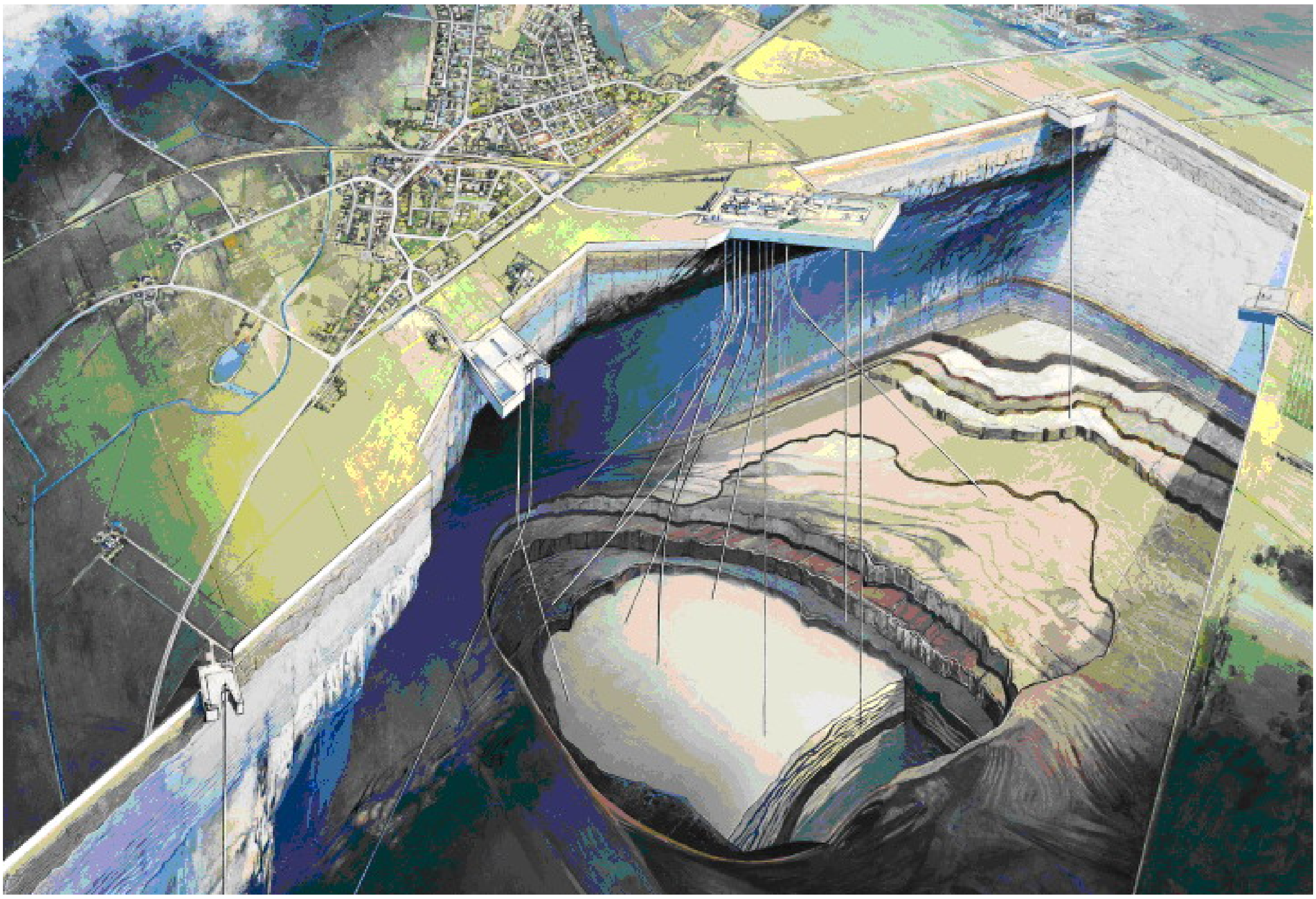

DG TREN C1

Study on natural gas storage in the EU

Draft Final Report

October 2008

RAMBØLL

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EXECUTIVE SUMMARY

PART I BACKGROUND

1. Introduction

In order to address the issues of availability and cost of gas storage in Europe in relation to market needs and security of supply the EU Commission has launched a 'Study on Natural Gas Storage in EU'.

The study will be used as input to:

- The new Commission communication – Second strategic energy review which will focus on security of supply.
- An evaluation report which seeks to evaluate the need of including storage in the Security Directive.[1]
- The work of the Gas Co-ordination Group (GCG).

The purpose of the project is to carry out a study on natural gas storage in the EU in order to analyse and assess the natural gas storage situation in the Member States in terms of availability of storage capacity and costs. It is the aim of the analysis to suggest a series of recommendations in order to secure a proper working gas storage market as well as recommendations on security of supply and strategic stock as a possible mitigation tool for a gas market that is becoming increasingly dependent on imported gas from non-member states[2].

The study intends to evaluate the availability of storage by the following measures; An assessment of present gas storage demand and the benchmarking of existing available storage capacity with future planned investments, an assessment of the principal investment drivers and the impact of and necessity for regulation in the market and finally to provide a perspective on a common EU strategy related to strategic stocks through an attempt to answer the following main questions:

- What is the available storage capacity in EU at present?
- What are the main drivers for development in the European natural gas storage market?
- What kind of natural gas storage market can we expect in the future and how should the storage market be organized in order to ensure optimal functioning?
- How should the EU approach the issue of strategic stocks?

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[1] In April 2004 the Commission passed the Directive 2004/67/EC1 concerning measures to safeguard security of natural gas supply, hereafter referred to as the Security Directive.
[2] Member States means EU Member States

PART II DEFINITIONS

There seems to be a wide range of definitions and designations adopted throughout the EU Member States for some of the principal terms that are subject to this study. In order to ensure that collection and analysis of data, as well as conclusions and recommendations, are given on a consistent basis the consultant would like to state the adopted following definitions.

2. Security of supply

The term 'security of supply' throughout this study refers to security of gas supply.

The definition of security of supply and its interpretation however remains contentious. Some definitions of 'security of supply' as presented below, indicate that this definition no longer refers only to the prevention of a physical disruption of supply but rather that the definition should also take into consideration economic and environmental issues that may affect gas supplies. The following definitions display the lack of a clear consensus on this topic;

Definition 1: "A standard definition of security of supply is a flow of energy supply to meet demand in a manner and at a price level that does not disrupt the course of the economy in an environmental sustainable manner."[3]

Definition 2: "Energy supply security must be geared to ensuring the proper functioning of the economy, the uninterrupted physical availability at a price which is affordable, while respecting the environment concerns. Security of supply does not seek to maximise energy self-sufficiency or to minimise dependence, but aims to reduce the risks linked to such dependence."[4]

Definition 3: "Security of supply is the capability to manage, for a given time, external market influences which cannot be balanced by the market itself".[5]

In order to develop a discussion of the above definitions, it is important to distinguish between:

- Security of supply in macroeconomic terms.
- Security of supply from the consumer's point of view.

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[3] Cambridge Energy Research Associates (CERA) Global Energy and Energy Security: A New Agenda 2001. European Energy: Revising Security of Supply 2005.
[4] Europe's vulnerability to energy crises, World Energy Council 2008.
[5] IEA Security of Gas Supply in Open Markets, 2004.

2.1 Security of supply, macro- vs. microeconomic terms

In the consumer's view security of supply is related to:

- Continuous physical supply to the consumer's premises under any conditions and;
- Affordable prices for the individual consumer.

2.1.1 Continuous physical supply to the consumer's premises under any conditions

The cause of a gas supply disruption to the consumer's premises (whether due to technical, political, extreme weather conditions or other reasons) is irrelevant to a consumer. The consumer expects the gas to flow any time he opens the valve. Ensuring continuous gas supply to the end consumer in the past has been the responsibility of the vertically integrated gas companies. It is now the responsibility (through a contractual obligation) of the consumer's supplier which the consumer chooses freely on the liberalised gas market.

2.1.2 Affordable prices for the individual consumer

In this context the discussion of affordability concerns non-commercial consumers, i.e. households. Economics theory dictates that a free market should balance the supply and demand with the consumer always having the physical possibility to buy gas if they accept the market price, however can they afford the price and what is the consequence if a large part of the population cannot afford it? Governments have often intervened by subsidising end-user gas prices for households in order to keep the price at an affordable level and thereby buy social peace. This has often resulted in inappropriate programmes subsidising both consumers who can and who cannot afford to pay the gas bills on behalf of the gas industry. The long-term consequence is that there is often a lack of investment and a resulting deterioration of infrastructure and subsequently directly diminished safety and security of supply to consumers. This 'solution' can no longer be implemented in the liberalised gas market. The barriers most commonly stated by operators/11/ include "Artificial low tariffs due to current regime that distort competition and regulated tariffs that do not cover the investments."

2.1.3 Vulnerability to gas supply disruptions

The vulnerability of an economy to gas supply disruptions depends on a number of parameters such as the share of gas in energy consumption and especially the import dependency of a country on gas, i.e. the share of net imported gas in the primary energy consumption. The parameters for the individual EU Member States are shown and discussed in section 1.

In general even if a country depends on imports it is not necessarily vulnerable to gas supply disruptions if its supplies are diversified both in terms of fuels and the number of suppliers. The vulnerability of an economy to supply disruptions therefore should not be assessed for different fuels separately but as the whole vulnerability to energy supply disruption however, when discussing gas only the diversification of supply routes and suppliers is more relevant than gas import dependency alone.

In addition to vulnerability of a physical supply disruption an economy can be affected by price volatility which is again related to the above-mentioned parameters such as share of net imported gas in the total primary energy consumption and even more relevantly the energy intensity. The impact of increased import gas prices (including volatility of exchange rates) in an energy-intensive economy will result directly in an increased energy bill often expressed through the GDP.[6]

2.2 Impact on the security of supply

Security of supply can be affected by:

- The technical failure of the gas infrastructure.
- Political uncertainties and disputes.
- Free market/regulatory regime issues.
- Extreme weather conditions and climate change.

2.2.1 Technical failure of the infrastructure

The infrastructure used for production, transmission and distribution of gas includes a complex system of pipes, compressor stations, storage facilities, pressure regulating stations, metering stations and a number of other auxiliary equipment. The risk of equipment failure or manmade mistakes in its operation can be minimised but never fully eliminated. Ensuring security of supply in terms of the minimisation of the risk of equipment failure is the responsibility of the respective infrastructure operator (producers, transmission, distribution and storage system operators) and relevant authorities within the country who evaluate the risks according to the specific technical and operational constraints of the infrastructure and define the safety codes and procedures for their implementation.

2.2.2 Political uncertainties and disputes

Due to the fact that economies are so dependant on energy supplies the potential misuse of energy infrastructure and energy supply could be applied as a tool to obtain political goals, both internally within a country and on wider geopolitical terms. In the context of the EU, the main gas supplies from Russia, which comprise a significant share of an increasing gas import, are transported through countries that politically are relatively unstable. Political risks should be evaluated and taken into consideration when a country's vulnerability to energy supply disruption is assessed – as previously discussed at the end of the supply chain the actual reason for a supply disruption is irrelevant.

2.2.3 Free gas market and market regulation

Ensuring the security of supply both in terms of the physical continuity of supply and affordable prices (in the sense discussed above) has traditionally been the responsibility of governments and implemented through the vertically integrated and state-owned companies and has included measures that have not always been market-based. A liberalised market shifts this responsibility to the market players. An issue arises from the question of whether the free market will be able to value

[6] Correspondingly to calculating vulnerability to oil disruption – the World Bank index.

the security of supply and provide the necessary signals to give enough investment in order to balance supply and demand.

Furthermore, security of supply is costly, and in a competitive market where operators try to minimise their operational costs they may try to 'save' on the safety and security of supply measures if not these are implemented through regulations.

The downside of regulation is that excessive or inappropriate regulation can suffocate competition and investment drive, resulting directly in less security of supply through lack of investment in the infrastructure. As shown in the GTE[7]'s Investment Report, based on a survey of GTE members in 2006 (/11/) the markets regulationary framework and the related legal issues in particular the uncertainty related to such regulation has been pointed out as an investments barrier. The barriers most commonly stated by operators include:

- Uncertainty concerning legal and regulatory framework.
- Uncertainty in the treatment of investments in the regulatory regime.
- Artificial low tariffs due to current regime that distort competition.
- Regulator not covering the investment through the tariff.

The discussion of the free market response in situations of gas supply disruption is further discussed in Section 7.

2.2.4 Extreme weather conditions/climate change

Gas infrastructure is created based on the supply required during peak demand. As gas is to a great extent used for heating and is gas consumption is therefore temperature related i.e. extreme low temperatures often a result in extreme demand. However defining extreme weather conditions is problematic, should it be winter conditions with the probability of occurring once in twenty or once in fifty years? Should the criteria on weather conditions be combined (occurring simultaneously) with events of technical failure? Furthermore, shall extreme winter standards (such as 1/20 and 1/50) be changed due to climate change?

2.2.5 Force majeure

Force majeure is a situation which essentially frees parties from contractual liability or obligation because of an extraordinary event or circumstance beyond the control of the involved parties. These events include: war, strike, riot, crime, act of nature (e.g., flooding, earthquake, volcano). How can force majeure be distinguished from a situation in which security of supply should be maintained? Is the Hurricane Katrina an example of force majeure? It did trigger release of the US's strategic oil stocks. The question is, for example, how much does a country want to allow itself to be affected, both in macro- and microeconomic terms, by a war in a country that is a transit country for its main energy supplies?

[7] GTE – GAS Transmission Europe

2.3 Operational security of supply

Obviously, the security of natural gas supply is a general term for risk management stating the likelihood of natural gas being delivered despite technical, climatic, commercial/market, economic and political constraints or events. Ideally the security of natural gas supply needs to be seen in combination with the supply security for other energy sources. In order to avoid market distortion with all its unwanted consequences, the definition of security of supply and the regulations for its implementation must be very specific and operational in terms of the actions that need to be taken by the operators, specifying:

- The extent to which supply is to be maintained (uninterruptible consumers only or all consumers etc)
- The allocation of responsibility

Table 1 distinguishes between:

- Short-term security of supply.
- Medium-term security of supply.
- Long-term security of supply.

Table 1 Short-, medium- and long-term security of supply

Security of supply	Duration	Events causing abnormal operating conditions/ supply disruption	Abatement options	Main responsible market player*
Short-term	1 day-2 months	Technical failure of the system Extreme weather	Line pack Interruptible demand Storage	Operator (TSO, DSO, SSO)
			Storage	Suppliers, shippers
Medium-term	2 months-5 years	Extreme prices Main supply disruption	Regulation Pipeline interconnector LNG terminal/storage Storage	Regulator responsible authority
Long-term	more than 5 years	Lack of economically viable gas reserves	New supply pipelines, including LNG terminal	Government, EU

*Responsibility for security of supply is complex and is overlapping between market players. Governments can intervene in short-term crises; however it is the operator that needs to take the first action in maintaining system balance and industry is certainly involved in long-term investments; however the industry will only invest if policy makers have created markets that send investment signals.

2.3.1 Short-term security of supply

Short-term security of supply concerns mainly the risk of technical failure in the system or extreme weather conditions. Security of supply is mainly insured by balancing the system (pressure) by using line pack and storage, possibly by increased gas production and by limiting demand through the interruption of supply to interruptible consumers.

The responsibility in terms of technical failure remains with the operators of the specific infrastructure where the failure has happened (residual balancing). In terms of extreme weather conditions the responsible market player at present differs between countries. Some countries have (traditionally) the TSO responsible to have gas in storage to be used in case of extreme weather conditions (Denmark), as part of a Public Service Obligation (PSO). In other countries this responsibility has been shifted to shippers (Italy) or suppliers (France). Placing the responsibility on different market operators creates different market conditions within the EU, as fulfilling the responsibility is directly related to increased operational costs and may result in displacement of industry towards less 'strict' areas.

2.3.2 Medium-term security of supply

Medium-term security of supply is related to supply disruption from major supply sources. These are country specific and in addition, the disruption of different supply sources can have a different impacts dependent on the share of the specific (disrupted) supply source in the total supply to the country as well as on the location of the disrupted supply in terms of possibility to reroute gas volumes from another source to the point of consumption.

Operational security of supply is further discussed in Section 7 in terms of raising it from a national to regional level and further to the EU level.

Regarding extreme market prices (in the sense discussed above), their impact on the market may be similar to (or may be a result of) a major supply disruption. Apart from investment in diversification of supply options – both routes and supplies, regulation (including use of storage) can be the mitigating tool if the event that caused the price surge is not already covered by the market.

2.3.3 Long-term security of supply

Long-term security of supply is related to strategic long-term planning of resources, such as available gas reserves, import routes, interconnections, investments in infrastucture etc.

2.4 Adopted definitions on security of supply

Security of supply is risk management of gas supply. It indicates the probability of supplying gas to end-consumers in spite of technical, political and economic risks and extreme weather conditions.

In terms of operation, security of supply is the responsibility of the gas market players and policy makers and, as previously mentioned, it overlaps. Short-term security of supply is primarily the responsibility of the infrastructure operators who need to take the initial action to maintaining system balance, however policy makers can intervene in short-term crises by imposing orders – for example on demand reduction. Medium–term security of supply can be the responsibility of any of the players (and should be unified throughout EU Member States, as it implies costs to the responsible operators and can otherwise distort the market). Finally long-term security of supply is the responsibility of politicians and authorities primarily as they need to create the market that will send the right investment signals to the industry.

3. Natural gas storage

Natural gas can be stored in few types of storage facilities, with specific technical and operational possibilities. The definitions presented in this section quantify and allow benchmarking of these technical and economic characteristics specific to the different types of storage facilities.

It is important to distinguish between definitions of storage capacity which describe the technical characteristics of the storage facility itself, and the definitions that give relative measures of the gas inventory.

The following definitions describe a storage facility in terms of storage capacity, irrelevant of the type of storage facility.

Cushion gas is the volume of gas intended as permanent inventory in the storage facility to maintain adequate operating pressure.

Working gas is the volume of gas in the storage facility above the cushion gas.

Storage capacity throughout this report refers to the storage working capacity, i.e. the capacity taken by the working gas.

Total storage capacity is the maximum volume of natural gas that can be stored in a storage facility (working gas plus cushion gas).

Withdrawal capacity is the amount of gas that can be withdrawn from a storage facility, expressed in millions of cubic metres per day (mcm/day), or the equivalent heat content of the gas withdrawn from the facility, most often expressed in kWh/day. This is also referred to as the deliverability or the deliverability rate.

The withdrawal capacity of a given storage facility is variable and depends directly on the total amount of gas in the reservoir at a given time: it is highest when the reservoir is most full and declines as working gas is withdrawn.

Injection capacity or injection rate is the amount of gas that can be injected into a storage facility on a daily basis, expressed in millions of cubic metres per day (mcm/day), or the equivalent heat content of the gas withdrawn from the facility, most often expressed in kWh/day.

The injection capacity of a given storage facility is variable and depends inversely on the total amount of gas in storage: it is lowest when the reservoir is most full and increases as working gas is withdrawn.

4. The role of storage

This report distinguishes between the following main roles of natural gas storage;

4.1 Storage capacity as a seasonal (low-frequency) balancing tool

The role of natural gas storage as a balancing tool for seasonal demand is to meet seasonal load variations, i.e. gas is injected into storage during periods of low demand (usually summer) and withdrawn from storage during periods of high demand (usually winter).

4.2 Storage capacity as a market high-frequency balancing tool

Increased market integration has lead to increased demand for storage capacity. Unlike seasonal demand which primarily is a question of storage working capacity, demand due to increased market integration requires relatively higher levels of injection and withdrawal capacity in order to be able to optimise supply/demand in shorter time intervals.

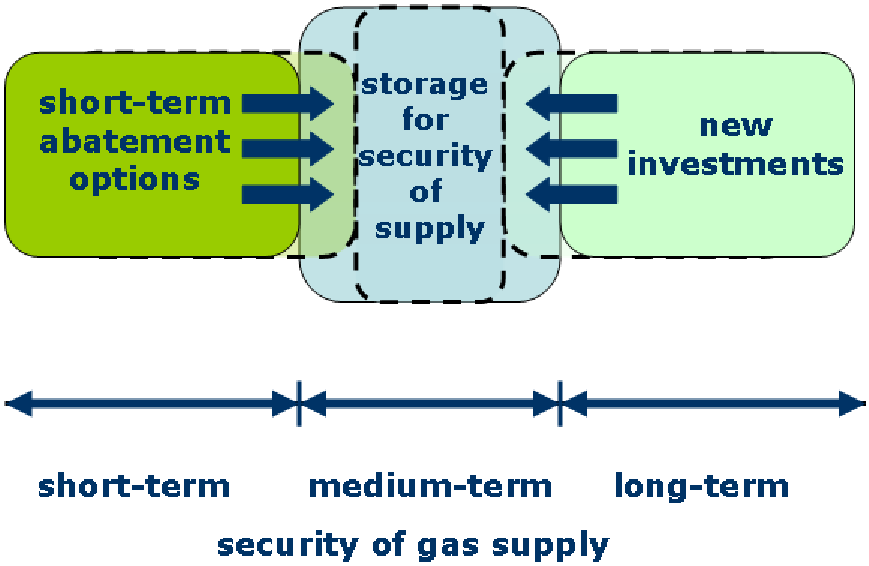
4.3 The role of storage in security of supply

As discussed above, the issues that can affect the security of supply and the events that can trigger the actual gas supply disruption and/or cause abnormal operation differ significantly in their character (technical, political or extreme winter), duration (short-, medium- and long-term) and probability of occurring. In case of any supply disruption/event causing abnormal operation, withdrawal of gas from storage indeed remains to be one of the main tools of abatement that can provide security of supply (Table 1), and is called storage for security of supply.

Keeping gas in storage is related to costs. A functioning market will therefore be expected to minimize the use of storage as a security of a supply tool in the sense that as long as there are alternative cheaper tools for security of supply, they will be used instead of storage. As long as feasible, storage will remain to be a tool for security of supply on the gas market and the market will balance the supply and demand in case of supply disruption by using withdrawal from storage.

Figure 1 illustrates the gliding borders between short and medium-term security of supply, and medium and long-term security of supply related to the volumes of gas stored for security of supply. An effective open gas market and long-term planning of resources and implementation of related investments decreases the necessity of storage being used to ensure security of supply.

Figure 1 Storage for security of supply on the open gas market



The flexibility tools to ensure short-term security of supply are beside stockdraw usually line pack, interruptible consumers, etc. The border where security of supply changes from short- to medium-term is unclear and depends to a great extent on the efficiency of the market. For example in the event of supply disruption in a fully open market, such as in the US there may be more possibilities for action, such as production surge, additional LNG supplies, interruptible consumers etc, however in a market with limited supply sources/suppliers, little or no interruptible consumption etc., where the share of gas kept in storage for security of supply i.e. in order to be used in case of a supply disruption might therefore correspondingly be larger.[8]

4.4 Strategic stock

[8] Depending on the cost of storage as a security of supply tool compared to alternative tools on the specific market

For the purpose of this study the Consultant would like to adopt the definition of strategic stock according to the International Association of Gas Producers (OGP):

"Strategic gas storage is the physical stockpiling of gas for use only as an emergency measure, released by a decision of the related Member State i.e. not available for use during normal market conditions. It will be used when non-market events have moved demand or supply outside of the supply standard, for example, a winter worse than the coldest one in twenty years, serious damage to infrastructure or political conflict. For strategic storage to be an effective emergency measure, the capacity to transport the gas to the consumer is essential. If strategic stocks are held, the conditions of their use must be clearly defined. Strategic stocks should only be released in serious, clearly defined cases of supply disruption or shortage as their arbitrary use will undermine the market and is likely to result in a serious loss of confidence by investors in existing storage infra-structure and potential investors in new storage. The considerable cost of providing additional stocks and related infrastructure would also need to be understood and its distribution determined."[9]

5. Public service obligation

A Public Service Obligation (PSO) is a notion of a responsibility imposed on a market player for fulfilling defined standards related to the security of supply of gas to customers.

When discussing PSO related to supply of gas to customers, storage is a tool that can be used by the market players to fulfil their PSO.

The imposition of a PSO on market players is not the same as imposing obligations to use certain tools for security of supply, such as storage (obligatory stockpiling) or obligatory diversification of supply sources. However the way the PSO is defined can result in de facto obligatory use of certain tools for security of supply among other storage for security of supply. This discussion is further developed in Section 6.

[9] OGP position paper on strategic storage

6. Regions

This study refers to the regions as defined by the study "TEN-Energy Priority Corridors", the relevant section of which is enclosed here as ANNEX 1 GAS REGIONS. This study makes use of regions, related to:

- Estimating gas storage demand.
- Available storage capacity.
- Regional operation related to possible common approach to security of supply.

The regions referred to in this study are defined as follows:

- Northern: Denmark, Sweden, Germany, Netherlands, Belgium, UK, Ireland, Luxembourg, Poland, Lithuania, Latvia, Estonia and Finland.
- South-West: Portugal, France and Spain.
- South-East: Austria, Italy, Greece, Romania, Slovenia, Bulgaria, Hungary, Czech Republic and Slovak Republic.

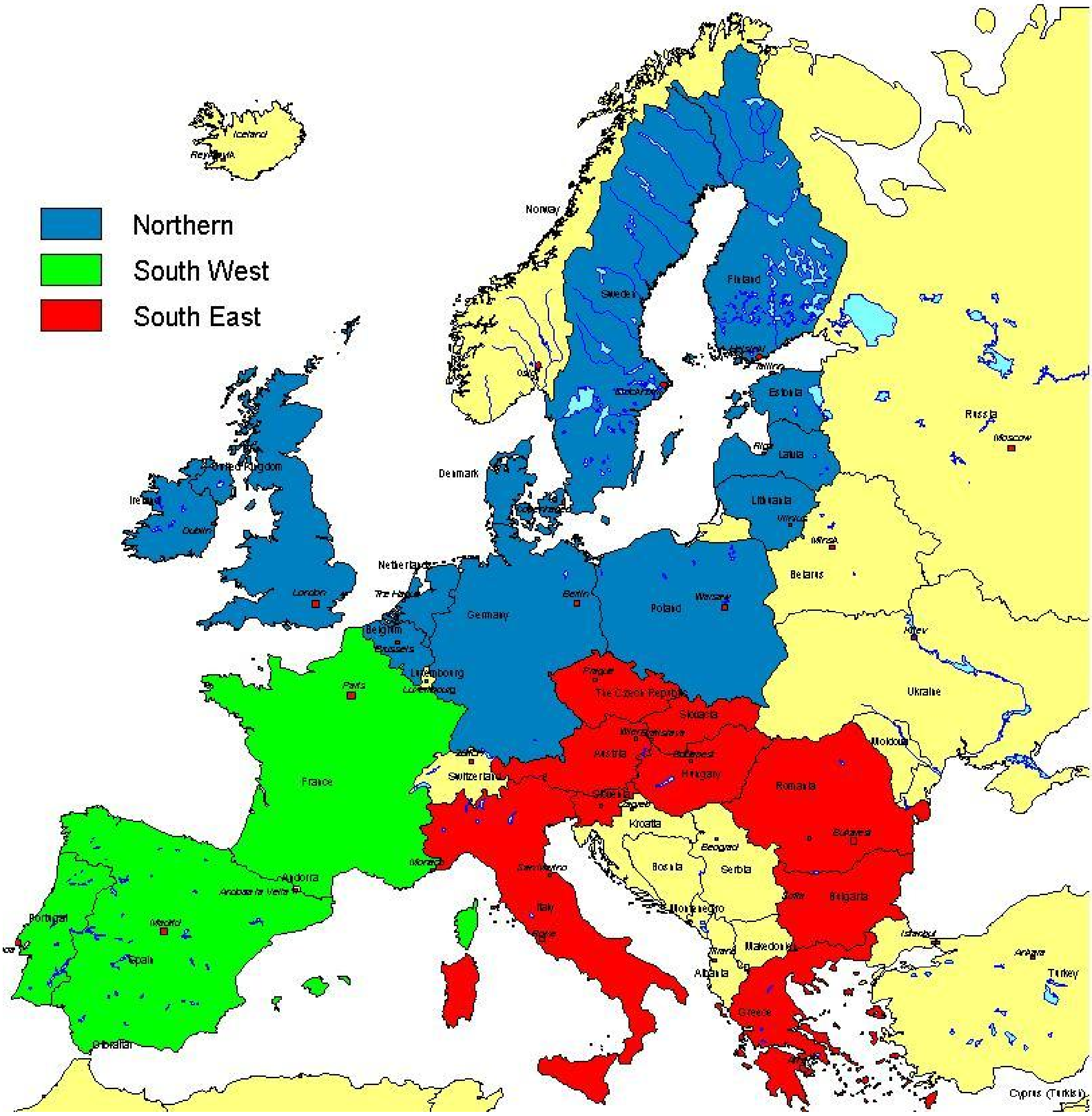
The purpose of defining these regions is to allow the evaluation of storage demand and supply at an appropriate level with the definition of the regions based on the following main considerations:

- The gas storage market in EU is an integrated market, where storage services can be bought across country borders. Benchmarking a single country's storage demand with the available capacity within that country's national borders will only distort the picture of availability of storage capacity in the EU.
- The defined regions are based on the level of market integration and the level of interconnection between countries that can be expected to be in place in 2020.

However the chosen regions do not affect the results or the conclusions of the report, rather they are used merely in order to evaluate the storage demand/supply situation at a more detailed level than the overall EU level which will also be used in the report.

Figure 2 below shows the regions used.

Figure 2 Regions



PART III NATURAL GAS STORAGE IN EU

SECTION 1 AVAILABILITY OF GAS STORAGE FACILITIES IN THE EUROPEAN UNION

There are three main types of natural gas storage facilities, each with different performance characteristics that make them suitable for fulfilling different storage roles;

- Depleted oil and gas fields.
- Aquifers.
- Salt cavities.

The technical and operational characteristics of these types of facilities are described and discussed in Section 5. Section 1 only presents an overview of the storage facilities and the available storage capacity within the EU.

In general the depleted fields and aquifers have larger storage capacity but provide less flexibility in terms of withdrawal rate compared with salt cavities. This makes the depleted fields and the aquifers more suitable for fulfilling the role of storage as a seasonal balancing tool, while the salt cavities are more suitable as high-frequency market-balancing tools.

A fourth option available is storing liquefied natural gas (LNG) in LNG facilities. The Gas Directive distinguishes between two types of LNG facilities:

- LNG facilities used for storage of LNG, i.e. LNG storages[10] and
- LNG facilities - terminals used for 'the liquefaction of natural gas or importation, offloading, and re-gasification of LNG'[11], including 'temporary storage necessary for the re-gasification process and subsequent delivery to the transmission system'.

There is an ongoing discussion related to the definitions and the actual difference/similarities between an LNG storage and an LNG facility as defined in the Gas Directive[12].

This discussion is outside the scope of this study, however what is relevant for this study are the LNG storages, i.e. LNG peak shaving facilities, and this study

[10] The LNG storages are usually put into use in high-demand periods to shave off peaks in demand, and are often referred to as LNG peak-shaving facilities.
[11] Gas Directive, Article 2 (11)
[12] /28/

only considers the LNG peak shaving facilities (i.e. LNG storages) identified as such by the GLE[13].

7. Overview of storage capacity and deliverability in the EU

7.1 Evolution in storage capacities in the EU

This section presents an overview of the evolution of storage capacities by type of storage in the EU since 1990.

As shown in Figure 3, the development of storage capacity in the period 1999-2006 varies quite a lot from country to country. While some countries, like Hungary, Romania, Bulgaria, Belgium and Latvia, experience no development in storage capacity, most of the other countries have increased their storage capacities, with Germany almost tripling its capacity from about 8 bcm total working capacity in 1990 to approximately 20 bcm in 2000. The Netherlands has in total increased its storage capacity by 4.5 bcm since 1990. Spain is another country in which we observe a relatively large increase in storage capacity, going from purely LNG peak-shaving storages to the major depleted fields.

Regarding the type of storage facilities being developed, the biggest expansion of capacity can be observed in depleted fields, such as in the Netherlands and in Spain, while Germany stands out with large investments in both depleted fields, aquifers and salt cavities in the period 1990 to 2000.

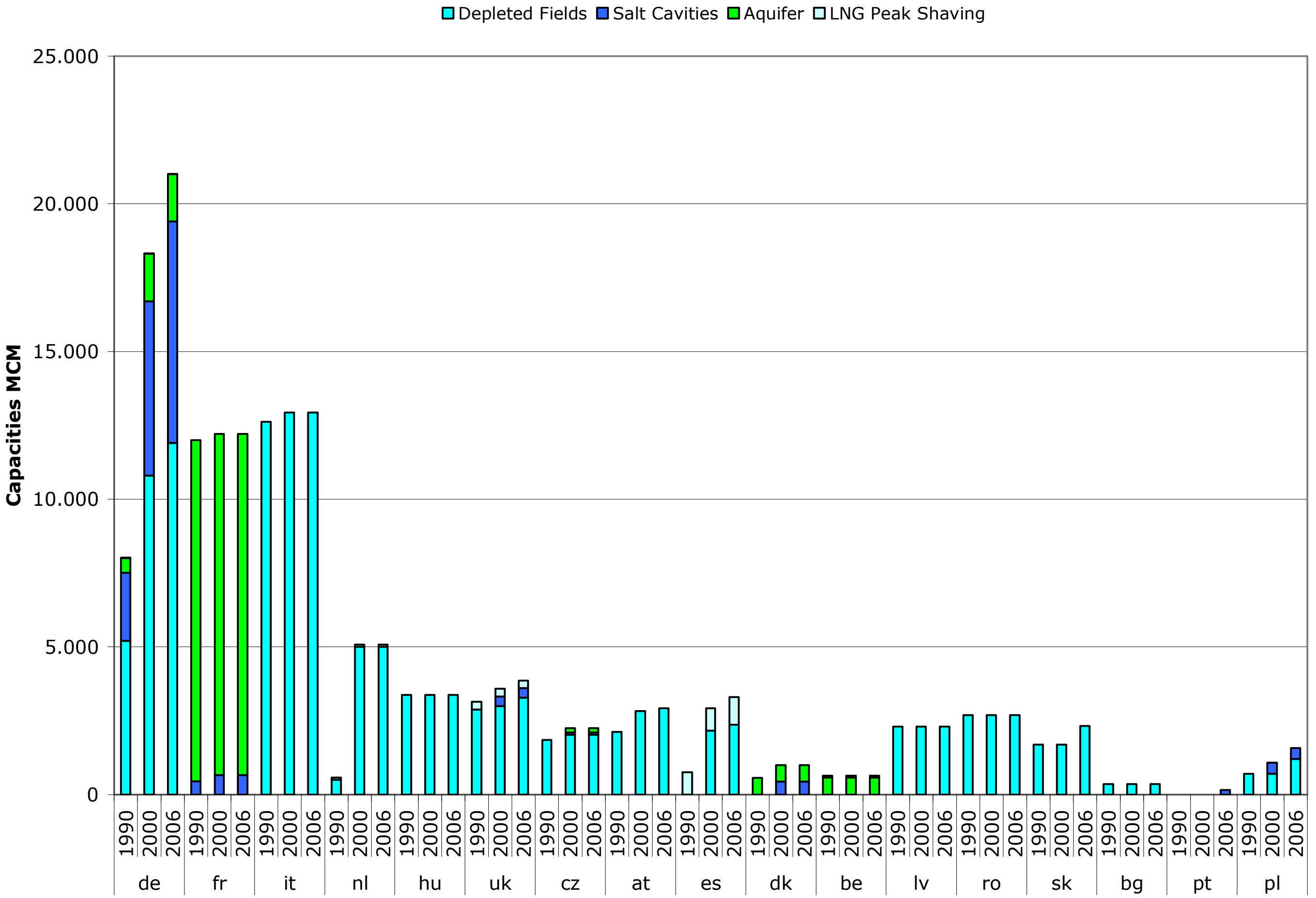
In general an increase in storage volume capacities can be observed throughout the 1990s while capacities have remained relatively constant since 2000.

In an attempt to understand the reason and the background of the different development of investments within EU an investigation into a possible correlation between development of storage capacity and few market parameters that might have an impact on the investment drive in discerned.

We start by relating the storage capacity to the gas consumption in the households sector presented to the ratio storage capacity/household consumption in Figure 4

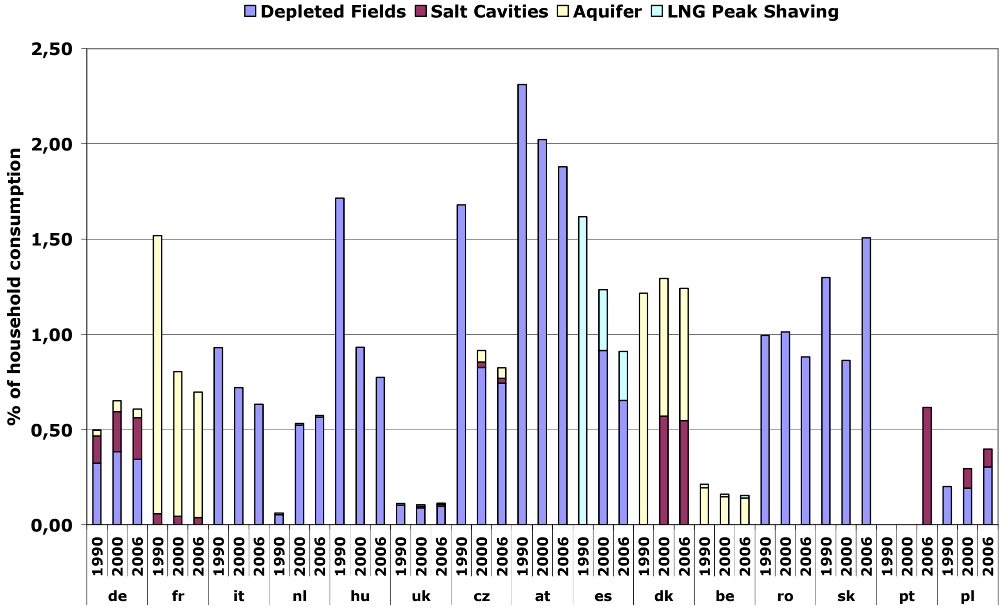
[13] http://www.gie.eu.com/maps_data/downloads/GLE_LNG.pdf

Figure 3 Evolution in storage capacities by type of storage.



Sources: "UGS in the world" Cedigaz, ERDÖL ERDGAS KOHLE 122. Jg. 2006, Heft 11

Figure 4 Storage capacity as percentage of household consumption



Source: Eurostat, ERDÖL ERDGAS KOHLE 122. Jg. 2006, Heft 11, & Cedigaz 2006
Note: Latvia and Bulgaria omitted due very low household consumption of natural gas

Several countries have more storage capacity than actual household consumption (ratio bigger than 1). However, there is a tendency for this ratio to fall indicating that the demand for natural gas is increasing at a higher rate than storage capacity can be developed.

Another observation that can be made is that gas producing countries tend to have low levels of storage capacity compared to their household consumption. In this respect Denmark stands out as having a fairly large storage capacity compared to household consumption. The development in Germany is also worth noticing, it indicates large developments in the investment in salt cavities. The highest ratios at the end of the observed period (in 2006) are found in Austria and Slovakia. Taking their geographical location into account, this high ratio could reflect that storage in these countries is mainly being used for storing gas flowing from east to west.

Two countries have actually been exempted from the figure – Bulgaria and Latvia - Bulgaria has a very low household gas consumption and Latvia houses the extensive storage of Incukalns, established in the time of the Soviet Union and for the purposes of balancing the large gas consumption in the Baltic region, Northwest Russia and Kaliningrad at that time. The storage capacity of Incukalns is still mainly being used by Gazprom for the same purposes.

7.2 Evolution in capacities from a regional perspective

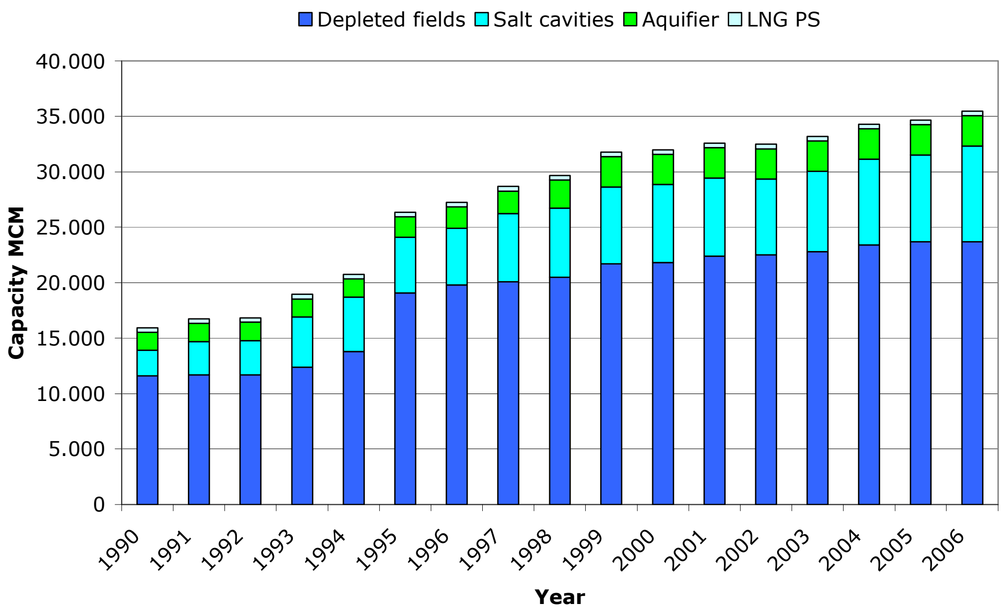
The following section gives an overview of the evolution of storage capacities at the regional level.

Figure 5 shows that the majority of the storage capacity in the Northern region in 2006 was in depleted fields. The region has experienced an increase in both depleted fields and salt cavities, while aquifers and LNG peak-shaving facilities have undergone only moderate increases since 1997. In total, the storage capacity has increased by about 17%-18% in the observed period, with the largest increases in salt cavities (about 20%) and depleted fields (15%).

The development in the Northern region is mainly driven by Germany, as can be seen in Figure 3. A large part of the demand for gas in Germany stems from household consumption; this means that the demand for gas is highly seasonal, which, as we will see later in the report, increases the demand for storage.

Other countries contributing to the increase in storage capacities are the UK and the Netherlands. Both countries have decreasing indigenous production and an increasing demand for gas. As a consequence of declining deliveries from the large Dutch Groningen field, two additional depleted fields were taken into use in 1997, thereby increasing the storage capacity in depleted fields in the Netherlands.

Figure 5 Storage facilities in the Northern region 1990-2006[14]

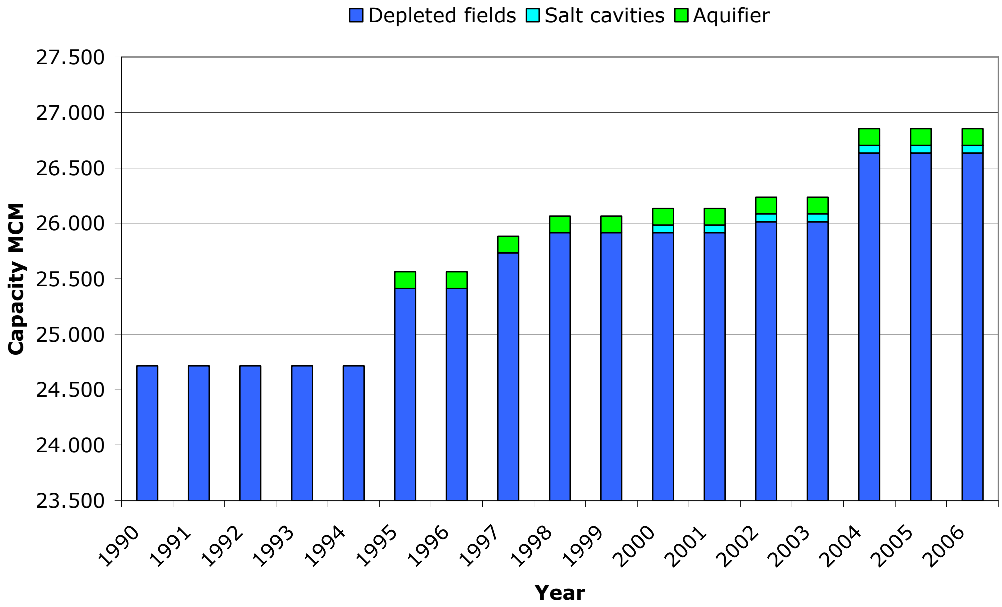


Source: "UGS in the world" Cedigaz, Erdöl Erdgas Kohle 122. Jg. 2006, Heft 11

[14] Precise data on storage capacities from 1991-1996 in Germany was not available.

A notable change seems to occur in 1994-1995 where this region saw a relatively large increase in depleted fields. The same pattern appears when we look at the development in the south-eastern region in Figure 6.

Figure 6 Underground storage facilities in the South-East region 1990-2006



Source: "UGS in the world" Cedigaz

Figure 6 shows that a substantial part of the storage capacity in the South-East region is in depleted fields. The availability of depleted fields in the region has made this type of storage a natural choice.

It is furthermore seen in Figure 3 that the countries driving the largest part of the development in this region are Italy (whose entire natural gas storage capacity is in depleted fields) the Czech Republic and Austria in the period up to 2000 and Poland in the period after 2000.

Some countries like Hungary and Romania experience no investment in storage facilities in the observed period, even though they have the geological potential necessary for development of storage facilities (section 7, Option 2), and even though the development i.e. the decreasing of the ratio of storage capacity/household consumption (Figure 4) shows that gas consumption in the household sector (which is the one relevant for storage demand) has been increasing, especially in Hungary.

We believe that some of the main reasons for a slow or no development in investments seen in this period in the South–East region may be the result of a number of factors including:

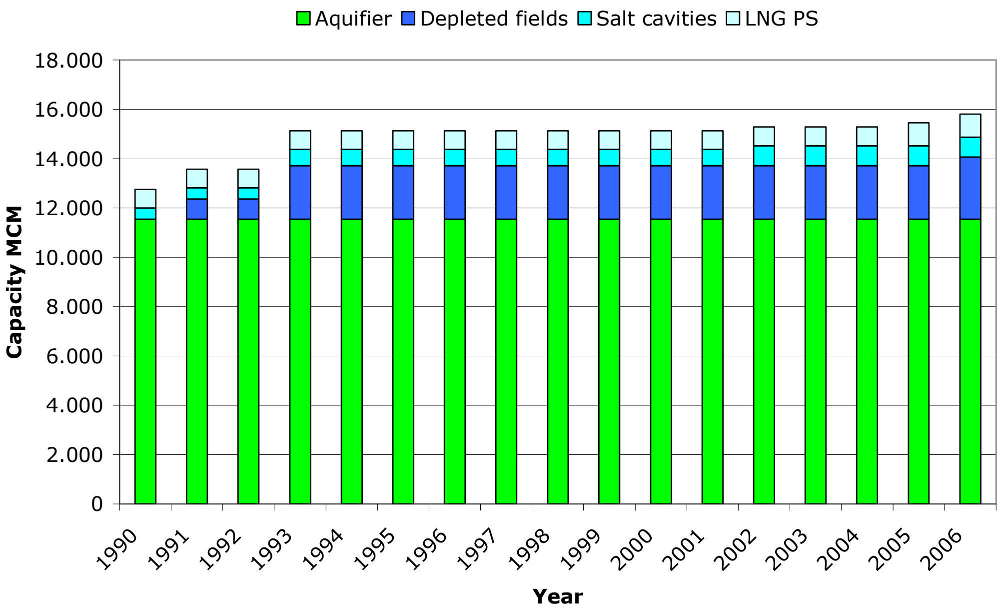
- the region includes countries that became EU Member States only in the beginning of the 2000s, resulting in a later opening of the gas market;

- the transition from planned to market economy has increased the uncertainty related to gas demand (and thereby storage demand);

- the application of non cost-recovery tariffs by some of these countries in order to protect the increasing energy poverty of the consumers as a consequence of the increased unemployment in the transition period.

The South-West region, comprised of Portugal, Spain and France is dominated by the large aquifer installations in France. Depleted fields and salt cavities are not very prevalent in these countries, as shown in Figure 3 and Figure 7.

Figure 7 Underground storage facilities in the South-West region 1990-2006.



Source: "UGS in the world" Cedigaz

The French gas storage situation is influenced by high seasonal variations in demand, as about 40% of the gas is used for heating purposes. This seasonal effect on demand is reinforced by the fact that the industry is not dependent on gas and to a large part relies on nuclear power. Thus the installed capacity is partly aimed at shaving off peaks in household demand. The types of storage confirm this suggestion, as capacity is made up by a mix of aquifers and salt cavities, the salt cavities, as we shall see later in the report, allow for high injection and withdrawal rates, which are particularly useful for accommodating peaks in demand. The other major country in the South-West region, Spain, has a storage capacity mix made up by a few depleted fields and five LNG peak-shaving facilities. The capacity of the LNG peak shaving facilities accounts for approximately 28% of the total Spanish storage capacity, making Spain the largest LNG-using country in the EU.

Figure 7 also illustrates that there have been only minor changes in storage capacity in the region since 1993.

7.3 The storage situation today

There are currently[15] 111 active underground storages within the EU area, distributed amongst 63 depleted fields, 26 salt cavities and 22 aquifers. Furthermore, 12 LNG peak-shaving facilities are distributed amongst five countries with Spain being the largest user, as mentioned above.

The distribution of storage facilities by region and Member State is presented in Table 2 and Figure 8.

[15] Based on 2008 data.

Table 2 Storage distribution by country, 2008. Storage capacities in mcm

	Depleted fields	Saline Cavity	Aquifer	LNG Peak-Shaving	Total	Max withdrawal rate mcm/day	Max injection rate mcm/day
North							
UK	3.279	325	0	259	3.863	76	30
DK	0	441	560	0	1.001	16	7
NL	5.000	0	0	78	5.078	177	40
BE	0	0	580	55	635	23	6
DE	9.877	7.082	1.415	14	18.388	444	198[16]
PL	1.205	370	0	0	1.575	34	19
LV	2.300	0	0	0	2.300	24	0
Total	**19.361**	**8.218**	**2.555**	**406**	**32.840**	**770**	**298**
South-West							
PT	0	150	0	0	150	7	3
FR	0	860	11.870	0	12.730	213	117
ES	2.726	0	0	1.103	3.829	153	10
Total	**2.726**	**1.010**	**11.870**	**1.103**	**16.709**	**373**	**129**
South-East							
CZ	2.030	70	150	0	2.250	36	26
SK	2.600	0	0	0	2.600	34	29
IT	13.014	0	0	0	13.014	254	133
BG	350	0	0	0	350	3	3
RO	2.694	0	0	0	2.694	22	3
GR	0	0	0	0	0	0	0
AT	4.120	0	0	0	4.120	44	40
HU	3.720	0	0	0	3.720	51	26
Total	**28.528**	**70**	**150**	**0**	**28.748**	**445**	**260**
EU Total	**50.615**	**9.298**	**14.575**	**1.509**	**78.297**	**1.588**	**688**

Source:GSE, ERDÖL ERDGAS KOHLE 122. Jg. 2006, Heft 11[17]

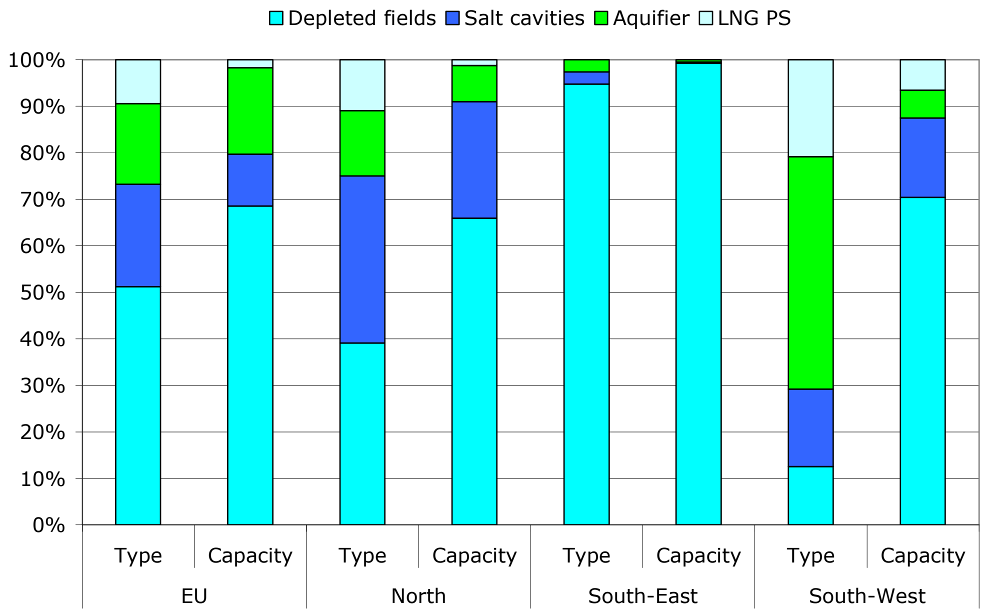
The storage capacities in Table 2 are obtained from the GSE database, which the Consultant considers as being the most updated in spite of occasional differences with data from other sources (for example with the IGU 2006, Cedigaz, OECD).

Table 2 and Figure 8 illustrate the difference between storage capacities in different types of storage– 56% of the storages (number of facilities) are established in depleted fields and account for approximately 65% of the total storage capacity (working gas) in the EU.

[16] Information regarding this parameter was estimated, assuming that the storages with no information on injection and withdrawal rates could be approximated by the averages for the German storages that we actually had data on.

[17] Some of the figures in Table 2 do not match 100% with the 2006 figures in Figure 3-Figure 7. This difference is, however, in most cases not significant, with Germany as the exemption.

Figure 8 Gas storage in the EU 2008.



Source: Based on data from Gas Storage Europe

The salt cavities on the contrary (the number of facilities) account for 23% which corresponds to only about 1% of the total storage capacity (in working gas) in the EU.

7.3.1 Injection and withdrawal rates

Injection and withdrawal rates vary depending on the amount of gas in storage at any given time, the withdrawal rate proportionally and the injection rate inversely. Hence withdrawal rates are typically much higher at the beginning than at the end of the winter period, when storages are empty.

The aggregated withdrawal and injection capacities relative to the total volume are illustrated in Figure 9. [18]

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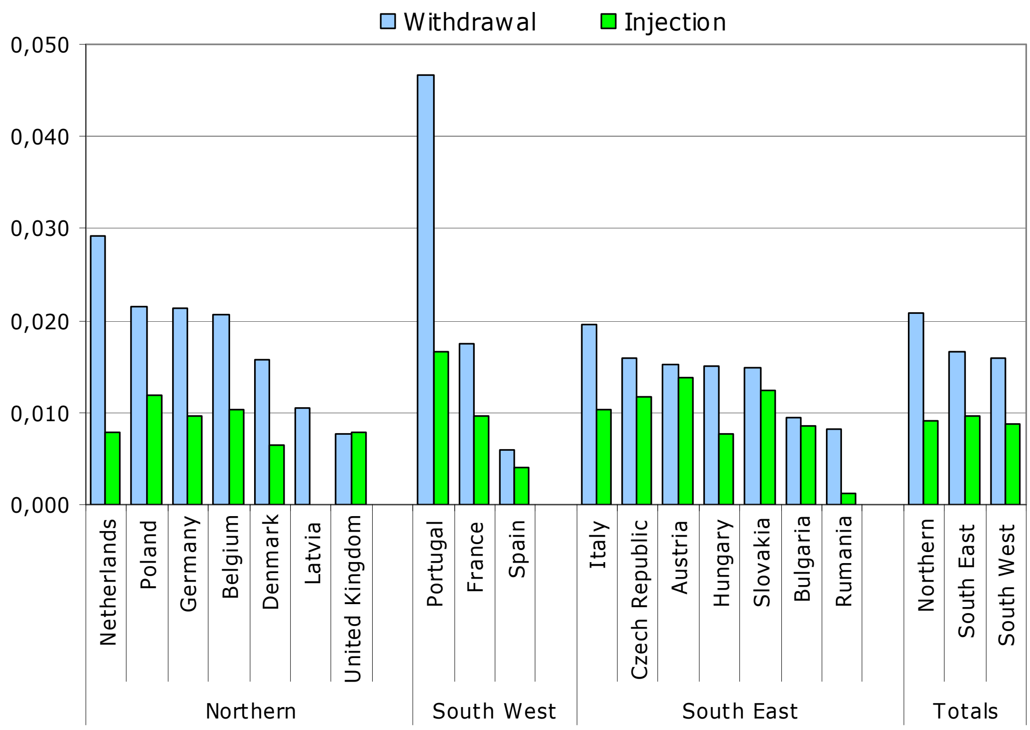
[18] Injection rates were not readily available for all storages in Romania, Latvia and Spain. LNG peak-shaving facilities have been excluded.

Figure 9 Maximum withdrawal and injection rates per unit of volume capacity 2008



Source: Based on data from Gas Storage Europe

The main conclusion to be drawn from this figure is that the overall level of flexibility, i.e. the level of (total) withdrawal and injection per unit of volume storage capacity, varies quite between countries, but is almost the same on regional level for all the three regions.

8. Comparison of storage capacity and key market parameters

8.1 Introduction

This sub-section examines possible correlations between storage capacity and a range of key-market-related parameters. The storage capacity of each EU Member State is plotted in synthetic graphs versus key market parameters of interest. The consultant is looking for patterns in the graphs more than looking to explain each country's position. The following graphs do not show anything about causality, i.e. they are merely meant to illustrate a possible correlation between storage capacity and the parameters of interest.

In addition to the synthetic graphs panel data analysis is presented investigating the development in storage capacity since 1998 at the end of this chapter.

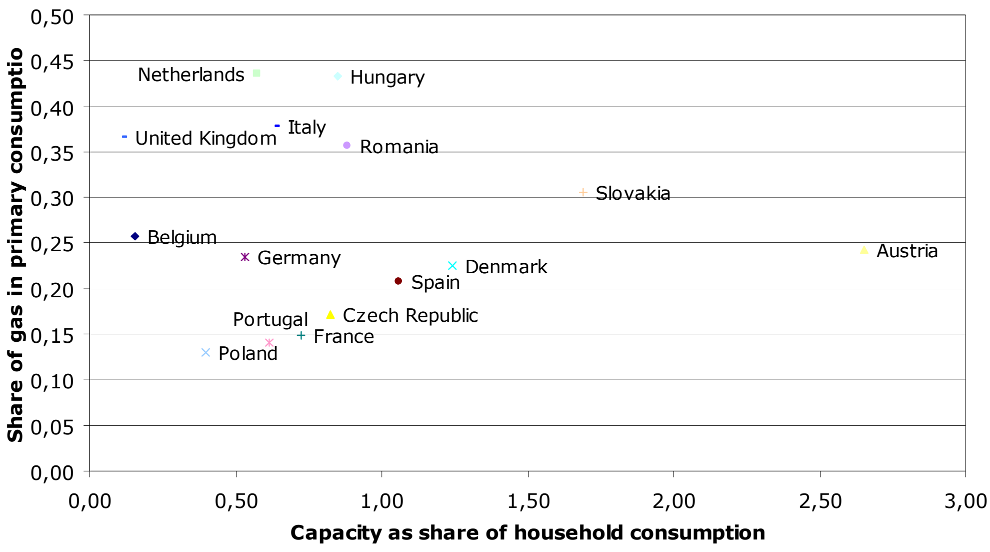
Correlation between storage capacity and following parameters has been analysed:

- Share of gas in primary energy consumption.
- Seasonality.
- The gas used for transformation purposes.
- Import dependency.
- Supplier dependency.
- Utilisation of import pipelines.

8.2 Storage capacity and share of natural gas consumption

Figure 10 shows each country's share of gas in primary consumption in relation to the ratio storage capacity/household consumption. The share of gas in primary energy consumption of a country provides an indication of how reliant the country's economy is on natural gas. When isolated this parameter cannot say much about the vulnerability of a country to gas supply disruption. However we would expect that when a country becomes more reliant on gas, i.e. has a larger share of natural gas in primary consumption, it would have relatively large storage capacity compared with a country with a smaller share of gas in primary energy consumption.

Figure 10 Share of gas in primary consumption 2006



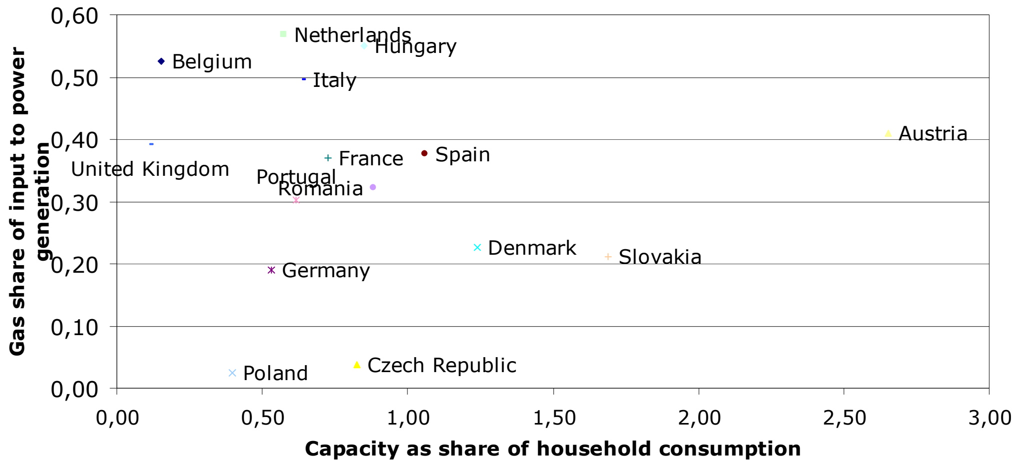
Source: Based on data from Eurostat & Gas Storage Europe Latvia excluded

Few countries (Poland, Portugal, France, The Czech Republic, Spain and Denmark) seem to create a trend of positive correlation between the share of gas in primary consumption and storage capacity, thus the initial belief of a positive relationship could be supported.

Another observation can be made related to gas-producing countries such as Romania, the UK and the Netherlands which all seem to be placed relatively low when it comes to capacity but at the high end when it comes to the share of gas in primary consumption. This could indicate that the demand for flexibility in these countries at least until now has been covered by their flexibility in indigenous production.

A factor such as gas for power production could also be associated with storage capacity. Below in Figure 11 it can be seen that there does not seem to be any systematic correlation between the two.

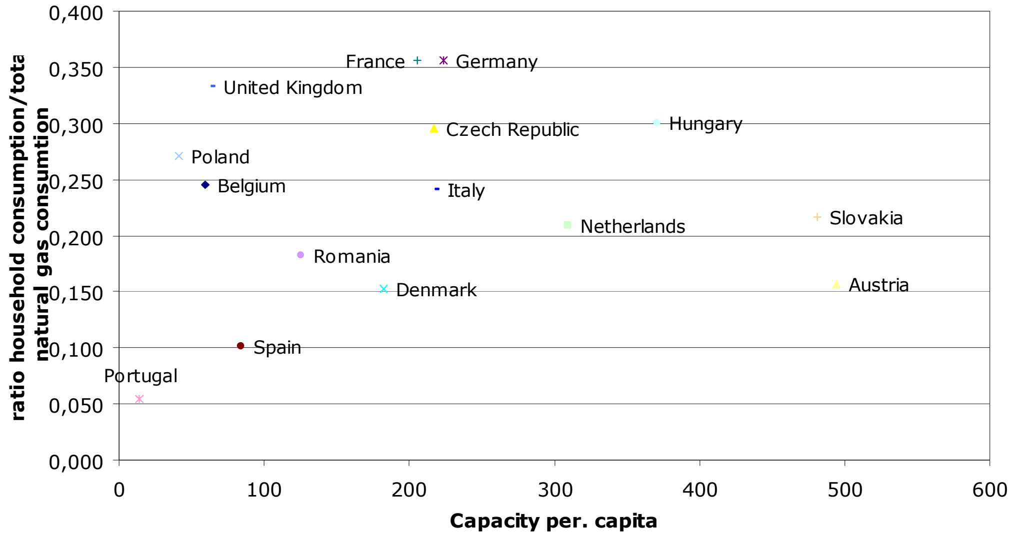
Figure 11 Gas' share in input to Power Generation



Source: Based on data from Eurostat & Gas Storage Europe Latvia excluded

The next figure, Figure 12, illustrates the relationship between gas consumption in the household sector and storage capacity per capita. Gas consumption in the household sector is mainly used for heating purposes and is therefore highly seasonal. Therefore household consumption is taken as a good proxy for seasonality.

Figure 12 Share of gas consumed by households



Source: Based on data from Eurostat Latvia excluded

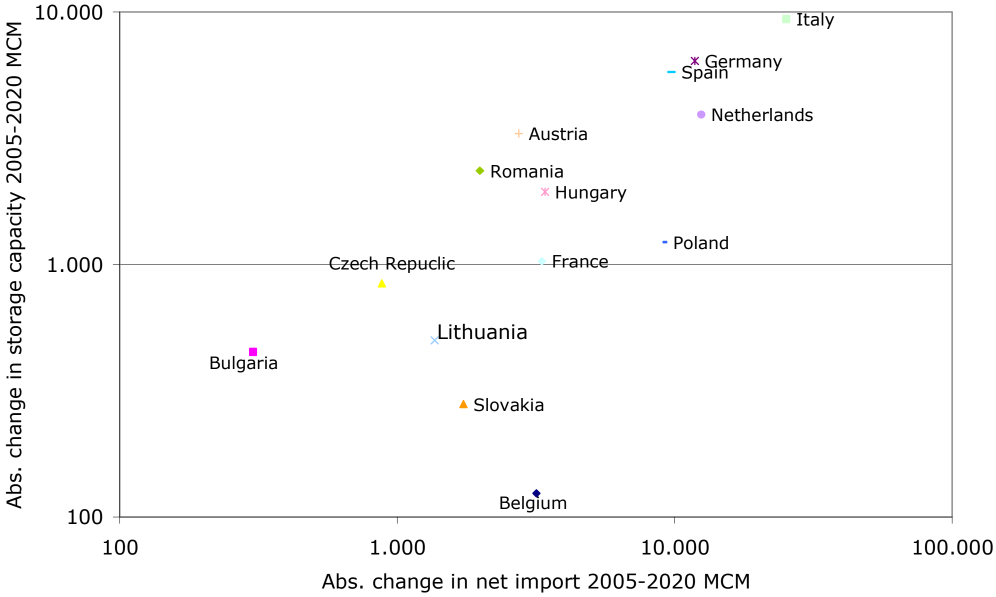
As the figure shows, Germany, France, Italy, the Czech Republic, and Hungary all have high household consumption and a relatively large storage capacity per capita, showing somewhat positive correlation. The position of the UK (low storage capacity compared to gas consumption share) may as previously mentioned, be explained by the fact that the UK has so far relied on indigenous production for flexibility. Slovakia and Austria both have large storage capacities per capita. As mentioned earlier this may reflect the fact that the storages may serve transit purposes.

8.3 Import dependency

Gas import generally provides less flexibility than indigenous production. As the share of imported gas to a country increases, the need for storage as a seasonal balancing tool is expected to increase. We would thus expect a positive correlation between the change in net import dependency and storage capacity, which are compared in the following figure.[19] Only countries in which storage capacities have changed in the period 2005-2020 are plotted.

[19] The changes in net import are based on projections made by in the PRIMES energy outlook for the EU.

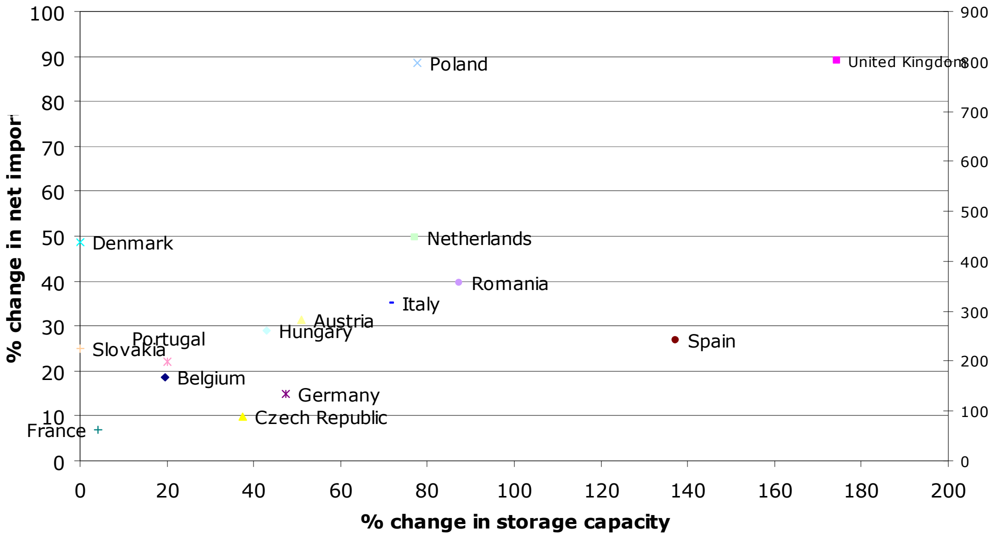
Figure 13 Import dependency



Source: Primes and Gas Storage Europe

It can be seen that there is a tendency for changes in storage capacity to follow changes in net import. This shows that in countries where there is an anticipation of higher demand for flexibility there also seems to be more planned investment in capacity. Measured in percentage changes we see that it still looks like there is a positive relationship between storage investments and changes in net import. Countries that stand out are the UK, Poland, Spain, and Denmark. As a consequence of falling indigenous production and higher demand, the UK experiences a large increase in net imports. Denmark and the Netherlands although experiencing a fall in indigenous production, will be net exporters of natural gas. This may explain the low level of investment at least in Denmark.

Figure 14 Import dependency relative changes. The UK measured on secondary x axis.

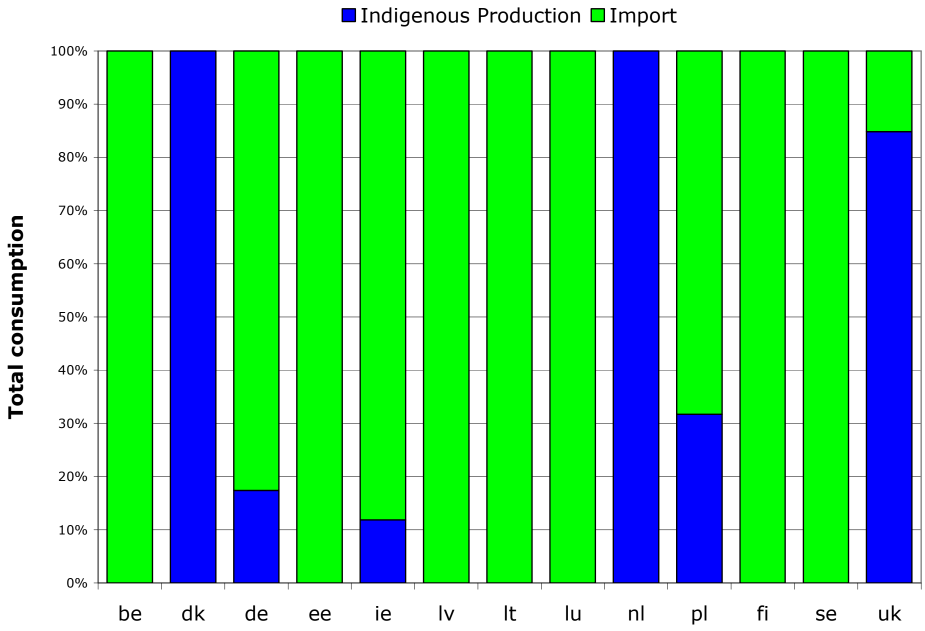


Source: GSE and Primes scenarios.

The net import for each EU Member State as of 2006 is presented in the following figures.

In the Northern region the Netherlands and Denmark are the only two self-sufficient countries. Quite a number of countries, such as Belgium, Estonia, Latvia, Lithuania, Finland and Sweden rely completely on imports.

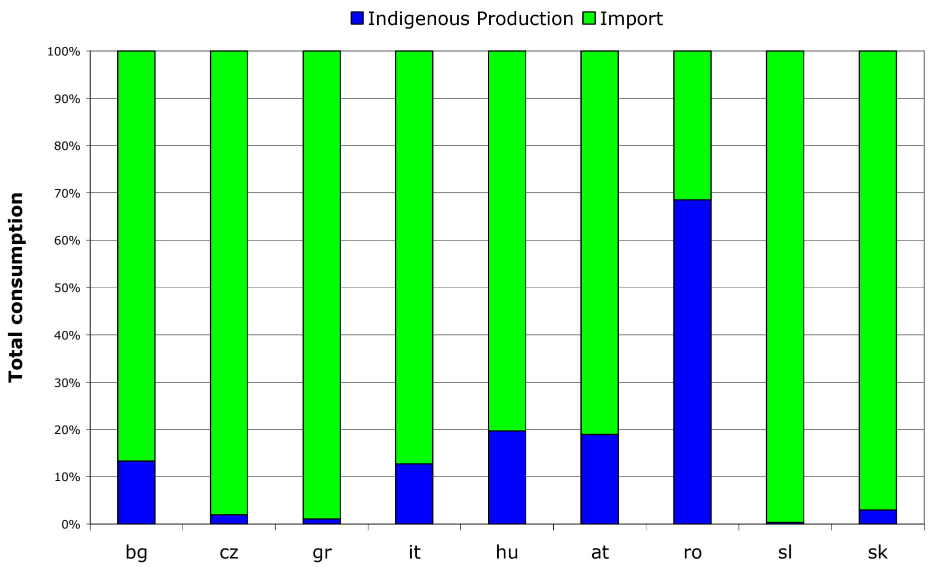
Figure 15 Northern region: indigenous production compared with total consumption, 2006.



Source: Based on data from Eurostat

In the South-East region, Romania is the only significant producer of natural gas, as can be seen in Figure 16 below.

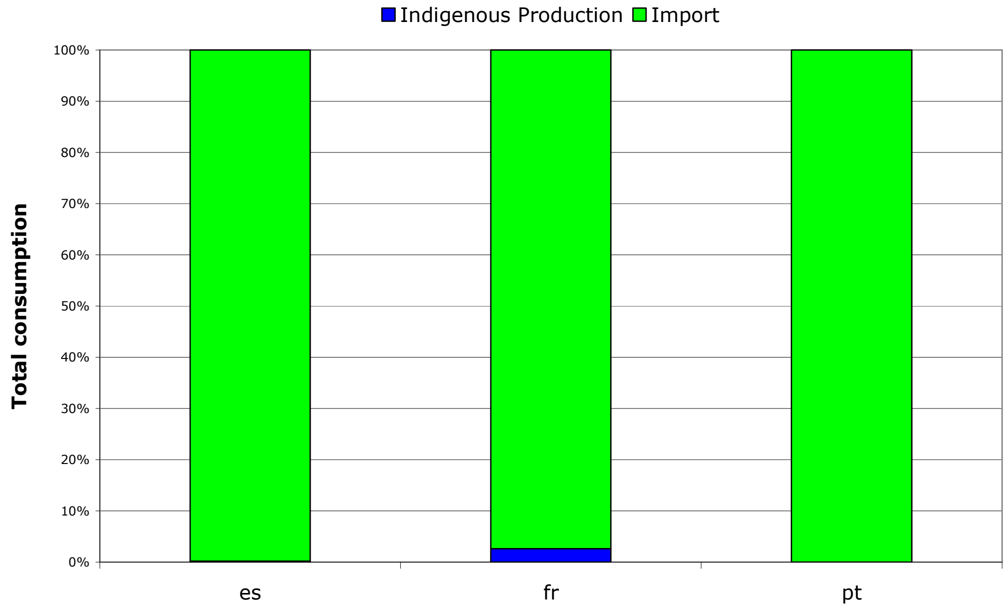
Figure 16 South-East region: indigenous production compared with total consumption, 2006.



Source: Based on data from Eurostat

France and the Iberian Peninsula are to a high degree reliant on import, as illustrated in Figure 17.

Figure 17 South-West region: indigenous production compared with total consumption, 2006.



Source: Based on data from Eurostat

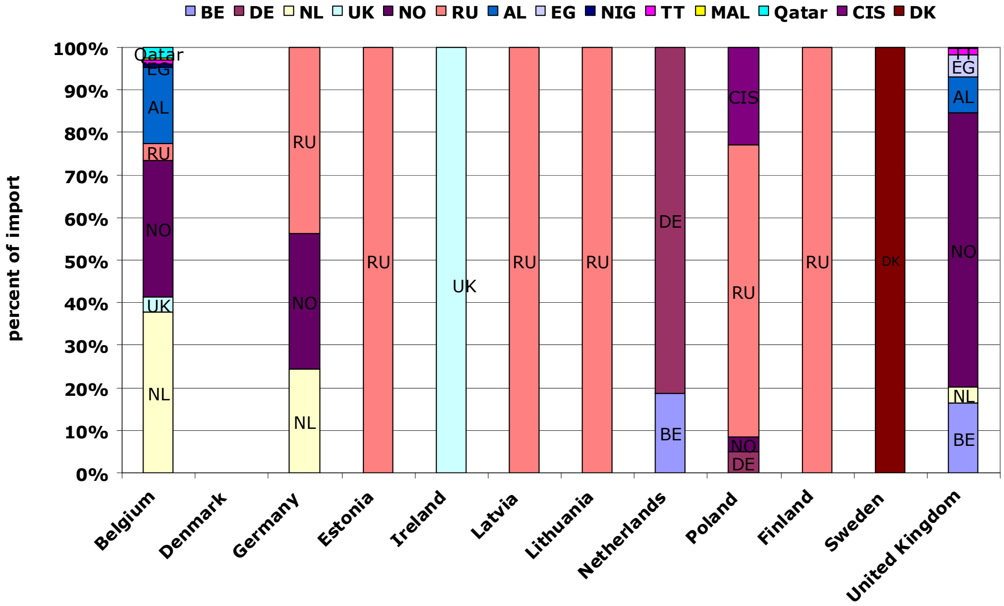
8.4 Diversification of supply

Import dependency in itself is not vulnerability if imports are diversified in terms of supply routes and suppliers. The following section looks at the diversification of supply of the EU Member States in terms of country of origin of the imported gas.

In the Northern region, Belgium and Germany are the countries that seem to have a high level of import diversification. The UK seems to be dependent on imports from Norway and the Netherlands. Finland, Sweden, the Baltic countries and Ireland depend on a sole supply source. Imports from the former Soviet Union are divided into imports originating from Russia and imports originating from the CIS[20]. The data from Eurostat shows that the Netherlands are importing, though earlier it was concluded that they were self-sufficient, this import is however a result of trade taking place, with gas arriving from pipelines in the North Sea.

[20] The rest of the CIS amounts to: Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Ukraine, Uzbekistan, hereafter labelled CIS

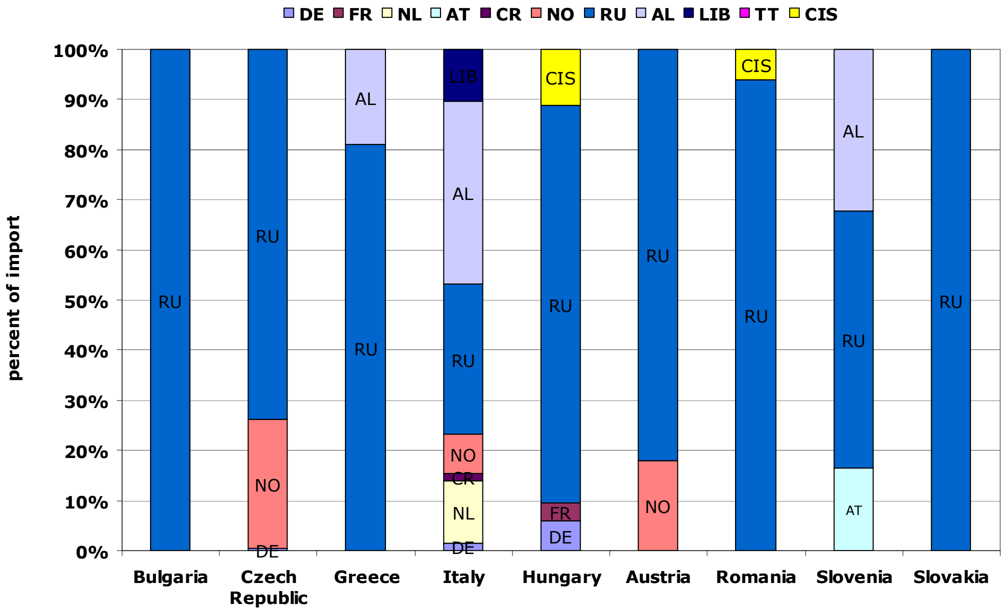
Figure 18 Diversification of supply, Northern region



Source: Based on data from Eurostat

For the South-East region it is seen in Figure 19 that there are three big suppliers to the South-East region: Russia, Algeria and Norway. Russia is by far the dominant supplier.

Figure 19 Diversification of supply, South-East region



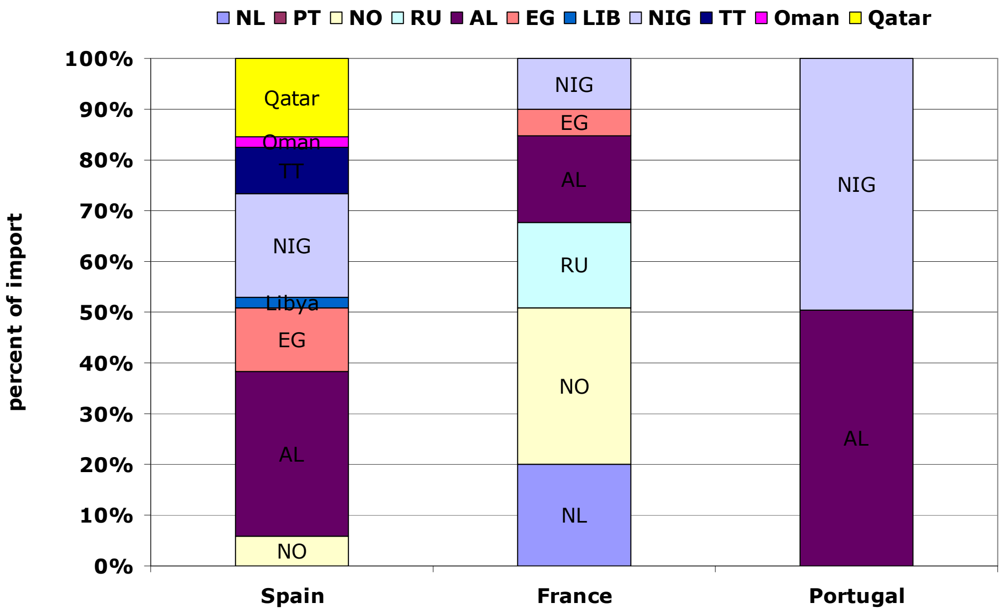
Source: Based on data from Eurostat

Italy is the only country with slightly diversified supplies; most other countries rely on very few import sources. There are no cases of countries depending on a sole supply source.

The supply situation for the South-West region is influenced by the proximity of northern Africa and the Middle East. This proximity facilitates diversification of import sources via LNG imports.

It is seen in Figure 20 that both Spain and France have very diversified import portfolios. This is possibly because both countries have several LNG terminals. As mentioned earlier, this enables import from a range of different countries. Portugal, on the other hand, is totally dependent on Nigeria and Algeria.

Figure 20 Diversification of supply, South-West region



8.4.1 Herfindahl index

To measure the relative level of diversification, an index called the Herfindahl index is computed. The index was originally constructed as a tool to measure the concentration of firms and their market share in an industry. However, it may also be applied to measure supplier[21] dependency. The index in this case is focused on each country's share of the total import in a country. If a country is dependent on import from few countries, the share of these countries' import out of the total import is relatively high. The Herfindahl index squares each import share and then adds them up.[22] To depict the supplier dependency as realistic as possible the indigenous production is also taken into account, this means that we are treating the indigenous production as a "source" of import. A country may have few sources of import but still be relatively well covered due to a large indigenous production. For example, if a country depends on only one supplier and has no indigenous production, the Herfindahl index for that country becomes $1^2 = 1$. A country such as Portugal has two import sources, Nigeria and Algeria, with import shares of 0.38 and 0.62, respectively, but no indigenous production. Thus the Herfindahl index for Portugal becomes: $0.50^2 + 0.50^2 = 0.50$. In general the more sources of supply and the smaller that supply from these sources becomes, the lower the Herfindahl index. A special case is Denmark

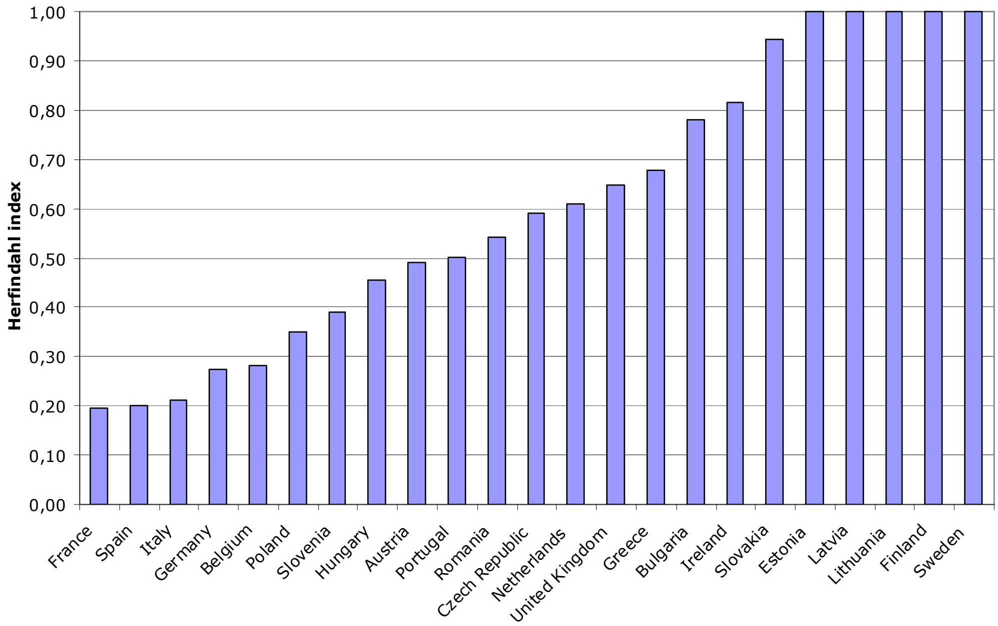
[21] referring to country of origin of the imported gas

[22] $H = \sum_{i=1}^{n} \alpha_i^2$. There are "n" importing countries, and α_i denotes country *i*'s share of the import.

which has indigenous production, and does not rely on import, for these reasons Denmark is not included in the figure.

The computed Herfindahl index is presented for each EU Member State.

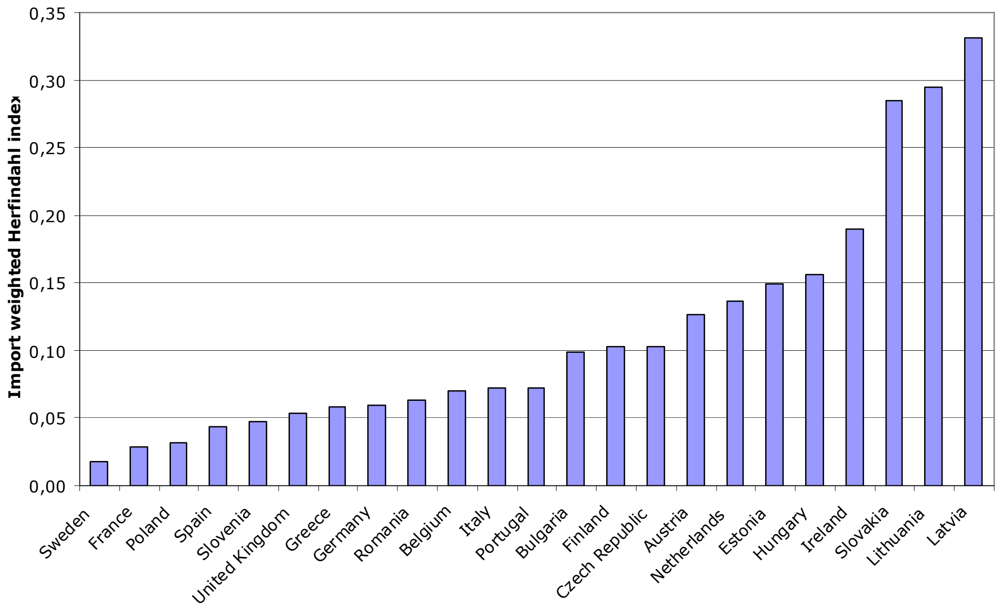
Figure 21 Herfindahl index



Source: Based on data from Eurostat

The Herfindahl index in its current version however, does not give in indication of the import vulnerability of the country. For example, a country like Sweden, where natural gas is of marginal importance, will still have a high Herfindahl index. In order to provide a better measure that indicates the importance of gas and the diversification of supply the Herfindahl index is weighted by natural gas imports relative to primary energy consumption in the following figure.

Figure 22 Herfindahl index weighted by import of natural gas relative to total primary consumption.



Source: Eurostat

Compared with the unweighted Herfindahl index, Sweden is now at the bottom, while the top is dominated by countries that rely on few import countries while having a significant share of gas in the primary energy consumption. The three countries with the highest weighted Herfindahl index are Lithuania, Slovakia and Latvia.

8.4.2 Utilisation of import pipelines

Flexibility in import and storage as flexibility tool complement each other, higher import flexibility results however in lower demand for storage for seasonal balancing.

In the following we present an analysis of the utilisation rates of the pipelines supplying gas to the EU as an indication of the availability of flexibility in the imports and relate the obtained measures of the utilisation rate to the current storage situation.

