Study on the benefits of additional gas interconnections between the Iberian Peninsula and the rest of Europe (REQUEST FOR SERVICES № DG ENERGY/B1/2015-282)

Final Report

Client: DG ENERGY - Directorate B: Internal Energy Market

Rotterdam, 15 April 2016

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Per Jørgensen - Ramboll

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Table of contents

1 Introduction

The consortium of DNV GL, Ecorys, ECN and Ramboll was awarded the *Study on the benefits of additional gas interconnections between the Iberian Peninsula and the rest of Europe*. Ramboll is carrying out the study with Ecorys as Quality Assurance.

After the award of the contract, a kick-off meeting was held in Brussels on 18 May 2015 with participation of representatives from the EU Commission, the Contractor Ramboll and Ecorys, and some of the stakeholders from Spain, France and Portugal.

An inception report was prepared with further detailing of the methodology, sources to be consulted and identification of stakeholders. The inception report was circulated to selected stakeholders for commenting, and these have as far as possible been taken into account in the present interim report.

A draft interim report was submitted in September and a final interim report in October after receiving comments from the client and stakeholders. The outcome of the interim report was presented in a meeting with stakeholders and the client in Brussels on 16 October 2015.

A draft final report was submitted in January 2016 and presented in meetings with stakeholders and the client in Brussels on 27 January and 6 April. As part of this process, comprehensive comments were received of which some have been incorporated. Other comments would require additional work which was not possible to perform within the framework of the contract.

Three of the main stakeholders, Enagas, TIGF and GRTGaz have developed a technical study on the possible use of the MidCat in different phases. The study was made available to Ramboll mid-July and has been used as input to technical assessment herein. The study and results are summarised and commented in Chapter 3 of the present report. It has been outside the scope of the present report to replicate these calculations as they are based on TSO in-house knowledge.

Bilateral meetings have been held with the following stakeholders:

- Enagas – kick-off meeting and telephone meetings
- GRTGaz – telephone meetings and physical meeting in Paris on 20 July 2015
- TIGF – telephone meetings and physical meeting in Pau 23 on July 2015
- CRE – telephone meetings
- ELENGY – telephone meeting
- Engie – telephone meeting and video meeting on 28 August 2015
- REN – telephone meetings

In connection with the meetings some internal documents with analyses and viewpoints have been exchanged between the parties.

The focus of the study has been on the MidCat project between France and Spain, and consequently less work has been done on the 3rd interconnector between Portugal and Spain.

The overall budget for the study was 75,000 EUR with a maximum of 75 man-days.

2 Findings and conclusions

2.1 Main conclusions

- This report cannot be the sole basis for decision making about additional gas interconnectors due to uncertainties. However, we find that sufficient evidence for establishing additional interconnectors has been found to initiate detailed feasibility and conceptual analyses to create a firm basis for decision making and final investment decision.
- The uncertainty about the actual gas demand in EU (and not only the countries involved) results in high uncertainty of the results and how the actual flow would be. As an example this study does not directly include the impact of Nord Steam 2.
- The quantitative cost-benefit analyses for additional interconnectors become very uncertain. However, the analyses clearly raise some questions which may be easier to communicate:
    - Shall it be possible to supply all parts of EU with gas transported by pipeline from inside Europe?
    - Shall EU be able to withstand long term disruption of gas from one of its main external suppliers – Russia, Norway, Algeria or Qatar?
- Increased interconnector, as the MidCat, is justified as it will integrate the Iberian gas market with the rest of EU in low demand scenarios, where there is little need for LNG import to EU, and at the same time make LNG terminals on Iberian Peninsula available for security of supply situations (Russia or Norway disruption) in particular in high demand scenarios where LNG terminals in the rest of EU will not have sufficient capacity. Thus there will be a case for the interconnector in more demand cases, with prevailing flow direction depending on EU demand and LNG versus gas hub prices.
- Security of supply can to a certain degree be created by only establishing the first step of MidCat, while full market integration will require large capacity and removing internal bottle necks in France in particular for North to South flow. This will include the Arc Lyonnais and Eridan projects. However, only a part of the capacity and hereby the cost for these pipelines can be allocated/attributed to the Iberian interconnector.
- If new LNG receiving terminals are established in North and Eastern Europe for security of supply reasons, they will contribute to increased North-South flow in the Interconnector as Norway and in particular Russia will seek new markets further away in EU. With a saturated interconnector, the Iberian Peninsula will be isolated.
- With limited LNG import to EU, the dominating LNG exporters can choose to use Northern European LNG terminals and hereby in a similar way create congestion on the interconnector and isolate the Iberian markets.
- Portugal is, as the most remote part of EU, depending on gas from Algeria and LNG. The 3rd interconnector between Spain and Portugal can be seen as an integrated part of the MidCat project, as the main purpose will be increasing security of supply by getting access to the integrated EU market. Without MidCat there will be limited benefit from the project.
- The MidCat pipeline should preferably be established with the same capacity as the Eridan project, which may increase the ultimate capacity from 8 to 20 bcm/year.
- The high border tariffs between France and Spain, which are expected to increase further when France establishes one market zone from 2018, contributes to splitting the Iberian Peninsula from the rest of the EU gas market, in particular for short term trade.
- A stepwise implementation of the interconnector is possible when accepting that mostly interruptible capacity will be available after the first stage MidCat.

