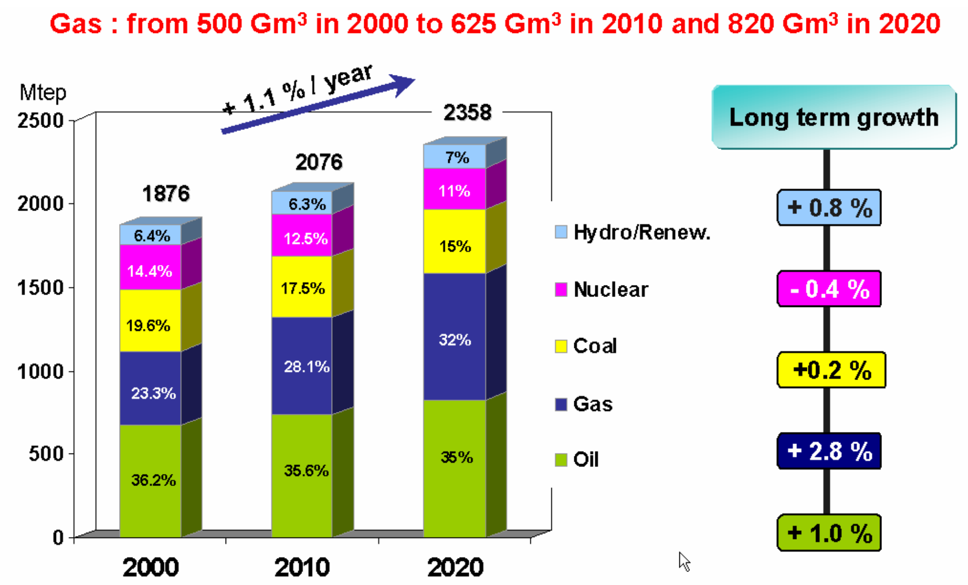
## 1. Europe will be the largest world market for imported natural gas between 2000 and 2020

Any attempt to address the problems of the long-term security of natural gas supplies to Europe has to rely on a proper evaluation of both future demand level and possible supply sources. On the demand side, several scenarios have been worked out by different institutions, agencies and consultants, and there is a consensus towards the probability of an exceptional growth period. We will not detail the obvious reasons advanced to support this consensus, but just recall the extremely high potential for natural gas as power-generation fuel in most European countries: natural gas is a clean fuel, and given its higher efficiency than its competitors of coal and fuel oil, it is clearly the preferred fuel.

The environmental features of natural gas are particularly favourable to allow a major reduction of $CO_2$ emissions even under a normal growth scenario. In this respect we have estimated that in a theoretical scenario, in which all thermal power plants are converted to gas-fired combined heat and power (CHP) plants, gas could contribute over half of the solution to the EU's $CO_2$ emissions-reduction problem.

Even without going to such an extreme option, a relatively conservative scenario is presented in Figure 1, which shows a major increase in the share of natural gas in the European energy mix from 2000 to 2020.

*Figure 1. Growth in use of natural gas from 500 Gm$^3$ in the year 2000 to 625 Gm$^3$ in 2010 and 820 Gm$^3$ in 2020*