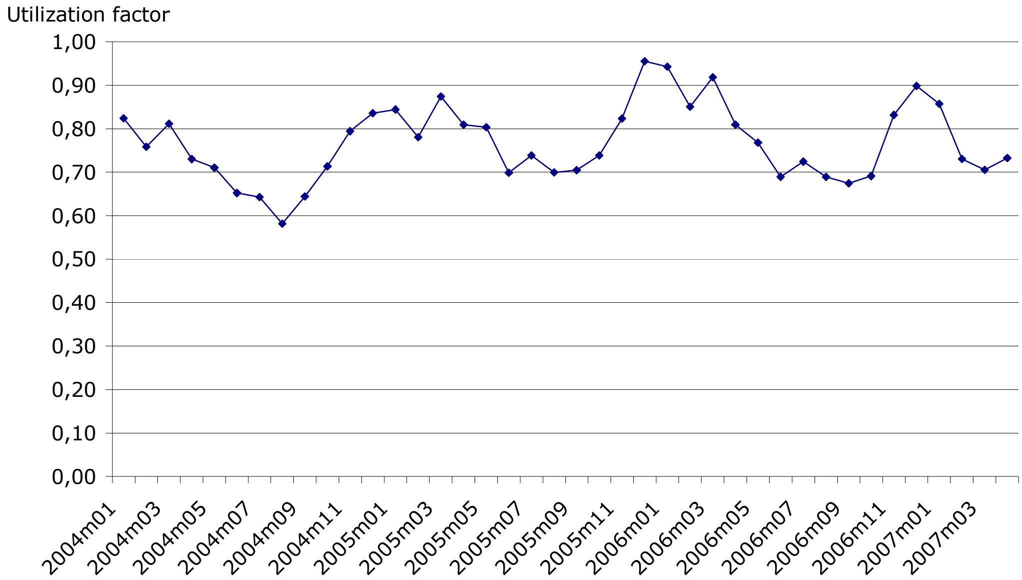
The capacity of each import pipeline is listed in Table 3. The data employed here was obtained from GIE's and GTE's databases.

We calculated the utilisation rate as the share of utilised capacity of the existing total maximum pipe capacity available through a period of one year.

Sorting the pipelines according to import source, we observe that the gas supplied to EU via pipelines originates mainly from Russia, Norway and North

Africa. The average annual utilisation rate for pipelines from Russia is 69.19%, 75.8% for import pipelines from Norway and 76.41% for pipelines coming from Algeria. It should be noted that the monthly utilisation rate is a result of seasonal swing in consumption and production patterns. Thus utilisation during the winter months may be much closer to 100% than during the summer months. The seasonality in import pipelines is illustrated by the monthly utilisation rates in Figure 23, where the utilisation factor has been aggregated across pipelines[23], indicating some degree of flexibility of import (i.e. gas is not imported at completely flat rate).

Figure 23 Utilisation factor



Source: GIE, Eurostat

In order to see whether there is correlation between the flexibility in the import, swing in consumption and possibility for indigenous production, we calculate the 'utilisation rate of import pipelines per destination country', as the actual pipeline imports from the source country divided by the maximum yearly flow rate for each country. In this analysis, it is important that the gas supplied is intended for the home market of the import country. For example, comparing the capacity of the 'Brotherhood' pipeline from Russia, going through Slovakia with Slovakia's pipeline import from Russia is misleading since the gas is distributed to Germany, the Czech Republic and Austria. In other cases such as Spanish or Italian import from North Africa the flow of gas is more transparent. This implies that the utilisation factors can be approximated and analysed.

[23] It should be noted that LNG has not been excluded from this figure.

Following differences can be observed in the utilisation pattern across EU:

- Countries with a lot of swing in consumption have more flexible import.
- Indigenous production seems correlated with smaller utilisation rates.

What can be observed is some available import capacity in the import routes from Norway.

Regarding storages it is interesting that the southern region which has the largest concentration of storage capacity per capita, also is the region with the highest degree of utilisation of import pipelines, indicating possibly the expected negative correlation between the import flexibility and demand for storage capacity.

It can also be argued that storages can facilitate a higher utilisation rate as the low import rates of the pipelines during the summer may be improved by establishing storage capacity along the supply route and increase the total amount of gas supplied to the EU, reduce the probability of bottlenecks in the import pipeline and thereby improve the overall utilization of the import pipelines.

Table 3 Pipeline utilisation rates

Pipeline No.	Export country	To	Max. yearly flow rate bcm	Total Max. yearly flow rate bcm	Pipeline imports from source country	Pipeline Import in bcm (2007 figures)	Total imports from source country	Utilisation rate destination country	Utilisation rate source country
55A	Russia	Slovakia(Via Ukrain)	108.0			5.8		na	
71	Russia	Lithuania(Via Belarus)	10.5			3.4		na	
67	Russia	Hungary(via Ukrain)	14.3			7.9		na	
76	Russia	Finland(Imatra)	7.0			4.3		na	
75	Russia	Latvia(Korneti)	1.3			1.6	155.58	na	69.19%
65	Russia	Poland(Wysokoje)	5.3		6.2			na	
66	Russia	Poland(Via Belarus)	31.3			8.5		na	
64	Ukrain	Poland(Drozdowicze)	5.7		2.3			na	
78	Ukrain	Romania(Isaccea)	37.5	224.9	3.5	3.5		na	
80	Ukrain	Romania(Mediesu Aurit))	4.0					na	
38	Algeria	Spain(via Morocco)	11.1	11.1	8.8	8.8	32.7	79%	76.41%
47	Algeria	Italy(Via Tunisia)	31.7	31.7	22.1	22.1		69%	
50	Libya	Italy(Gela)	10.0	10.0	9.2	9.2	9.2	92%	92.13%
1A	Norway	Belgium(Zeebrugge)	14.6	14.6	9.5	9.5		65%	
15C	Norway	Netherlands(Emden NPT)			7			61%	
15D	Norway	Netherlands(Emden EPT1)						73%	
15A	Norway	Germany(Emden NPT)			23.74				
15B	Norway	Germany(Emden NPT1)	28.91			30.7			
15E	Norway	Germany(Emden EPT)					86.1		75.80%
15F	Norway	Germany(Emden EPT1)		43.89					
16	Norway	Germany(Dornum/NETRA)	15.0						
31	Norway	France(Dunkerque)	18.6	18.6	15.1	15.1		74%	
58	Norway	United Kingdom(St.Fergus (vesterled)	12.4	36.4	16.4	16.4		45%	
83	Norway	United Kingdom(Easington)	24.0						
Total			**391.2**	**391.2**			**283.6**		**72.48%**

8.5 Correlation of key market parameters with storage capacities – a panel data approach

Throughout the previous section it was attempted to make an inference about the correlation between storage capacities and selected key market parameters.

Systematic trend and correlation were not straightforward and reliable information or clear conclusions could often not be deducted from the synthetic graphs.

There are several other problems connected to conclusions based on the synthetic graphs. First of all the sought correlation between storage capacity and the variables of interest may vary over time. This information is not contained in the synthetic graphs. Second a number of qualitative components such as geographical conditions and cannot be quantified and are therefore not taken into consideration. Thirdly the synthetic graphs do not deal with the question of causality.

Thus it is relevant to investigate the relationship between storage and the parameters of interest in a framework that:

- Allows analysis taking historical development of the variables into account.
- Deals with the question of causality.
- Deals with the issue of unobservable/unquantifiable components.

For this a panel data approach can be used.

In the following we present a panel data model with the purpose of explaining the development in storage capacities using data from 1998 to 2006 for the Member States.

8.5.1 Data and variables

The data used in the panel data analyses consists of yearly observations of each variable in each Member State, for the observed time period 1990-2006. If not explicitly stated otherwise, our source of data is Eurostat.

The main variable of interest is **Storage working capacity**[24] as this is the variable that we seek to explain - it will be labelled as endogenous in the model. It is measured in million of cubic meters (mcm).

The explanatory variables include:

- **Net import,** as suggested earlier there seems to be a correlation between a country's increasing imports and storage capacity, both for security of

[24] Source: Storage operators' websites, Cedigaz 2006, Erdgasspeicherung.

supply purposes but also for seasonal balancing. It is expected that this parameter has a positive impact on the amount of storage capacity in the panel data model.

- **Indigenous production** is taken into account in our model, as indigenous production has until now been the main source of flexibility. With decreasing indigenous production and therefore increasing imports the demand for storage capacity could rise in the countries with indigenous production. However positive effects on capacity from this variable to capacity are not expected within the coming years, and indigenous production is thus expected to be negatively associated with storage capacity.
- **Energy generating sector's gas consumption** and
- **Gas used in transformation input[25].** Some countries rely to an increasing extent on gas in energy generation. If this is the main purpose of consuming gas it would be highly relevant to dispose over some storage capacity.
- **Household** and **industrial consumption**. We expect that these two variables have different effects on storage capacity. Due to the seasonality of household consumption we expect that household consumption is positively associated with storage capacity, while industrial consumers have fuel switching possibilities and we therefore expect a weaker relationship between storage capacity and industrial consumption.
- **Other explanatory variables.** Taking other variables not directly related to the gas sector into account is also relevant, specifically variables instrumenting country size and weather conditions could be of interest. It was chosen to include the number of heating degree days in our model. It is also relevant to take changes in the price of gas into account. However, country specific prices are not available for all EU countries.

8.5.2 Endogeneity

One aspect which always should be approached in quantitative analysis is the question of endogeneity. In our analysis the only variable which is endogenous is the variable that we want to explain, the storage capacity. It is important that storage capacity in period t in country j does not affect the explanatory variables. For example, a storage completed in March could facilitate more import to a country. If such effects are present and not accounted for, our model will be rendered non-identified, which means that we in fact do not know which relationships (or rather between which variables exactly) we are estimating. One way of coping with this simultaneity issue is to lag our explanatory variables[26]. This approach relies on the fact that the explanatory variables in year j-k will not be affected by realisations of the storage capacity in year j. Thus we search in the past to document appropriate relationships between our explanatory variables and storage capacity.

[25] Gas transformed into other types of energy – such as in heating plants is labelled, corresponding to Eurostat 'gas used as transformational input'.

[26] The probability that a new storage in year j will effect the realisations of the explanatory variables in year j-k is relatively small.

8.5.3 Unobserved and unquantifiable effects

Some variables and relationships are impossible to quantify and take into account. In the gas sector we may have that investment in natural gas storages depends on special laws, traditions, politics, lobbyism etc. The effect of these parameters are difficult to measure, however if it is assumed that the partial effect from these parameters is constant, it is possible to take the unobserved effect into account. The panel data approach allows for systematic (constant) unobserved effects to be taken into account, this may sound arbitrary, for the sake of exposition we illustrate how the unobserved effect enters (and exits) our model.

8.5.4 Theoretic approach

We want to investigate whether storage capacities over time are correlated with a battery of key market parameters that are expected to be associated with storage capacity. We have a panel of 25 countries were we would like to investigate the correlation between the storage capacities in each country and our parameters of interest. The relationship of interest is expressed as:

$$y_{ij} = x_{ij}\beta + c_i + u_{ij} \qquad (1)$$

where y_{ij} denotes storage capacity in year j in country i, x_{ij} contains the explanatory variables in year j in country i, c_i is the unobserved effect which by assumption is constant over time, and u_{ij} is the error term. The above equation is at the moment not possible to estimate, as c_i is unknown. Several methods of dealing with the unknown effect exist. In choosing we have to make clear whether the unobserved effects such as lobbyism, favourable mining laws, etc, could be correlated with our explanatory variables. Certainly some variables, especially the ones that describe the different sectors' consumption of natural gas, will be correlated with for example the level of lobbyism. Thus we must allow for correlation between x_{ij} and c_i. This is commonly implemented by using fixed effects transformation. Fixed effects transformation implies demeaning the data by subtracting the averages of $y_{ij}, x_{ij}, c_i, u_{ij}$ from equation (1). As c_i is constant over time it disappears and we are left with the following relationship that we can estimate by pooled OLS:

$$\left(y_{ij} - \bar{y}_i\right) = \left(x_{ij} - \bar{x}_i\right)\beta + \left(u_{ij} - \bar{u}_i\right)$$

8.5.5 Empirical results

As indicated in the theoretical approach we use fixed effect transformations to deal with the unobserved effects. Before regressing the storage capacities on our battery of explanatory variables, a few other issues must be addressed. First of all taking a look at our data reveals that some countries do not have any storage. This can be due to geological reasons as some countries simply do not have the possibility to store gas in the underground. The inclusion of these countries in this analysis would distort the results and give a misleading picture of the correlations between storage capacity and the explanatory variables. Thus our analysis includes only the countries which have storage capacities. Furthermore to avoid endogeneity we chose to lag the explanatory variables for 6 years[27]. This can capture possible dynamics and interactions between the explanatory variables which would not have been caught otherwise. Thus our model looks like the following:

$$y_{it} = X_{it}\beta + u_{it} \quad (3)$$

Obviously, this is a lot of parameters (6x6) to estimate. To enhance the overview of the results the model is reduced by excluding the most insignificant variables one by one and then re-run the model[28]. Applying this iterative general-to-specific approach we end up with a model only consisting of significant parameters. Furthermore, we choose to present the estimates in form of elasticises. This means that the number in the first row indicates how much storage capacity would increase/decrease following a one percentage change in the explanatory variable. This effect is measured at the mean value of the variables. This implies that the stated effects are for the average membership country which has gas storage.

[27] Number of lags determined by the akaike selection criteria.

[28] The model was reduced by applying both general to specific and specific to general methods.

Table 4 Elasticities evaluated at mean values

Variable	Elasticity	Std. Err.	P>z	Mean
Heat degree days lag1	1.13	0.44	0.011	2831
Heat degree days lag3	0.53	0.24	0.031	2871
Heat degree days lag4	0.61	0.25	0.016	2857
Heat degree days lag5	0.61	0.26	0.022	2894
Indigenous production lag2	-0.32	0.18	0.067	0.38
Indigenous production lag5	-0.46	0.20	0.025	0.39
Household and service consumption lag5	0.82	0.21	0.000	0.32
Gas used for transformation input lag5	0.44	0.15	0.004	0.26
Energy sector consumption lag3	0.22	0.057	0.000	0.038
Energy sector consumption lag5	0.14	0.06	0.018	0.036
Industry consumption lag2	0.40	0.16	0.013	0.27
Industry consumption lag5	0.39	0.15	0.010	0.27
Net import lag2	-0.49	0.18	0.006	0.62
Net import lag3	0.20	0.11	0.073	0.61
Net import lag5	-0.71	0.23	0.003	0.58
Net import lag6	-0.29	0.11	0.010	0.57

The first finding of interest is the sign of the variables. It can be seen from Table 4 that the six variables: consumption in the energy sector, household/services and industry consumption, indigenous production, gas used for transformation input, and the number of heating degree days all seem to have the expected sign (i.e. positive or negative correlation).

The sign of the net import is ambiguous. This may indicate that net import until now has not been a clear indicator for storage investments; this picture could however as indigenous production is decreasing.

It is seen that a one per cent increase in the relative household consumption in period t-3 on average is associated with a 0.82% increase in the relative storage working capacity in period t. This is more than two times larger compared to the industry’s consumption.

A one per cent increase in the energy sector's consumption has the smallest effect, 0.14-0.22 percent.

A variable which is negatively associated with storage capacity is indigenous production. It is seen that a one percentage increase in indigenous production is associated with -0.32 to -0.42 percent less storage capacity.

The elasticises draw an interesting picture. First of all they illustrate that consumption is significantly and positively associated with storage capacity. Secondly, they provide a ranking of the importance of the different sectors' consumption. It is seen that household consumption by far matters the most while industrial consumption and the energy generating sector's consumption have the smallest effect on storage capacity.

The heating degree variable is in itself not especially interesting; however, the elasticities give an indication of which years have the greatest influence. It is seen that recent developments in temperature are the most important.

8.5.6 Sensitivity analysis

As mentioned the elasticities were evaluated at mean values. However, it may also be of interest to investigate the elasticities at other values. For example, how large is the effect on storage when household/service consumption changes in a country with little household/service consumption compared to a country with large household/service consumption.

Table 5 Elasticities evaluated at varying values.

Variable	Below	Average	Above
Household/service consumption	0.58 (0.10)	0.82 (0.32)	0.87 (0.5)
Industry consumption lag2	0.17 (0.08)	0.4 (0.27)	0.54 (0.48)
Gas used for transformation input	0.19 (0.08)	0.44 (0.27)	0.58 (0.47)
Energy sectors consumption lag3	0.007 (0.001)	0.22 (0.038)	0.37 (0.08)
Indigenous production	-0.08 (0.12)	-0.32 (0.39)	-0.63 (0.60)

In the first column the effect of a 1 per cent increase is measured when the variable attains a value below the average, in the second column the average effect is shown – this elasticity is the same as in. Finally the last column displays the elasticities when the variable attains a value above the average.

The first row indicates that the marginal change in elasticity is larger for countries with small household/service consumption (a concave relationship). Thus changes in household/service consumption have smaller effects the larger the consumption in the household/service sector is. Put another way, an increase in household consumption in a country like Belgium, which has relatively little household consumption, will imply larger effects on storage capacity than a one per cent increase in household consumption in France or Germany would. This could indicate that countries with small household consumption are more sensitive and respond much more to changes in the consumption pattern than those countries where household consumption constitutes a large part of the natural gas consumption.

8.6 Summary and conclusions on development of storage capacities in the EU

Existence of the necessary geological potential is a pre-condition for construction of underground gas storages and pre-determines development of storages as well as the type of storages within the EU.

We have in this section tried to investigate whether there are one or more market parameters act as additional investment drivers and affect the choice of the type of storage being developed. We tried to do so by analysing possible correlation between storage capacity in EU member States and following parameters:

- Share of gas in primary energy consumption.
- Seasonality of gas consumption.
- The gas used for transformation purposes.
- Import dependency.
- Supplier dependency.
- Utilisation of import pipelines.

The analyses included plotting of storage capacity of Member States (as it is at present) and the above parameters in synthetic graphs, as well as analysing the development of this possible correlation throughout the period 1997-2006 in a data panel approach. The analyses resulted in following main observations:

- There seems to be a positive correlation between capacity and several key market parameters, such as share of gas in primary energy consumption and variation in gas consumption, especially household consumption was correlated with storage capacity. However the synthetic graphs do not show anything about causality.

- Regarding the concentration of each Member State's import sources, the analysis indicated that the majority of countries were dependent on imports and that this dependency increases in the future. This increase was seen to be positively correlated with the change in the construction of new storage capacity, indicating that capacity investments are carried out to replace some of the flexibility which is lost with the decline in indigenous production.

- Vulnerability related to import dependency increases if import is concentrated on one or a few countries of supply. The Herfindahl index showed that the countries which had the most concentrated import were located in the South-East region and the Baltic countries in the Northern region.

- A panel data analysis of the key parameters showed that consumption parameters such as household gas consumption, industry consumption, transformation input and consumption in the energy sector all were significantly positively correlated with the storage capacity. Indigenous production was negatively correlated with storage capacity. The analysis furthermore showed that in the period after the first gas directive, the effect of a 1% increase in household consumption was associated with a 0.82% increase in the storage capacity, this effect was around 0.4% for industrial consumption and gas used for transformation input, while increases in the consumption of the energy sector was of less importance (elasticity of 0.22%). The marginal effect of these variables thus ranked household consumption as the variable having the largest effect on storage capacity, which is consistent with the expectation.

- The effects of the explanatory variables were measured at their mean values. By varying these it was seen that the effect of an increase in any of the variables were largest for countries with small realisations of the changed variables. Thus change in household consumption has larger effects in countries with little household consumption than in countries with large household consumption.

9. Assessment of future demand for storage

Referring to the role of storage as defined in PART II, storage demand and adequacy of available capacity will be estimated for:

- Storage capacity as a seasonal balancing tool (low-frequency seasonal demand).
- Storage capacity as a high frequency balancing tool.

Further, this section will analyse the potential of storage as a tool for security of supply i.e, the availability of storage to be used in case of a supply disruption. This will be done by performing a peak supply capacity analysis and a peak demand evaluation for daily winter peak demand and daily summer peak demand as well as looking at the potential of storage to supply gas in the event of a supply interruption.

9.1 Seasonal demand (low frequency)

The following sections analyse the demand for seasonal storage, which is also referred to as low-frequency storage because the frequency of gas injected and withdrawn is low.

9.1.1 Methodology

The approach used in this analysis for estimating the demand for natural gas storage in the future is shown below. The method is inspired by Höffler and Kübler (2007).[29]

Using the estimated natural gas consumption, production data and swing ratios, it is possible to extrapolate the demand for natural gas storage (volumes of working gas) necessary for seasonal balancing.

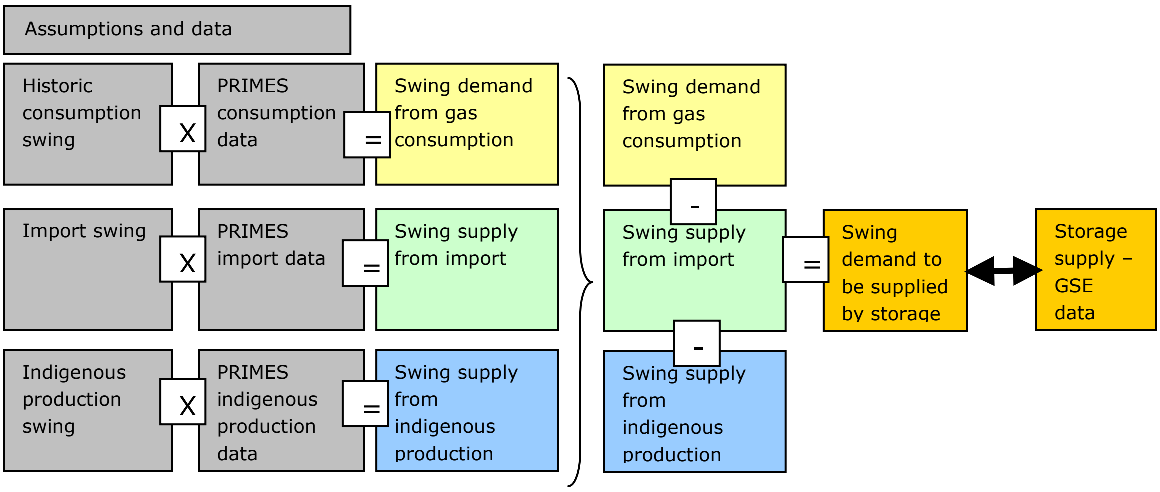
[29] Höffler and Kübler (2007): Demand for storage of natural gas in north-western Europe. Trends 2005 to 2030

The formula is as follows:

> *(future demand x consumption swing ratio) – (future own production x production swing ratio) – (future import x import swing ratio) = future demand for gas storage*

For the estimated gas consumption, we are using the data from the three 2005 PRIMES scenarios – Baseline, Energy efficiency and Soaring Oil and Gas price – and the 2007 PRIMES Baseline Scenario. The different scenarios shall account for the uncertainty related to future gas demand. [30]

Figure 24 The approach/methodology of the model used



For information on swing demand and swing supply, the Eurostat monthly gas consumption data available from the Eurostat database has been used.

The swing in demand for gas between seasons is due to temperature-dependent gas consumption. In this analysis, "swing demand" is defined as winter consumption (October to March) minus summer consumption (April to September) divided by total annual consumption.

Swing demand in the model can be covered by three different tools of flexibility on the supply side:

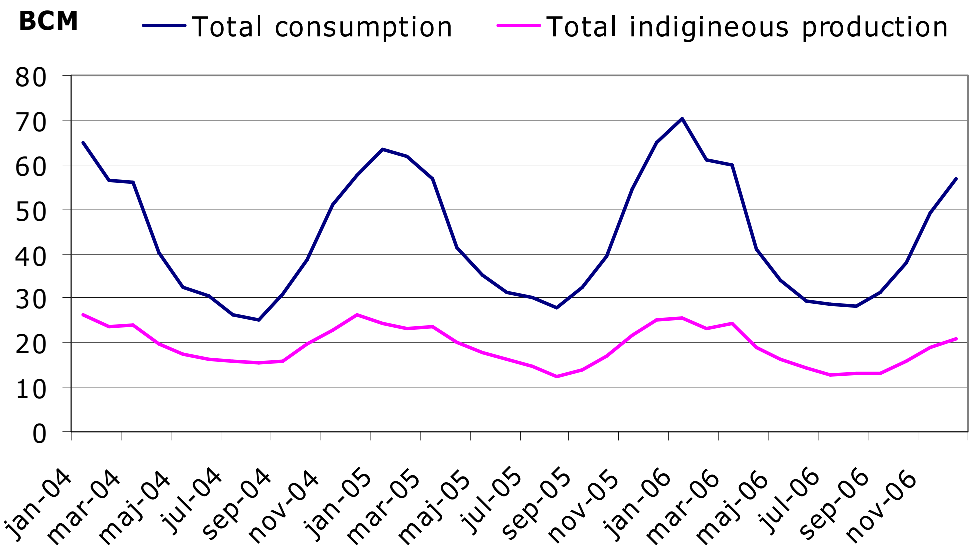
- Indigenous production.
- Natural gas imports.
- Gas storages.

Figure 25 below shows actual monthly consumption and monthly indigenous production. The gap between the dark blue line and the pink line is to be filled with

[30] Conversion factor used: 1 ktoe = 1,111 mcm

supplies from import and withdrawal from storages. It can be seen in the figure that the gap between production and consumption is growing tremendously during the winter months. If imports are relatively firm throughout the year the increase in demand during winter will have to be covered by either an increase in indigenous production or by gas from storage facilities. Figure 26 shows how consumption and indigenous production swing differ for the EU Member States.

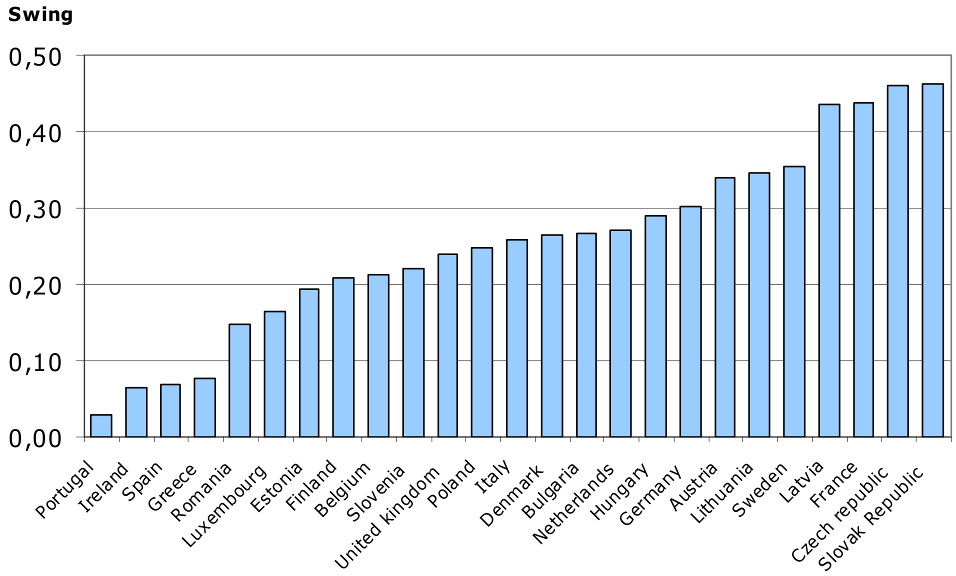
Figure 25 EU 27: Natural gas consumption and production profiles in the EU



Source: Based on data from Eurostat

Data for indigenous production and consumption swing is based on actual swing rates from 2004-2006 in each individual EU Member State.

Figure 26 EU Member States: consumption swing ratios average 2004-2006



Source: Based on data from Eurostat

The above figure shows the individual differences in consumption swing ratios. For example it indicates that the UK has a swing ratio of 24%, which means that the UK consumes 24% more gas in each of the months from October to March compared to the average monthly consumption.

The swing ratios are kept constant throughout the analysis. The import swing ratio is set at 7.5% for all imports, i.e. winter imports are 7.5% higher than average imports. The calculated average swing in EU gas imports in 2004-2006 was approximately 9%; however, it is most likely that gas in the future will be imported to the EU from further away compared with today, e.g. from the Barents Sea, Qatar or Nigeria. This will increase import costs and thus the incentive to optimise utilisation of import pipes. The reasoning is that the costs of building 'excess' capacity in pipelines increases radically with pipeline length or to put it in other words, the longer the pipeline the higher the benefits from optimising the utilisation of the pipeline and the higher the loss will be if the pipeline is built with excess capacity.

Based on the above notion it is likely that import swing will decrease over the analysed timeframe (until 2030) compared to the 2004-06 average used for the analysis made in this report. Thus keeping import swing constant in our analysis could have the effect of underestimating swing demand in the future compared with today. It is important to bear this in mind when analysing the results, because this implies that the results may be biased towards too-high swing demand today and too-low swing demand in 2030.

The main driver for storage demand in the model is the fact that gas consumption is seasonal, imports are more flat compared with indigenous production and therefore the demand for seasonal balancing, i.e. for storage, will increase in the future due to an increasing import dependency.

9.1.2 Storage demand scenarios

The demand for storage capacity (working volume) for seasonal balancing is calculated for the gas demand estimated in four PRIMES scenarios and for the years 2015, 2020 and 2030[31]:

- 2007 Baseline Scenario.
- 2005 Baseline Scenario.
- High Renewable/High Efficiency Scenario.
- Soaring Oil and Gas Price Scenario.

In addition, an evaluation of how the model predicts demand today compared with actual capacity is also included (designated as "calculated 2005") with the purpose to test the accuracy of the model in estimating storage capacity demand based on the ability of the model to replicate the present.[32]

The model described above allows one to estimate the future demand for gas storage, as well as enables one to evaluate the current level of storage demand with the current supply of gas storage.

Figure 27 and Table 6 show the expected development in gas consumption in the four above mentioned scenarios.

[31] Data on the PRIMES scenarios can be downloaded from the European Commission DG Tren homepage http://ec.europa.eu/dgs/energy_transport/figures/index_en.htm.

[32] Storage capacity data is the most recent data available from GSE - June 2008. Consumption data, however, is based on 2005 figures, as these were the latest available in the PRIMES dataset.

Figure 27 Gas consumption forecasts, indexed to 2005 gas consumption[33]

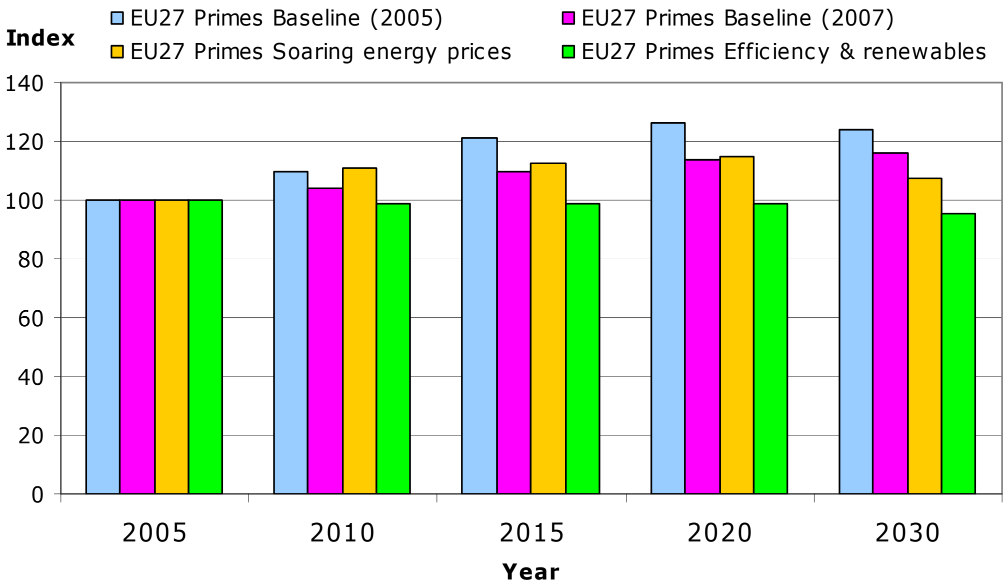


Table 6 Gas consumption forecasts, indexed to 2005 gas consumption

	2005	2010	2015	2020	2030
EU27 PRIMES Baseline (2005)	100	110	121	126	124
EU27 PRIMES Soaring Oil and Gas Price Scenario	100	111	113	115	108
EU27 PRIMES High Renewable/High Efficiency Scenario	100	99	99	99	95
EU27 PRIMES Baseline (2007)	100	104	109	113	116

It can be seen that for all scenarios except the high efficiency and renewables scenario gas consumption is expected to increase. The most recent update, i.e. the 2007 baseline scenario, expects gas consumption to increase by as much as 16% by 2030.

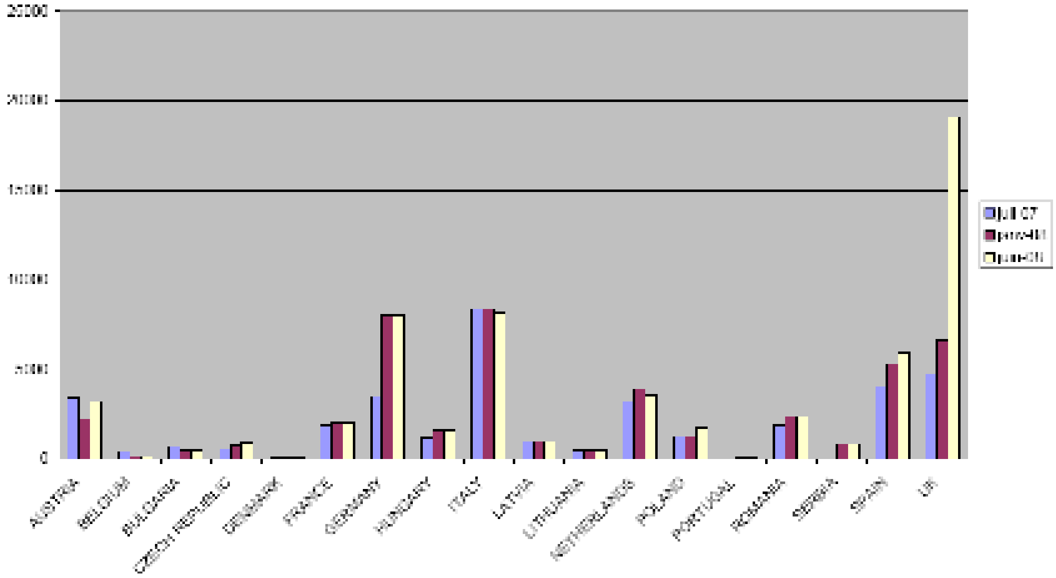
The gas demand estimated in the 2007 Baseline Scenario is however approximately 20 bcm or 18% higher than the gas demand estimated in the efficiency and renewable scenario in 2030 indicating quite significant uncertainty related to gas demand (and thereby demand for storage) in the future.

9.1.3 Storage supply scenarios

Storage supply is based on the development of investments in storage according to the GSE storage database of February 2008 and the updated investment database of June 2008, as presented on Figure 28.

[33] A conversion factor 1.2 from mtoe to bcm is used (www.energymarkets.eu.com and Eurogas)

Figure 28 New investments in storage (working volume, mcm), GSE database (updates July 2007, January 2008 and June 2008)



Source: GTE - Analysis following the update of the GSE Investment Database

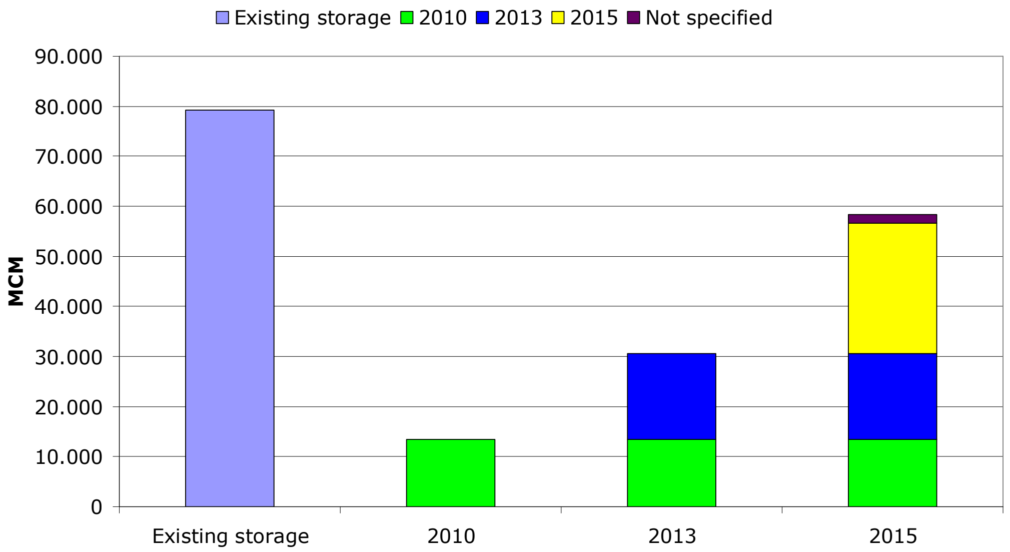
All investments listed in the GSE database of June 2008 taken into account, an increase of storage capacity of more than 50 bcm is expected constructed in the next 7 years. As a comparison, in the last eight years, total investments in storage capacity amounted only to around 3 bcm in the EU. In the period from 1990 to 2000, approximately 22 bcm of storage capacity were built in total, approximately 12 bcm of which in Germany.

This creates an uncertainty about the actual investments that will take place, and in order to account for this uncertainty when estimating the available storage capacity, two investment scenarios have been applied:

- the short-term scenario; and
- the long-term scenario.

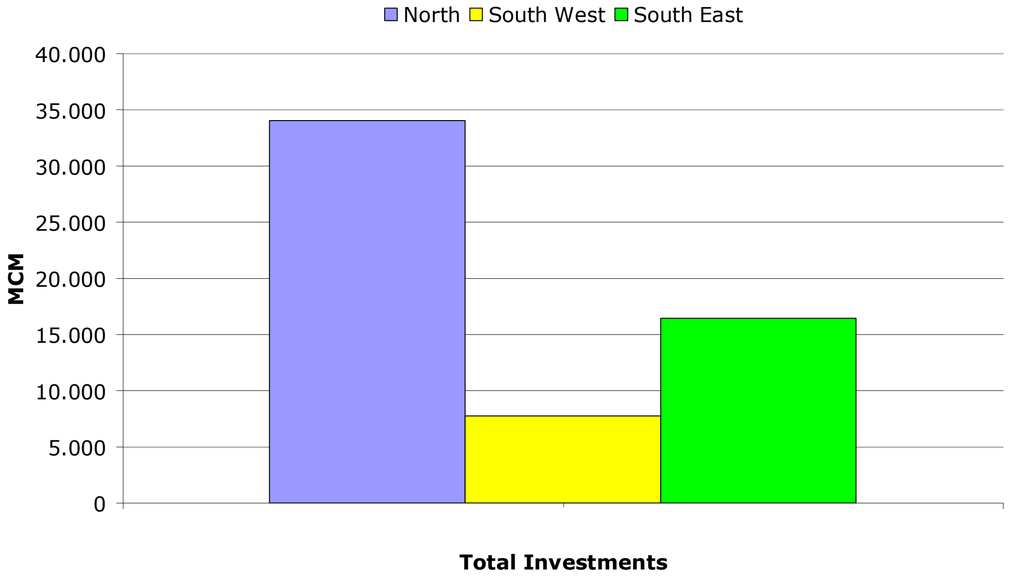
Both scenarios are, as mentioned, based on the investments database published by GSE in June 2008, however, while the long-term scenario takes into consideration all investments listed by GSE (Figure 29 and Figure 30), the short-term scenario takes into consideration only the already commenced (under construction) or committed investments in storage (Figure 31).

Figure 29 Long-term investments (working volume in mcm)



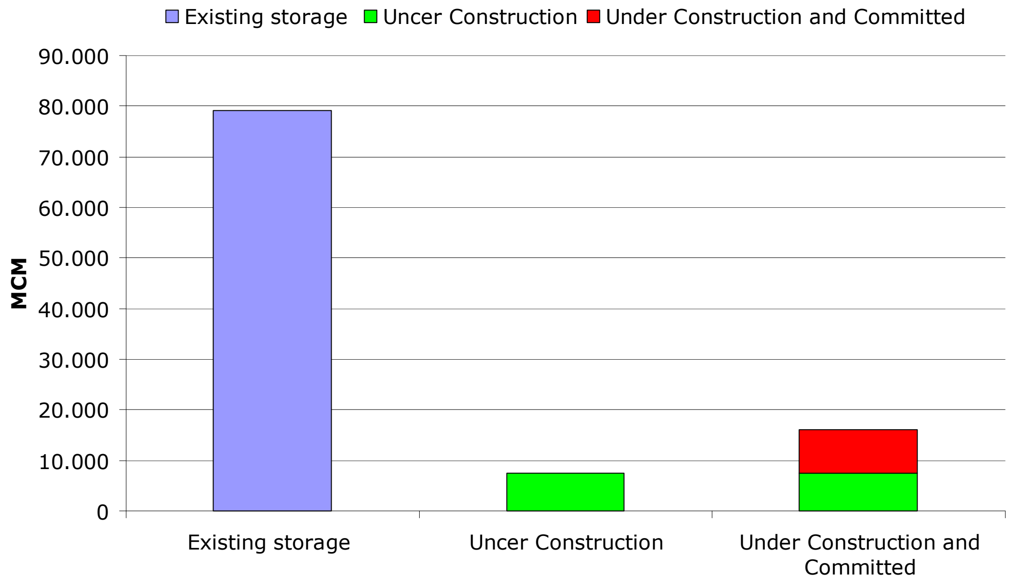
Source: GSE

Figure 30 Long-term investments by region (working volume in mcm)



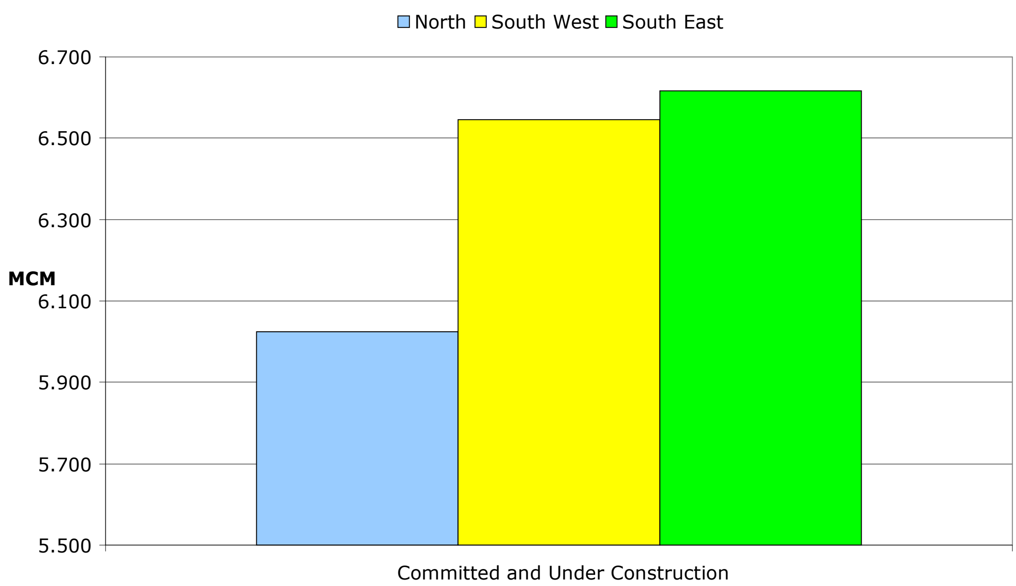
Source: GSE

Figure 31 Short term investments in gas storage capacity (working volume in mcm)



Source: GSE

Figure 32 Short term investments in gas storage capacity (working volume in mcm) per region

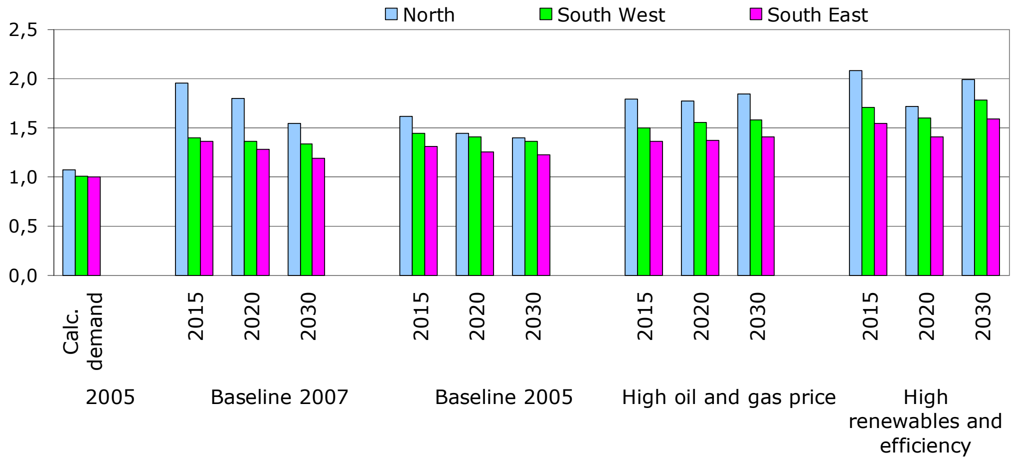


Source: GSE

9.2 Benchmarking supply and demand in the long-term investment scenario

Storage supply and demand in the long-term scenario are benchmarked by showing a supply/demand ratio (storage supply divided by storage demand) on Figure 33

Figure 33 Storage supply compared with storage demand long-term (supply/demand)



As can be seen from looking at the results for the various scenarios and various years, the storage capacity supply/demand ratio is increasing for all scenarios, i.e. supply of storage capacity is increasing relatively more than demand for storage capacity for seasonal balancing.

This means that the overall gas market in the future will be able to supply more storage capacity relative to demand for storage for seasonal balancing.

9.2.1 Regional analysis (Long-Term Scenario)

This section presents the results in terms of storage demand and supply per region.

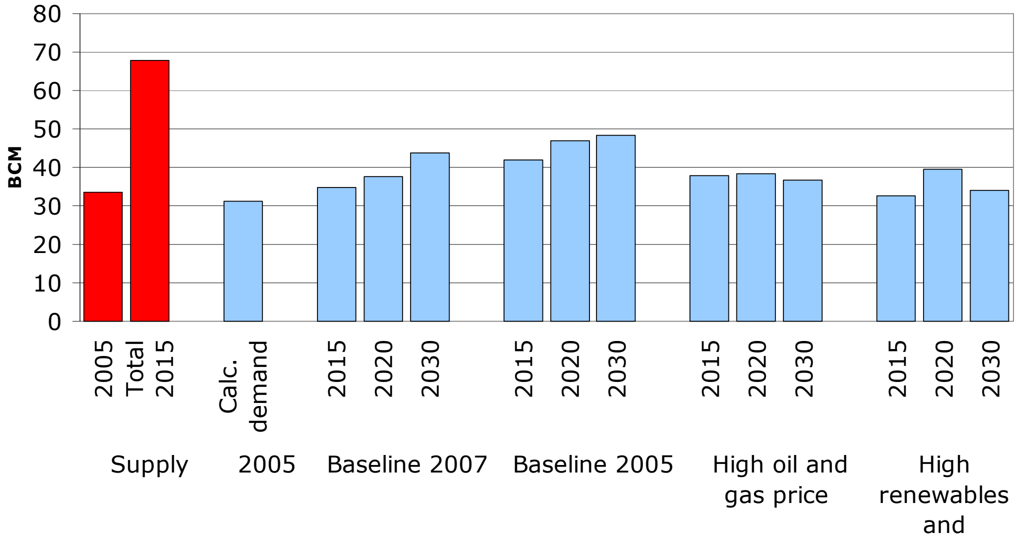
The Northern region

The Northern region is characterised by a very high level of activity in terms of planned storage investments (Figure 34

If all investments are realised, storage capacity will increase by more than 34 bcm by 2015, an increase of around 100%. This high level of planned investments is most likely due to the expected decline in indigenous production in the region.

Demand for storage in 2030 varies from 34bcm (in the High Renewable/High Efficiency Scenario) to 48 bcm (in the 2005 Baseline Scenario).

Figure 34 Gas storage demand and supply in the Northern region (bcm) long-term (red = storage supply, blue = storage demand)



Thus if investments are carried out as planned the available storage capacity in the Northern region is and will continue to be above storage demand for seasonal balancing.

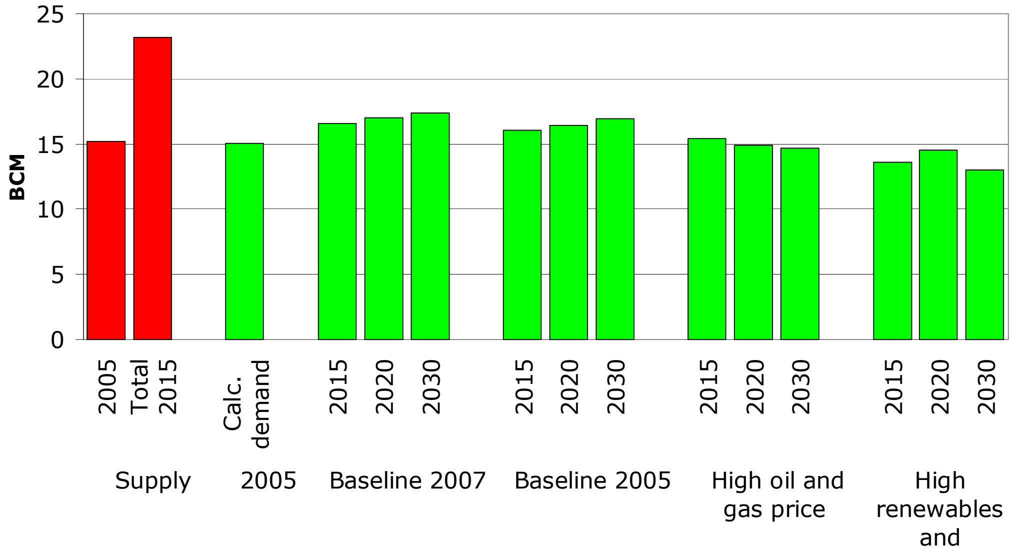
The South-West region

The results from the analysis of the South-West region are equivalent to those in the Northern region, i.e. the planned increase in storage capacity is more than able to meet the future demand for storage for seasonal balancing in the South-West region (Figure 35).

Planned investments in the region will increase storage supply from 15 bcm to 23 bcm. Storage demand in 2015 is expected to grow from between 13.5 bcm (in the High Renewable/High Efficiency Scenario) to 16.5 bcm (in the 2007 Baseline Scenario).

In 2030 the lowest demand is attained in the High Renewable/High Efficiency Scenario and is calculated to 13 bcm and 17 bcm in the 2007 Baseline Scenario.

Figure 35 as storage demand and supply in the South-West region (bcm) long-term (red = storage supply, green = storage demand)



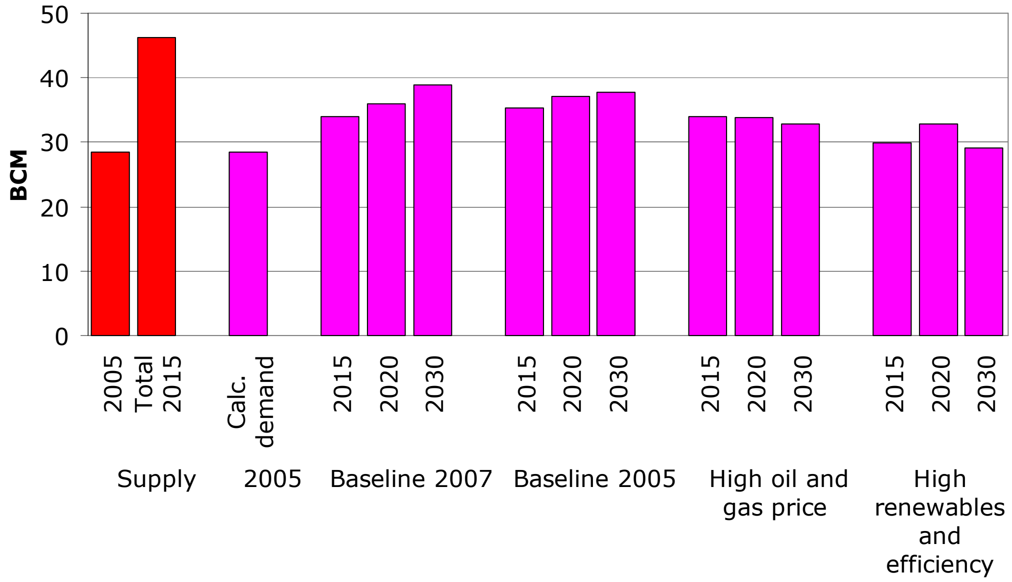
The South-East region

As was the case in the two previous regions, the future demand for storage for seasonal balancing can be met in the South-East region. Storage capacity investments in the range of 16.5 bcm additional working gas volume is planned, increasing the total capacity by more than 50% in 2015 to a total of 45 bcm.

Storage demand varies in 2015, from a low of 30 bcm (in the high renewables scenario) to 35 bcm (in the 2005 and 2007 baseline scenarios).

In 2030 the demand range varies from 29 bcm in the High Renewable/High Efficiency Scenario to 38 bcm in the 2007 Baseline Scenario.

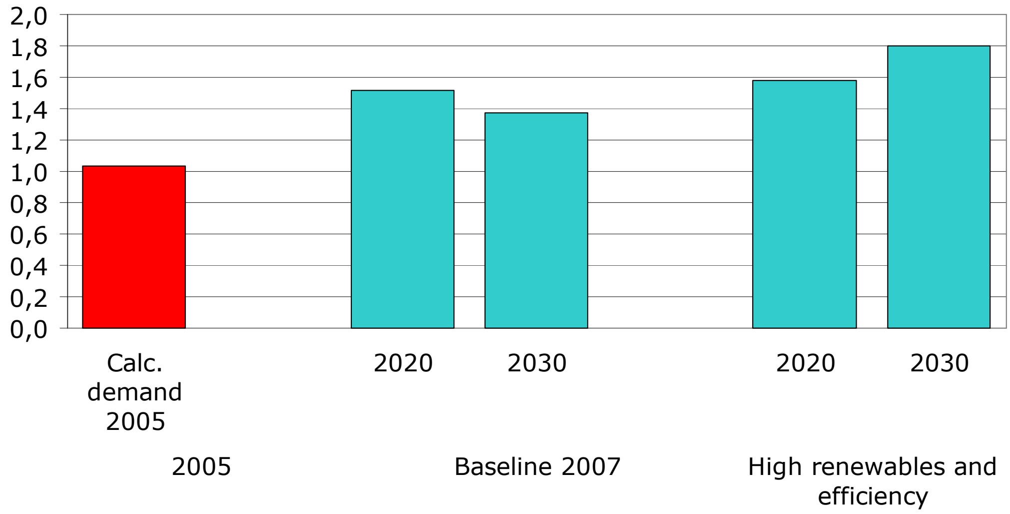
Figure 36 as storage demand and supply in the South-East region (bcm) - long-term



EU total

Figure 37 shows the planned long-term investment scenario benchmarked with the demand for storage calculated for the 2007 Baseline Scenario and the High Renewable/High Efficiency Scenario.

Figure 37 as storage demand versus supply, EU total long-term (red = situation today, turquoise = calculated future situation)



If all the planned storage facilities in the EU are built, there would be an excess of storage capacity relative to demand for storage for seasonal balancing of between 51% and 58% in 2020 and between 37% and 80% in 2030.

9.2.2 Summary on long-term scenario

The long-term scenario for supply of storage is based on all investments in storage capacity listed in the GSE database of June 2008. This supply is benchmarked with the demand for storage for seasonal balancing calculated based on the PRIMES scenarios.

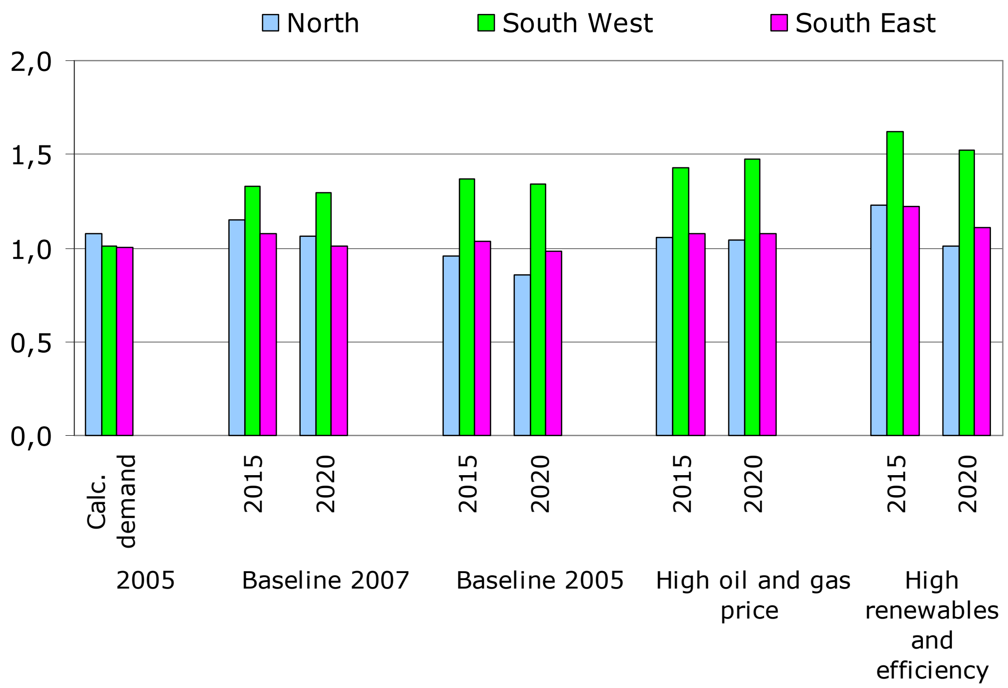
On EU level it seems that in 2020 the available storage capacity is 40% to 60% higher than the demand for storage for seasonal balancing and 40% to 80% in 2030. The relatively low demand for gas in the high efficiency scenario is the main driver of this result.

On a regional level it was seen that investments are enough to cover demand for storage for seasonal balancing in all regions. This is due to the fact that all regions will experience large increases in the supply of storage if all investments were carried out.

9.3 Benchmarking demand and supply in the short-term scenario

When only the investments that have been classified as under construction or committed are used, the overall picture of the storage supply situation changes somewhat.

Figure 38 Storage supply compared with storage demand – short-term scenario



Evaluating the results it becomes clear that the availability storage capacity highly depends on the natural gas consumption and thus the uncertainty with the gas demand in the future is reflected in an uncertainty related to demand for storage capacity for seasonal balancing. The calculations based on the most recent PRIMES

Baseline Scenario (2007) show that in 2015 there is enough storage capacity installed in all regions to cover the demand for storage for seasonal balancing. The supply demand prognosis based on the 2005 Baseline, which assumes a larger demand for gas, shows that in 2015 and 2020 the supply will fall short of demand in the Northern region while the in high price and high renewable scenario supply will be just adequate to cover demand.

9.3.1 Regional analysis (Short-term Scenario)

This section presents the results in terms of storage demand and supply per region.

The Northern region

The Northern region has approximately 6.23 bcm of storage capacity listed as committed or under construction,[34] which is an increase of approximately 18.5% compared to existing capacity. When evaluating this increase in storage capacity against the expected increase in demand for storage for seasonal balancing, it becomes evident that the ratio supply/demand in the 2007 Baseline Scenario and the High Renewable/High Efficiency Scenario are very close to each other. Investments corresponding to a few bcm before 2015 could be sufficient to balance supply and demand for storage for seasonal balancing in 2015.

However, if gas demand and the corresponding demand for storage for seasonal balancing develops as foreseen in the PRIMES 2005 Baseline Scenario, the Northern region may experience a lack of storage capacity for seasonal balancing.

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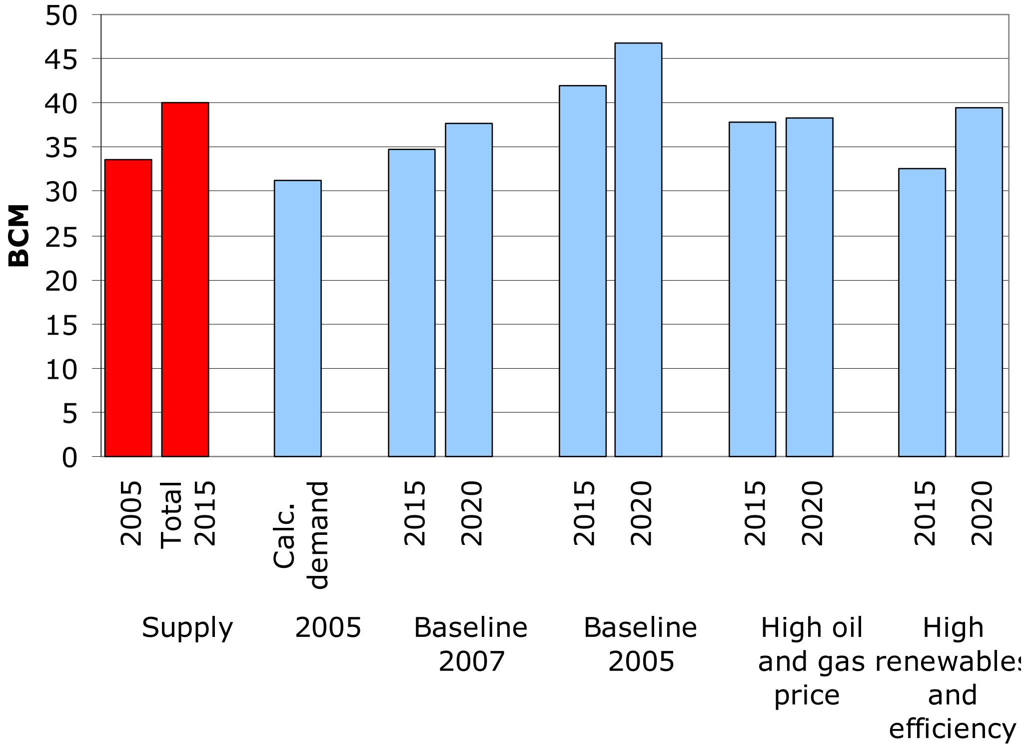
[34] Of these, 2.5 bcm are listed as planned/committed and 0.2 bcm as under development

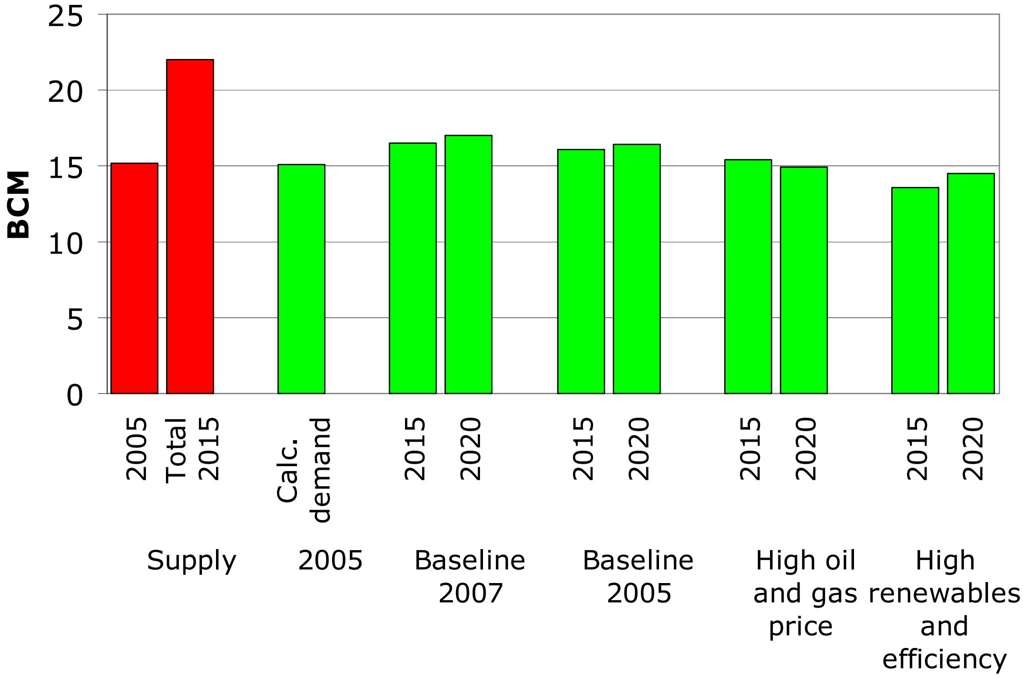
Figure 39 Gas storage demand and supply in the Northern region (bcm) – short-term (red = storage supply, blue = storage demand)



The South-West region

The investments that are under construction or have been committed in the South-West region will increase the total storage capacity by more than 42%, from around 15 bcm to around 22 bcm of working gas volume (Figure 40). Almost all of the investments will take place in Spain; only 0.58 bcm of storage capacity increase is scheduled to take place in France. Again it is observed that the uncertainty about gas demand manifests itself in very varying coverage levels. For example if the High Renewable/High Efficiency Scenario develops, a very significant oversupply of storage capacity relative to demand for storage for seasonal balancing is observed.

Figure 40 Gas storage demand and supply in the South-West region (bcm) – short-term (red = storage supply, green = storage demand)

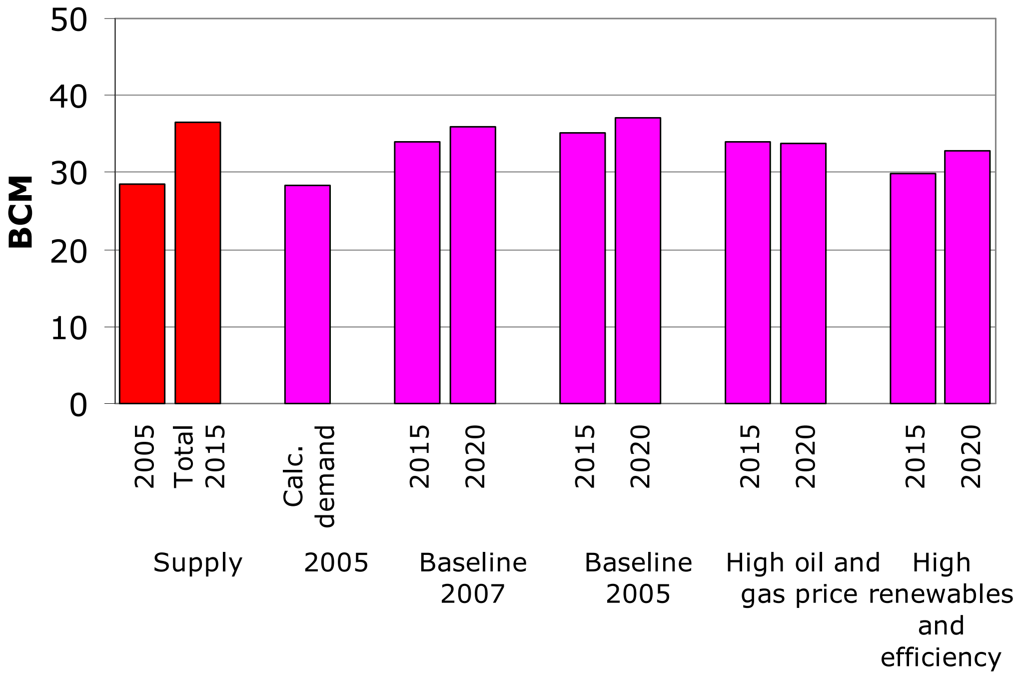


Thus in the short run investments in the south-west region seem adequate to cover the increase in demand for gas storage supply.

The South-East region

In the South-East region, 6.6 bcm of storage capacity has been committed or is already under construction. As Figure 41 shows, the total investment in the region implies a total increase of more than 20% working gas volume; the Italian market is particularly active with regard to investment in storage, with approximately 5 bcm of new storage capacity being installed in Italy. However the situation in the South-East region may result in lack of storage capacity for seasonal balancing unless more projects are converted from being planned to actually being constructed.

Figure 41 Gas storage demand and supply in the South-East region (bcm) – short-term (red = storage supply, pink = storage demand)

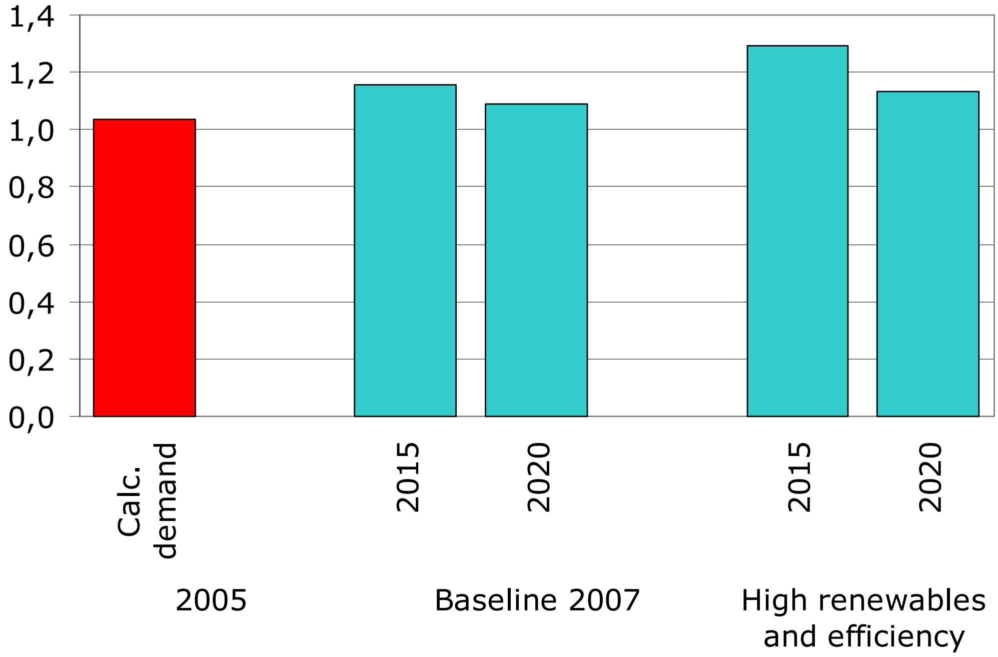


EU total

The figure below illustrates the demand versus supply scenario for the entire EU. In terms of both the 2007 Baseline Scenario as well as the High Renewable/High Efficiency Scenario, the supply of storage capacity is enough to cover the demand for storage for seasonal balancing; i.e. ratio supply/demand for storage for seasonal balancing is increasing.

If no additional storage capacity is built between 2015 and 2020, the available storage capacity will still be sufficient for seasonal balancing in the 2007 Baseline Scenario and also adequate in High Renewable/High Efficiency Scenario.

Figure 42 Gas storage demand versus supply, EU total – short-term (red = situation today, turquoise = calculated future situation)



9.3.2 Summary on short-term scenario

Even though Figure 42 showed that on EU level, the available storage capacity in 2015 and 2020 in short-terms scenario will be enough to cover the demand for storage for seasonal balancing, it is not sure that this will be the case for the specific EU Member States. Also on regional bases, in the 2007 Baseline Scenario , the investments carried out in all three regions would be enough to cover the demand. The supply varied from being 33% above demand in 2015 in the South-West region, 15% above in the Northern region, and 7% above demand in the South-East region.

The South-East region thus is the region which is most vulnerable to cuts in investments. The investments carried out in this region are primarily undertaken in Italy (roughly 5 bcm out of 6.5 bcm or more than 75% of the planned new capacity). If the committed investments in Italy (1.6 bcm) are not taken into account the short term investments would not be able to cover the 2007 Baselines' projected increase in storage demand in 2015.

The degree of coverage was seen to be very dependent on the demand for gas, it some instances overall supply will be higher than demand with up to 25% (the High Renewable/High Efficiency Scenario in 2015). The uncertainty and insecurity in the realization of demand for gas hence affects the overall demand for gas storages in a considerable way. If one wants to improve the investment environment this uncertainty should be minimized, perhaps by clarifying the extent to which the targets of 2020 are expected to be achieved.

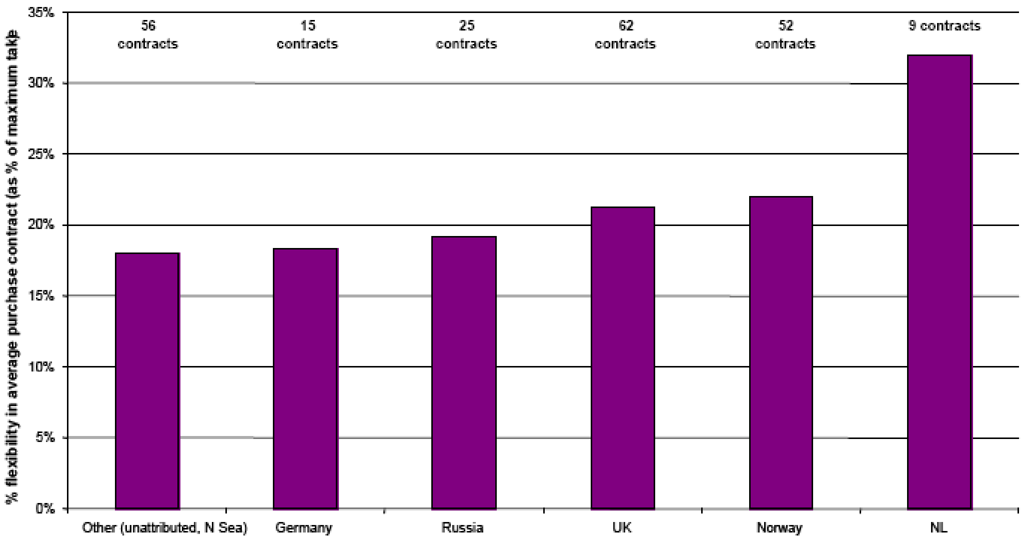
9.4 Increased Norwegian supplies, sensitivity analyses

This section analyses the impact on the gas storage supply/demand for seasonal balancing situation in the Northern region depending on the gas supplies from Norway in the coming years.

In 2006 Norway exported around 60 bcm or approximately 70% of its total export to the Northern region However, Norway is expected to increase the total exports to 125-145 bcm within the next decade. This would mean that the EU, and especially the Northern region, could increase gas imports from Norway considerably.

Gas imported from Norway is to some extent more flexible than from other exporters in terms of swing supply. This is illustrated by the flexibility in the import contracts provided by exporters of natural gas, see Figure 43.

Figure 43 Contract flexibility margins



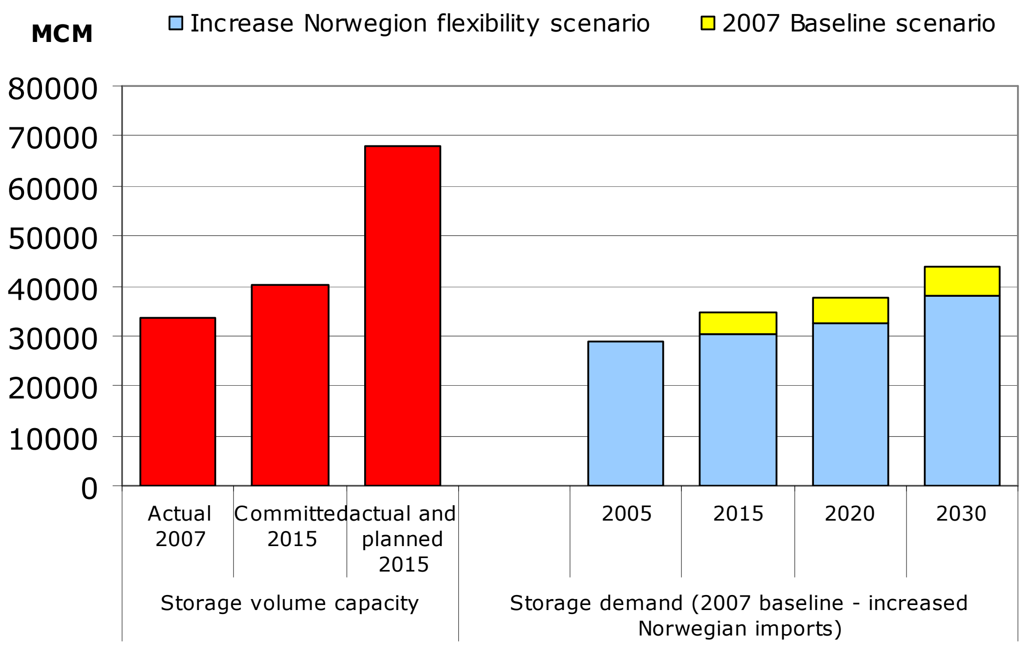
Source: DG competition report on energy sector inquiry 2007

Assuming increased imports from Norway and therefore an increased overall flexibility, i.e. the swing supply in the gas imported into the Northern region from 7.5% to 10%, we investigate the impact on the storage supply/demand for seasonal balancing in the Northern region.

Actual supply swing will depend on the actual amounts of gas etc. Therefore, this analysis mainly serves the purpose to evaluate the sensitivity of the demand for storage capacity in the Northern region in relation the level of supply swing.

The results are shown in Figure 44 , which shows that an overall increase in the import swing supply flexibility from 7.5% to 10% means a decrease in demand for storage for seasonal balancing of approximately 6 bcm working gas volume, i.e. a decrease of roughly 13% (volume).

Figure 44 Gas storage volume demand in case of increased Norwegian imports (Northern region) (red = supply, blue/yellow = demand)



An increase in flexibility due e.g. to increased Norwegian imports would increase the ratio between storage capacity/demand for storage for seasonal balancing both in the long- and the short-term scenarios.

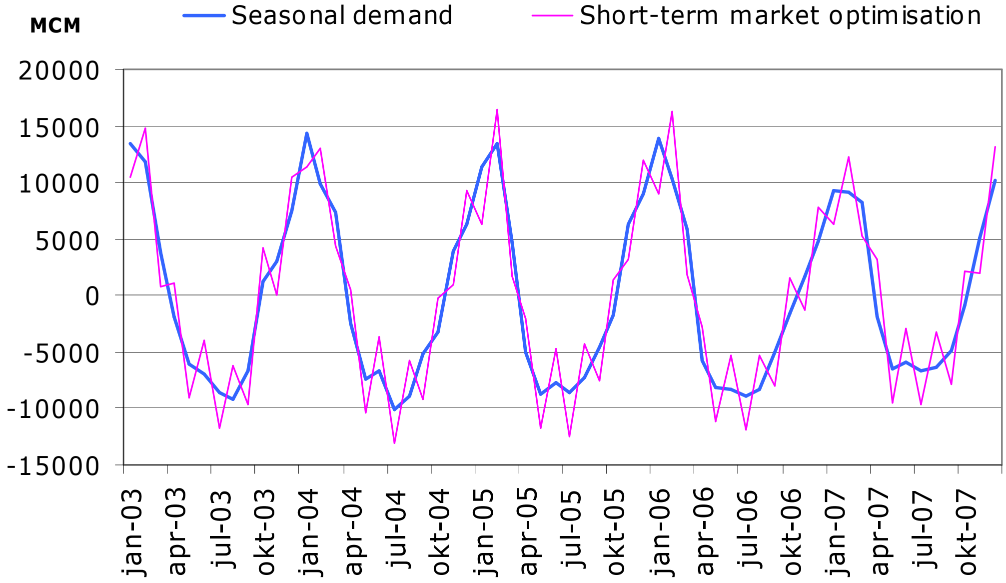
Further, this result also indicates that the level of storage demand in the future could be dependent on which import pipelines are realised, i.e. what strategy the EU will go for in terms of securing supply. Thus, the EU should carefully analyse and consider the flexibility of the import projects that are being constructed in the EU and consider how individual projects may affect the demand for storage.

9.5 Storage demand and supply for high frequency balancing

Increased market integration, could lead to increased demand for storage capacity because opening of the gas market will increase the possibility for market players to take advantage of any arbitrage possibilities that may exist in the market. Unlike seasonal demand, which primarily is a question of volume capacity, demand due to increased market integration requires relatively higher levels of injection and withdrawal capacity compared with seasonal storage; i.e. in order to be able to optimise supply/demand in shorter time intervals storages need not be able to hold more volume but rather to have higher withdrawal and injection rates and to utilise additional cycles of filling and emptying.

The basic idea can be seen in Figure 44 , in which the dark blue line shows the actual injection and withdrawal pattern in EU gas storages – positive stock changes are flows from the storage. It can be seen that the dark blue line follows the normal seasonal withdrawal/injection pattern, i.e. injection during the summer and withdrawal during winter. High-frequency optimisation, i.e. optimisation on a daily basis can be regarded as fine-tuning of the stock level. Short-term optimisation allows gas market agents to utilise the price differences that exist on a day-to-day basis, e.g. agents can sell gas during the five working days when gas prices are usually higher and then refill their storage capacities at the weekend, when prices are usually lower. Thus, at the end of the cycle the gas has been withdrawn and re-injected. This type of behaviour does not require more capacity in terms of volume; it only requires additional injection and withdrawal capacities.

Figure 45 Natural gas stock change (gas flows from EU storages) – high and low frequency demand profiles



Source: Seasonal demand – Eurostat (stock changes), Short-term optimisation is merely an illustration of the concept.

The economic benefits of optimising supply and demand on a short-term basis are currently being analysed by Dr Anne Neumann and Dr Georg Zachmann at the University of Dresden. Unfortunately, results have not been published yet. [35]

However, another study published March 2008 also indicates that when analysing the gas prices at NBP, Zeebrügge and TTF there exist a relatively high arbitrage potential which is not being exploited by market participants at the moment.[36]

Furthermore, Ramboll's own analysis of gas prices at the European gas hubs reveals a substantial trading potential. Estimates show that volatility in gas prices in the UK

[35] www.iaee.org/en/publications/proceedingsabstractpdf.aspx?id=519 -

[36] Stronzik, Rammerstorfer and Neumann (2008): 'Wettbewerb im Markt für Erdgasspeicher'

is relatively high, indicating a significant potential for trade. The average variation in the gas price within a month is 14% in the UK – the higher the level of volatility the higher the scope is for traders to buy gas at a low price, store it, and then sell days later at a higher price. Figures from hubs on the continent are somewhat lower, as the TTF produced a volatility level of around 5%. These figures are only indicative, as liquidity of these hubs is relatively low and the amount of data available is also limited, especially for the continental hubs.

These reservations aside, the analysis of prices on the NBP and the TTF shows that there is a potential for trade. Although the exact scope of this potential is undetermined, it does indicate that as markets integrate, and thus trading opportunities increase, the potential for trading would also increase. Therefore, it can be expected that short-term optimisation using gas storage facilities will increase and thus the demand for high-frequency optimisation and short-term, highly flexible gas storage products will also increase.

A demand for higher levels of flexibility and more flexible storage products would require an increased level of withdrawal and injection rates from storages.

One way to evaluate whether investments in storage are becoming increasingly flexible in terms of higher injection and withdrawal rates may be to look at the type of storages that are planned, as different types of facilities provide different levels of flexibility.

If most investment in storage is directed at relatively more flexible types of storage, i.e. salt caverns and LNG peak-shaving facilities, then this indicates that increased flexibility needs are being signalled to the market and transformed into investment.[37] We will look at investments in storage types for both long-term and short-term scenarios.

9.5.1 High-frequency long-term investments

Salt cavities and LNG peak-shaving facilities are the most flexible types of storage. Therefore, building this type of storage instead of using aquifers or depleted fields will allow investors to provide increased flexibility in terms of higher injection and withdrawal rates.

Figure 46 below shows that only 12% of all available storage capacity (working gas volume) today (2008 figures) is highly flexible storage. Figure 47 shows that 33% of the planned storage capacity (in volume) is of a type that provides higher flexibility, i.e. long-term investments account for an increase in the level of flexibility planned by the market.

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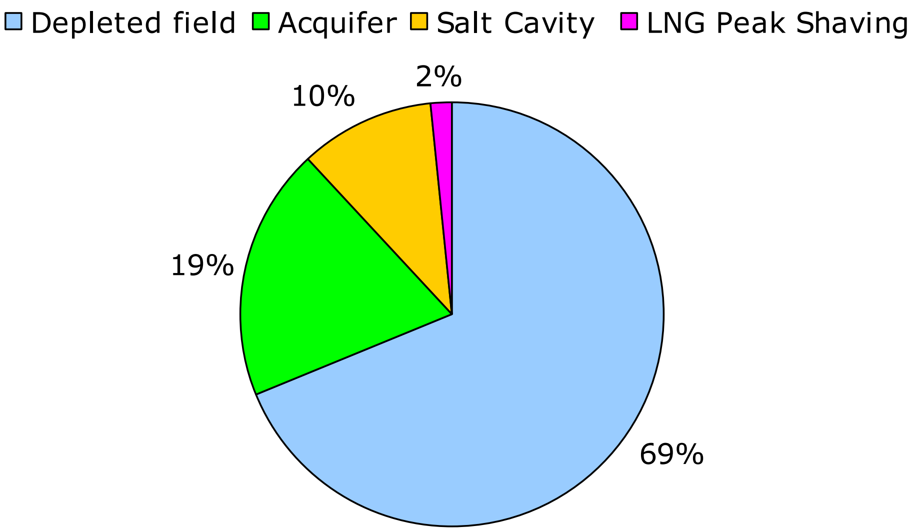
[37] This is, however, not the only possible explanation as it could also indicate that investment cost in the storage types have decreased relatively to depleted fields and aquifers.

Today (2008), there is around 7.9 bcm of salt cavity storages, plus 1.15 bcm of peak-shaving LNG storages; i.e. approximately 9.1 bcm of highly flexible gas storage are available.

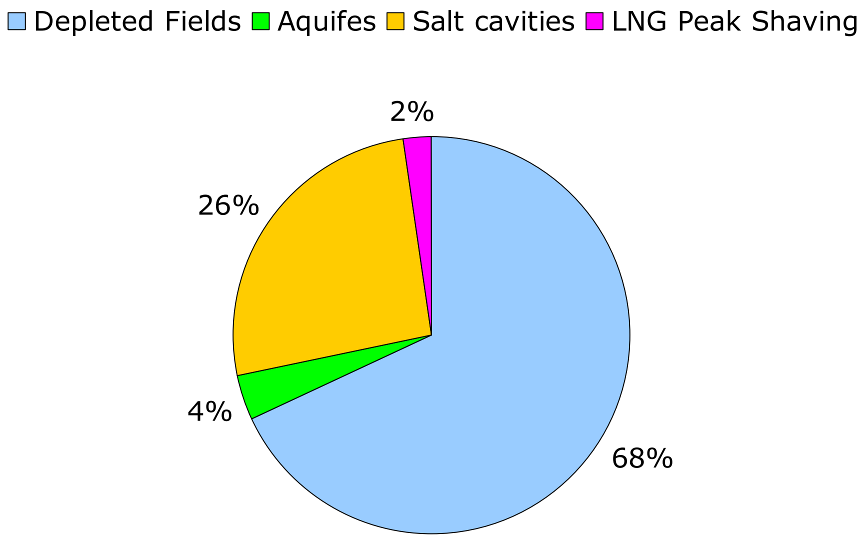
Figure 46 Shares of existing types of storages based on volume capacity



Source: GSE

Of the planned 58 bcm capacity investments in gas storage, around 15 bcm is working gas in salt cavities and 1.3 bcm is working gas of LNG peak-shaving facilities.

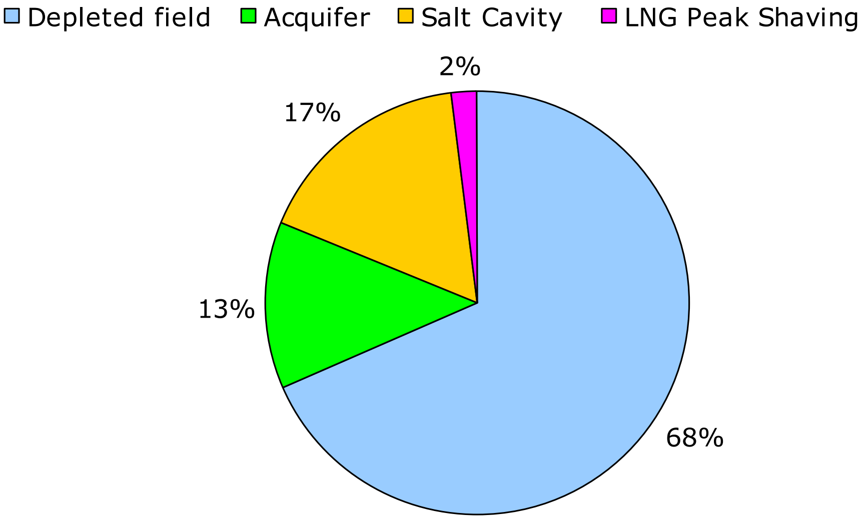
Figure 47 Investments in storage, all investments (long term)



Source: GSE

This increased investment in more flexible storage will change the share of highly flexible storages from around 12% to 19% in 2015 (working gas volume).

Figure 48 Shares of storages by type in 2015 (actual plus planned investments)



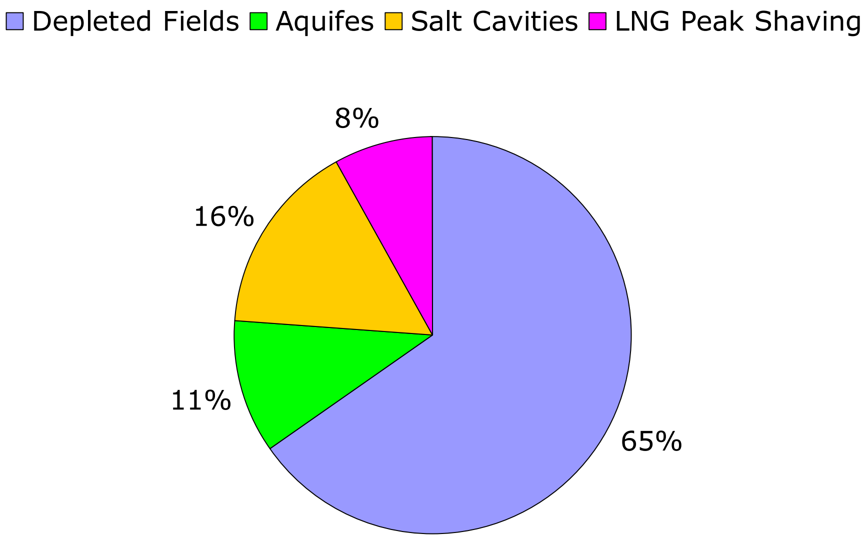
Source: GSE

Thus in the long run the type of the planned investments indicates that the flexibility of the storage available will increase.

9.5.2 High frequency short-term investments

If we look at only the investments that are under construction or committed, as shown in Figure 49, we see an even higher share of investment in highly flexible storage.