2.2 Findings and reflections

- Existing interconnector capacity between the Iberian Peninsula and the rest of EU is small compared to other main periphery interconnectors. This is found to be due to historical and technical/geographical reasons, as direct gas pipelines crossing the Mediterranean Sea to Spain were hindered by water depth until the technology was improved. Initially the Iberian Peninsula was operated as on Island based on LNG supply.

- Historically, the flow in existing interconnectors has been entirely from North to South. This reflects very particular global supply situation during the last 5 year with diverging global gas prices and historical long term contracts for Norwegian supply to Spain. Further, as the main LNG supplier to Europe, Qatar has chosen to use their own terminals in UK rather than the Spanish LNG terminals.

- Short Interconnector between Spain and France (MidCat first phase- 224 km) can contribute with some firm capacity (120 GWh/day from South and 80 GWh/day from North) under certain conditions, based on a shared study by the TSOs. However, there may also be conditions where there will be bottlenecks in the French systems. Further, such first phase can contribute with interruptible capacity with high probability and hereby increased security of supply even if systems in France and Spain are not strengthened. Implementation of new capacity allocation mechanism with focus on short term booking may unlock such capacity. In Spain probability estimates have been done, while more work needs to be done to determine in which situations capacity will be available in France.

- French one market zone policy may conflict with a wish for additional interconnector capacity to Iberian Peninsula with firm capacity, available at all time. This is because firm capacity will require substantial investments in the French system to maintain one market zone. One solution to accept the one zone policy could be that the firm capacity is limited to avoid such excessive investments.

- France, Spain and Portugal all have overcapacity of LNG receiving terminal as compared to present depressed consumption. There is a potential for sharp increase in demand when/if economy picks up again in South Europe. Yearly balances show that France has sufficient own capacity of LNG import facilities unless in a situation with high demand and low LNG prices compared to pipeline gas prices.

- Iberian-Europe interconnector shall be seen in context with Italian supply route from Algeria and Libya and new routes from Turkey, like TAP which is likely to push Algerian gas towards Spain. There has already been a move of Algerian gas towards Spain instead of Italy.

- Algeria has potential for increased gas production from conventional and unconventional sources, savings on own consumption and for transit for other gas sources, like Trans Saharan Gas Pipeline. Hereby, there will also be potential for increased export to EU. Increased Iberian-Europe pipeline capacity with reasonable cost may accelerate gas production in Algeria.

- North-West European gas production is likely to decline in coming years – The Netherlands, UK, Germany and Denmark all expect a decline in production, while Norway expects a stable or small increase. Norway uses its present system with high load factor, which makes it difficult to re-route gas from France to Germany. Should Norway decide to increase capacity to Germany or Denmark, it would be possible to increase EU import of LNG or Algerian gas via Spain.

- Nord Stream 2 is a game changer in North-West Europe and hence the overall North-South balance in Europe. However, it is still uncertain if new gas will be supplied or it will be re-routing of gas from other transit routes like Ukraine or Belarus. As Russia loses market share in Ukraine and as LNG terminals are established in Lithuania and Poland, there is a need for Russian gas to find new markets further away as in UK or Iberian Peninsula.

- Russia and Qatar are the two main contenders for EU gas market at present as it is found that other pipeline players use their full capacity and that only Qatar and Algeria are significant players on the LNG market. It still has to be seen if new LNG suppliers want to enter into the battle for the EU market.

  Disruption of Russian gas to Central Europe, like Germany, Czech and Slovak Republics, can to a certain degree be replaced by use of the Spanish and French LNG terminals. This can be done as a combination of re-directing Norwegian gas via Germany and Algerian gas via Italy as well as use of the new pipeline Artere des Flandres to redirect some Norwegian gas and LNG via Belgium. However, it can also be expected that LNG terminals elsewhere in EU will be used.
- Disruption of Norwegian supply will have some of the same impact as disruption of Russian supply. Although, the lost volumes would be smaller there may be more direct impact on the French/Iberian supply situation with a need to move even more gas from Spain to France. This is because Algerian gas will still be supplied by pipelines via Spain. However, also in this situation there may be preference for using other LNG terminals in EU.

- Difference in odorisation policy in South and North Europe makes it impossible to have reverse flow at present. The cost of changing the system will probably be very high – in the order of 500 MEUR. The focus is therefore on giving space for LNG in the Iberian and French market by re-directing pipeline gas before entering into the area.

- Disruption of Algerian supply can be replaced by increased LNG import to Portugal and Spain. This event will therefore not increase the physical need for increased import from France. However, it is likely that such event would increase LNG prices and hence increase use of the pipeline.

- LNG supply disruption cannot be ruled out and will in particular impact Spain, France and UK in Europe. This would create need for import of gas to Spain from Norway and Russia via France. There is sufficient capacity in France for this in low demand scenario. The probability of such scenario may be higher than recognised so far. During the last year, three LNG exporting countries; Egypt, Yemen and Libya have halted their supply. Qatar is at present by far the largest LNG supplier to Europe.