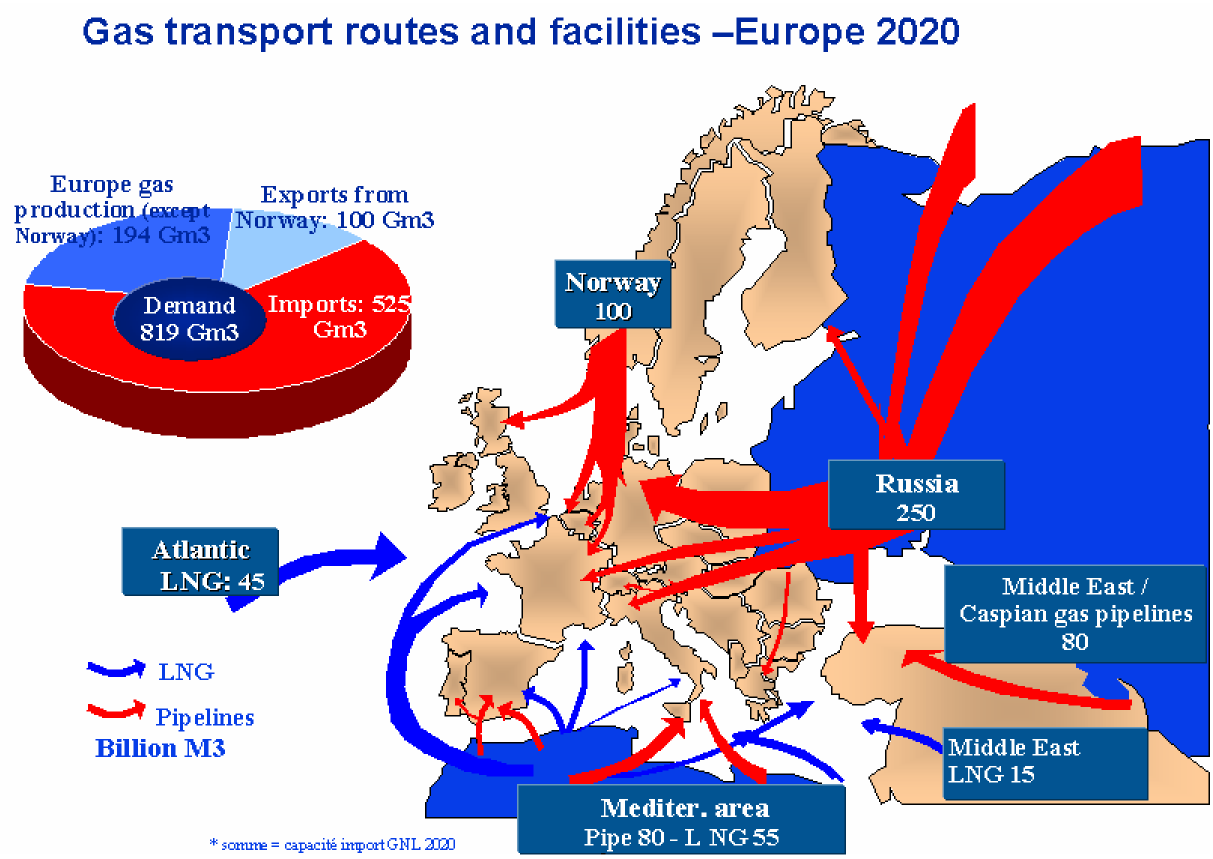


This scenario was established for an EU of 27 member states, including countries from Western Europe, Eastern Europe (excluding the former Soviet Union) and Turkey. Energy consumption is expected to grow at an annual average rate of 1.1%, and the share of natural gas in the energy mix is expected to increase from 23.3% in 2000 to 33% in 2020. Natural gas shows the highest average growth rate at 2.8% per year, followed by oil at 1.0% per year. Under such a scenario, an additional 320 billion cubic metres (bcm) per year of natural gas has to be supplied to Europe in 2020 compared with consumption in 2000.

## 2. Possible scenarios of gas supply flows to Europe in 2020: A huge need for new supplies by pipelines and LNG links

If we consider the above-mentioned gas demand as projected to the year 2020, a possible solution for supplying Europe could be that shown in Figure 2. Here it is estimated that Europe gas production would be limited to 194 bcm and that Norway exports would reach 100 bcm. Faced with a demand of 819 bcm, import flows would have to rise to 525 bcm.

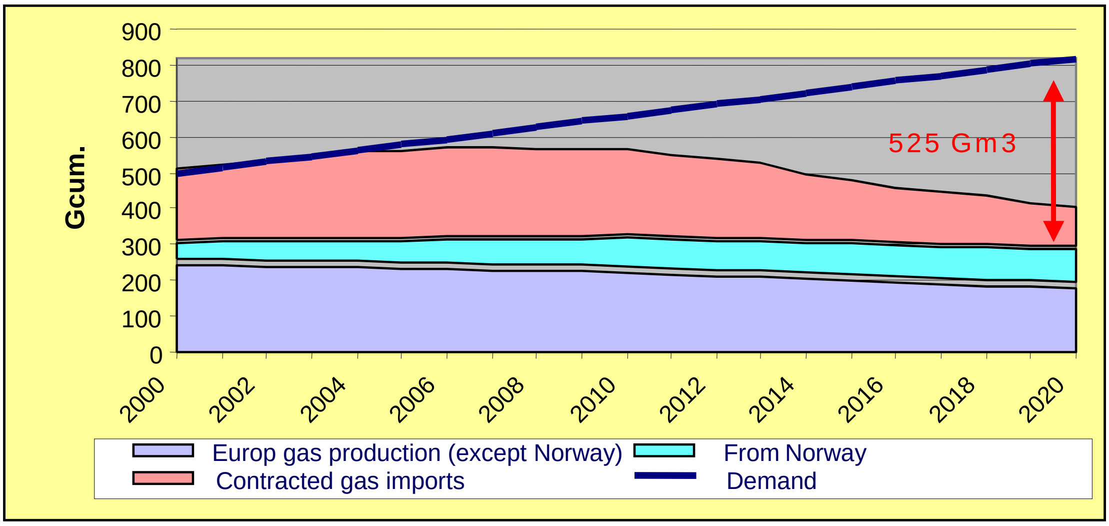
*Figure 2. European gas transport routes and facilities in 2020*




Russia would remain by far the main supplier with 250 bcm, followed by the Mediterranean area with 80 bcm of pipeline gas and 55 bcm of LNG. Additional, new supplies would be required from the Caspian area (80 bcm) and the Middle East LNG (55 bcm).