Figure 49 Investments in storage committed and under construction (short-term)



Source: GSE

The distribution of investments committed to and under construction seems distinctively different from the distribution of existing storages. About 24% of the capacity invested is invested into high flexibility storages.

The above analysis indicates that withdrawal capacity will increase relatively more than volume due to the fact that the types of storages built are more flexible.

9.6 Summary and conclusions on demand and supply for storage for seasonal balancing

The storage situation was evaluated for two different gas storage supply scenarios to account for the uncertainty of actual realization of investments and four different gas demand scenarios to account for the uncertainty related to gas demand in the future and the corresponding uncertainty of demand for storage for seasonal balancing. Furthermore, an analysis of the impact of Norwegian imports was done for the Northern region, as sensitivity analyses to investigate the impact of a more flexible import to the storage supply/demand ratio.

All demand scenarios showed an increasing gas demand and thereby increasing demand for storage for seasonal balancing both on EU level and on regional level.

In the short-term supply scenario, the gas storage capacity in the Northern region is 15% above the demand for storage for seasonal balancing in 2015. In the South-West region, 33% and in the South-East region 4%, It can be observed that most investment activity in this region is planned in Italy, this is however also the place were demand for gas according to PRIMES data is set to increase the most (32% from 2005-2015).

The fact that investments are being undertaken and that these investments keep up with the demand for storage, shows that market operators are adjusting their supply to the actual need.

The long-term scenario showed that if all planned investments were realised the supply of gas storage would increase significantly and by much more than demand. However, as the total planned capacity is approximate 73% (58/79) of the current capacity, it is highly questionable whether all these investments would take place.

The results obtained in the regional analysis on demand and supply for storage have been summarised in the following table.

Table 7 Results obtained from the model analysis

Region	**Storage supply**			**Calculated demand**												
				2005	**Baseline 2007**			**Baseline 2005**			**Soaring oil and gas prices**			**High renewables and efficiency**		
bcm	Today	Short-term 2015	Long-term 2015	2005	2015	2020	2030	2015	2020	2030	2015	2020	2030	2015	2020	2030
North	**34**	**40**	**68**	**29**	**35**	**38**	**44**	**42**	**47**	**48**	**38**	**38**	**37**	**33**	**39**	**34**
South-West	**15**	**22**	**23**	**15**	**17**	**17**	**17**	**16**	**16**	**17**	**15**	**15**	**15**	**14**	**15**	**13**
South-East	**30**	**36**	**46**	**28**	**34**	**36**	**39**	**35**	**37**	**38**	**34**	**34**	**33**	**30**	**33**	**29**

When evaluating the short term 2015 supply, which is the most certain supply scenario, with the latest demand update (Baseline 2007 Scenario), we see that supply is able to cover demand for seasonal balancing in both 2015 and 2020 in all regions. Supply exceeds demand by 14-15% in the North, 33% in the South West, while the balance is much tighter in the South East. This is evidence of that market players in the short term do supply the storage capacity demand.

In the long term supply covers demand in all scenarios and in all regions. Thus the overall conclusion to be made from the analysis on seasonal storage demand and supply is that the market responds to the signals for long-term gas consumption. Thus the market develops for the possibility that gas consumption could be as high as indicated in the most optimistic forecasts. This seems to be a sound judgment to do so because investments in gas infrastructure can have very long lead times, i.e.

the implementation period of projects are very long. These investment plans are then modified according to the actual demand. This can be seen from the fact that overall the investments already under construction or committed were in line with the short-term gas demand.

With regard to the sensitivity of the results we investigated how changes in the import flexibility and uncertainty of gas consumption affected the results of the model.

If gas imports were to be obtained from relatively flexible import sources, such as e.g. Norwegian fields, it would entail a lower demand for storage in 2030 of around 5.7 bcm in the Northern region, which is equivalent to a 13% lower demand for storage. This means that the demand for storage is very sensitive to changes in the flexibility of imports in the future.

As the analysis of the various scenarios showed, demand for natural gas storage varies considerably depending on the "chosen" scenario i.e. overall gas consumption, i.e. in 2015 gas storage demand varies by 10 bcm between the 2007 Baseline and the High Renewable/High Efficiency Scenario. In 2030 demand for natural gas storage varies by more than 25 bcm in the four scenarios analysed.

A considerable level of uncertainty as our analysis shows, in terms of the demand for natural gas storage, increases the risk of storage investments significantly. This will inevitably have an impact on the investment decisions made by the market players e.g. a high level of uncertainty may postpone the investment decision of investors, which could lead to supply of storage not meeting the demand in the short run. A postponement of investments is very critical in a market which is expected to just barely balance in terms of supply and demand.

In order to reduce risk, as well as the effects of an increase in the level of risk, we recommend that the gas storage investment climate is harboured and strengthened best possibly, allowing for market players to have as much information as possible and to reduce the level of risk as much as possible. This will allow market players to base their investment decisions on the best grounds possible and thus help to ensure that the necessary investments in gas storages are made. Focus should be on ensuring a functioning gas market i.e. ensuring transparency in the market, reducing regulative uncertainties etc.

Further, as was shown in analysis of the scenarios, gas demand in the EU is very sensible to political decisions, i.e. the implementation as well as the exact design of the climate package, may have a large impact on overall gas consumption and thus on the demand for natural gas storage.

Obviously the market is responding to demand. It would not take much of these capacity to be locked for strategic storage before there will be lack of capacity for seasonal balancing.

10. Peak-day demand and security of supply

In the previous section we analysed the supply and demand balance for different scenarios. In this section we investigate the capability of the storages within the EU to meet demand on days with extraordinarily high demand and in the events of a possible supply disruption.

10.1 Withdrawal capacity restrictions

By aggregating the withdrawal capacities of the storages we get an estimate of the total withdrawal capacities. It should be noted that the withdrawal capacity listed is the maximum technical withdrawal capacity. The actual withdrawal capacity depends on the pressure in the storage, i.e. how much gas is in the storage. Hence, withdrawal rates are decreasing the emptier the storage becomes. Furthermore, withdrawal rates also depend on the pressure level in the transmission system to which the storage is connected. This means that although it is technically possible to withdraw approximately 1.6 bcm per day from storages[38] this figure can be restricted due to the above-mentioned factors. Thus the figure of 1.6 bcm is to be considered as a technical maximum only.

The restriction can be exemplified by looking at the Danish transmission system where the two storages each are listed to have approximately 8 mcm/day of withdrawal capacity. The Danish transmission system is, however, not able to comply with this and in reality the withdrawal capacity is lower.

In order to account for this restriction the analysis performed for peak-day supply will include a limited scenario where the withdrawal capacity is listed as 1.04 bcm per day. This restricted capacity is based on the GTE winter outlook 2008. Throughout this section we evaluate on the basis of the GTE storage withdrawal capacity and only use the maximal capacity of 1.6 as a benchmark.

10.2 Peak-day analysis

In order to evaluate whether storage will be able to not only meet annual demand (analysed earlier) but also peak daily demand, we take a look at the peak supply and demand capacities. In the peak-day analysis we chose to look at summer and winter separately. In Table 8 peak daily supply and demand for winter are displayed. The table relies on the following assumptions about demand and supply:

- Consumption average peak is based on the average daily consumption in January 2006.
- Peak daily consumption, normal and exceptional, are based on data from the GTE winter outlook 2008.
- Pipeline capacity as well as LNG import terminal capacity for 2008 is based on data from the GTE winter outlook 2008
- The increase in import capacity is based on the assumption that import capacity has to increase in order to counter the decreasing indigenous production. It is

[38] GSE

assumed that import pipeline capacity increases by 33%, in total. This increase equals the estimated increase that is needed in order to bridge the gap in supplies caused by the decrease in indigenous production.

- Indigenous production capacity is based on the average peak month supply data from Eurostat.[39] This estimate is in line with the estimates of GTE.
- We also investigate how the situation is in the 2015 short and long-term scenarios. The total peak withdrawal rate amounts to 2.11 bcm and 2.84 bcm, respectively. These withdrawal capacities should be adjusted due to possible withdrawal restrictions; we do this by assuming that the relationship between the limited GTE Winter Outlook withdrawal rate and the aggregated GSE withdrawal rates prevails in 2015. Thus the capacity estimates should be reduced accordingly, which is by approximately 35%[40]; this yields a peak storage withdrawal rate of 1.35 bcm and 1.82 bcm for the 2015 short and long-term, respectively.

10.2.1 Winter

First we take a look at the peak day supply/demand situation during winter, which due to the high demand for natural gas for heating purposes is the time where the gas market is most vulnerable to a disruption in supplies.

[39] The analysis does not consider EU internal bottlenecks

[40] 1 - (1.04/1.615)

Table 8 Peak day consumption and daily supply capacities, winter (bcm)[41]

	2008 (Max. capacity)	**2008 (Lim. capacity)**	**2015 Short-term (Lim. capacity)**	**2015 Long-term (Lim. capacity)**
Daily supply capacities[42]				
Import pipeline + LNG	1.49	1.49	1.98	1.98
Indigenous production[43]	0.81	0.81	0.43	0.43
Storage[44]	1.62	1.04	1.35	1.82
Total supply	**3.91**	**3.33**	**3.76**	**4.23**
Total daily gas demand				
Average	2.36	2.36	2.70	2.70
Normal [45]	2.46	2.46	2.82	2.82
Exceptional	3.07	3.07	3.52	3.52
Total gas supply/demand				
Average	1.66	1.41	1.39	1.57
Normal	1.59	1.35	1.33	1.50
Exceptional	1.27	1.08	1.07	1.20
Storage gas supply/demand				
Average	0.68	0.44	0.50	0.67
Normal	0.66	0.42	0.48	0.65
Exceptional	0.53	0.34	0.38	0.52

By analysing the above table it can be seen that the total supply capacity is above the peak demand for gas. The supply demand ratio is ranging from 1.07 in the 2008 short-term scenario with exceptional peak demand, to 1.57 in the 2015 limited capacity with average peak demand. Evaluated against the short term scenario, peak day capacity demand increases slightly more than peak day supply in 2015 compared to 2007, thus we have a small decline in the Total gas supply/demand ratio. However, it should be pointed out here, that the decrease in only minor and further that supply is still above demand.

When evaluating the development in terms of security of supply, i.e. the share of total consumption which could be covered by storage, it is noticeable that this ratio is practically constant in the short term and increasing in the long term, i.e. in the 2008 limited capacity scenario the rate varies from 0.34 to 0.44 and in the 2015 short-term scenario this range has only slightly improved and is between 0.38 and 0.50. Finally, in the 2015 long-term scenario the ratio is from 0.52 to 0.67.

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[41] 2015 gas consumption is based on 2020 consumption figures thus the analysis evaluates consumption in 2020

[42] Conversion factor from GWh to mcm used is 11.11

[43] Source: GTE Winter outlook 2007 and Eurostat

[44] Own calculations and GTE Winter outlook 2007

[45] GTE Winter Outlook 2007

This means that in the event of a supply disruption occurring today storages would be able to cover between 34% and 44% of the total daily gas demand if the supply interruption depended on the demand scenario.

10.2.2 Summer

The table below shows the peak demand/supply situation for an average peak summer demand, i.e. demand has been estimated by dividing the peak summer month consumption in the EU when looking at data from 2005 to 2007.

Table 9 Peak day consumption and daily supply capacities. Summer (bcm)

	2008 Max. capacity	**2008 Lim. capacity**	**2015 Short-term**	**2015 Long-term**
Daily supply capacities				
Import pipeline + LNG	1.49	1.49	1.98	1.98
Indigenous production	0.81	0.81	0.43	0.43
Storage	1.62	1.04	1.35	1.82
Total supply	**3.91**	**3.33**	**3.76**	**4.23**
Daily demand				
Average peak	1.37	1.37	1.57	1.57
Supply demand ratios				
Total supply / Average peak	2.85	2.43	2.40	2.70
Storage capacity/ Average peak	1.18	0.76	0.86	1.16
Capacity without storage / Average peak	1.68	1.68	1.54	1.54

It can be seen that during summer, the total supply capacity can easily satisfy the daily demand. Excluding storage from the supply does not alter this picture.

As can be seen in Table 9 the share of total capacity that goes to consumption increases in the 2015 scenarios, this is due to the decrease in indigenous production. At the same time the overall storage capacity increases counter the fall in domestic production capacity.

During summertime a supply interruption in 2015 constituting around 35% of all consumption in a high-demand summer month could be dealt with by not using any gas for injection into storage facilities ((1.98+0.43-1.57)/(1.98+0.43)). In terms of capacity this equals a supply interruption in the amount of 0.84 bcm (1.98+0.43-1.57).

10.3 Supply interruption scenario

Table 8 analyses the implications of supply disruptions based on the GTE Winter outlook data. The largest single foreign gas supplier is Russia. If we imagine that all supplies from Russia were to be cut of on a very cold day[46] then this would reduce

[46] This scenario is only evaluated in order to create a benchmark

imports by up to 0.63 bcm of gas[47] on a daily basis. This is more than half the total import capacity from pipelines that would be cut off. Table 10 below illustrates how such an interruption to pipeline import affects the supply demand relationship. The figures in the below table have been calculated the following way peak consumption data divided by total supply which in the event of a supply interruption will be reduced by 0.63 bcm thus total supply in the 2007 limited scenario will be (1.49–0.63+0.81+1.04).

Table 10 Total supply compared to different levels of demand in case of a Russian interruption

Total supply/demand	**2008 (Max. capacity)**	**2008 (Lim. capacity)**
Average	1.39	1.15
Normal	1.33	1.10
Exceptional	1.07	0.88

If it is assumed that the peak withdrawal rate of storages is unrestricted then supply is just able to satisfy demand. In the more realistic case where storages are constrained we see that the peak daily supply capacity is sufficient in order to bridge the gap in supply, in the average and normal demand situation, but falls short by approximately 0.12% points, in the exceptional peak demand case.

The above analysis assumes that it would be possible to run all import pipelines and all LNG terminals at full capacity in such an event[48]. This is however unlikely to be realistic, as a major supply interruption could lead to an increased demand for LNG all over the world. Further assuming 100% utilisation of all other import pipelines may not be realistic, although on a monthly basis utilisation rates of overall import pipelines in the EU run as high as 92% indicating that on a daily basis close to a 100% could be possible.

In terms of LNG import average utilisation of LNG terminal capacity is fairly low in the EU. However, in an emergency situation it is not impossible that some LNG ships would be redirected towards Europe and thus increasing the utilisation rate during the supply interruption.

10.4 Storages ability to provide security of supply

In the event of a supply interruption, on a winter day with an exceptionally large demand, storages would be able to cover between 34% and 44% of all gas supplies[49]. This level of supply security is slightly improved when analysing the investments in storage facilities, which are already under construction or have been committed. When evaluating against all planned investments the share of total consumption, which storages are able to cover, grows to between 52% and 67%.

[47] Gas Infrastructure Europe (GIE) and own calculations

[48] On the other hand we also assume that the supply interruption implies an interruption of 100% of capacity

[49] Table 8

This increase is due to the EU increased reliance on storages to provide flexibility as indigenous production is decreasing

This analysis has been made using the consumption forecasts made by the 2007 baseline scenario for the year 2020 which is 4%-points higher in 2020 than in 2015. This puts the results attained in the above analysis on the conservative side, i.e. they could underestimate the actual level of security of supply in 2015, because a higher level of consumption has been used.

10.5 Security of supply and households

If we evaluate the results attained based not on total consumption but on household consumption, then we obtain an even higher level of security of supply. Households and service make up for approximately 40% of all gas consumption in the EU[50]. In some countries the share of households and services reaches more than 50%, e.g. France with a share of 56% in 2006 and Germany and Hungary with a share of 51%. During winter the actual share could be higher because households mainly use gas for heating purposes. Assuming that households during peak winter consume as much as 60% of all gas in the EU, this reduces gas demand by approximately 1.23 bcm in 2008, in the exceptional peak scenario, increasing to 1.41 bcm in 2015.

Table 11 shows the level of security of supply provided by storage and indigenous production, i.e. security of supply in the event of an external supply interruption. It is shown by evaluating the share of household consumption which can be supplied by storage facilities and indigenous production. This is done for the short and long-term scenarios and for both full and limited storage withdrawal capacities.

Table 11 Storage and security of supply, household consumption

	2008 (Max. capacity)	**2008 (Lim. capacity)**	**2015 Short-term (Lim. capacity)**	**2015 Long-term (Lim. capacity)**
Supply				
Storage and indigenous production	2.42	1.84	1.78	2.25
Household demand				
Average	1.42	1.42	1.62	1.62
Normal	1.48	1.48	1.69	1.69
Exceptional	1.84	1.84	2.11	2.11
Supply[51]/demand ratio[52]				
Average demand	1.71	1.30	1.10	1.39
Normal demand	1.64	1.25	1.05	1.33
Exceptional demand	1.31	1.00	0.84	1.07

[50] Source: Eurostat

The table shows that in the worst case scenario the EU will only be able to provide 84% of household consumption (exceptional demand scenario in 2015 short-term limited capacity) and in the best case scenario (2007 limited capacity) the EU has 30% of 'spare' capacity. It should be noted that these numbers only show how much of peak demand the EU can cover by the means available inside the EU.

10.6 Summary and conclusion on peak-day analysis

We analysed supply and demand on peak days. Estimates on peak import, peak indigenous production, peak storage deliverability and peak consumption were obtained from GTE, GIE, GSE and Eurostat. It was found that in the daily operations peak demand could be satisfied by the prevailing supply sources. When evaluated against household consumption only we had that although the supply/demand ratio was set to decrease it would only be in the event of exceptional high demand in 2015 that indigenous production plus storage would not be able to supply all households, that is it would take a complete interruption of all imports combined with exceptional high demand before we would have a situation were some households would not be able to be supplied.

Further, calculations showed that although peak day capacity demand is set to increase by slightly more than peak day supply, we have that supply is still above demand. Thus the developments in it peak day capacity should be sufficient in terms of everyday peak demand, for all demand scenarios, i.e. average, normal and exceptional.

In terms of security of supply in a situation with an interruption in imports from Russia, it was found that only in the average peak demand scenario would the supply be able to accommodate a shut-down in gas from Russia, it should be kept in mind though, that this implies both exceptionally high demand and a complete interruption in Russian imports, before this would become a real problem.

10.7 Storage capacity and consumption

One thing is to consider the capacity as above, another is to evaluate the actual volumes of gas available and thus for how long the EU would be able to withstand a supply interruption. The next sections will take a look at for how long the storages can provide security of supply, i.e. how much gas can potentially be supplied in the case of a supply interruption.

10.7.1 Overall level of storage volume compared to level of consumption

One indicator of the security of supply level is how much storage volume capacity exists compared to consumption.

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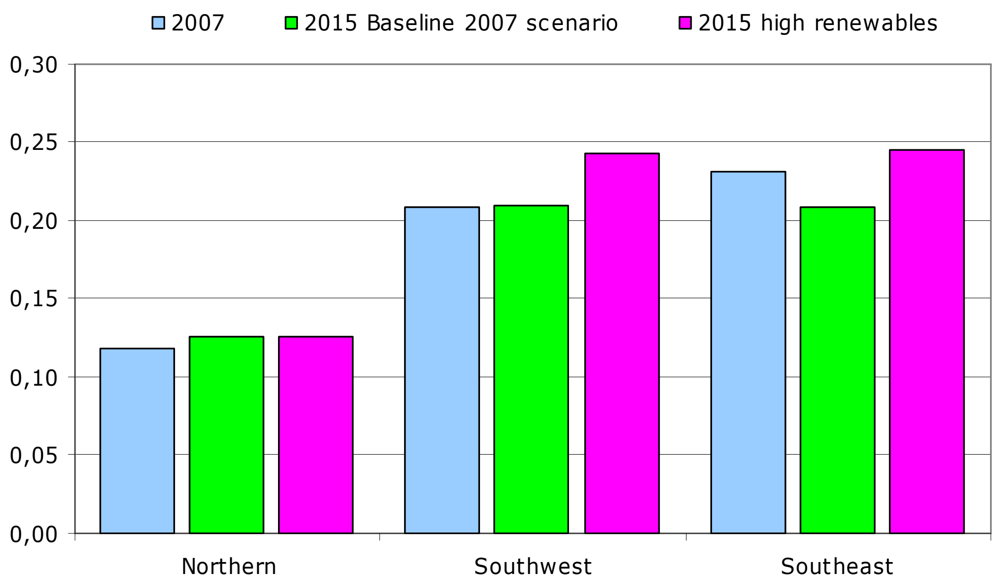
[51] Storage and indigenous production

[52] Households

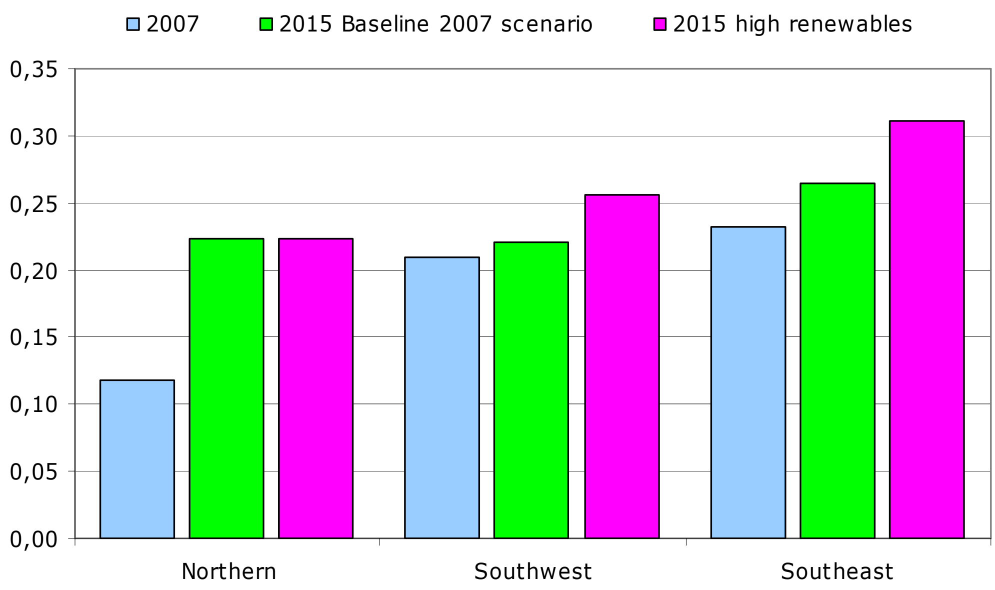
Figure 50 Storage to consumption ratio - short-term scenario



It can be seen from Figure 50 that in the short-term scenario the amount of storage capacity per unit of consumption increases only slightly in the Northern region from approximately 0.12 to 0.13 in both the 2007 baseline scenario as well as the high renewables scenario. In the two southern regions the overall level of storage volume per unit of consumption is considerably higher. This is due to the fact that the Northern region has relied much more on flexibility from indigenous production compared to the two southern regions. Further, it is noticeable that the ratio is set to decrease in the South- East region from approximately 0.23 to 0.21 in the baseline 2007 scenario.

Looking at the storage to consumption ratio in the long run, i.e. including all planned investments, Figure 51, improves the picture for all scenarios. Especially the Northern region improves its ratio by relatively much from 0.12 to 0.22, i.e. approximately an increase of more than 80%. This is due to the shift in flexibility supply from indigenous production to storage.

Figure 51 Storage to consumption ratio - Long-term scenario



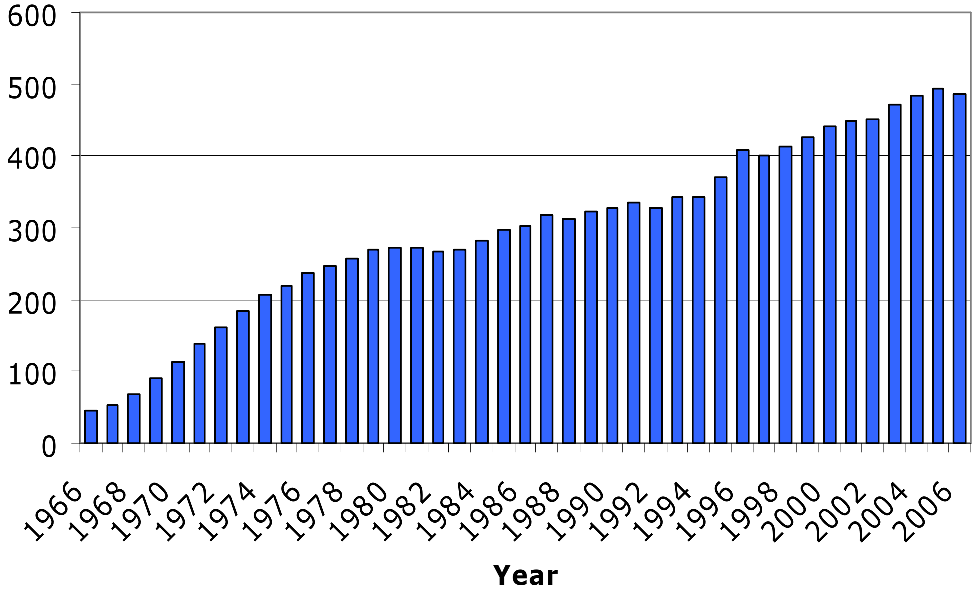
11. Cold winter analysis

This section analyses the capability of the gas market to provide the necessary gas supply during an exceptionally cold winter. If the EU experiences an extraordinarily cold winter then the market will require additional gas in order to accommodate this increased demand. The increase in demand during a cold winter can in principal be accommodated by increasing any of the three existing supply alternatives indigenous production, imports and supply from storages. However, as gas imports pipelines are often utilised close to 100% during winter months, imports are most likely not able to increase supplies. Indigenous production may be increased but as indigenous production is decreasing overall in the EU the share of demand that can be meet by an increase in indigenous production is also decreasing, this entails that the role of storages are possibly becoming increasingly important for supplying additional gas during very cold winters and therefore the importance of having adequate storage capacity is increasing. This section analyses the impact on storage demand in the event of a very cold winter.

11.1 Demand in a cold winter

The below figure showing gas consumption shows a clear increasing trend in gas consumption but some years seem to stand out e.g. 1996 which was a particular cold winter.

Figure 52 Gas consumption in the EU



Source: BP Statistical Review of World Energy June 2008

As actual data on how much gas consumption increases in cold years is not available, an estimate has been calculated based on the consumption data from the last 25 years. Estimates indicate that the biggest increase, not including the normal growth in gas consumption, in one year was approximately 6%. The cold winter which increased gas consumption occurred in 1996. However, in order to account for the uncertainty related to the calculations and because it is not obvious that an even colder winter could not occur, the analysis performed is based on an increase in consumption of 8%. Further the potential increase in indigenous production has been estimated to be approximately 7.5% based on the actual increase in indigenous production in 1996. The potential increase in indigenous production, is not a shift away from the overall trend of decreasing indigenous production in the EU, but merely an assumption that there is some flexibility in indigenous production on a year-to-year basis, e.g. the Groningen filed is restrained by a production cap this cap could be lifted in the event of a supply interruption, and thus increase indigenous production short term.

Swing consumption is kept fixed at the same level. This may at first seem questionable, as it could be expected that in a cold winter consumption would only increase in winter time thus we would expect swing ratios to increase. However in order to allow for an objective sensitivity analyses and comparison with the results of the “normal winter” scenarios presented previously, we assume that swing ratios are constant. This assumption is also in line with data from the cold winter in 1996. However we have to keep in mind that the results attained from the analysis are based on this assumption and thus result could underestimate the actual demand for storage in a cold winter.

Table 12 Cold winter storage demand, baseline 2007, bcm

2005		2015				2020				2030			
	Increase in demand (cold winter)	**Demand (normal)**	**Cold year**	**Increase in demand (cold winter)**	**Increase in %**	**Demand (normal)**	**Cold year**	**Increase in demand (cold winter)**	**Increase in %**	**Demand (normal)**	**Cold year**	**Increase in demand (cold winter)**	**Increase in %**
North	2.7	31.1	37.6	2.9	8.3	37.6	40.7	3.1	8.2	43.8	47.4	3.6	8.1
South-west	1.2	15.1	17.9	1.3	8.0	17.0	18.4	1.4	8.0	17.4	18.8	1.4	8.0
South-east	2.3	28.4	36.7	2.7	8.0	36.0	38.9	2.9	8.0	38.9	42.0	3.1	8.0
Total	**6.2**	**74.6**	**92.2**	**6.9**	**8.1**	**90.6**	**98.0**	**7.3**	**8.1**	**100.1**	**108.2**	**8.1**	**8.1**

11.2 Results from the cold winter analysis

Results have been attained using the model presented previously in Section 1 . As can be seen from Table 12 that a very cold year increasing gas demand by 8% would result in a total extra storage demand of 6.2 bcm in 2005 compared to a normal year. This figure increases to 6.9 bcm in 2015, 7.3 bcm in 2020 and 8.1 bcm in 2030. It is also noticeable that the figure it relatively constant when evaluating in all years 2015, 2020 and 2030.

Further analysis has shown that a 1% increase in consumption due to a very cold winter entails a 1% increase in gas storage demand.[53]

11.3 Summary and conclusion

When evaluating gas storage demand and supply in the light of a cold winter we see that the demand for storage increases in the event of a cold winter. A cold winter will require more storage capacity in order to supply the additional gas demand. Today (2005) will require 6.2 bcm more storage capacity in the event of a cold winter this figure will increase by approximately 30% to 8.1 bcm in 2030. However this increase in storage needed for cold winter supply is in line with the overall demand for storage which is also set to increase by approximately 30%. However it is important to consider that a growing gas demand, and a decreasing indigenous production, also raises the demand for storage capacity in cold years.

[53] Based on a fixed level of 7.5% increase in indigenous production

Even though we assumed constant ratios for swing we still have that the demand for gas storage is relatively fixed compared to the overall demand for storage that is a increase in consumption due to a cold winter will require relatively the same no matter whether we look at 2005 or 2030 i.e. an increase in consumption of 8% requires approximately 8% more storage today as well as in the future.

Overall this entails that the findings related to storage availability do not change when comparing the situation in 2030 with the situation today if the adequacy ratio is approximately the same in those years the gas markets ability to cope with a cold winter will be the same.

SECTION 2 AVAILABILITY OF GAS STORAGE ALONG THE MAIN SUPPLY ROUTE – THE UKRAINE

With an increasing amount of gas having to be imported to the EU[54] the technical reliability of the transmission infrastructure and the availability of gas storage facilities, both in technical and operational/accessibility terms along the main supply routes becomes a significant parameter in ensuring security of supply to the European gas markets.

With approximately 40%[55] of the gas imported to the EU coming from Russia and up to 80%[56] of these flows being transported through the Ukraine, the Ukraine is the main gas supply route to the EU at present.

This section tries to give an overview of the gas infrastructure used for transit of gas through the Ukraine as well as to reflect on the Ukrainian gas market in terms of transparency and accessibility.

12. The Ukrainian gas transmission infrastructure and flows

An overview of the Ukrainian gas transmission infrastructure and flows is given in the following.

12.1 Supply routes through the Ukraine

The Russian gas transported to Europe through the Ukraine moves along three main pipeline corridors, as illustrated in Figure 53.

1. The central corridor begins at the Urengoy gas field in western Siberia, crosses the Russian–Ukrainian border just north of Sumy and traverses the country in a westward direction. The pipeline brings gas to the Uzhgorod compressor station on the Ukrainian border with Slovakia and to smaller compressor stations on the Hungarian and Romanian borders. Another parallel pipeline (the Progress pipeline), which originates from the Yamburg gas field in western Siberia, is included in this corridor.

2. The pipelines from Briansk and Tula (the Bratstvo lines) bring gas to Kiev and then join the main westward system.

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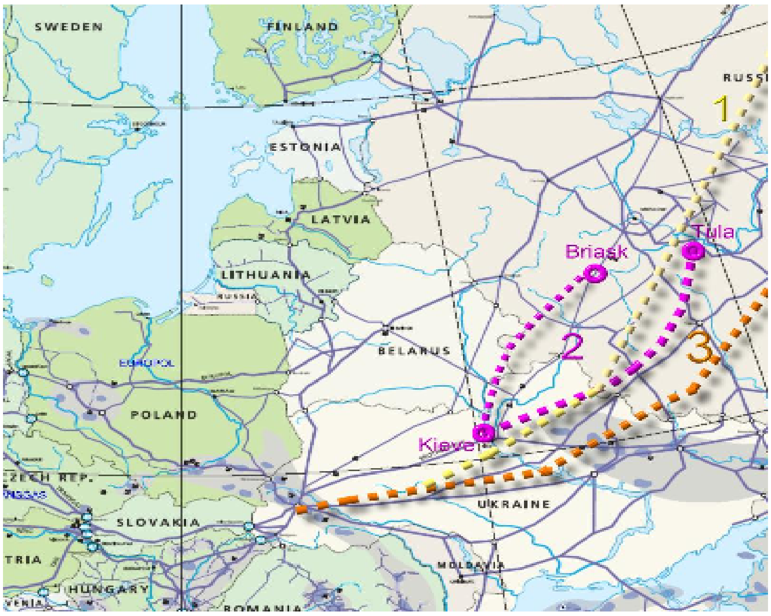
[54] Eurogas estimates 60% in 2015 and 74% in 2030 of the total gas supply to Europe will be imported /21/

[55] 42% in 2006, based on data from Eurostat

[56] reference

3. The pipeline from the Orenburg gas field in the Urals (the Soyuz pipeline) and other lines from the Russian–Kazakh border enter the Ukraine east of Novopskov and run westward to Uzhgorod.

Figure 53 Main supply corridors of Russian gas to the EU via the Ukraine



In addition, there are pipelines that bring Russian gas across southeast Belarus to the Ukrainian border to join the main pipeline system. There is also a pipeline system that crosses the Ukraine from northeast to south, part of which traverses Moldova, taking gas to Romania, the Balkans and Turkey.

12.2 The transmission system

The Ukrainian transmission system is presented in Figure 54, and system specifications are shown in Table 13.

Figure 54 The Ukrainian transmission system

Source: www.gasunion.org.ua

Table 13 Lengths of transmission pipelines and installed compression capacity, Ukraine

TRANSMISSION PIPELINES	**LENGTH, 1,000 km**	
	High-pressure mains (large diameter 40"-56")	22.2 (13.8)
	Branch lines	14.6
	Total	36.8
	DESIGN CAPACITY, bcm/year	
	Input	288
	Export capacity	178
	Export capacity to Europe	142
COMPRESSOR STATIONS	**UNITS**	
	Sub-stations	71 (108)
	Sets	692
	POWER, MW	
	Total	5380

As the table shows, the Ukrainian gas transmission system consists of more than 20,000 km of gas transmission mains, of which approximately 13,800 km are large-diameter pipelines (40"-56") and 15,000 km are branch lines. There are more than 1,400 off-take points to distribution networks.

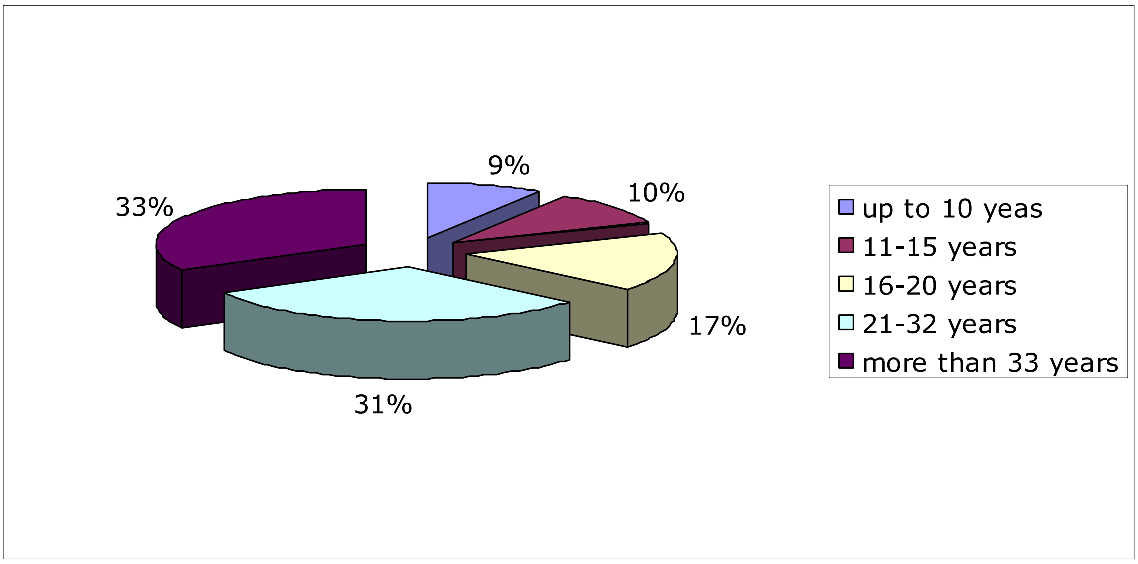
The installed power of the more than 600 compressors is 5380 MW.

Most of the facilities on the transit main pipes[57] are equipped with the SCADA system: compressor stations, gas measuring stations, gas distributing stations, underground storages gathering data in real time. From all other facilities of the gas transmission system data from the dispatchers is delivered every two hours, mainly through switchboard channels and partially through satellites and fibre-optic channels.

The age of the pipes is presented in Figure 55. One-third of the pipes are more than 33 years old, and another one-third is between 20 and 30 years old; i.e. older than the designed technical life of the pipes. This indicates that the Ukrainian gas transmission system may require significant investment in maintenance and replacement/repair.

In late 2006, Naftogaz announced a modernisation programme, projected to cost 4.6 BUSD that it does not have.

Figure 55 Age of pipes in the Ukrainian gas transmission system



Source: Based on data from Ukrtransgaz

In spite of the age of the pipes, Ukrtransgaz claims that the operating pressure is close to the design pressure of 55-75 bar and that there are no bottlenecks in the system.

12.2.1 Condition of the transmission system

To assess the actual condition and the available capacity of a system that was commissioned mainly in the 1960s requires a dedicated pipeline integrity study. Apart from the technical standards under which the infrastructure was established,

[57] The system does not have dedicated transit pipelines i.e. pipe routes that are closed for offtake by Ukrainian consumers

its condition depends to a high extent on the degree of maintenance. There are some indications[58] that in-line inspection of main trunk pipelines has been completed. However, the results of these studies are not available to the public.

Having said the above, we can present a few conclusions that may indicate the condition of the transmission infrastructure in the Ukraine. These conclusions are based on experience with pipe-integrity studies in a few countries of the former Soviet Union, undertaken by the Danish company, Balslev (some in cooperation with Ramboll).

The main conclusions can be summarised as follows (for a full list of technical conclusions see memo prepared by Balslev, enclosed as ANNEX 4 CONDITION OF THE GAS TRANSMISSION PIPELINES IN THE COUNTRIES OF THE FORMER SOVIET UNION:

- Pipelines were designed in accordance with the Russian GOST standards, at a maximum operating pressure of 55 bar; constructed and commissioned from 1962 up to early 1990s.
- Almost all of the pipe systems are in operation, though some at significantly reduced pressure downstream from regulator stations.
- Branches are operated as pressure vessels receiving gas from transmission lines. A failure in such branches may hence affect the transmission system.
- Incident records showed few severe incidents.
- All pipelines could still be refurbished for further utilisation.
- Maintenance was most needed.

12.2.2 Development of transmission capacity

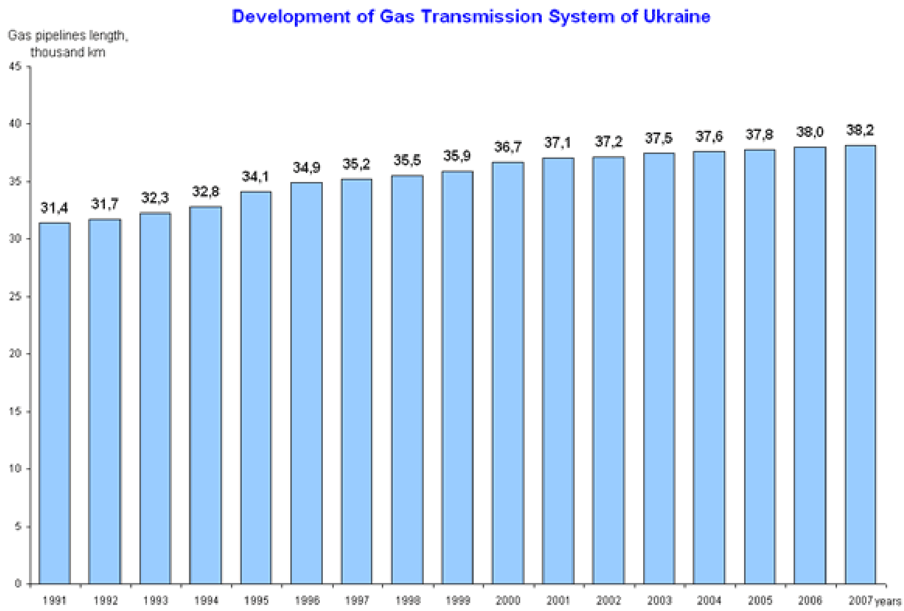
The historic development of the transmission system is shown on Figure 56.

Since 2000, two projects have raised external private finance to expand the network.

The first (shown in Figure 54 with a dotted line) is an expansion of the Trans-Balkan pipeline in Southwest Ukraine, which carries Russian gas from the Ukraine to Turkey, Bulgaria, Romania, Macedonia and Greece, aimed at reducing bottlenecks during peak periods. The project has been implemented in the period 2001–2003 (and the pipeline is now owned) by Gaztransit, a joint venture between Naftogaz Ukrainy (37%), Gazprom (37%), Turusgaz (owned by Botas, Gazprom and Enka) (18%) and Transbalkan (a consortium of four Turkish construction companies) (8%). Loans were raised from the European Bank for Reconstruction and Development, the Black Sea Trade and Development Bank and the private sector. The second and the third phases of the project, to complete a 380 km stretch of parallel pipeline, are pending.

[58] Ref /19/ and /20/

Figure 56 Historic development of the Ukrainians gas transmission system



Source: www.naftogaz.com

The second project is a smaller project, for domestic distribution rather than transit. It is a privately owned branch pipeline from the Soyuz pipeline to the Uman and Ulianovka areas of the Kirovograd region and the Pobuzhskii ferro-nickel works. The project has been supported by the government and Naftogaz Ukrainy and undertaken with the cooperation of the local gas distribution company, Kirovogradoblgaz.

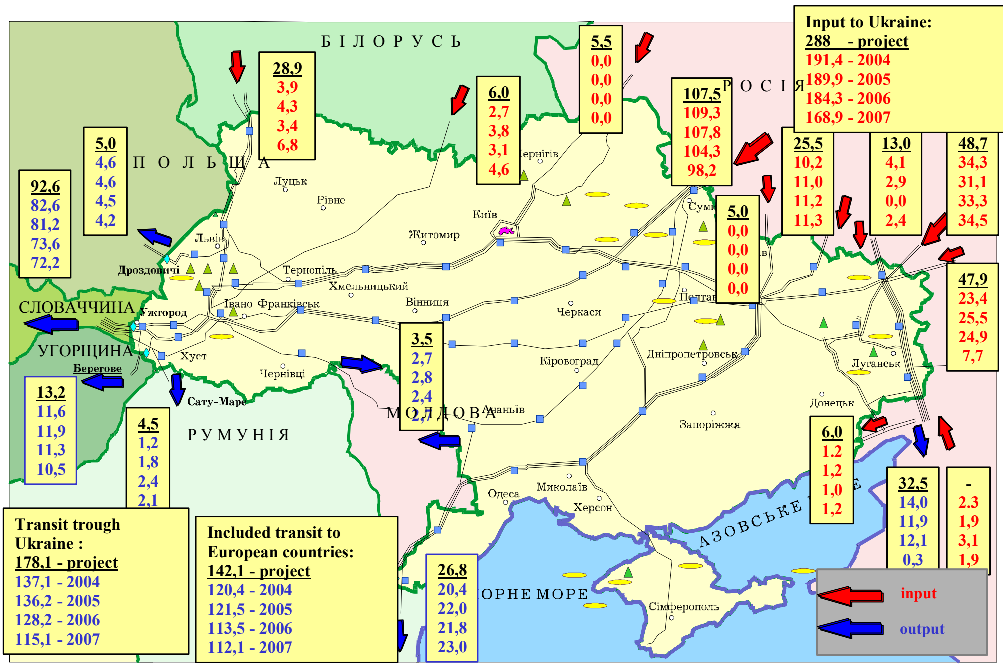
13. Gas flows and available capacity

The system is used to supply domestic consumers with domestic and imported gas, as well as to transit gas from Russia and Asia to European countries. There are no dedicated transit lines.

In the period 2000–2005 the network transported an average of 128.7 bcm of Russian and central Asian gas to Europe, peaking at 137.1 bcm in 2004 /6/, as well as transporting gas for domestic consumption.

Figure 57 presents an overview of the annual volumes of gas supplied to the Ukraine at each supply point, as well as the outputs in the export points in 2004-2007, and the estimated values (designated as 'project' in the figure) for 2008.

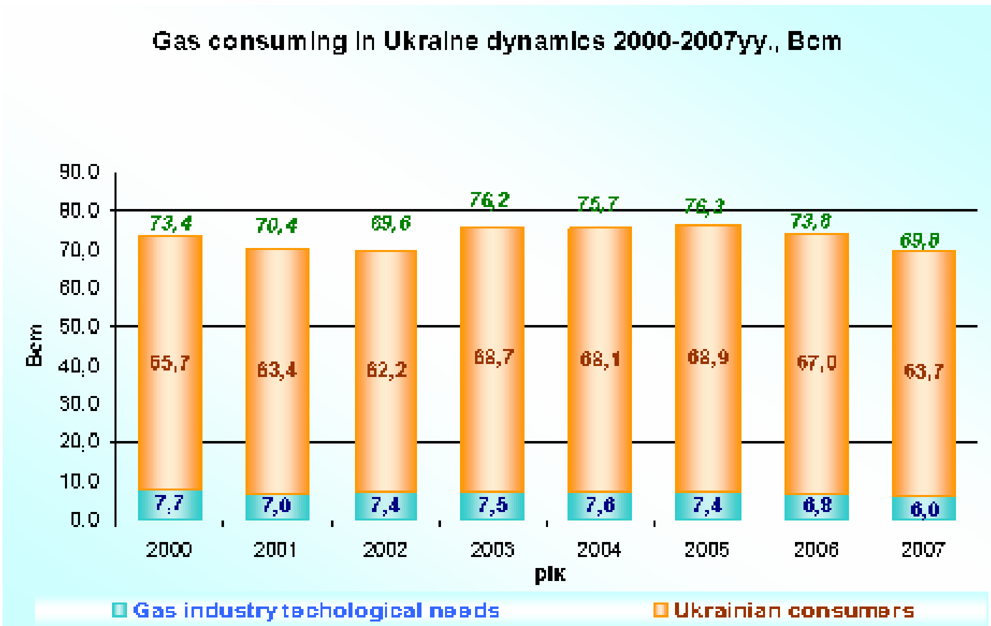
Figure 57 Supply/output points to/from the Ukrainian transmission system



Source: Ukrtransgaz

13.1 Own consumption

Figure 58 Annual gas consumption in the Ukraine, 2000-2007



Source: Ukrtransgaz

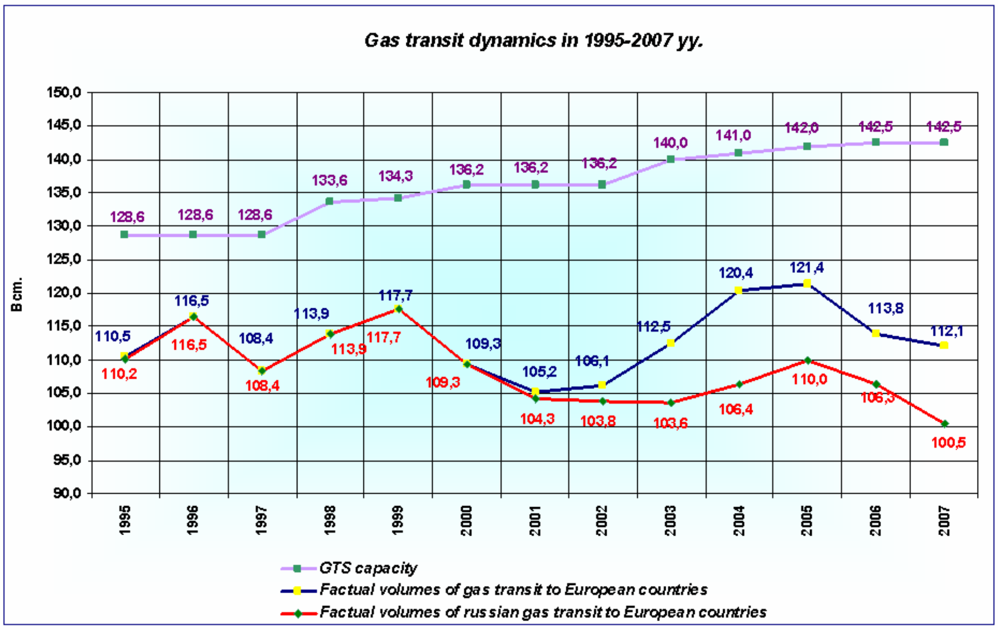
Annual gas volumes do not necessarily indicate the available capacity in the system, and therefore maximum daily capacity and demand should be analysed.

The maximum daily consumption in the Ukraine is approximately 100-110 mcm/day in summer and 350-420 mcm/day in winter.

The Ukraine experienced very high demand in 2006, when the maximum daily consumption reached 427 mcm/day.

13.2 Gas transit

Figure 59 Annual gas transit to Europe through the Ukraine, 1995-2007



13.3 Underground gas storage

There are 13 underground gas storage facilities in the Ukraine. The locations of the facilities are shown in Figure 60. The gas storage system comprises 12 underground facilities operated by Ukrtransgaz (of which 10 are in depleted gas fields and two are in aquifers) with an aggregate storage working capacity of approximately 30 bcm (See Table 14) and one operated by Chernomorneftegaz with a working capacity of 0,5 bcm.

Figure 60 Overview of UGS in the Ukraine

Source: Ukrtransgaz

Table 14 UGS in the Ukraine

Operated by	**Number of facilities**	**Type**	**Working capacity, (bcm)**	**Location**
Ukrtransgaz	12	10 depleted fields 2 aquifer	29,6	3 southeast complex 4 Central complex 5 Western complex
Cornomornaftogaz	1	depleted field	0,5	Crimea

Highlights of the information provided by Naftogaz to the International Energy Agency (IEA) regarding the storage system are listed in Table 14.

Table 15 UGS in the Ukraine

Region	Storage facility	Commissioning	Max daily withdrawal rate (mcm/day)	Volume of gas in storage (bcm)	
				Total	**Storage working capacity**
Western complex	Biltche-Volitsko-Ugerskiy	1983	90	32.1	15.7
	Ugerskiy	1969	20	3.7	1.8
	Dashavskiy	1973	25	5.3	2.2
	Oparskiy	1969	20	4.8	2.1
	Bogorodtchanskiy	1979	46	3.4	2.3
	Sub total		**201**	**49.3**	**24.1**
Central complex	Solohovskiy	1987	9.9	2.0	1.2
	Olishevskiy	1964	2.5	0.6	0.3
	Chervono-partyzanskie	1968	12.5	3.0	1.5
	Kegitchevskiy	1988	8.5	1.3	0.7
	Sub total		**33.4**	**6.9**	**3.7**
South-Eastern complex	Proletarka	1986	8.2	2.0/1.2	1.0
	Krasno-Popowskiy	1973	4.4	0.8	0.4
	Vergunskiy	1987	3.0	0.9	0.4
	Glebovskiy*	1983	4.0	1.0	0.5
	Sub total		**19.6**	**4.7/3.9**	**2.3**
	TOTAL		**254**	**60.9/60.1**	**30.1**

Source: Data from Naftogaz provided to for EIA
* Located in Crimea and operated by Cornomornaftogaz

The storage is concentrated in four main areas:

1. The Western underground storage complex, the largest in the Ukraine, which includes five facilities (Ugerskoe, Bil'che-Volitsko-Ugerskoe, Dashava, Opary and Bogorodchany)
2. Kyiv/central Ukraine (two facilities)
3. Donetsk/eastern Ukraine (five facilities)
4. Crimea (one facility)

The South-Eastern complex includes the storages of Chervobo-Popovka, Vergunka, Proletarka and Glibovske, used for the purposes of suppliers to domestic consumers, as well as transit to Moldavia, the Balkan Peninsula and Turkey.

The Central complex includes the storages Soloha, Mryn, Olyshevka and Kegychivka, used for balancing flows in the central and south-eastern Ukraine.

The Western complex includes the storages Bilche Volytsa, Ugersko, Dashava, Opary and Bogorodchany. The capacity of the Western complex is 80% of the total storage capacity in the Ukraine. These storages are used for balancing gas flows from Russia and middle Asia for transit to Europe.

The above groupings of storage and their seemingly pre-defined function are related to the technical possibilities of the system. The transit flows should be balanced with gas from storages from the west complex, as these are located close to the border export points. Transporting gas from the storages of the Central or South-Eastern complex to the Western border is possible, but takes up to 36 hours. The consequence of this regarding possible disruption of supply of transit volumes is discussed later in this section.

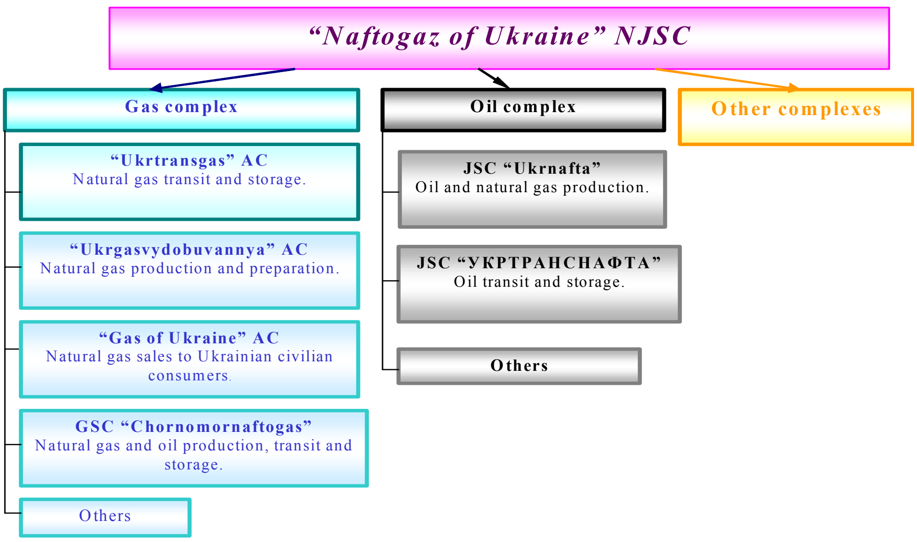
Storage is booked annually, and the season starts on 15 April. Since most of the underground gas storages in the Ukraine are depleted fields, they operate in six-month injection and withdrawal phases; i.e. they can only be used for seasonal balancing. The injection phase is during the period 15 April-15 October and the withdrawal phase is 15 October-15 April.

14. The Ukrainian gas market

14.1 Gas market participants

The main player on the Ukrainian gas market is the fully state-owned company Naftogaz of Ukraine, whose structure is presented in Figure 61

Figure 61 Organogram of Naftogaz of Ukraine



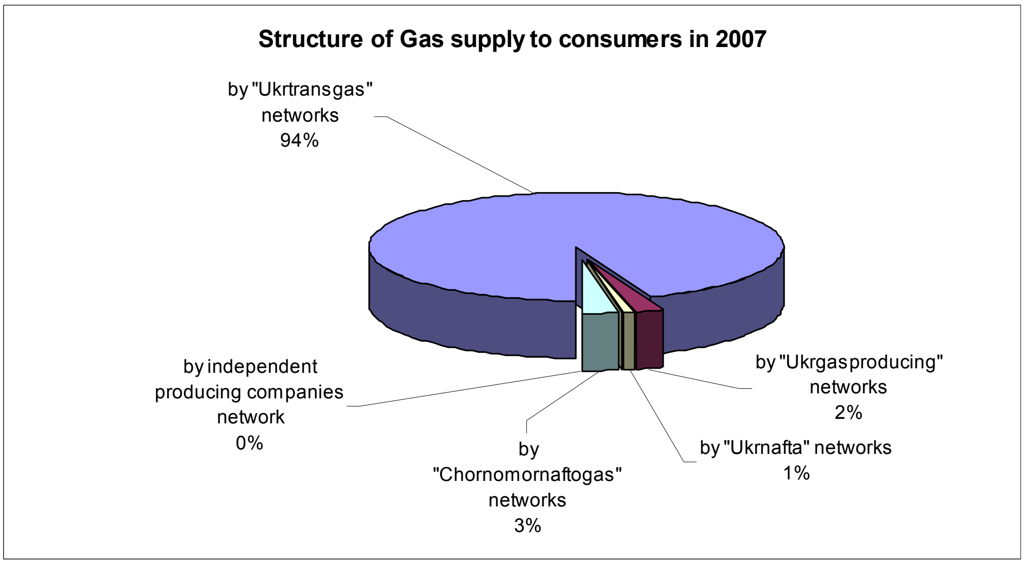
As the figure shows, Naftogaz of Ukraine covers the whole gas chain through its subsidiaries.

The subsidiary Ukrtgasvydobuvanya AC is licensed for gas production in the Ukraine.

The subsidiary Ukrtransgaz AC is licensed for transport of natural gas through the state-owned transmission network and operation of underground gas storages – with the exception of the island of Krim, for which the subsidiary GSC Chornomornaftogas has the licence.

Approximately 95% of the total gas flows through the transmission system in the Ukraine is transported by Ukrtransgaz, as illustrated with 2007 figures on the following illustration.

Figure 62 Structure of gas supply to consumers in the Ukraine in 2007



The activities of Ukrtransgaz include:

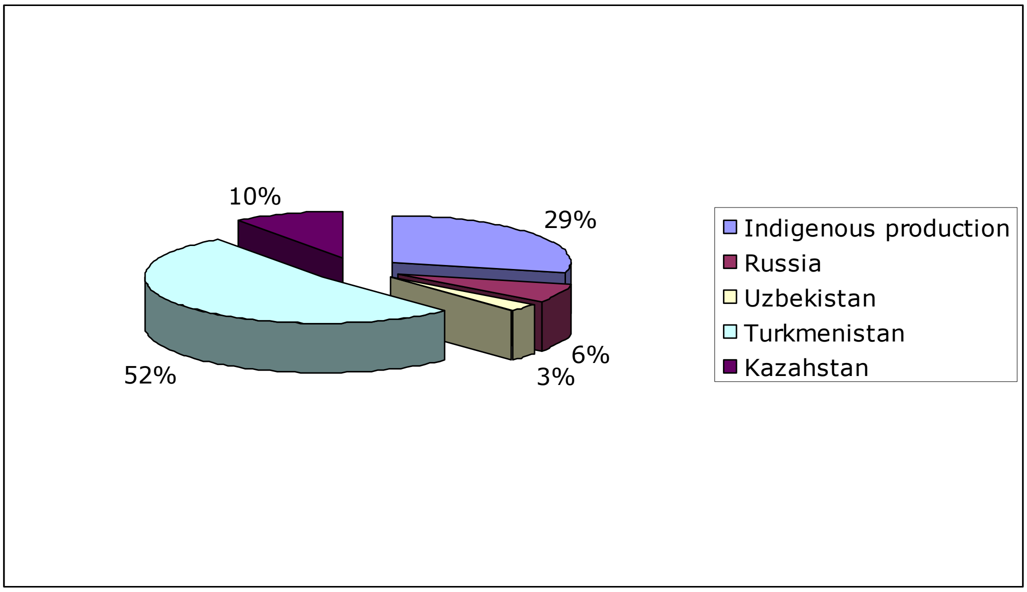
- Natural gas transmission for Ukrainian consumers.
- Natural gas transit to European countries through the Ukrainian territory.
- Natural gas storage in underground facilities.

Related to supply of gas to consumers, with the liberalisation of the market, consumers can freely choose between 230 suppliers, of which the subsidiary Gas of Ukraine is one.

14.2 Gas contracts

The structure of gas supplies for own consumption in the Ukraine is presented in the following figure.

Figure 63 Structure of gas supplies to the Ukraine in 2007



As the figure shows, 29% of gas supplies in 2007 came from indigenous production, 10% from storage and 64% from import. Gas is imported through the company RosUkrEnergo, a non-resident company delivering gas at the border to Naftogaz. Customs clearing takes one month. The structure of the imported gas as of 2007 is shown in Figure 63.

Transit gas volumes are based on the long term; i.e. five-year transit contracts signed between Gazprom and Naftogaz, the next long-term contract being for the period 2008-2015. Based on the long-term contract, at the beginning of every year a yearly contract is signed to specify the transit volumes for that year. The 2008 contract for transit volumes is for approximately 110 bcm.

14.3 Briefly on the gas market regulation in the Ukraine

Activities on the gas market are licensed by NKRE (the National Commission for Electroenergy Regulation).

The main player on the gas market functioning through its subsidiaries for production, import, transmission, distribution and operation of storage, is the state-owned Naftogaz of Ukraine. On the supply side, consumers can freely choose a supplier from among 230 suppliers.

Access to transmission is based on standard contracts, but there are no published network codes.

Access to storage is on a negotiated basis. The suppliers of domestic consumers are obliged by the regulator to store balancing/strategic gas corresponding to 10% of their annual supplies. Suppliers can freely trade gas, including gas in storage.[59]

According to the representatives of Ukrtransgas, withdrawal from storage corresponds highly to the estimates. In case of withdrawal higher than contracted, there are no penalties – for three consecutive days the operator warns the supplier, after which the operator can reduce or cut off supplies. However, no case of cutting off supply has been registered so far.

Retail prices for consumers are regulated based on the price cap principle and are subsidised.

15. Summary an conclusions on the availability of storages in Ukraine

The Ukrainian gas infrastructure is aged and it may need significant investments in maintenance and replacement/repair. Experience with inspection of gas transmission systems in former Soviet Union countries show that the gas infrastructure is quite robust in spite of age and lack of maintenance, which is though resulting in lower capacity in sections of the system, i.e. bottlenecks. Significant investments in repair/replacement are usually needed to remove bottlenecks, and upgrade the system (for example corrosion protection) in order to prevent its further deterioration.

The system is used for supply of domestic and imported gas to domestic consumers and transit of gas from Russia and Asia to Europe. More information is necessary to evaluate the available capacity in the system, even though annual volumes indicate available capacity in the system, as both own consumption and transit volumes show a tendency of decline. However, this has to be benchmarked with the actual technical capacity in the system (not the design one).

Approximately 30% of the total domestic consumption in the Ukraine is covered by indigenous production. The total storage capacity of Ukraine amounts to 30 bcm, which corresponds to approximately 60% of the volumes imported for domestic consumption. The total daily withdrawal rate amounts to 254 mcs/day, which corresponds to 59% of the peak daily demand (427 mcm/day, experienced in 2006). In an event of total import supply disruption, Ukraine may face problems in supplying all of its customers. Even more so, if only the storages of the South-Eastern complex are used for balancing domestic consumption (as claimed by Ukrtransgaz). The storage capacity of this complex corresponds to only 5% of the total annual imported volumes for domestic consumption and the daily withdrawal rate corresponds to only 7-10% of the average winter peak daily demand.

[59] Information by Ukrtransgaz

Gas for balancing transit flows can due to geographical/technical reasons only be stored in the Western complex of underground storages, located close to the Western Ukrainian border. The storage capacity in the Western complex amounts to 24 bcm. For a comparison, the storage capacity of the whole South-East region at present is 29 bcm.

Supply disruption of volumes for domestic consumption should not affect the transit volumes, but this can be difficult to prevent technically as there are no dedicated transit pipelines. If, in case of a total import supply disruption, some domestic consumers are not interrupted, on a winter day there is a risk that transit gas is used for domestic consumption.

Transit volumes usually do not need seasonal balancing as they are mainly delivered at a flat rate, so storing gas for transit purposes could only be for security of supply reasons. The obvious discussion issue is who is to store gas to be withdrawn from storage in case of disruption of supply of the transit volumes to the Ukraine.

There is no doubt that higher transparency related to the Ukranian gas market is needed. The market is dominated by a single player (except on the consumer supply side), access to storage on negotiated bases, and high subsidisation of retail prices, which indicates cross-subsidising with other activities, possibly also transit revenues.

In the context of suggesting minimum security of supply and regional operation (Section 7), the principle of storing gas for balancing only within national borders will be uplifted. Suppliers on the European market could use the storage capacity from the Ukrainian Western complex. This requires more transparency related to storage access.

SECTION 3 OWNERSHIP AND CONTROL OF GAS STORAGE FACILITIES IN THE EUROPEAN UNION

This section tries to give an overview of the structure and the ownership types within the gas storage industry.

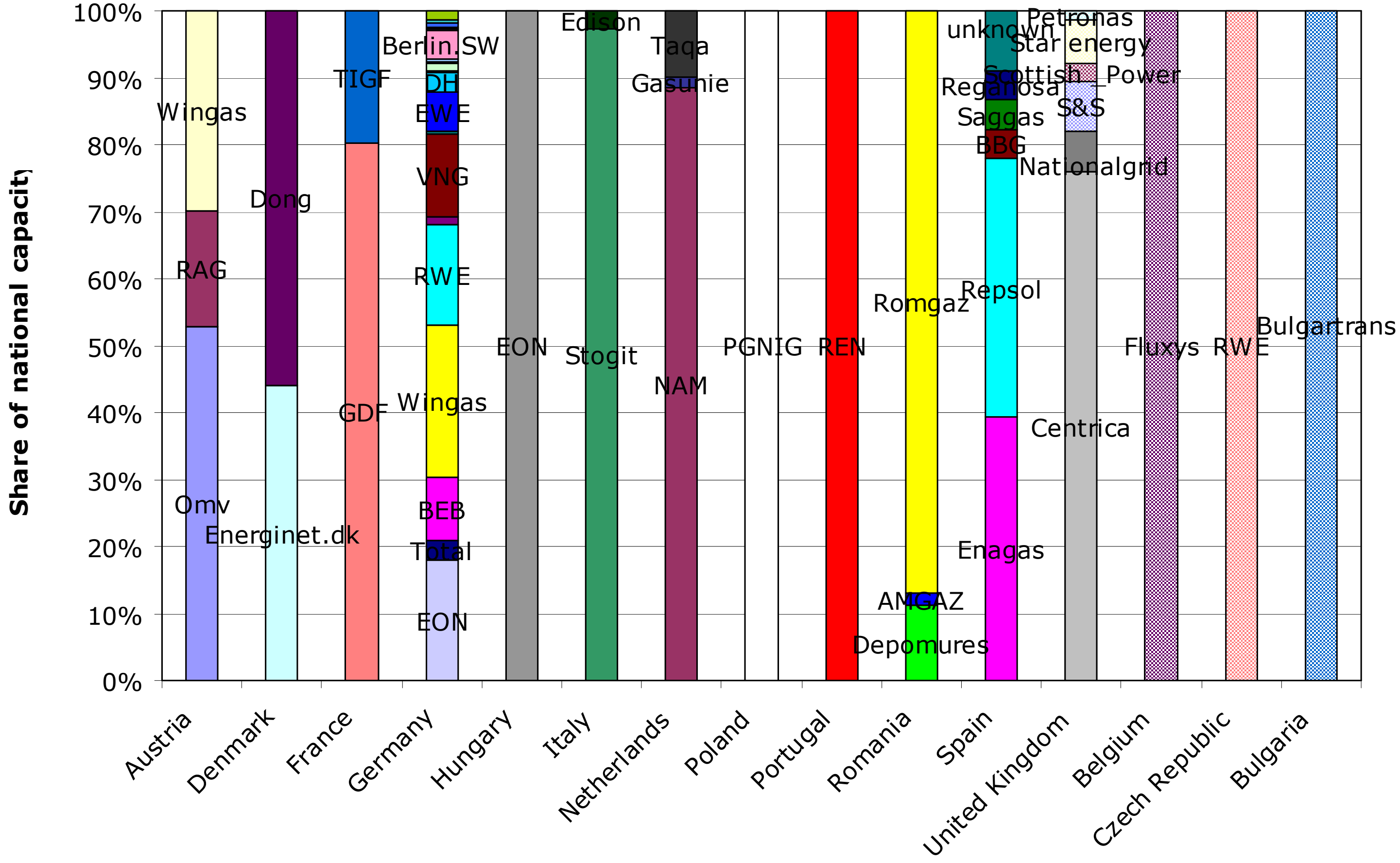
We present a description of the structure of the gas storage industry which entails an analysis of the market shares of the gas storage companies today and in the future. The information about market shares will for each country be summarised in the Herfindahl concentration index which indicates to what extent an industry is concentrated. We then look into the existing and future ownership types of the storage operators, and touch upon the requirements for unbundling within the gas industry.

16. Structure of the gas storage industry 2008

The structure of an industry, *expressed as the share of ownership of total capacity in a country*, and commonly referred to the distribution of market shares, *can* reflect the competitiveness within the industry, even though not taking the conduct or the performance of the companies into account.

To shed light on the ownership situation today we proceed with a graphical illustration of the distribution of the market shares (see Figure 64). Some of the countries which only have one storage operator are not included in the figure (Belgium, Czech Republic, Bulgaria).

Figure 64 Distribution of market shares 2008.



Source: Gas Storage Europe (GSE)

It is seen that some national champions dominate the picture with respect to market shares and that most firms stick to one market. Some of the few firms that do operate in multiple countries are Wingas, Gaz de France, E.ON[60] and RWE[61]. The UK, Spain, and Germany seem to be the countries with the highest degree of ownership diversity. It should also be kept in mind that several of the large firms hold shares in the smaller ones.

16.1 Structure of the gas storage industry in the short and long-term

In the following analysis of the structure of the industry we thus operate with the same short and long-term scenarios outlined in Section 1.

16.1.1 Short term

Under the assumption that the projects listed in the GSE database as committed or under construction will be carried out, we get the following distribution of market shares - Figure 65.

In the short term a few new companies will entered the storage market. In general, most investments will be carried out by the incumbent firms. It is furthermore noted that the diversity of ownership is increasing mostly in the countries which already have diversified ownership. The distribution of market shares across countries is thus characterised by this relatively low new entrance.

The UK experiences some new actors in its market, with WinGas and SSE/Statoil as the largest investors. The increasing expansion of capacities in the UK gas storage market is set to decrease the market shares of both Centrica and Nationalgrid. The German market remains relatively unchanged with the only major difference from 2008 being the investment by E.ON in the new Etzel facility (holds 2,500 mcm) in northern Germany. This is reflected in the increasing market share of E.ON.

The general conclusion is that though the industry experience investments of approximately 19 bcm in total, the relative distribution of market shares in most countries remains unchanged.

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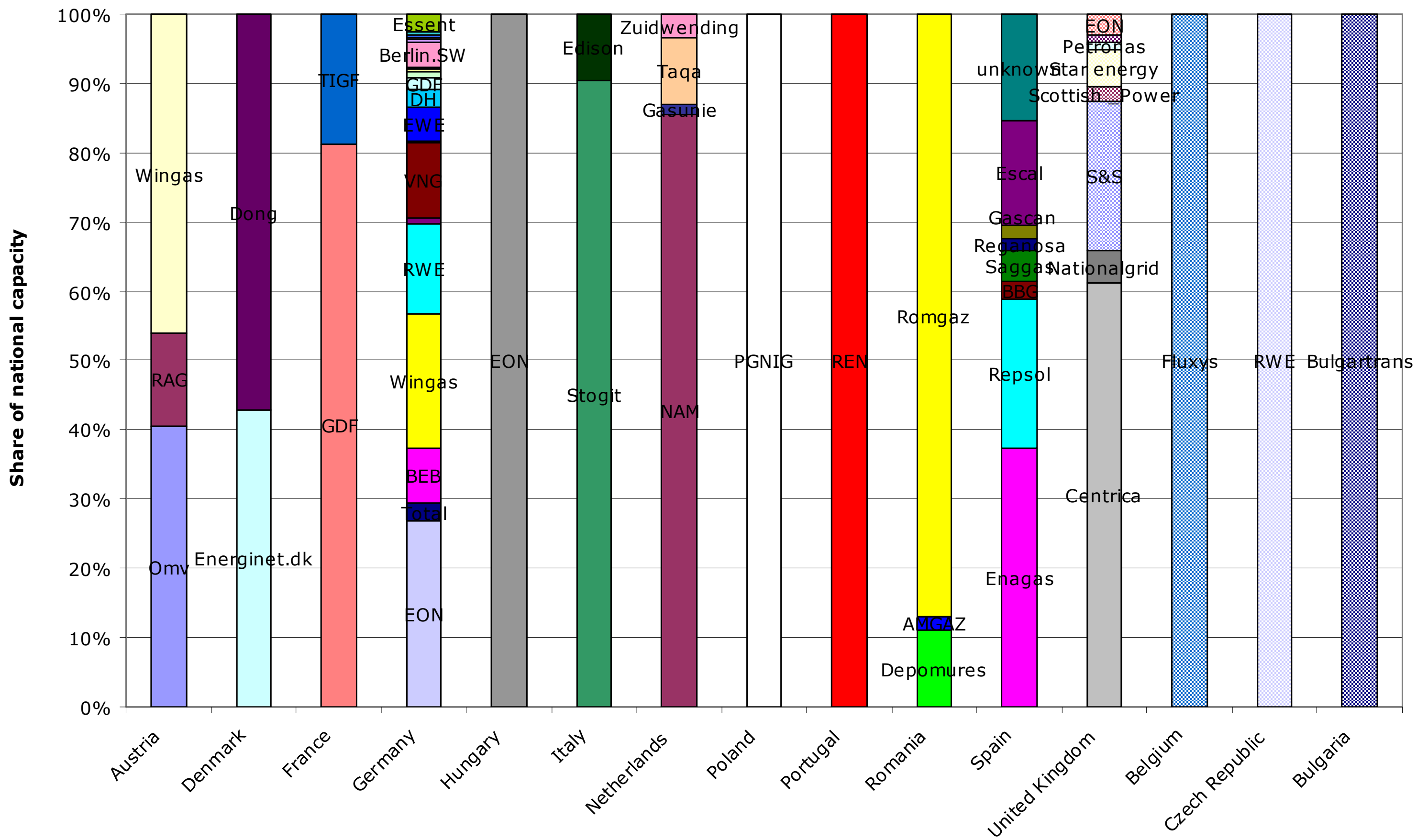
[60] 100% of the capacity in Hungary

[61] 100% of the capacity in the Czech Republic

Figure 65 Distribution of market shares, short-term scenario.



Source: Gas Storage Europe, (GSE), latest update june 2008.

16.1.2 Long term

Assuming that all planned investments in storage listed by GSE will be carried out, the picture changes to the one displayed in Figure 65.

It can be seen that by 2015, many new companies will enter the market for gas storage; especially the UK will experience an additional growth in new storage owners compared to 2008, more specifically 11 new storage owners will have entered the gas storage market in the long term scenario. Italy is also experiencing growth in the number of companies, going from two to four.

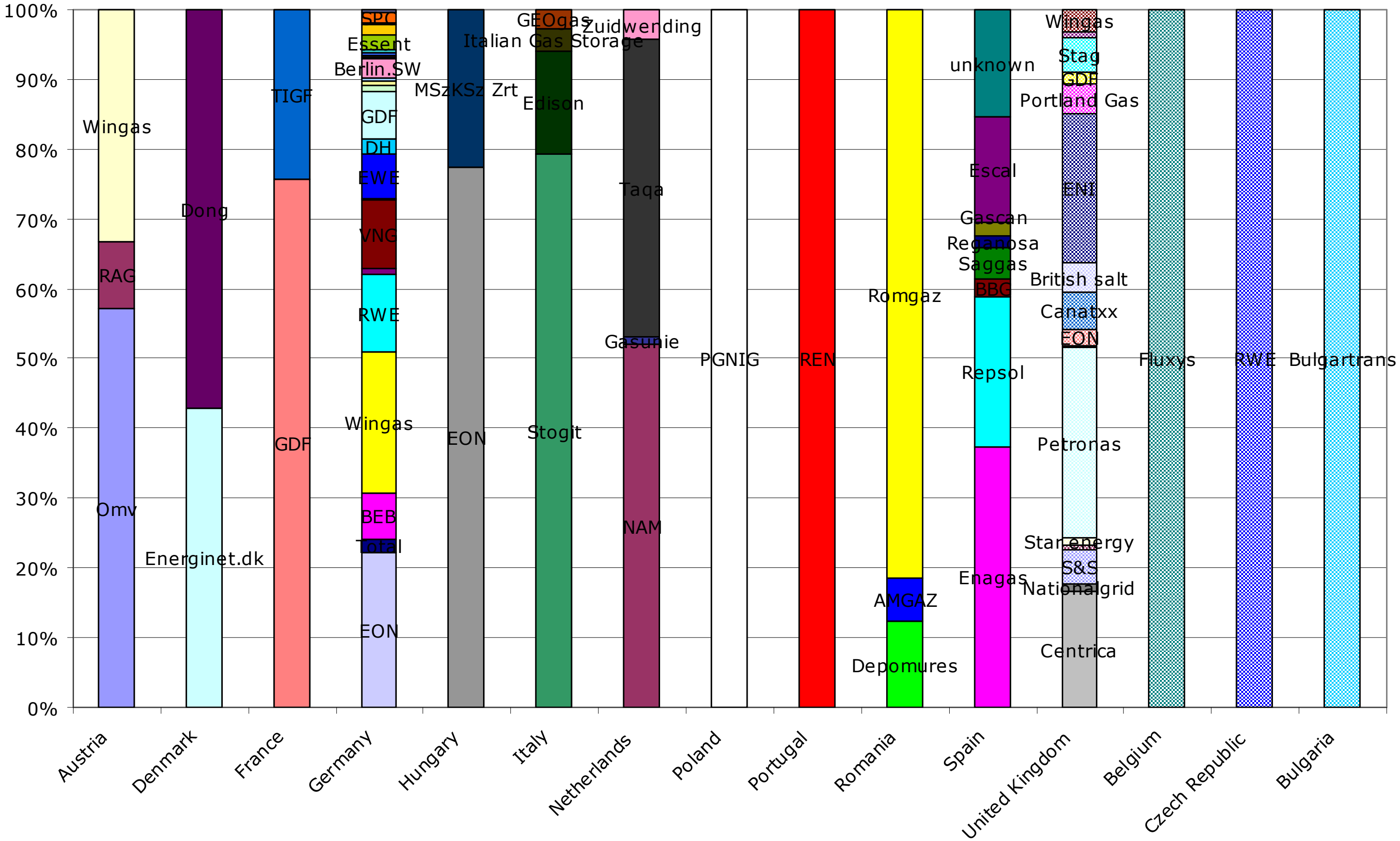
A second aspect of Figure 66 is the increased internationalisation of the large gas storage providers, Gaz de France, E.ON and Wingas, who are present in the gas storage market in the UK, Germany, Romania, and Hungary. This spread of activities reflects the priorities and strategies of the multinational companies, and possibly also signal that some sort of risk diversification.

Some countries do not experience the same inflow of new storage operators as the UK, the Netherlands, Spain, and Italy do, especially the eastern and southern European countries do not seem to experience many new market players. One exception is, as previously mentioned, Romania and Hungary where both Gaz de France and E.ON own and operate storage facilities.

A third aspect is the entrance of non-EU Member State gas storage owners. In general, most storage owners come from EU Member States, however a few exceptions exist, such as Taqa energy, owned by the government of Abu Dhabi. As seen from Figure 66, Taqa's share of the gas storage market will amount to more than 40% of the total storage capacity in the Netherlands in 2015. Furthermore, Statoil, Exxon and Gazprom have shares in some storage projects. In the long-term scenario, these companies will together operate approximately 2.5% of the total storage capacity.

It should be kept in mind that the market shares illustrated in Figure 66 are based on the companies' own projections in terms of planned investments in gas storage. Some companies could for strategic purposes have incentives not to reveal their investment plans or to misinform the market about the level of investment that they may engage in. It is nevertheless of interest to see how the structure of the industry would look like if the planned investments were realised.

Figure 66 Distribution of market shares, long-term scenario

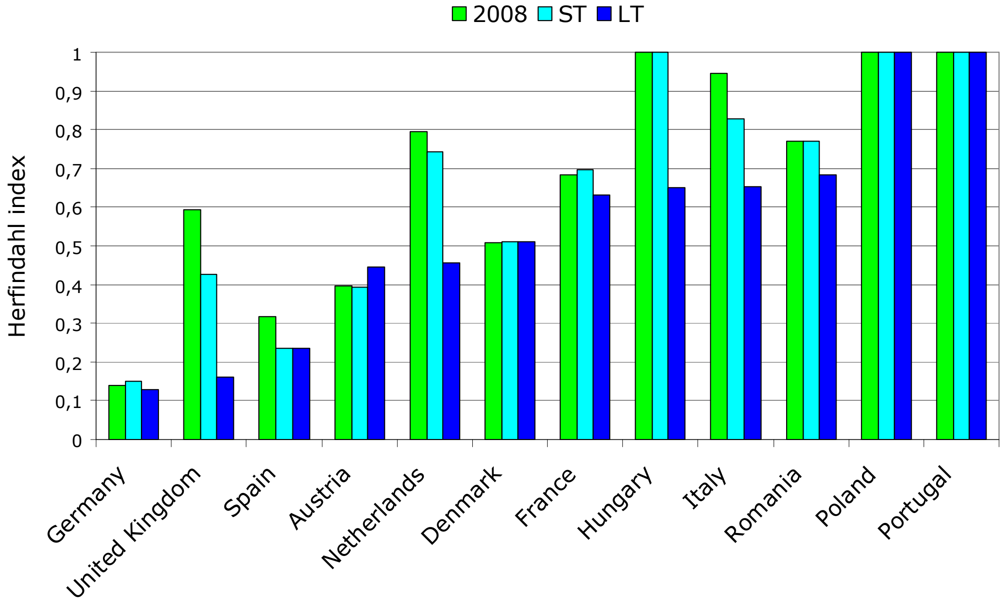


Source: Gas Storage Europe

16.2 A measure of concentration

The graphical exposition of the distribution of market shares can be summarised by calculating the Herfindahl index. As mentioned in Section 1 this is a common way to measure the concentration of companies and market shares in a market. The Herfindahl index transforms information about companies and their market shares in each country into a measure of the concentration of the industry. In Figure 67 the Herfindahl indexes each country for 2008 and the short and long-term scenarios are illustrated:

Figure 67 Concentration of the gas storage industry in each Member State



Source: Gas Storage Europe

Countries which have few or only one actor on their home market have a Herfindahl index close to one while countries where many different and relatively equally sized storage owners operate have smaller Herfindahl indexes.

The general trend in Figure 67 is that the structure in the national gas storage markets will be less concentrated in the future. In the short run the entry into the markets is limited, only the UK and Spain experiences significant changes.

However, the number of companies entering the storage market, both in the short and long-term scenario, increases. With regard to the Herfindahl index this increase implies that most countries will have a less concentrated industry structure, given that no companies leave the industry. The largest changes in the concentration index are found in the UK, the Netherlands, Hungary and Italy.

In some countries there seems to be a very low level of entrance of new owners into the storage industry. Especially France, Poland, Portugal (and Czech Republic, Belgium, Bulgaria these are not showed) remain highly concentrated and will in the long-term scenario end up among the most concentrated market compared to the remaining countries in Figure 67. This indicates that the markets are either unattractive for storage investors or unavailable to them. Geological preconditions of course also play a major role when investigating the distribution of new investments. Some of these countries do not have the possibility to develop new storages, this is naturally reflected in the investment data. The lowest concentration is found in Germany.

It should be kept in mind that not all gas storages in a country necessarily are in direct competition. Due to the high investment costs some storage owners may be naturally endowed with monopoly power, as the investment cost by itself constitutes a barrier to entry. The distance and the associated transportation costs between storages could also imply that storage owners can act non-competitively without losing customers, as the costs of switching and hence moving the gas can be higher than the gains of lower storage prices.

17. Unbundling of the gas industry and ownership types of storage operators

According to the definitions set out by the European Commission, a company is vertically integrated if it performs one of the following functions: transmission, distribution, LNG or storage, and at the same time is involved in production or supply of natural gas.[62]

Being vertically integrated implies that the company can influence the decisions taken by each business unit. There are both advantages and disadvantages to having a vertically integrated business. A vertically integrated business might be better in optimising its resources. Each part of the supply chain, (transmission, distribution and storage) may have incentives to price above marginal costs, as this would imply a positive profit. However, these multiple price mark-ups imply additional costs for the owner of the gas, as the gas is being transported through the supply chain, and in the end these extra costs are passed on to the end-consumers. When all parts of the chain a part of an integrated business, the entire profit of the chain would be maximised resulting in a price lower than in the vertically unbundled solution.

There could however, in a liberalized market be certain drawbacks connected to vertical integrated companies, such as risk of foreclosure or under-investment to prevent competition etc. which has therefore resulted in requirements to unbundle some business activities.

[62] Directive 2003/55/EC Article 2 count 20

17.1 Requirements for unbundling

The second Gas Directive imposed requirements for legal and functional unbundling of the TSO/DSO from the parent company. The discussion has been extended to a possible necessity of ownership unbundling, rounded in a proposal in the "Third Legislation package" , which is currently under public discussion, according to which the vertically integrated company may retain ownership of the entity, however, the daily operations must be carried out by an independent system operator.

The unbundling requirements of the Second Directive have not been binding for the the SSOs, are however being introduced with The 'Third Legislative Package' .In addition to this, the 'Third Legislative Package' proposes initiatives to ease the access to storages, including: making the GGPSSO binding, giving more power to national regulatory authorities, and more transparency in regulation of access to storages.

There is no doubt that transmission systems have received more attention related to unbundling, even though in theory the problems of conflict of interest, information sharing, and under-investment might apply equally to both TSOs/DSOs and SSOs. Requirements for unbundling of the SSOs must however be supported with evidence that storage operators are misusing their position and unbundling is therefore necessary.

17.2 Types of ownership

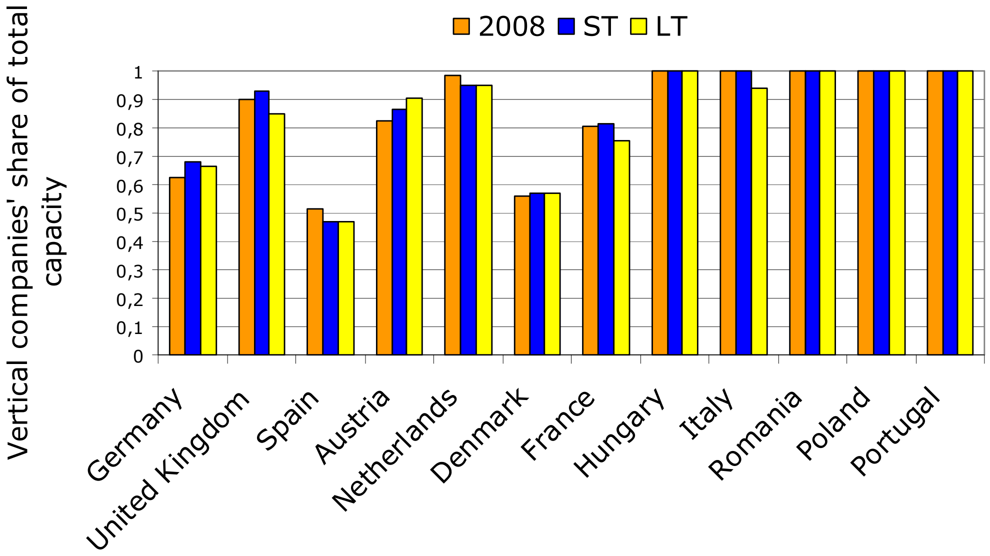
The unbundling requirements of the antitrust legislation have caused many different ownership structures to emerge. Due to these different ownership constructions it is difficult to present a clear picture of ownership patterns. Moreover, some companies may own shares in other companies. What *can* be said with certainty is that not many storage operators are completely independent; it is rare to observe that the storage business is the only activity within the energy sector in which the owner is involved.

In fact, of the 67 gas storage owners operating within the EU, approximately 53% are involved in extraction and production of gas[63]. The rest are either independent or TSOs such as energinet.dk disposing over gas storages. Thus, according to the European Commission's own definition of a vertically integrated company, approximately 53% of the gas storage owners are vertically integrated. In the following, focus will be directed to these types of owners.

In Figure 68 the market shares of gas producers are compared for selected countries. Vertically integrated firms control approximately 60% of the market for gas storage in Germany, while approximately 90% of the market in the UK is controlled by gas-producing firms (mainly Centrica in 2008).

[63] Again we do not take the relations among companies into account. Some companies are indeed affiliated with each other.

Figure 68 Market shares of vertically integrated companies, 2008, 2015 ST and 2015 LT



There does not seem to be a clear pattern, in some countries the market shares of the vertically integrated companies are decreasing, while in others the opposite holds true. The decreasing market shares of the vertically integrated companies may indicate that non-gas producing companies in general are gaining market shares on the storage market on behalf of the gas-producing companies. Hence the incumbent gas-producing storage operators do not invest much in capacity compared with independent storage owners. This is in the long run observed in Spain, the UK, France, and the Netherlands. A increase in the market shares of the gas-producing companies is observed in Germany, Austria, and Denmark.

The development in Figure 68 could imply a more competitive gas market, as the priority of gas-producing companies will always be to secure the supply of gas to their customers. Independent storage operators are not as restricted in their decision-making and thus have the freedom to take decisions without taking into account the security of supply of a customer group.

Whether the increased number of non-gas producing companies will increase competition cannot be said. However, it is likely that the entry of firms with motives that differ from those of the gas producers could lead to a stimulation of competition. Comparing with the Herfindahl index in Figure 67, it is seen that the development of the Herfindahl index resembles the development in the market shares of vertically integrated companies. This indicates that low concentrated markets could be positively associated with the number of independent storage owners.

17.2.1 Market power of gas storage owners

Despite of the unbundling of activities within the gas industry there is still a long way to go with respect to competition. Storage operators do possess market power as they have not been subject to much binding regulation.