- Tunisia should be addressed in same way as Belarus in security of gas supply analyses to Europe as a transit country from a main supplier to the internal European gas market. In case of disruption of supply, it will be possible to redirect gas via Spain to Europe. The probability of a disruption is low, but recent terror attacks can give reason for concern.

- French high dependency of nuclear power may result in repetition of “Fukushima” in Europe, although with low probability with increase in gas consumption. Based on the existing CCGT, the increase can be in the order of 15 bcm/y. In high demand scenario there will be a need for France to import LNG from Spain in such case, while French LNG terminals will be sufficient in other scenarios.

- The technical solution for the MidCat project is based on work carried out before the open season 2010. The routing and cost estimates have not been updated. From the ongoing work the definition and cost estimates on French and Spanish side are very different. For the first phase of the MidCat project the following findings are made:
  - Length 224 km, assumed DN 900 (36") and firm capacity of 120 GWh/day from South and 80 GWh/day from North under certain flow conditions in particular in France.
  - Total cost estimate of less than 500 MEUR, but uncertain as it seems as if Spanish side is underestimated and French side is overestimated.
  - It is cheap to prepare for future increase in capacity and the increase to DN1200 would only increase cost with a third, while capacity would be more than doubled.
  - Offshore solution should be considered if it becomes too expensive to go for the onshore route in France. However, this is less mature than onshore solutions and may change time schedule.
  - We suggest considering re-naming the project as original MidCat definition is outdated and biased with respect to use and purpose. Find name for first section from Hostalrich (near Girona) in Spain to Barbaira (near Carcassonne) in France.

- For the full MidCat there is a need for additional capacity in France and Spain. This includes a DN1200 Eridan project with a length of 220 km. The overall firm capacity will be 230 GWh/day. The investment of the full MidCat, as defined in the shared report, is more than 2000 MEUR. More options are possible for a full development and only the Eastern solution has been evaluated. There is uncertainty about which part of the investment should be allocated to the increased interconnection and which part to the one zone policy in France. Alternatively, only sections of the Eridan and Arc Lyonnais pipeline could be established.

- The cost of the 3rd interconnector between Spain and Portugal will be in the order of 360 MEUR for all phases in Portugal and initial phases in Spain

- The cost of the full MidCat and 3rd interconnector to Portugal will in total be about 3000 MEUR; however, some part of the cost should be attributed to better integration internally in France and at the entry to France. With a shared cost for such items the cost for full MidCat including the interconnector to Portugal will be 1650 MEUR.

- As the cost of capacity is much lower for the first step MidCat and because of uncertain market conditions, a preliminary conclusion is to only establish the first phase and to limit the firm capacity to a level which does not change the one zone philosophy in France. There will still be extra interruptible capacity for security of supply situations.

2.3 Need for further maturing of projects

- The technical definition of the MidCat needs to be matured with respect to routing, design, environmental and social impact to define a clear cost estimate for final decisions. This should also include an offshore solution as a reference for cost estimation.

- Capacity calculations should be based on probabilistic analyses for France as it has already been done for Spain. Hereby, the possible spare capacity for interruptible transportation in a first phase MidCat can be quantified. Such calculations should take into account the change in market conditions when one zone is established in France in 2018.

- Capacity calculations for the full MidCat including Arc Lyonnais and Eridan should also include the impact of Nord Stream 2, the reverse flow from Switzerland and the 3rd interconnector between Spain and Portugal.

- Transportation tariffs are presently influencing the use of the pipeline system and LNG import. As part of development of new network code, the possibilities to remove this barrier should be found.

- Renewable energy like wind, solar, hydro and biomass will impact the use of gas and create large variations from year to year. South-West Europe is further impacted by large variations in use of gas as result of weather conditions. There will be possibilities for using such variations to free capacity in the transmission system. It is recommended to further analyse these aspects. The variations are expected to increase when countries like France increases the use of renewable energy as new legislations impose reduction of fossil fuel.

3 Market Analyses of current and future situation

3.1 Objectives, background and historical use of interconnectors

3.1.1 *Objectives of increasing gas interconnection between Iberian Peninsula and rest of Europe*

The objectives of increasing gas interconnection capacity between the Iberian Peninsula, consisting of Spain and Portugal, and the rest of Europe are to support regional trade opportunities and arbitrage, and to enhance security of gas supply in the EU. These objectives were detailed in the EU Madrid Declaration on March 2015, in which it was stated that France, Spain and Portugal:

"recognize that a fully and integrated gas market, eliminating bottlenecks, connecting the regional markets, maximizing the diversification of the gas portfolio through new sources and routes, will reinforce the negotiating capacity and increase the European security of supply. In this sense, the President of France, the Prime Ministers of Spain and Portugal, also agree on the need to actively asses in order to complete the Eastern gas axis between Portugal, Spain and France, allowing bidirectional flows between the Iberian Peninsula and France through a new interconnection project currently known as the MIDCAT. The 3rd Portugal-Spain interconnection should be developed in accordance."[1]

Fulfilling these objectives lead to assessing the possibility of increasing gas imports from Algeria to Europe through the Iberian Peninsula. This would unlock the potential of the country's large gas reserves that are more than the double the reserves of Norway, which presently is EU's largest gas supplier. Furthermore, Algeria may have considerable reserves of shale gas available for export and besides, other African countries may likewise export natural gas via Algeria. One example of this is the Trans Saharan Gas Pipeline from Nigeria via Niger to Algeria and further to Europe.