The situation in terms of the security of supply in this 2020 scenario is even more worrying when taking account of contracted gas imports: among the total 525 bcm required for import, 400 bcm are not yet contracted. The graph in Figure 3 clearly illustrates the evolution of the situation from 2000 to 2020.

*Figure 3. Supply, demand and contracted gas imports*




## 3. Particular characteristics of LNG markets versus pipeline connections – possible evolution

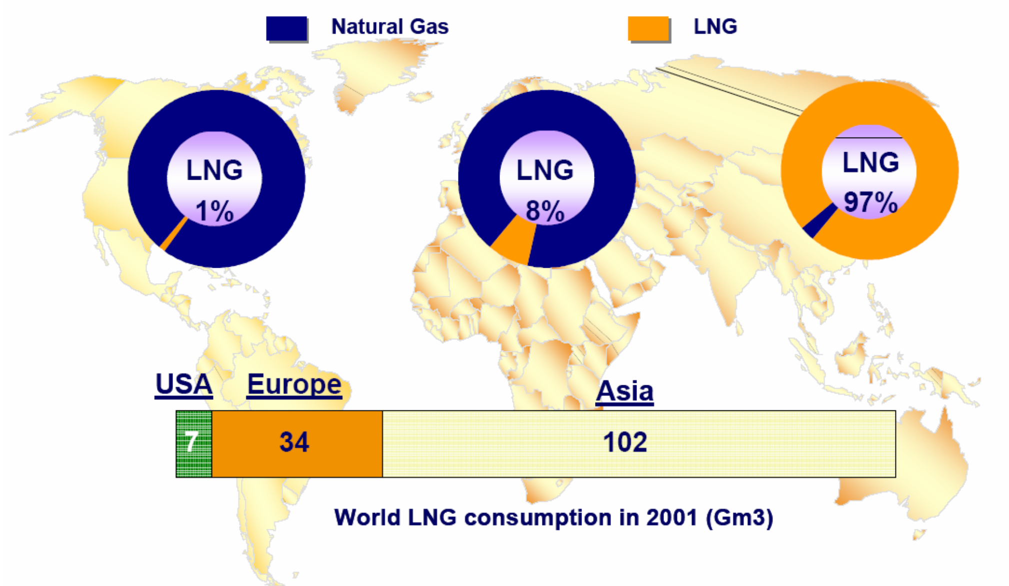
Although pipeline links were the first means to connect gas production areas to market areas, LNG links have developed on a fast track over the last ten years. Initially devoted to very long distances, for which pipeline projects were not economically justified, LNG is becoming increasingly feasible for shorter distances, as shown by the examples of Cyprus and Lebanon, which are launching projects to import LNG from Egypt or Algeria even for their relatively limited market. The type infrastructure investment required by these two gas transport modes is quite different:

- pipeline links involve only pipe tubes and compressor stations; whereas
- LNG links involve a whole investment chain, including a liquefaction plant, special LNG tankers and a reception terminal with liquefied gas storage and regasification plants.

The LNG chain is clearly far more capital-intensive than the pipeline link, which explains why LNG connections were initially developed for long-distance routes.

LNG markets have particular characteristics that have to be thoroughly analysed when questions of the security of supply are addressed. But it is interesting to first understand how these LNG markets function today and what their expected development is. Figure 4 illustrates the very different roles played by LNG in the three current markets: Europe, the US (Atlantic Basin) and Asia (Pacific Basin).

*Figure 4. LNG Consumption in 2001(Gm3) in Europe, the US and Asia*




With a total world LNG-consumption of 143 bcm in 2001, Asia accounted for 97% and Europe only 8% of the total market. The Asian market is dominated by the high demand of Japan, followed by South Korea and Taiwan. Indonesia is the largest LNG producer, followed by the Middle East (Qatar), Malaysia and Australia. European LNG demand is still limited. Algeria is Europe's main supplier, while Libya and Egypt are newcomers. The US market is very limited on account of the still high production level of domestic fields, but this situation is changing and the US will inevitably become a large LNG importer because of declines in domestic production. Until now, these three markets were practically separated, excepting some occasional spot deliveries from the Middle East and Algeria to the US and Japan. But contracts between markets are becoming more frequent, subject to the limitations of transport costs. Figures 5 and 6 illustrate our view of the most likely developments in LNG connections. The current situation is relatively simple, but things will probably become more and more complex.