Market power in this context should be understood as the ability to set prices above costs and is in general defined by three factors: elasticity of demand, the concentration of the market and the degree of collusive behaviour. Estimation of the elasticity of demand for storage of gas is practically impossible; however, there is no reason to believe that users of gas storages do react strongly to small changes in prices of storage, as the transportation costs of switching could be considerable compared with the gains of switching to a cheaper storage. Furthermore, the gains from storing the gas with the purpose of reselling it at a later point in time may be so large that the customer becomes insensitive to price differences on gas storages. With regard to the structure of the industry, we saw earlier that there was a high degree of concentration in most national markets. Thus, due to the inelasticity of demand, the vertical structure of many owners and transportation costs, storage owners must everything else being equal possess market power.

Ensuring transparent and non-discriminatory access to storage is therefore crucial to competition, as also required by the Gas Directive and as discussed in the following section.

18. Summary and conclusion on ownership and control of storage facilities in the EU

Given the planned investments in new gas storages, the market concentration and the structure of the industry across EU will not change much in the short run. In the long run there is a tendency for the market concentration to decrease, the largest changes are to be expected in the UK, the Netherlands, Hungary and Italy.

Very low level of entrance of new owners into the storage industry is expected in France, Poland, Portugal, the Czech Republic, Belgium and Bulgaria who will in the long-term scenario end up among the most concentrated markets compared to the remaining Member States.

Regarding ownership types, according to the European Commission’s definition of a vertically integrated company, approximately 53% of the gas storage owners in EU are vertically integrated at present and this picture remains even in the long-term scenario.

There has been no evidence of storage operators abusing their position. The Third Legislative Package is introducing requirements for legal and functional unbundling of storage system operators.

SECTION 4 ACCESS RULES

Transparent and non-discriminatory third-party access (TPA) to gas networks is the backbone of a liberalised gas market. Access to storage capacity, meaning access to storage volume, withdrawal and injection capacity in this context, is crucial, as storage remains one of the main flexibility tools for market participants.

The rules and recommendations for third-party access are outlined in the Gas Directive[64] whose implementation has been supported by discussion forums within the gas industry and guidelines for best practice – related to storage - the Guidelines for Best Practice for Third Party Access to Storage (GGPSSO).

The Gas Directive and the GGPSSO recommend principles for access regime, ownership and types of storage services and products. However, the principles are not binding, and the level of opening the storages for TPA therefore varies amongst Member States. If the 'Third Package' is fully implemented the guidelines provided in the GGPSSO will be converted into legislation. The Gas Directive leaves the right to negotiated or regulated access regime to the Member States.

This section reviews the requirements and recommendations outlined in the Gas Directive and the GGPSSO and presents an overview of their implementation in the EU Member States related to:

- Access regime.
- Storage services/products.
- Exemption of storage from TPA for Public Service Obligation (PSO) purposes

19. The Gas Directive and GGPSSO on access rules to storage

The GGPSSO were published by ERGEG[65] on 23 March 2005. The implementation of these guidelines has since been monitored, most recently in the 2006 Report on Monitoring the Implementation of the Guidelines for Good TPA Practice for Storage System Operators (GGPSSO). CEER[66] recently distributed a questionnaire to the Member States, which included questions related to access to storage. However, only preliminary results were available at the time of publishing this report.

Highlights related to the discussion in this section are presented in Box 1.

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[64] EU Directive 2003/55/EC concerning common rules for the internal market in natural gas and repealing Directive 98/30/EC, hereafter called the Gas Directive.
[65] European Regulators' Group for Electricity and Gas.
[66] Council of European Energy Regulators.

Box 1 Guidelines for Good TPA Practice for Storage System Operators (GGPSSO)

Access regime:

- The Gas Directive leaves the right for negotiated (nTPA) or regulated (rTPA) access regime to the member states.

Storage services/products:

- Under the GGPSSO, the services offered by the SSO may reflect storage technical constraints and the economically efficient use of the storage infrastructure.
- Bundled services (SBU) of space and injectability/deliverability with determined technical ratios and with an appropriate size.
- Unbundled services supplementing SBUs at least for available storage capacity at the beginning of the storage year.
- Long-term (≥ 1 year) and short-term services (<1 year) down to a minimum period of one day.
- Both firm and interruptible storage services. The price of interruptible services may reflect the probability of interruption.

PSO

- PSO shall be clearly defined, transparent, non-discriminatory and verifiable. The PSO shall not be used as an instrument to close access to storage and hamper market development. The implementation of security of supply obligations defined as PSOs must affect the development of trade and competition only in the least possible manner.

19.1 Storage access regimes

As stated above, third-party access (TPA) to storage on the EU gas storage market is provided through two main forms of access regimes - regulated access (rTPA) and negotiated access (nTPA). According to the Gas Directive, the negotiated or regulated access regimes are under the jurisdiction of the Member States. This entails that the access regimes in the EU gas market vary from Member State to Member State as both regimes are allowed. The regulator is free to decide which approach should be used for a particular facility but has to publish the criteria on which this decision is made.

An overview based on the ERGEG 2006 Report on Monitoring the Implementation of the Guidelines for Good Practice for Storage System Operators (GGPSSO), the DG Competition Report on Energy Sector Inquiry and Gas Storage Europe is presented in Table 16.

Table 16 Access regimes for gas storage in the EU

	Regulated Access	Negotiated Access
ERGEG 2006 Report on Monitoring the Implementation of the Guidelines for Good Practice for Storage System Operators (GGPSSO)	Belgium Czech Republic Hungary Latvia Poland Italy Spain	Czech Republic Hungary Austria Germany France The Netherlands Denmark United Kingdom Slovakia Sweden
Energy Sector Inquiry 2007	Belgium Italy Spain Czech Republic Hungary Latvia Poland United Kingdom	Austria Germany France The Netherlands Denmark
Gas Storage Europe (GSE)	Belgium Italy Hungary Romania United Kingdom Spain	Germany France Czech Republic Austria The Netherlands Portugal Denmark Slovakia

Source: ERGEG Report on Monitoring the Implementation of the Guidelines for Good Practice for Storage System Operators, Energy sector inquiry 2007, GSE

The distinction between what is regulated access and what is negotiated access to storage is not clear. This is made evident by examining the above table. Some countries are listed as having both regulated and negotiated access; depending on the individual market set-up, i.e. some countries have market segments that are regulated and some that are subject to competition. The above table seeks to show the most appropriate picture possible, which entails showing the differences in how several analyses of access rules evaluate different schemes, e.g. the energy sector enquiry and GSE have listed the Czech Republic in different categories illustrating the lack of transparency which exists with regards to access regimes in the EU.

The definition of regulated third-party access implies that 'tariffs, or at least the methodologies underlying their calculation, are to be subject to ex-ante approval by the relevant regulatory authorities'.[67] However several of the countries with a negotiated access regime do have some sort of regulatory involvement. This involvement may have the form of e.g. indicative terms and conditions or possible ex-post intervention in the case of any abuse.

Based on economic theory there is no economic reasoning that one regime is better than the other; the mechanism applied should be the best suited to the specific market in which it applies. Markets should only be regulated if they lack competition or if there are serious market imperfections. If this is not the case, markets should be capable of determining the 'right' price for the services via the market mechanisms.

The general rule is that in competitive markets, access should be negotiated, and markets, with no or weak competition, are better off with regulated access. This is an evaluation of whether the market is better at setting prices or whether the national regulators are better at setting the tariff.

Newcomers to the storage market complained about negotiated access because of lack of transparency, high prices, lack of secondary markets and inadequacy of storage services in the 2007 sector enquiry.[68]

Looking at Figure 69 and the countries that have opted for the negotiated approach, it would seem as if the north-western European countries, where markets are the most developed, generally are also the ones that have opted for the negotiated access regime.

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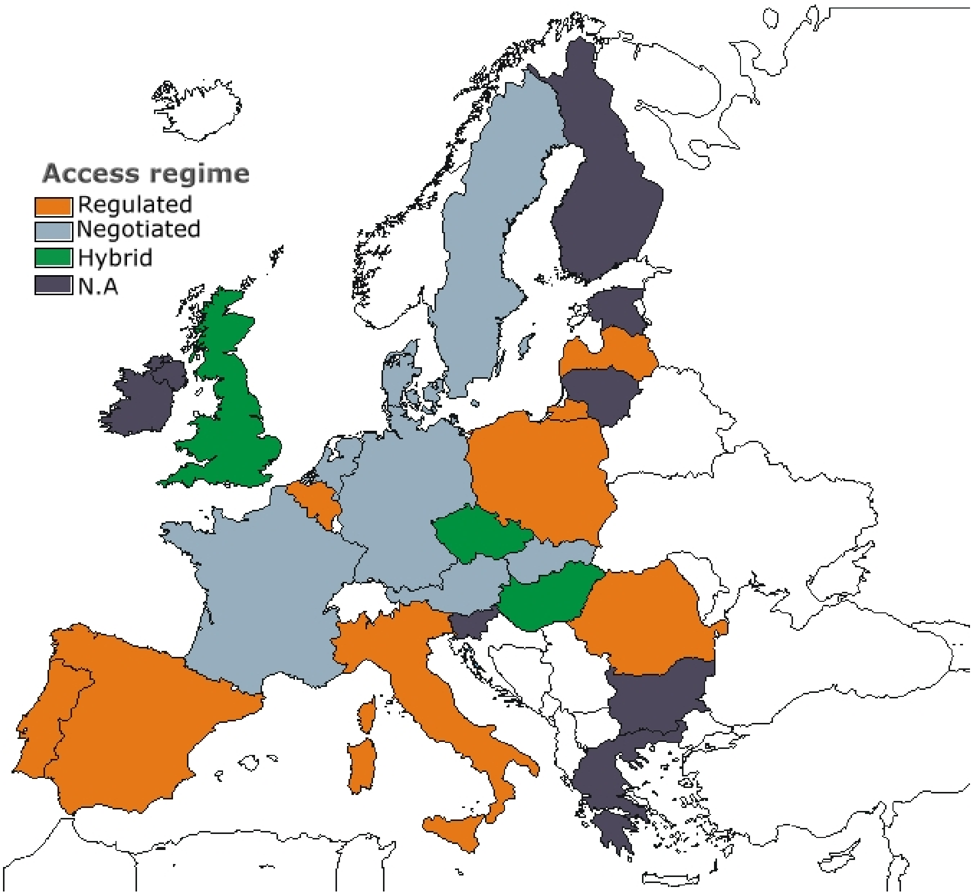
[67] Ofgem

[68] DG Competition Report on Energy Sector Inquiry (SEC(2006)1724, 10 January 2007)

Figure 69 Access regimes gas storage



Source: The ERGEG 2006 Report on monitoring the implementation of the Guidelines for Good Practice for Storage System Operators (GGPSSO), the DG Competition Report on Energy Sector Inquiry and Gas Storage Europe

19.2 Commercial storage access – storage services/products

Another relevant aspect when examining storage access rules concerns commercial access to storage, i.e. the availability of storage services/products. This is evaluated in the forthcoming sections. First, we look at how and why storage products look as they do today and why the demand for storage products may have changed or be changing.

19.2.1 Development of storage services/products

Historically, storage facilities have been constructed and operated by vertically integrated companies who built storages suited to their flexibility requirements. Storage in this context was only one of the flexibility tools available to the vertically integrated company, which also included re-injection of gas in production fields during summer months, burning of gas for electricity generation, different import contracts with various flexibility options, line-pack in distribution and transmission pipelines and, today, also trading. Because the lion's share of gas storages were built before the market opening – 75 bcm out approximately 78 bcm of today's total storage capacity were built before 2000 – most storages serve the specific flexibility needs of the owner, i.e. the (national) vertically integrated company.

New entrants to the market may not have the same flexibility tools available to them. Thus new entrants may require a different level of flexibility from storage. A storage operator that still is a vertically integrated company may not have any incentives to modify the storage products. Changes in products would mainly be in the interest of newcomers to the market. Thus by changing products to accommodate the flexibility requirements of new entrants to the market, the storage operator would increase the competitiveness of those newcomers. This most likely would not be in his own interest if the storage operator is part of a vertically integrated company. In Section 3, Figure 68 on the market share of vertically integrated companies, we saw how vertically integrated companies are dominant in most EU markets.

This problem can be solved either by the unbundling of storages, as was discussed in the previous section on ownership, or alternatively by requiring storage operators to adjust their storage products in accordance with actual flexibility demand in the market.

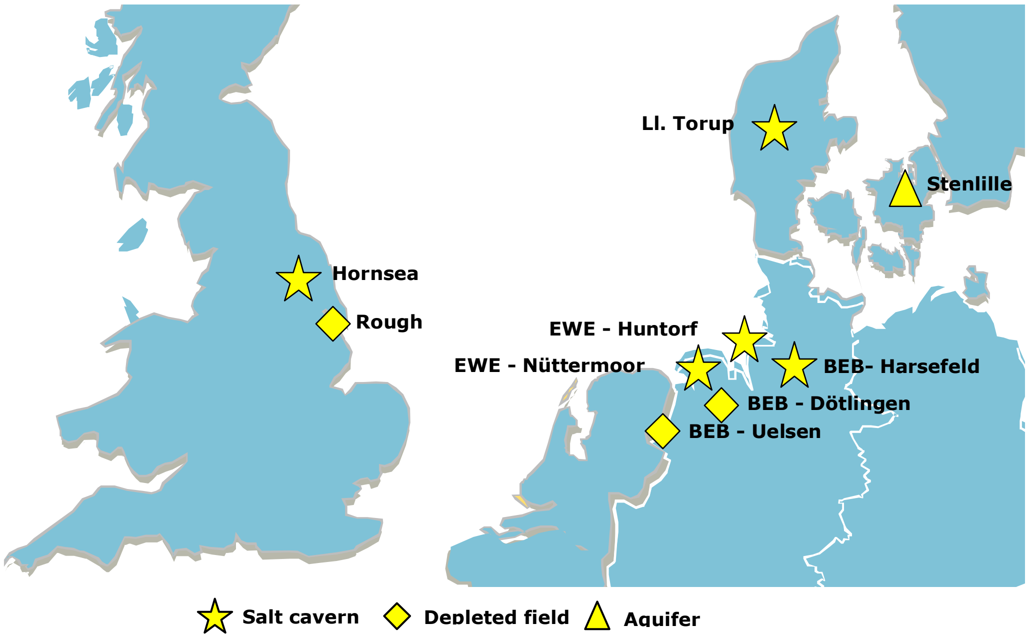
19.2.2 Standard storage products

In general, storage capacities are sold in bundles called standard bundled units (SBU); these SBUs contain a mix of volume capacity, injection capacity and withdrawal capacity. Often these SBUs are based on the restrictions of the specific storage, i.e. injection/withdrawal capacities as well as volume are constrained by some physical/technical limits of what the storage can technically deliver. If capacities are sold individually storage operators risk selling out one capacity before others and thus making the remaining two capacities useless to new customers, i.e. customers who have not already purchased all three capacities.[69]

Ramboll has evaluated some of the different storage products that are available in the north-western gas market.

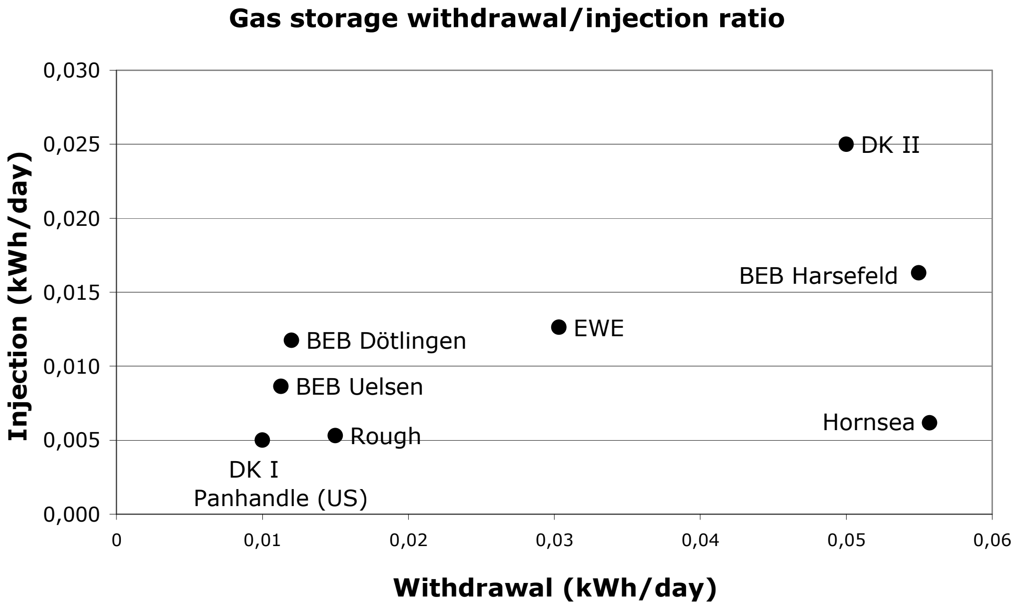
[69] E.g. buying volume capacity makes no sense unless it is possible to fill up this volume and empty it again, thus injection and withdrawal rates are necessary.

Figure 70 Storages evaluated (2007)



The different SBUs offered by the storage operators in north-western Europe are presented in Figure 71. As the figure shows, SBUs vary a great deal from storage to storage. Both within markets and across markets the products offered are very different. This could be an indication of the fact that storage products are not set in accordance to overall market needs but are more likely a product of the technical specifics of the storages. That is, if the variety of products offered by the storage operators were testimony to big differences in flexibility requirements of the shippers in the market, one would expect to see storages within the same region offering several products. Thus, the differences in products could be attributable to the fact that storage products are offered in alignment to the technical restrictions of the storage facilities with no or very little consideration to what the market may, in fact, require or demand.

Figure 71 Gas storage withdrawal/injection ratio per kWh of volume (2007)



Shippers may have quite different needs for storage flexibility depending on their individual demand/supply portfolio; e.g. some shippers may cater to households that use natural gas for heating and therefore require greater flexibility, while others may have a supply portfolio containing mostly imported gas or mainly industrial consumers requiring less flexibility.

Thus shippers in order to optimise their storage portfolio may have to buy storage products from different operators or alternatively they can buy it all from one operator and buy/sell necessary/excess capacity on secondary markets. Neither solution however is optimal because storage products bought from several storage operators may entail higher transaction[70] and administrative costs for the shipper, and possibly additional transportation costs. It may not even be possible to find storage operators within geographical vicinity that can accommodate the shipper. Regarding a secondary market for gas storage capacities, the market very often lacks the necessary liquidity.

If storage capacities are sold mainly in predetermined bundles, this may be an entry barrier for market players, who due to perhaps relatively small portfolios are somewhat subject to having a certain type of customers which may require a different combination of storage capacities than those offered via the SBU.

Allowing any possible combination of withdrawal, injection and volume capacity to be sold, i.e. abandoning the idea of offering storage products in SBUs and selling each capacity individually, could naturally cause a less than optimal utilisation of storage

[70] entry/exit costs

capacity, because storage operators would risk ending up with spare capacities. The use of SBUs is actually one of the recommended practises in the GPSSO. The advantage of SBUs is that products are more comparable and that storage operators are ensured that they always have a sellable product to offer, i.e. no missing capacities.

However, it is possible to combine the benefits of both systems. An example of this can be seen in the way the Danish storage operator Energinet.dk sells its storage capacity, see Section 19.3.2.

19.3 Optimising access rules and products

The (theoretical) advantage of introducing a more flexible and optimal SBU system is the possible increase in the total capacity of EU storages. This would be achieved by minimising excess capacities bought by shippers who have purchased excess capacity of one capacity in order to attain enough of another capacity. If the secondary capacity markets are not efficient and shippers are not able to sell the excess capacity, the usage of SBUs will most probably lead to a situation in which shippers purchase too much of one of the capacities, because they are obliged to purchase capacity in the preset SBUs. This could lead to allocation of capacities that is not optimal.

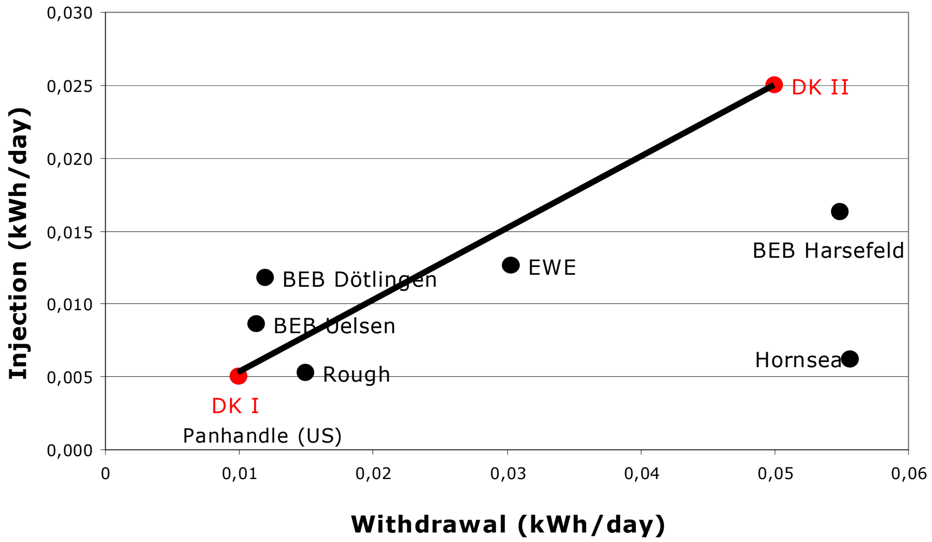
Secondly, two shippers with diverging needs for storage may be able to collectively obtain a mutually optimal capacity mix that will allow the storage operator to fully utilise his capacities. For example, a market operator who needs low volume capacity but high withdrawal and injection capacity (this would be a typical trader who optimises his portfolio on a daily basis) could 'co-operate' with a classic seasonal operator who needs high volume capacity but relatively low injection and withdrawal capacities. Obviously these two shippers could obtain the SBUs and then trade the excess capacities with each other, volume for injection/withdrawal. However, in order to do this, secondary markets need to be relatively liquid, which is not the case at the moment.

19.3.1 Offering multiple SBUs

One way of benefiting from the transparency and simplicity of the SBUs and at the same time adding some flexibility to storage customers in terms of offering a storage product that suits each customer’s requirements, would be to offer several different SBUs. More SBUs would allow storage customers to combine SBUs in order to attain the optimal mix of flexibility for their requirements. Figure 70 and Figure 71 show how adding a second and a third SBU to the product portfolio offered by storage operators would increase the range of options available to storage customers in order to optimise their requirements for storage flexibility.

Introducing two SBUs would allow shippers to optimise their flexibility requirements anywhere on the line between the two red dots in Figure 72.

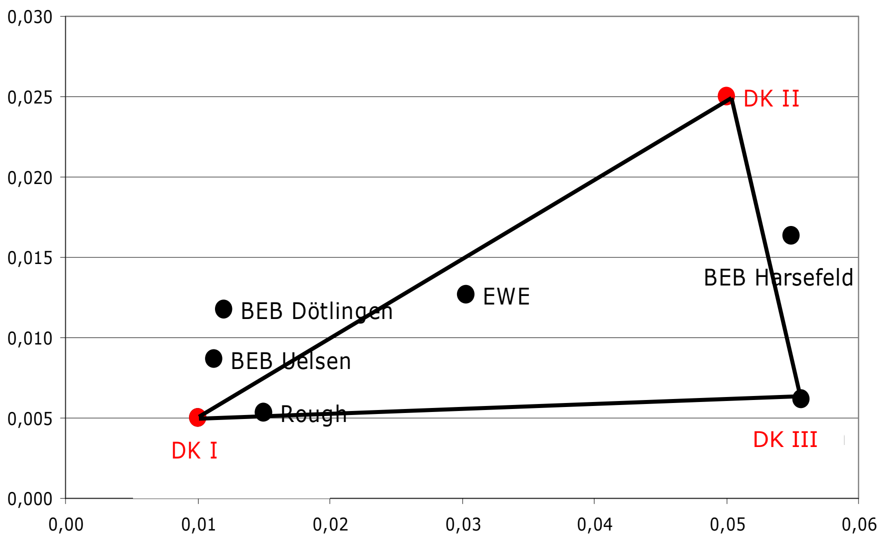
Figure 72 Introducing two standard bundled units



Introducing a third option would allow shippers to optimise their flexibility needs anywhere within the depicted product triangle.

Figure 73.

Figure 73 Introducing three standard bundled units



19.3.2 Experience of introducing flexible storage products (Energinet.dk)

The first year in business Energinet.dk[71] introduced a product triangle allowing customers to buy any mix of withdrawal and injection capacity they preferred within a product triangle similar to the triangle depicted in .

Figure 73. Thus Energinet.dk was able to offer its gas storage customers increased flexibility in terms of storage products by offering three different SBUs and was able to do so in the company's first year of operation. This is testament to the fact that storage operators are not necessarily restricted by technical constraints.

In its second year Energinet.dk changed its approach choosing to sell capacity using an auctioning principle. Storage product flexibility was increased even further, as it first auctioned a single SBU with a relatively low level of injection and withdrawal. After the auctioning of the single SBU Energinet.dk had two separate auctions for withdrawal and injection capacity. This allowed storage customers to purchase just the amount of injection and withdrawal capacity that suited their specific needs. This is another example of the fact that storage operators are able to construct mechanisms that allow storage customers to purchase flexibility products that are in compliance with their individual needs.

There may be drawbacks to the specific mechanisms used by Energinet.dk; e.g. the auctioning principle lacks transparency in terms of final price. Nonetheless, it demonstrates that it is possible to offer flexible storage products.

In order to optimise the products Energinet.dk has several forums every year in which the company presents its ideas and the thinking behind the ideas. It also invites customers to offer input with regard to flexibility needs; i.e. Energinet.dk constantly tries to optimise its services. This is in the interest of Energinet.dk, because the company has an incentive to create as much demand for its storage product as possible, which is not necessarily the case for vertically integrated storage operators. Although vertically integrated storage owners do benefit from maximising their storage units, the supply branch of the company may benefit if storage services are inaccessible and less transparent because this makes it more difficult for competitors to enter the market.

By offering different levels of flexibility, Energinet.dk has been able to assess whether there is varying need for flexibility amongst different customers. Experience so far indicates that in spite of the fact that customers do buy different levels of flexibility, demand for flexibility is not overwhelmingly varied. Another interesting fact that revealed itself when analysing the case of Energinet.dk is that Energinet.dk

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[71] Two years ago Energinet.dk bought one of the two Danish storage facilities, the Ll. Torup facility, which is a salt cavern storage. Energinet.dk is the independent Danish TSO (for both gas and electricity) and, compared with most EU storage operators, is an independent operator, in the sense that it is not a vertically integrated company, as it does not have production. Energinet.dk has some obligations in terms of security of supply and therefore does buy gas for emergency purposes.

has experienced a huge elasticity in the demand for storage products; i.e. the level of demand may change comprehensively from year to year. This may be due to several factors, like differences in spreads between summer and winter prices, sales mechanisms, changes in customers' flexibility portfolios, increasing storage capacity availability etc. Regardless of the reason for the variations in demand, this flexibility in demand should be countered by a large flexibility in supply to allow supply and demand to always be synchronous. Increased supply flexibility could be provided by offering customers standardised contracts with different contract lengths.

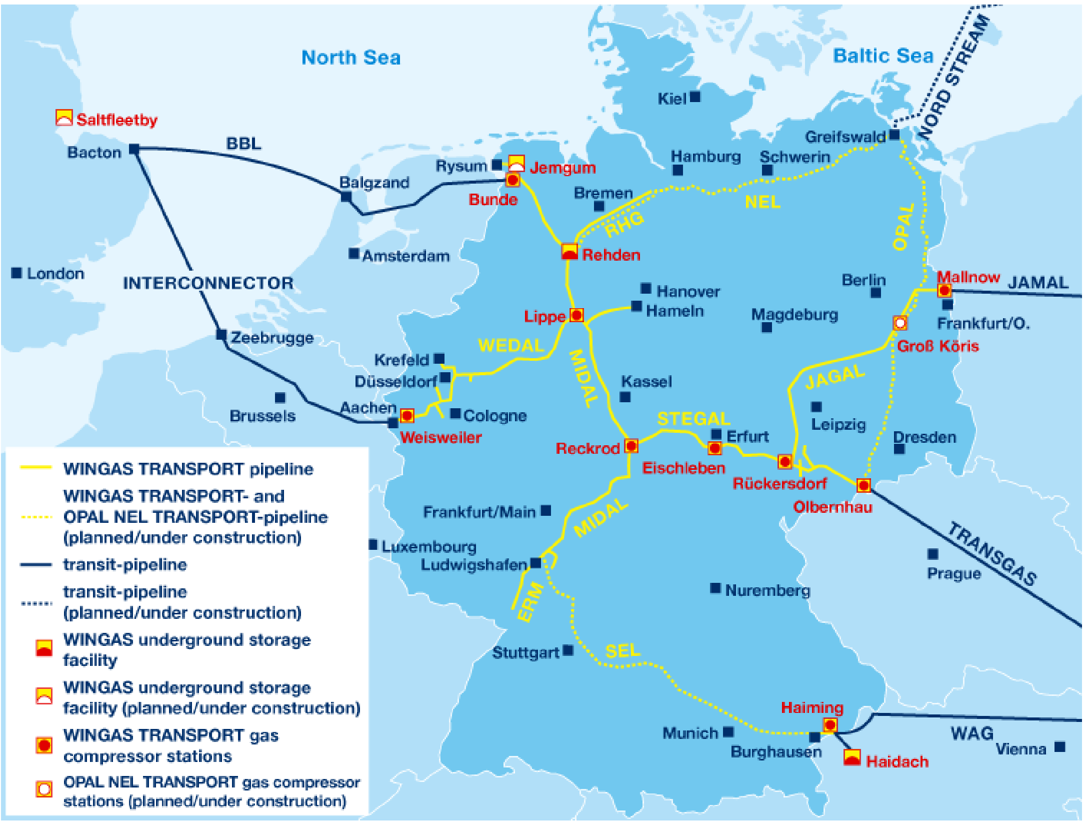
The lessons that can be learned by the review of the Energinet.dk case are that it is possible to offer different and flexible products and that demand for different products exists, but storage operators do not need to find ways to offer products that are radically different. Furthermore, if storage operators opt for only one flexibility product, it is important that this product is in line with market demand. A deeper understanding of market demands could be achieved through customer forums.

19.3.3 Experience of introducing flexible storage products (Wingas)

Depleted fields are in general considered less flexible than e.g. salt caverns, thus the argument could be raised that flexibility in storage products can only be provided by storage operators with salt cavern storages.

The German gas company Wingas operates, amongst others two gas storage facilities, the Rehden facility in Germany, which is the largest storage facility in Western Europe with 4 bcm of working gas, and the Haidach facility in Austria with 2.4 bcm of working gas. Both storages are depleted fields. As can be seen from the below map the storages are situated far away from each other and thus supply two different parts of the European gas market.

Figure 74 Rehden and Haidach storage facilities



Source: http://www.wingas.de 2008-10-07

When analysing the products offered by Wingas in two of Europe's biggest depleted fields, we see that some level of flexibility is possible also for operators of depleted fields. The below table shows the products that are available to gas storage customers at the Haidach and Rehden facilities.

Table 17 Storage product offered for the Rehden and Haidach facilities

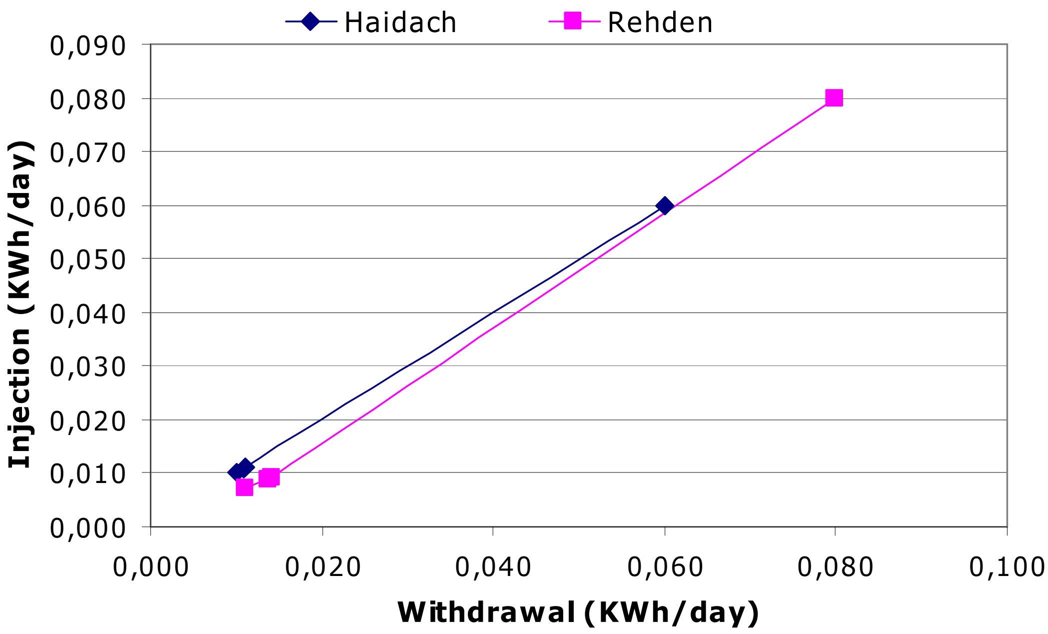
Haidach Storage facility		
PACK	a) Injection rate:	10.00 kWh/h
	b) Withdrawal rate:	10.00 kWh/h
	c) Working gas volume:	22,000.00 kWh
	Units available:	180,375 bundles
	Minimum booking:	2,000 bundles
ADD	a) Injection rate:	up to 2.0% in addition to WINSTORE® PACK
	b) Withdrawal rate:	up to 2.0% in addition to WINSTORE® PACK
	c) Working gas volume:	up to 8.0% in addition to WINSTORE® PACK
PART	a) Injection rate:	10.00 kWh/h
	b) Withdrawal rate:	10.00 kWh/h
	c) Working gas volume:	4,000.00 kWh
	Units available:	37,740 bundles
	Minimum booking:	1,000 bundles
Rehden Storage facility		
PACK	a) Injection rate:	6.50 kWh/h
	b) Withdrawal rate:	10.00 kWh/h
	c) Working gas volume:	17,500.00 kWh
	Units available:	2.15 Mio. bundles
	Minimum booking:	2,000 bundles
ADD	a) Injection rate:	up to 2.5% in addition to WINSTORE® PACK
	b) Withdrawal rate:	up to 2.5% in addition to WINSTORE® PACK
	c) Working gas volume:	up to 23.0% in addition to WINSTORE® PACK
PART	a) Injection rate:	10.00 kWh/h
	b) Withdrawal rate:	10.00 kWh/h
	c) Working gas volume:	3,000.00 kWh
	Units available:	35,000 bundles
	Minimum booking:	1,000 bundles

Source: http://www.wingas.de, 2008-10-07

As Table 17 shows the two storage facilities offer 2 different products, PACK and PART. The PART product is the high flexibility product which offers approximately 6 times more injection and withdrawal per unit of volume. Further an add-on product is offered, ADD, which allows for storage customers to optimise the PACK product by increasing injection, withdrawal and volume separately in addition to the PACK product.

Offering customers to choose between two main products a high flexibility project and a low flexibility product in essence allows customers to optimise the storage flexibility by combining any number of high flexibility bundles with low flexibility bundles. This allows customers to pick any point on the two upward sloping lines depicted in Figure 75. The markers indicate the different products available.

Figure 75 Flexibility offered at the Rehden and Haidach storage facilities



Source: http://www.wingas.de, 2008-10-07

19.3.4 Storage products and storage investments

Optimal storage products will only be offered in a competitive market. If investments in storage are curbed, because of high level of uncertainty as was discussed in section 1, then the incentive for storage owners, to offer flexible products crumbles, and shortage in storage capacity will leave storage customers with no choice other than to buy what is offered. Thus, an investment climate which is hampered by uncertainties and a non-optimal regulative climate risks, may lead to too little investments, which in turn may reduce flexibility in the existing storages.

Thus from a product point of view, ensuring a sound investment climate i.e. ensuring that sufficient investments are undertaken, is also a key issue in terms of securing flexibility in storage products.

19.4 Virtual storage

In this section, when referring to virtual storage, it is not the purely financial definition that applies, but a 'virtual' compilation of multiple physical storages operated as one single storage facility.

Storage operators with several storage facilities may be able to offer several bundled units by combining their services from several different storage facilities. That is instead of operating different storages independently, storage operators with several storage facilities within the same area may offer their services as several different SBUs from only one virtual storage facility. This would allow storage operators to continue to customise SBUs in relation to the technical constraints but would allow shippers to optimise their portfolios by dealing with only one 'storage operator'.

A system somewhat like the system that is available for transmission in Germany could perhaps be created. This system for transmission implies that shippers only have to contact one transmission company in order to book capacity throughout the entire German system, which consists of several transmission operators. Storage operators that own and operate several storage facilities could be required to offer their storage services as virtual services as well, if the storage facilities are situated within the same market.

19.5 Access rules and the third package

As was also mentioned in the previous section on ownership the 'Third Package' proposes a series of initiatives intended to ease the access to storages. On an overall level these initiatives are supported by the Consultant as they will increase competition, transparency, deal with congestion management, create legal unbundling etc, all initiatives that should have a positive impact on the storage market.

However one issue will not be a part of the 'Third package'. The issue of flexible products will not be dealt with as this is not a part of the GGPSSO or of the other proposals in the 'Third package'. In order to ensure that the products offered by the storage operators the GGPSSO should be amended in order to ensure that products offered by the storage operators are in line with the needs of all market players. Ensuring legal unbundling is a step in the right direction but it is not probable that this measure will ensure that gas storage products will adapt in order to meet the requirements according to the discussion made above, and thus secure that the gas storage market will be meeting all the flexibility requirements posed by the different shippers in the market.

The consultant thus proposes that the gas storage operators are required to ensure that the flexibility products they offer are in line with flexibility products required by the market. As the 'Third package' already proposes to enhance the powers of the national regulators in terms of overseeing access to storage, these powers could also include the powers to oversee that flexibility offered is in line with demand for flexibility.

19.6 Exemption from TPA

The importance of transparent and non-discriminatory third-party access to storages is unambiguous. Storage remains the main flexibility tool for gas market participants. Having no access to storage can imply balancing penalties for shippers/suppliers and thereby increased gas transmission costs. Being unable to balance portfolios and therefore consequently being in imbalance can lead to the market participant loosing his license (Denmark). Furthermore, few Member States, e.g. Poland and Italy, require suppliers of imported gas to maintain gas in storage corresponding to a certain share of their portfolio. No access to storage would act as a direct barrier to the market for these aspirants.

The Gas Directive provides the following reasons for granting an exemption from TPA to existing storage facilities:

- Under both the negotiated and regulated regimes**,** storage operators can only refuse access to the facility on the basis of lack of capacity.
- Where the access to the facility would prevent them (the storage operators) from carrying out their public-service obligations[72]; or
- Where the access to the facility would cause the storage operator serious economic and financial difficulties as a result of take-or-pay contracts being in place

The PSO is anchored in the Directive 2004/67/EC concerning measures to safeguard security of natural gas supply, which is then transposed into national legislation. The interpretation of the directive and its implementation, as well as the resulting PSO obligation for storage, varies widely throughout EU Member States.

It is important, however, as recommended by the GGPSSO, that the amount of storage exempted from TPA be published and the reasons be clearly indicated. The GGPSSO also requires that parties responsible for PSOs demonstrate that they do not use more storage than is required to meet their PSO obligation.
Exemption from TPA to existing storage facilities should be approved by the national regulatory authority.

19.7 Summary, conclusions and recommendations on access rules

Whether an access regime is negotiated or regulated in a competitive market is of less significance, what matters is transparency. The general rule is that in competitive markets, access should be negotiated, and markets, with no or weak competition, are better off with regulated access.

The rules regarding regulated and negotiated access regimes may though need some further specification as they are less clear today.

There is quite clearly scope for further analysis of the commercial access rules and how they are regulated in the EU storage market.

Storage and storage products are optimised to function in a pre-liberalised market world; this could create difficulties in terms of making sure that storages operate and supply in a manner that ensures that the products and market flexibility also facilitate competition and an efficient usage of storages.

Most storage operators offer only a single SBU to the market. This creates a relatively transparent market, although different storage operators often use varying calibrations, i.e. the bundles offered are not of the same size in terms of volume.

[72] Furthermore, the TSO is allowed to exclusively reserve storage facility or a portion of it for carrying out its functions.

This makes it more difficult to compare prizes and products. Ramboll would suggest that an overall EU map of available storage products is created in line with Figure 71. Further, a principle of prices could be added: for example, a system where the most expensive bundle is indicated by a red dot in the graph and the least expensive by a green dot; all the bundles in between would then receive appropriate red/green colouration

Further, storage operators that are part of a vertically integrated company may have preferences for the flexibility of the product they offer, which differs from the flexibility requirements of especially new market entrants. Thus vertically integrated players may choose to offer only a single SBU that is in line with their own needs as opposed to the overall demand for flexibility in the market.

In a market that is becoming increasingly dependent on flexibility from storages, both in terms of storage for seasonality and for daily trading, the access rules in terms of available storage products will also become increasingly important. Thus ensuring the appropriate balance between transparency and flexibility is significant, both to allow for increased market integration and development in terms of portfolio optimisation and trading as well as removing any market barriers in the form of availability of the right flexibility products for new entrants.

We recommend that the issue of aligning supply of storage services with the demand for storage services is promoted. The issue of storage products should thus be further analysed and possibly incorporated in the next gas directive. It could be made the responsibility of the national regulators to oversee the flexibility of the supply offered.

The presented examples show that it is possible to create new and more flexible products but products should be created in cooperation with customers.

SECTION 5 COST OF GAS STORAGE FACILITIES IN THE EUROPEAN UNION

Due to the nature of the gas storage industry access to cost data is opaque at best. Companies do not have any incentive to share such information and as a result in addition to problems of standardising the cost of storage facilities with unique geological characteristics, there exists an additional problem of sparse tangible data from which to draw any conclusions. Thus average investment figures should be treated with caution and not seen as definitive.

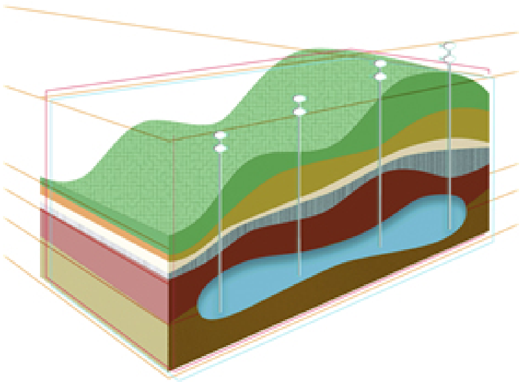
In order to evaluate investment in gas storage and ascertain primary costs involved in such storage creation we need to understand investment through an evaluation of the structure of the principal costs associated with the creation of the various forms of gas storage and both the technical advantages and economic incentives which different types of storage can provide investors. Once principal investments have been delineated it may then be possible to extrapolate, through breakdown analysis, the primary investment drivers and their respective influence on overall costs.

20. Methods and economic characteristics of gas storage types

There are three principal methods of natural gas storage all with distinct economic and physical characteristics relating to their suitability from a commercial perspective, as storage facilities. The various technical characteristics of storage methods can lead to their utilisation for different operational functions, for example salt cavity storage can provide high withdrawal and injection rates but offer less impressive volume capacities whilst depleted reservoirs will provide significant volume capacities but poorer withdrawal rates. In order to generate an appropriate perspective of the investment costs it is necessary firstly to be aware of any advantages and disadvantages that are associated with each type of storage.

There are three principal types of underground gas storage principally in use in the European Union at present, depleted field reservoirs, aquifers and salt caverns and additionally recent years liquefied natural gas (LNG) has assumed a growing role in gas storage. With regard to LNG at present the considerable technical, economic and operational difficulties in the creation of such a form of storage have made such a method of storage more suited to a peak-shaving role and will not be discussed in detail in this chapter.

20.1 Depleted reservoirs



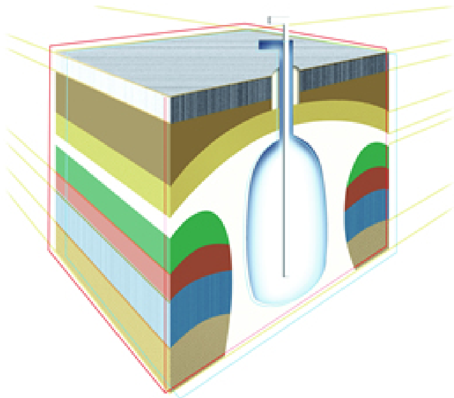
Source: Ecorpusa.com

Advantages
Depleted fields are the most commonly used method of storage in both the European Union and on a worldwide level. Depleted Reservoirs are natural formations that have already dissipated their recoverable natural gas reserves. The gas is stored in porous rock and is contained by water pressure from beneath. Such a form of storage has a number of attractive qualities, of principal note is the comparatively low economic cost of such storage units and for this reason depleted fields remain the most ubiquitous form of storage. Although certifying whether a structure is suitable for gas storage is an often complex process involving seismic exploration and geostatistics, depleted reservoir formations will provide greater confidence in their geological formations and suitability as containers for natural gas than other methods of storage, as having previously contained hydrocarbons the possibility of leaks is likely to be less. Depleted fields also commonly have an advantage with regard to reduced capital costs through technology such as existing wells and pipeline connections often remaining in place from the conversion from a producing to a storage field. Depleted fields are also often characterised by larger storage capacities than alternate methods of storage, for example the Rehden facility in Germany can store 4.2 bcm of gas representing one fifth of the entire storage capacity of Germany.

Disadvantages
Depleted fields are however limited by a number of negative aspects which while perhaps not as fundamental as the flaws of other forms of storage exhibit should still be reviewed. Depleted fields could be hindered as an investment through the substantial initial investment needed in cushion gas that is required in order for them to maintain functionality. On average cushion gas contributes to around 50% of the total capacity of a depleted reservoir and contributes to approximately 30% of the overall investment cost of such a facility. The significant volatility in cushion gas prices makes the potential investment in this form of storage a potentially risky investment proposition. Due to the long lead times that creation of any storage projects entails there can often be considerable speculation on the price of gas

options which is complemented by a notable lack of liquidity in the gas futures market. Such a dichotomy may lead to uneconomic decisions regarding the creation of storage. Depleted fields are also characterised by lower deliverability and injection rates thus making them unsuitable for dealing with short-term shifts in demand. The relative speed of withdrawal and injection tends to be fairly slow, for example Rough, an existing gas storage facility in the UK, is designed to fill in about 180 days and empty in about 70 days at maximum rates. Considering these weak withdrawal rates depleted field facilities tend to be more suited for seasonal swing balancing.

20.2 Salt cavities



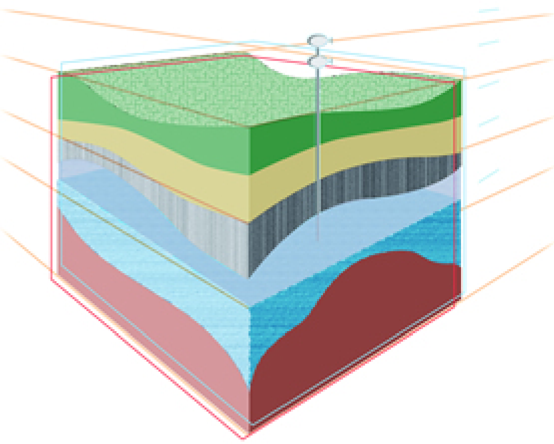
Source: Ecorpusa.com

Advantages

This form of gas storage is comparatively more recent in its adoption and has a number of qualities making it specifically suited to dealing with short-peak deliverability and injection. The development process is detailed as follows; salt is dissolved leaching with freshwater and removing brine through an exit well the salt is eventually dissolved and forms an underground cavity with walls that are impermeable thus reducing the risk of leaks. The principal advantage of this type of storage is the attractive injection and withdrawal rates such storages can facilitate. Rates of withdrawal and injection provide more technical dexterity as gas is being pumped directly into a large cavity in the salt layer rather than porous rock as in a depleted field or aquifer, the result is a typical cycle period of 10-30 days which is significantly less than that of an aquifer or depleted field. The salt cavity method is often attractive to investors seeking to exploit short-term price gains and has become more popular in liberalised markets where there is opportunity to exploit spot prices. For example the considerable development of such storages in the liberalised UK market, with 80% of planned gas storage projects being salt caverns shows this form of storage may have an increasing role to play in liberalised markets. The cushion gas requirements of such storages are another positive aspect of salt cavities as the ratio of cushion to working gas ratio is at approximately 20%, significantly less than that of aquifers or depleted reservoirs and provides good working-capital economics.

Disadvantages
Salt cavities do however have a number of drawbacks meaning they are specific in their capabilities and subsequently only suitable for particular tasks. The volume capacities of salt cavities are significantly less than that of depleted field reservoirs and aquifers, and they are often required to be close to significant volumes of water to be economically feasible as vast volumes are needed to leach initial cavities. The development and maintenance of salt cavities can be more costly than other forms of storage due to the expensive leaching process and the corrosive environment salt presents. However, the attraction of their multi-cycle options can reduce per unit costs of a given volume of gas injected. Salt cavity storage is also dependent on a number of geographical situations being satisfied and reliant on finding areas where the salt is significantly thick to create the initial cavities. Such formations are not an option for a number of European states with the preponderance of salt cavities being located in northern Europe as an analysis of the geographical distribution of storages shows. Finally, the operational costs of such forms of storage are generally high due to a number of factors including the higher pressure that such storage operates at, the corrosive environment that the cavities function in and the increased environmental regulation that such storage is exposed to.

20.3 Aquifer reservoirs



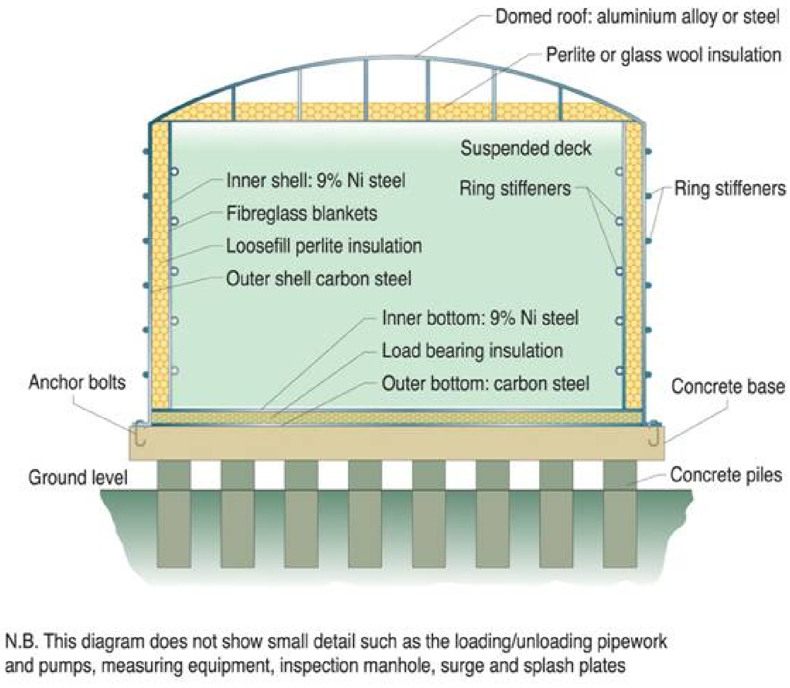
Source: Ecorpusa.com

Advantages
Aquifers work on the principle of injecting gas into the cavity of an aquifer formation. The volumes of such a method of storage are similar to that of depleted fields however the suitability of such reservoirs is dependent on a number of existing geological conditions being satisfied. The withdrawal, deliverability and cycling rates are also similar to that of a depleted reservoir.

Disadvantages
Aquifers are the least attractive type of storage facility due to the comparatively higher capex costs per unit of gas that such a method necessitates. The preliminary geological research that goes into determining the suitability of aquifers for storage

is often an intensive process and thus costly with the porosity, composition and pressure of the rock having to provide a suitable match otherwise the reservoir will remain unsuitable for gas storage. In addition to the determination of the geological suitability of the aquifer, it is also necessary to provide the associated infrastructure to facilitate storage which usually requires significant expenditure in the form of wells and compressors. Such extensive exploration and initial capital expenditure mean that an aquifer project usually has a longer development period than other forms of storage which can be, at up to four years, twice the development period of depleted reservoirs which provide similar levels of performance. Due to aquifers being full of water powerful injection equipment at considerable expense is often required to push down the remaining water and replace it with natural gas. There is also an issue with the cushion gas as there is no original gas in the cavity. Such a method often requires up to 80% of such gas which is unrecoverable following its injection. For the aforementioned reasons aquifers are often less preferable to the two previous forms of storage and used where salt and depleted storage facilities are unfeasible.

20.4 Liquid natural gas



(MJM Energy)

In recent years there has been significant gas storage investment in Europe in the liquid natural gas (LNG) sector. Higher volumes to both Europe and Asia have resulted in an 11.7% growth rate in trade. LNG works by the process of storing natural gas in liquefied form at below -162 °C. In this form liquid gas is 600 times less voluminous than vaporised gas. LNG is often adopted for purposes of 'needle peaking', due to its ability to provide high daily deliverability close to the market place at a relatively low cost. LNG is stored in peak-shaving units, the average capacity of such storage is variable but in Europe it is 126 mcm of natural gas converted from the liquid state. Such storage is often most suitable for areas where the storage needs are moderate or other forms of storage are not geologically possible. For the purpose of this study LNG storage does not include LNG stored in receiving terminals as this volume is constantly fluctuating and acts more as a pipeline extension rather than a definite storage capacity and as such there is considerable difficulty in calculating the European 'storage' value of the receiving terminals. A tendency could be made to overestimate the gas storage that currently exists in this form of storage as such gas is effectively always in transit and not storage.

Advantages
The principal benefits that this method of storage provides are very high rates of deliverability with the added benefit that none of the gas will leach away as the storage is not dependent on any pre-existing geological conditions. The average withdrawal rates are 9% of working volume per day at base load and 13% at peak. This is approximately four times that of a salt aquifer further demonstrating the peak load suitability of such a form of storage. Costs to make such plants remain high due to the extremely low temperature that gas in this form has to be stored at (-162°C). Such facilities can complement existing forms of storage to ensure that even in times of peak demand supply can be met.

Disadvantages
Due to the considerable energy cost involved in cooling the gas to the temperature required in order for it to become liquid, such a storage method is not feasible for large quantities or for significant periods of time, and so comparisons in the role of LNG as a storage provider with the more established methods of depleted field, salt and aquifers could prove quite desultory. Rather LNG should be seen to compliment existing gas storage infrastructure and provide peak shaving for periods of extremely high demand where it can be injected in large amounts into the system in short periods of time.

21. Investment and operational costs of underground storage

In this section the investment and operational costs of underground gas storages will be evaluated. The principal costs associated with gas storage are in the initial capital expenditure of the project with the cost levels of storage often being contingent with the type of storage created.

Investments vary significantly not only with regard to individual projects but also for each storage option. Unique factors such as the pre-existing geological conditions and differing technical standards ensure that there is no set investment cost for any type of storage. Costs are further obfuscated when the lack of data regarding actual storage costs in Europe is considered. Companies are often very reluctant to part with potentially sensitive information regarding the cost of storage facilities if information regarding such costs were in the public domain it may expose firms to part with potentially sensitive cost information the result of which could be to distort market competition and firm strategy or alternately lead to the facilitation of co-ordination in an oligopolistic market. It is neither in the firm's interest nor the market's to part with such information and as a result analysis of costs in different regions is not possible.

Listed below are the principal cost factors in the creation of each type of gas storage facility and the relative importance that they assume in the overall cost of the storage. There is no typical expenditure on each element for each type of storage, but as a general rule the capital expenditure involved initially in creation of the facility is far in excess of the overall operating expenditure. The table below provides a brief overview of the comparative cost drivers for each form of storage and where the investments differ the implications of these cost differences for storages will be discussed later in the chapter. LNG peak shaving facilities will be reviewed separately due to the composition and cost of such storage which differs greatly from that of the field storages listed below. Typically the high cost of liquefaction means that LNG peak-shaving facilities are rarely used for storage where other options are available, and are mostly their role is to provide security of supply on very extremely cold days, or in the case of a system failure.

Table 18 Cost elements for storage

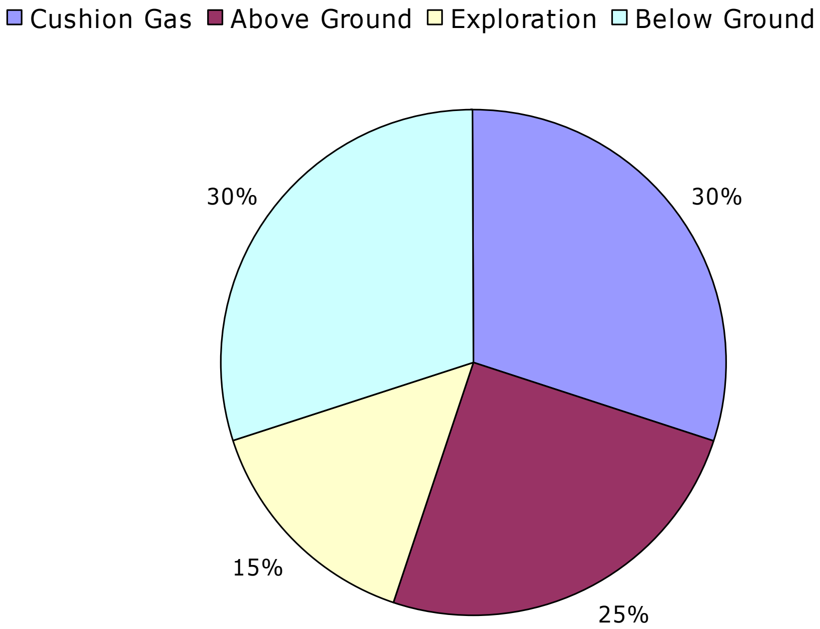
	Aquifer	**Depleted**	**Salt cavern**
Exploration	High Cost	Low Cost	High Cost
Above Ground Facilities	Similar Costs	Similar Costs	Similar Costs
Below Ground	High Cost	Low Cost	High Cost
Cushion Gas	Medium Cost	High Cost	Low Cost

Source: Study on Underground Storage in Europe and Central Asia, 1999

21.1 Investment cost component distribution

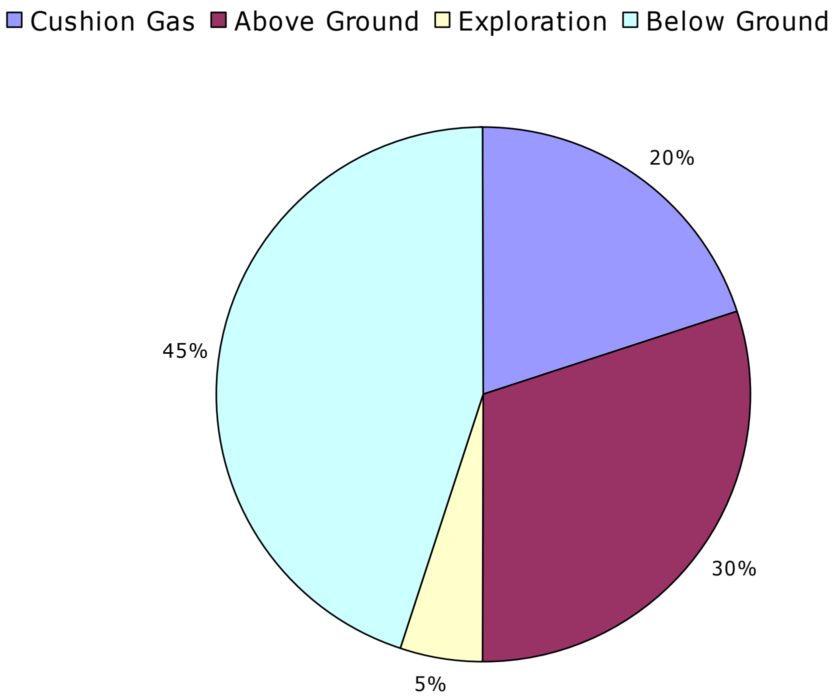
The charts listed below detail approximate values of the percentage share that each component of capital contributes to the total costs of the listed storage facilities.

Figure 76 Shares of investment cost distributions for aquifer fields



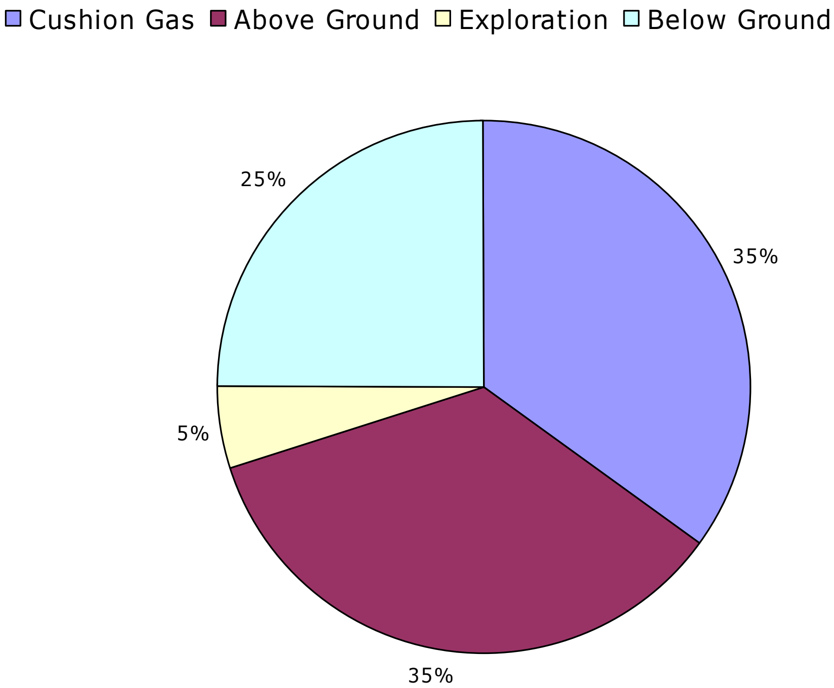
Source: Underground Gas Storage in the World, 2006

Figure 77 Shares of investments cost distribution for salt cavities



Source Underground Gas Storage in the World, 2006

Figure 78 Shares of investment cost distribution for depleted fields



Source: Underground Gas Storage in the World, 2006

From the above distributions it is evident that in salt caverns below-ground costs contribute to the majority of the cost of the storage. This is due to the expensive leaching process that is used initially to create the facility and the disposal of the brine that is resultant from this process. In depleted-fields-cost distribution the cushion gas cost and above ground costs constitute the majority of the cost.

Looking at the typical investment elements of gas storage types it is significant that for depleted fields and aquifers cushion gas will assume a much larger proportion of the overall investment costs.

The following table shows proportions of sub-surface and surface facilities in the investment costs for depleted fields and aquifers. As can be seen in the depleted fields, sub-surface and surface costs account for an equal distribution of the costs with the principal cost driver in the sub-surface being the cushion gas and in the surface the compression of the gas. In the aquifer structures, the sub-surface costs account for slightly more than the surface costs of the facility with the principal cost component being the wells of the storage.

Table 19 Cost Distribution

Storage Type	Share		Main Cost Driver	
	Subsurface	**Surface**	**Subsurface**	**Surface**
Depleted gas fields	50%	50%	**Cushion Gas**	**Compression**
Aquifers	60%	40%	**Wells**	**Compression**

Source: International Gas Union, 22nd World Gas Conference, Report of Working Committee "Underground Storage"

A more detailed breakdown of the investment elements of storage is produced below, which further delineates the differences that exist in the investment parameters of each form of storage.

Figure 79 Typical investment cost elements for underground storage facilities

Investment Elements	Depleted Fields	Aquifers	Salt Caverns
Wells	25%	33%	15%
Cushion Gas	30%	30%	12%
Dehydration	8%	7%	8%
Compression	16%	11%	18%
Piping (Above)	5%	4%	4%
Auxiliary Units	5%	4%	3%
Buildings	5%	4%	6%
Others	6%	7%	2%
Leaching			32%

Source: (International Gas Union, 22nd World Gas Conference, Report of Working Committee 2 Underground Storage)

The below table provides evidence of the technical comparative advantages that each type of storage possesses the same volume of working gas, i.e. 500 mcm.

Table 20 Example of working storage technical parameters (example taken from US fields)

	Dep.field	Aquifers	Salt cavity	LNG
Total gas (mcm)	900	1075	725	35
Working gas (mcm)	500	500	500	32
Cushion/Working Gas	80%	115%	45%	9%
Pressure (bar)	150	150	150	1
Compressor capacity MW	30	30	32	NA
Input mcm/day	2.4	2.4	5.0	0.35
Filling time (days)	208	208	100	91
Delivery mcm/day	7.2	5.4	23.8	5.0
Output duration (days)	69.4	92.1	21.0	6.4
Full cycle time (days)	278	300	121	98
% of cushion gas initially in place	25%	0%	0%	0%

Source: Cedigaz, 2006

The most significant differences from an investment perspective are the cycle time, cushion/working gas ratio and the daily delivery that each form of storage can provide. From the table it is obvious that salt caverns enjoy the greatest degree of versatility enhancing their value. Looking at both the cycle time and daily delivery salt cavities show considerable flexibility and can also combine this flexibility with a lower ratio of cushion/working gas, though these advantages come with an added capital investment cost as mentioned previously. Aquifers and depleted fields provide a comparatively equal level of performance with aquifers being significantly more costly in their initial investment for this similar level of performance.

21.2 Component cost analysis macroeconomic perspective

Capital expenditure costs include the exploration costs associated with the storage, the cost of the land, drilling services for both injection and withdrawal capabilities, piping to link the storage to the network, cushion gas and leaching and disposal of brine (for salt cavities).

As projects usually have a long lead time, which can be up to 8 years, the cost of capital in the industry assumes a major role. Such costs will differ significantly from project to project with initial investment factors being dependent on issues unique to each project, including the depth of the structure, volume of the proposed facility and the porosity or permeability of the storage.

The volume of a proposed storage is relevant as larger storage facilities will yield economies of scale which in turn lowers the unit investment costs, whilst the porosity and depth of the facility relate to the pressure issues and the ratio of cushion gas to working gas which also assumes critical relevance from an investment point of view.

The location of the facility is another principal issue for any potential investor with storage facilities being optimally located where there is no extensive additional pipeline needed to link the storage to existing gas transmission networks. Salt cavities are particularly affected by their location as a large amount of water is required in order to leach the cavity, and during this process there are significant amounts of brine to be disposed of. As a result of such disposal these facilities are at a considerable economic advantage if they are located near a large body of water.

21.3 Capital cost index developments

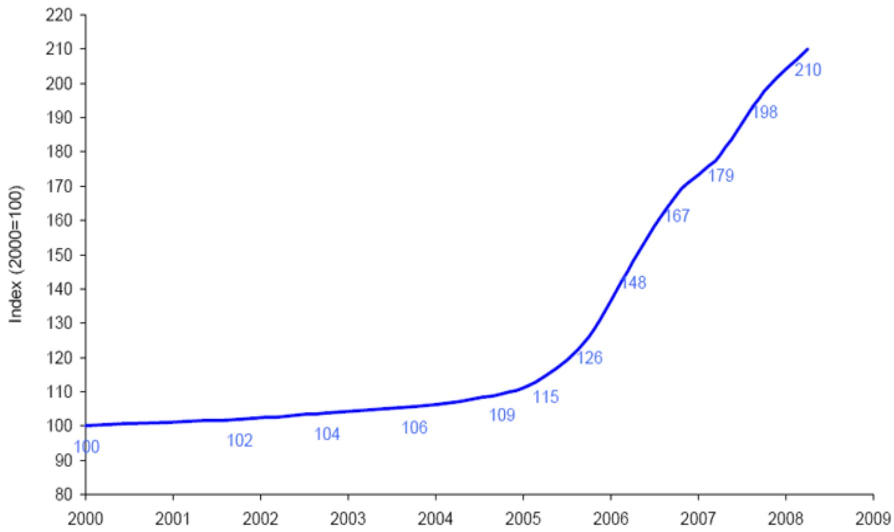
Although the cost of an individual storage can be difficult to discern there has in recent years been a pronounced increase in the overall costs of creating all forms of natural gas storage.

The diagram below shows the significant increase that has occurred recently in the capital costs for creating gas storages. The index accounts for the increases in capital costs including the equipment, facilities, construction materials and personnel. Reviewing the index it is evident that in the past six months alone costs have increased 6% and have doubled since 2005, meaning that a piece of equipment that cost €100 in 2005 would cost €210 today. These increases have been driven in part by the rising costs for the raw materials and transportation needed to create such storages. Raw materials such as the iron ore that is needed to produce steel have increased considerably partly due to the lack of major discoveries of iron ore deposits needed to create the steel initially, for example in 2008 alone prices were seen to rise by as much as 60% in the steel industry.[73] Rising fuel prices have in turn drastically increased the shipping costs for the materials needed to create the storages.

[73] Analysis of steel price developments – Spring 2008, EEF 2008.

The dramatic cost increases in the market should have a marked effect on the strategic planning of companies, these higher costs, combined with an increase in gas prices may make some previously proposed projects uneconomical.

Figure 80 CERA Upstream Capital Cost Index



Source: Cambridge Energy Research Analysts, Upstream Capital Cost Index, 2008.

Reviewing the impact that such increases in cost will have on gas storage it would seems that all forms of storage will experience a marked increase in their respective capital costs, however it is those projects that have high fixed capital costs, most notably salt cavities which will be principally affected. A salt cavity's cost distribution is dominated by the engineering cost as evidenced by the proportion that the below ground costs contribute. The considerable expense of the leaching process that is used to create salt cavity storages means that any increases in price will be most profoundly felt in this form of storage.

With a number of salt cavities planned particularly in the Northern region it will be interesting if these recent high costs alter or at least delay the proposed investments.

21.4 Cushion gas needs operational considerations

Reviewing the typical parameters of storage facilities as detailed below a primary variation that can be noted is the discrepancy existing in cushion/working gas ratios. Facilities are developed with either high or low cushion gas ratios which in turn results in three direct consequences:

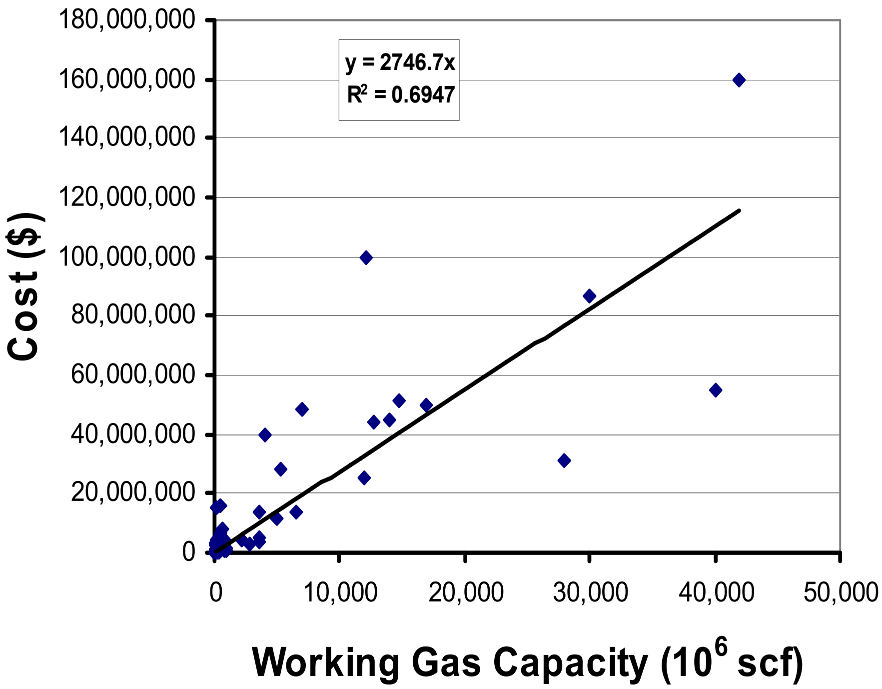
- The delivery rate of the gas is altered.
- Average injection rate is altered.
- Available working volume is changed.

21.5 Cushion gas needs Financial Considerations

The below graph shows the linear relationship that exists between underground storage working gas capacities and the overall costs of storage. A relationship can distinguished between the costs of the storage and working gas capacity, although there are couple of noticeable outliners whose position could perhaps be explained by the form of storage which is not determinable for this graph.

Although the graph exhibits the relationship between working gas and costs the relationship between working gas and cushion gas is proportional i.e., storages with larger working gas capacities will also have to have larger cushion gas capacities such a ratio is principally dependent on the geological qualities of the storages. The graph reveals that the cost of cushion gas will contribute to a significant proportion to the overall cost of the storage particularly for aquifers and depleted fields where the average ratio of cushion to working gas is around 1:1 and in salt caverns the ratio is typically 0.45:1.[74]

Figure 81 Cost of Underground gas storage as function of working gas capacity

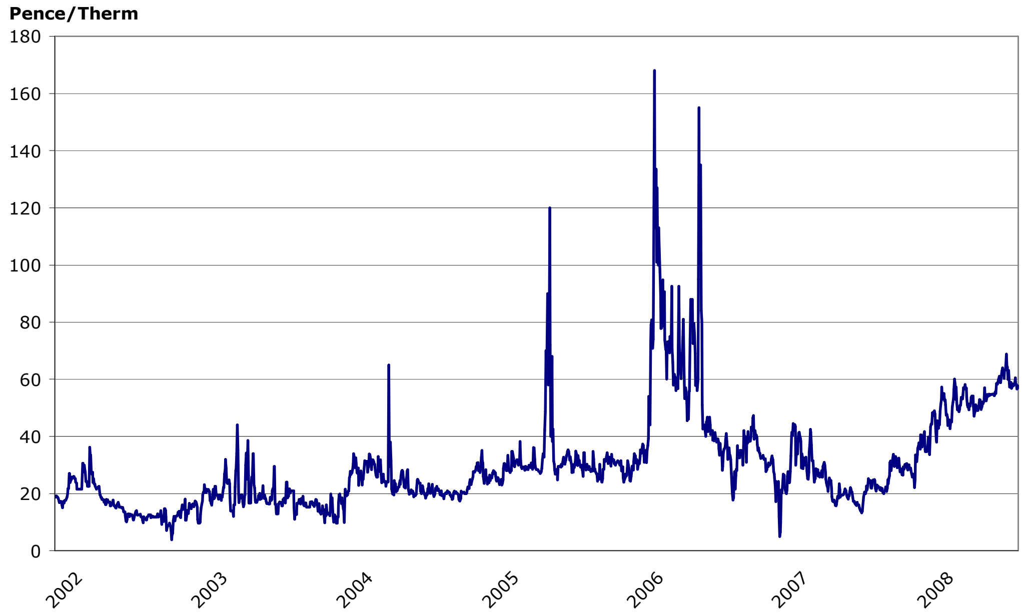


[74] Third Party Access to Storage and Flexibility: Progress Report, CEER, 2003.

Source: Argonne National Laboratory Transportation Technology R & D Centre, 2002.

The component of cushion gas is one of the most important elements in any gas storage project and as a commodity natural gas shows considerable oscillation in its price. Natural gas prices remain fairly stochastic with market forces dictating the price of natural gas through supply and demand. The past 18 months have been described by the International Energy Agency as "tumultuous" in terms of natural gas prices.[75] Gas prices have been at consistently high levels and shown considerable volatility throughout 2008. The high prices are driven in part by considerably higher oil price levels, cold weather and strong demand in particular for power generation. The graph below details the increased cost in natural gas over the past six years from the NPB hub which has been uniform throughout Europe and shows no sign of abatement.

Figure 82 NPB natural gas prices, pence per therm 2002-2008



Source: Reuters

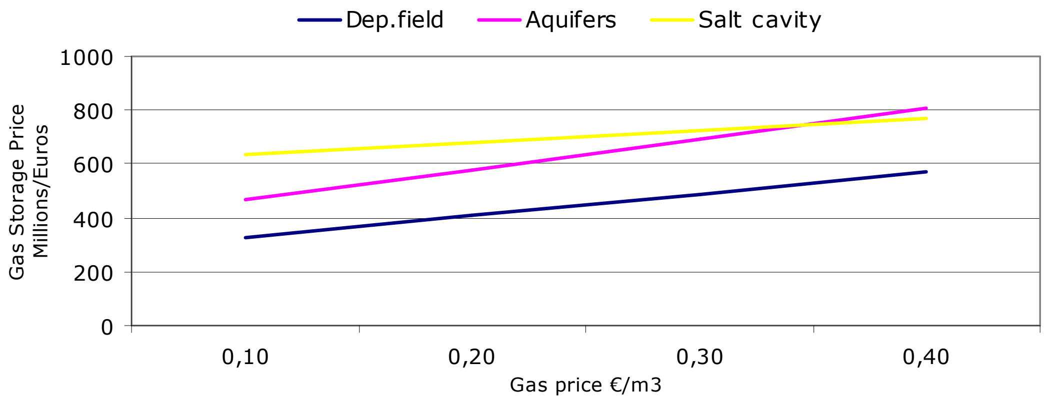
Evidently the present volatility in the price of natural gas will have repercussions in storage investment, particularly if such a pattern is maintained.

The figure below simulates the effect that an increase in gas prices could have on the overall cost and hence profitability of different forms of storage analysed above. It is evident that a continuing increase in the price of natural gas would lead to salt cavities becoming comparatively cheaper than aquifers per m³ of natural gas. This trend can be explained through the lower volumes of cushion gas that such a storage facility requires and the significant impact of cushion gas requirements on the overall

[75] IEA Press Office, 17/9/2008.

capital expenditure of gas storage facilities. Aquifers would also be affected by such a development as there is no cushion gas present to begin with in the creation of such fields, so such storage would be affected detrimentally by the increase in gas price. It should also be noted that an increase in price would lead to the investment attraction of salt cavity facilities further increasing with greater opportunities created for price arbitrage due to the superior withdrawal and deliverability rates that such storage can deliver.

Figure 83 Effect on storage price/millions of increasing gas prices



When investing in the storage facility considerable care must be given to the selection of an appropriate ratio of working to cushion gas that will enhance the commercial value of a facility. During such evaluation the essential dynamic that should be contemplated exists between the benefits of higher deliverability against reduced working gas volumes, injection rates and opportunity costs of the cushion gas. Depending on the storage operator's perceived role for the storage the cushion gas can be adjusted to accommodate their necessary specifications.

Although companies that are vertically integrated could be considered to have an advantage in the initial sourcing of the cushion gas the opportunity cost of the using the gas as cushion gas has to be considered and thus such an advantage may not be as significant as assumed. Such companies will have to sacrifice the income generated from the gas that could otherwise have been expected had they chosen to sell the gas on the market.

21.6 Wells and compression financial considerations

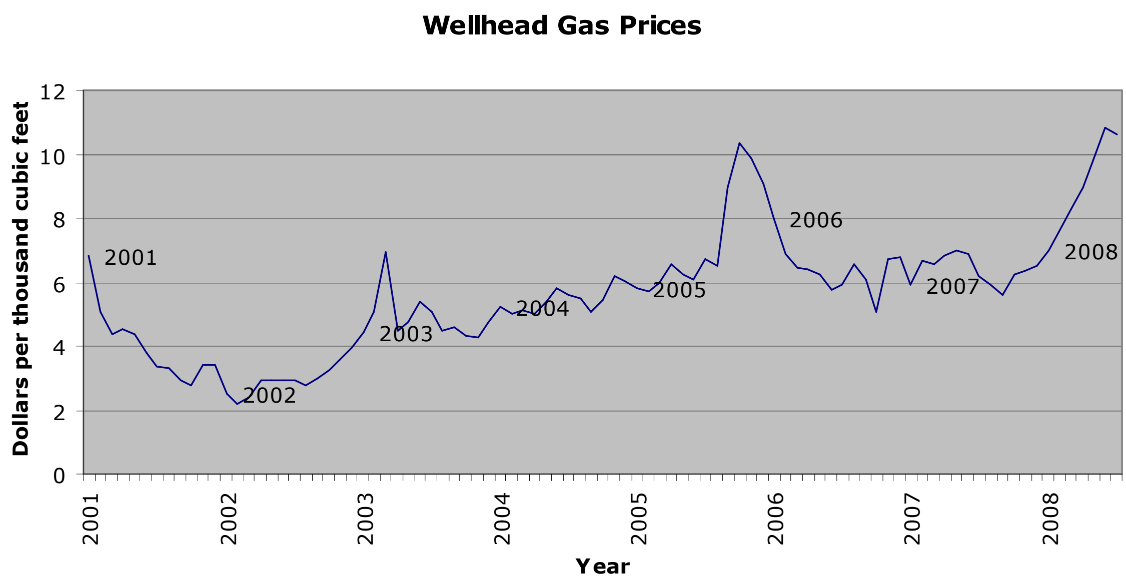
With regard to the wells and compression costs the storage depth and geological characteristics will affect the number, spacing and cost of the wells as well as the facilities cost. Well costs depend on specific technology, depth, location, the scale of the operation and the local regulations in existence. The cost of wells remains a major component with individual wells ranging in cost from approximately 135,000 EUR for onshore sites to 17 million EUR for offshore horizontal wells.[76] Obviously there is a considerable difference in such costs due to the differences in geological

[76] Bock et al, Economic Evaluation of Storage and Sink Options, DOE Research Report, 2006

characteristics of the proposed storage. The geological characteristics of the injection formation are a major cost driver with the reservoir thickness, permeability and effective radius affecting the amount of gas injection and subsequently the number of wells needed. The costs of the creation of such wells are highly correlated with those of the oil industry. In addition to the cost of the wells another cost that has been seen to increase is the cost in the supply of high pressure pumping services (for well stimulation and hydraulic fracturing) which account for about 30-35% of the cost of a typical gas well have increased by about 25% in the past year.[77]

The graph below shows recent increases in wellhead costs which include expenditure pertaining to exploration for the gas storage using seismic technology, the drilling of the wells to extract the gas and completion of the process of drilling the well. In the gas industry there has been a sharp rise in the costs of such drilling services.

Figure 84 Wellhead Gas Prices 2001-2008



Source: EIA, 2008

A convergence of factors has led to a shortage of supply in the drilling market. Principally this shortage has been driven by rapid increases in commodity prices, the result of which is that oil and gas industries have been competing to use the same equipment thus driving the costs of equipment and services.

The above analysis shows that the costs of storages are particularly sensitive to parameters such as cushion gas costs and the price of drilling, the cost of the wells and the physical properties of the reservoir. Therefore variation in any one of these parameters can lead to significant variation in the costs of natural gas storage making the task of ascertaining a set average cost for any form of storage difficult.

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What can be said with certitude is that the cost of producing such storages has increased noticeably in recent years, with cushion gas, wells and drilling services, the three principal components of any storage all pertinently increasing in cost.

21.7 Effect on storage market

With a multitude of the factors principally economic increasing the cost of creating storages the effects of these dramatic increases in cost should be postulated on the supply of storage and whether it could lead to a distortion in the investment climate. The cost escalation as evidenced may complicate the industry's ability to respond to higher prices with new supplies. Larger investments will not pay for themselves until the storage is well into its operation life. With upfront costs rising sharply and the costs of drilling remaining high it is seems axiomatic to assume that a number of projects may be cancelled or postponed. However economic theory suggests that rising prices for equipment and services would potentially lead to more investment in those areas picking up slack over the long term, but until the supply gap is bridged there could be rising prices which will ultimately be for the consumers.

It should be mentioned briefly that the present economic climate could, if sustained, result in a cessation of economic growth leading to a reduction in the competition for the commodities such as steel or facilities such as drills in the oil and gas industry, so the supply problem may be somewhat mitigated if current market conditions are sustained. However the result of the present crisis should lead to higher borrowing costs and more stringent borrowing terms will be expected, this will push energy companies to rely on their own balance sheets to finance investments such as gas storage which are often due to their lead times and reliance on fluctuating commodity prices considered as relatively risk burdened projects, this may result in less investments.

21.8 Cost estimates

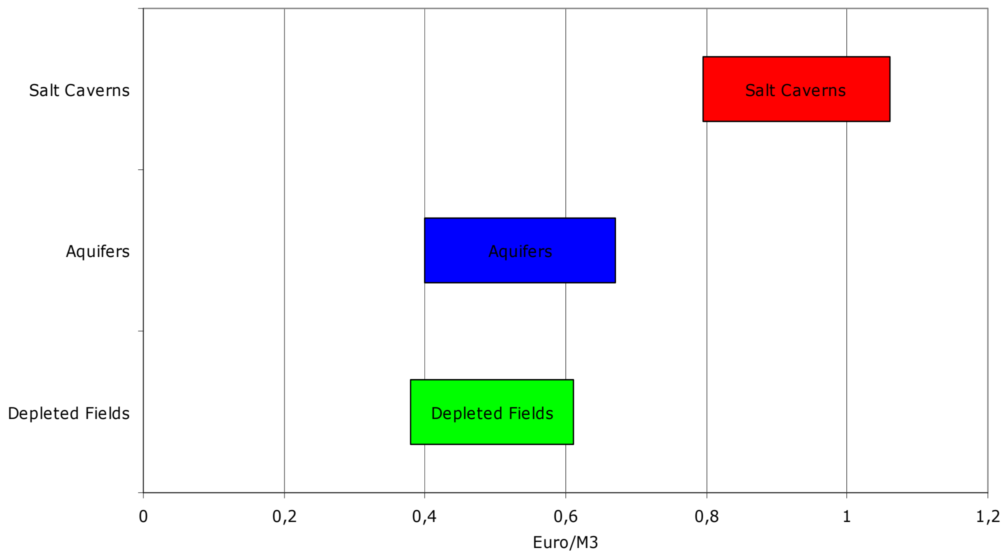
The cost estimates generated below are preliminary and cannot be upgraded until a specific site is designated then designed in detail and until quotations are received for the equipment required and the wells to be drilled. The individual wells cost estimation is dependent upon the equipment required and the number of wells that have to be drilled. The purpose of such analysis should not be for a definitive cost for a particular volume of storage, but rather as a scoping estimate for economic and business planning. Both the engineering and economic data that is used in cost estimation are subject to uncertainty, there is also obvious potential variations in unit costs as market conditions change.

Below is outlined a range of CAPEX costs for storage creation which were determined from examination of existing storages, previous economic storage studies, Rambøll's own cost estimations of proposed storages and present cushion gas prices.

It is seen that the development of salt caverns is significantly higher in cost than that of aquifers and depleted fields per m^3 of gas, though it should be reiterated that the multi-cycle capabilities of the salt cavity significantly reduce its unit cost, and that additionally such storage is often specific to investments where operators are looking to exploit the additional flexibility this type of storage can provide.

Aquifers remain more costly than depleted fields due to both the higher ratio of cushion gas that is required for such storage and the additional technical requirements that are needed in order for this type of storage to function.

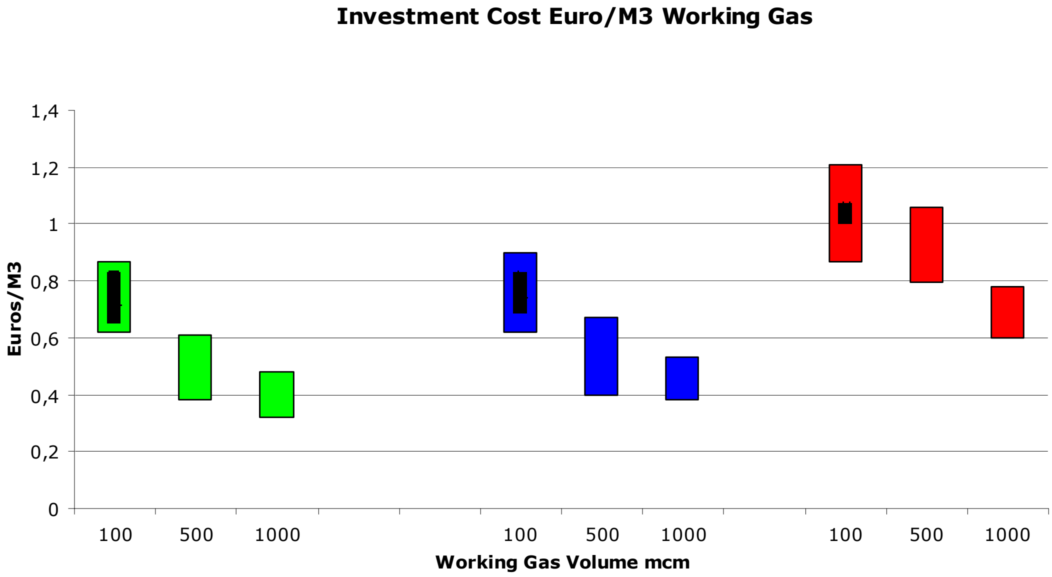
Figure 85 Average Capex cost of storage EUR/m³ for 500 mcm facility



21.9 Economies of scale

A more detailed investment cost range is presented below showing that considerable economies of scale exist for all forms of porous storage. It should, however, be mentioned that in the case of salt cavities there are additional risks that come with higher volumes as the geological and technical requirements become too strenuous due to the high operating pressures that such storages have to operate at and the expensive process of brining and leaching to create the cavern. It is also evident that, in general, depleted fields are the most economically efficient per m³ of working gas as mentioned previously as such structures combine less cost in terms of exploration with the advantage of utilisation of existing wells and capital such as existing cushion gas and certainty of geological conditions.

Figure 86 Investment cost EUR/m³ for different volume storages



When consulting the above figure it should be kept in mind that the cost of storage is dependent upon the utilisation of the storage. If the storage operator needs seasonal storage with greater working gas capacities then depleted fields or aquifers offer lower costs. However, if the operator is looking for peaking services and high withdrawal rates then salt caverns can provide the lowest cost per unit.