In recent years, comprehensive investments have been made in LNG receiving facilities in south western Europe, with a combined import capacity on the Iberian Peninsula of 77 bcm/year or more than the double of the present consumption. However, these LNG plants have been operating below their full capacity. The three countries mentioned above – and in the same context – are likewise committed to "contribute to a strategy with robust LNG infrastructures in their countries" and to "diversify their gas supply with a comprehensive LNG strategy that addresses also geopolitical concerns."

Therefore, the possibility of using the LNG facilities and also underground gas storages will significantly enhance creation of a fully and integrated gas market as intended.

Supplying gas from between the Iberian Peninsula and the rest of EU is today restricted by lack of physical pipeline capacity, long-term contracts for use of existing capacity and preference to existing users of the transportation system. The new EU wide Network Code on Capacity Allocation Mechanism went into force in 2015 and should contribute to more focus on flexible short-term contracts for capacity. Further, a challenge as the different practise in use of odorisation of natural gas in the transmission system has to be solved or bypassed. This is in particular an issue between South Europe who odorizes gas in the transmission system and Germany who only does this in the distribution system.

[1] SOURCE: Madrid Declaration 4 March 2015

Gas demand in EU was severely struck by the financial crises and high oil and gas prices during the last five years. The use of renewable energy – in particular photovoltaics (PV) which quadrupled from 2010 to 2015 – impacted the use of gas for power generation. Moreover, the Fukushima accident in Japan resulted in large quantities of LNG being diverted away from the European market, due to increased demand in Japan to make up the loss in nuclear generating capacity. This event now seems to have passed, and a situation where new LNG supplies from Australia and the USA are entering the market has developed. An increased possibility of physical exchange of natural gas between the Iberian Peninsula and the rest of Europe may contribute to optimising Europe's benefit of such supply situation.

Russian gas supply and transit via Ukraine and Belarus have been impacted by the conflict in Ukraine. So have the plans for new infrastructure such as the offshore pipeline South Stream across the Black Sea, which was cancelled and replaced by plans for the TurkStream pipeline to Turkey. Also, plans for constructing the Nord Stream II pipelines to Germany were launched. Thus there is still significant uncertainty about the decisions on new gas supply routes from Russia. Iberian Peninsula is the only part of EU (apart from Malta and Cyprus), which cannot be fully supplied by pipeline gas delivery.

Increasing cross-border interconnections for exchange of natural gas across the Pyrenees will be an important step towards increasing the robustness of the EU Internal Energy Market. As such, it "constitutes a fundamental dimension to build the European Energy Union, i.e. to ensure secure, affordable and sustainable energy, which is a key instrument to strengthen the competitiveness of the European industry and therefore the growth and jobs across the EU," [ref. the Madrid Declaration].

3.1.2 *MidCat project is the main proposal for further increase in interconnector capacity*

The MidCat project, with an eastern connection between Spain and France is the main proposal for increased interconnector capacity between Iberian Peninsula and the rest of Europe. The project was initially launched almost a decade ago, and an open season was held in 2010 to test the market response.

Since the open season for MidCat in 2010, at least three major events have impacted the gas market and the cost benefit of additional interconnections. These are:

- Arabic Spring – resulting in less gas supply from North Africa to the EU and high oil prices from 2011 to 2014
- Fukushima nuclear accident in Japan – resulting in high LNG prices from 2011 to early 2015
- Ukraine conflict – resulting in re-routing of gas within the EU, including export to Ukraine, cancellation of the South Stream project and Russian focus on gas export by pipeline to China.

These events have created increased uncertainty about LNG supply and demand globally and about Russian gas supply to Europe. Therefore the market response from 2010 may not be valid anymore.

In addition to these major events, the period was characterised by a depressed gas market as shale gas in USA pushed coal to the EU replacing the use of gas in power generation. The second wave of the financial crisis hit the South European countries particularly hard, but was generally a major contributing factor to the decline in gas consumption in the EU.

On the issue of gas supply, some of the major events have been the commissioning of the Nord Stream gas pipelines, which pushed large volumes of gas of the same magnitude as the idle LNG terminals on Iberian Peninsula into North Europe, the decision to cancel the Nabucco pipeline, opting for the Trans Adriatic Pipeline (TAP) via Italy, and finally the decision to cancel the South Stream pipeline across the Black Sea. A new LNG terminal came into operation in Lithuania, thus breaking the Russian monopoly in that region.

Major non-events of the period were the fact that shale gas did not develop in Europe and that the giant Russian Shtokman gas field was postponed or cancelled.

3.1.3 *Iberian Peninsula was late to be connected to the rest of Europe*

The connection between the Iberian Peninsula and the rest of EU is small seen in a European context. The capacity is only 5 cm/y via two smaller pipelines crossing the Pyrenees in the western part. In late 2015, the capacity of the two pipelines was increased to 7 bcm/year from South to North as firm capacity. Illustrated in Figure 3-1 below.

The Iberian Peninsula is hereby the only part of the EU, apart from Malta and Cyprus, which cannot be fully supplied by natural gas by pipelines.