*Figure 5. The initial scheme was simple…*

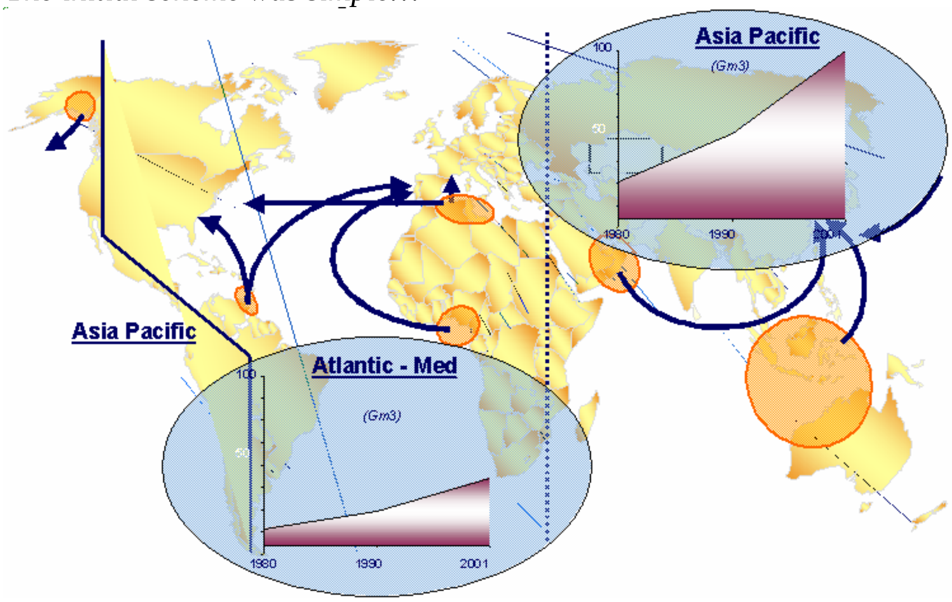
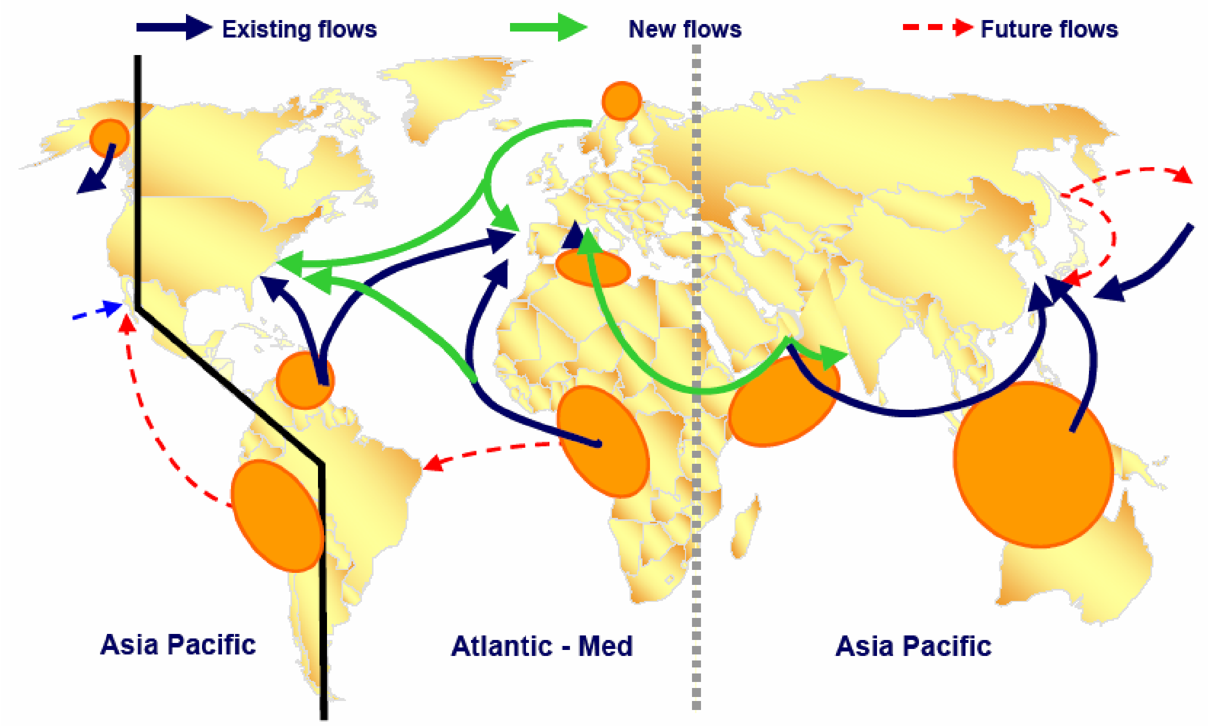
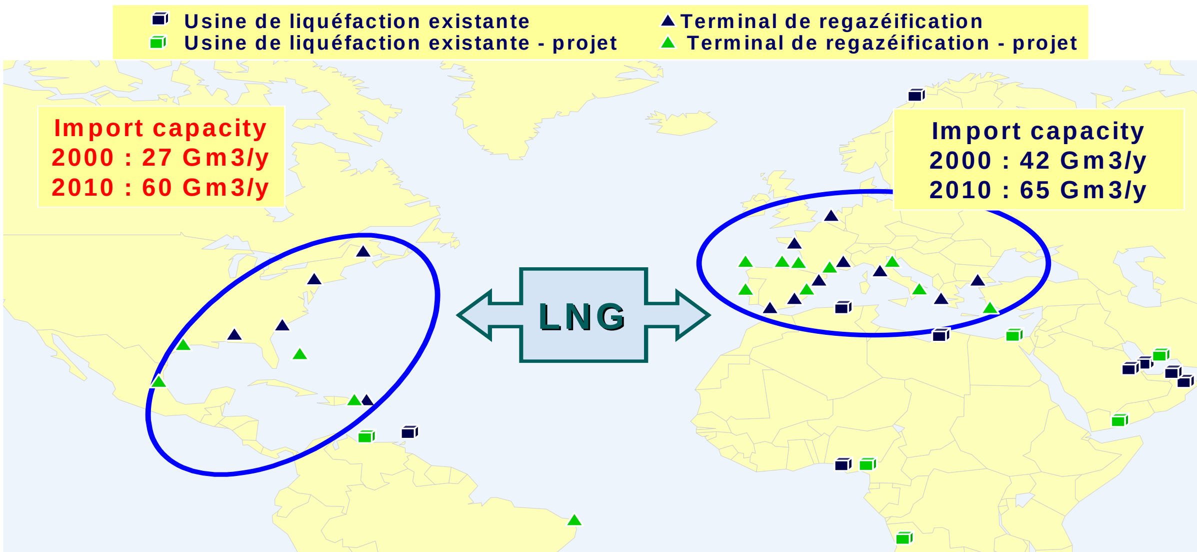