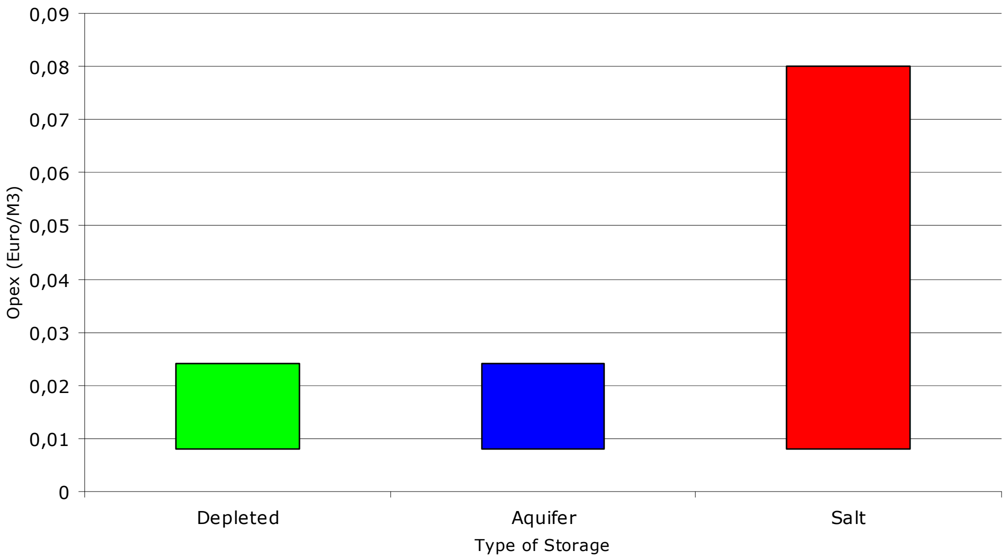
It should be reiterated, however, that there are exceptions as there is no such thing as a typical gas storage facility with these exceptions dependent on the geological and technical qualities of individual fields. For example there are types of depleted fields such as reef structures that are favourable in achieving higher levels of deliverability. The cost of working gas in depleted cells is often affected through a demand for higher deliverability due to more wells and compressor equipment being required to produce such levels of deliverability.

Another factor that can increase the value and hence profitability of a storage that cannot be simulated here is its proximity to a high-consuming area. For instance, if a salt cavern is located close to a high-consuming area then the cost of the storage is significantly reduced.

21.10 OPEX costs

Unit operation costs of a storage facility vary significantly according to the volume and depth of the storage. Exploitation costs of storage in porous reservoirs range between 0.008 USD/m³ and 0.024 USD/m³ and can be significantly higher for storage built in salt caverns. Storage builders are keen to minimise such costs to put themselves in a strong competitive position. The below graph demonstrates the OPEX expenditures per m³ for each type of storage.

Figure 87 Operating costs of storage by type EUR/m³



As the above graph demonstrates salt cavities show a much wider variation in the operating expenditure than either aquifers or depleted gas storages. This is due to the increased technical requirements that are required to operate such facilities which require higher pressures and increased levels of monitoring due to the fragile geological conditions that they are subjected to. In addition, the design of salt cavities differs to that of depleted fields or aquifers due to secure the high deliverability expected. For example comparatively more may be spent on aspects such as energy supply for the compressors in order to ensure that there are no supply disruptions due to maintenance issues.

The principal cost components for depleted fields and aquifers are labour 25-30%, maintenance 25-30% and fuel energy consumption with 25-30%. Salt cavities are subject to somewhat higher maintenance rates as additional concerns such as environmental regulation and the corrosive quality of salt have to be considered making the associated maintenance costs higher.

With regard to the expected lifetime of storages this is largely contingent with the type of storage and the individual geological and technical characteristics of the storage. With increased lifetimes of storages there may be detrimental effects on the operational abilities of the storages, this may occur for a number of reasons including reservoir compaction, hysteresis and the relative capillary and permeability aspects of the storages. It is expected that the vertical reservoir compaction of storages will be in the region of 5% over a lifetime and part of this compaction will remain irreversible leading to a loss in storage capacity, and in addition and perhaps of greater relevance is that the permeability of the reservoir may decrease. At present gas storages are designed for approximately 30 years however when maintenance is stopped the storages degrade quickly therefore continuous maintenance is required to prevent 'mothballing'. Extended exploitation, tail end gas production and tight gas developments may all lead to an extension of the production profiles supported by low cost development and production technologies. As an example of the potential lifetime of well maintained and operated storage the Tvrdonice complex in Czechoslovakia has been operational since 1973 with the latest phase of modernisation and construction completed in 2005, this operation period is more impressive when the geological characteristics of the well are considered which require a relatively high number of exploitation and monitoring wells.[78] Due to the corrosive nature of salt and the higher pressures at which salt caverns operate at the lifetime of such storage could be expected to be less, such formations are prone to a reduction in volumes under certain pressures and circumstances. As the depth of the cavern increases the differential stress and the temperature affecting the cavern walls increases causing the salt to undergo increased deformation and corrosion, however this rate of corrosion is dependent on site specific characteristics and cannot be accurately predicted.

21.11 Withdrawal and Injection

In an effort to further understand the underlying costs for gas storage owners it is necessary to review the costs to store natural gas. One of the principal challenges that new entrants to the European gas storage market face is that of a general lack of transparency regarding both the price and valuation of storage. This is accepted throughout the industry and is a matter that the European Commission has endeavoured to address however at present there still remains considerable difficulty in collating the data which can be selective and obfuscate any tangible meaning. Gas storage facilities do not supply gas direct to the end consumers their role is typically characterised as facilitating the storage of gas for gas shippers and suppliers promoting the delivery of gas into the system at times of peak demand or withdrawn from the network and reinjected at times of lower demand like summer. In comparison to the capital costs of storage the injection and withdrawal costs are notably lower of but show a considerable degree of heterogeneity with a number of pricing mechanisms currently in use throughout Europe. Trying to analyse such data on a country by country comparison is challenging as the considerable differences that exist could be in part due to what particular operators include as withdrawal and injection costs. Differences could be due to any number of underlying conditions including the size of the gas market as measured by total demand with larger demand contingent with higher cost and the reporting methods for such costs. It is highly likely that in Romania for instance other charges are applied that are not available in the public domain. The table below shows the data available for a selection of fields in Europe, all fields are sometimes not applicable or discernable from the available data, but for each type of storage a total annual cost has been generated.

[78] RWE storage website

Table 21: Total Annual Costs Gas, Injection and Withdrawal 2008.

Storage Name	Location	Injectability Cost Annual (Million Euros)	Delivery Annual Cost (Million Euros)	Total Annual Cost (Million Euros)
Rehden	Germany	3.971	7.156	12.487
Rough	United Kingdom	N/A	N/A	7.101
Sarmasel	Romania	0.230	0.294	0.756
Zsana Nord	Hungary	1.089	0,369	8.209
Chiren	Bulgaria	N/A	N/A	1.601

Source: Published Company Tariffs.

It is evident from the above table that the cost of storage differs significantly on a national level, all costs are based on depleted fields so as to ensure that the differences generated cannot be purely based on the technical characteristics of the storages. In general South Eastern Europe is shown to have significantly lower annual costs per mcm for its storage, although the rates displayed are also reflective of regional market conditions which may heavily influence costs.

Table 22: Storage Cost Euros/mcm

Ranking	Country	Name	Cost Euro/mcm
1	Romania	Sarmasel	4.28
2	Bulgaria	Chiren	9.07
3	UK	Rough	40.21
4	Hungary	Zsana Nord	46.47
5	Germany	Rehden	70.71

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21.12 LNG Peak Shaving

Due to the differences in cost, volume and role that LNG peak shaving facilities play in gas storage in Europe they are not directly comparable to that of the more common field methods of storage.

The first difference is that such storages are not designed to accommodate significant volumes, according to the GSE database the average volume of the four new LNG facilities planned in Europe is 0.175 BCM, in terms of usage for strategic storage their impact would be negligible. Finally the cost differences between LNG peak shaving and other forms of storage are vast, at present it would be totally uneconomical to consider such a form of storage as fulfilling a substantial role in security of supply on a European level.

21.13 Cost of LNG Peak Shaving

In terms of cost LNG facilities are widely disparate dependent on their technical characteristics and there is at present very little tangible information at present with regard to the cost of both proposed and existing facilities. Often the figure that do exist on such facilities include the cost of the liquefaction and shipping of the LNG making the storage cost difficult to determine. According to the EIA (Energy Information Administration) the costs of regasification terminals can range from 77 million euros to 1.5 billon euros dependent on the site specific requirements with storage tanks often being subject to country specific regulatory requirements which may inflate the cost somewhat.[79] A recent 140,000 m³ (84mcm) expansion at the Zebrugge terminal in Belgium was quoted in industry publications to cost in the region of €165 million whilst a similar storage expansion in Spain at the Bilbao Bahia LNG terminal of 150,000m³ (90mcm) cost €120 million.[80] The cost of the provision of 1 bcm of storage could be estimated at around €1.5 billion, at present such high costs mean that LNG is at present limited to a peak shaving role or provision of storage where other methods are not geologically feasible.

22. Conclusion on storage investment costs

Gas storage is fundamentally a costly enterprise, with the respective investment components of each form of storage all having been exposed to considerable commodity inflation and subsequently an overall increase in storage costs in recent years. What effect this sustained increase in prices will have on investment is difficult to envisage, however it seems that if these costs continue in their present upward trajectory it would not be unreasonable to postulate upon the delay of a number of projects and even their cancellation.

Salt cavities remain the most costly form of field storage at approximately €700 million per BCM whilst depleted fields cost approximately €400 per BCM of storage, though due to the unique nature of each storage project the costs are likely to oscillate from this estimation making an ‘average’ cost difficult to determine. The respective technical characteristics each form of storage affords the investor and in particular the withdrawal and injection rates of storage should also be considered in order to generate an accurate perspective on the investment costs.

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[79] EIA, The Global Liquified Natural Gas Market: Status and Outlook, 2006.
[80] King & Spalding, LNG in Europe an Overview of Terminals, 2008.

With regard to investment in depleted and aquifer storages such methods of storage are heavily dependent on cushion gas prices with this component making up approximately a third of overall costs for these storages. If the appreciation of gas prices continues investment in such storage is likely to be affected with the comparative difference in costs being reduced between these forms of storage and salt cavities, though the geology of such storages would still give them an advantage in providing seasonal storage due to their superior volume capacity.

Finally regulatory environments can foster investment climates that may prove more conducive to attracting new entrants to invest in specific areas. An example is Germany where regulation for storage creation is comparatively more liberal as it is governed by mining law, has minimal government intervention and an unregulated tariff system all of which promote attractiveness to investors, such attractiveness is reflected in the amount of activity in this area.

SECTION 6 EXPERIENCE OF STRATEGIC STOCKS

As defined in Terms of Reference, for this section, the definition of 'strategic stock' refers to 'gas stored in order to be used in case of a supply disruption (excluding seasonal variation').

This section gives an overview of the existing national provisions within the EU concerning gas storage in relation to security of supply. The discussion is extended to an overview of the national provisions for complying with the standards for security of supply defined in the Security Directive, as often Member States have national provisions which de facto imply obligation on stockpiling of gas to be used in case of a supply disruption, without necessarily calling it storage for security of supply or strategic stock.

On selected examples we try to illustrate that the individual definitions of strategic stocks that may be optimal for the security of supply of the individual country may not necessarily be optimal seen from a common EU viewpoint. In fact, different national provisions may even be counterproductive, when evaluated at the European level, in that they may only raise the security of supply in the short run and at the expense of the future or may raise the national level security of supply at the expense of neighbouring countries.

The last part of the section presents an overview of the markets in the US and Japan, as examples of the level of security of supply provided in liberalised gas markets without regulatory provisions on strategic gas stock.

23. Existing EU regulation on gas storage related to security of supply

In April 2004 the Commission passed the Directive 2004/67/EC concerning measures to safeguard security of natural gas supply. The Directive provides a frame within which EU Member States establish their national provisions concerning measures to ensure security of natural gas supply.

The Directive defines a set of criteria, referred to as 'security of supply standards', which are related to security of supply for specific customers. The Member States who have transposed these into national regulation, have done so through national provisions on Public Service Obligation (PSO) imposed on one or more gas market players (in accordance with Article 3 of the Gas Directive).

Article 4, paragraph 4

There are different tools for achieving the security of supply standards, and according to the Directive (and relevant to this discussion): 'Member States, having due regard to the geological conditions of their territory and the economic and technical feasibility, *may also take the necessary measures to ensure that gas storage facilities located within their territory contribute to an appropriate degree to achieving the security of supply standards*' (Article 4, paragraph 4).

It is important to note that this paragraph is provisional and imposes as such no obligation on stockpiling or other obligation on use of storage for security of supply.

In addition the article refers to the use of storage facilities located within the territory of the respective EU Member State as mentioned, to be further defined with national provisions.[81] Some EU Member States with national provisions on obligatory stockpiling have further specific requirements that gas is kept in storage within their territory such as Poland.[82]

ANNEX 2 NATIONAL EMERGENCY PROVISIONS gives a brief overview of the national provisions on PSO and on obligations for storage for security of supply. Only EU Member States with relevant national provisions are shown. The Member States not included in the table do not have existing regulation on PSO and storage for security of supply, and are not in the process of developing one.[83]

The following patterns can be distinguished between the varieties of national provisions of the EU Member States related to storage for security of supply:

- Stockpiling is imposed indirectly through imposed PSO on the TSO – Denmark, Belgium, The Czech Republic, Bulgaria.
- Direct obligation for stockpiling imposed on one or more market players-
    - Suppliers of imported gas only – Portugal, Poland and Italy.
    - Shippers – Spain.
    - Strategic stock as a national reserve – Hungary.

Obviously, most of the EU Member States have direct or de facto obligations on stockpiling for security of supply.

23.1 The role of the TSO and related storage capacity

For the purpose of the discussion further down this section, it is important to clarify the role of the TSOs and the storage maintained by the TSOs for fulfilling this role.

[81] This remark is relevant to a later discussion on a possible common approach regarding strategic stock at EU level.

[82] Act on reserves of crude oil, petroleum products and natural gas, and rules of procedure to be followed when the state's fuel security is threatened or the petroleum market is disturbed of February 2007.

[83] Based on data submitted from each Member State to ERGEG, according to obligation defined in the Security Directive

The TSO has a residual balancing role, i.e. has an obligation to maintain the system (pressure) balance in events of supply or infrastructure loss. 'The TSO shall be equipped, either through ownership control of assets and gas or through formal contracts or agreements, with sufficient system resources including natural gas necessary for carrying out their functions.'[84]

The Storage System Operators (SSO) are obligated to make available the storage capacity that the TSO needs for fulfilling its obligations, which indirectly means that storage capacity, both volume and deliverability, is booked (and exempted from TPA) in order to be used in case of a supply disruption.

Article 2 of the Gas Directive even excludes this storage from the definition of 'storage facility'[85]: Using their definition a "storage facility" means a facility used for the stocking of natural gas and owned and/or operated by a natural gas undertaking, including the part of LNG facilities used for storage but excluding the portion used for production operations, and *excluding facilities reserved exclusively for transmission system operators in carrying out their functions*'.

In its nature this storage complies with the above definition of strategic storage – it is gas stored to be used in case of infrastructure loss, which results in supply disruption. It is also excluded from TPA. However, it is important to highlight here that there is a difference between gas stored by the TSO to be used *only* for the purpose of maintaining the system pressure in the immediate period following operational stresses such as a result of an unexpected pipeline and/or plant unavailability (which is for the purpose of carrying out the function of the TSOs and as is the case in the UK), and not for supply to end-users (which is not for the purpose of carrying out the function of the TSOs and as is the case in Denmark for example). The difference will be illustrated below on the examples of Denmark, Belgium and the UK (also the Czech Republic and Bulgaria have he same arrangement).

24. Overview of national provisions on storage for security of supply within the EU

24.1 Obligation on the TSO to overtake supply in emergency situations (Denmark, Belgium, the Czech Republic, Bulgaria)

24.1.1 Concept of insurance policy (Denmark)

By its definition, and based on EU requirements for unbundling, the activities of a Transmission System Operator are related only to the transport of gas through the transmission system and are separate from supply activities. A TSO is therefore allowed to own only gas necessary for system operation, i.e. for maintaining the system pressure but may not buy gas from suppliers and sell to customers.

[84] Guidelines for Good TPA Practise

[85] With the purpose of excluding this storage capacity from regulation

Consequently if the obligation for supply in a situation of partial or full supply disruption is imposed on the TSO, the TSO must have gas in storage in order to fulfil this obligation – a TSO cannot buy gas on the spot-market as suppliers (theoretically[86]) could do.

Denmark is self-sufficient with gas at present, and receives all the gas from the North Sea. In case of a total supply disruption (offshore failure in the North Sea), the TSO in Denmark is obligated to be able to deliver gas to all consumers for 60 consecutive days (which is the time estimated necessary to restore supplies from the North Sea) during normal weather conditions and for three consecutive days with temperatures of –14 °C (1 in 20 probability). Corresponding gas volumes are stored in the underground gas storages in Denmark, referred to as 'Storage for Emergency Supply'.

These volumes are on top of the gas stored for the purpose of maintaining the system pressure in the immediate period following operational stresses, referring to the discussion above (in Denmark called 'System operator storage'[87]). Compared to the Danish TSO, National Grid in the UK stores only gas for the purpose of maintaining the system pressure in the immediate period following operational stresses.

This service provided by the Danish TSO, i.e. emergency supply, is charged through the transmission tariffs. The concept resembles an insurance policy – upon an insurance premium added to the tariff (commodity based), customers receive gas also in an emergency situation. Large consumers (with an annual consumption above 2 mcm) can choose not to have this insurance and will therefore be interrupted in case of an emergency. These consumers do not pay 'the insurance premium' and receive further discounts established based on auctions. All large consumers (as defined above) will receive an invitation to take part in the auction and to send an offer. The Danish TSO, Energinet.dk, will then contract interruptible emergency supply with the consumers that can offer to be interrupted upon lowest discount.

24.1.2 Belgium

Similarly to Denmark, the role of the Belgian TSO, Fluxys, includes an imposed PSO to be able to continuously supply all uninterruptible consumers in case of 1 in 95 probability, based on the winter 1962/63 or 5 consecutive days in case of temperatures of -11 °C.

For this purpose, Fluxys maintains de facto strategic storage – gas and capacity reserved at the Loenhout storage as well as at the Dudzele peak shaving facility.

This service provided by the Belgian TSO is charged through the transmission tariffs.

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[86] In practice, in Denmark, in case of failure of the offshore supply, the capacity of the other supply point is very limited, so if the supply from the offshore is totally cut off, withdrawal from storage is presently the only possibility.
[87] Systemoperatørlager

24.2 PSO obligation on suppliers (Germany, the UK)

Unlike a PSO obligation on the TSO for supply in case of partial disruption and/or extreme weather conditions, the same PSO obligation placed on suppliers does not necessarily impose stockpiling obligation.

Suppliers in Germany are obligated to supply the non-interruptible consumers at any time, even in case of partial supply disruption (not specified) and in the case of unusually high demand in extreme weather conditions (not specified) as long as it is economically reasonable (as judged by the supplier). There is no direct obligation on the suppliers for stockpiling.

In the UK suppliers are obligated to be able to supply non-interruptible consumers in extreme weather conditions, defined as a peak day in a in 1 in 20 winter or a 1 in 50 year, but there is no direct obligation for stockpiling.

This means that suppliers can choose the most feasible tool available on the market to fulfil the PSO imposed on them. Stockpiling is one of them but so also are import contracts, buying on the daily spot market and agreeing commercial interruptibility with larger consumers.

How is it then ensured that non-interruptible customers will be supplied according to the security of supply standards of the Security Directive?

In the UK the National Grid operates a monitoring system and ensures that storage stocks do not fall below defined levels; the levels being defined for each type of storage facility and for each day of the winter.

The levels of stock related to the above PSO of the suppliers, ensuring coverage of firm supply demand in a severe winter (1 in 20) are called Firm Monitors and are published for information, i.e. as a feedback to the industry only.

In addition to the Natural Grid's monitoring function it also has a responsibility to take action if necessary (though they have not yet had to do so) to ensure that levels of storage necessary for ensuring adequate pressure in the system (related to the above-discussed residual role of the TSO) are available at all times, which is defined as safe operation of the system in 1 in 50 winters (compared to the 1 in 20 obligation to the suppliers). These levels are called Safety Monitors, and provide a type of trigger mechanism for taking action to avoid a potential gas supply emergency situation.

Gas and services necessary for this mechanism are purchased in the form of Operational Margins as explained further in the text.

There is also a Gas Balancing Alert mechanism, under which National Grid notifies the market of the levels of demand that could not be physically be met from available supplies. This is intended to help market participants to identify opportunities for demand-side response.

24.3 Concept of monitoring levels for security of supply

24.3.1 Operational margins (the UK)

As previously discussed, in the UK the PSO obligation for supplying gas to non-interruptible consumers in conditions of extreme winter defined as 1 in 20 is placed on the suppliers, while the Gas Transporters have an obligation to make the necessary transmission/distribution capacity available.

Further to these PSOs the regulation referred to as the Safety Case places an obligation on National Grid Gas to maintain Operational Margins (OM) at levels and locations determined throughout the year (Safety Monitors, discussed above). The OM are both gas and services, typically to be used to maintain system pressures in the immediate period following operational stresses such as a result of a failure offshore, or unexpected pipeline and/or plant unavailability. A quantity of OM (gas) is also kept in reserve to manage the orderly rundown of the system following the declaration of a Gas Supply Emergency (national definition).

For example, as indicated in ref. /26/, it may take four to five hours to restore gas supplies following a supply loss in the south east of the system or for actions by shippers to source additional gas to take effect. During this period and without the use of OM, pressures could drop below the minimum level permitted in parts of the network to maintain normal network operation resulting in a gas supply emergency and curtailment of gas supplies to consumers. In addition, a lack of OM would also compromise the management of an orderly rundown during a gas supply emergency.

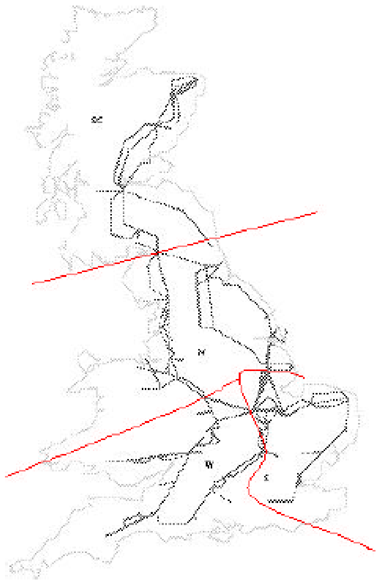
Use of an OM service will result in additional gas being available to the system, i.e. gas that would not ordinarily be available had an OM service not been used.

There are three groups of OM requirements currently defined as follows /26/:

- GROUP 1 includes those events that although unlikely to occur coincidently with a 1 in 50 winter, would have a major impact on the safe operation of the NTS. This group includes a loss of supply or loss of infrastructure.
- GROUP 2, though better described as multiple events, includes those events that could reasonably be expected to happen during any winter, but potentially more so in a severe winter as alternative supplies are expected to be less available and occurrences of such events could escalate due to higher demands. Inclusion of the OM is required in order that OMs are kept available for a series of such events. This events group includes analysis for compressor failure, routine forecast errors and significant supply losses.
- GROUP 3, orderly rundown, is OM stock to ensure safe rundown of the system in the event of a Network Gas Supply Emergency while firm load shedding takes place.

Due to the fact that transporting the gas to the place of consumption requires pipe connections and transmission capacity, it is not possible to identify a single OM quantity for the UK as Operating Margin gas must be available on a locational basis.

Figure 88 Geographical areas in the UK transmission system



Source /26/

The National Transmission System has been considered as four geographical areas: Scotland, North, West and South (Figure 88) and the total OM requirements per area are estimated against the locational and non-locational elements. These give a minimum volume requirement for each area (i.e. the volume required to meet the locational elements of Operating Margins which must be sourced from that area) and a maximum (i.e. the locational elements plus the full extent to which that area could meet the substitutional elements of Operating Margins).

OM services include:

- **Demand (offtake reduction)** Shippers of NTS-connected consumers would offer a service to reduce and limit its hourly offtake at a specified location.
- **Supply (gas delivery)** Shippers at NTS entry points would offer a service to increase or not decrease its hourly rate of delivery at a defined location.
- **Storage (gas delivery)** Providers with gas held in NTS-connected storage facilities would offer a service to increase the rate of gas delivery to a defined level and for a defined duration.
- **Importation facility (gas delivery)** Providers of gas flowing through importation facilities would offer a service to increase the delivery rate and duration of delivery to the NTS.
- **DN (offtake reduction)** Operators of DNs would offer a service to reduce and limit the hourly offtake at defined exit points. Note: demand offtake reduction services will be limited to covering Groups 1 and 2 Events as they would be unavailable during Orderly Rundown.

National Grid Gas purchases the gas and the services on tenders for contracts varying from 3 to 10 years.

24.3.2 Regional control leader (Austria)

The Regional Control Leader in Austria does not monitor levels of strategic storage but of available transmission capacity. The example is still presented here, as it is an interesting concept that may be combined with monitoring of storage levels for the purpose of security of supply on EU level.

The transmission system is 'divided' in three control areas, each operated by an Independent System Operator. They are coordinated by the Regional Control Leader, who in case of crises alerts the Federal Ministry of Economy and Labour. The Federal Ministry of Economy and Labour then imposes instructions to the respective parties for production, transport and storage, as well as orders to the end-users.

24.4 Direct obligation for stockpiling on suppliers (France, Spain)

In France the PSO is defined as an obligation for ensuring uninterruptible supply of households and non-interruptible clients (supplying hospitals etc) in case of a 6 month disruption of the main source of supply in a normal winter, and for 3 consecutive days in extreme temperatures (1 in 50 probability).

Suppliers in order to fulfil their Public Service Obligations, must book at least 85% of the storage capacity rights associated to their domestic and specific customers (such as hospitals), every 1st of November. This is de facto a direct requirement for stockpiling however not strategic stock, as once booked the storage capacity and volume can be used.

In Spain, shippers have to store gas corresponding to 20 days of the fast deliveries to distribution companies, of which 12 days at any moment (10 days are strategic under government control) and further 8 days during October. Direct consumers (own shippers) have to store gas corresponding to the above defined days of their consumption. The Ministry of Industry and Energy can change the number of days at any time.

24.5 Direct obligation for stockpiling on suppliers of imported gas only (Italy, Poland)

This section analyses the impact of the obligation for stockpiling imposed on suppliers of imported gas only (as implemented in Italy and in Poland[88]) through the example of Italy.

24.6 Requirements

24.6.1 Requirements in Poland

In Poland the obligations for maintaining storage as defined by the 'Act on reserves of crude oil, petroleum products and natural gas, and rules of procedure to be

[88] Italy distinguishes between gas imported from the EU or non-EU country, while Poland does not.

followed when the state's fuel security is threatened or the petroleum market is disturbed' include:

- An obligation to keep gas in storage only for companies that are importing gas.
- The volume of mandatory reserves will in 2012 cover 30 days of the actual average daily import of that company.[89]
- The Polish Regulator, URE, assesses whether the costs connected with the maintenance, release and supplementation of reserves are justified.
- Obligatory storage of natural gas shall be maintained throughout the whole year.
- Obligatory storage of natural gas shall be maintained in storage facilities capable of sending out the entire volume of reserves to the gas system within a period of 40 days.
- The President of URE shall control:
    - The size of the obligatory storage established by the entity obliged to create them.
- The maintenance of the compulsory reserves.
- The Transmission System Operator shall assess whether the storage facilities in which the obligatory storage shall be maintained comply with the technical conditions of supplying those gas volumes to the system specified by the Act.
- Exemptions from the obligation of creating and maintaining compulsory gas reserves for an energy company or an entity importing gas from abroad if the number of consumers does not exceed 100,000 and the sale of natural gas does not exceed 50 mill. m^3/year. The exemptions shall be granted by the Minister of the Economy.

Compulsory stocks of natural gas shall be maintained exclusively within the territory of the Republic of Poland, in storage installations connected to the gas system.

24.6.2 Requirements and strategic stock arrangements in Italy

According to the Ministerial Decree of May 2001, the strategic gas reserve shall correspond to the possibility of withdrawing gas during a 60–day period in winter conditions at a delivery rate of 50% of the import capacity from non-EU countries. The quantity is set by the Italian Ministry of Production Activities (MPA) each (thermal[90]) year.

Shippers, in order to be authorised for import of gas originating from a non-EU country, shall maintain a strategic stock corresponding to 10% of their annual imports.

The emergency criteria are defined as the most severe transportation conditions. The most severe scenario for the importation from Russia and North Africa is a summer scenario, (in which, as a consequence of the reduced market off-takes as a result of

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[89] Timetable for obligatory storage for companies involved in trade of imported gas: 11 days to 30 September 2009; 15 days from 1 October 2009 to 30 September 2010; 20 days from 1 October 2010 to 30 September 2012; and 30 days from 1 October 2012.
[90] Starting October.

storage injection, the entry gas volumes must be transported for longer distances). The most severe scenario may also be a winter scenario, in which pressure levels that support the supply to shunts, must be guaranteed at significant points of the network.

The conditions that allow use of strategic stock are:

- Imports interruption or reduction (both EU and non-EU).
- Emergency on national pipelines.
- Extremely cold winter (1 in 20).

Each shipper having an obligation to have strategic storage capacity has to have a corresponding capacity payment based on the foreseen import quantities. At the end of the year the shippers are required to give the actual values of imported gas for new tariff calculations.

The gas itself is owned by the Storage System Operator. The Storage System Operator is obliged to sell and buy strategic gas as requested.

The cost for the strategic gas is covered by the storage tariff, which includes remuneration of 'immobilised strategic gas' (valued by AEEG[91] at about 85 EUR/1000 m^3).

24.7 Policy implication

Applying requirements for obligatory strategic stock in general has several direct or indirect implications on the market. The direct effect is that it raises the demand for storage radically because of the demand of storage for strategic purposes. In the case of Italy, where approximately 62 bcm of natural gas are imported from non-EU countries this policy will require a volume of around 6.2 bcm of strategic storage.[92] With around 14 bcm of storage capacity available in Italy at present and approximately 8 bcm of storage capacity planned and/or under construction,[93] the effects of a policy call for 6 bcm of storage for strategic purposes can have a large effect on the Italian storage market and possibly on neighbouring countries and the EU in general as well.

24.7.1 Strategic stocks as a market hindrance

The strategic stock requirement on the importers only is not only additional cost for importers. It can also act as a restraint for newcomers in that newcomers may only have access to imported gas.

The 10% rule makes it simply more expensive for companies that rely 100% on non-EU imports to operate in Italy compared to a company that has access to indigenous

[91] Italian Regulatory Authority for Electricity and Gas
[92] Source: Eurogas
[93] Source: GSE storage investment database

production which is often the national incumbent, because they have to secure 10% of their imported portfolio as strategic stocks.

Further this could also serve as a protectionist measure in order to protect local suppliers. In 2005 around 14% of all gas consumption came from Italy. Although this figure is declining it can still be a market hindrance for companies with less EU-produced gas in the portfolio, and the strategic stock obligation in essence could therefore serve as a protectionist measure to protect local incumbents, i.e. assuming that it is the local incumbents that own the domestic reserves.

If the national storage operator is further a part of the national incumbent (as the case is in both Italy and Poland) the national incumbent might benefit economically from this policy as a result of the increased storage demand.

24.7.2 Strategic stocks and opportunity costs

Due to the ex-post way of accounting for storage usage, the storage code in Italy in effect opens up the possibility for shippers to access strategic stocks at times when there is no actual supply interruption.

Shippers can withdraw more gas than they actually have in stock by withdrawing strategic capacities, but are penalised according to the storage code if they do so. This in effect regulates the costs of the strategic stocks in that it ensure that the opportunity costs of attaining such a strategic storage do not become too high. By allowing shippers access to strategic stocks the effect is that shippers can/will withdraw gas from storage at times when the market value of natural gas is above the penalty they must pay for accessing the strategic stocks.

This policy in effect can be regarded as a price-cap mechanism. When the price of gas becomes too high i.e. the price becomes higher than the purchasing price plus the penalty, then gas will flow from the strategic stocks to the market and dampen prices. Thus the penalty mechanism can be regarded as measure for the level of gas prices the Italian government thinks is reasonable. The penalty price mechanism also lets the market 'decide' when the strategic stocks should be utilised instead of making it an *ad hoc* political decision.

This practice makes the decision on the level of the penalty very important as the penalty level determines when it is profitable to utilise the strategic stocks.

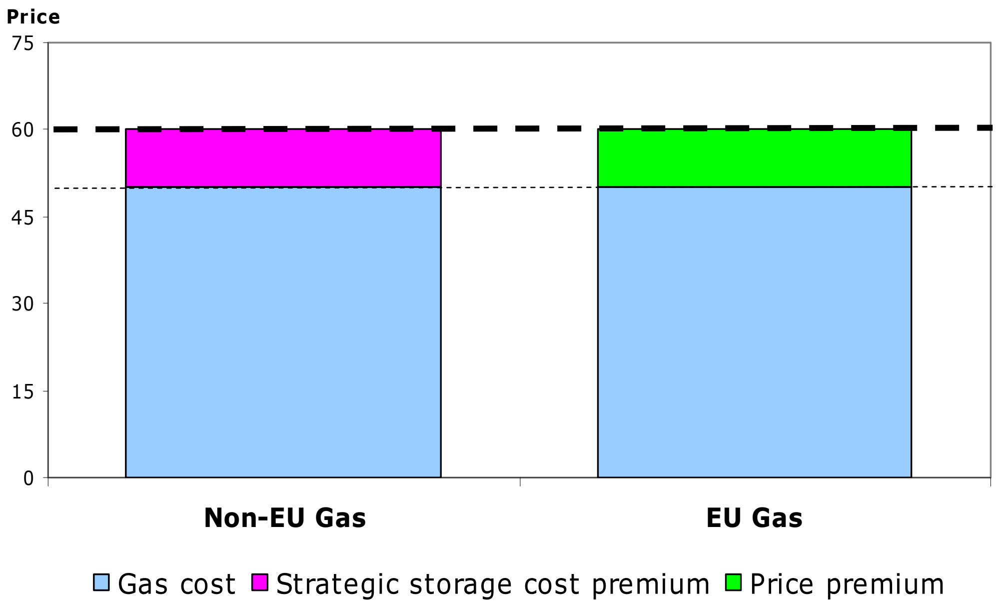
Thus if the penalty is set too low the strategic stocks risk not being used as a safeguard against supply interruptions, i.e. is *de facto* not a strategic stock and becomes instead a protectionist measure that penalises gas suppliers who do not have domestic gas supplies.

Thus to use strategic stocks in combination with a penalty creates a transparent policy that allows market players to anticipate the value of their own gas stocks. However, if the penalty level is set too low the strategic stocks will not be effective against supply interruption (will not be strategic any more) and instead will serve as a protectionist measure. On the other hand, if the penalty is too high the cost of the strategic stocks becomes very high.

24.7.3 Increasing value of domestic gas

Requiring that non-EU imported gas has to secure 10% of the total import in effect raises the value of EU gas in Italy compared with non-EU gas. This can attract EU-produced natural gas from all over Europe towards Italy. This means that the value of EU gas is higher in Italy compared with non-EU gas which in turn means that in Italy owners of EU domestic gas can earn a premium on their domestic capacities as well as on their EU gas capacities. The premium of the EU/domestic gas will be equal to the costs of the strategic storage requirement of the imported gas. This is illustrated in Figure 89 below in which the thin dotted line represents the gas price where EU gas is dominant and price-setting, and the bold dotted line represents the case where non-EU gas is dominant and price-setting.

Figure 89 Premium on EU/domestic gas



The distance between the bold dotted line and the dotted line is the price of securing 10% of storage capacity.

With natural gas prices being relatively inelastic the price of natural gas will probably settle close to the upper bold dotted line, allowing gas suppliers with EU gas in their portfolio to earn the storage-requirement premium. The Italian policy may not only be an advantage for local suppliers that have access to domestic gas supplies and thus favours local producers over foreign, but by putting a premium on domestic gas the policy may in fact have an adverse affect on neighbouring countries.

24.7.4 Beggar thy neighbour

Theoretically higher prices for EU-produced gas in Italy can lead to more EU gas flowing towards Italy, thus raising the security of supply in Italy at the expense of security of supply in the rest of Europe. This indicates that national measures on strategic storage may be sub-optimal because they may have a negative impact on neighbouring gas markets.

A policy like the Italian 10-% rule, if applied on an EU scale rather than on a national scale, i.e. as a general EU rule, would function as an import tariff on non-EU gas.

However the long-term security of supply could also be impeded by this policy because increasing the value of EU gas could be an incentive for gas suppliers to use the indigenous resources at a faster rate. Increasing the value of indigenous gas relative to non-EU gas has the effect of making it relatively more favourable to consume indigenous gas today because the profit (i.e. costs of the gas are much lower due to less transportation costs as well as the fact that indigenous gas does not have to pay for strategic stocks) is in effect higher and this will thus in effect quicken the rate of which indigenous reserves are being consumed. i.e. the strategic measures may raise security of supply in the short run but worsen security of supply in the long run.

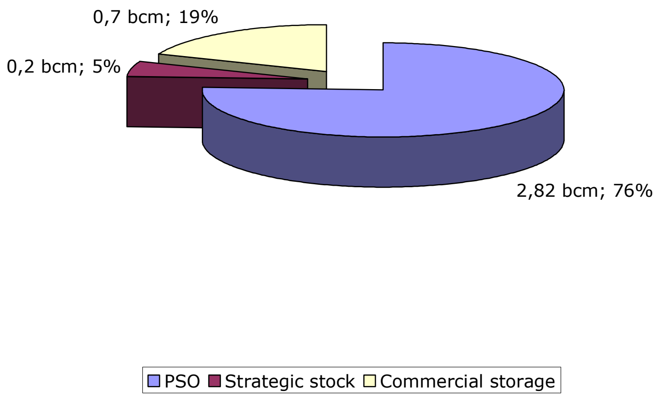
24.8 Strategic stock operated by association (Hungary)

24.8.1 Storage for PSO vs. strategic stock[94]

Contrary to the above arguments that storage based on PSO obligations is often de facto strategic stock, the Hungarian legislation actually distinguishes between gas and storage capacity booked for PSO and gas and storage capacity booked as strategic stock.

[94] This section has been prepared based on materials received from HEO

Figure 90 Storage in Hungary



There is no explicit definition of the PSO placed on the 'Natural gas undertakings'[95], however a storage capacity corresponding to 76% of the present total storage capacity in Hungary is reserved for this purpose (Figure 90).

The strategic stock (called security storage or security stock piling in Hungary) is defined by a separate act as: 'Natural gas stored in underground gas storage for non-commercial purpose'.

The storage capacity reserved as strategic storage is at present 0.2 bcm corresponding to approximately 5% of the total storage capacity in Hungary. According to the Act on strategic natural gas storage the gas volume stored for strategic (security) purpose shall reach 1.2 bcm by 1 January 2010 (the level of the strategic stock must then not fall below 0.3 bcm at any time), for which it is estimated that construction of new storage capacity is necessary. The daily withdrawal capacity of the strategic stock shall correspond to 20 mcm through 45 days at least. The 20 mcm/day correspond to the average daily winter consumption of the Hungarian households. This is in the other Member States a typical PSO definition based on the security standard defined in the Security Directive. However, irrelevant whether the purpose is called 'PSO' or strategic stock, the result is stockpiling of gas to be used in case of a supply disruption, corresponding to being able to supply all the households with gas during a period of 45 days in an average winter).

24.8.2 New strategic stock facility, ownership and financing

The Hungarian example is interesting as the Hungarian Energy office is planning construction of a new storage facility owned and operated by an association,

[95] Natural gas undertakings are natural gas market players authorised by the Hungarian Energy Office (HEO).

established for this specific purpose. The Hungarian Hydrocarbon Stockpiling Association[96] includes members such as: the public utility wholesaler, the public utility distributor, the gas trader selling gas to consumers, the gas producer selling gas to consumers, the registered consumers having licence for access to cross-border pipelines.

The members of the Hungarian Hydrocarbon Stockpiling Association have to pay a fee based on the heat content of the gas they have sold, bought and imported, respectively. This association also has a licence for commercial storage activity, which makes the new storage facility not solely dedicated for strategic purpose.

24.8.3 Emergency and release of strategic stock

Emergency means 'serious imbalance in natural gas supply-demand, the situation if demand is much higher than the possible gas procurement or there is a threat of such a situation'.

According to the Act on natural gas strategic (security) storage on suggestion of the system controller or the Hungarian Energy Office, the minister of economy and transport may give permission by a decree to utilise the gas stored in the strategic (security) storage in case of existing or expected serious system imbalance.

In the decree he has to set the reason and purpose of the utilisation, the quantity permitted to be utilised and also the order of replacement.

The minister shall set the price of the gas withdrawn and the terms and conditions of the utilisation. The revenue shall cover the cost of replacement.

The Hungarian Hydrocarbon Stockpiling Association is responsible for injection and maintaining the requested gas levels in storage.

25. Experience from the United States

The US imposes no obligations for strategic stock on market participants. It is therefore interesting to see what level of security of supply is ensured under such a regime.

25.1 A brief overview of the US gas market

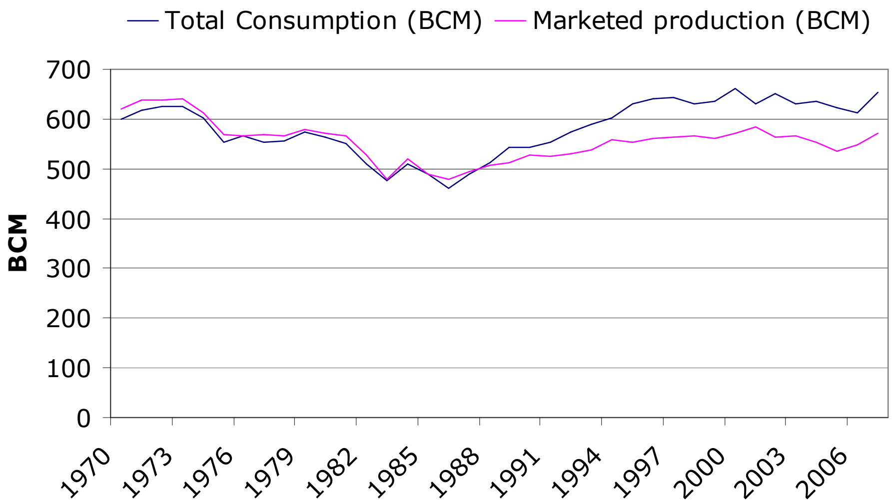
The US gas market consists of approximately 8000 producers of natural gas. There are 150 major pipeline companies that transport the gas from the producers to approximately 1500 distribution companies (LDCs). In places where the transmission lines intersect each other gas is often being traded at hubs. More than 30 hubs exist in the US, with the Henry Hub being the largest.

[96] http://www.kkksz.hu/

The US gas market is in many respects very different from the European market; it is, however, facing problems similar to those in the EU. Declining growth rates in indigenous production paired with increasing growth rates in the demand for consumption has led to discussions about how security of supply in the future should be ensured.

Figure 91 shows how the discrepancy between indigenous production and total consumption has been widening since the beginning of the 1990s.

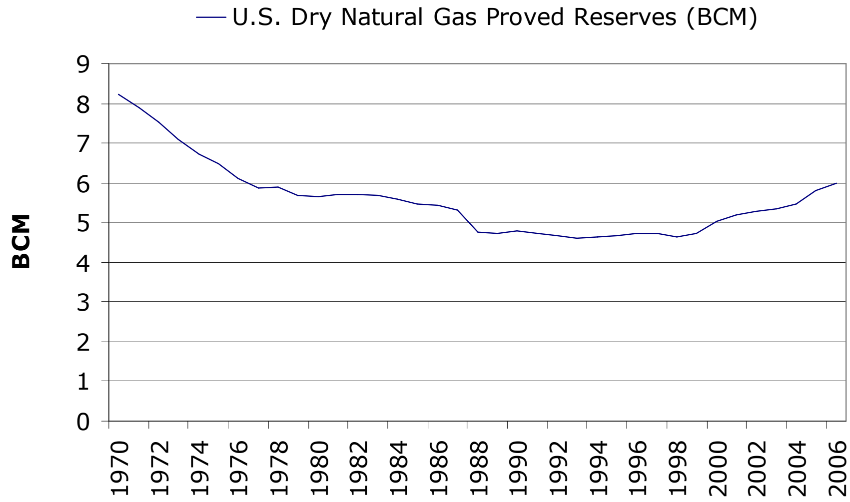
Figure 91 Development in consumption and production



Source: Energy Information Administration

It is important to acknowledge that compared with the EU the US is endowed with large supplies of natural gas and actually still has unexploited sources. Many of these are, however, located in environmentally sensitive areas (Alaska and close to coastal areas) and have therefore been considered inaccessible. Figure 92 below shows how the proven natural gas reserves have declined since the beginning of the 1970s, but start increasing again in the late 1990s. This increase in exploration of new reserves could be the result of increasing and unregulated prices.

Figure 92 Development of proven reserves



Source: Energy Information Administration

However with everything else being equal, the increasing discrepancy between consumption and indigenous production, and the small growth rates in proven reserves, imply that the US will become more dependent on import. US consumption is currently covered by indigenous production (84%), imports from Canada (15%)[97] and LNG imports (1%). Unless alternative energy sources are developed, the import dependency is bound to increase over time.

25.2 Regulatory environment in the US

Regulatory issues in the US are left to the individual States however interstate regulation in the US is dealt with by the Federal Energy Regulatory Commission (FERC), operating on a federal level. This entails among other things, regulation of construction and operation of interstate pipelines, storages, and LNG terminals.

The reforms on the US gas market started in 1935 by separating transmission and distribution. Being convinced that the tariff regulation and the long-term contracts result in inefficiencies and provide the TSOs with wrong incentives with regard to cost reductions, the environment, and investments, the FERC passes Order 436 in 1985, offering the TSOs the possibility to provide open access and encouraging unbundling of activities. Later, in 1992, Order 436 was replaced by Order 636 which made it mandatory to provide open access to transportation and storage, and to unbundle sales from the transportation services.

[97] The US and Canada are so interconnected that these two countries usually are regarded as one region.

Unbundling of sales made it possible to sell natural gas without authorisation from the FERC, and facilitated the development of a well working spot market for natural gas.

25.2.1 Regulation of tariffs

As mentioned above, the FERC is convinced that regulated tariffs resulted in inefficiency. Only transportation tariffs in the USA are regulated. The FERC requires transmission system operators to provide the FERC with detailed cost-of-service information. The price being charged will thus be the cost-of-service plus a mark-up equivalent to the rate of return. The final price that the LDCs charge the end consumer is determined by the market, thus production prices are unregulated.

With regard to regulation of underground storages the picture is less clear. There are 400 underground storages, which are regulated by either the FERC or by the state regulatory agencies. The price of storage is also subject to regulation by the FERC, however exemptions are usually made if it is estimated that the storage operator does not possess significant market power. Exemptions may also be made if it is estimated that the market-based rates are in the public's interest and necessary to encourage construction of storage capacity in areas in need of storage.

It is also worth mentioning the development of the regulation on the LNG facilities in the USA concurrently with its changing role on the US market. The additional import needed to balance supply and demand in the future will not only come through Canada, but also through an increased importance of LNG import. LNG imports are favourable, as they are very flexible and thus especially useful in situations where supply has been stressed. Until 2002 LNG terminals in the US were considered part of the transportation network and thus subjected to regulation and requirements for open third-party access. From 2002 the regulations were amended, and LNG terminals changed status to an import source, meaning that the open access requirement was abandoned. This has facilitated significant investment into LNG terminals.

25.3 Security of supply in the United States

25.3.1 Risk of supply disruptions

In general the risk of having supply disruptions in the US is relatively small. First of all as was explained in the introduction, the US does not import much from outside North America. Thus import dependency is low. Furthermore the industry structure in the US is characterised by almost 8,000 producing firms, 150 large transmission system operators, and 1,500 distribution system operators. This means that if one pipeline breaks down another will almost certainly be available. Thus the risk of large supply disruptions is low.

25.3.2 Shocks to the US market

A number of events can be labelled abnormal and do tell us how the US gas market reacts to extreme events, offering a good indication of how the market adapts and whether there are any learning effects from shocks. Since the market is relatively well functioning supply shocks should be reflected in the price of natural gas. The development in US natural gas spot prices is represented in Figure 93 and gives a good indication of when the market has been under pressure.

It can be seen from that spikes in the price for natural gas occurred in 1997, 2001, 2003 and in 2005. The spike in 1997 occurred due to a very cold and long lasting winter across the US. Furthermore, the situation that year was worsened by low inventory levels at the beginning of the heating season.

The spike in 2001 reflects extraordinary weather, a gas pipe rupture in New Mexico and low storage inventories at the beginning of the heating season. These events played a part in the development of the Californian energy crisis. The Californian energy crisis was mainly a product of bad regulation of the electricity sector, inelastic supply of power generation, increases in energy demand, decreases in import from other states, and increasing prices for nitrogen oxide emission credits (Joskow and Kahn 2001). All these factors along with the events on the gas market, caused bankruptcy and default of the local distribution companies which caused several blackouts in California. The interesting question is: How much did the events on the gas market contribute to this crisis? Several studies have tried to break down the effects of the different events. The main conclusion seems to be that the Californian government would have been in trouble even if the imposed regulation was without any flaws. It is hard to say whether the events that led to high gas prices by themselves would have caused blackouts in California. A point of interest in relation to the role of gas prices in the Californian energy crisis is the fact that gas prices at their peak were about 5 times as high as in the rest of the country. Research has shown that taking all the above-mentioned factors into account, the market price of gas was still unnaturally high. This suggests that generators could have been taking advantage of their market power and priced well above marginal costs.

Would California have experienced blackouts if the strategic gas storages had been in place? Surely natural gas prices would have been affected by the possibility to increase supply. However two things suggests that strategic gas storages would not have changed the situation significantly: First of all, the price of NO_x permits contributed significantly to the increased electricity prices, the increased price of NO_x was mainly due to the increased use of old gas-fired electricity-generating turbines. This effect would crowd out the price effects that the release of strategic gas in storage might have had. Secondly, the crisis did not only occur due to the events on the gas market, for the reasons mentioned before it was very long lasting, implying that strategic gas storages have been less effective.

Figure 93 US natural gas spot prices 1992-2008

Source: Energy Information Administration

The third large change in prices occurred in winter 2002/2003 as a combination of cold weather, rising economic activity, and falling production of natural gas. In addition to this, oil prices increased in this period causing some substitution away from oil towards gas. Finally the spike in mid 2005 represents the effects of the hurricanes Katrina and Rita which hit the Gulf coast in August and September 2005, respectively. About 20% of the US domestic production comes from onshore and offshore plants in this area. The two hurricanes together damaged and interrupted nearly 75% of this processing capacity[98].

A major factor that facilitated that the gas supplies were secured during the above mentioned periods of stress was the flexibility of the pipeline system. This flexibility enabled markets to clear by directing gas to the areas where it was most needed (and prices were highest). Thus market-based security of supply actually seemed to work.

25.3.3 Obligations in case of a supply shock

Even though the US has a well-functioning market and the risks of disruption are relatively small, security of supply is a high priority issue for the Department of Energy (DOE). Basically their role is on behalf of the US government to ensure that the supply of energy is reliable, affordable and environmentally correct. This means ensuring that the right investments are carried out such that the infrastructure and supply can accommodate the increasing needs of the future. Other stakeholders who

[98] 'Impact of the 2005 hurricanes on the natural gas industry in the Gulf of Mexico' Department of Energy.

have obligations with respect to the gas supply are the local distribution companies who are obliged on a non-discriminatory basis to deliver to their customers.

The US government has not taken any initiatives on a federal level to establish strategic stocks. The only obligations which can approximately resemble strategic stocks are obligations at the beginning of the heating season for the interruptible customers to have alternative supplies for 15 days of consumption. These regulations are applied on a state level and thus not imposed nationwide.

Furthermore if an emergency situation appears and the market is not capable of securing the supply to all consumers the department of energy can order TSOs and LDCs to allocate gas to high priority consumers. Moreover, the DOE can authorise import of natural gas if it finds it necessary.

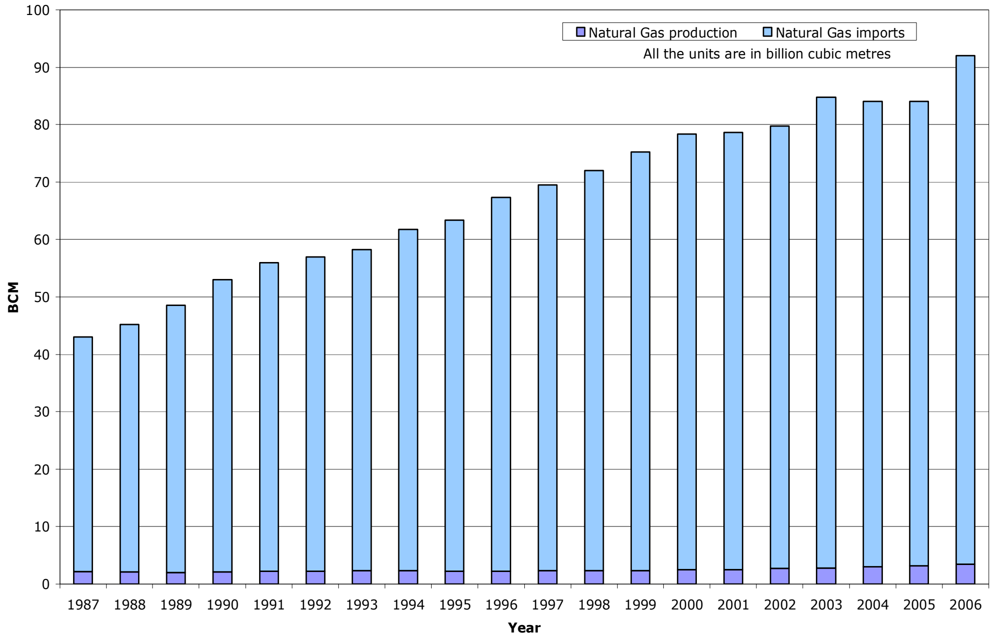
26. Experiences from Japan

Japan began importing LNG (liquefied natural gas) from Alaska in 1969, making it one of the first countries to pioneer LNG trade. Despite having virtually no domestic natural gas resources, Japan is the seventh largest natural gas consumer in the world and imports virtually all of its natural gas from other countries in the form of LNG. Japan additionally lacks any international pipeline connections or any form of underground storage further emphasising its dependence on LNG for fuel and the uniqueness of its gas market.

Japan was the first Asian country to import LNG and is currently the world's biggest importer, taking 88.63 bcm in 2006 from twelve supplying countries. The variety of supply sources substantially contributes to security of energy supply.

The graph below illustrates the imports and production of natural gas over the years in Japan.

Figure 94 Natural gas consumption in Japan



Source: IEA, Natural Gas Information report, 2007

26.1 LNG import terminals

Japan is completely reliant on its import terminals for its supply of LNG. Japan has at present 26 re-gasification terminals with a total capacity of 603.6 mcm/day or 200 bcm/year which gives it considerable spare capacity. The storage capacity is 12.18 mcm of LNG equivalent to 7.3 bcm of gas which is considerably higher when compared to any other LNG importing countries, but as this is the only option applicable to gas storage in Japan this puts the figure somewhat in perspective. Many terminals only serve specific power plants but some are shared between electricity and gas companies. Gas accounts for around 12% of the energy mix in Japan with two thirds of all LNG imports being utilised for gas power generation and the rest for city gas.

26.2 Regulation

Due to the unique nature of Japan's natural gas market Japan has concentrated its regulation to take account of its structure and attempt to compensate for its dependency on LNG through a variety of strategies.

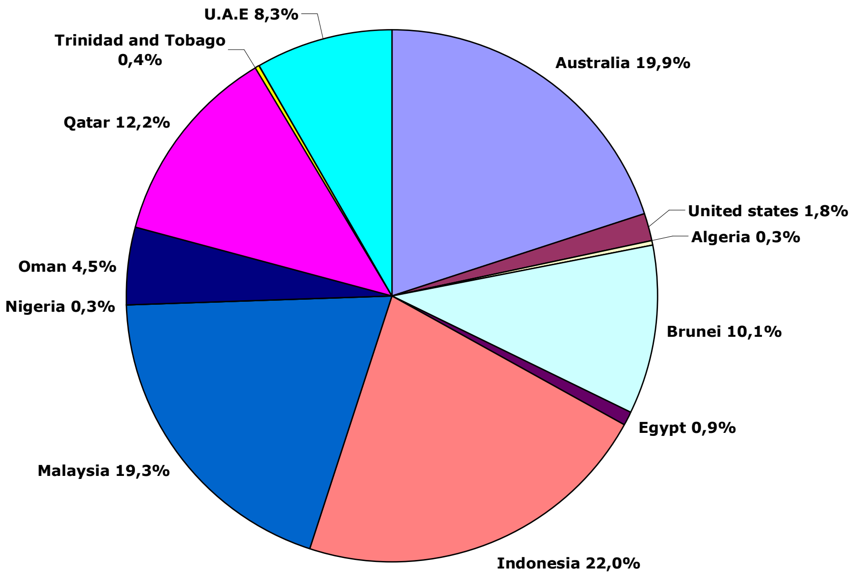
There have been considerable changes to regulation since the market was shaken by the financial crises of 1997-1998 when gas buyers found themselves tied to contracts well above their requirements. This motivated Japan into addressing the need to reduce the length of the contracts it was involved in and prompted a shift toward a general increase in flexibility. Such changes are beginning to be visible with the current renegotiation of contracts. Regulation has been introduced to incorporate different portfolios of contracts ranging from long-term to medium as well as spot transactions which will allow greater levels of adaptability when coping with demand patterns and uncertainties. An example of the above can be taken from a contract made between three Japanese gas utilities and the Malaysian LNG provider Tigsil. The agreement stipulated that Tigsil would supply a combined 680,000 tonnes of LNG per year for 20 years and an additional 340,000 tonnes for single years beginning in April 2004. The single year component of the contract could be updated annually with volumes specified a year in advance. The short/long-term contract provides 40% volume flexibility instead of the 5 – 10% available under more conventional contracts.

A continued commitment to flexibility of supply in Japan can be demonstrated through the special structure of the market which is designed in order to allow it to react to changes in supply with minimal levels of disruption. The following measures have served Japan well and no serious supply security problems have been encountered, even when one considers the failure of the Arun plant in Indonesia in 2001. The Japanese approach to their extreme situation with reliance upon LNG for gas is comprehensive and seeks to promote the following methods to ensure its security of supply.

- Alleviate and conserve energy loads through increased energy conservation.
- Obtain the optimal mix of energy supply through a diversification of both the supply sources and by using environmentally friendly fuels.
- Decentralisation of supply sources and the promotion of further consumer-producer dialogue.
- Increased stockpiling in preparation of emergencies.
- Measures to curb price volatility by establishing a stable market that mitigates the effect of liberalisation.

In addition to the general measures detailed above there are more specific policies that have been undertaken in order to ensure security of supply in Japan. For example with regard to modular supply systems the production and liquefaction plants in use utilise a number of separate units with several tankers involved in each contract and most importing companies have more than one terminal with more than one jetty. There is also a noted degree of standardisation of shipping capacity with extra supply available from one particular source being available for other companies facing difficulties. The below figure details the diversity of supply that Japan has in terms of the countries from whom it imports LNG to ensure that it is not too heavily reliant upon one particular source.

Figure 95 Country of origin and share of total imports on the Japanese market in 2006



Japan has also promoted considerable substitution in its energy sources for gas-fired power generators, as 40% of such facilities are dual-fired with crude and fuel oils as the main alternative fuels. Japan also has notable above-ground capacities designed to cope with fluctuations in supply of total storage, total storage at 7.3 bcm, amounts to 34 days of average consumption which is actually superior to that of a number of European countries including the UK which at present stores enough gas for 16 days of average consumption.

In conclusion Japan has proven highly organised to deal with the added risk and unique problems that importing all its gas creates. The essential quality is that regulation has fostered a flexibility and prudent planning to ensure that the market adapts supply through cooperation, substitution or whatever measures the situation requires.

26.3 Current market situation

As of May 2006 Japan's Ministry of Economy Trade and Industry (METI) has attempted to develop a new national energy strategy with security at its core. This policy provides tangible numerical targets in energy conservation, reductions of oil in energy mix, reduction of oil in the transport sector and the development of additional nuclear power. There has also been procurement at high and sustained levels with Japanese buyers buying LNG for short-term supply until 2010 in order to meet the expect sharp gas demand increase caused by fuel switching in the industrial sector as well as power generation demand as a result of nuclear problems. Industrial consumers who were previously using oil-based fuels have responded to the rapid rise in oil prices through converting to natural gas. LNG gas demand growth has thus been increased at the expense of oil. LNG imports to Japan under long-term contracts were over USD 4 MBtu cheaper than JCC (Japan Crude Cocktail) in 2006. Even though the previous winter was warmer than average and thus residential demand for gas was decreased this was counteracted by strong increases in the industrial sector. Natural gas increased by 7.2% in 2006 driven by a strong demand of 13% extra in the industrial sector which required 86 bcm (62 million tonnes) of LNG.[99]

To help mitigate the country's shortfall of domestic natural gas resources, Japanese companies have actively sought participation in natural gas exploration and liquefied natural gas (LNG) projects overseas. Inpex is one of the major players in Japan with activities in Indonesia, Australia, the Middle East and South America. One of Inpex's largest initiatives was the USD 6-billion Ichthys project in offshore Western Australia. In 1998, Inpex acquired a 100% stake in the WA-285-P field in the offshore Ichthys natural gas-bearing structure. The company has since put forward plans for the project to eventually produce 6 million tonnes per year (8.2 bcm/y) of LNG, all of which would be exported to Japan. In August 2006, Inpex announced that it had transferred a 24% participating interest in the project to Total Oil and Gas, while Inpex would remain the Ichthys project operator.

Another high profile LNG project in which Japanese companies have a stake is the Sakhalin-II project in Russia. The project is being developed by Sakhalin Energy, with Shell as the operator (55% controlling stake) and Japanese companies Mitsui (25%) and Mitsubishi (20%) holding participating stakes. In September 2006, the Russian Natural Resources Ministry froze a key environmental permit for Sakhalin-II, which has effectively curtailed operations. The project is slated to begin LNG production in 2008, although it is unclear whether this will be delayed as a result of the current environmental problems. Russian officials have proclaimed their discontent with the rising costs of the project, which the Shell-led consortium estimates will reach USD 22 billion, almost double the 2001 estimate of USD 12 billion. At its peak, Sakhalin-II is expected to produce 9.6 Mmt/y (13.2 bcm/year) of LNG, of which eight Japanese companies have already signed contracts to buy 4.7 Mmt/y (6.5 bcm/y).

Japanese companies have also invested in several natural gas projects in Indonesia. In October 2006, Inpex announced that it had found substantial natural gas reserves in the Masela Block in the Timor Sea, in which Inpex holds a 100% stake. The company did not offer a specific reserve estimate, but Inpex will reportedly submit a USD 4.2 billion project proposal to the Indonesian government. The project will aim to ship 3-5 Mmt/y (4.5-7 bcm/y) of LNG to Japan and elsewhere by 2015[100]. Inpex is currently involved in two other LNG-producing projects in Indonesia, one on Kalimantan Island and another on the island of New Guinea.

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[100] Source: IEA, Natural Gas Information report, 2007

26.4 LNG imports into Japan (long and short-term contracts)

Japan holds several long and short-term contracts with natural-gas-supplying nations. Lacking international pipeline network, Japan has been importing liquefied natural gas (LNG) for several decades now.

The first Australian North West Shelf contracts that started in 1989 are set to expire in March 2009. The contracts involved eight Japanese foundation buyers for a total of 10 bcm per year. Renewal deals are being negotiated between the sellers' consortium and the individual buyers, rather than the buyers' consortium as was the case for the original contracts. The renewals of these contracts are also being negotiated at reduced volumes for most of the buyers – at a total of 7 bcm per year with shorter durations and possibly higher pricing arrangements.

Two contracts between Indonesia's Pertamina and six buyers in western Japan, amounting to 16.3 bcm per year and representing 20% of Japanese LNG consumption, are expiring in 2010 and 2011. Although the two sides agreed in principle to renew half of the volume in 2005, no final agreement has been reached yet. Now at least 4.1 bcm per year, and potentially as much as 8.2 bcm per year, is expected to be renewed.

Nine Japanese gas and power companies have contracted to purchase 6.7 bcm per year (4.94 mtpa) of LNG from the Sakhalin II venture in Russia's Pacific region. Two of the buyers were expected to receive cargoes from 2007 having reached agreements with the venture in 2003. But when Shell, then majority owner of the project company, announced doubling of the project cost in summer 2005, it was also revealed that the commencement of the project would be delayed to 2008. After 18 months of controversy over the cost increases and revenue sharing, alleged environmental violations, and Gazprom participation, the foreign partners agreed to hand over a majority stake to the giant Russian gas company.

Furthermore, some Japanese gas and electric power companies are negotiating with Qatar for long-term supplies from the Middle East producer's mega-trains, originally planned to supply LNG to the United Kingdom and United States markets. These volumes may be available in the short-term as prices at NBP in particular are lower than expected.

In recent years, long-term supply from Indonesia, previously the world's biggest LNG producer and the major Japanese supplier, has fallen below annual contract levels by at least 10%. These supplies have been successfully replaced by supplies obtained from the growing LNG spot market. This in turn has been made possible by mild weather in other IEA markets, which has freed up LNG from the Atlantic Basin for delivery to Pacific markets.

27. Summary and conclusions on national provisions on storage for security of supply

Based on the Security Directive, the majority of the Member States have transposed the security standards through provisions of PSO on one or more market players.

The overview of the national provisions on storage for security of supply within the EU shows that the majority of the countries do have provisions obligating at least one market player to stockpile gas to be used in case of supply disruption, which is de facto the definition of strategic storage. This indicates that most of the Member States feel more secure when having gas in storage – as this is not a direct requirement by the Security Directive.

Gas for security of supply purposes is stored within the borders of the individual Member States. This is partly resulting from the Security Directive Article 4, paragraph 4. In the view of an integrated gas market and a common approach on security of supply and considering the discussion on solidarity this provision should be changed. As shown later in Section 7 strategic oil stocks can be held across borders, so there are no reasons to have this restriction in place for gas. In practice, storing gas in storages across borders will be determined by the transmission connection, i.e. the possibility to transport the gas from the storage to the consumers in case of an emergency.

All TSOs have some amount of gas in storage to be used in case of supply disruption caused by technical failure. As the actual cause of the supply disruption is irrelevant, this storage also complies with the definition of strategic storage, but it is important to distinguish between TSOs that keep gas in storage only to be able to re-establish system pressure (this storage is to be used exclusively for the functions of the TSO and is exempted from TPA and other regulation) and gas kept in storage by the TSO to be able to overtake supply in case of an emergency situation. Supply is not the role of a TSO, but is imposed on the TSO as a PSO.

If the PSO does not include direct overtake of supply, imposing PSO on the TSO does not have to imply strategic stock – the National Grid buys gas and services to be provided by producers, storage system operators etc in an emergency situation in stead of storing gas self.

The example of National Grid and the concept of monitoring and Operational Margins could be implemented on EU level for example through the European TSO (reference to the Third Package). The European TSO could coordinate the national TSOs, similar to the regional controller in Austria.

Imposing PSO on the Suppliers does not directly imply stockpiling. Suppliers can choose the most viable option for fulfilling their PSO. The example of Germany shows that the market for storage is booming without direct obligation on strategic storage imposed on the market players.

The markets of Germany and the UK in this sense are in theory no different than the liberalised markets of the USA and Japan, where no direct obligation for stockpiling is imposed.

It is important to note that the markets require a certain level of diversification prior to being able to cope with supply disruption without market players having direct obligations on stockpiling. For example in Denmark, theoretically there is no other way (at present) of achieving continuous supply in case of supply disruption from the North Sea apart from supply from storage. In this sense it makes no difference whether the strategic stock will be maintained by the Suppliers (as they do not have other possibly more feasible option to choose) or the TSO.

The US market is further interesting as it shows the impact on deregulation. In the experience of the FERC, the period of regulated tariffs has resulted in lack of investments compared to a period of liberalised prices on production resulting in new fields being developed previously considered not feasible (an impact nonetheless enhanced by the high gas price), as well as a number of LNG storages and terminals.

The US and the Japanese market also show the increasingly important role of LNG storages and terminals. It is worth noting though that Japan is comparatively isolated in a unique situation while Europe has a number of interconnections. Exporters of gas also rely on exporting their gas to the contracted destination, while LNG ships can easily change their course.

It is evident that the Japanese gas market is very different from other traditional gas markets around the world. Over time despite its high dependency on imports, Japan has successfully maintained high security of supply by diversifying its supply sources and maintaining its flexibility through a variety of measures. Whether it is countering the supply shocks induced from Indonesia in 2001 with the closure of Arun or fallen supplies from other producers, with increased flexibility and diversification Japan has successfully managed to avoid supply shocks.

Japan's situation can be contrasted with that of the US. Whilst the US relies on the market and an abundant infrastructure to adjust to supply emergency events Japan, which has a noted lack of gas storage infrastructure, has successfully diversified its supply and adopted greater flexibility with a strategically based approach to deal with the vulnerabilities it is exposed to through its adoption of LNG as its sole source of supply.

Both the USA and Japan can be seen to have functioning markets during supply crises, yet maintain quite different structures. The EU whose storage market lacks the considerable natural capital and structure of that of the US but is equally less exposed to the externalities that the Japanese market is could attempt to compliment the positive aspects of both systems, i.e. the flexibility of the Japanese system complimented with the efficiently functioning aspects of the US market. Indeed with increased reliance from external markets such as Russia the European

Market should review the flexibility that the Japanese market displays and the measures that it has put into practice.

SECTION 7 IS THERE A NEED FOR COMMON APPROACH REGARDING STRATEGIC STOCKS AT EU LEVEL

Based on the overview and the analyses made in the previous sections, in this section we look at the need for common approach regarding strategic stock at EU level.

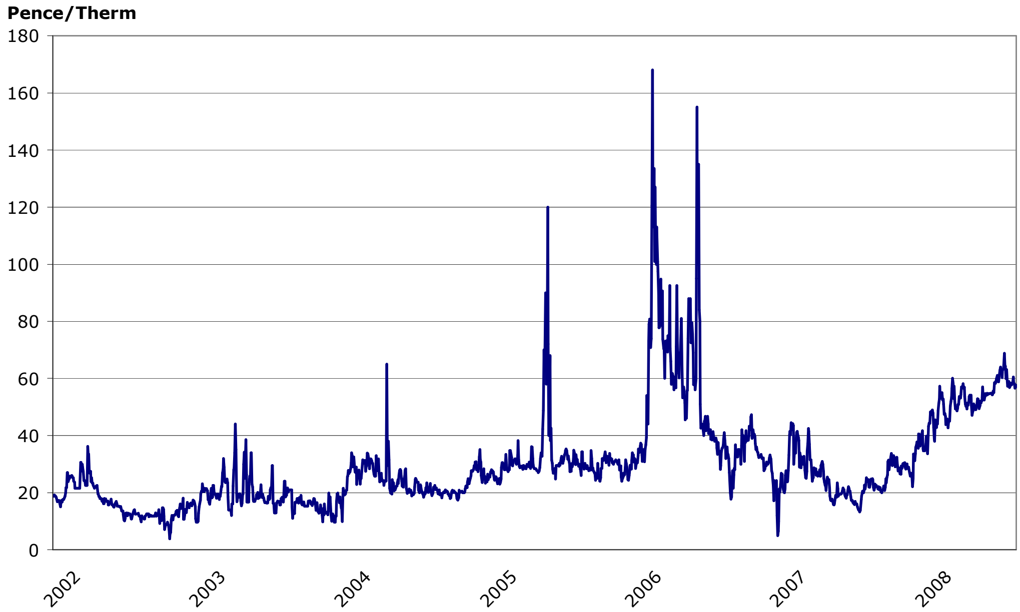
28. The response of the market

The market responds to a gas supply disruption by allocating gas to the area where the supply interruption has occurred through its price mechanism. Price signals in the market allow gas suppliers to redirect gas supplies towards the supply interruption because the scarcity in gas created by the interruption in supplies will raise prices to the level where gas supply and demand are equalised.

The market response can be illustrated with the example of the Rough storage fire in the UK during the winter of 2005-2006, in which the gas storage facility, which covers 70% of total storage capacity in the UK, caught fire and was shut down, cutting short the total gas supplies to the UK by around 40 mcm/day (equalling approximately 15 bcm on an annual basis). The storage breakdown coincided with a cold-snap, which made the situation even worse and more serious than it otherwise would have been.

These two events led to a large increase in UK gas prices (Figure 96), and the increase in price led to a number of responses, by market players both on the demand side as well as on the supply side.

Figure 96 NPB prices, pence/therm



On the supply side, natural gas was to some extent redirected from continental Europe towards the high prices in the UK, which can be seen from the flows in the Interconnector between Belgium and the UK, Figure 97.

The Rough incident happened in February 2006 and Figure 97 shows how imports via the Interconnector between Zeebrügge and Bacton were more than double the average of the preceding and following two years.

The situation was further alleviated by a response on the demand side, where fuel-switching in the power-generation sector replaced more than 40 mcm/day of additional gas supplies by switching to alternative fuels like coal or distillate in response to the high prices. The 40 mcm/day figure should be compared to the capacity of the Langeled, which is 20 bcm, and the Interconnector, which has a capacity of approximately 25 bcm (annually).

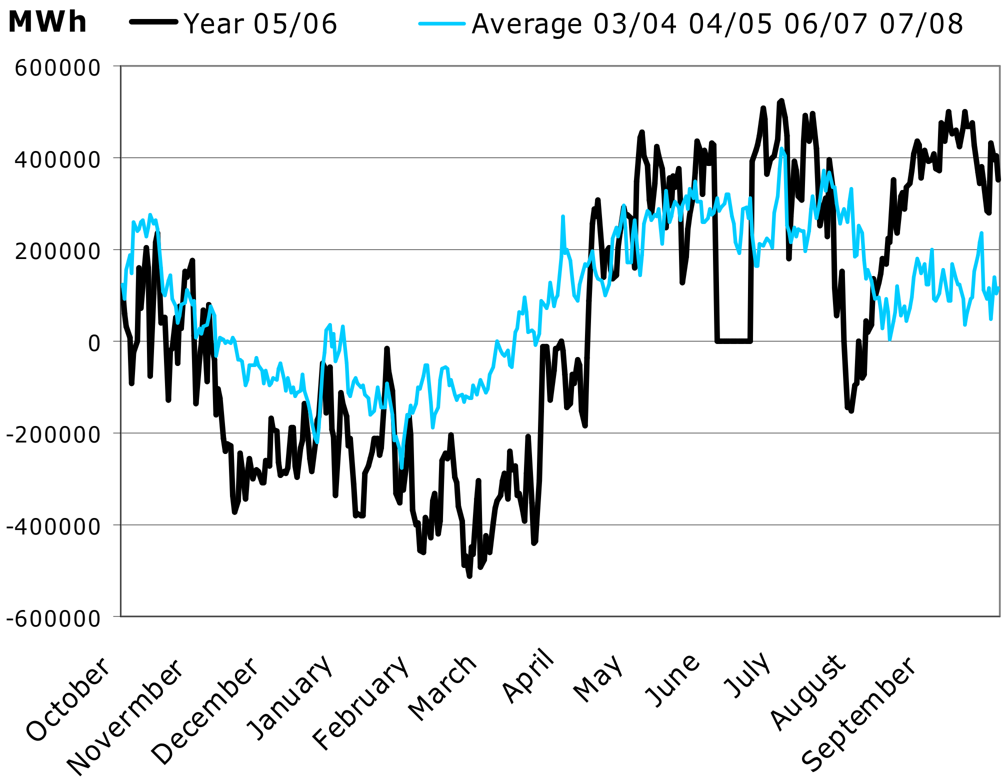
The tight supply situation in the UK since the winter of 2005-2006 has been eased significantly by a series of new investments, e.g. the Langeled import pipeline from Norway and the BBL from the Netherlands. All in all, these new investments led to an increase in the import capacity in the UK by 140% from the 2005-2006 winter to the 2006-2007 winter.[101]

The UK winter crisis in 2005-2006 showed that markets can cope with supply interruptions in the short-term, such as the Rough fire and they are also able to provide valuable investment signals for the long-term security of supply, allowing

[101] Source: Introduction to price and price signals in the gas market, October 2007. Department for Business, Enterprise and Regulatory Reform , URN 07/1537.

market players to make investment decisions based on the price signals revealed by the market.

Figure 97 Interconnector flows between Zeebrügge in Belgium and Bacton in the UK



Source: www.interconnector.com

29. Option 1 Experience from oil stocks

Strategic oil stocks have been in place for a number of years now. The first EU regulation on strategic oil stocks dates back in 1968, even before the International Energy Agency (IEA) and the signing of the Agreement on an International Energy Program (IEP Agreement) which introduced an oil security system to be established as a direct reaction to the oil crisis in 1974.

Thus this section gives an overview of the existing regulation on strategic oil stocks, of both the IEA and the EU and its implementation and discuses the possibility of using experiences from it as background for a possible implementation of regulation on strategic gas stocks, such as experience with:

- Definition of emergency events/triggering event of oil stock release.
- Minimum levels of oil stocks.
- Responsibility for maintaining strategic stocks/financial scheme.
- Monitoring the strategic stocks.
- Stock release mechanism/coordinated action.

29.1 General comparison

Before opening the discussion whether experiences from oil strategic stocks can be used for gas strategic stocks, we investigate whether there is a comparable background between oil and gas.

Referring to the discussion on definitions, we look at the security of supply in terms of risk of a supply disruption affecting the economy and supply disruption from the consumers' point of view.

The vulnerability of an economy to oil and gas supply disruption or high oil/gas prices depends directly on the share of oil/gas in the primary energy consumption combined with the energy intensity. The World Bank has introduced the so called World Bank index on vulnerability to oil disruption[102], and the same index could be used for natural gas.

Related to the vulnerability of the consumers, consumers within power generation and industry are equally vulnerable to disruption whether they use oil products or

[102] WB index =Oil imports/GDP = (oil imports/total oil use) x (total oil use/total energy use) x (total energy use/GDP)

natural gas. They are (typically) dual-fuel consumers and usually not directly affected by a supply disruption[103].

Households use oil and gas for the same purpose – for heating and hot water. Referring to the discussion on the security of supply the household consumer's concern is affordability and reliability. The difference between the oil and gas consumer is that the household using oil usually has an oil stock[104]. This implies that:

- The household gas consumer is more vulnerable to a supply disruption than households-oil/oil products consumers, as it is immediately[105] exposed to the supply disruption.
- An oil disruption will not affect the majority of households simultaneously to the same extent as in an event of gas disruption, even though generally oil stocks are refilled at the same period of the year - before the heating season and are therefore empty around the same time of the year.

For the reasons listed above, political pressure is sometimes exerted by threatening to cut off supplies in harsh winter conditions is more relevant for gas.

An interesting consumer sector is the transport sector. The oil dependency of the transport sector and its vulnerability to supply disruption is obvious. Gas supply disruption will not affect the transport sector to this extent as the share of gas in the transport sector is much less than compared to the oil. Furthermore, oil for transport for the military can be quite a sensitive issue but irrelevant on the natural gas side.

29.1.1 Crowding-out effect

An issue which deserves particular interest is the crowding-out effect that a policy on obligatory strategic stockpiling could have on commercially operated storages.

Use of strategic storage for other than the strictly defined purpose of supply in case of a supply disruption in a pre-defined event and thereby interference in the commercially operated storage market (such as for example use of strategic storage as price reducing mechanism), can indirectly result in reduction of the commercially based storage investments. This effect is referred to as the crowding out effect, i.e. investments in strategic stock may "crowd out" investment in commercial stocks. If one m^3 of strategic storage crowds out one m^3 of commercial storage, then the investment in strategic stock is completely futile. The exact ratio of crowding out, however, can be anything from zero to one, or even more than one.

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[103] Switching to other fuel in an event of supply disruption may cause a domino effect – interrupting dual-fuel consumers is therefore not risk-free in terms of the impact of the security of supply on the economy.

[104] Referring to relevant oil product.

105 Relative term, depending on the measures taken by operators etc.

In this respect strategic oil and gas storages are significantly different, oil storages can also be commercially operated, but they are not necessary for seasonal demand balancing. Gas storages on the other hand are an integrated part of the system and are necessary flexibility tool for seasonal balancing.

The crowding-out effect is further discussed in ANNEX V.

29.1.2 Transport of oil/gas

Gas is transported through pipelines – oil only to limited extent. This imposes a significant difference related to the discussion on strategic stock. Ensuring gas volumes in storage is not enough; it has to be combined with ensuring transmission capacity for transport of these gas volumes to the place of consumption. In an event of supply disruption, storage should be combined with alternative flexibility tools, such as interruptible consumers, which will then release some of the transmission capacity and make it available for transporting the volumes of gas from storage.

The above issue implies that much more coordination and cooperation between operators and authorities across borders are necessary for strategic gas storage than for strategic oil storage.

29.1.3 Storing oil/gas

The discussion of storing oil vs. storing gas revolves around two main points:

- Geographical restrictions.
- Storing costs.

Geographical restrictions do impose a restriction on the location of natural gas storages while installing oil storages/terminals in this respect, everything else being equal, is easier. In option 2 it is illustrated that 4-5 Member States have the possibilities of holding strategic gas stocks.

Another major difference between gas and oil stocks is the cost of installing oil vs. gas storages. Several costs aspects exist:

- Crowding out effects
- Creation costs
- Cost of filling the storage

The crowding out effects was described earlier in this section.

The construction costs are bound to be different as the location of natural gas storages is highly dependent on the geological conditions. As an illustration, a very general comparison of the construction costs per energy unit stored is given in the following: The construction costs for oil storages are estimated to be 150 MEUR per million ton of oil (capacity). One million ton of oil corresponds to 45 PJ, thus the price per PJ of stored energy is 3.33 MEUR. In Section 5 we saw that the construction price of gas storage varies between 464 MEUR/bcm and 650 MEUR/bcm depending on the type of gas storage. As one bcm corresponds to 38.7[106] PJ, the price per PJ is in the range 12-16.7 MEUR for gas storages. Compared to the average price per stored energy unit for oil storages it is thus seen that oil storages are up to 5 times cheaper to construct than gas storages are.

In addition to the difference in construction costs it is also of importance to consider the cost of actually buying the gas/oil and filling the storage. Filling costs are naturally very dependant on the prices of gas and oil, thus the discussion on storing costs becomes rather uncertain in a situation of very volatile and surging oil prices. As an illustration, for a strategic storage of 14bcm[107] (excluding cushion gas, cushion gas is contained in the capex cost) and buying gas at the NBP spot market price (medio October 2008) of 7.554 GDP per GJ, yields a total price of 5.28BEUR.

14bcm is equivalent to 12.6 million tonnes of oil equivalent, which converted into barrels of oil gives approximately 92.36 millions of barrels of oil. The cost of one barrel of Brent oil is (medio October 2008) 64.4$~50EUR. Thus the cost of 92.36 millions of barrels of oil is approximately 4.62 BEUR, which 14.4% less than the equivalent gas storage.

Thus gas storages are both more expensive in terms of construction and filling costs. A third aspect is the operating costs but as we saw in section 5 these were relatively insignificant for gas storage.

29.2 Regulation on strategic oil stocks

As mentioned in the introduction both the EU and the IEA have regulation of strategic oil stocks. In this section we give a brief overview of the similarities and differences with respect to regulation and requirement for strategic oil stocks. The first regulation imposing obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products dates back to 1968, and required that 65 days of internal consumption should be covered. Since then the regulation of strategic stock has been updated several times. The latest update is the 2006 directive where 98/93/EC was repealed. This is the most current EU regulation on strategic oil stocks available.

The oil crises in 1973-1974 triggered the formation of the International Energy Agency (IEA), and the signing of the 1974 Agreement on an International Energy Program (IEP Agreement) which introduces an oil security system and includes[108]:

- Maintenance of national emergency oil reserves and plans for co-ordinated use – strategic oil stocks.

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[106] Assumed average gas calorific value
[107] Corresponding to calculations in Option 4, see Table 40
[108] Ref /23/

- Other national measures, including demand restraint, fuel switching and surge oil production.
- Operation and co-ordination of effective national emergency organisations.
- Testing response measures and providing training in real-time emergency situations.
- Mechanisms for industry advice and operational assistance (the Industry Advisory Board Industry Supply Advisory Group); and
- A system for reallocation of available supplies, if necessary.

As seen from the above, the strategic oil stock is combined with other flexibility tools such as demand restraint, fuel switching and surge oil production, all of which may correspondingly be implemented on the natural gas side.

Both the EU and the IEA systems of strategic stocks have characteristics that may be useful when evaluating whether or how a similar system for strategic storage of gas should be implemented. This section describes the requirements of the two systems.

29.2.1 Definition of event

The question of defining the event (amount and duration) of the supply disruption that should trigger release of strategic stocks is just as challenging for oil as for gas. The IEA defines it as general as 'the event of an actual or potentially severe oil supply disruption', and this is, as a rule of thumb, a drop of more than 7% of imports for any single member. The IEA, as shown above, requires then stocks corresponding to 90 days of net oil imports of the previous year. It is not clear what the 90 days are exactly based on.

The IEA stock draw potential is, according to IEA /23/ 'sufficient in magnitude and sustainability to cope with the largest cited historical supply disruption' (an overview is given in the following).

As we have discussed in this report, the supply events have a varying impact on the EU Member States based on a number of factors, and net import is not an indicator of vulnerability on its own. Therefore, even though IEA's definition of "7% of imports for any single member", is slightly more specific than the definition of the Security Directive on the gas side of "a situation where the Community would risk to loose more than 20% of its gas supply from third countries", it still does not depict the impact of this disruption on the IEA/EU Member States.

The supply shock event is in the EU system not as explicitly defined as in the IEA. Both Member States and the Commission can suggest triggering of the strategic stocks. Prior to using their strategic stock Member States must consult the Commission which then coordinates a response among the Member States. In this consultation the Oil Supply Group established by the 1973 Directive should also be consulted. If withdrawals take place without such a meeting the Member State must explain why such an action was needed and what is being done to re-establish stocks.

The events of supply disruption should be made operational i.e. defined in terms of duration and responsibility for taking action, and minimum level of service provided, and the size strategic gas stock is related to the functioning of the gas market and should be determined on regional (or EU level) based on analyzing the specifics of the region and a correspondingly prepared operational plan, including the use of alternative flexibility tools.

29.2.2 Supply obligations

IEA net oil importing countries have legal obligation to hold emergency oil reserves equivalent to at least 90 days of net oil imports of the previous year.

The EU requires that 90 days of internal consumption for the three oil types, gasoline, and middle distillates, and fuel oils, should be covered. The current storage situation is illustrated in Table 23 below.

Table 23 days of consumption covered by strategic oil storage, June 2008.

	Gasoline		Middle distillates		Fuel oil		Total	
	Days	Storage*	Days	Storage*	Days	Storage*	Days	Storage*
EU-27	127	33954	101	85444	247	24.022	119	143420

*1000 tons. Moreover 7 of the new MS countries are in a transition state.

Source: European Commission.

With regard to petroleum production Member States with production may deduct this from their stockholding obligation, this deduction must however not exceed 25% of the total consumption.

29.2.3 Responsibility, release mechanisms and monitoring

Both the IEA and the EU stocks are managed by each Member State. Member States' Governments may choose to establish an entity which is responsible for the strategic stocks, manage the stocks themselves, or to impose requirement on commercial operators. Currently in the EU, 62% of stock volume is hold by the industry, 3% by Governments, and 35% by appointed agencies[109]. Stocks may be held outside the territory of the Member State, if this is the case the Member State on whose territory the stock is held must ensure that the strategic stock is available to the Member State in need. About 40 bilateral agreements exist, these are mainly concentrated in North West Europe, and moreover seven countries do not accept strategic oil stocks outside their territory.

The IEA has 28 members, 25 of which net-importing countries and 3 net-exporting countries. Every IEA member country has industry commercial stocks, which are held by companies. 20 out of 28 countries place a stockholding requirement on industry, i.e. 8 countries do not place an obligation on industry, but their commercial stocks are counted towards the IEA obligation of 90 days of net imports.

[109] European Commission DG-Tren. Annex to Consultation Document "On the revision of the emergency oil stocks regime in the EU" Towards a modern and effective system of oil stocks in Europe. 2008.

An overview of the different stockpiling regimes in the IEA Member Countries can be seen in Table 24. Agency and Government have in this context no difference – it is public strategic stock.

Table 24 Stockpiling regimes of IEA Member Countries

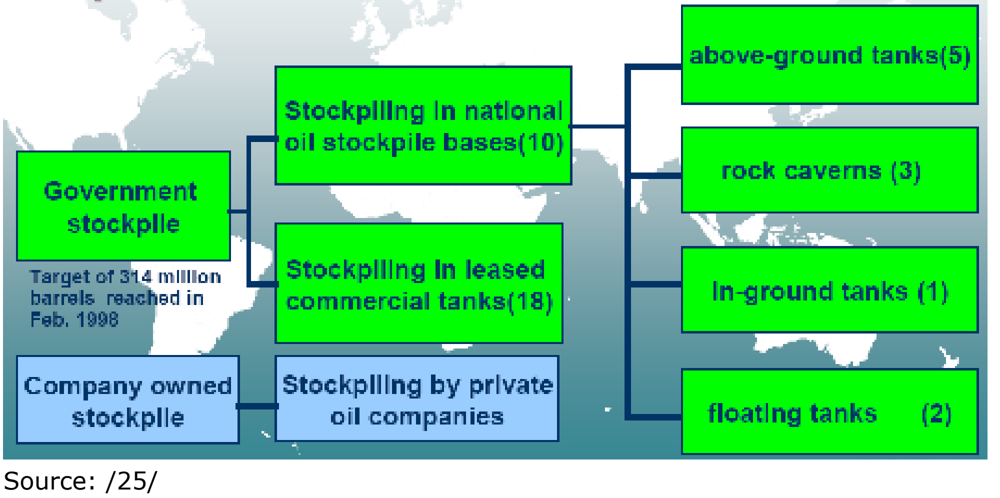
Industry	Agency	Government	Agency/Industry	Government/Industry
Greece	Germany	Czech Rep.	Austria	Ireland
Italy	Hungary	Slovak Rep.	Belgium	Poland
Luxembourg		US	Denmark	Republic of Korea
Sweden		New Zealand	Finland	Japan
UK			France	
Turkey			Netherlands	
Norway			Portugal	
			Spain	
			Switzerland	

Source: /25/

In the US, oil from stocks is released primarily by tender, the sales being open to any person or entity (however in severe energy supply disruption the decision is made by the US President) or through Oil Exchange program (loan), which is essentially exchange a volume of SPR oil for return of a larger volume at a later date, this decision is taken by the Secretary of State.