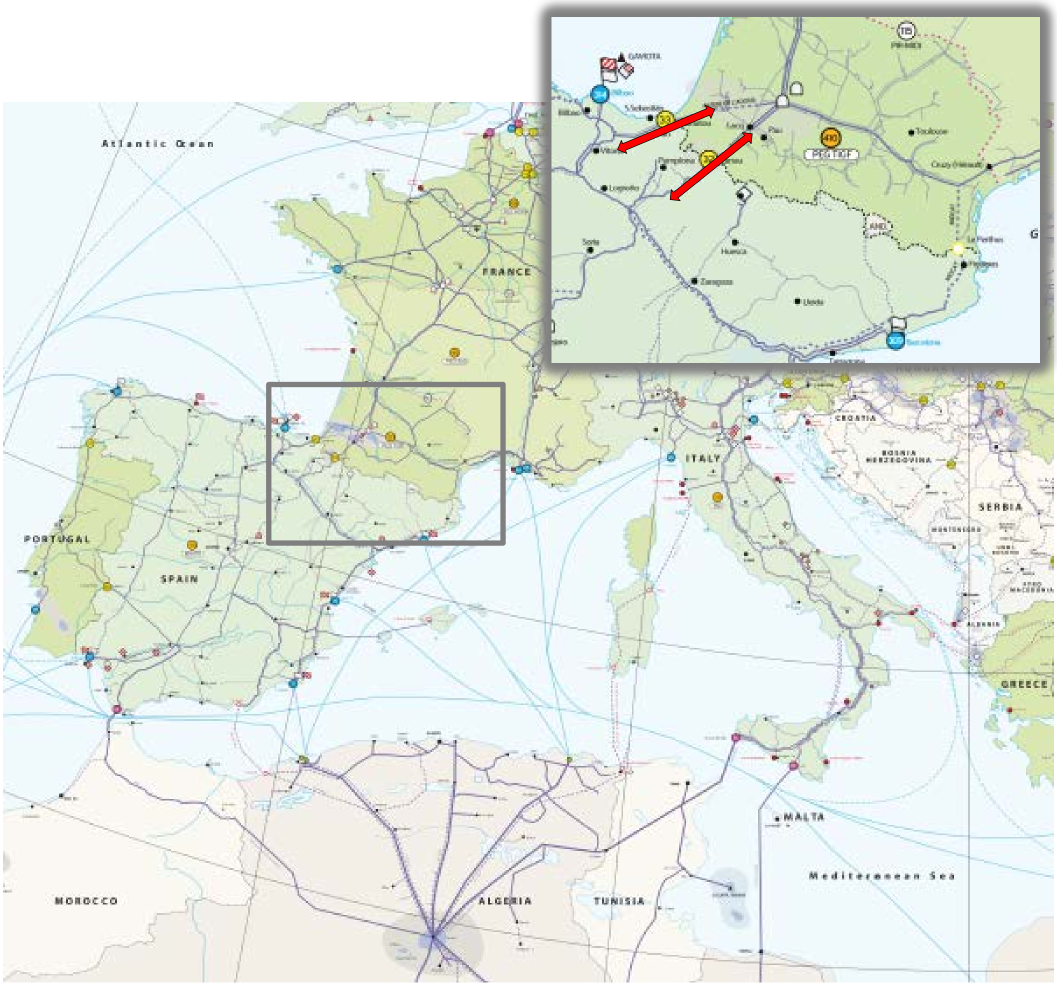

Figure 3-1 Gas transmission line in countries around the western Mediterranean Sea

This can be compared to the large connections between Italy and the rest of EU with several large diameter pipelines crossing the Alps from Austria (TAG pipeline) and Switzerland (TENP pipeline) and connections to Slovenia and Croatia. The combined capacity of the Italian grid from the rest of EU is approximately 55 bcm/y, while the reverse capacity from Italy to Austria and Slovenia is approximately 7 bcm/year. It has recently been decided to increase the capacity from Italy to Switzerland and further to Germany and France via the TENP pipeline.

Both Spain and Italy are connected to Algeria via Morocco and Tunisia respectively. Spain has also a direct pipeline, Medgaz, from Algeria with a capacity of 9 bcm/year. The Medgaz pipeline is prepared for a second pipeline.

Spain, Portugal and Italy all have LNG import terminals, and in particular Spain has developed many terminals to compensate for the lack of pipeline connections and lack of indigenous gas production and suitable geological locations for large scale underground gas storage. The purpose of the Iberian LNG facilities is hence a combination of import and storage. An overview of the terminals is presented below in Figure 3-2.

The difference between the connections between the Iberian Peninsula and the rest of EU and between Italy and the rest of EU can to a certain degree be explained by different history and decisions made in the past, before implementation of the internal gas market in year 2000.

Spain

Development of the natural gas system in Spain was initiated in the 1960´ies based on small volumes of own production and by import of LNG to Barcelona. Only small volumes of gas were found in Spain and the initial development of gas in Spain was based on LNG imported from Libya including LPG which was extracted at the plant in Barcelona. The use of gas in Spain was initially based on LPG as the main source.