*Figure 6. But LNG trade is becoming more and more complex*




Looking only at the horizon for 2010, we have estimated that there will be a substantial development of LNG-import infrastructure in Europe, from 42 bcm in 2000 to 65 bcm in 2010. During the same period, import capacity in the US area (Atlantic basin) would more than double, from 27 bcm in 2000 to 60 bcm in 2010, but not for exactly the same reasons.

- As has been indicated above, Europe is likely to require more than 500 bcm of imported gas around 2020. This gas has to come from ever more remote sources, involving distances where LNG is fully competitive with pipelines (the Middle East, South America). But LNG could also be preferred for reasons relating to the security of supply, in so far as it is not required in this case to cross countries that feature political risks. This issue is reflected in current LNG projects under study for gas from the Shtockman and Yamal fields in Russia, where an additional cost for the security of supply would have to be taken into account.

- The US poses a different scenario, as this country is at the start of a process in which it will progressively become a massive importer of gas, resulting from the exhaustion of its reserves and thus declining production. Most operators in the US think that the best strategy to deal with its gas decline is to import gas (mostly in the form of LNG). As power generation is a very large potential consumer of gas, the alternative of clean coal technology is seriously considered and substantial progress is underway. This alternative provides emissions profiles close to those of gas, but it is now admitted that this technology will not be fully commercial before 2010 at the earliest.

## 4. The magnitude of the required infrastructure investment for pipeline and LNG connections

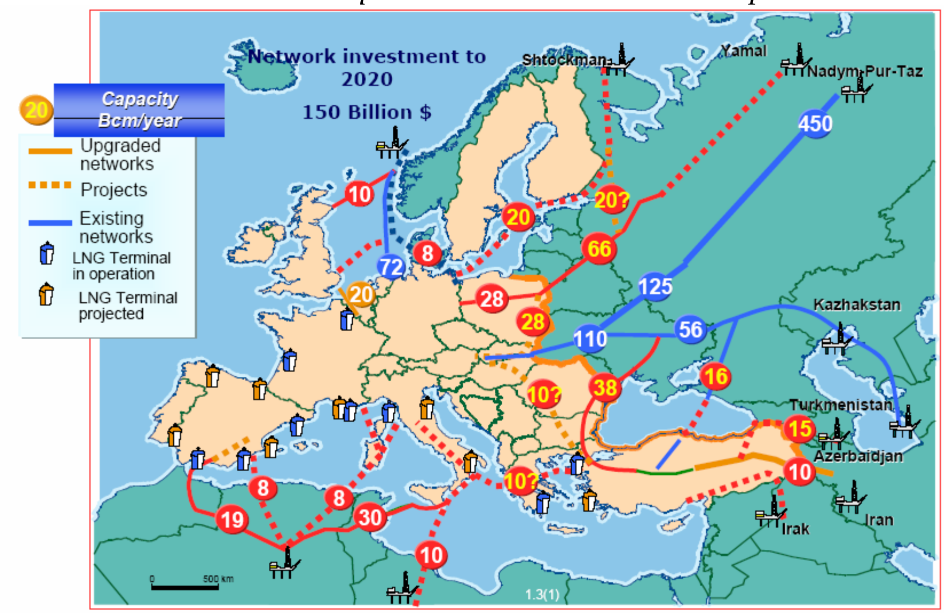
Demand and supply projections recently developed for Europe (see sections 1 and 2), even when based on moderate expectations of future demand for natural gas, have shown the existence of a substantial gap between demand and the potential supply from outside Europe.