In Japan, the oil stockpiling has started in the private sector in 1971, followed by national (public) oil stockpiling in 1978. After building up national oil stocks to a certain level, stocks in the private sector have been decreased gradually while national oil stocks increased. Current stockholding obligation on industry is at least 70 days of imports.

Figure 98 Stockpiling regime in Japan



Source: /25/

In Germany introduction of compulsory stockholding in the Federal Republic of Germany has been introduced in 1966, and has been in 1975 been levelled to 90 days minimum stocks according to IEA obligation. In 1978, the Founding public stockholding law has been passed establishing EBV ((Erdölbevorratungsverband - Germany stockholding agency, in which membership is compulsory by law for all oil companies refining crude or importing products – covering costs by fees). When in 1998 EBV stocks increased to 90 days the industry has been relieved from the stockpiling stock obligation. Monitoring of stocks is done by the Ministry of Economics.

Comparing the EU and IEA ownership structure reveals that there in general is large diversity in the ownership relations. The diversity in ownership and management of the strategic stocks contributes to a muddy picture of the system of strategic stocks. Recently the EU has expressed concerns about this diversity, as the fact that large parts of the strategic oil stocks are held by industry operators makes it difficult to ascertain the true size of the strategic oil stocks. Questioning of the credibility of the system of oil strategic stocks could open up for speculation and volatility in oil prices. It has therefore been proposed that monitoring of the strategic oil stocks is enhanced. A 100% government controlled strategic oil storages so that commercial and strategic stocks are fully separated is also discussed /29/, however the costs of implementing such a policy has until today been found to outweigh the benefits of such an arrangement.

29.2.4 Procedure in the event of a shock

In theory, the response mechanism of IEA can be outlined as follows:

1. In the "event of an actual or potentially severe oil supply disruption", the IEA Office of Oil Markets and Emergency Preparedness assesses the market impact and the potential need for an IEA co-ordinated response. This market assessment includes an estimate of the additional production oil producers can bring to the market quickly, based on consultation with producer governments.
2. Based on this assessment, the IEA Executive Director consults with and advises the IEA Governing Board (GB), which is comprised of senior energy officials from member countries who determine the major policy decisions of the IEA. This consultation process to determine the need for an IEA co-ordinated action can be accomplished within 24 hours, if necessary.
3. Once a co-ordinated action has been agreed upon each member country participates by making oil available to the market, according to national circumstances. An individual member country's share of the total response is generally proportionate to its share of the IEA member countries' total consumption.

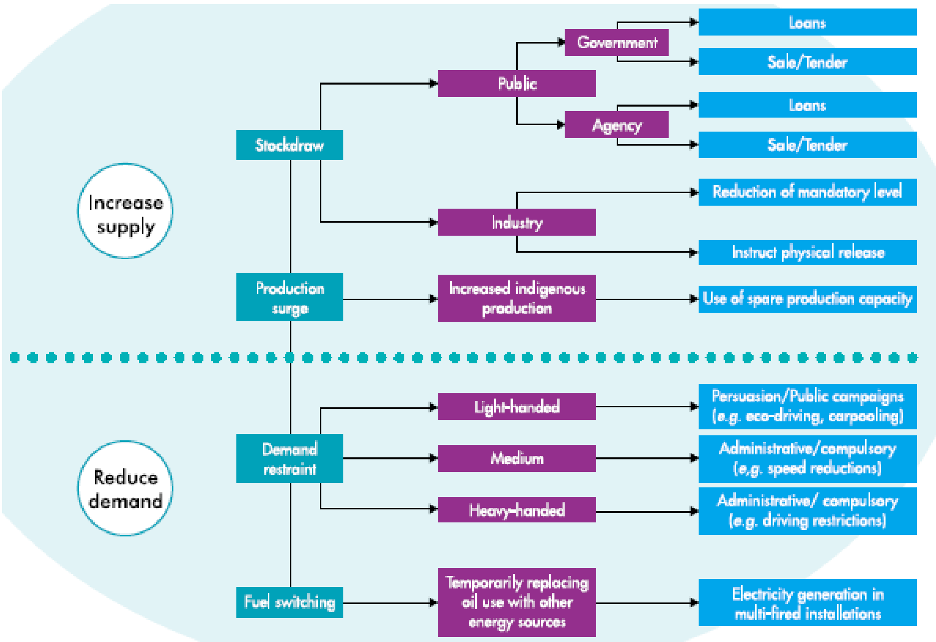
There have been no events in the past that can be used to verify whether the above mechanism actually works. The events in the past in which strategic oil stocks have been released, presented in section 29.3, have been released by alternative procedures.

The general approach to managing a supply disruption event is by implementing measures to:

- Increase supply (production surge, storage – commercial, obligatory on industry or public).
- Reduce demand (fuel switching).

It is then up to the governments of the IEA Member States to decide how to comply with the requirements of the IEP Agreement i.e. in terms of stockpiling regimes - placing the responsibility for maintaining strategic stock, monitoring the stocks and in terms of the stock release mechanism. The general approach to complying with the requirements is illustrated in Figure 99.

Figure 99 IEA Response measures



Source: /24/

Thus specific task in the event of an event are defined for IEA members.

At present no common EU wide response mechanism exists in the EU. The response/obligation of the Member States is outlined in the following three directives:

- 2006/67/EC imposing obligations to maintain minimum stocks of crude oil and petroleum products.
- 73//238/EEC Measures to mitigate the effects of in the supply of crude oil and petroleum products.

- 77/706/EEC which sets community targets for reduction in the consumption of primary sources of energy in the event of difficulties in the supply of crude oil and petroleum products.

As described in the discussion of the definition of the stock releasing event, each member state can ask the Commission and the oil supply group for advice. Furthermore, in the case of a coordinated IEA action it is the task of the Commission to ensure a coordinated response by the Member States which are members of the IEA.

The lack of rules ensuring a common response strategy to supply shocks has recently led to criticism and suggestions to improve upon regulation. Issues such as fairness and solidarity are not treated in any of the directives, for example must all member countries respond to emergency situations (also if the emergency situation is merely regional)?

29.3 Events that triggered establishment and release of oil stocks

In this section we describe the events that led to the release of the IEA and EU strategic oil stocks.

Turning to the EU we see that the system of strategic oil stocks has been in use a number of times. Most recently in following cases:

- 2008: The Czech Republics draw on reserves in connection to the shutdown of oil deliveries from Russia in June 2008, following the acceptance of the US missile defence project. The drawing on reserves was combined with increase imports from Germany.
- 2007: Dispute between Belarus and Russia results in shutting down the Druzhba pipeline. The OGS met to discuss the appropriate measures which might be taken.
- 2005: Following the tropic storms Katrina and Rita an IEA request to the EU IEA members to participate in a collective action resulted in the full compliance of EU IEA member states and the full support for the emergency measures taken from non IEA EU Member States. More specifically the Commission recommended that oil products belonging to the first group (gasoline) should be released. Furthermore Member States should in coordination with the OGS find ways to reduce demand for oil.
- 2003: Crisis in the Middle East.

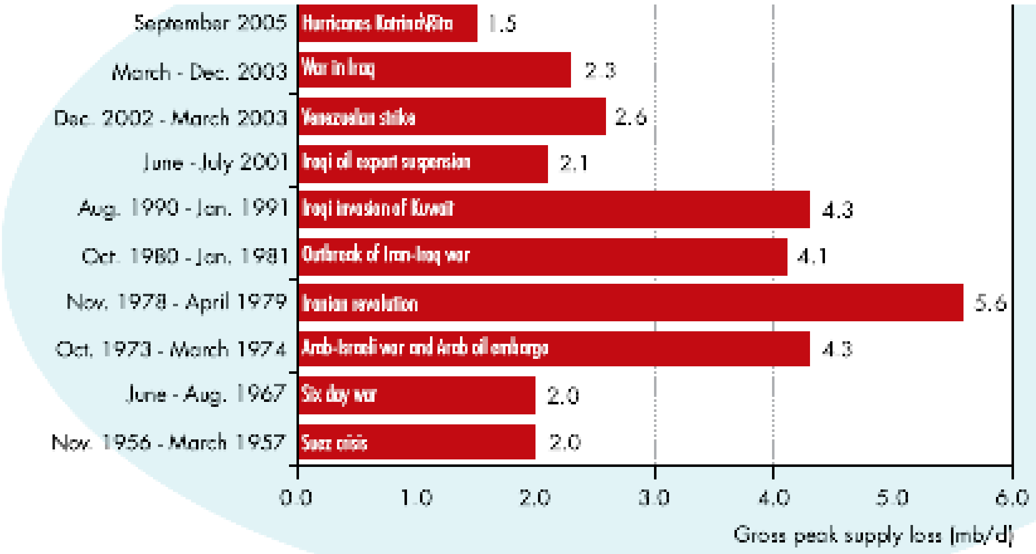
In these events only the tropic storms Katrina and Rita triggered a considerable release of oil. Even though the action taken during this crisis in general was considered a success, the short comings of the system were also displayed. More specifically there were problems in relation to identifying the contribution of the industry[110].

[110] "Emergency preparedness: Lessons from the Hurricanes" IEA document 2006.

Figure 100 lists the events in which strategic oil stocks have been released from the IEA. According to IEA, strategic oil stocks are intended for use in response to the physical loss of oil supply, not for use as a price management tool /25/, which if true would be a different definition of security of gas supply and the related use of strategic storage, which no longer only takes physical supply disruption into consideration, but also the economic aspects of these supplies i.e. gas prices.

However few examples on release of strategic oil stocks in the US, presented below show that far from all of these events have been "event of an actual or potentially severe oil supply disruption". The examples are borrowed from the latest edition of Foreign Affairs, reference /26/:

Figure 100 Events that triggered release of oil stock in the past, mb/day



Source: /24/

- The Yom Kippur War in 1973; the Arab oil states reduce exports and raise prices in retaliation for Western support of Israel causing the price of crude to surge from about $3 to about $12. In 1975 US Congress passes legislation that authorizes the construction of the SPR (Strategic Petroleum Reserves) in order to empower the U.S. government to acquire and store oil and release it when needed;
- The Iranian revolution in 1979-80, causing again oil price surge;
- The Exxon Valdez oil spill in 1989, (oil shipments from Alaska), creates shortages on local markets and boosting prices once again.
- Saddam Hussein invades Kuwait and seized its oil fields in 1991. The US authorizes a five million barrel "test" sale, which accomplishes little. The market calms down, but mainly to the coalition forces' victory on the battlefield and assurances from Saudi Arabia that it would boost production if needed. The US finally sells 17.3 million barrels during Operation Desert Storm.

- In 1994 President Bill Clinton struck a deal to sell some reserves in order to help balance the budget [111]
- The invasion of Iraq in 2003
- The hurricanes Katrina and Rita devastated the oil-supply and oil-refining systems in the Gulf of Mexico; the Bush administration did sell or lend more than 20 million barrels of SPR oil after and the move helped ease the ensuing shortages of crude oil, combined with extra supplies of refined products, such as gasoline, and temporarily easing environmental restrictions, which allowed fuel markets to operate more flexibly.

The lessons that can be learned from the IEA release of oil stocks are that:

Large players will always use their power for political purposes unless they are prevented from doing so by appropriately designed institutions. In order to avoid market distortion, it is then better to specify the events that are not covered by the market and in which storage shall be used (as a non-market measure) for this purpose.

The pure size/volumes of the supply disruption are not relevant as the impact is country and situation specific. During the oil shock that followed the 1979 Iranian Revolution, in spite of serious shortages, they have failed to reach the seven percent mark (set by IEA). The Exxon Valdes case later causes the US Congress to re-evaluate the regulation and allow release of gas stocks also in "instances that fall short of a severe energy supply interruption"/26/. This tends to be in line with our arguments for revision of the MSD event in the Security Directive.

29.4 Summary and conclusions on whether a scheme alike the oil strategic stock or parts of it can be used for establishing gas strategic stock

The concept of strategic oil stocks have been in place for a number of years now. Taking into consideration the comparable vulnerability of the end consumers and the economies to oil supply disruption and gas supply disruption respectively, one could argue that if there is a need for oil strategic stocks, then there also is a need for gas strategic stocks. However, we have in this section tried to argument why the strategic oil stock scheme does not seem to be an optimal tool for security of gas supply, not only based on the cost differences, but also based on the differences in the risk of distorting consequences on the gas market and nonetheless the difference in "logistics" related to transporting the oil/gas from the storage to the point of consumption.

In the following we summarize the analyses and the recommendations.

[111] Not indicated in the above figure by EIA.

In order to investigate whether some of the experience related to the existence of this scheme can be used as background for a possible implementation of regulation on strategic gas stocks we have analysed the implementability of some of the main items defining the scheme, namely:

- Definition of emergency events/triggering event of oil stock release – how is the event defined and can it be relevant for gas strategic stocks;
- Minimum levels of oil stocks – what is the level of security of supply provided by the strategic stocks and can it be directly or indirectly transposed for gas strategic stocks;
- Responsibility for maintaining strategic stocks/financial scheme – who is maintaining (and paying for) the strategic stock
- Monitoring the strategic stocks – who is ensuring that the strategic stocks actually are in place?
- Stock release mechanism/coordinated action – what is the actual procedure for releasing the strategic stocks

The general conclusion is that the Consultant is not of opinion that the scheme of oil strategic stocks can be transposed into a scheme of strategic gas stocks neither completely nor partially.

The experience from the IEA Response Measures can be used as a background in establishing a common EU Emergency Supply Plan for common EU action in case of a supply disruption.

We started the analyses by a general comparison of the similarities and differences between oil and gas as fuels and came to following observations:

Vulnerability to supply disruption

The vulnerability of an economy to oil supply disruption in macroeconomic terms is comparable to the vulnerability to gas supply disruption.

The World Bank index on vulnerability to oil disruption expressed through oil import dependency, share of oil in the primary energy use and energy intensity might directly be implemented for gas. This might be an argument for implementation of strategic gas stocks. Even if the risk of supply disruption is not the same for oil and for gas supplies, decreasing the vulnerability to gas supply disruption would improve EU's negotiation position in case energy supplies are being (misused in foreign policy.

Looking at the level of the end consumer sectors, households-gas consumers are more vulnerable to gas supply disruption than to oil supply disruption. However the transport sector (including the military) is the consumer sector that makes securing oil supplies much more strategic than gas supplies.

Risk of market distortion

Oil stocks can be used for seasonal demand balancing, but gas storages are an integral part of the gas supply chain and a crucial flexibility tool in seasonal demand balancing. The gas storage market is therefore much more exposed to a possible crowding out effect i.e. much more susceptible to distortion by a possible misuse of the strategic stock.

Cost comparison

A very general comparison of the storage construction costs shows that the cost of construction of gas storage per unit energy stored is 3.6 times higher than oil storage. The total costs of an oil storage compared to gas storage will though very much depend on the actual oil and gas prices, a comparison of the filling costs showed that an oil storage, medio October, was 14% cheaper to fill than a gas storage.

Furthermore, the supply of natural gas implies transport of natural gas mainly through pipelines. Ensuring available transmission capacity from the strategic gas stock to the place of consumption must therefore be part of the strategic gas stock scheme. This not only entails additional costs in maintaining "strategic transmission capacity", but also a far more complex coordination between relevant parties than in the case of the oil strategic stocks.

On the main parts of the scheme for strategic oil stock, following can be concluded:

Definition of emergency events/triggering event of oil stock release

It is challenging to define the event that triggers the strategic stock release in a way that avoids that strategic gas stocks become political tools or otherwise be misused. It was therefore interesting to see whether the definitions of the corresponding event that triggers the oil strategic stocks release can be used.

The EU does not have a definition of a supply disruption event in which the strategic oil stocks should be released; both Member States and the Commission can suggest triggering of the strategic stocks. Prior to using their strategic stock Member States must consult the Commission which then coordinates a response among the Member States.

The Consultant would not recommend the establishment of strategic gas stocks but recommends establishing a specified mechanism for common action in case of gas supply disruption. The above approach towards the event that will trigger the common action is recommended (to be used as a background for a further specified action plan), based on following considerations:

At present the Security Directive defines an event of a Major Supply Disruption (MSD) as "A situation where the Community would risk losing more than 20% of its gas supply from third countries and the situation at Community level is not likely to be adequately managed with national measures." The foreseeable length of such a supply disruption should cover "a significant period of time of at least eight weeks".

Related to the effect of this supply disruption on the Member States:

- Even if assuming the defined reduction of supply of 20% at the EU level means an evenly spread supply reduction to EU Member States, it will have quite a different impact on the security of supply in the different Member States

- It is not irrelevant where the gas supply disruption occurs – Member States are affected differently, depending on where the gas supply interruption occurs

The different impacts of the MSD, as defined at present, on the Member States depend, among other factors, on:

- the share of gas in the country's primary energy use combined with energy intensity
- the share of gas in the country's final energy use/swing ratio
- interruptible consumers
- import dependency
- supply diversification
- the functioning of the gas market

The variation of these parameters and throughout EU Member States was observed in Section 1, indicating quite a different vulnerability of the country's economy to a potential gas supply disruption.

Looking at IEA's definition of 'the event of an actual or potentially severe oil supply disruption', it is, as a rule of thumb, "a drop of more than 7% of imports for any single member".

As we have discussed in this report, net import is not an indicator of vulnerability on its own, and a supply disruption from an indigenous source can have quite the same impact as a supply disruption from import, as illustrated with the example on the fire at the Rough storage in the UK.

Therefore, even though IEA's definition of "7% of imports for any single member", is slightly more specific than the definition of the Security Directive on the gas side of "a situation where the Community would risk to loose more than 20% of its gas supply from third countries", it still does not depict the impact of this disruption on the IEA/EU Member States.

Based on the above discussion, following conclusion can be made:

Member States should have the possibility to apply for a common EU response based on an idiosyncratic emergency supply situation that they are not able to tackle individually. However it should be noted that the magnitude of the crises shall be above certain benchmark before it actually can trigger common response. The Major Supply Disruption event as defined in the Security Directive can play this role, but might be more efficient if revised following the IEA example by referring to drop of supply (but not import only) per Member State.

There should also be a mechanism of constant update of the definition, for example through the Gas Coordination Group, so that it corresponds to the changing conditions of gas supply to EU (in terms of net import, new supply sources etc).

Each Member State shall be able to announce idiosyncratic emergency supply situation and apply for common response by Member States.

However, common response by Member States can be triggered upon approval by the Gas Coordination Group only.

Minimum levels of oil stocks

The level of the oil strategic stocks, the 90 days of consumption seems arbitrary. In its consultation document on the revision of the emergency oil stock regime /2/, the Commission states that "the internationally accepted 90 days coverage provides reasonable protection in case of disruption", however not supporting this statement with any argument for or against. It also calls for "a switch from a consumption-based calculation method to a net import based method used by the IEA".

A strategic stock corresponding to 90 days of consumption has never been used in the period in which the scheme has existed.

Based on the lack of evidence on how the 90 days have been established, it does not seem justified to use such a requirement as a direct inspiration for the considerations for a gas strategic stock strategy.

Responsibility for maintaining strategic stocks/financial scheme/monitoring

The issues related to ownership and responsibility in the EU strategic oil stock scheme are also subject to revision /29/ and cannot provide background for using a similar scheme for gas strategic stocks.

One of the identified problems, also of relevance for a possible strategic gas storage concept, is the difficulty to distinguish between strategic and commercial oil stocks. When strategic stocks are not separate facilities dedicated to strategic stocks only, resulting in a lack of overview of the actual level of strategic stocks at any time.

Another issue is the lack of a coordinated action/stock release mechanism and clear definition of each Member States' as well as the Commission's role and responsibility in the event of a supply disruption. The Commission does not have any power to determine who should release stocks and what amounts should be released.

It seems that the EU Commission is also trying to define better stock release management and coordinated action in case of an emergency. The EIA action plan has never been used as such and therefore provides not much experience.

30. Option 2 Limited number of strategic stocks located at key points of the network

When evaluating the possibility of the development of a limited number of strategic stocks for mutual use at a European level the first, and most exigent task, is to identify which areas of Europe presently have the requisite geological conditions necessary for the creation of the various volumes of storage needed to provide security in the scenarios stipulated.

The possibility of developing such strategic gas storage is not however solely dependent upon the present geological suitability of prospective storage regions, there is also a need to evaluate areas from an economic and technical perspective to ensure that potential selections are evaluated ion terms of their feasibility as storage locations.

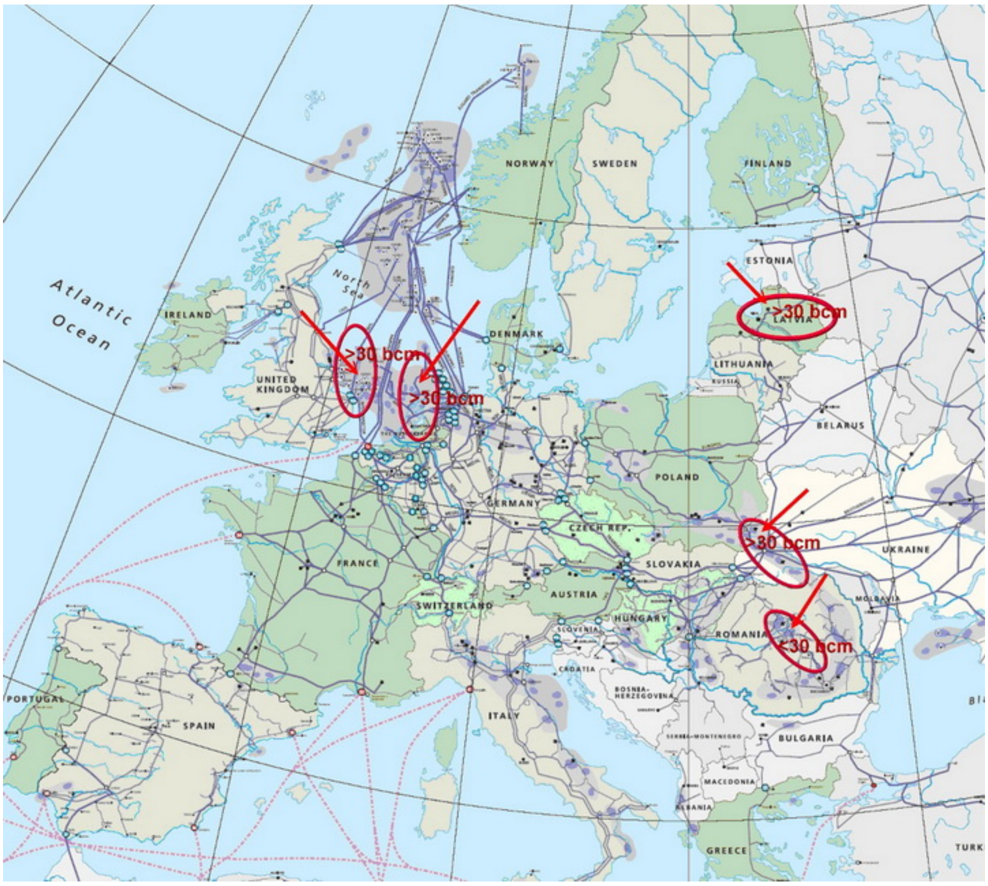
A logical method for the evaluation of this option would be to propose a series of requirements concerning each potential host country's ability to have such storage and subsequently eliminate storage regions which fail to meet these requirements for the volumes that have been stipulated. Once a series of viable areas have been determined for locating the storage the feasibility of theses countries can be determined through the analysis of their existing networks, current legislation and indications of the stability and ability to host such considerable volumes of natural gas storage and a variety of options subsequently presented.

This section will use the volumes of storage as calculated in section 7 option 4 as the capacities needed to provide varying degrees of supply security throughout Europe.[112]

[112] See Section 7 option 4 for additional details

31. What Type of storage?

Figure 101 Map of depleted field distribution in Europe



Source: GSE Storage Map 2008

Analysis undertaken in previous sections of this report suggests that for the considerable volumes of gas needed to provide strategic storage in the scenarios of security delineated previously the storage types that would provide both economically and technically effective storage would be in depleted fields either onshore or offshore.

Depleted fields are technically attractive due to being able to provide the greater volumes of storage capacities than both salt and aquifers and additionally they will provide economically the lowest costs per billion cubic meter (bcm) of storage gas. Depleted fields will also provide the necessary seismic, geological and well certainty as their long term sealing capacities have been previously proven by their previous use. Such certainty reduces both the cost and risk in storage creation. Salt caverns would be unusable, in the majority, to provide such large volumes of gas storage with the porous nature of the reservoir implying significantly more flow resistance. Salt cavities also remain unsuitable due to the higher fixed costs associated in their initial creation due to processes such as leaching and brine disposal and in addition their storage volume capacities are generally unsuited for long term strategic storage such as the type envisaged in the security scenario. Salt caverns would be unusable, in the majority, to provide such large volumes of gas storage with the porous nature of the reservoir implying significantly more flow resistance. Salt cavities are also unsuitable due to the higher fixed costs involved in their initial creation and also in their storage volume capacities which are generally unsuited for long term strategic storage.

Aquifers whilst potentially providing the volumes that are requested are limited by relative economic inefficiency in comparison to depleted and the substantial costs of cushion gas, compressors and wells needed in order for such storage to be created. With compressors costing in the region of €70 million for an onshore mid sized compressor to €620 million for an offshore compression system, obviously such costs need to be kept to a minimum and aquifer storage would not prove conducive to reducing such costs. The sealing capacity of an aquifer’s overlying layer has to be extensively assessed first and such studies are both expensive and time consuming, in addition there is generally less information available for aquifers than depleted fields which provide greater levels of certainty in their geology. In conclusion depleted fields are clearly at an advantage when developing significant volumes of storage to provide security at a regional level.

31.1 Where are potentially suitable depleted field formations distributed in Europe?

Having established that depleted fields provide the economic and technical qualities that are required for the considerable volumes that have been calculated to provide security, potential locations for such storages are investigated.

Geologically suitable sites for the storage would have a good capacity and injectivity rates with high rates of geological certainty regarding their suitability as storage sites. Factors such as the depth of the storage formation relate to the increased drilling that would be needed and the compression costs, which will affect the economic viability of the storage sites. Particular levels of porosity and thickness will also be required in order to provide an adequate capacity and injectivity rates. Such intricate information can only be discerned from specific and detailed analysis of the proposed sites, but a number of regions in Europe have been shown to have the requisite geological ability. Looking at depleted field distribution in Europe there are five areas that show abundant geological potential needed for the development of strategic European storage. The regions are selected primarily on their geological suitability for the accommodation of such considerable volumes of storage and following this the appropriateness of the region/country is evaluated considering its existing gas network and location on the European gas network as linking the storage to the network remains critical if the storage is to provide a common security of supply throughout Europe.

With such vast capital costs in the creation of such storage it would be unfeasible to create storage where there was not the means to transport the gas in the event of a supply disruption. There is considerable benefit in having such storages located in multi regions, technically it may be argued that the more localised the delivery of gas at individual points in the network the greater stress the network will be put under so there is additional investment required to alleviate the constraints. From a practical point of view multi region storage could, if the requisite storage is available, provide security for each region of Europe. However the reality at present is that the pipelines are not presently in existence nor is there sufficient storage in all regions for this.

The diagram below shows the main existing and potential import pipelines for natural gas into Europe. It clearly shows that at present from the options presented the Ukraine’s western storage facilities and the northern European fields in the Netherlands and offshore United Kingdom are well positioned for storage creation to facilitate and enhance the existing network, they satisfy the criteria of being near the major consuming areas in particular the British and German markets that account for a considerable proportion of European gas consumption. There are a number of additional pipelines that are in development that could alter the existing situation by incorporating countries that may have been previously deemed unfavourable due to their position in gas network.

Figure 102 Existing and Planned Major European Gas Pipeline Routes

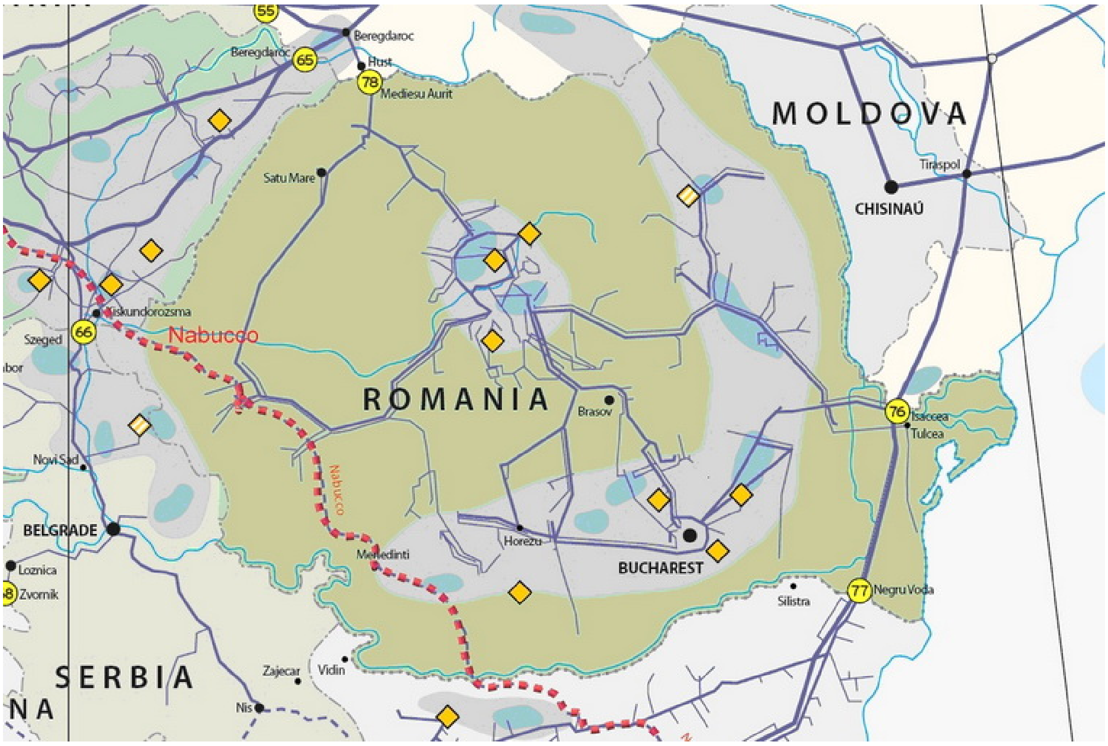
Source: GSE Storage Map 2008

It must be stated that the proposed list of potential sites for gas storage is not exhaustive; there are perhaps additional areas where storage may be created however the sites suggested have been selected due to the range of issues that they present. In giving a number of proposed sites that show considerable heterogeneity a greater number of issues can be explored and deliberated upon and clear criteria for potential storage sites can be discerned.

31.1.1 Romania

From a strategic point of view Romania may have a future role to play in storage in Europe. Romania's potential storage role is enhanced through vast volumes of storage that it could provide if its producing fields, which have been declining in recent years, are utilised. Additionally an increase in the gas import price has led to added interest domestically in the expansion of its existing underground options.

Figure 103 Romanian Network Map



Source: GSE Storage Map 2008

Romania's first underground storage was created in 1978 and at present there are eight storages in use with one additional planned to come into operation in 2009. Storages in Romania can be subdivided into two categories depending on their geographical position and secondly upon their geological characteristics. UGS in Southern Romania has potentially very large storage volumes due to a variety of factors including excellent thickness, porosity and a large surface area. The UGS in Transylvania is characterised by heterogeneous sedimentation and the depths of the storage in this region is quite shallow with low pressures required in order to inject the gas. In addition to these two sites Romgaz (Romania's natural gas company) has made a survey of depleted fields in Romania in order to generate ideas for potential storages.[113] The Romgaz selection criteria for firstly gas fields was that such fields should have enough gas already in place to act as cushion gas as due to the present high costs of cushion gas Romgaz would be unable to undertake the development of storages that would require a build up of cushion gas.

[113] Energy Sector Management Assistance Programme, Natural Gas Development Strategy, Report 192/96, 2006

There has been 236 million euros worth of investments in 2006 to increase both the storage and productive capacities.[114] The most likely current prospects for gas storage in Romania are the Sarmasel field in the Transylvanian basin and the Roman Margineni which is a large depleted field in north eastern Romania with initial reserves of 4.7 bcm and remaining gas reserves of 1.4 bcm, if the reaming gas was utilised as cushion gas it could make the storages more cost effective. In addition underground gas storage is possible in the Silimini Ghercesti region with a potential depleted field 300 m deep with a capacity of 4bcm. So there remains obvious opportunity for expansion in Romanian gas storage system, but the feasibility of using this as a strategic storage point needs to be evaluated given the current infrastructure.

31.1.2 Network Infrastructure

Romania has at present over 12000km of transmission pipelines and 569 km of international transit pipelines with an overall transmission capacity of 30 bcm a year. Considering the geographical position within the Balkan region, Romania may well play a role in achieving a new transit corridor for gas coming from the Caspian Sea area into Western Europe. At present there is the stipulated Nabucco pipeline that will transfer gas from Turkey to Austria via Bulgaria, Romania and Hungary. Nabucco is expected to be able to provide 25.5-31 bcm of natural gas a year for the European market. By offering incentives and investment in Romania’s gas storage infrastructure Europe could benefit from its abundance of gas storage capacity and the combination of investment and the potential Nabucco pipleine could mean that Romania is ideally located for investment in storages to enhance European natural gas supply.

31.2 Latvia

Latvian natural gas stability is ensured through the Incuklas Underground Gas Storage which is the third largest UGS facility in Europe having a total volume of 4.4 bcm with an active volume of 2.3 bcm. Extensions of the existing facility with a technical reconstruction proposed to create a further 3.2 BCM of working gas.[115] In addition to this current considerable gas storage there is scope to develop up to 50 BCM of storage in Latvia due to its unique geological conditions. A number of wells were created in the 1970’s to analyse the potential of Latvia for gas storage with 12 still in operation at present. One depleted field alone (Dobele) was determined to have a working gas capacity of 10 BCM. There are at present no plans to construct new storage however a decision has been made on the expansion of the Dobele storage facility, financed 50% by the EU and 50% by the state.[116]

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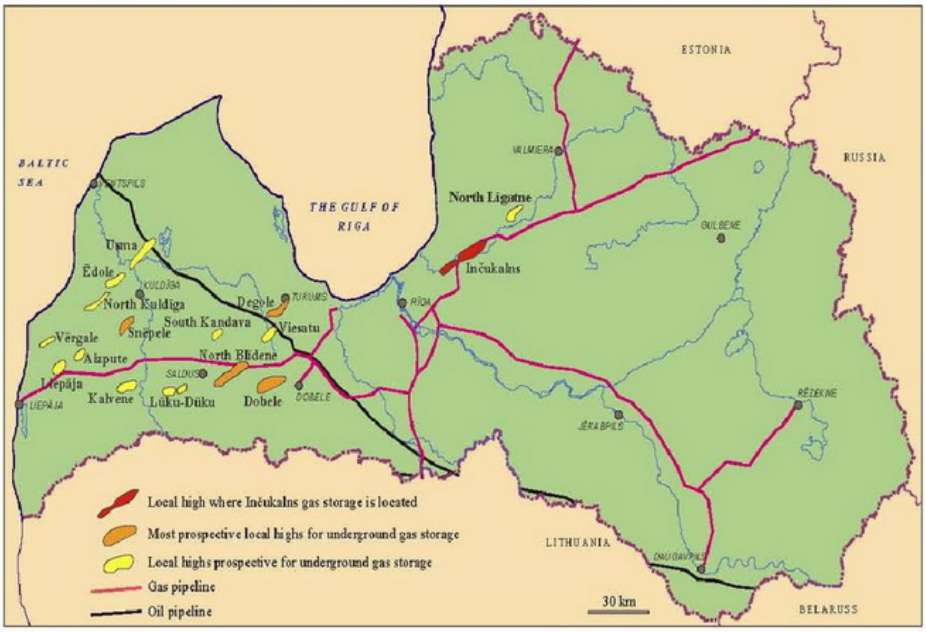
[114] Outlining of the Role of Romania in the European Gas Transit Chain Current Status and Prospective, Tranzgaz Centre of Romania, G.Stephan, 2007.

[115] Increasing interdependence of the Latvian Energy Sector in Regional and Global Energy Systems, Dr A Davis, 2007.

[116] Increasing interdependence of the Latvian Energy Sector in Regional and Global Energy Systems, Dr A Davis, 2007.

Figure 104 Potential Latvian Natural Gas Storage Sites



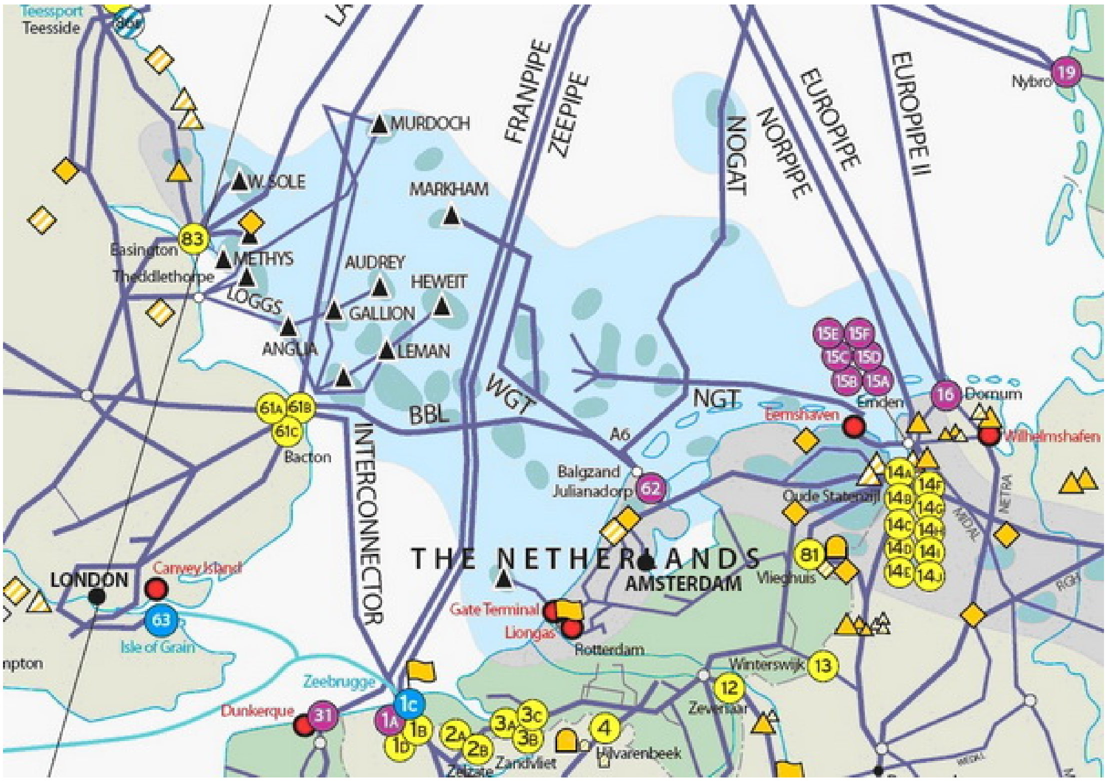
Source: United Nations Economic Commission for Europe, the outlook for Latvian potential Underground Storages, 2003.

31.2.1 Network Infrastructure

The Baltic region is abundant with depleted field storage with Lithuania, Estonia and Latvia situated in one common Baltic sedimentary basin. The gas supply system of these three Baltic Countries is not at present connected to the European Union's and Russia is the only country that supplies gas to all three Baltic States. The Latvian supply system is connected only at present to the Russian, Estonian and Lithuanian supply systems, it would not be inaccurate to refer to Latvia at present as an isolated gas market.

31.3 The Netherlands

Figure 105 Netherlands Network Map



Source: GSE Map 2008

The Netherlands natural gas resource base is estimated at around 4500 bcm, two thirds of this comes from the giant Groningen field and the remainder from a few other smaller fields and exploration prospects. The Netherlands small fields policy has been directed at giving full room for exploration and production of small fields, using Groningen to balance supply and demand almost like a giant gas storage facility. The policy serves sustainability the Groningen field technically where it produced at a much faster rate, it would have been depleted by now.

The Netherlands portfolio of natural gas assets has become mature by now with many fields in decline and reserves additions from exploration decreased. Indeed the total production from such field seems to have reached a plateau. By 2014 the Netherlands portfolio of gas will have matured with reserves and exploration having also decreased. With such potential for potential gas storage present the Netherlands could serve to act as security of supply for the Western European market, whilst domestic production is reduced and supplies come from more remote regions.

31.3.1 Present Gas Storage Situation

Currently there are two large underground storages in the northern Netherlands in the vicinity of the Groningen field, Norg and Grojpskerk. The total working gas in the Netherlands is around 5 bcm. Since the Groningen field is running at a low base load production the field in its present function may be considered as giant gas storage with a work volume close to its annual production of around 30 bcm. The regulatory cap put on Groningen production for the coming 10 years at an average of 42.5 bcm/yr, however it is expected that the field will lose its swing capacity and between 2020 and 2030 turn into a 'normal' small field in production decline. Various policy reports point out the strategy that the Netherlands could potentially turn into a gas hub in the European West European market.[117] Such a strategy implies the role of the Groningen Field will have to be taken over by additional work volume in underground gas storage. The additional seasonal work volume of around 25-30 bcm should be installed in the next 15-20 years and it is clear that smaller fields will be unsuitable for this task. Geographically new storages would be located close to the larger transport network and hub. The conversion of these fields into underground storages does not have to wait until the field is fully depleted, in fact the two larger UGS projects in the Netherland were installed earlier in their field life cycles, for example Norg when it was 50% depleted and Grijpskerk before any depletion, the advantage with this is similar to the advantage with the UK offshore fields in that less time and costs are involved in filling the UGS with cushion gas.

31.3.2 Network Infrastructure

With regard to the gas infrastructure currently in place in the Netherlands there is a national high-pressure network having a total length of 11,600 km with ten export stations, and the network transported approximately 100 bcm of gas in 2006, this includes the transit of Norwegian gas to Belgium and France and British gas to Germany.[118] With about 100,000km the distribution network is one of the most developed in Europe as the Netherlands shows the highest network connection rate. The Netherlands gas transportation network is expected to be further enhanced through a substantial investment of 500 million euros of European investment bank loans expected to further expanding its natural gas network. The loans will part finance an ambitious €1.1 billion project to maintain the Netherlands position as one of Europe's major gas hubs through an additional 300 km of pipelines and associated infrastructure.[119]

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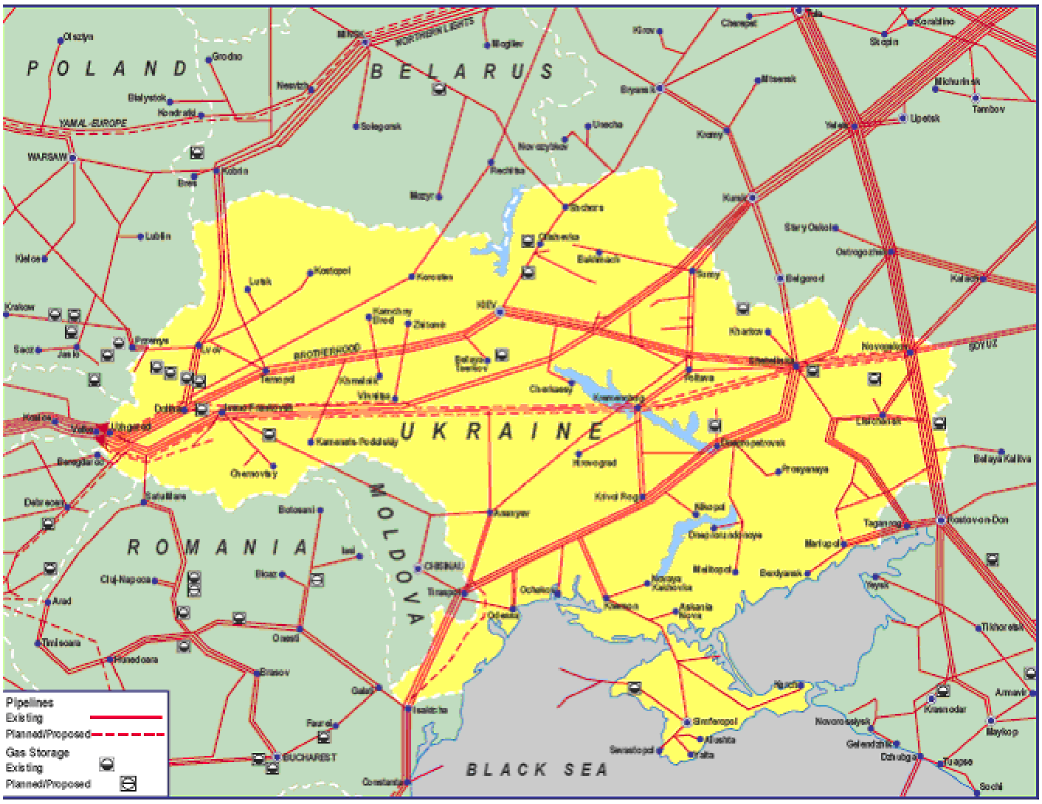
[117] The Netherlands: A case of Optimisation of Recovery and Opportunity for Re-Use of Natural Gas Assets, 23rd World Gas Conference Amsterdam, 2006.

[118] Underground Gas Storage in the World Serving Market Needs, Cedigaz, 2006
[119] European Investment Bank: http://www.eib.org/projects/press/2008/2008-058-the-netherlands-eib-to-lend-up-to-eur-500-mln-for-natural-gas-network.htm, 2008.

31.4 The Ukraine

Figure 106 Ukraine Network Map



Source: Gas Transmission System of Ukraine Current System and Priorities for Sustainable Development, 23rd World Gas Conference, 2007.

The Ukraine assumes a pivotal position in the European gas network with over 20% of Europe's gas passing through its borders. In addition four fifths of Russian gas exports to Europe pass through the Ukraine. Evaluating the Ukraine's potential to store gas for the European Union we should consider its geological potential for expansion of storage, the storage facilities that it currently possesses and the transit system and then finally review its political stability and relationship with Russia which may lead to its potential storage as a viable gas storage solution for Europe to be questioned.

31.4.1 Present storage capability

In terms of its present storage the Ukraine has twelve underground storage facilities operated by Uktranzgaz with ten depleted fields and two aquifers and an aggregate storage capacity of approximately 30 bcm. The storages are concentrated in three main areas; the Western underground storage complex which is the Ukraine's largest and includes five facilities, there are an additional two facilities in the central Ukraine in Kyiv and in the East of Ukraine in Donetsk there are five further facilities. The facilities in the western complex remain the most important from a strategic storage point of view as they are used almost exclusively for servicing export i.e. gas is stored there for delivery to European customers at peak periods. One of the distinguishing features of gas storage in the Ukraine is that there is considerable unused capacity and Naflogaz has been trying for some years to sell storage to customer in Germany, France and Poland. The UGS facilities only use 60-70% of their working capacity and at maximum storage and output rates 250 mcm can be withdrawn from the storages on a daily basis.[120] Due to this considerable storage the underground the facilities located in the Western regions of the Ukraine may eventually play a much more prominent role in securing the gas supplies to neighbouring countries.

31.4.2 Network Infrastructure

In addition to this storage capacity the Ukraine's transportation network is one of the largest in the world with 38,000 km of pipelines and an annual input capacity of 280 bcm and output capacity of 175 bcm. Of the 37,800km of pipelines 22,000km are high pressure pipelines and around 13,800km are large diameter (1000-1400mm) lines. At present the transportation network is the principal route for transit of Russian gas to Europe. In 2000-2005 the network transported an average of 128.7 bcm of Russian and central Asian gas to Europe peaking at 137 bcm in 2004.

31.4.3 Disadvantages Ukraine

Whilst the transport network is technically reliable and capacity is expanding slowly major investment is required for upgrades that would prompt further expansion. The estimated cost of such upgrades has been put at a figure of 4.6 billion dollars.

In addition to the essential investment needed in the transit system the Ukraine's relations with Russia and its validity as a storage solution for Europe can be further diminished through it political altercations with Russia and the resulting impacts on gas transit and storage. Principally there remains uncertainty as to what the Ukraine's unresolved conflicts with Russia means for its viability as a strategic gas storage location in Europe.

Diversification of supply routes has been a long term strategy of Russia with a wish to diversify the transit of gas to Europe away from Ukraine. In 1999, 95% of Gazproms exports to Europe (excluding CIS and Baltics) were transported via Ukraine and by 2002 the proportion had fallen to 82%.

As late as June 2008 there has been a notable increase in gas storing in states such as Hungary, Poland and Slovakia by Russia in order to meet its European obligations despite the fact that it is 60-70% cheaper for Russia to store its gas in Ukraine.

[120] Ukraine's Gas Sector, Oxford Institute for Energy Studies, Simon Pirani, June 2007.

31.5 North Sea Offshore

A potential candidate for the development of substantial regional strategic gas storage could be the North Sea. Abundant opportunities exist to convert fully or partly depleted offshore fields that (where not already decommissioned, as in the case of Esmond and Gordon) would otherwise need to be decommissioned at considerable cost. These include several of the large Southern North Sea fields that have supplied the UK with gas since the 1960’s and 70’s. The possibility of avoiding the huge costs associated with decommissioning may also be attractive to the owners of the fields and transportation systems. With the UK having recently become reliant upon imported gas and with the flexibility from North Sea fields declining in coming years, there is likely to be considerable investment in storage facilities which will boost the country's security of supply and could if done on a larger scale potentially act as storage and supply for other European regions. The offshore fields in the United Kingdom may provide an opportunity for regional storage development combining the advantages of both a central location with an extensive existing network linked to the European market through an interconnector linking the National Transmission System to continental Europe’s high-pressure gas grid.

The existing Rough facilities have shown that it is possible to develop and operate a successful offshore gas storage business. Rough was an early (1968) discovery 18 miles off the Yorkshire coast, finding gas in homogenous, high quality Rotliegendes sandstone at a depth of about 2750 metres. It was then developed with two offshore platforms, installed in 1982, and an onshore gas processing terminal at Easington. It was ‘turned around’ into a storage facility in 1983/4 [started as gas storage facility in 1985] with 1 billion m3 ‘cushion’ gas (to maintain pressure in the reservoir).

The Easington terminal processes the gas before it enters the National Transmission System, separating dry gas and a small amount of condensate from the production stream. Easington also withdraws gas from the National Transmission System during periods of low gas demand and sends it for injection into the Rough reservoir.

It is evident that the North Sea and in particular the UK offshore also has a heritage of oil & gas infrastructure, mainly offshore, and has had an endowment of gas the very depletion of which offers the opportunity to move ahead with the development of offshore gas storage in well-known reservoirs.

Figure 107 Northern European Gas Fields and Networks

Source: GSE Storage Map 2008

31.5.1 Disadvantages

It must be said that some would argue that the economics for offshore gas storage, where the UK has abundant depleted fields, have not been convincing. In order to create such facilities one may be looking at hundreds of millions of euros of investment both to extend the field life and to develop terminals on the coast and perhaps twice as much again to provide the 'cushion' gas that would be needed to make these huge reservoirs effective. The suitability of such infrastructure is also questionable, whilst the fields may provide a potentially suitable infrastructure there are often major gas gathering systems that are not always designed to pump the gas back into the depleted fields in the summer i.e. against the flow of the system.

The United Kingdom has suffered from a degree of regulatory uncertainty with regard to offshore gas storage potential in the past; in particular it has been cited by a number of potential developers that the likelihood of offshore gas storage investment in the United Kingdom is limited through a regulatory framework that has been described as "unclear, overly complex and incomplete". Furthermore, in the absence of a systematic claim to the applicable sovereign rights under Part V of the UN Convention on the Law of the Sea (UNCLOS), an element of legal uncertainty attaches to the grant of exclusive rights to operators to make use of areas of the seabed and water column beyond the 12 nautical mile limit of the territorial sea; and even that small degree of legal risk may have been enough to discourage investors.

In 2006 therefore, the UK Government consulted on options to improve the regulatory framework. As a result the UK is legislating through the Energy Bill 2007-2008. The Bill will enable the UK to assert the relevant sovereign rights under UNCLOS, within an area designated as a "Gas Importation and Storage Zone" (GISZ) which will extend beyond the 12 mile limit up to a limit of 200 nautical miles; and the relevant rights within the GISZ will be vested in the Crown, for administration by The Crown Estate. The Bill also introduces a fit-for-purpose licensing scheme for all types of sub-sea natural gas storage and unloading of imported natural gas within the territorial sea and the GISZ. The Energy Bill is going through Parliament currently and is expected to get Royal Assent later this year. The reforms will provide regulatory certainty for investors.

Storage investors are beginning to realise the potential of UK offshore depleted fields in the North Sea as storage facilities. A number of projects are at early stages of consideration. In July 2008 UK listed Encore Oil said it will begin a pressure well test to determine whether it may be possible for the Esmond and Gordon Fields to be converted into what would be the UK's largest natural storage facility holding a potential 4 billion cubic meters of gas storage. Assuming the project is deemed commercially viable at €1.9 billion this may be further encouragement that offshore storage in the North Sea could provide an adequate strategic storage point for use on a regional level. Centrica announced earlier this year that it is considering investing over £300 million in a new offshore gas storage facility (at South Bain in the Eastern Irish Sea). Stag Energy is proposing a £500 million offshore import terminal and underground gas storage facility located in the Irish Sea.

As far as the onshore planning environment is concerned, historically there were also some risks for onshore investment, making it potentially time-consuming and expensive to develop infrastructure. Indeed, the Gas Storage Operators Group as recently as April 2008 has described planning delays as the 'main investment risk' for gas storage projects involving onshore UK fields.[121] The UK Government is now legislating through a Planning Bill to set up an Infrastructure Planning Commission to determine planning consent for nationally significant infrastructure. The Commission

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[121] Gas Storage Operators Group "Issues influencing the development of gas storage in the UK" April 2008

will be able to consider applications to build gas storage and supply infrastructure providing that there is a National Policy Statement in place.

32. Summary and costs

Reviewing the potential for development of strategic storage in the European Union there appears to be numerous geologically suitable regions for the further expansion of underground gas storage. Latvia, Romania, the Netherlands, the Ukraine and offshore fields in the North Sea all could provide the geological conditions for considerable storage volumes but it remains a combination of the geological potential of a region *and* the feasibility of the existing gas network that determines whether an area is feasible as a host for storage.

Latvia and Romania, whilst well equipped in storage potential presently lack the fundamental infrastructure to act as storage points for regional European Union consumption. Romania's feasibility as a future gas storage region is heavily dependent upon the progress of the Nabucco pipeline and it's current pipeline infrastructure is totally unable to transport the significant volumes of gas that it would be required to transport in a role of regional provider. Latvia also suffers from the same affliction as Romania, there are abundant and indeed seemingly unique natural storage capabilities but the infrastructure is simply not present for it to be realistically envisaged as a strategic storage point for the European market. Ukraine may be deemed too risky a proposition for storage for the European market when one considers the political instability of the country, investment needed in the gas transit system and its relationship with Russia who is trying to divert as much gas as possible along alternate transit routes. However when considering the option of storing gas in the Ukraine in a scenario where 14 or 19 BCM is required such risks may be deemed a preferable in the short term to providing Europe with costly new gas storage.

32.1 Potential Solutions

Dependent on the level of security that is required certain options to security of storage can be deliberated.

32.1.1 Offshore Storage

It seems then that the two most viable options for the creation of regional strategic storage points at present examined are the North Sea offshore fields bearing in mind the above discussions of the infrastructures available and the certainty required of the investment conditions for such a considerable amount of storage. The Netherlands, as previously discussed, could potentially provide significant volumes of storage space and have perhaps the most suitable infrastructure and geographical location to provide storage for Europe, being in close proximity to a number of high consumption areas, there is also continued investment in the country's gas infrastructure ensuring that it is well equipped to act as a regional storage centre for the foreseeable future. However, due to diligent planning on behalf of the Dutch government its role as a storage provider cannot be realistically envisaged in the immediate future, indeed it is likely that the realisation of its potential as a gas storage destination may only become feasible in around 2016 with the huge Groningen field expected even later.

This leaves the UK offshore gas fields which may be the most feasible for a regional storage destination were a regional strategic storage to be developed. Such fields although economically costly may provide the huge storage that would be needed to cover the supply interruption as detailed in the following section. The fields benefit from the equipment remaining in place from their use as producing fields slightly lessening the economic burden in their creation and additionally potentially using gas from the fields as cushion gas reducing the overall cost given the massive volumes of the storages that are presently offshore.

The UK would be ideally situated to act as a storage hub with an excellent existing transport network. An interconnector to Belgium links the British National Transmission service to continental Europe's high pressure gas grid. The United Kingdom has already started to further develop its gas infrastructure in response to its recent shift to net importer status, so there would be domestic support for gas storage development in this area. Although at present the UK suffers from a degree of regulatory uncertainty the government is addressing this problem, particularly in relation to its rapid shift to becoming a net importer and it seems to have identified offshore storage as an area for regulation streamlining. However were the UK to be identified as a feasible area to act as a strategic storage point the general rule for conversions is the sooner the better, importantly there should not be too long a waiting period between the cessation of the field for production and its 'taken up' as storage facility as the fields and wells cannot remain indefinitely to 'mothball' and have to be utilised quickly for the equipment to be reused. Another potential attraction of the conversion of these fields into depleted storages as it will allow operators to avoid the potentially huge costs in decommissioning. Decommissioning costs are expected to be approximately in the range of €25-30 billion for the British North Sea fields alone, so there remains an obvious economic benefit in the conversion to gas storages.

32.1.2 Ukraine Storage

Whilst the Ukraine should not be envisaged as a long term solution for supply security for the reasons as stated previously i.e. its instability, Russian's motivation to diversify its transit route and the investment needed in its network, it may certainly have a role to play if the volume of storage required to provide security matches that of the flat rate policy as calculated in section 7 option 4. It makes sense to utilise both its existing storage and the Ukraine's critical position in the European gas network if the volume needed to provide security of supply is approximately 14 or 19 bcm. As mentioned previously the Ukraine uses approximately 60% of its existing storage leaving up to 40% unutilised. Rather than investing in new storage at considerable additional cost it may be more practical and considerably less costly to use the Ukraine's storages, even taking into consideration the investments needed as detailed above in the network. It may also be useful to calculate in the 50 bcm scenario how significantly the cost would be impacted upon by using 19 bcm of the Ukraine's storage, although the potential cost savings may be significant it should be kept in mind that such an option entails a higher degree of risk.

32.2 Cost and scenario evaluation

This sub section examines the combinations of investment and the associated estimate costs needed to supply 19 bcm, 50 bcm and 14 bcm of gas storage. The combinations examined include either investing fully in the provision of storages in the North Sea or using a combination of investments in the North Sea and using the Ukraine to provide the remainder. The following combinations will be evaluated;

- For 50 bcm of storage, either creating 50 solely in the North Sea offshore storage or 36 bcm in North Sea storages and the remaining 14 bcm in the Ukraine.

- For the 19 bcm scenario, either creating 19 bcm of storage in the North Sea, or utilising the Ukraine's spare capacity of 14 bcm and creating a further 5 bcm in depleted fields or salt cavity storage respectively.

- For 14 bcm of storage, in the North Sea, or in Ukraine

Having evaluated the potential for strategic storage to provide security in Europe a decision upon the feasibility of the creation of storages for mutual use could be further enhanced through an examination of the approximately level of investment that would be needed to provide such storage.

32.2.1 Scenario 1: UK offshore gas fields

Taking firstly the option as presented above of the UK offshore gas fields we need to consider the following issues

- The cushion gas requirements

- Investment and infrastructure costs

- Planning requirements and the lead time to develop such a storage facility.

A gas field that has been producing will already have a substantial amount of infrastructure in place so it is likely that a connection to shore through a subsea pipeline that ultimately hooks up to the domestic National Transmission would be a realistic assumption in the case of a UK depleted field, additional investment could be expected however in order to get the compressors to inject the gas into the storage. Planning will not be a major cost as the facility is already in existence, if the existing infrastructure is in good condition the creation of a offshore gas storage could be realised in two years, making it potentially faster than the creation of an onshore storage. In addition a consultation of the Gas Transmission Europe Winter

Outlook Report shows that the North Sea is free from bottlenecks in the result of even an exceptionally cold scenario with additional capacity available through the transport route into Western Europe, though at a 96% utilisation rate the margin is perhaps not optimal indicating that there may be investment needed in the future however under normal cold conditions the current utilisation flow rates are more than adequate.[122] In relation to the Ukraine the Winter Outlook gives a slightly less optimistic picture under exceptionally cold conditions the flows rates may be problematic. With bottlenecks occurring in the flows to Hungary and the flow capacities from the Ukraine to Poland and Slovakia at 98% and 97% this may be an area where development could be needed in the near future as the capacity of such pipelines is already stretched.

An overview of the costs of recent storages either proposed or created in the North Sea offshore is given below at 2008 prices. These costs could principally be reduced through the reuse of cushion gas from the producing fields, cushion gas as detailed in section 5 contributes to the majority of the cost of a depleted field storage facility.

Table 25 Costs of recent offshore projects

Name of Storage	**Baines**	**Esmond**	**Gateway**	**Rough**
Size of Storage (BCM)	0.566	4.1	1.1	4
Cost Million €	372-434	1426	620	1364
Cost per BCM Million €	748-872 (inc cushion gas) 374-436	358	564	341
Known Specifications of Projects		No cushion gas, 2 Compressors and platforms, 200km 42" pipelines and terminals at Backton with compression excluding cushion gas.	Salt Cavern 15 miles offshore.	Excluding cushion gas.

Source: www.oilvoice.com

The storage cost per BCM of storage in the North sea works out at approximately €360 million per BCM for offshore storage in the North Sea excluding the cushion gas, as the structures that would be created are likely to be of substantial volumes

[122] GTE + Winter Outlook, Preliminary Version Meeting Gas Coordination Group, 2008-2009.

the inclusion of the cost of cushion gas is likely to account for a considerable cost of the overall storage. Using summer gas prices, as the storage providers would be likely to buy the cushion gas when the price was lowest, the cost for providing the cushion gas for 1 BCM of storage can be estimated at €298.92 million using an average of summer gas prices from the past five years and assuming a working to cushion gas ratio of 50%.

Assuming an overall cost per bcm for the offshore storage of €660 million, the approximate costs of the provision of such offshore storages are likely to be €12.94 billion for the 19 BCM scenario, €33 billion for the 50 BCM and €9,24 billion for the 14 bcm scenario.

Table 26 Potential costs, advantages and disadvantages of selected scenarios for up to 50 and 14 bcm.

50 BCM	**Up to 50 BCM in North Sea**	**14 BCM Ukraine/36 BCM North Sea**
Costs (Billion €) 14 bcm 50 bcm	 €9,26 €33	 €8,5 €32.26*
Benefits	High Security Utilisation of existing facilities Abundant depleted Potential Excellent existing gas network capability Close to major consuming areas	Lower cost Increased Flexibility Provision of storage at two main gas entry points
Disadvantages	High fixed costs Cushion Gas Non conducive regulatory conditions Potential tariffs likely to enhance overall cost	Partly outside EU Geopolitical instability

* Cost estimation includes €1.5 billion for the upgrading of the Ukraine network and €7 billion in tariffs for ten years storage provision.

32.2.2 Scenario 2 Ukraine and North Sea

It would also be of benefit to evaluate the impact upon overall cost that using the Ukraine's potential for storage could have on the overall costs for the selected scenarios. As mentioned previously the Ukraine should be reviewed as a more tentative partner for the provision of gas storage in any potential future security arrangement.

Firstly reviewing the cost of utilisation of the Ukraine's storage for the 50 BCM scenario we can see that the effect of using the Ukraine to provide such storage is negligible at approximately €0.74 billion and it is questionable whether the savings in cost compensate for the detrimental impact on overall security. It would seem logical to assume from the costs presented above that with the added risk that using the Ukraine's storage entails this would not be a sensible investment. However the strategic storage that would be created would almost certainly also have tariffs which may alter the overall cost, it would not be prudent to estimate these tariffs in this report as if based on the average of existing tariffs as any estimation would be highly speculative given that such storages would not be acting on a commercial basis, such as the others already in existence but rather for solely strategic purposes. As such arbitrary estimations upon this hypothetical tariff given the storage's specific role are not included but should be kept in mind when reviewing figures. .

Reviewing the 19 bcm scenario the use of the Ukraine's existing facilities could potentially provide up to 14 bcm of storage that is at present unused. The additional 5 bcm of storage could be provided through either salt cavern or depleted field creation. The provision of 5 bcm of storage could be provided in a number of regions throughout the network as numerous regions contain the requisite geological conditions for this comparatively minor volume of storage. The combination of depleted fields in Ukraine and 5 bcm of salt cavity storages at a key points in the network may provide Europe with security that is both financially less costly and technically very efficient with the salt cavities providing security to deal with both the short term supply problems throughout the respective regions until additional gas can be sourced from the Ukraine storages.

The cost of implementing the above would be in the region of €12 billion to €10.5 billion according to the estimates as generated in Section 5 for 5 bcm of salt cavity storage plus the additional investment needed in the maintenance and restructuring of the Ukraine gas system which is difficult to quantify but could be estimated at around €1.5 billion.

In addition to the cost of any upgrades that are needed to the Ukraine's gas network an additional cost that should be added is the expected Ukraine gas storage tariffs for gas storage, withdrawal and injection services. The Ukraine's present tariff rate for the gas importer RosUkrEnergo, is €1.59 per thousand cubic meter (tcm) More indicative costs for the scenario can be estimated through reviewing some typical European costs of storage, for example in the Czech Republic RWE Transgas operates storage facilities and provides related services of injection, storage and withdrawal at an estimated €77.7 per tcm whilst in Germany the company BEB operates its three underground storage facilities at €61.51 per tcm.[123] The Ukraine's tariff of €1.59 per tcm cannot be directly benchmarked to those quoted from the Czech Republic or Germany as various factors including bundle units and time horizons mean that such direct comparison would obfuscate any tangible or definitive cost. If the Ukraine were to allow Europe to store gas the charge for storage could be estimated at significantly more than the present one that RosUkrEnergo enjoys but possibly less than that of the RWE's or BEB's due to the Ukraine's eagerness to act as a gas storage point for European security and unused storage. A potential tariff of approximately €50 per tcm would seem a more appropriate when compared with European storage tariffs were the Ukraine to act as a storage destination for the EU gas, although such a tariff is an estimation it would add a considerable cost of €0.7 billion a year in storage tariffs this figure would appear more reasonable than its present arrangement.

Table 27 Potential costs, advantages/disadvantages of suggested scenarios for up to 19 bcm.

[123]Gas Storage tariffs along the export route to EU markets, Institute for Economic Research and Policy Consulting in the Ukraine v12 technical note, 2007

* Cost estimation includes €1.5 billion for upgrading of the Ukraine network and €7 billion in tariffs for ten years storage provision.

The saving is more pertinent in the case of 19 bcm with the potential difference of up to €1.22 billion, however lower costs associated with the Ukraine must however be reviewed with the added consideration that the Ukraine is at present an unreliable partner to provide Europe security with its gas storage.

19 BCM	**Up to 19 BCM in North Sea**	**14 BCM Ukraine/5 BCM Salt**	**14 BCM Ukraine/5 BCM Depleted**
Cost (Billion €) 14 bcm 19 bcm	 €9,26 €12.54	 €8,5 €12*	 n/a €10.5*
Benefits	High Security Utilisation of existing facilities Strategic location Abundant depleted Potential Excellent existing gas network capability	Increased flexibility Location	Low cost Location Low Opex
Disadvantages	High fixed costs High Opex Cushion Gas Non conducive regulatory conditions	Low security Poor existing network, severe deterioration.	Low security Poor existing network, severe deterioration.

32.3 Future Developments

The above analysis has shown that given the specific geological criteria for development of storages several possible locations exist. Of these the North Sea appears to be the best solution at present due to both the existing infrastructure and the possibility to develop the depleted fields. However the long term projections of pipeline investments suggest that these "corners" of Europe (Romania, Latvia, Netherlands) will be connected to gas supplying and gas consuming regions. Latvia might be more integrated with the rest of the EU if the Amber project is implemented. Romania is being passed by the planned Nabucco pipeline transporting gas from Azerbaijan through Turkey to Eastern Europe, and although it is not feasible at present strategic storage in the southwest of France the Laqu field which is rapidly reaching the cessation as a producing field and could in the same way be supplied by the Medgaz pipeline (if the interconnection between Spain and France was enlarged) and the Trans Saharan pipeline. The proximity to major supply routes will first of all insure that the strategic storages will be connected to the infrastructure, implying that these always can be supplied by large gas fields. It must be reiterated however that the situation envisaged above is far from becoming a reality and at present out of the four examined areas of known depleted field abundance only the North Sea can provide a realistic region for present development.

32.4 Summary and conclusion on the possibility to establish limited number of strategic stocks at key points of the network

In order to look at the possibility of establishing a limited number of strategic stocks at key points of the network, we use the volumes calculated as shortfall of capacity under option 4, and develop a 50 bcm strategic stock and a 19 bcm strategic stock scenario. These volumes show worst case scenarios in which security of supply in case of supply of disruption is to be provided to all gas customers and by withdrawal from strategic stock only, in the two different policies analysed in option 4 in order to show the magnitude of strategic stock necessary if alternative security of supply tools are not used, and in order to evaluate the possibilities of storing such “extreme” volumes. When only uninterruptible consumers were taken into consideration, we see in option 4 that the shortfall in storage capacity instead becomes 14 and 3 bcm. The different options evaluated here then also cover the possibility of establishing smaller strategic stocks corresponding to the 14 and 3 bcm.

Reviewing the possibility to develop a limited number of strategic storage at key points on the network it can be seen that such development is firstly primarily related to the geological characteristics of certain regions. Without the requisite depleted fields, which are not ubiquitous throughout Europe, strategic storage for a major supply disruption cannot be created. Reviewing this question a number of potential countries with suitable geological conditions were evaluated. It became evident that although a number of countries could potentially accommodate such large volumes of storage, the fundamental requirement of having requisite infrastructure to deal with such large volumes of storage was limited to the Netherlands, North Sea offshore fields and the Ukraine. With further developments in the form of envisaged pipeline projects there may be potential in the future to provide strategic storage on key points in the network. For the provision of 48 bcm of storage the creation of North Sea offshore storage is the most suitable solution. Such storage could be utilised at a regional level through connection to the interconnector to Belgium but this storage would be limited to Northern European regions, areas such as South West and South East Europe would be unlikely to benefit from the creation of such storage.

The conclusion is that for the provision of volumes in the range of 50 BCM the creation of North Sea offshore storage may be the most suitable solution.

If the level of volumes needed matches that of the 19 BCM then the option was presented to utilise existing storage in the Ukraine and provide the additional storage in the form of flexible salt cavity storage at suitable points in the network. Such a decision would result in less security but would lead to reduction in cost and perhaps increased flexibility in supply in the event of a disruption.

This section should not be seen as a recommendation for establishing strategic storage and definitive guide about the exact location of storage to provide security in Europe but rather as a discussion of the qualities that storage providing regions would be required to provide to be considered as viable alternates for use at a regional level. Depending on the volume of storage needed and risks deemed acceptable the alternate options for security provide comparative advantages. Although the costs of the creation of new storage should be reviewed bearing in mind that such storages would be subject to tariffs but due to their strategic nature it would not be prudent to estimate in this report what this cost would entail.

A situation of creation of strategic points on the network for usage at regional level could be better envisaged once the eventual denouement of current pipeline projects has been ascertained, at present investment in storage in countries with underdeveloped infrastructures is neither possible nor desirable.

Establishing limited number of strategic stocks at key points of the network remains problematic for a variety of reasons.

The location of the strategic stocks is pre-determined by geological potential and not selection of key points on the network. This implies that transmission infrastructure is not or is only partially in place to facilitate the use of these strategic stocks. Also an intense cooperation between related parties would be required to enable the operation of the system in case of supply disruption.

33. Option 3 Strategic stocks as part of solidarity agreements

This section examines the possibility and benefits of including facilities for strategic stocks in solidarity agreements.

Solidarity agreements between countries are generally established so that countries can respond in a rapid, efficient and flexible manner to come to the aid of partner country in the event of a major natural calamity, war, terrorist attacks, etc. The European Solidarity Fund for disaster management, Nordic Regional Cooperation for regional development and NATO for defence are some of the well known agreements. The CERN particle project is another piece of evidence of areas were corporation between Member States has been successful. The very nature of such agreements may differ based on the purpose, however, the core goal of such type of agreements is to deal with disasters and quickly respond with an appropriate action.

In 2002, European Union set up a solidarity fund in order to be able to come to the aid of any Member State in the event of a major natural disaster[124]. The Fund has an annual budget of one billion Euros. Under this fund, to name a few, the Commission mobilised EUR 48.539 million in 2003 for affected regions in Portugal, in the year 2004 EUR 21.9 million for regions struck by fires in Spain and regions affected by floods in Malta and France and in the year 2006 EUR 92.88 million for Estonia, Latvia, Lithuania and Sweden following a storm that had catastrophic effects.

Would there be any gains in including storage facilities for strategic stocks in a similar scheme?

As we are here discussing "mobilizing" gas, we start by investigating the possible gains of regional gas market integration. In order to investigate whether there is an incentive and meaning for regional cooperation and agreements i.e we want to investigate whether neighboring countries can benefit if their markets are integrated in terms of possible trade via interconnections or use of storage capacity in general for security of supply in case of supply disruption i.e. not necessarily in a form of strategic stock, across borders.

We have previously analysed the gas consumption across Member States (ANNEX 3) and could conclude that gas consumption follows the same patterns i.e. is correlated across Member States, which is obviously due to the fact that gas consumption is very much temperature related and winter occurs at the same time across the EU region, and that less correlation in the gas flows across borders indicates bigger potential for trade across borders. We could also conclude that trade across borders is partially a substitute for use of storage. The general conclusion can be summarized as:

Correlated gas consumption between two countries i.e. gas consumption following same patterns indicates large potential for use of storage and less on cross-border trade.

We are in the following developing a discussion that we can use the correlation of the gas consumption as an indication of the risk (of supply disruption) correlation

[124] Council Regulation (EC) No 2012/2002 of 11 November 2002 establishing the European Union Solidarity Fund

between Member States, as explained further in the text. Namely, if risks of supply disruptions are uncorrelated across countries (i.e. the countries are affected by different risk to supply disruption, such as have different supply options etc.), then a supply disruption in one country could be dampened by supplies from another country. However, this requires uncorrelated gas consumption in which case interconnection is probably a better way to tackle these risks than storage.

Opposite, if risks are correlated across countries or in other words for countries sharing same risks, such as for example being dependant on the same supplier, storage is likely to be the best way to tackle them, but on the other hand in that case the gains from risk sharing, and thus the incentives for engaging in regional agreements, might be low. The different perspectives of using either storages or interconnections are summarized in Table 28.

Table 28

	Correlated risk	**Uncorrelated risk**
Storage	Better than interconnector. Small gains from risk sharing	Gains from risk sharing
Interconnector	Small or no gains from risk sharing	Better than storage. Gains from risk sharing

The mentioned analysis of correlation of gas consumption, enclosed in (ANNEX 3) showed that the Iberian Peninsula is less correlated in its gas consumption with the rest of Europe, whereas most other European countries have a closely correlated seasonal and overall consumption pattern. In this sense the integration of the Iberian Peninsula with France in a single unit (the South-West region) stands to generate the greatest gains from integration, and we use them as a case study for Option 3.

33.1 Sharing (correlation) of risks

As already hinted at in the introduction, we choose gas consumption as an indicative a measure of risk correlation. When consumption increases in the three countries constituting the South-West region (PT, ES, FR) they are more likely to turn to the same supplier of gas thus increasing the correlation of the risk of supply disruptions.

In describing the gas consumption the first task is to summarize the data for the three countries and for the integrated region (detailed analyses is enclosed as ANNEX 3 BACKGROUND ANALYSES). Table 29 shows some summary statistics: average consumption for 2007 in mcm (Av C), the standard deviation of log consumption (after removing trend and seasonality) in two sub-periods, 2002-2004, and 2005-2007. After removing trend and seasonality we get the variations that are caused by the non deterministic elements in consumption.

We can see that consumption is more volatile later in the sample for all countries and also that Portugal accounts for only 5% of total market consumption.

Table 29 summary statistics France, Spain, Portugal

Ca	**Av C 2007**	**% of total consumption**	**σ(Log(C)) 2002-2004**	**σ(Log(C)) 2005-2007**
FR	3621	52.85	0.0571	0.0627
ES	2866	41.83	0.0598	0.1112
PT	365	5.32	0.1240	0.1554
SUM	6852	100	0.0502	0.0681

The next table shows the correlation of consumption deviations from trend and seasonality. The raw correlations of consumption also increase in a similar manner. The left hand side matrix measures the correlation of consumption variations for the period Jan-2002 to Dec-2004, and the right hand side matrix measures the correlation in the following 36 months.

Table 30 correlations of consumption

	2002-2004			**2005-2007**		
	FR	**ES**	**PT**	**FR**	**ES**	**PT**
FR	1	0.33	0.09	1	0.61	0.52
SP	0.33	1	0.66	0.61	1	0.77
PT	0.09	0.66	1	0.52	0.77	1

It can be seen Table 30 that consumption has become more correlated over time (the correlation numbers are increasing). This is important because:

- Gains *from trade* occur mostly if consumption is uncorrelated across countries.
- Gains from risk sharing occur if *risks* are uncorrelated.

The numbers in Table 30 suggest a significant movement towards market integration is already occurring. They also suggest that there are still gains from further integration (correlation numbers are not 1 yet), thus there is a scope for regional corporation.

The correlation of observed consumption is of course a very imperfect measure of whether or not risks are uncorrelated. Considering the specific region, consumption may be a very imperfect measure of risks of supply disruptions. France receive relatively more gas from the North Sea than Spain and Portugal, thus Spain and Portugal are not directly affected by supply disruptions from the North Sea, while France might be. However as Spain, Portugal, and France become more reliant on gas from North Africa and the Middle East the correlation of risks could rise.

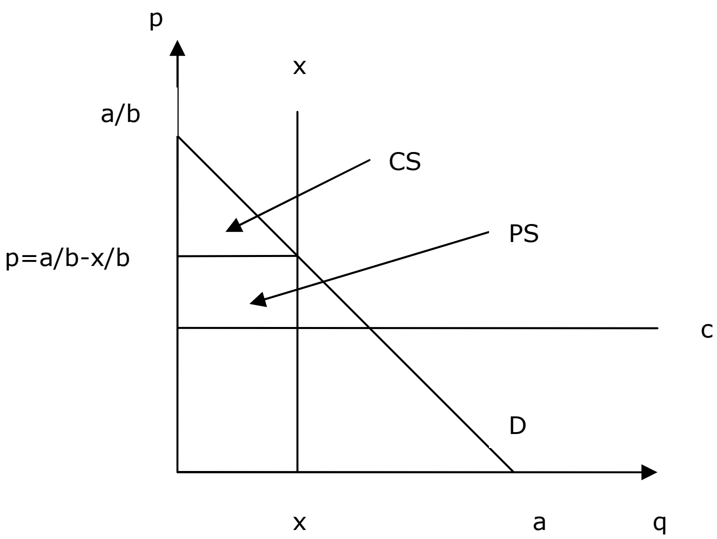
We now look at how to measure gains from trade. We need a tool of analysis in order to examine the benefits of joining the different markets and of having a common gas storage resource pool.

33.2 An example of gains from trade

We use here an example to illustrate how the gains from aggregating markets can be computed.

Consider a linear demand and vertical supply model for gas with n countries. In each country demand is given by the expression q=a-b*p, where q is quantity demanded and p is the price. At a price above a/b the quantity demanded is zero. At a price of zero the maximum quantity demanded is a. Demand is steeper (more inelastic) the smaller the value of b.

There is constant unit cost of production c, and assume that supply is vertical at a quantity x< a. These assumptions are justified by the argument that in the short run it is difficult to adjust supply to changes in demand, thus supply is fixed at x, at least in the short run. Market equilibrium is given by x=q=a-b*p (supply=demand), which defines a price of p=a/b –x/b. The characteristics of the mode are illustrated in the figure below.



At the price which clears supply and demand we are interested in the total surplus to society which is given by the sum of consumer and producer surplus. Consumer surplus is the area under the demand curve down to the price. This is the triangle given by

$$CS = (a/b-p)*x/2 = x^2/(2b)$$

For total surplus we add the rectangle of producer surplus which is the area (p-c)*x:

$TS = CS + PS = (a/b - c)x - x^2/(2b)$

Moreover we assume that supply is stochastic, this means that supply can either be "normal" with probability π, or low (with shortages) with probability 1-π.

In this set-up we are interested in computing the expected total surplus in this market:

$$E(TS) = \pi[(a/b - c)x_n - x_n^2/(2b)] + (1-\pi)[(a/b - c)x_L - x_L^2/(2b)]$$
$$= (a/b - c)[\pi\, x_n + (1-\pi)x_L] - [\, \pi x_n^2 + (1-\pi)x_L^2]/2b$$

$$= (a/b - c)E(x) - E(x^2)/2b$$

Where $\pi\, x_n + (1-\pi)x_L$ is just the expected value of x, E(x).

33.2.1 Aggregation in a deterministic environment

Now, we need investigate how the total surplus looks like when we aggregate N countries.

Total demand at a given price is given by:

$Q = a_1 - b_1{*}p + a_2 - b_2{*}p + \ldots + a_N - b_N{*}p = \Sigma a_j - (\Sigma b_j){*}p = A - B{*}p$

Total supply is given by $\Sigma x_j = X$.

In the combined market the equilibrium price is given by $p=(A-X)/B$.

Total surplus in the aggregated market is given by:

$TSA = (A/B - c)X - X^2/(2B)$

We are now ready to study the implications of this model. In case 1 we study the size of the total surplus when supply shocks are identical across countries. This amounts to investigating a situation where risks are correlated. In case 2 we calculate the total surplus when supply shocks are uncorrelated. Finally we compare these surpluses to infer if gains from risk sharing occur and to investigate the impact of the parameters in the model.

33.3 CASE 1: Identical countries with deterministic (constant) identical supply shocks.

In this case, as we saw in the aggregation in the deterministic environment above, Total Surplus is given by:

$$TSA = (A/B - c)X - X^2/(2B) = TS = ((Na)/(Nb) - c)(Nx) - (Nx)^2/(2Nb)$$

$$= (a/b-c)Nx - N^2x^2/(2Nb) = N\,[(a/b-c)x - x^2/(2b)] = N{*}TS(x).$$

All we do in this case is sum the surpluses of the individual countries and no gain is obtained by joining the markets.

The reason there are no gains is that the marginal consumer is identical in each market and so no gains can be obtained by serving high value consumers in one country at the expense of low value consumers in another. There are no gains from trade.

33.4 CASE 2: Identical countries with iid[125] stochastic supply shocks.

In this case the countries are still identical but their supply shocks are completely uncorrelated.

With identical countries and perfectly correlated supply shocks across countries, we saw that there were no gains from risk sharing. If countries are not equal, the gains from aggregation are not due to risk sharing because with perfectly correlated shocks there is no scope for risk diversification. The gains from this case are therefore pure gains from risk sharing, and this is what concerns us. Expected surplus with stochastic supply shocks is given by

$$E(TSA)= (a/b - c)NE(x) - E((\Sigma x)^2)/(2Nb)$$

Where N denotes the number of countries.

And this is to be compared to the case where no risk sharing occurs (the sum of N countries' total surplus'):

$$NE(TS)= (a/b - c)NE(x) - NE(x^2)/(2b)$$

It can be seen that there is a gain from risk sharing, the expected surplus from risk sharing is larger than if no risk sharing occurs, E(TSA) is larger than NE(TS). The issue at hand is how big this gain is likely to be. The following table shows the percentage gain in expected surplus, (E(TSA)-NE(TS))/(NE(TS)), from numerical implementations of this simple model first for two (columns two and three) and for three (columns four and five) identical countries.[126]

The assumptions behind the computations are the following:

- Probability of normal supply (п) is set at 0.95, thus there is a 5% risk of a supply disruption.

- Normal supply (nx) is assumed to be 80% of total possible demand, a. Low supply is assumed to be either 50% or 10% of total possible demand, a.

[125] independent identical distributed

[126] Remaining parameters are as follows: a=1, xn = 0.8a, pi = 0.95=19/20, c=0.05a.

- Finally the marginal cost is assumed to be constant

Table 31

	Number of countries				
	2			3	
Supply	xn=0.8a	xl=0.5a	xl=0.1a	xl=0.5a	xl=0.1a
Inelastic demand (b=0.1)	0	0.0023	0.0127	0.0030	0.0170
Elastic demand (b=2)	0	0.0027	0.0151	0.0036	0.0202

It can be seen from Table 31 that the gains from risk diversification in this example are around 2%. If, for the purpose of the example we assume a drop in supply down to 10% of potential demand (down from a normal supply of 80% of potential demand), the gain in expected surplus for three countries is 1.7%. In a scenario were demand is relatively flexible (b is high) the gain in expected surplus is at 2%. Thus what seems to matter is:

- The amount of countries participating, n. Going from two to three countries increased the gains in all scenarios.

- The flexibility of demand, b. The more flexible demand is the higher the gains

- The size of the supply reduction.

It is true that the risk has a relatively low probability, but in turn the losses are extremely high. This 2% figure may not seem very high, but 2% of the expected surplus (virtually all the area under the demand curve) in the joint market of three countries is certain to be a significant nominal value. [127]

The main message here is that gains occur if risks are uncorrelated and we should expect such gains not to exceed the low single digits in terms of percentage gains in market surplus. This can still amount to a large gain.

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[127] As a back of the envelope calculation, total consumption in 2007 for these three countries was 82224 mcm and 2% of this volume is 1644 mcm. Surplus would then be the profit associated with this quantity plus a measure of consumer surplus at this quantity and at the observed price. A competitive market of course has zero economic profits so that only the consumer surplus part would be counted.

33.5 Summary and conclusions on evaluating the benefit of sharing storage facilities across borders for strategic stock

Can countries respond in a rapid, efficient and flexible manner to come to the aid of partner country in the event of supply disruption by using strategic stock across borders?

As a first step we tried to investigate whether there are any gains of sharing storages across borders to be used in a situation of supply disruption. In order to do so, we look into the possible gain of sharing risk across countries. These gains depend on the correlation of risks of supply disruptions for the countries in question.

- As a proxy for the correlation of risks we have used the correlation of consumption.
- An analyses of the correlation of consumption showed that the Iberian Peninsula is less correlated in its gas consumption with the rest of Europe, whereas most other European countries have a closely correlated seasonal and overall consumption pattern. In this sense the integration of the Iberian Peninsula with France in a single unit (the South-West region) was used as a case study for Option 3.
- We compared the total surplus in a situation with risk sharing with a situation were no risk sharing occurred. This example showed, that the total surplus was larger in a setting were risk is shared than when each country is by itself. The difference in total surplus (the gain) amounted to approximately 2%.
- A sensitivity analysis showed a positive effect on the gain in surplus i.e on the gain from market integration in case of:
    - increase of the magnitude of the supply reduction, and
    - larger number of countries sharing the risk.

Based on this exercise we conclude the following:

Withdrawal from storage across borders (not necessarily strategic stock) is the best tool for security of supply between two countries that share the risks of supply disruption.

For countries that do not share the risks of supply, interconnection is a better tool for security of supply than withdrawal from storage across borders.

34. Option 4 Imposing minimum standards on commercial stocks

Minimum standards on commercial stocks are defined as a requirement to keep a certain percentage of the storage filled and untouched, such that a minimum amount of gas always will be available to be released into the system in case of an emergency situation. Thus minimum standards are meant to function as a buffer which can be used in situations of emergency.

This section consists of two parts. In the first part we investigate the impact of the policy on "the profit of the storage operating firm". This gives an idea of how distortionary the impositions of minimum standards for obligatory stockpiling can be for the operators of commercial storages.

The second part describes the actual impact of having gas in storage for coverage of consumption to exposure to risk of supply disruption. By measuring the actual level of storage relative to consumption we attempt to characterize the current level of risk exposure of Member States. We then investigate how much storage capacity would have to be increased through an example of selected EU Member States if minimum standards on commercial stocks were imposed.

34.1 Minimum standards for obligatory stockpiling in place in the EU

We look at three different forms of policy imposing minimum standards on commercial stocks, the Danish, the Italian, and the French.

The Danish policy approach requires that the TSO, at any time during the year is able to supply the uninterruptible customers with enough gas to cover 60 days of consumption in case of total supply disruption. This means that the volume of gas stored as a result of this regulation differs during the course of the year. We refer to this policy as "a time varying policy".

The Italian policy requires obligatory storage at any time of a fixed amount of imported gas. This solution implies that the obligatory strategic stock will remain constant throughout the year. We refer to this policy as the "flat rate policy".

The French policy requires that suppliers have a defined minimum volume of gas in storage at the beginning of the winter season (November 1st). The French policy differs significantly from the two others, as the obligation is not to have a certain amount of gas "at any time", but it still imposes (a temporary) obligatory stockpiling on the market players.

34.2 The costs of imposing minimum standards on commercial stocks on the storage operators

This sub-section analyses the cost implications of introducing minimum standards on the profitability of the firms operating gas storages[128] and a qualitative assessment of the effects on the supply of gas storage capacity.

We first try to define what the cost might constitute. The cost to the storage operator implied by the policy arises as a loss of profit, as some storage capacity which would otherwise have been used for seasonal arbitrage is reserved as strategic stock and therefore "inactive". The inactivity of the part of the storage which is used as a strategic stock therefore constitutes a cost to the storage operator.

Another factor that affects the loss to the storage operator is the frequency of the events, the more often the strategic stock can be released the more activity in the storage. Activity in the storage is a source of income to the storage operator, every time gas goes into the storage the storage operator earns money. Thus higher frequency of events is expected to yield lower profit loss to the operator.

Relating the costs to the storage operator to the three different policies in practice gives us an indication of which policies are the most expensive in terms of losses to the storage operators.

As the three policies differ so does the costs of imposing them. The time varying policy must secure that gas corresponding to (uninterruptible) consumption 60 days ahead is in storage at any time, while the flat rate must secure a constant volume of gas in storage at any time. This implies that the time varying policy requires more gas to be stored in winter than the flat policy, when the value of the gas is higher, hence we expect the profit loss of the storage operator to be larger for the time varying policy.