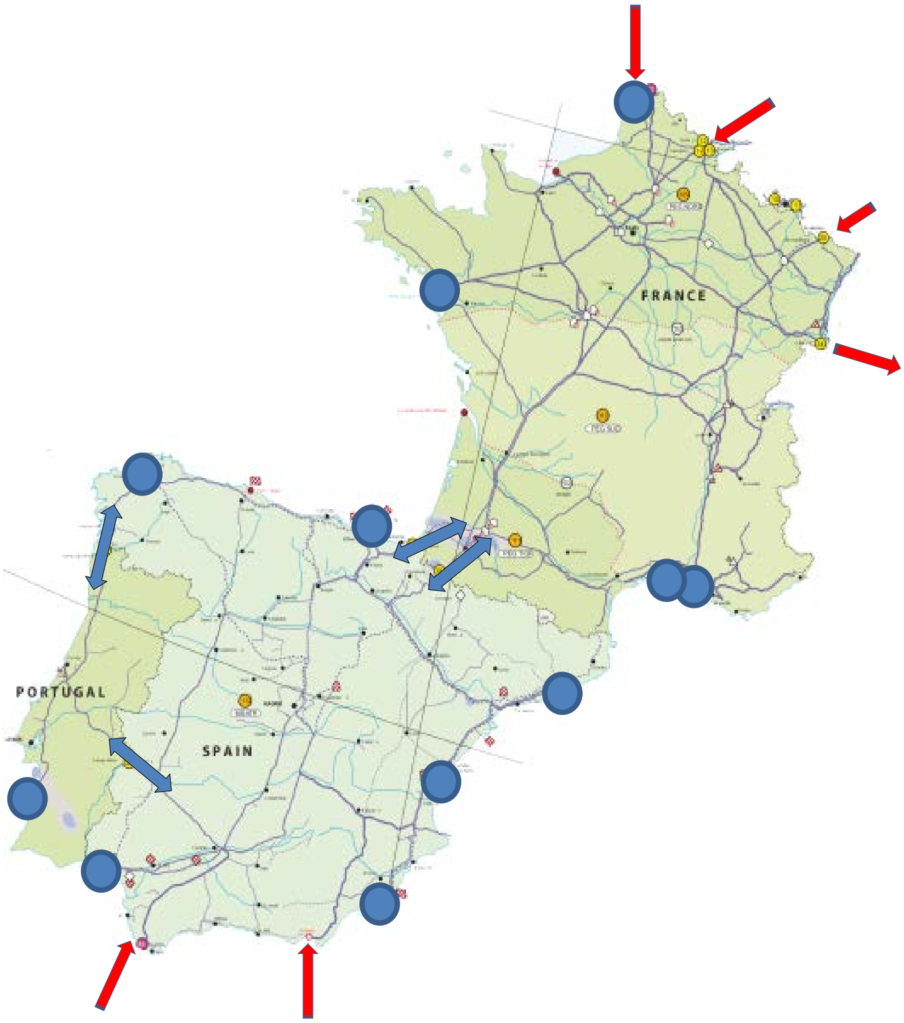

Figure 3-2 LNG import terminals - storage and regasification – and pipeline im-/exports of natural gas (red) to the area under consideration with present gas interconnectors (blue)

Spain became member of the EU in 1986 and shortly after an agreement was made to import gas from Norway via France. The first connection from Algeria via Morocco was developed in the early 1990'ies with a dual pipeline crossing of the Strait of Gibraltar. The reason for selecting transit of natural gas through Morocco was that the offshore pipeline technology at that time did not allow for pipe laying in deep waters as would be encountered if a direct route from Algeria to Spain was settled for. Only when the technology was developed after year 2000, a direct pipeline, Medgaz, was constructed and commissioned in 2008.

France was initially involved in the Algeria - Morocco pipeline to Spain. However, France withdrew and instead the Spanish gas system was developed as a meshed grid with the purpose to supply natural gas to the country as such and to connect to the country's LNG terminals. The Spanish transmission network consists of smaller diameter gas pipelines that are less suited for transit of large volumes of natural gas. Italy has for comparison implemented a strategy based on large diameter north-south transmission pipelines making it easier to transit gas to Europe through the country.

Portugal

Portugal had the choice between LNG import or pipeline via Spain and Morocco from Algeria. It was decided to go for the pipeline connection, which helped to make the Maghreb-Europe gas pipeline project viable. Later, Portugal has constructed an LNG import terminal and an underground gas storage for security of supply and market reasons. Presently, there are two pipelines connected with Spain.

France

The French natural gas supply was initially based on indigenous production from the Lacq gas field north of the Pyrenees. The gas system was developed to transport gas from the South of France towards Paris. Later on gas was supplied from the Netherlands via Belgium, from Russia via Germany and from the middle of the 1990'ies from a direct pipeline from Norway.

LNG was developed early in France with the first LNG to Le Havre in 1965 and from the early 1970'ies to Fos near Marseilles, mainly based on import from Algeria. Later on more LNG terminals were constructed.

When the indigenous gas fields in the south were depleted, some were converted into underground gas storages. In addition, dedicated gas storages in the area were developed. The overall storage capacity in France is more than 12 bcm and the maximum combined withdrawal rate is 213 mcm/day, while the injection rate is 108 mcm/day. This shall be compared with the peak load of approximately 330 mcm/day, showing that the capacity of the storage is much more important than the pipeline supply during a security of supply crises, allowing for a flexible use of import pipelines on short term.