In the real world, however, there is no supply or demand gap but market forces and decisions by leading actors who are continuously work to attain a sustainable balance. Achieving this balance clearly requires a substantial amount of capital investment in both production and transmission infrastructure. The extensions and new gas connections that need to be implemented to meet demand in 2020 are shown in Figure 7, and mainly involve:

- new pipelines from Russia (from the Shtockman and Yamal fields);
- new pipelines from Algeria (to Italy and Spain);
- new pipelines to supply gas from the Caspian sea area to Europe via Turkey; and
- new LNG terminals to receive LNG from Egypt and the Middle East.

A rough estimate of the bill for these infrastructure projects is in the range of $150 to 200 billion.

*Figure 7. Network investment required to meet demand in Europe in 2020*



### Typical LNG chain investment

To illustrate the magnitude of the infrastructure investment, below is a recent estimate for an LNG chain from Egypt to Cartagena in Spain (2,735 km):

- The capacity involves 3.50 million tonnes of LNG (4.8 bcm) corresponding to the capacity of one standard LNG train.
- A liquefaction plant in line with recent technological improvements and capital cost reductions is estimated to cost $900 million (liquefaction cost equivalent to $1.0/mm Btu).
- Shipping two tankers of 135,000 tonnes represents a capital investment of $360 million, in order to link the liquefaction plant from an area close to Port Said to Cartagena (2,735 km) with turnaround times of ten and a half days. The resulting shipping cost is $0.40/mm Btu.
- Regasification in a terminal, including 240,000 $m^3$ of storage (three tanks of 80,000 $m^3$) for a total capital investment of $320 million. The resulting regasification cost is thus $0.41/mm Btu.

A typical, small LNG chain such as this involves a capital investment of $1,580 million (excluding upstream field development) to deliver 4.8 bcm of gas to the pipeline network at $2.56/mm Btu (the technical cost assumes a production cost in Egypt of $0.65/mm Btu).

### Typical gas pipeline interconnection investment

Similarly, an example of new pipeline connections is the MEDGAZ project from Algeria to Spain, with the following characteristics:

- an onshore line of 547 km from Hassi'Rmel field in Algeria to Beni Saf on the coast;
- an onshore line of 200 km from Beni Saf to Almeria; and
- a capacity of 8 bcm per year.

This kind of pipeline link involves a capital investment of $1,166 million, including compression, to deliver gas in Spain at $1.17/mm Btu (the technical cost assumes a production cost in Algeria of $0.45/mm Btu).

## 5. Impact of technological progress on pipeline and LNG costs

The capital investment required for the gas transport infrastructure will be substantially affected in the next decade by technological progress, for both pipelines and LNG facilities. Such progress will mainly result in reductions in future gas transport costs, which are particularly sensitive on long-distance connections, and will favour the connections between more remote production and consumption centres, with an obvious impact on the security of supply.

The magnitude of cost reductions presented below is based on a study carried out in 2000 by the ENI Group and IFP (Institute Francais du Petrole), on behalf of the European Commission (DG TREN) entitled "GATE 2020 – Gas Advanced Technology for Europe at the year 2020".

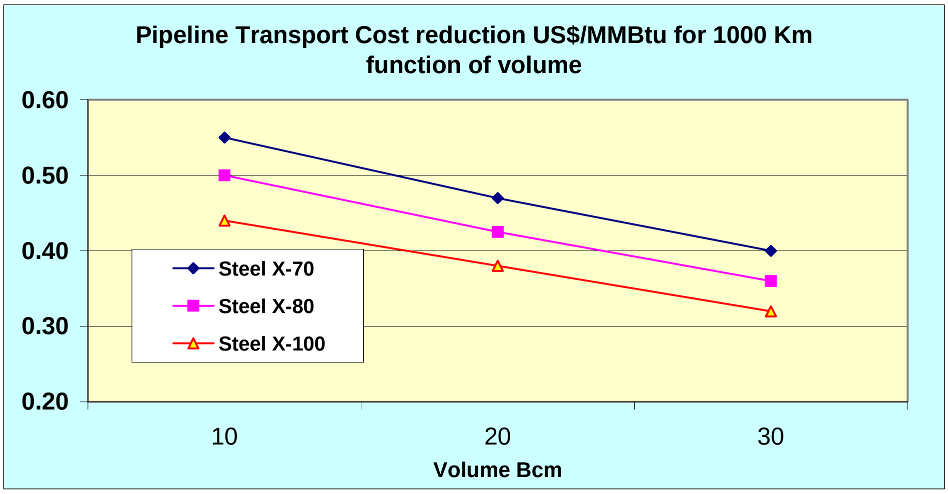
Concerning pipelines, current high-capacity onshore connections use steel grades up to X70 and operating pressures under 75 bar. Recent studies have concluded that by using higher steel grades (X80 and even X100) pressure levels could be increased to 140 bar, allowing for the same pipe diameter to:

- transport a higher gas volume
- and make savings in compression needs.

Europipe II is the first pipeline to use X80 steel. Using higher grade X100 steel allows a pressure of 140 bar without requiring a higher wall-thickness, as is the case with traditional pipes.