With regard to the French policy, the impact of the policy is limited to the following: Due to the imposition of a penalty for non compliance with a full stock on November 1st, the suppliers may take a precautionary approach of filling up (buying gas) too early, not necessarily at the best summer prices, in order to be sure that they comply with the requirements on November 1st. As to the impact on the storage operator, once the firms have filled up the storage, the capacity cannot be used for short term arbitrage, which might affect the profit of the storage operator if storage was filled too early.[129] Suppliers are de facto restrained from using the storage for

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[128] Hence here we consider the direct costs to the firm, we do not investigate how each different policy distorts the investment decision of the storage operators.

[129] In spite of the very theoretical nature of these assumptions (storages are probably going to be filled on 1 November anyhow), we have made these assumptions for the sake of the exercise to compare the possible impact of this policy with the impacts of the flat rate and time varying policies.

short term arbitrage in days leading to the 1st of November which may result in loss in profit for the storage operator.
We here restrict our attention to the practices of the time varying and the flat rate policy, which we analyse in the following through specific examples (and by using actual data) of Italy and Denmark.

34.2.1 The model

The purpose of the model is to evaluate the profit of the storage operating firm, we perform evaluation with and without minimum restrictions on storage. First we present a framework in which we analyse the profit of the firm. The monthly profit function for the firm can be expressed as:

$$\pi_t = P_t x_t - h(x_t, S_t) - k(S_t)$$

P_t is the realisation of the spot price in period t.

x_t denotes the net purchases or sales in month t, in terms of mcm.

$h(x_t, S_t)$ is a technical constraint which ensures that the physical injection and withdrawal limits of the storage are not exceeded.

$k(S_t)$ is the policy variable, this policy variables punishes storage owners that fail to comply with the minimum standards imposed on commercial stocks by incurring fixed costs whenever the stock goes below the minimum required level. $k(S_t)$ is given as:

$$k(S_t) = [k_0 + k_1(\lambda - S_t)] \times (\lambda > S_t) \times (1 - IN_t)$$

where λ is the minimum standard that the commercial stock must not go below, thus for Italy it is constant and for Denmark it varies with time. The first bracket indicates that the punishment is linear, thus a fixed cost is always incurred no matter how small the violations of the restrictions are. The second term indicates whether the commercial stock restriction has been violated, if it is violated, the linear punishment is imposed. The last term is also an indicator function where IN_t takes the value one in circumstances when the strategic stocks have to be released.

We use this expression for calculating the effect of the policy on the profit of the firm. Our benchmark is no policy imposed thus $k(S_t)$ equals zero.

Before simulating the impact of the policy we present the main assumptions here:

34.2.2 Assumptions

Following general assumptions are basis for the model.

- The policy implies that the commercial supply of gas storage shall be supplemented with an extra stock to be released in case of emergency
- Storages are effectively unbundled from production activities, and do function in a competitive environment

As to the assumptions on gas prices, the price process is modelled as a Markov process with 3 components: seasonality, temporary shocks, and emergency events.

$$P_t = P_t^S P_t^C P_t^{sea}$$

The seasonality is modelled as a deterministic change in the average price from month to month, thus there are no random elements in this process. The temporary process is modelled as a first order autoregressive process; this specification generates small price variations around the seasonal mean in each period.

The emergency event consists of a very small probability of a very large increase in price. This price increase is completely dependant on the specific conditions related to that even and is therefore not to be estimated. In order to determine a benchmark for a very high price and for the probability for such a large price to arise we chose to model the high price (that occurs in winter) as twice the low price (that occurs in summer) and exceptionally high prices are assumed to be twice as high as the usual winter price based on observed actual price shocks at the NBP.

The probability of this event is defined as both once (one month) every 5 years ((1/60) at monthly frequencies) and once every 8 years (1/96 at monthly frequencies) – the impact of this assumption on the results is discussed further in the text.

34.2.3 Simulation of policy impact

We are now ready to examine the behaviour of the model with and without the k(S) constraint. We look at both the Italian and Danish cases. The model is simulated at monthly frequency. The artificial sample is of 1200 periods, which is 100 years. In every experiment (every row) the same exact occurrence of emergency events is used.

Table 32 Policy Experiments

	Min. standard. λ	Prob. of an emergency event	Emergency price	Profit of firm no action V0	Profit of firm min. std. V1	Percentage change in firm value	Number of emergency events
IT	0.378	1/60	2	3.545	2.966	-0.163	26
IT	0.378	1/96	2	3.475	2.879	-0.171	17
IT	0.378	1/60	1	3.349	—	—	26
IT	0.378	1/60	3	3.805	3.237	-0.149	26
IT	0.189	1/60	2	3.544	3.355	-0.053	26
DK	λ (n)	1/60	2	4.963	3.970	-0.200	26
DK	λ (n)	1/96	2	4.873	3.861	-0.208	17
DK	λ (n)	1/60	1	4.725	—	—	26
DK	λ (n)	1/60	3	5.267	4.330	-0.178	26
DK	λ (n) /2	1/60	2	4.964	4.583	-0.077	26

The first column of Table 32 shows the minimum standard that the strategic stock cannot go below, it is seen that for Italy it is fixed while for Denmark it varies with time. The second column shows the independent identically distributed (iid) probability of an emergency event each month. We look at two values, 1/60, which is once every five years, and 1/96, or once every eight years. The third column shows the price. Columns four and five show the net present value of the firm's profit evaluated over the entire period , first with k(S) = 0 (i.e. without implemented policy, when the whole storage capacity is available for commercial trade), then with an active penalty/policy. Column 6 shows the cost of this policy in terms of the profit of the firm. Column 7 shows the number of emergency events actually occurring in the artificial sample. Column 5 deserves special attention because V1 is the "factual" profit when policy is active. This profit is of course conditional on our scenario assumptions for prices and probabilities of an emergency event, which, for example, in the first row are that p=2 and q= 1/60.

We computed also the pure option value for the firm. This is calculated by imposing the same time series of shocks on the model's optimal decision, but shutting down the occurrence of the emergency event prices. In all cases the resulting profit of the firm is about 0.25% different from what we show here. This means that the impact of the emergency event prices on the profit of the firm is essentially an option value. It is the fact that high prices may occur in the distant future that creates value.

The first five rows of Table 4 examine Italy. The first row takes as benchmark an emergency event frequency of one month every five years. This results in a profit loss from being constrained of 16% relative to the unconstrained case. Changing the frequency of the emergency event from once every eight years (row two) to once every five years (row one) has a negligible effect on the profit of the firm, again stressing that what really matters is the possibility of using the strategic stock during normal times. The small decrease in profit loss that the change in probability of an emergency event implies, illustrates that what drives the result is not the frequency of the emergency event but rather the possibility to use the captive stock for arbitrage purposes. Hence, if the probability was changed to one in 20 years the difference in the profit of the firm would remain marginal. In row 3 we compute the unconstrained profit for a world without emergency event. This generates a profit difference with respect to the unconstrained profit in row one of 5.5%. The fact that no emergency events occur thus lowers the profit of the storage owner as the storage owner is not able to benefit from the high prices that an emergency event entails. In row 4 we raise the emergency price to 3 times the normal price and the profit of the firm increases by about 7%. The value difference from the constraint is roughly the same. Row 5, on the other hand, shows the impact of reducing the strategic stock requirement by a half. This reduces the cost of regulation more than proportionately, again confirming that what matters for the firm is the possibility of disposing over the strategic stock during normal times.

Rows six to ten examine Denmark. Here the profit loss from the cyclical constraint is around 20%, whereas in Italy it was around 16%. All other qualitative results are similar to the ones obtained for Italy.

Our final experiment is to impose the time varying policy of Denmark onto Italy .
To simulate that, we impose on Italy a cyclical constraint with the pattern of their 60 day-ahead consumption, but normalized so that it is on average 0.378 of the stock.

Table 33 Italy with a cyclical constraint

	Min. std. λ	Prob. of emergency	Emergency price	Profit of firm no action V0	Profit of firm min. std. V1	Change in firm profit (V1−V0) /V0)	Number of emergencies
IT	0.378	1/60	2	3.545	2.966	-0.163	25
IT	λ (n)	1/60	2	3.546	2.813	-0.207	25

This alternative actually reduces the profit of the firm because it increases the strategic stock above 0.378 during the winter when prices are high, and reduces the strategic stock during summer when prices are low, and this is actually worse for the firm than the constant level of the constraint. The constant constraint provides less insurance but gives the firm higher profits.

Examination of the implications of imposing the French policy was carried out by imposing a restriction on the profit function, restricting the storage to be 99% full at the 1^{st} of November. This restriction implied, interestingly enough by using both the Danish and the Italian data an indicative 4.4% decrease in profit compared to a situation were no restriction was imposed. The assumption is that the loss to the storage operators arises due to the fact that the suppliers have incentives to try to fill the storage perhaps earlier than what would otherwise have been optimal depriving the storage operator of additional profit on short term arbitrage possibilities as the approach the 1^{st} of November.

We hereby want to underline again that the actual loss in profits calculated here are based on the assumptions made in the model. These numbers are therefore only for the purpose of illustrating the effect i.e. costs that implementation of the policies can have on the storage operators.

34.2.4 Effects on the supply of storage capacity

It might be tempting to conclude that a minimum standard policy does not require investments in new storages as it makes use of the existing ones; however this is not the case. If a minimum requirement is imposed it means that a certain part of the operator's capacity becomes unavailable for seasonal balancing. Thus there will, everything else being equal, be an undersupply of gas storage. Due to the rigidity of the supply of gas storages (it takes years to construct a storage), such policy will, if demand for gas storages remains the same, inevitably lead to higher charges for storing gas. In the end there is a risk that this price increase will be passed on to the end consumer leading to higher energy prices.

34.3 Summary and conclusion on the impact of implementing minimum standards for obligatory stockpiling on the profitability of storage operation

In this option we try to model of storage of natural gas that replicates the behaviour of stocks and flows and then simulate implementation of a policy for obligatory stockpiling by making part of the capacity in the commercial storage inactive for seasonal arbitrage. We investigate how implementation of this policy affects the profit of the storage operator. We compare two types of policies that appear in the EU – a flat policy and a time varying policy through the examples and analyses of actual stock flow data from Italy and Denmark. We also try to impose the French policy on the Italian and the Danish data in order to see the impact of this policy, which is quite different, as it imposes obligatory stockpiling, but does not require that the gas remains in storage at any time – as the Italian and the Danish policies.

The simulation is based on assumptions of gas price ratios in normal and emergency conditions, as well as assumptions on the probability of emergency events occurring and this should be taken into consideration when looking at the resulting numbers – their purpose is only to illustrate the possible impact of the policy on the profit of the storage operator.

Our simulation results suggest that:

- The probability of the emergency event (which should trigger the release of the strategic stock) affects the value of the firm operating the storage where part of the storage capacity is reserved as strategic stock. The value loss for the firm becomes smaller the more frequent the emergency events occurs, suggesting that emergency events which occur in 1 out 20 or 50 years would lower the profitability further than shown in this model, as we assumed higher probability of emergency events occurrence.
  The effect of the probability is visible but is however relatively small, almost marginal.

- The parameter having significant impact is the minimum standard (expressed through the level of obligatory stock) imposed. The more storage capacity is available for seasonal arbitrage to the storage operator the higher the value of the firm.

- The flat rate policy gives less security of supply compared to the time varying policy. The time varying policy ensures gas enough for (in this case) 60 day ahead gas consumption. This means that there is no risk for the storage to be empty for seasonal balancing after the strategic stock has been used to mitigate supply disruption emergency event. This risk is present with the flat rate policy, and the French policy.

- The flat rate policy is less costly for the storage operator than the time varying policy, as the time varying policy results with more gas reserved for strategic stock in winter, when gas prices are high than the flat policy i.e. bigger storage capacity is booked for strategic stock relative to total storage capacity available to the storage operator. As an illustration, it was seen that our calibration for Italian and Danish data yields a cost of regulation of around 16% for the flat rate policy compared to 20% of discounted net present value of profits for the time varying policy. Imposing the French policy on the Italian and the Danish storage models yield a loss of profit of 4,4%.

34.4 A cross country analysis of risk exposure

As noted in the introduction this second part of our analysis looks upon the risk exposure, expressed through levels of storage (working gas) relative to consumption. It should be noted that this exercise is done by using total levels of storage and not only strategic. Also the total gas consumption per Member State is looked upon as a first step. This is done with the purpose of creating a same benchmarking level for all Member States irrelevant of their policy related to strategic gas stock. Operating with the total gas consumption will show the importance of having alternative tools to storage if all customers are to be provided security of supply.

We first look at the actual stock levels, which gives us an overview of the current situation. We then compute the actual minimum and average coverage in terms of days this is done by relating working gas at the beginning of the month to the actual consumption 15, 30 or 60 days ahead. This enables us to compute the frequency with which countries have gas covering less than 15, 30 or 60 days-ahead consumption in storage.

We thereby try to illustrate the risks that countries may be facing in case of supply disruption. We can then calculate the shortfall in capacity which would arise if policies for minimum levels of stocks were to be implemented, alike the above presented examples of flat rate and time varying policies.

The data used is obtained from OECD reports and consists of total working gas levels and stock changes data in millions of cubic meters. Throughout much of the analysis we use monthly working gas capacities. This data was not readily available and therefore had to be derived from accessible data sources, as outlined in the following.

34.4.1 Capacity measurement

Capacity measurement is shown in Table 34. In the first row, in order to estimate the working gas capacity we take the maximum withdrawals- and injection flows for each country over the five or six years of data available from 2002 onwards and take the absolute value of this quantity (the sum) as a proxy for capacity.

This is a lower bound on working gas capacity as it is a measure of realized i.e. actual and not necessarily maximal variation. This measure does not distinguish between strategic and commercial stock. What we obtain in the first row of Table 34 is actually a measure of the capacity used over the seasonal cycle. In the second row of Table 34, we calculate working gas capacity as the difference between the maximum and minimum stock attained in the sample for each country, the "opening stock level".

In the third row, the maximum stock attained over the sample for the series of "opening stock level" is shown for each country and benchmarked with actual data from OECD and GSE in the last two rows (this data includes cushion gas on top of working gas and is therefore not directly comparable to the measures of working gas, but has to be compared with the estimated maximum level of working gas in storage).

Table 34 Capacity measures, mcm

Capacity	UK	DE	I T	FR	ES	DK	PL	BE	CZ	PT	AT	HU	IE	GR	SK
Sum Fls	3044	13729	9645	12032	1120	701	1624	974	2704	165	2432	3814	24	47	1595
ΔStocks	3654	13729	9645	14108	1385	886	1843	998	3003	195	3014	3814	41	59	1871
Max Stock	5834	13729*	20048	18482	2404	2272	2131	1066	3294	211	3780	3916	45	100	2106
OECD	4364	19138	13250	10800	2366	840	1652	635	2285	NA	2849	3500	NA	NA	2740
GSE	3863	18388	13014	12730	3829	1001	1575	635	2250	150	4120	3720	NA	NA	2600

note 1*The German OECD data contains no information on stock levels, only on stock changes, and therefore by construction, all three capacity measures in the first three rows must be identical.

Finally, the working gas capacity for the sample of country is calculated as follows: First compute the max of total gas stock over the sample. Then compute the max of the capacity measures in rows 1, 2, 4 and 5 of Table 34 for each country. The difference between the two provides a (fixed) measure of cushion gas. Current working gas is then computed as current total stock (opening stock level series) minus this fixed measure of cushion gas.

34.4.2 Characterizing existing coverage

The level of actual coverage (expressed in number of days of consumption that can be covered by gas from storage) is highly seasonal. For example, in the UK, actual storage – measured relative to immediate future consumption – covers, at its minimum (March 2003), about 3 days of immediate consumption, whereas at its peak (September 2007) covers about 21 days. It is therefore important to be clear **when** coverage is to be measured or defined.

Table 35 informs on the following ratio: working gas stocks at the start of the period (each month) divided by the consumption during the period (current month). It also shows the minimum ("Min") and average ("Av") attained over the twelve months of each year. The minimum is attained usually in March. This gives an idea of the available coverage in days of **realised** consumption.[130] The population of the countries covered is circa 400 million people.

Table 35 Ratio of working stocks to 30-day-ahead consumption: minimum number and average number of days covered over 12 months.

		UK	DE	IT	FR	ES	DK	PL	BE	CZ	PT	AT	HU	IE	GR	SK	Year average
2002	Min	5	29	18	9	48	8	5	0	33	0	59	3	0	3	44	18
	Av	9	56	41	60	56	26	22	12	89	0	98	46	1	6	103	42
2003	Min	3	29	26	17	37	13	0	6	24	0	42	0	1	0	37	16
	Av	7	55	46	63	42	31	15	15	83	1	77	53	2	4	106	40
2004	Min	3	28	18	0	35	16	3	0	32	0	43	2	2	2	45	15
	Av	9	55	39	47	39	32	19	11	92	1	73	49	3	5	108	39
2005	Min	4	27	15	29	29	18	1	2	15	0	40	5	3	1	61	17
	Av	12	55	38	89	37	44	19	13	73	2	80	48	4	3	161	45
2006	Min	7	18	13	28	28	10	2	5	0	6	42	9	3	0	64	16
	Av	13	52	39	99	37	38	22	16	67	12	103	55	3	2	162	48
2007	Min	9	34	35	24	28	28	14	2	42	11	83	44	2	1	76	29
	Av	14	53	51	97	36	54	30	16	87	13	139	77	3	2	147	55
Country average	Min	5	28	21	18	34	15	4	2.5	24	2.8	51	11	1.8	1.1	55	24
	Av	11	54	42	76	41	38	21	14	82	4.8	95	54	2.5	3.6	131	55

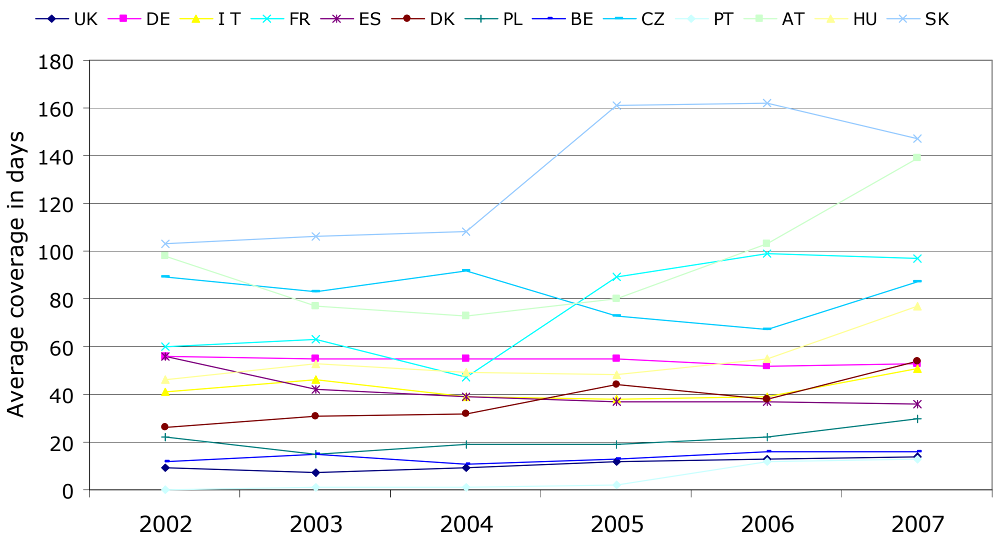
In Table 35 the minimum and average number of days covered for 2002-2007 are shown. It shows how important it is to define when coverage is to be measured. On average throughout the year most countries are reasonably covered, with the UK, Belgium, Portugal, Ireland, and Greece having the lowest coverage from storages.

By looking at Figure 108 below it can be seen that this coverage seems stationary over time for most countries, this reflects that there are no large changes in working

[130] The data is taken from the OECD and measures stocks and consumption in millions of cubic meters. The average coverage actually uses the 60 day ahead realized consumption instead of only the 30 days ahead consumption, but the difference in days is not significant.

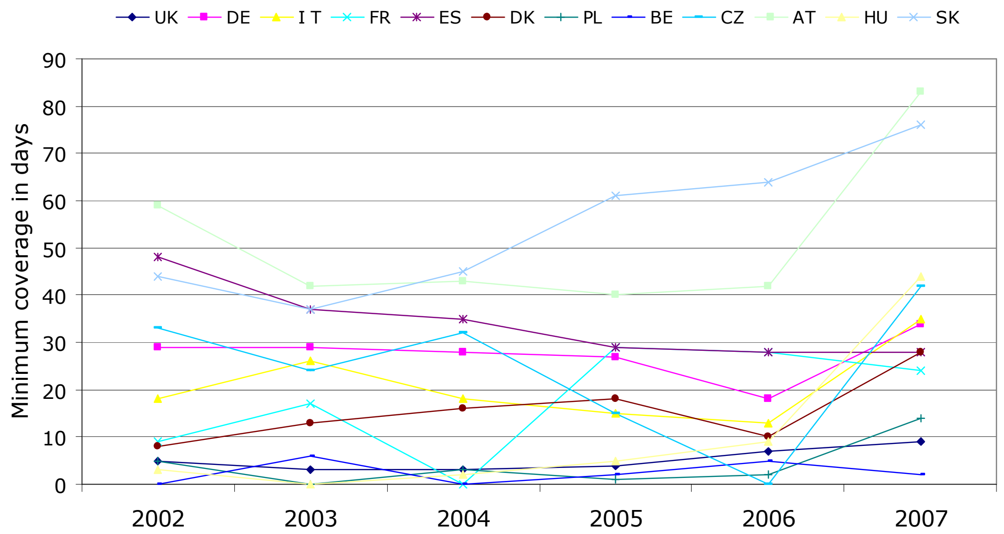
gas levels and total consumption. Most countries including, Denmark, Italy, France, Hungary, Austria, and Poland have a higher average coverage in 2007 than in 2002. Only for France, Slovakia, and Austria there seems to be a structural break in the number of days covered.

Figure 108 Average number of days covered



If we measure coverage at the most vulnerable time of the year (end of winter) then the situation is somewhat different. Of these countries Belgium, Poland, the UK, and Portugal are significantly exposed at the most vulnerable time. The UK and Belgium of course derive security of supply from other sources including indigenous production in the UK. In Figure 109 below the development in the minimum number of days covered is illustrated.

Figure 109 Min number of days covered



It can be seen that the minimum days covered is much more volatile than the average coverage. Most countries had the lowest coverage in 2006, this corresponds well with the yearly averages in the last column in Table 35, where the 12 days covered is considerably below the average of 19 days.

Table 36 computes the **number of months** where initial stocks of working gas are less than 15 days, 30 days and 60 days of *realized* immediate consumption, for these countries, for each year.[131]

Table 36 Frequency (number of months) of scarcity.

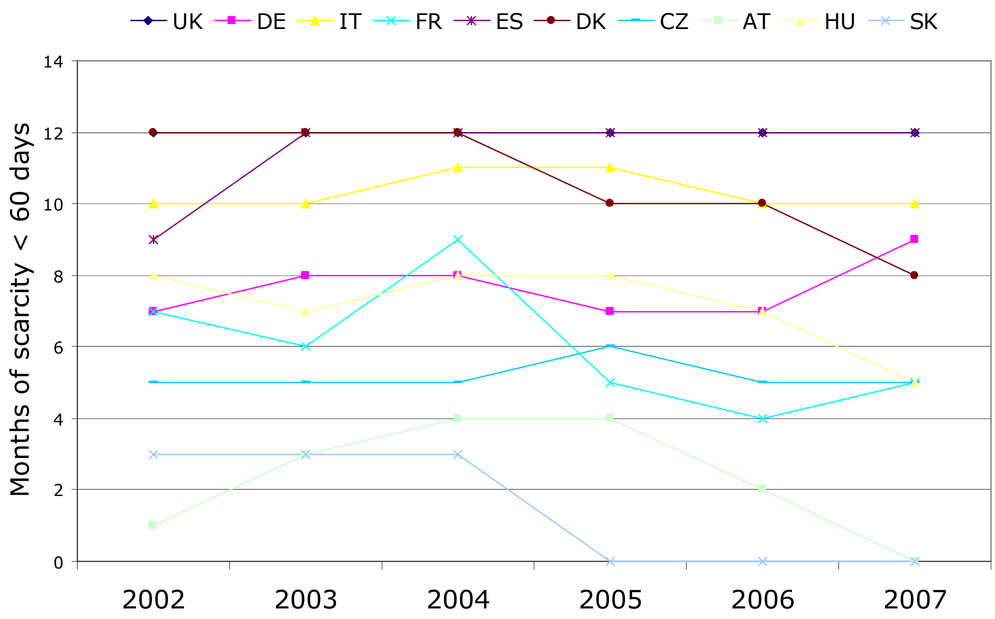
		UK	DE	IT	FR	ES	DK	PL	BE	CZ	PT	AT	HU	IE	GR	SK
2002	<15	12	0	0	2	0	2	5	6	0	12	0	3	12	12	0
	<30	12	1	4	4	0	8	7	12	0	12	0	5	12	12	0
	<60	12	7	10	7	9	12	12	12	5	12	1	8	12	12	3
2003	<15	12	0	0	0	0	2	5	6	0	12	0	3	12	12	0
	<30	12	2	2	4	0	5	10	12	2	12	0	5	12	12	0
	<60	12	8	10	6	12	12	12	12	5	12	3	7	12	12	3
2004	<15	10	0	0	3	0	0	5	7	0	12	0	3	12	12	0
	<30	12	1	4	4	0	6	9	12	0	12	0	4	12	12	0
	<60	12	8	11	9	12	12	12	12	5	12	4	8	12	12	3
2005	<15	8	0	1	0	0	0	5	7	0	12	0	3	12	12	0
	<30	12	1	4	1	2	4	8	12	3	12	0	4	12	12	0

[131] The sixty-day-ahead consumption ratio is computed exactly from the data by dividing the initial stock of working gas at the start of each month by the sum of consumption in the current and the following month. The 15-day-ahead measure just uses half of the current month's consumption in the denominator.

	<60	12	7	11	5	12	10	12	12	6	12	4	8	12	12	0
2006	<15	8	0	1	0	0	2	4	5	2	9	0	2	12	12	0
	<30	12	4	4	1	2	5	8	12	4	12	0	4	12	12	0
	<60	12	7	10	4	12	10	12	12	5	12	2	7	12	12	0
2007	<15	7	0	0	0	0	0	1	4	0	10	0	0	12	12	0
	<30	12	0	0	2	1	1	6	12	0	12	0	0	12	12	0
	<60	12	9	10	5	12	8	12	12	5	12	0	5	12	12	0
Mean		11.2	3.1	4.5	3.2	4.1	5.5	8.1	9.9	2.3	11.7	0.8	4.4	12	12	0.5

Again, in terms of the frequency of risk exposure we get the same picture as Poland, Belgium the UK and Portugal have the highest frequencies i.e. are least covered. This is illustrated in Figure 110 below. Here the number of months in each year where storage capacity was less than 60 days of consumption are illustrated. It can be seen that the majority of countries, including the UK, Germany, and Denmark, do not always have enough gas in storage to secure supply for more than 60 days.

Figure 110 Months of scarcity



Furthermore the figure above shows that Denmark, Hungary, France, and Slovakia in 2007 are experiencing fewer months of scarcity compared to 2002.

The UK currently produces around 60% of its gas consumption. It produced around 90% of its gas consumption in 2000. With the current storage capacity, in order for the UK to face a serious strategic exposure, its indigenous production will have to fall below 15 percent of consumption.

34.4.3 Do storages comply with national regulation?

We saw in section 6 that some countries in terms of days covered have specific security of supply requirements. By relating the months of scarcity with this requirement we can infer how big a role storage plays in fulfilling the requirements imposed by the national governments.

It is important to bear in mind that the requirements can be met not only by using storage; other tools such as interruption of consumers are also be utilized to meet these requirements. Thus the numbers presented in Table 37 are upper bounds on risk. Table 37 below thus illustrates the current situation as if storage was the only available tool.

Table 37 Minimum months of compliance

Months of compliance							
	Requirement (days of consumption)	2002	2003	2004	2005	2006	2007
BE	5	6	6	5	7	7	8
ES	10	12	12	6	8	10	11
PL	11	7	7	7	7	8	11
DK	60	0	0	0	2	2	4

The data above suggests the following:

- Denmark cannot meet the requirements they impose on themselves by using storage only, this suggests that other measures such as interruptible consumers are used,

- Belgium and Poland both lie in the middle, however as their requirements are below 15 days we cannot really observe whether they conform to these. The number of months with compliance is thus the number of months were they for certain complied with the regulation. Thus the months of compliance for these two countries constitute a lower bound.

- Spain lies relatively high compared to the other countries, taking the interruptible consumers into account it is reasonable safe to conclude that its requirements for strategic storage are met.

In general it can be said that if storage was not combined with other measures such as interruptible consumers then only Spain and Poland would be close to fulfilling the imposed requirements.

34.4.4 Risk exposure

The last exercise in this section computes the ratios between existing storage and the desired level of coverage. imposed as flat and the time varying policy across countries.

We examine first the **flat policy** as a requirement that each country has enough gas is in storage to cover 30 and 60 days of *average* total consumption.

Table 38 compares the estimated working gas capacity with the average consumption of 30 and 60 days of consumption respectively.

The numbers in Table 38 are computed as follows:

- The first row in Table 38 shows the current working gas capacity (existing stock) in millions of cubic meters, computed as the maximum value of the capacity estimates in rows (1,2,4,5) of Table 34. The second row shows the average consumption (AC) over 30 and 60 days observed in the sample.[132]

What the tables show is the amount of storage capacity relative to 30/60 days of average and maximal consumption. It is clear that most countries do not only rely on storage in emergency situations, these tables give an idea of to what extent countries must either invest in more storage or depend on other measures to secure supply if they want to have a coverage corresponding to 30/60 days of consumption .

Table 38 Flat Policy of 30/60 days of average consumption.

30 Days	**UK**	**DE**	**IT**	**FR**	**ES**	**DK**	**PL**	**BE**	**CZ**	**PT**	**AT**	**HU**	**IE**	**GR**	**SK**
Existing Stock	4364	19138	13250	14108	3829	1001	1843	998	3003	195	4120	3814	41	59	2740
Ave. Cons.	8195	8251	7047	3697	2806	418	1362	1262	781	356	732	1178	404	308	542
Difference	3831	0	0	0	0	0	0	264	0	161	0	0	363	249	0
60 Days	**UK**	**DE**	**IT**	**FR**	**ES**	**DK**	**PL**	**BE**	**CZ**	**PT**	**AT**	**HU**	**IE**	**GR**	**SK**
Ave. Cons.	16388	16480	14048	7392	5634	835	2715	2522	1560	711	1463	2356	812	623	1080
Difference	12024	0	798	0	1805	0	872	1524	0	516	0	0	771	564	0
Uninterr.%[133]	0,45	0,51	0,37	0,53	0,15	0,21	0,40	0,37	0,48	0,10	0,27	0,52	0,24	0,05	0,41
UI of Av. cons	7322	8356	5175	3905	858	179	1091	928	755	70	390	1221	197	32	441
Difference	2958	0	0	0	0	0	0	0	0	0	0	0	156	0	0

The 30 days outcome for Poland may seem surprising, but capacity has been increasing[134]. For the 60 day scenario it is seen that the UK, Italy, Spain, Poland, Belgium, Portugal, Ireland and Greece have least coverage. The difference between existing stock and the 60 days of average consumption amounts in this case to approximately 19bcm. Here we want to stress again, that coverage is expressed in

[132] Here we compute two averages, one for the entire sample and another for the last two years available, and then pick the highest of these. We do this in case consumption increases in the last part of the sample.

[133] We use a four year average of the households and services share of total natural gas consumption for each country

[134] When compared to average consumption capacity is not so small, but when compared to peak consumption it is just about 30 days.

number of days of consumption that can be covered by gas from the working storage capacity and not strategic storage only.

We redo the computation under the assumption that only uninterruptible customers (household and services) must have 60 days of average consumption covered. This is calculated in the last three rows of Table 38. We see that in this case only the UK and Ireland lack coverage. The difference between existing stock and the 60 days of average household consumption amounts in this case to approximately 3.1bcm.

We now redo this computation for a time varying 30 and 60 day policy. This amounts to consider maximum consumption (in order to be covered at the worst of times) instead of average consumption. The maximum here is simply the highest value observed in the entire sample. The results are displayed in Table 39 below.

Table 39 Time varying policy of 30/60 day-ahead consumption (storage capacity shortfall – working gas - based on maximum consumption values over the sample).

30 Days	**UK**	**DE**	**I T**	**FR**	**ES**	**DK**	**PL**	**BE**	**CZ**	**PT**	**AT**	**HU**	**IE**	**GR**	**SK**
Existing Stock	4364	19138	13250	14108	3829	1001	1843	998	3003	195	4120	3814	41	59	2740
Max Consumption	12179	15680	11635	7656	3645	655	2126	2082	1611	491	1306	2239	484	431	1128
Difference	7815	0	0	0	0	0	283	1084	0	296	0	0	443	372	0
60 Days	**UK**	**DE**	**I T**	**FR**	**ES**	**DK**	**PL**	**BE**	**CZ**	**PT**	**AT**	**HU**	**IE**	**GR**	**SK**
Max Consumption	23391	28673	22603	13818	7501	1278	3985	3977	2948	877	2504	4229	999	851	2227
Difference	19027	9535	9353	0	3672	277	2142	2979	0	682	0	415	958	792	0
60% of Max Consumption	14035	17204	13562	8291	4501	767	2391	2386	1769	526	1502	2537	599	511	1336
Difference	9671	0	312	0	672	0	548	1388	0	331	0	0	558	452	0

Compared to the flat policy we now observe that Poland has difficulties fulfilling the requirements by storage alone. When the UK runs out of indigenous gas, if it wants permanent coverage of 30 days, it would have to nearly triple its current working gas storage capacity. Belgium must double it and Portugal is somewhere in between. If 60 days of max consumption should be covered massive investment would have to be undertaken, in total almost 50bcm should then be installed. This illustrates the need for alternative tools for security of supply.

We redo the computation for the household and services' consumption; it is assumed that the households consumption during high demand periods constitutes approximately 60% of maximal consumption. Again it is seen that several countries will not be able to meet this requirement if storage was the only tool available. Most notable is the UK which has a large maximal consumption and a low level of storage capacity. The sum of the shortfalls amounts to approximately 14bcm.

Table 40 aggregated differences between existing storage and 60 days of average and maximum consumption, in bcm

Policy	Flat rate	Time varying
Full coverage	19	50
Uninterruptible consumers	3.1	14

34.4.5 Caveats

One issue that requires discussion is how the numbers computed here relate to stated security policy goals in the different countries. One piece of information available directly from the source regards stored gas in Denmark. In this country the fraction of interruptible gas in storage is virtually zero so that the Danish numbers should be close to the true picture.

34.5 Summary and conclusions on coverage from storage

We looked into the actual level of storage in Member States in terms of coverage from storage of their total gas consumption.

By taking the total consumption into consideration, we obtain the same background for comparison of the level of storage relative to consumption across EU.
The numbers showed a large difference between countries. While Germany has working gas corresponding to in average more than 50 days of its total gas consumption, Portugal has less than 5, and Ireland less than 3. The actual risk exposure depends on the availability of alternative tools in the Member States. So, by showing the total numbers, countries can see how much equivalent storage capacity they should provide in a form of alternative tools for security of supply in order to achieve a certain level of coverage of their customers.

We adopt this approach also in showing the risk exposure if either the flat rate or the time varying policy was implemented. It was found that if the flat rate policy was implemented with the purpose of securing 60 days of coverage of the *average* (total) consumption from storage only, then additional 19 bcm of capacity was needed on EU level. If the flat rate policy is implemented with the purpose of securing 60 days of coverage of the *average* consumption of uninterruptible customers only, the shortfall in capacity is approximately 3.1 bcm. This implies that at least 15.9 bcm storage equivalent can be provided in form of alternative tools on EU level.

For the time varying policy, with the purpose of securing 60 days of coverage of the *maximum* (total) consumption from storage only, additional 50 bcm of capacity are needed. If the time varying policy is implemented with the purpose of securing 60 days of coverage of the *maximum* consumption of uninterruptible customers only, the shortfall in capacity is approximately 14 bcm. This implies that at least 36 bcm storage equivalent can be provided in form of alternative tools.

The above volumes are additional to the storage demand for seasonal balancing.

The Consultant does not recommend common minimum standard defined as common minimum level of stocks in storage, as this actually implies different level of security of supply to the customers across member States depending on the alternative tools available to the specific Member State.

Imposing minimum standards in a form of imposing to market players an obligation for stockpiling of strategic stock in commercially operated facilities is not recommended, due to:

- immobilizing storage capacity that was planned for other purposes (seasonal balancing), might eventually result in lack of storage capacity for seasonal balancing. Such undersupply of storage capacity can have consequences for the price of gas to the end consumer.

-the cost of regulation in terms of profit loss to the storage operator are significant and may outweigh the benefits, furthermore it could lead to disincentives to invest in storage.

If a common security of supply level is desired for customers across EU, a minimum standard on coverage can be imposed i.e minimum number of days of consumption of specific or all customers to be ensured, leaving the market players to choose between the tools available on the market of the specific Member State in fulfilling this obligation.

35. Option 5 Alternative equivalent solutions

Mechanisms for mitigation supply disruption situations include:

- Demand-side mechanisms i.e. reducing the demand for gas and
- Supply-side mechanisms i.e. increasing supply by production surge and/or storage

This section investigates the EU´s potential and cost of fuel switching as an example of a demand-side mechanism and production cap as an example of supply-side mechanism.

35.1 Demand-side mechanisms

Demand-side mechanisms include:

- Interruptible customers
- Fuel-switching

These two "main" mechanisms, i.e. interruptible customers and fuel switching, are actually to some extent two sides of the same story. That is the customers who opt for an interruptible contract may most likely have an alternative to gas and thus be able to switch fuel when and if they are interrupted.

However, this is not so per definition as one can think of emergency situations where consumption, which is not "vital", could be interrupted in the event of an emergency. An example of this is the recent gas explosion in Northwest Australia, which has caused for severe gas shortages in Northwest Australia, as a response skyscrapers and shops in Perth had to shut down lift and turn off lights in order to save energy[135].

35.1.1 Interruptible customers/auctioning interruptible products

The first and perhaps most evident measure in the event of a supply interruption is to 'simply' cut off some consumers. By cutting off some gas consumers the demand could be reduced and aligned with the gas supply. The challenge, however, is to determine what the potential of this measure is, who would willingly be cut off in the event of a supply interruption and how much they should be compensated.

Gas suppliers do offer products today that give consumers who are willing to assume the risk of being cut off during certain periods a discount in the gas price. Interruptible products are available for gas supplies, transport as well as for storage products. Interruptible products are usually only interesting for consumers who have alternatives to gas consumption and are able to switch fuels.

The challenge is to find out how much such a service is worth and how to ensure that this measure is utilised within the proper scope; i.e., simply creating a non-interruptible product no one can afford is not feasible.

The TSO could once every year have an auction where gas customers would indicate their price for being cut off in the event of a supply reduction. These cases of supply interruption should be carefully defined in order to reduce uncertainty and risk, as this would lead to a higher price level. Once consumers indicated the amount of compensation they would require in order to buy the interruptible product, the TSO could evaluate the price of the product.

This system would ensure flexibility in terms of how much strategic storage is needed; i.e. because a reduction in gas demand is equivalent to an increase in supply.

As the need and thus the value of strategic stocks could decrease because of new investments (which lower the value of strategic stocks) or increase because of increased gas consumption (which raises the need for strategic stocks), flexibility in an auctioning system would become very useful, because the number of interruptible customers could change from year to year.

[135] http://www.news.com.au/heraldsun/story/0,21985,23876702-662,00.html

In some markets it would be relatively inexpensive to buy this 'interrupt-ability' from gas consumers. This would be the case in markets where consumers have alternatives in terms of alternative fuels. Therefore, these consumers would be able to switch fuels at a relatively low cost and would thus not have to be compensated as much, compared with consumers with no alternatives that would facilitate non-interruptible gas delivery.

The economics behind the idea is to let customers with the lowest value of uninterruptible gas deliveries receive compensation for cutting off their gas supply. Furthermore introducing an auctioning system will reveal the gas market's valuation of security of supply and thus allow for the appropriate mix of costs and level of security.

35.2 Fuel-switching

As was seen in the Rough fire case, fuel-switching in the electricity sector in the UK provided a decrease in gas demand of around 40 mcm/day by electricity generators switching to other fuels. This offers great potential for replacing gas consumption with alternative fuels in the event of a major supply interruption.

The next chapter looks at the evolution of natural gas generated electricity and combined cycle generation capacity.

35.2.1 Natural gas, electricity generation and CCGT

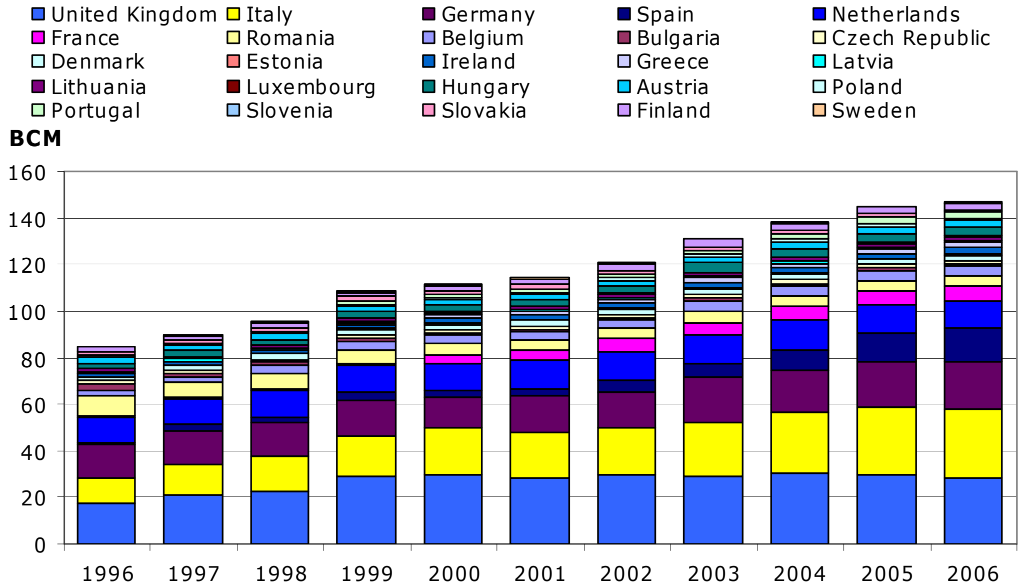
Natural gas has been utilised for electricity generation for a long time, but with the introduction of the internal gas market, opportunities for gas utilisation have increased due to increased access to transmission capacity, storage and gas markets.

The development of the gas and electricity markets has given power generators with gas-fired generation capacity increased access to flexibility, e.g. third-party access, and secondary markets to natural gas storage and transmission capacity provide power producers with various flexibility options in order to optimise their natural gas supplies. At the same time the establishment of electricity markets provides power producers with efficient price signals and a way to sell their electricity on an hourly basis via electricity spot markets.

Thus the potential for operating in the markets has increased significantly for power producers.

Furthermore, gas consumption for electricity generation has increased significantly over the course of the last 10 years. Figure 111 shows how total consumption has increased by around 70%, from around 85 bcm in 1996 to approximately 147 bcm in 2006.

Figure 111 Development in gas consumption in the electricity sector



Fuel-switching availability may be restricted because of environmental issues; e.g., during the 2005-2006 gas crises in the UK, the environmental agency introduced some special arrangement softening the restrictions on using alternative fuels. The fact that fuel-switching options may be restricted in some countries due to environmental considerations calls for an evaluation of under what conditions fuel-switching should be allowed. Clear and transparent legislation on this issue will ensure that electricity generators can respond in the event of a supply interruption. Clear and transparent legislation would further allow electricity generators to estimate the value of fuel-switching and would thus allow them to invest in fuel-switching capabilities.

35.2.2 Cost of fuel switching capacity

This section will estimate the costs of providing 2 month of fuel switching capacity equivalent of a supply interruption from Russia (The supply disruption scenario developed in Section 1).

Two months of missing Russian supplies is equal to 60 x 0.63 bcm today or 60 x 0.84 bcm in 2015 i.e. a total of 38 bcm in 2007 and 50 bcm. ILEX[136] has calculated what the costs of providing fuel switching capacity equivalent of a 3.3 bcm strategic storage in the UK. The equivalent of 3.3 bcm of gas storage in terms of Combined cycle generation turbines (CCGT) fuel switching capacity is 10 GW of CCGT. Fuel switching capacity is provided by installing distillate storage at the CCGT plants. The

[136] ILEX energy consulting "Strategic storage and options to ensure long-term gas security", 2006

cost of creating fuel switching capacity for this is estimated by ILEX to between 1,102 and 1,419 million £ (Central fuel price and high fuel price scenarios).

In order to cover for 38 bcm the EU would need 11,5 times the potential of 10 GW CCGT capacity (i.e. 11.5 x 3.3 bcm = 38 bcm). In 2015 the EU would require 15.2 times 10 GW (i.e. 15.2 x 3.3 bcm = 50 bcm).

This gives us total fuel switching cost of between 16.1 and 28.0 Billion Euros for the 2007 scenario i.e. capacity equivalent of 38 bcm storage and costs in 2015 between 21.2 and 36.8 billion Euros for fuel switching capacity of 50 bcm.

Table 41 Cost estimates fuel switching

Scenario	Distillate price assumption	CCGT capacity needed (GW)	Costs per GW (1000 €)	Total cost Euro Billion €
	Central fuel price	115.2	140.0	16.1
2007	High fuel price	115.2	180.2	20.8
	Very high fuel price	115.2	242.9	28.0
	Central fuel price	151.5	140.0	21.2
2015	High fuel price	151.5	180.2	27.3
	Very high fuel price	151.5	242.9	36.8

Thus we have that fuel switching costs are very fuel cost sensitive and total costs could amount to more 35 billion € in order to install capacity equivalent to strategic storage in the amount of 38 and 50 bcm. This equals a cost of between 424 and 736 million EUR per bcm of strategic storage equivalent.

Table 42 Price per bcm equivalent of strategic storage in fuel switching capacity

fuel price scenario	**Cost per bcm (million €)**
Central fuel price	424
High fuel price	546
Very high fuel price	736

Total cost are however not only sensitive to overall fuel price development but also to CO_2 prices as fuel switching entail an increase in CO_2 emissions.

35.2.3 Fuel switching potential

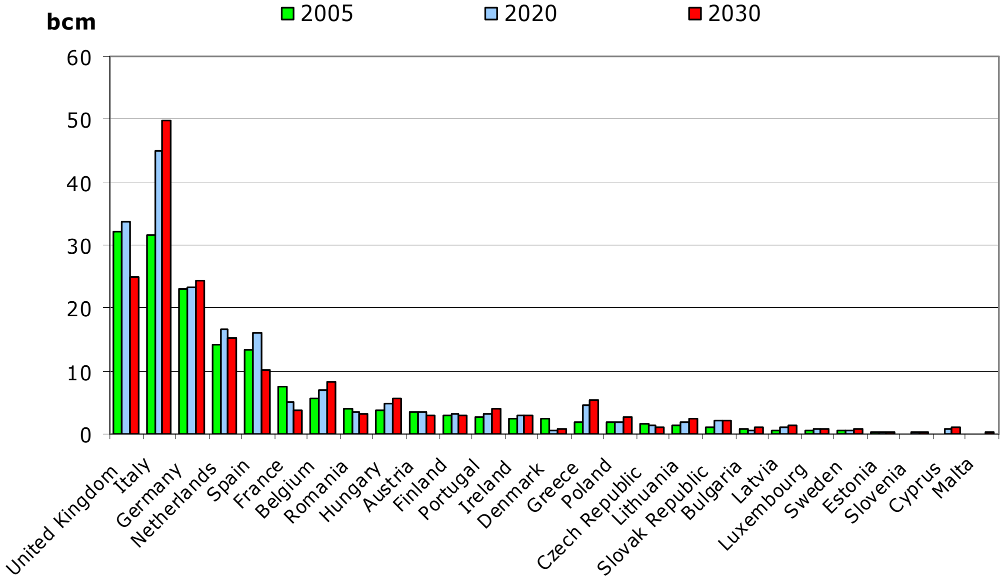
With an over all CCGT capacity in Europe of more than 850 GW[137] there should be plenty of electricity generation capacity available[138]. However CCGT capacity may not be evenly distributed across the EU and thus it may be a viable solution for all

[137] data on CCGT capacity is not complete – total CCGT capacity listed by Eurostat is approximately 850 GW, but several countries are not listed e.g. Germany

[138] Not all CCGT capacity is not necessarily gas fired

countries. If we look at the gas that is being used for electricity generation today and in 2020 and 2030 we can see where there is a viable potential for fuel switching.

Figure 112 Natural gas consumption for electricity generation in the EU

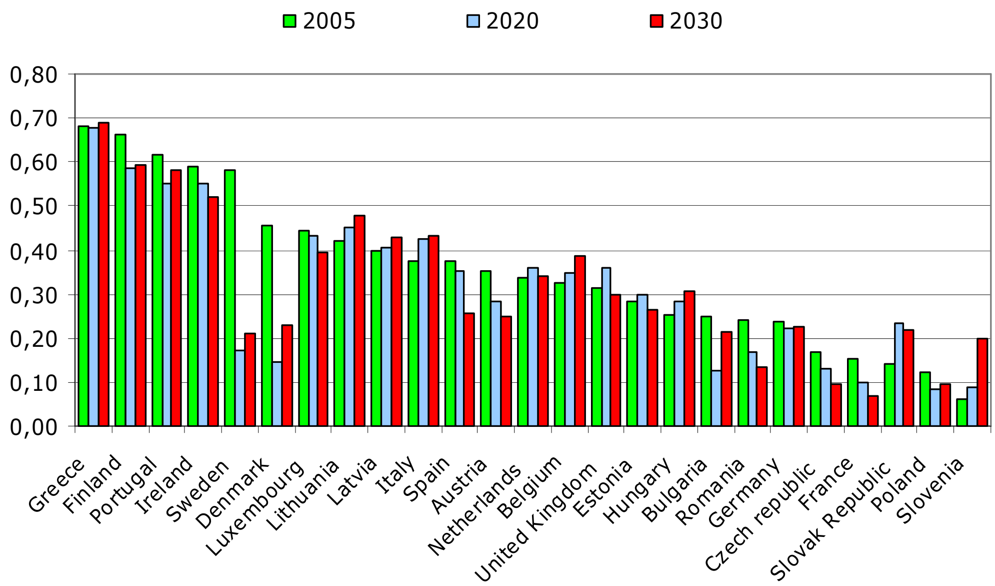


Source: Primes 2007 baseline scenario

The above graph shows that only a handful of countries in the EU use more than 10 bcm of natural gas for electricity generation. The UK, Italy, Germany, The Netherlands and Spain used approximately 21% of total annual gas consumption in the EU for electricity generation in 2005 – the share of gas consumed out of total is expected to be relatively stable until 2030.

Thus these large countries have a large potential for installing fuel switching capacity, whereas Bulgaria, Latvia, Luxembourg, Sweden, Estonia and Slovenia only consumed 3 bcm combined in their electricity sector in 2005 a figure which is expected to grow to 4.3 bcm in 2030. On an overall EU level these countries will thus not be able to provide a significant level security of supply by installing fuel switching capacity. However on a relative level fuel switching could be a viable solution depending on the share of total gas consumption that is being consumed in the electricity sector in each country.

Figure 113 Share of total gas consumption used for electricity generation



Source: Primes 2007 baseline scenario

Evaluating the fuel switching potential from a relative perspective It becomes evident that fuel switching might be a viable solution for many of the countries that use a relative large share of there gas for electricity.

35.2.4 Conclusion fuel switching

The section demonstrated that fuel switching is a viable option for many countries in the EU in terms of providing security of supply both today and in the future. However it was also demonstrated that fuel switching is a relatively expensive solution with prices ranging from 424 and 736 million EUR per bcm of storage equivalent provided.

35.3 Supply –side mechanism: capped production and small field policy, the Dutch model

Another way of increasing the overall level of security of supply and creating a possible measure to ward against a supply interruption is by controlling indigenous production.

An example of such a measure is the Netherlands small field policy. The Dutch policy was opted in order to maximise production from small fields in the Netherlands, by introducing an off-take guarantee for gas from small fields and putting a cap on the production from the very flexible and lucrative Groningen field. This policy de facto has led to a prolongation of the lifetime of the Groningen field, and as a consequence the Netherlands will have indigenous resources for longer than if production was not capped.[139]

By imposing a cap on the production from the indigenous production field Groningen, the Dutch government in effect stretches the indigenous gas resources in the Netherlands and thus increases the security of supply in the long run. At the same time it allows the Groningen field, in essence, to function as a strategic storage that may provide additional gas supplies in the case of, e.g. an emergency interruption.

The Groningen gas field is believed to have the capacity to supply gas for more than 25 years, given the latest cap set out by the Dutch gas act.

The small field/gas cap policy in the Netherlands has been in place since the 1970s. This means that in effect the Netherlands has had strategic storage available and will have strategic storage available as long as the Groningen field may supply gas to the market.

The Dutch policy not only provides security of supply in the long run by assuring that indigenous gas volumes will be available over the next 25 years. It also provides short-term security, in that production from the Groningen field may in the case of a supply interruption remove the cap and increase production.

The Dutch model thus combines long-term and short-term security of supply at the cost of possible higher short-term import dependence or increased costs of gas from the small fields. The short-term import dependency, however, is countered by the possibility of an indigenous production increase.

35.3.1 Consumption today vs. consumption tomorrow

The Dutch model shifts earnings from gas from today to the future. Whether this an economically optimal solution depends on a variety of factors, such as discount rate, the value of long-term security, costs of short-term import dependency, etc.

The actual value of Groningen as a strategic storage was estimated by Mulder and Zwart[140] to be up to as much as 0.9 billion euros, depending on the scenario used. The estimate, however, did not include potential losses from crowding-out effects; i.e., by capping the Groningen field the Dutch government may crowd out potential investments in flexibility and security of supply by private investors.

The Dutch model has another advantage compared with building gas storage with the sole purpose of supplying increased security through strategic storage. When

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[139] For more on the Dutch small field policy see: Government involvement in liberalised gas markets, A welfare-economic analysis of the Dutch gas-depletion policy, Machiel Mulder and Gijsbert Zwart, February 2006, CPB Netherlands Bureau for Economic Policy Analysis.

[140] For more on the Dutch small field policy see: Government involvement in liberalised gas markets, A welfare-economic analysis of the Dutch gas-depletion policy, Machiel Mulder and Gijsbert Zwart, February 2006, CPB Netherlands Bureau for Economic Policy Analysis.

putting a production cap on an existing gas field and thus creating strategic storage, implicitly the investment costs are saved. Investment costs today may be significant due to high prices of, e.g., cushion gas. The cushion gas, which is to some extent a sunk cost, is also saved.

35.4 Summary and conclusions on fuel switching

This section investigated the potential and the costs of fuel switching as a tool for security of supply alternative to storage.

The overall CCGT capacity in Europe is more than 850 GW giving quite a large potential for fuel switching.

The potential is however not evenly spread across EU, on the contrary it is limited to a handful of countries in the EU using more than 10 bcm of natural gas for electricity generation, which include the UK, Italy, Germany, The Netherlands and Spain.

The cost of installing CCGT fuel switching capacity was estimated to range from 424 MEURO to 736 MEURO per bcm of storage equivalent.

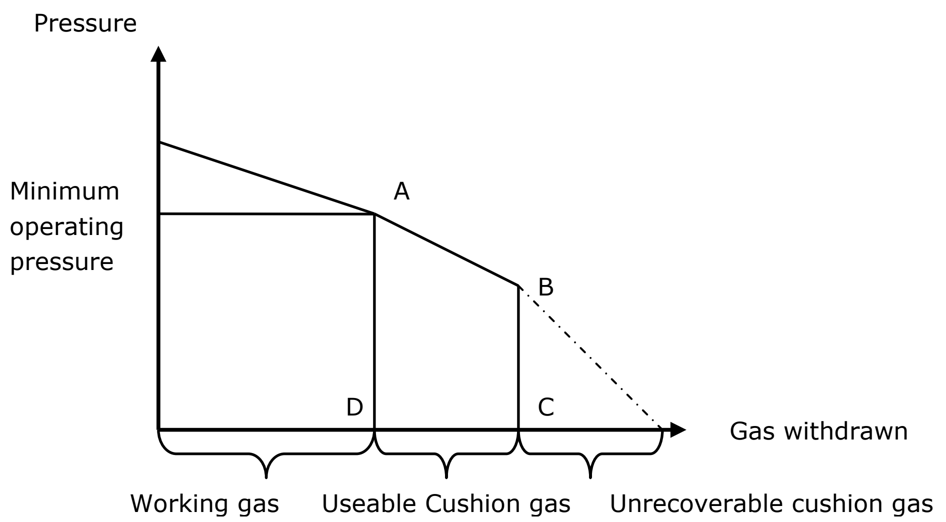
36. Option 6 Cushion gas as a strategic stock

In this section we investigate the possibility of using cushion gas as strategic stock Cushion gas is defined in PART II DEFINITIONS as gas intended as permanent inventory in the storage facility to maintain adequate operating pressure. Using the cushion gas as strategic stock could pose an alternative to working gas to be deposited as strategic storage. There are two immediate advantages of this: There is no need for buying large quantities of gas (to be stored as strategic), as the cost of installing the cushion gas has already been incurred. Moreover crowding out effects will be less of an issue as the incentive to use of the cushion gas is lower than it is for working gas, thus the distortion to the market will be limited. Secondly, insofar as new storages follow the demand for gas, strategic storage in the form of cushion gas will automatically be installed concurrently with new gas storage installations.

In the following we examine the possibilities of using cushion gas from each of the three types of storages previously described in the report: salt cavities, aquifers and depleted fields.

36.1 Salt cavities

As mentioned in Section 5, salt cavities are one of the most expensive types of storages to construct. Withdrawing cushion gas from this type of storage is possible; however typically the amount withdrawn is subject to a pressure restriction. Removal of the cushion gas occurs causes the cavern to shrink, and carrying it out five or six times may require larger renovation of the cavern. Hence a pressure restriction is imposed in order not to destroy the cavern. The figure below illustrates this inverse relationship between the stored gas and the pressure. The dotted line symbolises a usage level under which the gas is unrecoverable. The potential strategic stock is marked by the area ABCD.

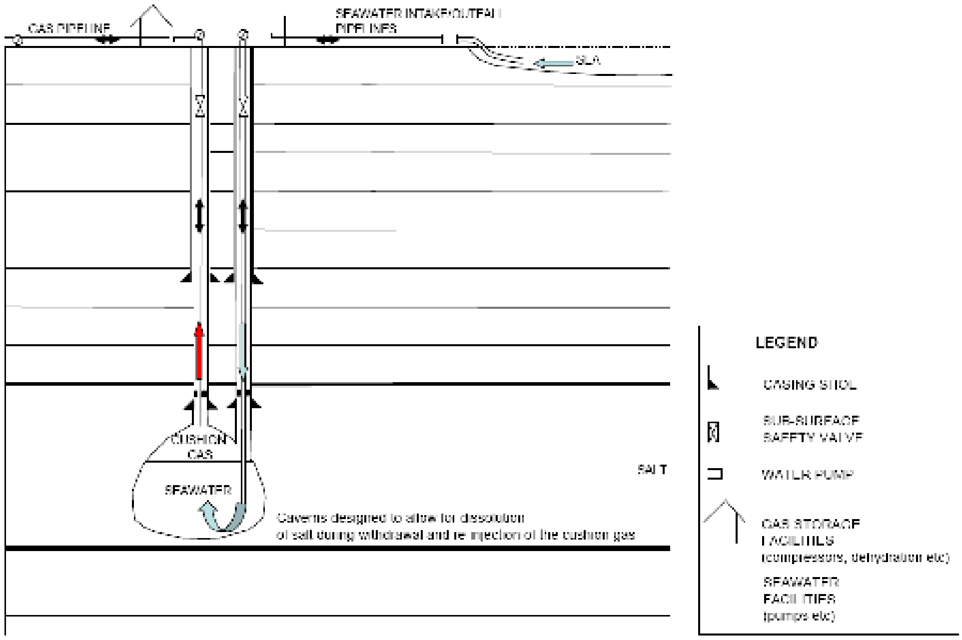


The withdrawal rates' dependence on the pressure in the storage implies that the withdrawal of cushion gas necessarily will be at low withdrawal rates, becoming lower the more cushion gas is taken out. Potentially the whole cavern could be emptied for gas; this would though require filling the storage with water, thereby pushing the gas out. The related costs include:

- The cost of the procedure itself
- Emptying the cavern and pumping in new gas
- A period of time when the cavern will be inactive, thus not creating any profit.

Investigation in creating new ground breaking technology that may facilitate such procedures in a cost efficient manner are being carried out. Recently Portland Gas filed a patent application for developing such technology. In short the technology will enable the SSO to use *all* of the cushion gas in salt cavities by pumping sea water into the cavern. The procedure is illustrated in Figure 114 below.

Figure 114 Extraction of the cushion gas in a salt cavity.



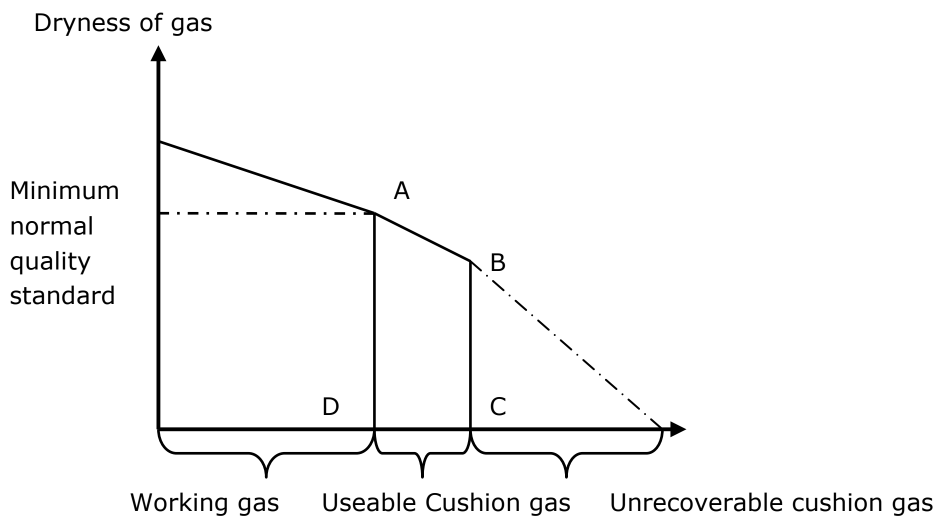
Source: Portland-Gas

It should be kept in mind that the procedure of injecting water to use the cushion gas is both time and resource consuming. It takes around 3-6 months to empty the cavern and refill it with gas, in these 3-6 months the storage cannot be used for ordinary purposes. Nevertheless this example illustrates that the untouchable cushion gas in salt caverns in fact is not as untouchable as first indicated.

36.2 Aquifers and depleted fields

Using the cushion gas in aquifers and depleted fields is also not a straightforward decision. As gas is being removed, the water which initially was removed by injection of the gas will return. This means that the gas extracted will be wetter than the normal working gas. Drying the wet gas is an expensive procedure, to reduce this cost and to minimise the negative effect on the quality of the gas, the cushion gas must be withdrawn at a slower speed. Furthermore changing the pressure inside the aquifer could potentially also damage the structure of the aquifer. The relationship between the quality of the gas and the amount extracted is illustrated in the figure below.

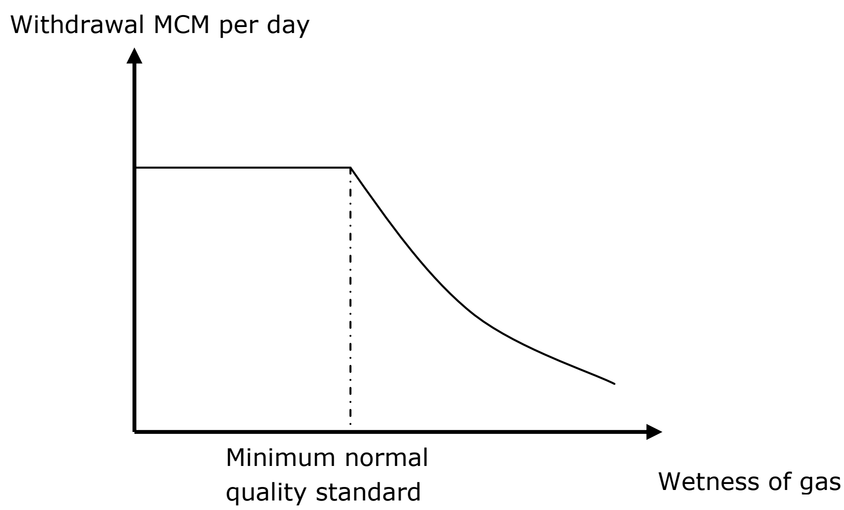
Figure 115 Quality of gas depending on extracted amount



Due to the characteristics of aquifer formations large parts of the cushion gas may prove to be unrecoverable. This is illustrated by the larger area of the unrecoverable gas in Figure 116.

In Figure 116 the relationship between the withdrawal rate and the wetness of the gas is illustrated. Here it can be seen that the more wet the gas becomes the slower the withdrawal rate must be.

Figure 116 Withdrawal rate vs. wetness of gas



Depleted fields posses many of the same characteristics as the aquifer, however as it is easier to keep the gas inside the storage it is better suited for extraction of cushion gas. Issues such as declining gas quality and higher risk of damage may also exist.

36.3 General issues

Some advantages and disadvantages are common to the three types of storages. An important one is the need for compressor capacity, once the gas reaches the surface it might not be compatible with the pressure in the pipelines. This implies that compression facilities are needed in order to send the gas into the transmission system.

36.3.1 Frequency of events

One should bear in mind that security of supply tools are not meant to be used every second year. The European Commission defines the supply disruption event of 20% disruption in supply, hence cushion gas as a security of supply tool will not be frequently used, and the damage on the storages therefore would be limited.

36.3.2 High costs work as strategic stock preserving mechanism

In relation to strategic stocks the high costs of dipping into the cushion gas might be an advantage and possibly work as a strategic stock preserving mechanism. If the extraction costs were low, society would have no assurance that there would be sufficient cushion gas in the storages when a supply emergency event occurred. High extraction and processing costs ensures that the cushion gas only will be used in the event that the spot market price is extremely high, reflecting an acute scarcity.

The above discussion suggests that determining the amount of cushion gas that could be extracted in case of a supply emergency event is not straightforward. Nevertheless the potential of using cushion gas as strategic stock should be recognised and thus further investigated.

Hence using cushion gas is a sensitive issue, because the accompanying disadvantages, such as lower quality of gas, lower withdrawal rates and shrinkage of the storage, are costly and potentially capacity-reducing. When using cushion gas, the storage owner must trade off the risk of experiencing these disadvantages against the immediate profit gained by selling the gas at high prices.

In the next section we try to present some examples from the US where cushion gas has been used and try to identify to what extent[141].

36.4 Empirical evidence from the US

To try to establish the scope for using cushion gas as a strategic stock, we turn to data from the US, as the only available data on developments in cushion gas stems from the US. What may make us believe that cushion gas is being used more actively is the EIAs own definition of cushion gas:

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[141] Preferably this analysis should have been made by the use of EU data, however no useable precise estimates on cushion gas exists.

'Base (cushion) gas is the volume of gas stored as semi-permanent inventory in a reservoir and is used to maintain adequate drive pressures and deliverability rates throughout the withdrawal season.'

What is worth noting in this definition is the notion 'semi-permanent'. This is a indication of that cushion gas can have a more active role than assumed. In fact, this is partly confirmed by the Energy Information Administration's natural gas storage report from 2001, which states that some storage owners had to dip into the cushion gas to satisfy demands that year. Furthermore, there is also evidence that storage operators transfer cushion gas to working gas in times of supply disruption.[142]

Currently there are few estimates of how much of the cushion gas can be used. As mentioned above, use of the cushion gas can damage the storages, and the storage operator will surely not use it unless upon appropriate compensation. Thus we would expect to see the largest changes in cushion gas in periods of high natural gas prices. In the following we investigate changes in cushion gas for depleted fields/aquifers and salt cavities.

A quick glance at the development in cushion gas in non-salt cavities (aquifers and depleted fields) reveals that changes do occur. It can be seen from Figure 117 that relatively large changes in general occur in winter periods; the years 1996, 1997, 1999, 2001, and 2005 stand out especially as having relatively large negative changes in the cushion gas.

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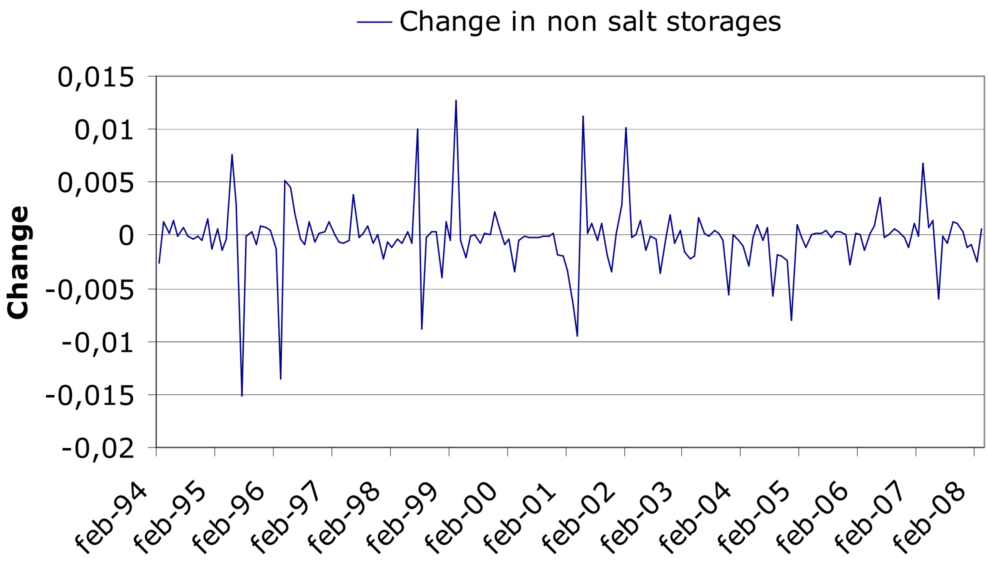
[142] "During 2005, Gulf South Pipeline Company transferred 12.9 Bcf of base gas to working gas capacity at its Bistineau, Louisiana, facility to help mitigate the loss of 4.5 Bcf of working gas capacity at its Magnolia storage field in Louisiana, which became inoperable after a well bore casing collapse in late 2003 caused a natural gas leak." Source Energy Information Administration.

Figure 117 Change in cushion gas, non-salt storages.



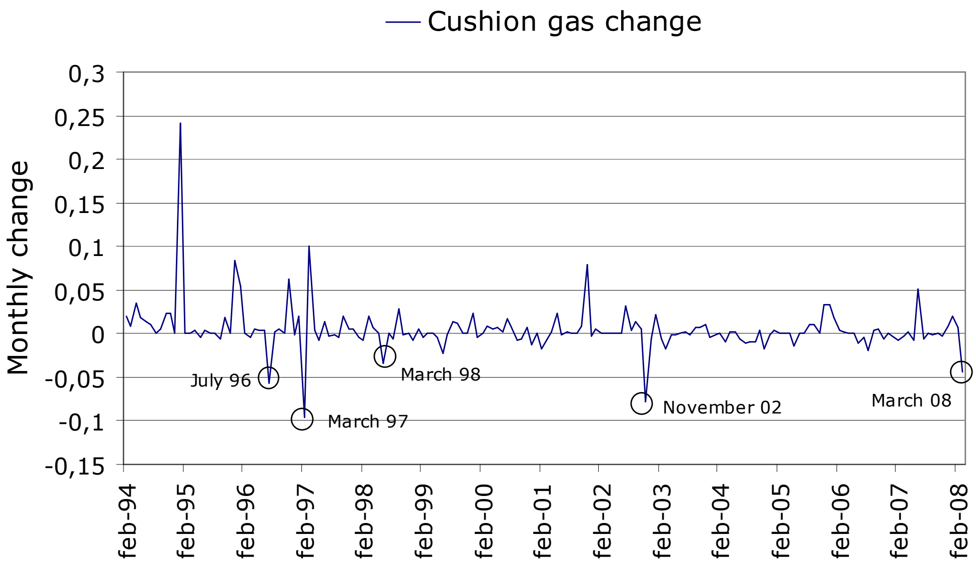
Source: Energy Information Administration

The changes in 2001 and 2005 especially could indicate that some storage owners have been tempted to dip into the cushion gas.

Hence it seems as if some parts of the cushion gas are working as type of security of supply tool. The scope for using the cushion gas a kind of strategic stock, based on the small percentages in Figure 117 is not very big. However as Figure 117 only contains data on aquifers and depleted fields it might not give a precise picture of the actual prospects for using cushion gas as a strategic stock. As salt cavities are the most flexible and sometimes operate with several turnovers in the course of a year, it could be possible to identify larger potential for withdrawals from these types of storages in times of crisis. In Figure 118 the development in the cushion gas in salt cavities is presented.

Compared with Figure 117 we see that there are three negative changes in the inventory that exceed 5% compared with the previous month. Identifying a pattern in the negative changes in the cushion gas is not straightforward. Even though it is evident that the largest negative changes occur in the winter months, some negative changes occur can also be observed in the summer as well.

Figure 118 Change in cushion gas, salt cavities



Source: Energy Information Administration

However, another explanation to why the cushion gas in salt cavities seems to be more used, could be that salt cavities generally are smaller than depleted fields and aquifers, thus salt cavities are more often faced with the possibility to use the cushion gas, as cushion gas is only used after all working gas has been used. This has implications for the timing of the use, usually storages are full at the beginning of the winter and empty around March or April this flow pattern implies that cushion gas in most cases will be extracted in March or April and not during peak periods. This is the case in three out of five cases in Figure 118.

To further investigate whether cushion gas is being used as a kind of security of supply tool, the average variation in the cushion gas in salt cavities in the winter months (December, January and February) is compared with the average variation in the rest of the year. If cushion gas is being used in times of shortages there should be more variation in the cushion gas during winter than during the rest of the year. As can be seen from Table 43 the average variation during the winter months is almost three times as high as during the rest of the year.

Table 43 Winter variation compared with the rest of the year

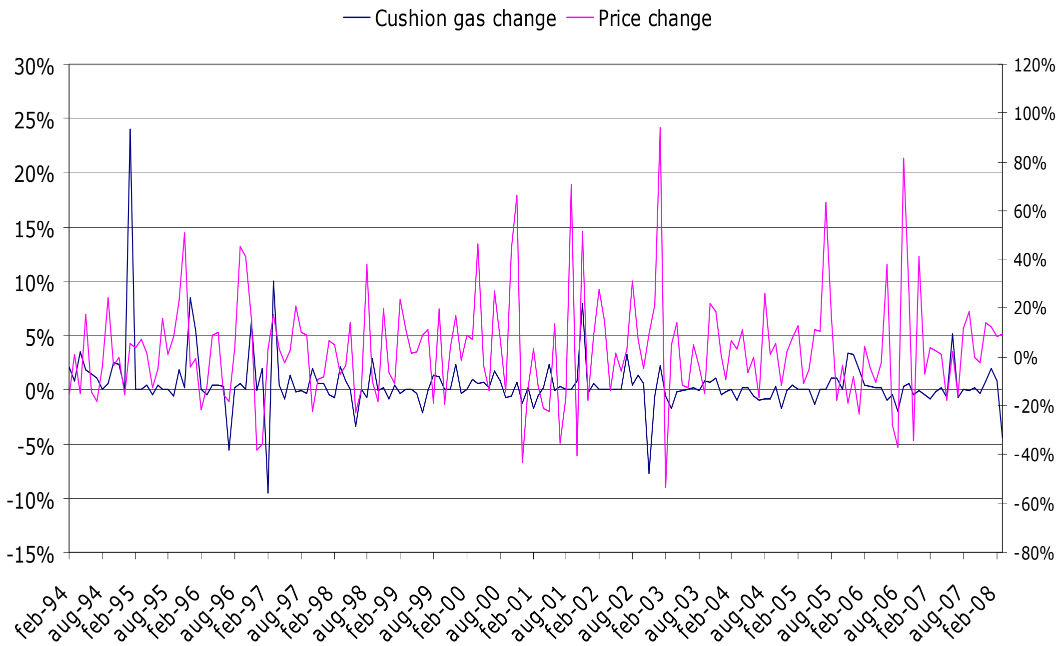
	Mean	**Std.dev.**
Winter	**0.009**	**0.05**
Rest of year	**0.0037**	**0.019**

Source: Energy Information Administration

A test of whether the average variation during the winter months is equal to the average variation during the rest of year is accepts the hypothesis that the variation are not different from each other with a *p*-value of 0.102. This means that we cannot claim statistically that the variation in the cushion gas for salt cavities is different from the variation in the rest of the year. However, this does not necessarily mean that storage owners do not use the cushion gas it may very well reflect that cushion gas is not used on a regular basis, but only in events of supply shortages.

Next we turn to a comparison of developments in cushion gas and spot market prices, as it might provide a rough indication of the extent to which price changes and changes in cushion gas follow each other. The prices are spot prices listed on the New York Stock Exchange. This is illustrated in Figure 119.

Figure 119 Change in spot prices and changes in cushion gas



Source: Energy Information Administration (DOE) and Reuters

Large decreases in the cushion gas are seen to be consistent with price increases in winter 1996/1997 and 2002/2003. One would expect that the large price increase following the hurricanes Katrina and Rita should have led to decreases in the cushion gas. However, one should bear in mind that most of the salt cavities in the US are located along the Gulf of Mexico and therefore the large disruptions that occurred in the transmission system deprived the storage owners in that area of the opportunity to sell their cushion gas.

Trying to interpret Figure 119 we undertook a time series analysis of whether changes in prices cause changes in the cushion gas[143]. Our goal is to discover relationships between realizations of the spot price for natural gas and changes in cushion gas for both salt and non salt storages. It was found that it cannot be statistically claimed that large changes in prices were significantly negatively associated with changes in the cushion gas, thus supporting the previous test of equality of variation. Again it should be noted that the frequency of these events is so little that it can be difficult to find any systematic relationship in the data .Secondly, data is aggregated on states, doing the analysis on a state level would give a more detailed overview of the situation.

Thus the hypothesis is that storage owners are tempted to dip into the cushion gas in times of supply shortages is supported by the EIA in both its yearly report of 2001 and their definition of cushion gas, yet relationships proving this were not possible to derive from the data available. There is some evidence in favour of cushion gas being used as a security of supply tool, yet the data does not show that high prices causes changes in the cushion gas, this shows that cushion gas primarily has been released due to supply shortages and not due to high prices.

36.5 The scope for cushion gas as strategic stock in the EU

As was seen in the previous section there is some indication of cushion gas being used as security of supply tool in the US. From a European point of view it could be interesting to know the potential of cushion gas as a strategic stock. Not all storages are equally suited for this manoeuvre. Some sources claim that only depleted fields and salt cavities can be used,[144] while others[145] suggest that aquifers can in fact also be used. There is also some uncertainty about how big a share of the cushion can be used, and not much literature is available on this issue. ”The 2002 European Gas Storage Study” estimates the following cushion gas usages displayed in Table 44:

Table 44 Cushion gas as potential strategic stock

	Max cushion gas available for usage
Depleted field	33%-50%
Aquifer	33%
Salt cavity	20%

Source: “The 2002 European Gas Storage Study”

The estimate seems to conform well with our discussion about the possibilities of extracting cushion gas.

[143] Running the following regression never yielded any significant negative coefficients on the price difference. $\Delta Cushion_t = \alpha + \sum_{i=1}^{11} \delta_i d_i + t + \sum_{i=1}^{n} \beta_i \Delta \mathrm{Pr}ice_{t-i} + \varepsilon_t$. Where d is a dummy for each month.

[144] Energy Information Administration.

[145] ”The 2002 European Gas Storage Study” p. 9-25 ch.9.

Using the above estimates and the cushion to working gas ratios from Section 5 and pairing them with storage data from Section 1 provides us with input to roughly estimate the potential available cushion gas. This is illustrated in Table 45

Table 45 Potential for cushion gas as a strategic stock in the EU

Storage type	Cushion/working gas ratio	Volume (bcm)	Cushion gas (bcm)	% withdrawn	Potential strategic stock (bcm)
Salt cavities	45%	9	4.1	20%	0.82
Depleted fields	80%	54	43.2	33%	14.25
Aquifer	80%	14.4	11.52	33%	3.8
Cushion gas for strategic stock		**77.4**	**58.82**		**18.87**

The above example illustrates that, given the assumptions about the cushion and working gas relationship, the potential for cushion gas remains relatively large. To put the 18.87 bcm into perspective, we can compare it with the actual average consumption of gas in the winter months in Europe.

The average consumption lies around 2 bcm per day in the months, December, January and February, assuming 60% of the average consumption in these months to be household consumption yields 1.2bcm of household consumption per day. This means that the cushion gas could potential provide strategic storage for about 15-16 average days for the entire EU. Furthermore, it is unlikely that the supplies of the entire EU would be shut down. This means that the potential is larger on a regional basis: Germany, for example, has most of its storage capacity in depleted fields and salt cavities; the same is true for many of the central/east European countries. Hence, 15 to 16 days constitutes a lower level for the usage of cushion gas as a strategic stock as it is unlikely that gas supplies to the entire EU will be shut down.

However, the scenario presented might be optimistic; if we return to the data from the US, we observe that the percentages withdrawn have been rather modest, with 1.5% as the maximum for depleted fields and aquifers, and 10% as the maximum for salt cavities. A scenario for EU based on these percentages would imply only 1.6 bcm available for strategic stock.

These empirical estimates must nevertheless understate the true potential of cushion gas as a strategic stock, as cushion gas is the last resort of supply. One has to take the supply flexibility in the US, both with respect to the transmission system and with respect to the LNG facilities, into account. This most likely attenuates the need for dipping into the cushion gas. Thus the real potential for cushion gas as a strategic stock most likely lies between these two scenarios. In Figure 120 below it is illustrated how much cushion gas could be available for strategic stock given the amount extracted.

Figure 120 Cushion gas potential

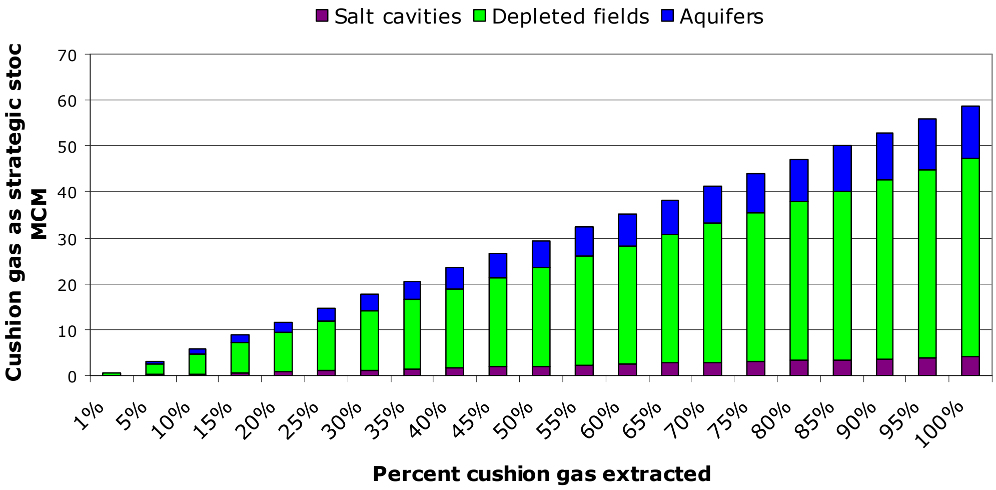


Figure 120 merely illustrates how much could be used as a strategic stock when varying the extraction possibilities. It does not take any costs into account.

Another issue which is important to evaluate when considering the scope of the cushion gas is the events in which it can be used. The previous analysis suggested that during "normal" shortages the cushion gas could be used, however in situations which are not anticipated and where fast delivery of gas is of crucial importance the scope for using cushion gas could be limited as the limited pressure and the possible damages to the storages do not allow for high withdrawal rates.

36.5.1 Days of supply in case of a disruption

We estimated that cushion gas had a possible potential of 18-19 bcm, in the following we evaluate this against the maximum possible supplies coming from each import source. This enables us to get a rough estimate of what the cushion gas is capable of covering.

The following table analyses the potential of emergency supplies from cushion gas in storages. Table 46 is generated by dividing the cushion gas potential with the daily capacity delivery from each import country. Thus the 60 days appears as a result of Norway being able to maximum supply 0.315 bcm per day[146]. (18.87/0.315=60).

[146] For reference see pipeline capacity table in section 1 page 23.

Table 46 Max number of days of cushion gas supply from storages in the event of a supply interruption

Supply interruption				
	Norway	North Africa	Ukraine	Russia[147]
2007	60	126	39	30
2015 Long term[148]	69	148	46	35
2015 Short term	53	113	35	27

Source: GTE and own calculations

Table 46 shows the number of days that the cushion gas potential theoretically would be able to replace supplies from each of the 4 main sources of supply. It can be seen that the cushion gas in gas storages are potentially capable of covering relatively significant supply interruptions for a relatively substantial period.

36.6 Compensation

It is important that storage owners are given the right incentives to use cushion gas in the right situations, by providing a scheme that allows proper compensation one needs first to determine why we have to compensate.

In the following we present a proposal to create a tender scheme that ensures that cushion gas is being supplied to the market and that SSOs are being compensated for their potential extra costs.

36.6.1 Tender scheme

One way to ensure that the SSOs are being compensated could be to launch a voluntary tender to supply cushion gas in the event of an emergency situation. In this fashion a market for cushion gas which only takes effect in case of emergency is formed, moreover competition in the supply of cushion gas could also be enhanced.

Creating a market for cushion gas entails:

- That the Commission clearly defines the emergency situation[149]. As noted earlier in this report this is of crucial importance, the SSO should know exactly what would trigger the release of cushion gas. Furthermore monitoring mechanisms should be in place securing that the cushion gas is not subject to unauthorized use.
- In the beginning of each year the SSOs specify how much cushion gas they are willing to supply and at what price. The price would cover the possible depreciation of the value of the storage.
- This allows supply being matched with demand, implying buying the wanted amount of gas at the lowest price possible.

[147] incl. Ukraine

[148] Import capacity is assumed to increase by 33% for all countries in 2015.

[149] The current situation the emergency situation is defined as a situation where the Community would risk losing more than 20% of its gas supply from third countries and the situation at Community level is not likely to be adequately managed with national measures.

The advantage of this tender process is that it allows inference about the shape of the supply curve of cushion gas. Knowing this will allow the TSOs to choose how much gas should be supplied to the market given the observed prices. Furthermore it could create some competition in terms of prices.

The main gain of applying this voluntary tender based system is that it imposes minimum distortion to the functioning of the internal gas market. In this respect it meets the requirements of the security of supply directive of 2004 that establishes that security of supply obligations should not impose unreasonable burdens on the gas market players. Furthermore it does not require large investments in new giant storages or pipelines. The investment that must be undertaken primarily lies within development of new technology.

The proposed tender solution is based on voluntary participation, thus it is up to the storage operator to decide whether to participate or not, and what amount to supply and at what price to supply it. We do thus not suggest an obligation for all storage operators to supply cushion gas but merely the possibility of looking into this area.

36.6.2 Limitations to supply

We acknowledge that given the risks of damages to storages, the incentive for dipping into the cushion gas could be related to the age of the storage. Thus we expect that owners of old/mature storages would be more inclined to be a part of this tender scheme than owners of newly constructed storages would. To get an idea about the scopes of using the cushion gas, studies relating to the consequences of using of the cushion gas must be carried, only then we can get a picture of the full scope of this opportunity.

36.7 Legislative barrier to use of cushion gas

Some national legislation concerning running gas storages, such as in Denmark, actually prevents usage of the cushion gas. Thus legal barriers in the different EU countries could prevent a successful implementation of usage of the cushion gas.

The problems that such national differences in legislation pose for usage of the cushion gas should be addressed by including the possibility to extract cushion gas in a framework such as the GGPSSO.

36.8 Total cost of supplying cushion gas

As mentioned earlier determining the total cost of supplying cushion gas is outside the scope of this study, however what can be said about the total cost is that when comparing the cost per bcm of supplying cushion gas to the most expensive option, the total cost should not exceed the cost of the most expensive alternative 10.304BEUR (14*0.736BEUR) by much, as this would render the cushion gas option uncompetitive to the other options.

36.9 Summary and conclusion on the potential of using cushion gas as strategic stock

Extracting some parts of the cushion gas in a pre-defined emergency situation of supply disruption could be an alternative solution to strategic storage and should be further investigated.

Examination of the definition and the development of cushion gas in the United States indicated that cushion gas is being used. The withdrawal of cushion gas was sometimes as high as 10%. However, extraction rates never were as high as estimated in the literature.

It was also found that some storage operators in the EU are in fact looking into this possibility. This indicates that advances in the technology perhaps have made extraction of the cushion gas more economically viable.

The potential of cushion gas depends on the assumptions taken; a relative conservative approach resulted in an estimate of almost 19 bcm. This would be enough to cover approximately 15-16 days of average household winter consumption.

Reimbursement of the storage system operators was investigated. A voluntary tender solution which implies that the SSOs on a case by case basis declare how much they would supply at a given price could potentially create a market for cushion gas.

37. General comparison of all options

Having analysed the various options this chapter provides a summation of the main findings and recommendations under the options to facilitate an easier comparison between the options. The options are reviewed under the following principal criteria:

- The **cost** of implementing the proposed option and where this is not calculable a qualitative cost estimation will be pursued;
- The **distortionary** effect of the option on the market if it were pursued;
- The practical **implementability** of the option, evaluating its feasibility;
- The impact of the option upon **security of supply**.
- A **recommendation**, following consideration of the above criteria and a summation of the overall quality of the option.

It is important to highlight that the options are not necessarily mutually exclusive.

The options were, to the extend possible, compared based on a strategic stock of 14 bcm as calculated in Option 4.

38. Option 1

The objective of this option was to investigate whether the concept of strategic oil stocks should be used and whether it may be possible to transpose this existing oil stock scheme for strategic natural gas stocks.