In recent years, the possibility of producing shale gas has been a topic for much public debate in France. So far it has been decided to exclude the use of hydraulic fracking and projects are put on hold. However, plans are under consideration to develop bio-methane to natural gas quality, according to among others GRTGaz.

France is today connected to the following EU member states: Belgium and Germany to the North and Spain in the South. Further, France is indirectly connected to Italy via Switzerland; the offshore pipeline Franpipe connects Norway and France directly with a capacity of 52 mcm/day. The French system is not directly connected to neighbouring countries Italy, Luxembourg or UK. Also, there is not yet any direct offshore pipeline connections from Algeria, although a spur line to Corsica is planned as part of the Galsi pipeline, connecting Algeria and Italy as a combined off- and onshore pipeline that will cross Sardinia. Due to the delay in the Galsi project, it is now been considered to establish a FSRU on Corsica.

Interconnections within the EU

The interconnections between the centre of EU and the periphery differ with respect to number of connections and capacity. This is due to difference in geography, history and gas supply sources. There are still a few "missing links" for which interconnections are being considered.

Area	Connection	Popula-tion (million)	Gas consumption (bcm/y)	Pipelines	Capacity from rest of EU (bcm/y)	Capacity to rest of EU (bcm/y)
Iberian Peninsula	France	50	30	2	5	7
UK and Ireland	The Netherlands and Belgium	60	78	2	45	20
Italy	Austria, Switzerland	55	64	3	55	6 To be increased from 2018
Denmark/Sweden	Germany	15	4	3	5	5
Ireland	UK	5	4	3	15	
Sweden	Denmark	10	1	1	2	0
Greece	Bulgaria	10	3	1	3	1 Will be increased with TAP project
Baltic	Poland	10	7	0	Missing links	GIPL being implemented
Cyprus	Greece	1	0	0	Missing links	
Malta	Italy	1	0	0	Missing links	

Table 3-1 European cross border pipelines and their capacities

The comparison shows that the Iberian Peninsula is relatively poorly connected to the rest of EU as compared to other areas with respect to capacity. Interconnectors have traditionally been used in flexible ways as periphery areas often have different suppliers. As an example the UK-Belgium interconnector was originally constructed for export from UK. Now the line is used for export during summer and import during winter as EU storage facilities are used. Further, the existence of the interconnector between UK and the Continent contributed to attract new supply routes from Norway.

In conclusion, Interconnectors serve to ensure supply from the periphery to the centre of EU and at the same time ensures access to the internal market for gas and contributes to ensure security of supply for the entire EU.

3.1.4 *Iberian LNG import overcapacity*

Spain has a large LNG import capacity, which is significantly underutilised. In 2015, the LNG import to Spain was only 15 bcm, while the capacity is 69 bcm, resulting in an overall utilisation of only 22 per cent. It can be seen as a paradox that LNG is shipped to the UK and other north-western European countries and indirectly supplied by pipeline to the South targeting Spain via France as there is a net flow from the UK to Belgium and further to France during the summer period. The additional time spent in sea transport from typical Middle-East exporters of LNG is approximately one week.