The combination of the above advantages implies that the unit transport cost using X100 steel can be reduced by 20% compared with the costs associated with the current X70 pipes. Figure 8 shows the reduction in transport costs for a pipeline connection of 1,000 km, which is in the region of $0.10/mm Btu.

*Figure 8. Reductions in pipeline transport costs by the grade of steel transported*



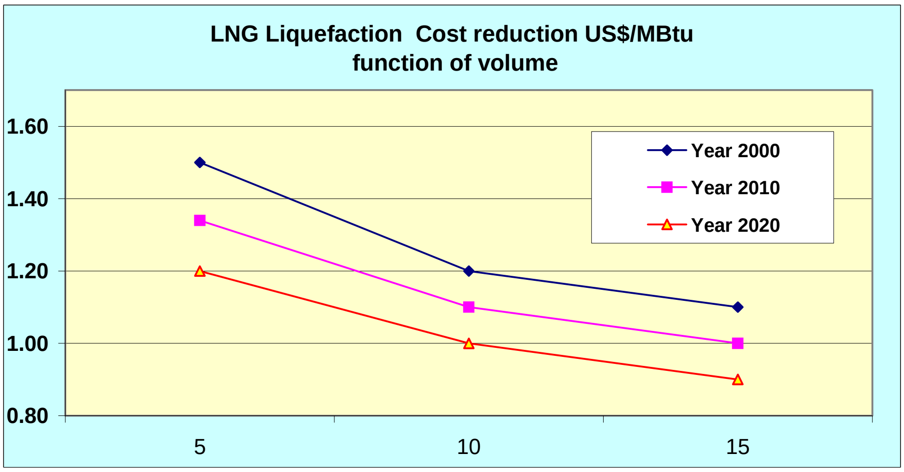

*Source:* Study for the European Commission (DG TREN) (2000), "GATE 2020 – Gas Advanced Technology for Europe at the year 2020" by the IFP and ENI Group.

With respect to the LNG chain, technological developments and cost reductions are expected in 2010 and 2020, mainly in the design of liquefaction plants and the capital costs of tankers. Looking at the 2020 horizon, the following developments are expected:

- a reduction of 20% in liquefaction plant capital costs and maximum train sizes of 6 million tonnes per year (up from the current 3 million tonnes per year);
- shorter plant construction periods of four years instead of five;
- faster operation build-up profiles; and
- a reduction of 10% on tanker capital costs with higher tanker sizes (200,000 $m^3$ instead of the current 130,000 $m^3$).

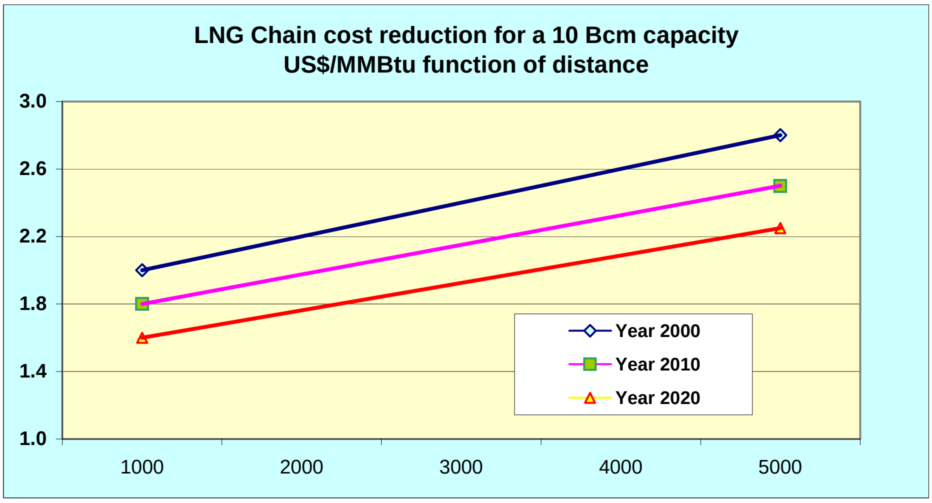
Figures 9 and 10 illustrate the reduction in liquefaction costs as a function of volume and in the total LNG chain costs for a 10 bcm capacity (7.5 million tonnes per year) as a function of distance.

*Figure 9. Reductions in liquefaction costs as a function of volume*




*Source:* Study for the European Commission (DG TREN) (2000), "GATE 2020 – Gas Advanced Technology for Europe at the year 2020" by the IFP and ENI Group.

*Figure 10. Reductions in the LNG chain as a function of distance*




*Source:* Study for the European Commission (DG TREN) (2000), "GATE 2020 – Gas Advanced Technology for Europe at the year 2020" by the IFP and ENI Group.

## 6. Constraints on the realisation of infrastructure investment

In our view, the effective realisation of these huge infrastructural investments will have to face at least three obstacles: the uncertainty about future gas prices, the difficulty of financing and some possible adverse effects of excessive regulation.