Costs

A cost comparison between 14bcm of gas storage and the oil storage in corresponding energy equivalent showed following:

- The cost of construction for 14 bcm gas storage was estimated to 6.5BEUR-9,1 BEUR. The construction costs for oil storage (corresponding to 14 bcm in energy equivalent) is estimated to approximately 1.8BEUR i.e. up to 5 times less;
- The "filling costs" for 14bcm strategic gas storage were estimated to 5.28BEUR and the energy equivalent in oil storage to 4.62BEUR i.e. a difference of 14%, based on oil and gas prices of medio October 2008).

A total cost for having 14 bcm of gas stored in a new storage is therefore estimated to approximately 12-14 BEURO compared to 6,4 BEURO if the corresponding energy was stored as oil in a new oil storage.

Implementability

Reviewing the main items that define the strategic oil stocks scheme, and bearing in mind that the scheme is already in the process of being updated due to imperfections such as lack of transparency, lack of overview over the available stocks etc, the scheme does not seem to be appropriate to be directly transposed into a strategic gas stock scheme.

However, the main arguments making the strategic oil scheme not applicable for strategic gas stock are the differences in transport and storage of oil and gas. Construction of gas storage is subject to geological constraints and gas is transported via pipelines implying that an adequate transport infrastructure needs to be in place in order to enable transport of the gas at any time from strategic stocks to the point of consumption. A significant coordination between the parties is necessary as well.

Market effect

Crowding out effects can be present on both the oil and the gas side but since gas storages are a crucial balancing tool and therefore an integrated part of the natural gas infrastructure, crowding out effects may have more serious consequences on the gas than on the oil market.

Security of supply
Vulnerability of the end consumers and the economies to oil supply disruption is comparable to vulnerability to gas supply disruption. Based on this finding one might argue that if there is a necessity for strategic oil stocks there is a necessity for gas strategic stocks as well.

However, as previously elaborated, the crowding out effects may directly result in lack of investments and thereby directly decrease the long-term security of supply.

Recommendation
In spite of the comparable vulnerability of the end consumers and the economies to oil and gas supply disruptions, based on the findings related to cost, implementability and especially possible consequences to the market , it is not recommended to transpose the strategic oil stocks scheme to strategic gas stocks.

39. Option 2

In this option the possibility was investigated to develop a limited number of strategic stocks located at key points on the network.

However, the location of the storages is determined by geological conditions, which are not necessary at the key points of the network.

Cost
Costs for storage were established for both the time varying and flat rate policies as detailed in Option 4 and considered both the geological and network constraints that inhibit the location of such storages. The cost of the provision of storage for 14 bcm was evaluated under three different scenarios;
14 bcm invested in new in depleted field storage throughout would cost approximately €6.1 billion.
14 bcm invested in utilising the Ukraine’s existing storage would cost approximately €8.5 billion
14 bcm invested in the North Sea offshore depleted fields costing approximately €9.26 billion.

Implementation
The implementation of such an option would probably prove too challenging in reality. The option of setting up three or four storages at key points on the network ignores the key facts that the necessary geological conditions are only present at certain locations not necessarily coinciding with key points. Therefore the possibility to to distribute the gas from the storages to the point of consumption becomes the crucial challenge in implementing this option. Some countries, having the geological conditions to develop storages need significant investments in transmission capacity.

Market Effect
It seems likely that the creation of such storages would have a detrimental effect on the market with crowding out a probable result of this option. If such strategic storages were created there would be considerable uncertainty in the market as to whether or not the storages would be utilised in a commercial role and the result may act as a disincentive to investment.

Security of Supply
The effect on security of supply is dependent on the type of investment pursued. In the high security example of 60 days supply for both household and industrial consumers the costs were high but the security of supply provided was correspondent to the high cost, even if the investments were made due to the logistical and infrastructure requirements suggested above it seems unlikely that such investment would provide security of supply throughout Europe but rather in limited areas.

Recommendation
Overall this option does not seem to be one that would be prudent to pursue given the considerable difficulty in implementing, funding and creating such storages. The storages would almost certainly not provide full security for certain parts of Europe and investments would only cover certain regions rather than provide comprehensive security of supply.

40. Option 3

This section evaluated whether the possibility of using storage facilities across borders for strategic storage will enable countries to respond in a rapid, efficient and flexible manner to come to the aid of partner country in the event of supply.

Cost
The costs of implementing Option 3 are similar to the risks of implementing Option 1 and 2 related to dedicated facilities for strategic stock, and similar to the costs of Option 4 related to imposing standards on existing storage facilities.

Implementation
A precondition for implementing this option is interconnection of the transmission systems of the countries in question so that gas withdrawn from storage can be transported to the place of consumption across borders

Market Effect
The risk for distortion of the market is based on the concept of strategic stocks. The option of sharing the strategic stocks is then of no relevance.

Security of Supply

Withdrawal from storage across borders (not necessarily strategic stock) is the best tool for security of supply between two countries that share the risks of supply disruption.

For countries that do not share the risks of supply, interconnection is a better tool for security of supply than withdrawal from storage across borders
However, if the storage is strategic, same risk of actually decreased secutiry of supply on long term exists due to crowding out effect.

Recommendation
Regional cooperation for security of shall be further enhanced and storage as tool for security of supply shall be shared across borders.

If an obligation for maintaining strategic gas storage is imposed on EU Member States, use of storage facilities as strategic gas stock across borders must be allowed, as some EU Member States do not have storage facilities at their territories.

41. Option 4

The objective of this option was to evaluate the impact of imposing minimum levels for strategic stock on commercial storages i.e. imposing obligations for mandatory stockpiling on one or more market operators in existing commercial storages.

Two different mandatory stockpiling policies were investigated: a flat rate policy, which required a constant amount of gas to be stored, and a time varying policy that relates the stockpiling requirement to the level of consumption. A third policy requiring suppliers to store a certain amount of gas before the 1st of November was benchmarked to the two above.

Costs
The costs of imposing a mandatory stockpiling requirement relates to the degree in which a stockpiling policy interferes with the normal operations of the storage operator and the storage users. The net discounted profit of the storage operator was simulated for each policy, with and without the minimum requirement imposed. It was found, that compared to a situation without a minimum requirement the net discounted profit decreased with 20% for the time varying policy, 16% for the flat rate policy, and 4% for the policy requiring filling before the 1st of November. It is thus the policy which introduces the largest changes to normal operations which is the most expensive for the storage operator.

Market Effect
The distortion to the market does in this option relate to the immediate undersupply of storage which such a policy could create in some parts of the EU. Section 1 showed that the supply of gas storage in certain regions could be tight in the coming years, making a part of the storage unavailable to the storage operator could increase prices for storage which in the end could be passed on to the consumers.

Furthermore given the decreased profits described in the cost section, disincentives to invest in storage could arise. This could tighten the supply - demand balance further.

Implementability
No creation of new (dedicated) storage facilities. However given the different flexibility tools available for the Member States a uniform requirement may affect Member States differently.

Security of supply
The flat rate policy gives less security of supply compared to the time varying policy. The time varying policy ensures gas enough for (in this case) 60 day ahead gas consumption. This means that there is no risk for the storage to be empty for seasonal balancing after the strategic stock has been used to mitigate supply disruption emergency event. This risk is present with the flat rate policy.

Recommendation
Due to the significant risk of distortion of the market it is not recommended to proceed further with this option.

42. Option 5

To investigate security of supply tools alternative to strategic gas storage, specifically fuel switching.

Costs
The cost of fuel switching is related to the prevailing price of installing distillate storages in the proximity of the user of the fuel switching facility. Estimates suggest that the price per bcm equivalent strategic storage ranges between 424 and 736 MEUR depending on the prevailing energy prices. One should furthermore take the environmental cost that a shift from natural gas towards a more polluting source would have, into account.

Distortion to the market
The events in which the consumers will be interrupted should be clear and agreed upon by all parties such that uncertainty and risk of distortion is minimized.

Implementability
The option can only be implemented in countries were there is a potential for fuel switching, hence countries that use gas for electricity generation.

Security of supply
The option increases security of supply.

One should though be aware of risks of domino effects. Moreover as environmental issues are receiving more attention, some countries could be reluctant to support fuel switching arrangements.

Recommendation
Strategic storage as a security of supply tool shall be replaced by alternative tools such as fuels switching to the extend possible. The risks of domino effects must be evaluated

43. Option 6

To present and investigate the potential and the technical possibilities of using cushion gas as strategic gas stock.

Costs
Since this is a relatively unexplored field, the costs of withdrawing cushion gas are not straightforward to quantify. Obviously the extra cost of withdrawing the cushion gas should be taken into account. Furthermore potential damages to the storages caused by extraction of cushion gas should be investigated. In evaluating the costs one should bear in mind that security of supply tools are not meant to be frequently used and the damage on the storages therefore would be limited. When comparing the cost per bcm of supplying cushion gas to the most expensive option the total cost should not exceed the cost of the most expensive alternative 10,3BEUR, as this would render the cushion gas option uncompetitive to the other options.

Market effect
The advantage of withdrawal of parts of the cushion gas is that it does not entail interference with current working gas capacity, in form of mandatory stockpiling. Moreover it does not require huge investments in new infrastructure in the form of dedicated strategic gas storages, thus the probability of crowding out effects are not significant. To avoid uncertainty it is nevertheless important that clear rules, defining situations in which cushion gas can be supplied, are set up.

Implementability
To implement this option it is crucial that market mechanisms, that ensure that cushion gas is supplied on a voluntary basis, are established. Since it is difficult to ascertain each storage operator's costs of supplying cushion gas, the best way of securing voluntarily supply is to launch a tender scheme for the supply of cushion gas.

Security of supply
The study concluded that 16 days of average household winter consumption could be covered by the use of cushion gas if necessary. It is important to emphasize that the supply of cushion gas is only an issue for seasonal balancing, peak days are not

covered since the cushion gas due to pressure restrictions and quality assurance cannot be extracted fast enough to accommodate peak demand.

Recommendation

Considering the fact that strategic gas storages are to be used only in the event of a major crisis, the costs are being outweighed by the benefits. Introduction of free market principles and voluntary participation in this scheme implies that the distortion to the current investment climate will be limited. Therefore it is recommended that this option is explored further. A study of the consequences and potential for each type of storage of supplying cushion gas must be carried out, such that more exact conclusions about the European storages' abilities to supply cushion gas can be determined.

Table 47

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Objective	To investigate whether the present strategic oil stock scheme can be transposed into strategic natural gas storage stocks.	To investigate the possibility of developing a limited number of strategic gas stocks located at key points on the network.	To investigate whether countries can respond in a rapid, efficient and flexible manner to come to the aid of partner country in the event of gas supply disruption by using gas strategic stock across borders	To evaluate the impact of imposing minimum levels for strategic stock on commercial storages.	To investigate security of supply tools alternative to strategic gas storage, specifically fuel switching.	To present and investigate the potential and the technical possibilities of using cushion gas as strategic gas stock
Cost BEUR	A total cost for having 14 bcm of gas stored in a new gas storage is estimated to approximately 12 BEURO compared to 6,4 BEURO if the corresponding energy was stored as oil in a new oil	The cost of the provision of storage for 14 bcm was evaluated under three different scenarios; 14 bcm invested in new in depleted field storage throughout would cost approximately	The costs of implementing Option 3 are similar to the risks of implementing Option 1 and 2 related to dedicated facilities for strategic stock, and similar to the costs of Option 4	Significant loss in profit for the storage operator, depending on number of parameters defining the strategic stock policy such as – levels of gas in the storage for strategic purpose,	Depending on the energy prices the total cost for 14bcm varies between 5.936-10.304BEUR.	Total costs not available, however to remain competitive to other options the total costs should not exceed 10.304BEUR by much.

	storage.	€6.1 billion. 14 bcm invested in utilising the Ukraine's existing storage would cost approximately €8.5 billion 14 bcm invested in the North Sea offshore depleted fields costing approximately €9.26 billion.	related to imposing standards on existing storage facilities.	gas price at the moment of the emergency event, frequency of the event etc.		
Implementability	Practically possible, but very difficult to implement. Significant problems would be expected with regards to, transportation of the gas, location of storages and existing networks.	The risks of implementing Option 2 are similar to the risks of implementing Option 1.	A precondition for this option to be implementable is the connection between the gas transmission infrastructures of the countries.	Can be implemented by "simply" imposing a regulation. The consequence could be lack of storage capacity for seasonal balancing. Given the different flexibility tools available for the member states a uniform	Potential in countries using significant volumes of gas for electricity generation only.	Introduction of market based principles, should create incentives to engage in voluntary supply of cushion gas. However there remains a degree of technical uncertainty with regard to the technical feasibility of such an option.

				requirement may affect member states differently.		
Distortion to market	Implementing a regulation on strategic gas stocks similar to the strategic oil stocks scheme imposes significant risk of crowding out effect and thereby distortion of the gas market.	The risks of implementing Option 2 are similar to the risks of implementing Option 1	The risks of implementing Option 3 are similar to the risks of implementing Option 1 and 2 related to dedicated facilities for strategic stock, and similar to the risks of Option 4 related to imposing standards on existing storage facilities.	Disincentives to invest in gas storage. Tightening in the demand supply balance by the immobilization of part of storage.	No direct distortion to the market. However the conditions in which supply can be disrupted should be clearly established.	Minimal distortion as there is no interference with current working gas capacity. However clear rules should be in place to ensure transparency and minimize insecurity.
Security of supply	The cost of the option makes the strategic gas stocks not an optimal tool for security of supply. Furthermore the crowding out effect might result in	The three investments offer differing levels of security. Investing 14 bcm in depleted fields throughout Europe may provide the greatest level of	Withdrawal from storage across borders (not necessarily strategic stock) is the best tool for security of supply between two countries that share the risks of	The different policies imply different levels of security of supply.	Risk of domino effect.	Gas already in place close to existing consumer areas and transmission networks. Moreover withdrawal of cushion gas may not be flexible enough to accommodate

	direct lack of investments and consequently decrease of security of supply.	SoS as it would be within European borders and may be distributed throughout a number of regions. 14 bcm in the Ukraine would not provide a high level of SoS as the Ukraine's network is sub optimal and it is outside of the EU Finally 14 bcm in North Sea would not provide adequate SoS throughout Europe, but only Northern Europe.	supply disruption. For countries that do not share the risks of supply, interconnection is a better tool for security of supply than withdrawal from storage across borders However, if the storage is strategic, same risk of actually decreased secutiry of supply on long term exists due to crowding out effect.			peak demand.
Recommendation	Not recommended to transpose an already inadequate sytem of strategic oils stocks to a system of strategic gas stocks.	Overall this option does not seem to be one that would be prudent to pursue given the considerable difficulty in implementing, funding and	Regional cooperation for security of shall be further enhanced and storage as tool for security of supply shall be shared across	The option is not recommended as: - immobilizing storage capacity that was planned for other purposes (seasonal balancing), might	Recommended for further investigation as perhaps a short term solution.	This option may be proposed for further investigation provided it is deemed technically feasible.

		creating such storages and its limited impact on a European security of supply.	borders. If an obligation for maintaining strategic gas storage is imposed on EU Member States, use of storage facilities as strategic gas stock across borders must be allowed, as some EU Member States do not have storage facilities at their territories.	eventually result in lack of storage capacity for seasonal balancing. the cost of regulation in terms of profit loss to the storage operator are significant and may outweigh the benefits, furthermore it could lead to disincentives to invest in storage.		

CONCLUSIONS AND RECOMMENDATIONS REGARDING COMMON APPROACH TO SECURITY OF GAS, STORAGE FOR SECURITY OF SUPPLY AND STRATEGIC STOCK AT EU LEVEL

Strategic gas stock is gas and corresponding storage capacity reserved and immobilized to be used in a pre-defined emergency event of gas supply disruption.

Being an event of high impact but with very low probability of occurring and with the market having no information about it, this emergency event is a non-market event. Even a well functioning market cannot be expected to provide security of supply in non-market events. If gas customers are to be supplied with gas in non-market events, this can only be obtained by use of non-market measures such as strategic stock.

The overview and the analysis of the gas storage market within EU shows that the market is receiving investment signals and is responding to them. Correlation of storage capacity to market parameters shows that the main investment drive for storage capacity is the demand for storage for seasonal balancing, which is directly linked to seasonal gas consumption. The planned investments correspond to the most optimistic scenarios for gas consumption on long-term and are being adjusted to the more realistic situation on short-term. Even in parts of EU, such as the South-East region where development of storage capacity has until 2000 been somewhat slower than in the rest of EU.
However, also taking the planned investments into account, not much of the storage capacity can be immobilized as strategic before the capacity available for seasonal balancing will be less than the demand. The market is not and cannot be expected to receive signals to invest in strategic storage.

Is the market receiving signals for security of supply in market events? It is difficult to evaluate the exact degree of security of supply that the market can as such provide at the moment. A simple overview of the levels of coverage from storage only, shows quite a big difference between the available storage capacities across EU. While Germany has in average more than 50 days of total consumption in storage, Portugal gas less than 5. The actual level of coverage of the customers depends then on the other tools for security of supply available on the market of that specific Member State.

The picture indicates a lack of overview of the actual security of supply on EU level. The difficulty EU to have a clear perception at any time of the actual level of security of gas supply in the separate EU Member States and in the EU as a whole, is perhaps one of the immediate weaknesses with the existing regulation, and possibly the strongest argument for reviewing the existing approach to security of gas supply.

An overview of national provisions on security of gas supply across EU shows that even though the existing regulation on security of gas supply (referring to the Security Directive) does not impose direct obligation for stockpiling of gas, most of the Member States require some kind of de facto strategic storage, imposed on one or more market players. Some of these national provisions are even counterproductive when it comes to the security of supply on EU level.

Furthermore the coordinated action and the oil stocks release related to the hurricane Katrina showed the necessity of coordinated common action. Gas supply disruption can be a form of force major or can be caused by one, and as such should be tackled by coordinated common EU action.
The three-step mechanism approach mentioned by the Security Directive for measures to be taken in case of gas supply disruption should be further specified into an operational EU Emergency Supply Plan.

We are therefore of opinion that there is a need for more specified common approach towards the security of gas supply on EU level. Common approach related to storage for security of supply is not necessarily a common regulation on direct obligation for stockpiling of gas to be released in case of a gas supply disruption.

In the following, and based on the results of the analyses and observations presented in this study we give few recommendations on

- how to modify the existing regulation in order to strengthen the common approach to security of gas supply and
- possibilities on a scheme for a EU Emergency Supply Plan for common action in case of a gas supply disruption

43.1 Unified security of supply standards

Unified security of standards will result in the same level of security of supply for the customers irrelevant of the Member State they are located in or in other words, so the EU at any time has an overview of the level of security of supply across Member States.

A uniform standard would be:

- "continuous supply of all uninterruptible consumers in a normal winter or x number of days in a 1 in 20 winter"

- "continuous supply of all (uninterruptible) consumers for x number of days in a normal winter or y number of days in a 1 in 20 winter"

These definitions are already bases for the security of supply strategy in most of the Member States in a form of PSO imposed on one or more market players, defined based on the (general) security of supply standards of the Security Directive.

Instead of transposing the security standard into national legislation through provisions on PSO, the PSO could be defined on common EU level.

The PSO responsibility should be clearly placed on the suppliers. It should be left to the suppliers then to choose the most feasible tools available on the market to fulfil this PSO, one of them being storage.
A direct obligation on stockpiling of any form is not recommended.

Imposing PSO for supply (in emergency) on a TSO results in a direct stockpiling obligation, irrelevant of whether this is the most viable security of supply tool to be used. The TSO will still have its storage necessary to maintain its function for residual balancing of the system, which is to maintain the pressure in the system following a system imbalance, but not to supply end consumers.

The TSOs and ENTSOG shall have a monitoring security of supply role as well as a role of providing the necessary information related to security of supply to the market players.
The monitoring role of the TSO can be justified with the risk related to the fact that market players will always be tempted to use gas or capacity for security of supply for purposes other than security of supply whenever they deem profitable. Availability of tools for security of supply purposes should therefore be constantly monitored; control and monitoring can only be done by the TSOs – who have the real-time data on all inputs and offtakes in the transmission system. The principle of Firm and Safety Monitors used by national Grid could be applied.
The above monitoring role is on operational level and is therefore not to be confused with the monitoring role placed on the Commission by the Security Directive.

43.1.1 Regional cooperation/regional forums of the GCG

In spite of correlated gas consumption across EU, there is proved gain from market integration, also in terms of security of supply. Member States can benefit from interconnections and sharing of storage facilities. A regional cooperation on operational level related to security of supply might enhance the process of this market integration.

A parallel can be drawn from the Regional Energy Markets REM's to establish a number of Regional Energy Security of Supply Forums (RES), within the already established Gas Coordination Group. The purpose of these RES´ will be to deal with issues of security of supply on a regional level to make sure that regional security of supply is adequate and attained in the most efficient manner at the lowest costs. The RES also present opportunities for Member States to discuss and tackle obstacles and to plan the overall development in terms of security of supply within the region, as well as to plan a coordinated action in case of supply disruption within the EU Emergency Supply Plan.

This solution might also enhance the use of Article 4, paragraph 5 of the Security Directive, which does not seem to be in use at present. On the contrary there are examples of Member States requiring gas for security of supply to be stored exclusively on their territory. It shall be possible to use tools for security of supply across borders (it is discussible whether this should also be allowed for outside EU for example Ukraine). The creation of a number of RES would make it more operational for Member States to coordinate and possibly pool their policies and measures dealing with security of supply issues.

With this suggestion we are making an attempt to lift the first level of the three-step mechanism outlined in the Security Directive from national to regional level.

The concept is illustrated on Figure 121.

43.2 Common emergency response/ EU Emergency Supply Plan

The EU Emergency Supply Plan shall be prepared by the gas Coordination Group within the Regional Energy Security of Supply Forums following the example of the IEA's response measures.

It shall include actions on both the supply and the demand side, as illustrated on the Figure 122.

Increased supply includes:

- stockdraw and
- production surge
- possible use of cushion gas (to be investigated further)

Demand reduction:

- temporary fuel switching

Services such as stockdraw, use of cushion gas and production surge are contracted previously, on regional level, based on multi annual frame contracts received on open tenders.
Reference is made to the purchase of Operational Margins (gas, capacity and services) by National Grid.

Each Member State shall be able to announce idiosyncratic emergency supply situation and apply for common response by EU. Common response by Member States is however only triggered upon approval by the GCG.

Beside Member States also ENTSOG can alert the GCG of emergency supply situation.

Figure 121 Levels of cooperation on security of supply within EU

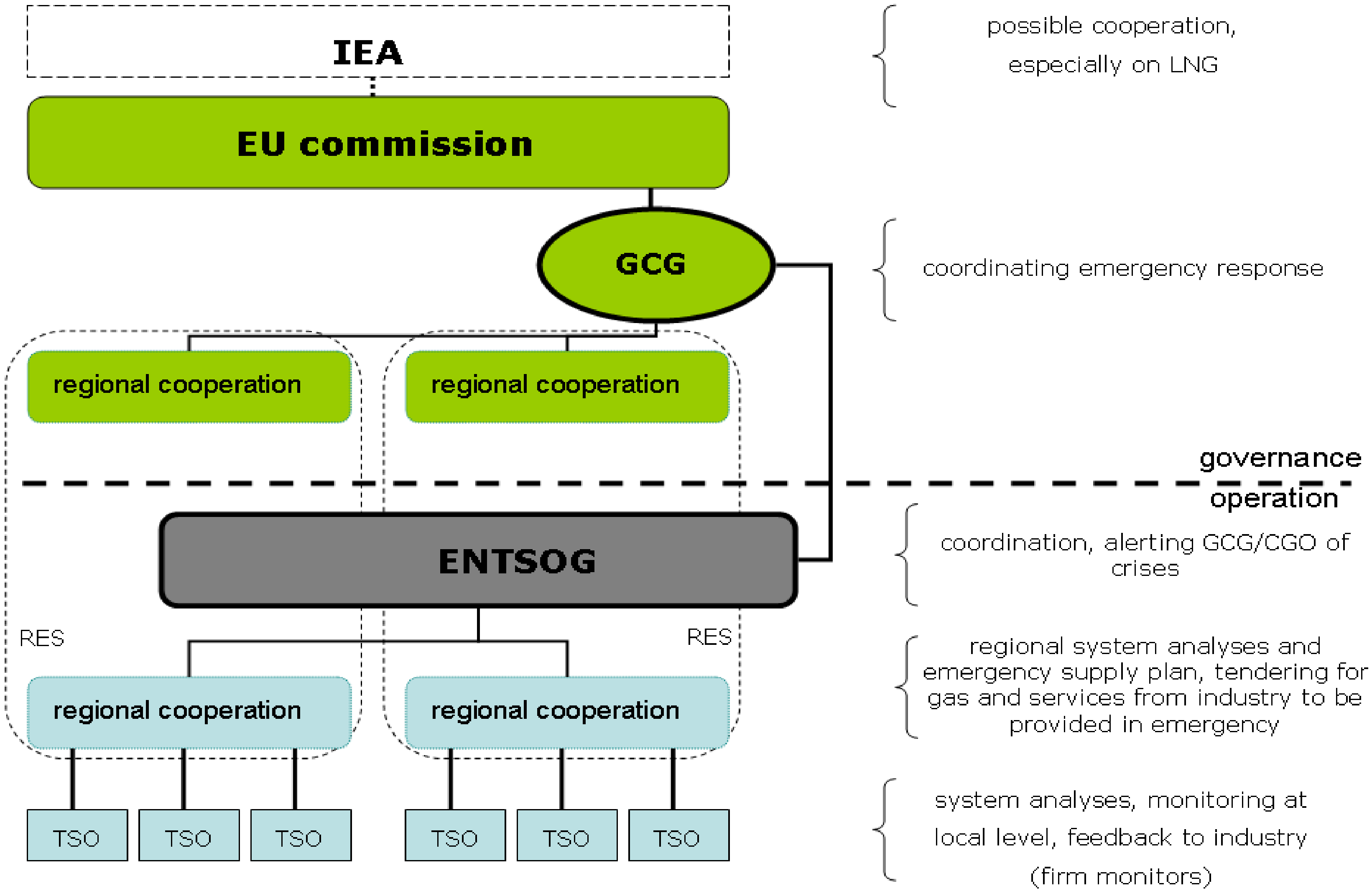
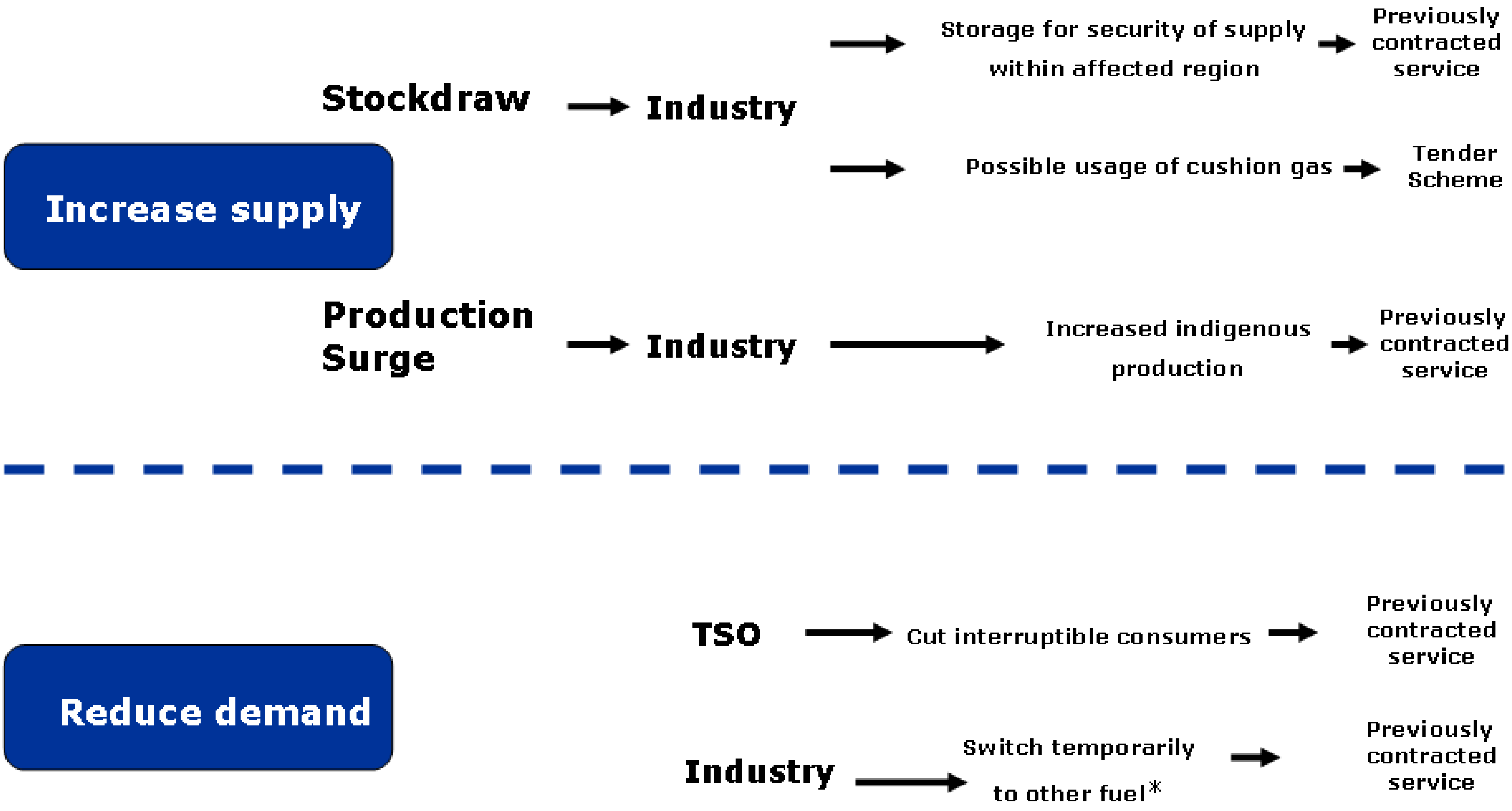


Figure 122 EU Emergency Supply Plan



PART IV ANNEXES

ANNEX 1 GAS REGIONS

44. Selection of suitable gas regions

In the Priority Interconnection Plan the development of coordinated planning at regional level is mentioned as action 3 where the purpose is quoted as: "this framework should provide a platform for undertaking monitoring and analyses on the existing and future developments of networks in each energy area that improves the transmission capacities between Member States on a regional basis. It will facilitate the dialogue between stakeholders with due regard to socio-economic and environmental considerations. It will prepare, fully in line with national planning procedures, regional plans for network developments as well as forecasts for balancing supply and demand (for peak and baseload). In carrying out its tasks, it will take due account of the opinion of regulators and other relevant fora for electricity and gas (i.e. Florence and Madrid fora, respectively)".

The European gas network has been established gradually over the last 70 years. Initially, the European gas system was developed around national gas fields in Southern France, Northern Italy, Germany and Romania. In the 1960's the large gas field Groningen was found in The Netherlands. Large scale gas import from Norway, Russia and Algeria only took over as the main source of gas supply in the 1980's after the two oil crises. In the 1990's gas was introduced and developed in Greece, Portugal and Ireland. After 2000 there have been three main challenges i) to connect the UK gas market to the Continent and the Norwegian gas fields in line with depletion of indigenous gas fields and to integrate the gas systems, ii) to connect and integrate the new member states to the system of the old member states and iii) to create new import channels as import pipelines from North Africa and the Caspian Sea and establishment of new LNG import facilities.

The next challenges which the EU gas market is facing in the coming years are a.o the following three:

- The increasing dependency on gas imports and uncertainty about availability of sufficient gas reserves in Russia and other main external supply countries.
- The development of a single European gas market, including the completion of the integration of the EU gas network, a.o. in view of the EU enlargement.

- The climate change challenge where natural gas will be a bridging energy until sufficient renewable energy sources will be available.

This calls for the creation of appropriate regions where challenges can be handled within a setting that allows for efficiency and uniformity considering both challenges and solutions within the region.

Only six of the EU member states are not connected to the integrated gas network: Finland, Estonia, Latvia, Lithuania, Malta and Cyprus. In order to create a single European gas market it is considered as a goal in itself to connect at least Continental member states to the integrated systems.

With 27 member states and possibly even more in the future it is practically difficult to make an overall planning of the TEN-E networks. Also, due to the cost of transmission of gas there is a clear tendency to use the gas as close to the sources as practically possible, with a few exemptions where gas is supplied over longer distances for security of supply and diversification reasons. It can be foreseen that the 'influence sphere' of gas from different sources will change in the coming decades in line with depletion of the gas fields in the UK, Germany, Denmark and The Netherlands.

44.1 Existing regional initiatives - ERGEG

Gas regions are already a well-known concept in the EU gas market as the approach is already used by the ERGEG Regional Initiatives, where the Gas Regional Initiative (GRI) is operating in three regions. The purpose of the GRI is defined as the following (from energy-regulators.eu): *The overall aim of the Gas Regional Initiative is to push forward, at a practical level, the development of regional gas markets in collaboration with industry, Member States, the European Commission and other stakeholders.*

The GRI is operating with three gas Regional Energy Markets (REMs) North-west, South and South-southeast, the purpose of these REMs is defined as: "*The gas REMs tackle at a regional level barriers to competition, such as the lack of market integration, transparency and balancing issues, highlighted in DG Competition's energy sector inquiry".*

The GRI regions are made up of the following Member States:

Table 48 Regional Energy Markets, GRI

North-West	South South-East	South
The Netherlands	Austria	Spain
Belgium	Bulgaria	Portugal
France	Czech Republic	France
Ireland	Greece	
Great Britain	Hungary	
Germany	Italy	
Denmark	Poland	
Sweden	Romania	
Northern Ireland	Slovakia	
Norway (observer)	Slovenia	

The above regions are mainly aimed at tackling market issues and are thus not necessarily optimal for dealing with large-scale transmission such as huge import pipelines that may cross market regions on their way from supplier to consumer.

44.1.1 Baltic Gas Associations

Baltic Gas Association http://www.balticgas.org/ is a privately organised organisation of gas transmission and supply/trade companies around the Baltic Sea. The organisation was established in the late 1990's with the purpose of promoting the use of gas in the region and to exchange information. Norwegian StatoilHydro has also joined the organisation. Also, Gazprom from Russia is a member of the organisation.

Despite the work of the organisation, very few new gas systems have been finalised in the Baltic Sea Region over the last decade.

44.1.2 Observatoire Méditerranéen de l'Énergie

The Observatoire Méditerranéen de l'Energie (OME) is a non-profit oriented organisation whose main objective is to promote the co-operation between the major energy companies operating in the Mediterranean basin. The Association is a centre of studies and information on energy in the Mediterranean area as well as a pole of reflection and a permanent meeting forum between its members.

The member organisations are energy companies within the EU and external suppliers as e.g. Sonatrach from Algeria.

44.1.3 South-East Europe – energy community treaty – Athens process

The development of new gas infrastructure in South-east Europe has been one of the topics of the energy community treaty which was signed by most countries in the region.

44.1.4 North Sea

In the North Sea there is no formalised organisation and cooperation takes place among producers and from a project-to-project basis. However, the huge Norwegian transportation system is organised in a common company, Gasled, while the planning of the development of the system takes place in the state-owned Norwegian gas transmission company Gassco. The consequence of this organisation is a strong centrally planned system.

44.1.5 Is there a need for streamlining of regions?

As described above, there are different existing regional initiatives which are mostly used for informal exchange of information. As there are often competing interests and projects between members of the organisations it is mostly outside the scope of work for these organisations to prioritise between different projects and corridors.

Also, in line with change in the supply and demand balance the historical regions may change and there is a need for combining some regions and, in some cases, to focus on particular issues.

44.2 Criteria for regions and sub-regions

The following criteria are proposed for establishing new regions:

The origin of the main source of gas now and in 2020.
The origin of a possible secondary source of gas now and in 2020.
Geographical distance to potential new sources of gas.
Pooling of gas storage in view of typical weather in order to smoothen peak demand.
Pooling of LNG use and import.

Creating the appropriate regions should entail creating regions within which challenges and market conditions are relatively similar, as stated above. However, the most important thing, considering the intention of the priority corridors, is to connect supply with demand. Thus the regions should take into account all stakeholders starting at the supply point and ending at the demand point. Therefore when setting up appropriate regions in terms of dealing with gas transmission, the issue of supply and demand is the central balance.

44.2.1 Supply routes

There are roughly speaking four possible main gas pipeline supply/import routes into the EU:

North-western route – through the North Sea

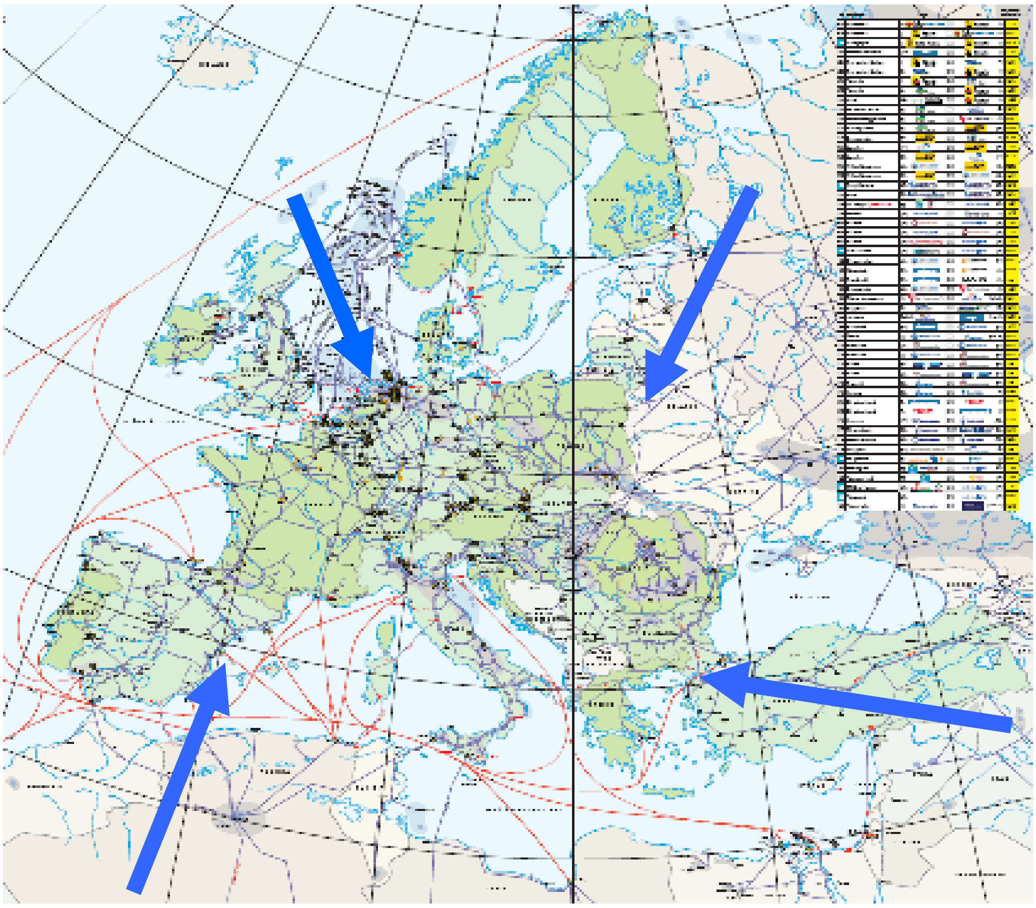
North-eastern route – from Russia

South-western route – through Northern Africa

South-eastern route – through Caucasus/Central Asia/Middle East

Depending on the development and agreements between supply countries and companies, some of these corridors could be combined. As an example, gas from the Norwegian and Russian part of the Barents Sea could be transported in the same pipeline. Gas from the Middle East could be transported to the EU via Turkey/the Black Sea or via the Mediterranean Sea.

Figure 123 Main gas import routes to the EU



Source: Underlying map from Gas Transmission Europe (GTE)

Today, the most commonly utilised routes are the north-western, north-eastern and south-western routes as most of the gas imported to the EU comes from Russia, Norway and Algeria. However, in the future it is possible that more gas will come through the south-eastern import route as it holds options to import gas from Russia, Caucasus, Central Asia and the Middle East.

In recent years there has been a clear tendency to push the technological development of pipelines and LNG to ensure direct supply from producer to consumer. Examples of this are the Franpipe, Blue Stream, Medgaz, Galsi, Nord Stream, Langeled, SkanLed. This indicates that the gas producers have experienced some disadvantages of transporting gas via transit countries.

LNG import terminals are, by definition, located at the coasts and will in some cases need new pipeline network to connect to inland markets.

44.2.2 Demand areas

Evaluating demand areas are done in perspective to the supply routes, i.e. where is the gas that is supplied through each import route in general consumed.

Gas from the North Sea is mainly consumed in North-western EU. Gas from Russia goes to North-western EU as well as to the north-eastern part and south-eastern part of the EU. Gas from Africa is mainly consumed is South-western EU and gas from the Caucasus area and Central Asia is mainly consumed in south-eastern EU. These geographical links between import route and consumption allow for the creation of a set of new regions. A few longer distance supply routes exist such as supply from Norway to Spain or from Russia to France. However, with an integrated network there should be no need for dedicated transportation routes in the future.

44.2.3 Missing links and proposed interconnectors

Some of the interconnectors included in the TEN-E Guidelines are listed below together with missing links.

	Country 1	Country 2	Inte-grate	Inter conn ect	Capa city
Amber	Lithuania	Poland	x		
Baltic Connector	Estonia	Finland	x		
Baltic Pipe	Poland	Denmark		x	
Baltic Gas Interconnector	Germany	Sweden/Denmark		x	x
SkanLed	Norway	Sweden/Denmark		x	
No Name	Norway	Denmark		x	
UK-Denmark Interconnector	Denmark	UK		x	
IGI	Italy	Greece		x	
TAP	Italy	Greece/Albania		x	
Nabucco	Turkey	Bulgaria			x
	Bulgaria	Romania			x
	Romania	Hungary		x	
	Hungary	Austria			x
No Name	France	Spain			x
No Name	France	Italy		x	

It can be seen that two interconnectors, the Amber project and BalticConnector, are the only projects which will contribute to integrate more Member States into the EU integrated gas system. It can be argued that a dedicated sub-region should be introduced to promote these projects in particular.

44.3 Proposed regions – conclusion and description

The proposed regions are listed in Table 49.

Table 49 Proposed regions for priority corridors

North	South-East	South-West	Sub region Baltic integration	LNG forum
The Netherlands	Austria	Spain	Finland	Spain
Belgium	Bulgaria	Portugal	Estonia	France
Ireland	Czech Republic	France	Latvia	Belgium
UK	Greece	Italy	Lithuania	UK
Germany	Hungary	(Switzerland)	Poland	Italy
Denmark	Italy			Greece
Sweden	Romania			Portugal
Luxembourg	Slovakia			
Finland	Slovenia			
Poland	Germany			
Lithuania	Cyprus			
Latvia	(Turkey)			
Estonia	(Croatia)			
Czech Republic				
France				
(Norway)				

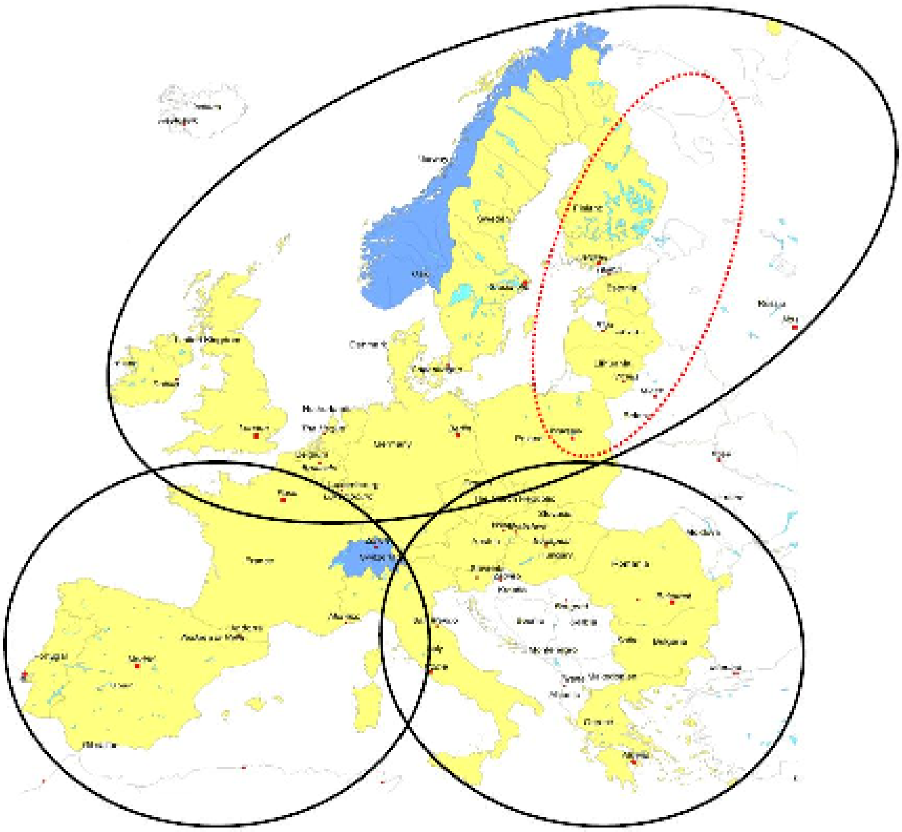
France, Italy, Germany and the Czech Republic are included in more regions to act as bridges between the three main regions:

France:	North to South-west
Italy:	South-west to South-east
Czech Republic and Germany:	South-east to North

The listed regions imply one major change compared to the REMs and that is the creation of one large North region that includes both North-western and North-Eastern EU. Norway should be considered a part of the North region.

Figure 124 shows an indication of the suggested regions.

Figure 124 Indicative display of proposed regions



44.3.1 Northern region

It is proposed to include all countries around the Baltic Sea and the North Sea into one region. The main reasons are:

Norwegian suppliers will have to choose between gas sale to Western Europe or Eastern Europe.

New Norwegian fields in the Norwegian Sea and the Barents Sea are located quite easterly and can possibly be coordinated with Russian fields in the Barents Sea. Gas transmission could be offshore via the Norwegian Sea and the North Sea, the Baltic Sea (Nord Stream extension), or onshore via Russia, Latvia, Lithuania, Poland (Amber) or via Finland, Sweden (previously known as Trans Scandinavia).

Projects like the Mid-Nordic Gas grid could be re-vitalised with positive impact on security of supply in the entire region.

Many ongoing TEN-E projects cross between the North Sea and the Baltic Sea in order to create diversification of supply, mainly to new Member States.

Depletion of gas fields in the UK, Germany, Denmark and The Netherlands will have to be replaced by gas supply from Norway or Russia. Timing and priority of field developments is an integrated part of the overall planning of new gas infrastructure.

Major energy companies like Total, StatoilHydro, E.On, Gazprom are share owners and partners in field developments and gas infrastructure in Norway and Russia and in development of gas infrastructure as NordStream.

Different approaches have been used for approval and planning of projects in the North and Baltic Sea. There is room for learning from best practice.

44.3.2 South-West region

The South-West region is mainly supplied from Algeria via the existing Transmediterranen and Maghreb-Europe pipelines and LNG and the Medgaz project being implemented. Further gas is supplied from Russia, Norway and The Netherlands to France and Italy which are included in more regions and as such will be the bridging countries to neighbouring regions.

The main reasoning behind the region is the following elements:

Full integration of the Iberian peninsula to the rest of Europe.

Possibly direct interconnection between France and Italy. Today there is only an indirect link via the non- EU and non-EEA Switzerland. Otherwise the shortest direct connection is via Austria and Germany. This means in reality that there is limited redundancy on the gas supply from Algeria to the EU via the transit countries of Tunisia and Morocco.

Long-term supply options from Africa as the Trans Sahara pipeline from Nigeria which would secure the EU a competitive advantage over LNG export where the EU would be in competition with the USA and Asian LNG importing countries.

44.3.3 South-East region

The South-East region has been very much in focus during the last decade due to the break-up of Yugoslavia and the Soviet Union and the vicinity of the region to the huge gas reserves around the Caspian Sea and in the Middle East. This opens for the possibility of import via the south-eastern corridor on a long-term perspective.

The reasoning behind the region is the following elements:

Integration of EU Member States, which is partly limited due to lack or reverse flow in existing pipeline systems. This is the background for the Nabucco project and the different proposals for interconnections of Italy to Greece and further to Turkey.

Long-term gas supply from the Caspian region, which has already been initiated via the South Caspian Pipeline from the Shah Deniz project in Azerbaijan.

Selection between main supply routes, Nabucco, South Stream and White Stream.

Long-term gas supply from the Middle East via Syria, Iraq or North Africa.

Possible connections to Cyprus.
Integration and development of the western Balkan into the EU system.

44.3.4 Sub region for Baltic integration

The four Member States, Finland, Estonia, Latvia and Lithuania, are the only continental member status not integrated into the integrated EU network. In order to create a fully functioning EU internal market it is considered as an objective in itself to ensure such integration. This shall also be seen in view of the discussion about the Nord Stream which could reduce the security of gas supply to non-integrated Member States in case of insufficient availability of gas from Russia.

The reasoning behind the region is the following elements:

Integration of Lithuania, Latvia, Estonia and Finland.
Development and use of gas storage in the region.
Establishment of a gas exchange to create an import price from Russia on the EU side of the border.

When the interconnections between the four Member States and the existing network are established, the sub region should be dissolved.

44.3.5 LNG Forum

A special forum is suggested for Member States involved in LNG projects. The reasoning behind this forum is the following elements:

Creation of uniform criteria for implementation of LNG projects with respect to technology, safety, environment and regulation.
Act as a counterpart towards existing and potentially new supply countries and companies. Today, this role is played by single companies and Member States.
Act as counterpart towards the shipping industry, IMO etc to ensure consistent rules and regulation.

44.3.6 Comparing the regions – why are they so different?

The proposed regions are quite different in size and number Member States. The largest region, the Northern, includes more than half of the EU population and more than half of the gas consumption. The reason to have this as one region is partly due to geography and market development. As there is no possibility for gas supply by pipeline from the West, gas has so far to come from the North and East in line with depletion of gas production within the region. This creates need for pipeline connections which may be coordinated or competing.

The South-West region is the smallest with respect to number of Member States. It is characterized by the Iberian Peninsula which does not receive gas from Russia. Hereby, the peninsula is very much depending on gas supply from one source, Algeria, and the region has been created with the dedicated purpose of bridging this to France and Italy in order to create back-up possibilities.

The South-East region is characterized with a large number of Member States with relatively small gas consumption. It will also be the region with potential for new members in line with enlargement of the EU. The purpose of the region will be to fully integrate the new Member States with the old ones and to establish new import routes from the Caspian Sea and balance this supply option with North Africa and Russia. Supply from Norway has little impact in the region.

ANNEX 2 NATIONAL EMERGENCY PROVISIONS

ANNEX 3 BACKGROUND ANALYSES

45. Some facts about gas consumption cross country correlations

We are interested in the cross country patterns of correlation in gas consumption. Low correlation implies a large scope for trade, and trade is a partial substitute for storage.[150]

We take monthly consumption totals from 16 European countries, from the OECD-IEA natural gas information 2005 and 2007. The countries considered are France, Germany, Italy, Poland, Spain, the U.K., Austria, Belgium, Czech Republic, Denmark, Finland, Hungary and the Netherlands, Norway, Portugal and Slovakia. The data covers 60 months, from January 2002 to December 2006.[151]

In this group of countries the raw data is highly correlated for all countries except Spain, Portugal and Norway. The average correlation between Spanish monthly gas consumption and that of the other 15 countries is 0.39, while for Portugal and for Norway this value is 0.14 and 0.04 respectively. If we separate the other 13 countries their average bilateral correlation is 0.985. The correlation between Portugal and Spain is 0.81. Norway’s consumption is uncorrelated with that of the other countries.[152]

The next step is to isolate the contribution of seasonal variations. For each country we run an OLS regression of monthly consumption against a constant, a trend, and eleven monthly dummies (with January taking the value of zero).

$$c_{j,t} = \beta_0 + \beta_1 T_t + \sum_{j=2}^{12} \delta_j D_{j,t} + \varepsilon_t$$

These regressions have 60 observations and 13 explanatory variables. Their R squared is on average 0.9542 for the 13 countries excluding Spain Portugal and Norway, while for Spain it is 0.88, for Portugal 0.58 and for Norway 0.31. A high R squared indicates the model captures most of the movements in the left hand side variable.

[150] Even if two countries with uncorrelated consumption import all their gas from a third country they still have incentives to trade as trade partially substitutes for storage. Trade can happen out of storage or out of the transmission/distribution grid with gas already in the pipelines.
[151] We should add 2007 information if possible.
[152] Norway has abundant hydro electric supply.

	RSQ	F(11,47)	β1	T(β1)
FRA	0.97	126	0.000805	2.1
GER	0.94	68	0.000425	1.0
ITA	0.96	106	**0.002372**	7.8
POL	0.95	85	**0.002244**	7.0
SPA	**0.89**	**9.0**	**0.006908**	**17.5**
UK	0.98	186	-0.00081	3.3
AUT	0.95	88	0.001302	3.2
BEL	0.95	83	-0.00054	1.5
CZR	0.96	117	-0.00035	0.8
DNK	0.97	125	-0.00024	0.7
FIN	0.88	31	-0.00017	0.3
HUN	0.96	117	0.000631	1.5
NTL	0.95	82	0.000031	0.1
NOR	**0.31**	**1.8**	**-0.00083**	**0.8**
POR	**0.58**	**1.3**	**0.004906**	**7.4**
SVK	0.97	129	-0.00190	4.8

Italy, Poland, Spain, and Portugal have significant and large positive trends (coefficient β1 with associated T statistic). France and Austria have small positive trends. Slovakia has a moderate negative trend.

The F test on the joint significance of the seasonal dummies shows they are not significant for Norway and Portugal, and significant for all other countries.[153]

The next table shows average two-country correlations for the raw data, for the seasonal component, and for the residual. The first row has the values for the full sample and the second row for the subsample that excludes Norway, Portugal and Spain:

N	Raw	Seasonal	Residual
16	0.699	0.775	0.447
13	0.962	0.983	0.554

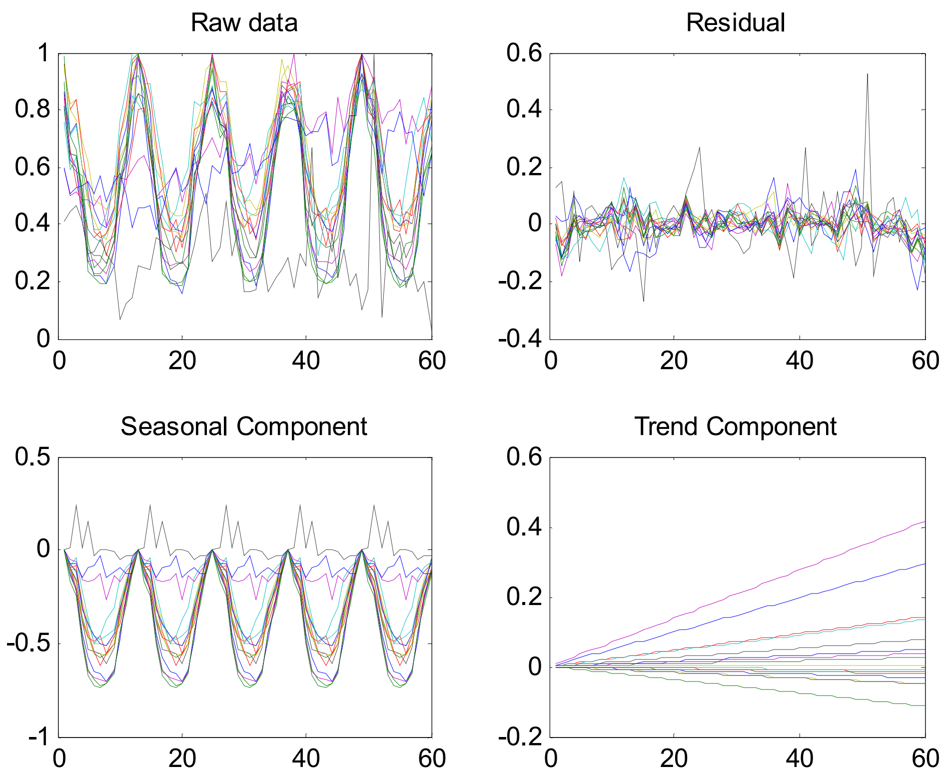
Seasonal variation (captured by the projection of the raw data on the seasonal dummies) is highly correlated across the 13 countries excluding Spain, Portugal and Norway. This is understandable: winter happens in the same time of the year for every country in the same hemisphere. But again, Spain's seasonality is much less correlated (at 40%) with the other 13 countries, and both Portugal and Norway correlate even less with them, at around 10%. Although gas consumption in Portugal and Spain is small when compared to the consumption of large countries such as

[153] The critical values for the F(11,40) statistic are 1.73 at 10% and 2.04 at 5%.

France and the UK, the correlation of the seasonal component is so low that there may be potentially large seasonal gains from interconnecting them.[154]

The residual in these regressions is (by construction) uncorrelated with the seasonal variation and captures the variation in consumption above and beyond the seasonal swing. While the residual captures less than 5% of total variation for all countries except Spain, Portugal, Finland and Norway, the fact that it has an average correlation across countries of around 0.45 suggests significant marginal gains exist from trading across borders.

The picture below shows the raw consumption data, the seasonal component and the residual for the 16 countries. The data for each country is divided by its maximum value to normalize all series in the unit interval. It is easy to spot the outliers (Spain and Portugal with the upward trend and Norway with the high spikes).



45.1 Is the seasonality of total consumption changing

[154] The report "Natural gas supply for the EU in the short to medium term" from the Clingendael International Energy Programme (2004) also takes this view.

Here we look at the relationship between winter and summer consumption. The five columns show the ratios of consumption of December over July each year.

	DEC/JUL02	DEC/JUL03	DEC/JUL04	DEC/JUL05	DEC/JUL06
FRA	3.21	3.83	3.23	3.80	3.76
GER	2.92	2.90	2.68	2.57	2.38
ITA	1.79	1.84	1.85	2.05	1.64
POL	2.51	2.06	1.87	2.11	1.85
SPA	**1.17**	**1.11**	**1.21**	**1.16**	**1.06**
UK	1.93	2.18	1.87	1.99	2.15
AUT	2.81	2.30	2.77	2.37	2.16
BEL	2.21	2.12	2.14	2.22	2.07
CZR	4.75	4.35	4.13	4.31	3.68
DNK	2.73	2.84	2.31	2.70	2.12
FIN	2.61	1.84	1.57	1.95	1.71
HUN	3.65	3.26	3.83	3.34	2.91
NTL	2.18	2.26	2.28	2.13	2.02
NOR	**0.42**	**1.95**	**1.49**	**1.05**	**0.08**
POR	**0.67**	**0.79**	**1.14**	**0.99**	**0.81**
SVK	4.34	4.29	3.89	4.20	3.67
AV	2.496	2.496	2.393	2.435	2.131

It is hard to see any robust pattern. Only Germany seems to have a sustained decline but even in this case other measures of the summer winter gap fail to show a pattern. A statistical test for the difference in the means rejects that the 2.131 average of 2006 is different from the 2.496 average of 2002 and 2003.

We emphasize again that where a trend is present, a constant pattern in seasonality implies an increase in the **level** of seasonal variation. But this does not imply seasonality itself is changing. On the other hand, a consistent pattern of falling seasonal ratios would be indicative of a falling rate of return on seasonal storage investments.

Overall, consumption paints a picture of a strong fundamental for gas storage, even if some non negligible gains from trade still remain to be exploited.

46. Gas Imports

One reason why imports may matter is that this source of gas is less flexible than indigenous production, possibly due to technical and contractual restrictions. This implies the need to store gas, in order to match an inflexible (or flat) supply of imports with a swinging demand.
One question we may ask then is: how flat are imports?

We take the data on gas imports from the OECD which matches our consumption data, and run the same regression as above to separate trends and seasonality. Denmark and Norway do not import gas and so are not present in this sample.

	RSQ	$F(11,47)$	$\beta1$	$T(\beta1)$
UK	0.86	12	**0.00774**	12
FRA	0.65	7.8	0.00052	1.0
GER	0.83	20	**0.00198**	4.2
ITA	0.97	105	**0.00424**	22
SPA	**0.89**	**2.9**	**0.00807**	**19**
NL	0.10	0.5	-0.00001	0.0
POL	0.82	13	**0.00423**	9.3
BEL	0.84	22	-0.00051	1.0
HUN	0.44	3.1	0.00099	1.3
AUT	0.82	7.7	**0.00531**	11
CZK	0.29	1.7	-0.00009	0.1
FIN	0.88	31	-0.00017	0.3
POR	0.58	0.9	0.00561	7.5
SVK	**0.53**	**4.3**	**-0.00166**	**2.1**

Most countries have significant seasonality in imports. One clear exception is the Netherlands as it is a gas producer.

The fact that imports have a seasonal behaviour must be emphasized. It is not that imports are flat throughout the year. They vary which implies they have some flexibility.

But are imports more or less seasonal than consumption? They are far less seasonal than consumption. We can evaluate that by measuring the **standard deviation of the seasonal component** for both series. We recall here that both consumption and imports data are normalized, by country, by the maximum value each series attains in the sample, so that all series vary within the unit interval, and so the standard deviation measure is strictly comparable.

	Std(Con)	Std(Imp)	Ratio
UK	0.1878	0.1249	1.50
FRA	0.2454	0.0850	2.89
GER	0.1976	0.1197	1.65
ITA	0.1770	0.1125	1.57
SPA	**0.0676**	**0.0407**	**1.43**
NL	0.1979	0.0365	5.42
POL	0.1673	0.0943	1.77
BEL	0.1819	0.1423	1.27
HUN	0.2580	0.0735	3.51
AUT	0.2146	0.0749	2.86

CZK	0.2577	0.0607	4.24
FIN	0.1676	0.1676	1.00
POR	0.0434	0.0396	1.09
SVK	0.2585	0.0910	2.84
Mean	**0.1873**	**0.0902**	**2.38**

Column 3 in this table shows the ratio of the standard deviation of consumption over the standard deviation of imports (seasonal part). The median ratio is 1.71 while the mean ratio is 2.38. There is little doubt that consumption is far more seasonal than imports, which is enough to drive the need for storage. Finland is an interesting exception in that it imports **all** the gas it consumes, is very seasonal, *and yet has no storage*.

The next two columns measure something different: the standard deviation of the residual of the regression in the second half of the sample divided by that in the first half of the sample. For this subset of countries we actually have data for 2007, totalling 72 observations. The regression results with the extra 12 observations do not change significantly.

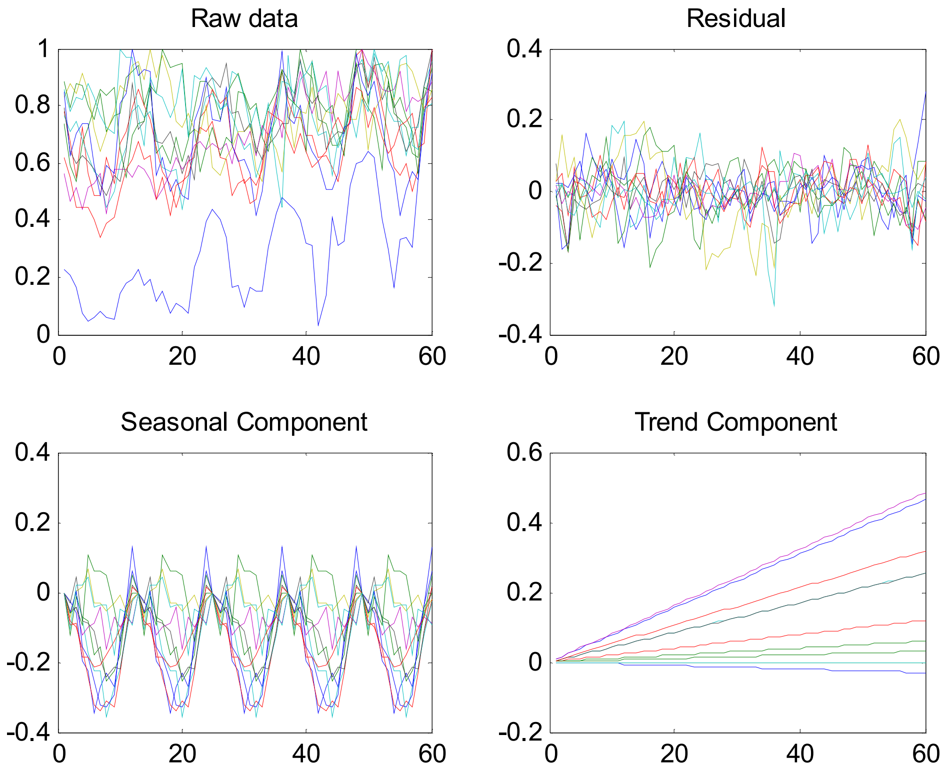
	Ratio C	Ratio I
UK	0.8879	1.4324
FRA	1.0722	1.1788
GER	1.5891	1.5964
ITA	1.4485	2.6836
SPA	1.8664	2.1623
POL	1.1794	1.2523
DNK	1.2609	
Mean	**1.3292**	**1.7176**

Italy is a good illustration of what may be happening. As indigenous production falls, imports approach the behaviour of consumption (suggesting a vertical supply of storage in the short and medium run). However, something else is happening: the volatility of deviations from trend and seasonality increases in the latter part of the sample. As a rule of thumb, higher volatility suggests an increased demand for storage.

On the other hand, the average correlation between any two countries of both imports and consumption increases in the second half of the sample, suggesting gains from trade are falling and the relative need for storage is increasing.

Trend behaviour may seem a bit odd, but for the larger countries, only France is an outlier without a trend. The UK, Italy, Germany, Spain and Poland which among them have about 280 million people, all have sizeable positive trends.[155] The Netherlands, of course, also display no trend in imports.

The following figure shows the data for gas imports and its components:



47. Some facts on seasonality of prices

The first exercise is to compute monthly averages of our price data and then, on the monthly data, run the following regressions:

$$\overline{p}_{j,t} = \beta_0 + \beta_1 T_t + \sum_{j=2}^{12} \delta_j D_{j,t} + \varepsilon_t$$

$$\widehat{\varepsilon}_{j,t} = \gamma_0 + \gamma_1 \widehat{\varepsilon}_{j,t-1} + u_t$$

[155] This is not changed by adding the data for 2007. This is important since the last year has witnessed what looks like a structural change into very high energy prices. If anything, gas demand is now more likely to increase.

The first regression has 13 explanatory variables (constant, trend and 11 dummies). The second regression takes the estimated residual from the first one, and measures the first order serial correlation. The monthly prices of each series are divided by their respective average. The Zeebrugge price is eliminated because there are not enough months to run this regression successfully with that data.

	β1	T(β1)	RSQ	F	N	γ1	T(γ1)	RSQ
NBP	0.0045	6.16	0.48	1.95	78	0.81	12.1	0.66
BEB	0.0037	2.84	0.27	0.62	55	0.88	13.3	0.77
TTF	-0.0004	0.14	0.24	0.72	38	0.90	11.9	0.80

The F test for the seasonal dummies rejects seasonality except for the NBP series. However, this is most likely due to lack of data as there are very few observations to estimate each dummy. The value for the NBP 5% test statistic is $F(11,65)=1.94$, and the outcome is just above that at 1.95. The one month lag of prices is significant as we see from the residual regression. The fact that the first order serial correlation is very high implies a emergency event to the level of prices has a long life.[156]

Prices are seasonal and emergency events to price levels are long lived. In the NBP case the significance of seasonality is important because it shows that the market is not just trading short run scarcity of gas, but also reflects the low frequency cycle of demand.
The fact that most gas is traded on long term contracts does not prevent the market from capturing seasonal variation.

Throughout these exercises we prefer the notion of value to that of price. In a competitive market, the price correctly values the marginal unit of gas, and so provides a correct measure of the value that can be extracted by an increase in (storage) capacity, as long as that extra capacity does not affect market prices.

Here we take a look at variations between winter and summer spot prices. Specifically we look at January and July average spot prices for the markets available. No trends in this seasonality measure are apparent, and to complicate matters the winter of 2007 is atypical:

	JUL03	JAN04	JUL04	JAN05	JUL05	JAN06	JUL06	JAN07	JUL07	JAN08
NBP	0.096	0.167	0.117	0.178	0.171	0.396	0.234	**0.160**	0.177	0.319
TTF					0.489	0.830	0.623	**0.487**	0.435	0.780
ZEE						0.186	0.396	**0.242**	0.166	0.182
BUO		0.193	0.179	0.239	0.260	0.438	0.328	**0.219**	0.243	0.390
OIL	0.265	0.291	0.356	0.409	0.536	0.584	0.682	**0.498**	0.723	0.860

[156] The effects of serial correlation and of the trend may be hard to distinguish but there is no evidence of unit roots.

If we measure the ratios of January to July, JAN08/JUL07 and JAN07/JUL06, etc, we expect to find a value greater than one. If seasonality is increasing we should see the summer-winter gap increasing. But with our limited data the pattern is unclear:

	JAN04	JAN05	JAN06	JAN07	JAN08
NBP	1.75	1.52	2.32	**0.68**	1.80
TTF			1.70	**0.78**	1.84
ZEE				**0.61**	1.10
BUO		1.34	1.69	**0.67**	1.60
OIL	1.10	1.15	1.09	**0.73**	1.19

There is no clear reason to think seasonality will abate in the near future. An example is the increase in seasonal fluctuation observed in the UK since 2000 despite the fact that the UK has the most liquid gas market in Europe. NBP gas prices show a relatively low seasonal variation before 2000/2001, a somewhat higher variation until 2004, and an extremely high winter price in 2006 accompanied by an unusually low winter price in 2007.

The higher variation since 2000 seems therefore to be more of a level effect than a change in the nature of seasonality. We know from the evolution of Spanish consumption that a trend in consumption is associated with a bigger level gap between summer and winter quantities.

The high spike of winter 2006 is not demand driven. In 2006 the UK had the coldest march in a decade but even so not that cold, and January and February were not unusual. Oil prices were not un-seasonally high that winter either. However, on Thursday 16th February, 2006, there was a small fire on the 3B Rough offshore platform, causing a Force Majeure interruption of service lasting until November 20 2006.[157] This had a significant impact on gas prices. Even so, gas supply to the UK was ensured via the interconnector and beach swing without major problems.[158]

One important feature of this particular emergency event to the market is that all of the price series above increase at that time. The Rough interruption spilled over to most other markets and this is an important indicator that markets are working.[159]

The low winter price in 2007 seems to be connected with new pipelines becoming active and allowing new imports of gas from Norway and the Netherlands into the UK. ILEX (2004) does report concerns for a large reduction in this seasonal variation in case most planned new storage and pipeline projects are undertaken in the UK. However, the 2007 effect on prices seems to have been short lived as winter 2008 sees a high price again.
This high price of winter 2008 relative to 2007 is puzzling.[160]

[157] Centrica press announcements, February 16 and November 20, 2006.
[158] Optima energy news, April 7, 2006.
[159] In fact they work better than one may think. Injections and withdrawals of gas into storage *in Denmark* are significantly correlated with the NBP gas price.

48. Actual shocks to market equilibrium.

The final topic in this section is to examine whether significant variations occur in observed consumption. In the following we go further into the question of the market performance in extreme events. More specifically we look into the correlation between temperature data and consumption data.

The hypothesis we are investigating here is whether unusually cold winter months imply unusually low gas consumption following those months. The idea is that, if there is an adequate supply of gas, a cold winter will not imply scarcity. Of course, low gas consumption can also occur because of unusually high temperatures in March following a very cold February so we must control for that.
If we find that unusually cold winter months are followed by unusually low gas consumption even though temperatures are still normally low - and therefore demand should be high - we may not reject that supply is inadequate and vulnerable to cold winters, which may suggest poor storage capacity.

48.1.1 Data

While data on realized consumption (from the OECD) gives us information on the realized market equilibrium, we can use temperature data to investigate whether this observed equilibrium is a scarcity event or not. Here we use the data on "heating degree days" (from Eurostat) and on gas consumption for several countries to see whether we can detail the market performance in extreme events.

48.1.2 Approach

Using the data on heating degree days we first compute the deviations from the normal seasonal values by running – individually for each country - an OLS regression of the heating-days data against a constant, a trend and eleven monthly dummies. The residual of this regression represents the deviation from the normal or predictable pattern. This residual is then normalized (divided) by the mean value of the original data for each country[161].

We first add the values of the normalized temperature residual for January and February in each country and each year, giving us 10 years and 25 countries, totaling 250 observations. We label this variable X. We look at the data for these two months because we are only concerned about the consequences of an unusually cold

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[160] Lower indigenous production, a fall in the GBP, high oil prices, colder winter relative to last year, a large increase in Irish consumption, LNG supply to the UK has fallen due the cold winter in the US, a shortness of storage capacity in the UK?

[161] The panel has 25 countries: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Latvia, Lithuania, Luxembourg, Hungary, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, UK. The data is monthly and has 114 months for each country, starting in January 1999.

winter and use these two months as an indicator of whether a winter is cold.[162] The summary statistics for this variable is displayed in Table 50

Table 50

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Mean	0.054	-0.027	-0.185	-0.361	0.449	0.199	0.220	0.537	-0.493	-0.393
Std	0.107	0.248	0.256	0.117	0.191	0.152	0.307	0.206	0.443	0.222
#>0.1	9	6	3	0	24	22	16	24	4	1
#>0.2	1	3	2	0	22	15	12	22	3	0

The first row shows the mean of X across the 25 countries in each year. A positive value means there were on average more heating degree days than normal in January and February. A high positive value is therefore indicative of a high unusual demand for heating: unusual because these are values over and above the normal trend and cycle. The second row shows the cross country standard deviation in this statistic, and row three and four measure how many countries have a value of this statistic above 10% and 20% respectively.

Two years clearly stand out, 2003 and 2006. And of these, 2006 seems to be the year with greater unusual demand. In both years the cross country standard deviation is not outside the norm, which suggests that the high demand and the cold winter occurred across all countries.

This then establishes the year 2006 as a cold year in terms of the heating demand indicator.[163] We note that the fact that this is a cold year does not automatically imply this is a catastrophe year.

We will now establish whether realized consumption was unusual after this period. In particular, we examine how the deviation – computed exactly as above for temperature - of consumption from normal times in March of 2003 and 2006 correlates with the deviation of temperature in January and February, controlling for March temperature. We label the consumption residual variable for March of these years as Y.

The idea is that if the winter is unusually cold and gas stocks are depleted too early we may have a problem of supply (due to lack of storage) in March. We ignore April because April will often have already high enough temperatures such that low consumption during this month is not a reason of concern.

[162] Using values for December, January, and February yields the same picture.

[163] The heating indicator is based on temperature, namely the number of days where outside temperature falls below 15 degrees. This does not imply that gas demand is high. If everyone decided to wear extra blankets and sweaters and turned down the heating at the same time, we might not see any increase in gas demand. However we do know that temperature and heating demand are closely aligned.

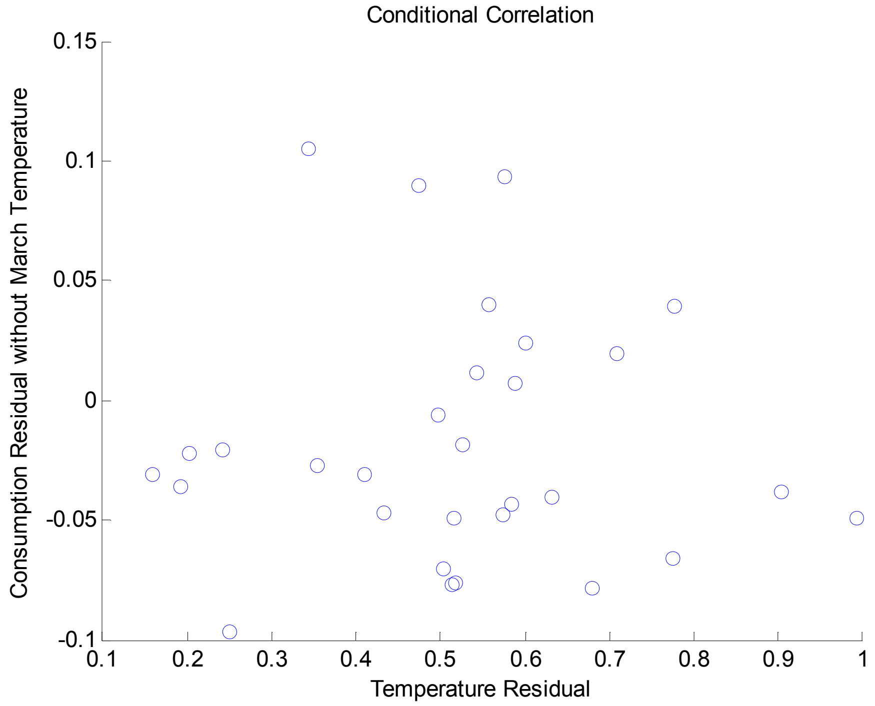
For this exercise we are restricted to 15 countries[164] Furthermore, we need to control for March temperature to be able to obtain the correct correlation. To this effect we run a simple OLS regression of the consumption residual Y against a constant and a variable Z which is simply the corresponding March value of the heating degree day residual.

$Y = a + bZ + e$

We then construct a new variable $\hat{Y} = \hat{a} + \hat{e}$, where $\hat{a}$ is the estimated intercept and $\hat{e}$ is the estimated regression error from the previous equation. This is the variable that we now correlate with X, the January and February indicator. This new variable does not have the impact of March temperature from the consumption residual.

For the 2002-2006 sample of 75 observations the correlation is 0.241, What this shows is that over the entire sample, if X is positive (heating days above normal in January and February), then Y tends to be positive also (gas consumption above normal in March). If we restrict attention to the reduced sample of only 2003 and 2006 the correlation value is now -0.0007. For the hypothesis to be supported this correlation should have been significantly more negative. Thus there is no apparent relationship between the severity of winter and the behavior of consumption in March.

The following graph shows the scatter plot of the observations of $\hat{Y}$ and X.



[164] The countries considered in this exercise are 15, for which we had readily available gas consumption data from the OECD: France, Germany, Italy, Poland, Spain, the UK, Austria, Belgium, Czech Republic, Denmark, Finland, Hungary, the Netherlands, Portugal and Slovakia.

It is clear from this correlation plot that there is no significant relationship between, the temperature and the consumption residual.

48.1.3 Conclusion

There is no evidence of vulnerability in the data. This does not imply that there really isn't vulnerability. The winters of 2003 and 2006 have been the most severe in the decade that includes the winters of 1999 until 2008, but they are not necessarily very extreme winters. However, the fact remains that there is no statistical evidence that March consumption was significantly affected by January and February patterns over an entire decade.

ANNEX 4 CONDITION OF THE GAS TRANSMISSION PIPELINES IN THE COUNTRIES OF THE FORMER SOVIET UNION

Memorandum prepared by the Danish Company BALSLEV, based on their experience with pipeline integrity assessment in few countries of the former Soviet Union.

48.2 Introduction

Balslev made pipeline integrity assessments in Poland and the former SU states in the 1990'ties and up to year 2003.

The inspected structures were non-pigable natural gas transmission pipelines, i.e. the only option was external direct assessment. The output of the pipeline inspections was an estimate of the assets and a comprehensive number of important instructions on integrity management as for example maintenance and operation of the structures, in some cases including recommendations on reduced gas pressure (MAOP). In addition here to, on the job training of the maintenance staff was made.

Furthermore, Balslev has introduced relevant normative material to Eesti Gaas and Estonia, and Balslev has been responsible for the corrosion protection parts of a Codes and Standards project for all three Baltic States and their national gas companies.

48.3 Technical Approach

Balslev has with a very high success rate used the following approach and methodology.

Planning and Pre-investigations - a detailed planning of the inspection, covering locations to be inspected and the methods applied. The basis for this planning has been a review of existing design, construction and operation records combined with on-site pre-investigations and interviews of operation staff.

On-site inspection – includes above ground measurements of the condition of the corrosion protection system followed by a range of non-destructive examinations (NDE) at a number of locations on the pipelines. The locations selected for the NDE were the most critical by the results of a corrosion protection survey, or identified to be critical from sources as incident reports and the like.

Development of rationalized data - the evaluation of the inspection results is usually displaying a scatter in computed data. Some results even appear to be inconsistent. Field measurements were taken in a few (but selected) discrete locations that might not represent the most critical condition of the pipeline. A crucial step was therefore to develop rationalized data on the basis of all available information. Appropriate statistic methods combined with engineering judgements were applied in those analyses.

Balslev and Force Technologies developed this methodology in 1994 as a sound engineering approach on a pipeline in Poland. Pipeline rehabilitation has become an important safety and asset stabilising factor, and normative material as NACE Standard RP0502-2002, which covers ”External corrosion direct assessment”, is in line with this approach.

The direct outcome of the pipeline inspection programs in the Baltic States – Estonia, Latvia and Lithuania was an increased and important understanding of pipeline integrity management in all three states. Prioritised rehabilitation secured the assets and the training programs carried out enabled the pipeline operators to continue pipeline inspection on their own.

48.4 Pipeline inspection in Georgia and neighbouring Krasnodar

Following the projects in the Baltic States, Balslev continued with the GGIC system in Georgia in close cooperation with Rambøll. The pipeline infrastructure in this region is similar with the infrastructure analysed in the Baltic States.

Further more, from a joint effort with Russian Gazprom subsidiary Orgenergogaz, Balslev became familiar with the condition of pipelines in the Southwestern region of the Krasnodar, Russia bordering to Georgia.

48.5 Experience

- Pipelines were designed in accordance with GOST standards.
- MAOP 55barg.
- Constructed and commissioned from 1962 up to early 1990’ties.
- Comprehensive documentation in printed drawing format available.
- Welding procedures not always documented.
- Pipe certificates, when available, not always linked to the individual pipe joints.
- Seamless, spiral welded as well as longitudinal welded pipes are used.
- Internal diameter varies along the individual pipeline sections.
- Sharp pipebends.
- Pigging not possible in most pipes.
- Branches are operated as pressure vessels receiving gas from transmission lines. A failure in such branches may hence affect the transmission system.
- Daily pressure variations are transferred to all parts of the system.
- Corrosion protection based on coating and Cathodic Protection (CP).
- Coating was mainly bitumen type and decomposed.
- All pipelines were galvanic interconnected in the former SU. It was hence not possible to effectively control the corrosion protection.
- High temperature zones in combination with high CP current densities down stream from compressors could compromise the affected sections.
- Stray current from electric traction (railways and trams) jeopardizes the corrosion protection in some areas.
- Circumferential weld seams may be critical with regard to bending if pipeline sections are excavated.
- Burial depth often insufficient.

- Some pipe sections are unintended above ground.
- Almost all of the pipe systems were in operation, though some at significantly reduced pressure downstream from regulator stations.
- Incident records showed few severe incidents.
- All pipelines could still be refurbished for further utilisation.
- Maintenance was most needed.

ANNEX V ON MARKET/NON-MARKET EVENTS AND CROWDING-OUT

The idea to built strategic storages is to increase security, in case of an interruption in gas supplies, caused by events, which are not covered for by the market, so-called non-market events, e.g. such as political unrest in a transit country or and extreme cold weather (e.g. a 1 in 50 winter). The issue and the challenge is to define what does the market cover for and what events can we not expect the market to deal with?

Further, it is crucial to establish, whether the events that are not covered by the market, are not so, because it is an actual non-market event, which the market will never cover for voluntarily, or whether the lack of security it is due to something else e.g. a non-efficient investment level caused by lacking stability in the regulatory regime, difficulty in planning procedures etc. If this is the case, then the correct measure is not to built strategic storages, but instead to remove the investment barriers and thus allow the markets to implement the correct level of security through market mechanisms.

48.6 Crowding out

If it has been establish that a shortage in the level of security of supply is caused by a non-market event, which cannot be dealt with by removing investment barriers or by introducing any other market measures. Then it may be appropriate to introduce strategic storage. However, as strategic storages are supposed to deal only with events outside the scope of the market they should not affect the regular gas storage market in any way. This implies that the utilisation of strategic storages should not have any affects on commercial storage. This may be very difficult to ensure as the next section will demonstrate, because it is almost impossible to ensure that the creation of strategic storage does not interfere with commercial storage both physically but also on expectations and the decision-making process in the commercial market. The following section examines the possible effects of introducing strategic storages and the effect such a decision may have on commercial storage. The main question to answer is:

How will the imposition of strategic storage affect the market operators' incentives to invest in new storage facilities?

This issue is very important, because if mandatory storage obligations, in the form of e.g. strategic storage obligations have a negative effect on market based investments, then such an obligation risks doing more harm than good i.e. security of supply in the event of non-market events may rise (strategic security of supply), but at the expense of security of supply in the market-based provision of security of supply.

The problem occurs if the management of strategic stocks at any point is used for other events (other than the intended non-market events) and in doing so interferes in commercially based storage operation, e.g. if strategic stocks are used as a tool to reduce market prices for gas[165]. Such usage of the strategic storage will lead to uncertainties with regards to the value of investing in storage, because investors are uncertain about to what extent arbitrage possibilities are taken away by strategic stock interventions in the market. Thus, if strategic stocks are used as a price reducing mechanism then the scope for private investments is reduced, because the opportunity to create a profit is reduced. This does not only imply in the case of direct interferes in gas prices, any usage of strategic stocks that intervenes with developments in the market, which the commercial side of storages is supposed to deal with, will affect the supply of gas and thus the price. Thus, we have that any interference in the commercial side of the gas market, by strategic storage, may create uncertainties and reduce the profitability of commercial storages, which may lead to a lower level of investments in commercial storages, thus strategic storages may "crowd out" commercial storages.

To minimize this crowding out effect it is important that the definition of what constitutes an event, which calls for the utilisation of strategic storages, is defined very carefully. Hence in order to allow investors to make informed investment decisions, the strategic policy should be transparent, clear and credible. Credibility is extremely important because if strategic stocks are not credible i.e. if commercial investors do not believe that policymakers will not intervene in the event of high prices, even though they said so, then they won't choose the optimal level of investments.

If strategic stocks, in any way, reduces the amount of investments in commercial storage, because they either decrease incentives for investments directly by lowering the potential profit, or if they simply increase the uncertainty in terms of the profitability of new investments in storage, this will decrease the value of strategic stocks significantly, because they indirectly reduce commercially based storage investments. If one m^3 of strategic storage crowds out one m^3 of commercial storage, then the investment in strategic stock is in principle completely futile. The exact ratio of crowding out, however, can be anything from zero to one, or even more than one, this depends on the exact definition and the credibility of the strategic stock.

Thus the creation of strategic storages can have negative effects on the future investments in commercial gas storages, if they are not constructed in a transparent, clear and credible manner. However, creating such a set of rules for when strategic stocks can be applied is very tricky and it is questionable whether it can be achieved in a manner that will completely remove the element of uncertainty and credibility and thus minimise the crowding out effect. This should be considered carefully when evaluating the costs and benefits of strategic storage.

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[165] I.e. when prices increase due either an increase/decrease in demand/supply, in order to establish a market based balance between supply and demand.

49. ANNEX VI NON-COMPLIANCE WITH THE TERMS OF REFERENCE

This section identifies and explains the reasons for non-compliance of the study with the Terms of Reference.

Section 1:

Non compliance:
This section will present the investments realised in gas storage facilities from 1st January 1990 to 31 December 2007, expressed for each Member state in euros at current and at 2007 prices.

This section will also present the investment planned to be realised between 1st January 2008 and 31 December 2020, *describing the costs (at 2007 prices).*

Referring to section 5 it proved very difficult to find actual reliable data on the costs of creating gas storages. Cost data is very often being treated as confidential information by the storage owners/investors.

Correlation between utilisation rates of import pipelines and storage capacity. The correlation between utilisation rates of import pipelines and storage capacity will at best be spurious as storages receiving imported gas are not necessarily placed in the EU country that borders the exporting country. Moreover an EU country may be connected to import pipelines from different exporters, making an average utilisation rate less transparent.

Instead the utilisation of import pipelines have been qualitatively addressed in section 1.

Section 2: Availability of gas storage facilities along the main pipeline supply route

Non-compliance:
The study will present the status of these facilities (technical characteristics, ownership and control, legal framework, potential need for investment, future developments).
The Consultant has used all publicly or otherwise available data, as well as data provided by Ukrtransgaz. Direct contacts with stakeholders within Ukraine was not envisaged.
This study encloses a memo that makes an attempt to describe the condition of the condition of the gas system in Ukraine, based on experience with inspection of gas infrastructure within the countries of the former Soviet Union.

The study will liaise with EU supported projects in Ukraine that may relate to these storage facilities.
The study has liaised with the study "The Role of Storage for Reliable Transit of Natural Gas" prepared by the Secretariat of the Energy Charter Group on Trade and

Transit, as the sole identified EU supported projects in Ukraine that may relate to these storage facilities.

Section 5:

Non-compliance:

This section will present the average investment cost (including cushion gas), per type of storage and per various range of size (to be defined in the methodology) at 2007 price. These data will be presented for at least the following Member states: Germany, United-Kingdom, France, Italy, Hungary and Poland. In its proposal the contractor may propose a more comprehensive survey.

The information requested above is not available in the public domain. Although an average cost of storage can be determined from Ramboll's own cost estimates from projects worked upon and limited number of additional projects costs that have been released there is not country specific information available due to confidentiality and competition issues. Companies and investors have no incentive to release such data and the release of such information would probably be detrimental to both the market and investing individuals.

Non-compliance:

The cost analysis will take into account the difference between average costs for existing storage facilities and the marginal cost for developing new stock. It shall in particular identify those Member States where all possibilities to develop facilities at a reasonable price have already been exploited and where the new storage facilities would cost much more than existing ones.

This cost data is unavailable for the reasons stated above as this information is not released and the cost of marginal extensions of facilities is unavailable for a host of countries. There is also the problem of the identification of a *'reasonable price'* with each storage varying significantly in their cost due to differing geological and technical factors and the value to the individual entity investing in storage being dependent upon their perceived role for the storage. In addition the consultant has attempted to identify in section 7 option 2 where storage may be realistically created and provided a number of criteria with which to evaluate the suitability of a country to provide storage.

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