### Uncertainty about future gas prices

The relationship between gas and oil prices (coupling versus decoupling) is the subject of hot debate. A simple analysis, however, can highlight the specificities of the European gas market. In Europe, the average value of gas is a netback value for its different usages and substitutes (halfway between gas value in the US and in Japan/Korea). As an average, the EU gas import prices (pipelines or LNG) have been at 80% of Brent parity for 1985 to 2000, and this relationship has been rather stable. The much-publicised ‘decoupling’ has therefore not occurred and will be more ‘optical’ (pricing seasonality) than ‘real’. On the contrary, coupling could even improve (with a progressive shift towards 100% Brent parity for gas import prices at the EU borders).

It is clear that the fear of decoupling – leading to lower gas prices that are linked to spot markets – does not provide the right conditions for financing the huge projects for new supplies. Although it would indeed secure a fair degree of market liquidity and facilitate short-term management, it would not be appropriate for the long-term security of supply.

## Financing difficulties

The development of gas infrastructure at such a scale is a complex and capital-intensive effort. Many of the benefits such as energy efficiency and environmental improvement are manifested in ways that require governments to either mobilise the funds or set clear paths and guidelines to promote development by the private sector.

Liberalisation in the downstream market unfortunately instigates market uncertainty for traditional gas purchasers, and consequently for producers and transporters with regard to the ability of gas purchasers to commit on volumes and prices over the long term. This risk adds to the difficulty of securing adequate financing conditions. In this respect, the European Commission has clearly understood the value of long-term contracts to secure financing and create confidence in the lending community.

Innovative financing methods will have to be worked out within an environment of capital competition. Where long-distance pipelines cross countries that have political insecurities, the risks incurred may also be an impediment to securing appropriate and feasible financing packages. Partnership along the gas chain will provide an effective response to market uncertainty.

Financing gas development in producing countries will also be a major challenge. In this respect, it can be suggested that partnerships between national oil companies and international oil companies would bring not only improved lobbying positions but an improved ability to finance new projects; further, its advantages would go far beyond these in terms of efficiency gains all along the gas chain.

## Excessive regulation

An example how an excessive regulation could hinder the development of gas infrastructure was recently given by the Federal Energy Regulatory Commission (FERC) in the US. The obligation of open access to newly constructed LNG-receiving terminals had to be eased, as major companies argued that they could not justify building new, capital-intensive LNG terminals if they could not also control the shipments through the plants. Japan has offered a good model of providing only negotiated third-party use of Japan’s 24 LNG-receiving terminals in its new, draft deregulation law.

## Conclusions

- The enlarging EU is facing a major challenge over the next 20 years: how to secure the required investment in gas infrastructure to import up to 525 bcm of gas (and even more if Kyoto commitments have to be fulfilled) to meet increasing demand.
- The development of LNG markets may ease some concerns related to the diversification and security of supply, but with an added cost.
- The question of uncertainty about future gas prices is still unresolved and may have an adverse impact on raising appropriate financing.
- The regulations applied to construction and access to infrastructure facilities (LNG terminals and pipelines) will have to be calibrated so as not to hamper their timely development.

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# About INDES

This publication, part of the INDES Working Paper Series, originates from the project "Insuring against Disruptions of Energy Supply – Managing the Risks Cost-Effectively" (INDES). INDES has been a one-year joint research project under the initiative of the Centre for European Policy Studies (CEPS) together with the Energy research Centre of the Netherlands (ECN) and the Fondazione Eni Enrico Mattei (FEEM). The project was supported by the Fifth Framework Programme and funded by the European Commission Directorate-General for Energy and Transport.

The INDES project focuses on market-compatible, cost-effective security of supply responses by the European Union. Security of supply is understood as insurance against risks, in which responsibility is shared between the EU, member states, energy companies and customers. Thus security of supply is seen as an economic risk-management strategy. Critical to such an approach is first the minimisation of the insurance 'premium' to achieve the degree of security that is politically called for. Second, there is a need to identify the best systemic actor able to 'hedge' the risk. This can be governments, companies, consumers or in some cases, the market itself subsequent to careful design. Based on these premises, INDES research has emphasised two areas: i) costs of energy supply disruptions and ii) costs of potential policy responses. Towards this end, robust methodologies to assess costs and a sound empirical basis for cost data were used as the precondition for informed policy choices reflecting both effectiveness and cost-efficiency. Following this work, INDES research sought to identify the appropriate market-compatible instrument and the associated actors that would convey the process, be they governments, companies or consumers.

INDES has operated around three axes. The first was academic workshops that developed and refined the methodological framework and empirical base. The second was stakeholder workshops that presented and discussed findings with policy-makers and other stakeholders. The third axis has been the promotion of publications – both academic and policy-relevant – that aim at participating in the existing academic debate and influencing policy-makers. For more information on the project and the series of working papers, visit the INDES website at http://www.energymarkets.info/indes/index.html.

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