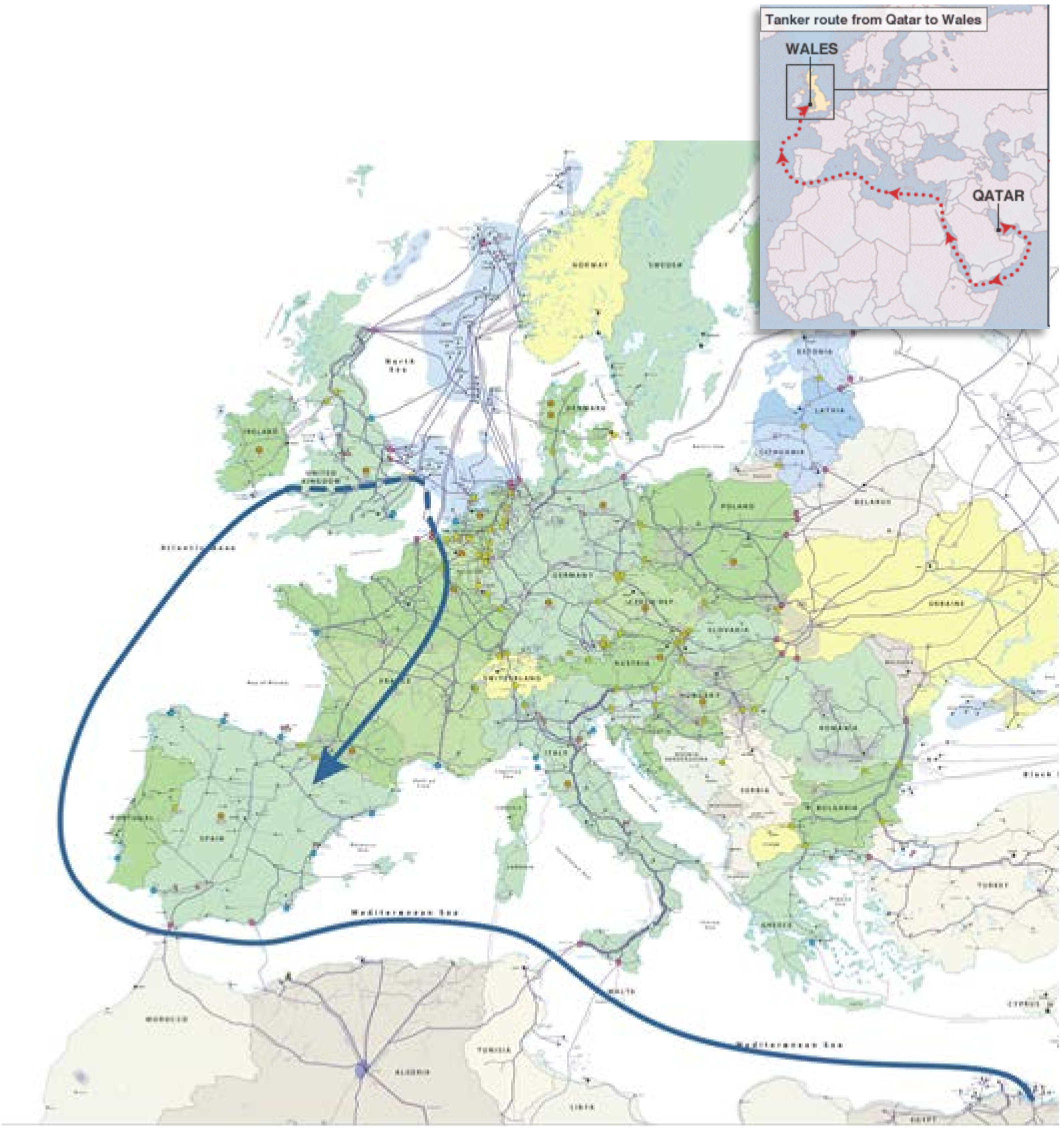

Figure 3-3 Transport route for Qatari LNG to UK – bypassing Iberian Peninsula

The reason for bypassing Spain on its way to Europe cannot be found from price differences alone. It is more likely to be caused by take-or-pay obligations, the overall EU supply/demand balance, long term contracts, difference in market liquidity, shared ownership of receiving terminals, destination clauses etc. Long-term contracts under favourable conditions, giving incentives for Spanish gas import from the North. Qatar is the main LNG supplier to Europe and has heavily invested in the UK import terminal South Hook. The South Hook Terminal, located at Milford Haven in Wales is part of the Qatargas 2 integrated value chain. Thus, the use of UK terminals instead of Spanish and French terminals is due to such long-term commitments, but also because the cost of using South Hook terminal can be seen as sunk cost from a Qatar view point.

The LNG terminals in the UK, and North-West Europe in general, have the advantage of the existence of a liquid market place where it is possible to sell gas with good visibility. Qatar, which is by far the largest LNG supplier to EU, is co-owner of gas receiving terminal in UK and is one of the reasons for not balancing the LNG market by using Spanish LNG terminals.

Spain has a total LNG import capacity of 69 bcm/y, which was developed in response to strong gas demand forecasts during the boom years before the financial crises and to regional priorities. The actual decisions about supply of gas are not only based on short term prices. Information about long term contracts is not public available and it is therefore difficult to assess the impact. However, LNG receiving terminals are often seen as part of integrated supply chain including upstream facilities, liquefaction, sea transportation and regasification. In such cases there are no incentives to choose the regasification terminals in Spain, Portugal and France.

3.2 Market and/or security of supply for Iberian Peninsula and for France and rest of Europe

Benefits of the existing and possible new gas interconnections between the Iberian Peninsula and the rest Europe are in the present study found to include the following:

- further implementation of the internal EU gas market
- increased use of LNG terminals in the Iberian Peninsula
- better and more even use of gas storage facilities in France and Spain
- diversification and new gas supply, including additional supply from Algeria
- better negotiation power and position for European shippers, implying lower gas prices.
- more 'sustainable' transport of natural gas through pipelines than transport of LNG over short distances
- increased security of gas supply to EU and to the involved countries and regions.

Implementation of the internal EU gas market

The implementation of the internal gas market includes creation of transparent market places and hereby also price visibility. At present there is not a well-functioning gas market in Spain and Portugal and no liquid market place exists. Similarly, a major gas supplier like Sonatrach from Algeria is not directly selling gas to end users in France, The benefit of implementation of the gas market may be lower prices for consumers in average.

Increased utilisation of LNG terminals

Increased use of LNG terminals in Spain and Portugal can replace construction of new terminals elsewhere in Europe and can create competition between LNG terminals. This will depend on the overall cost of bringing gas to consumers and taking into account long term commitments and national obligations, such as the N-1 principle for security of supply.

Diversification and new gas supply

Seen from an overall EU perspective, an increased gas transport capacity between the Iberian Peninsula and other EU member states can be part of a new major supply route from Algeria to the integrated EU gas market. Hereby it could also act as a back-up for supply via Tunisia to Italy.

Figure 3-4 Gas transmission pipelines exiting Algeria with exports to EU (Financial Times 23 June 2015)

A considerably much higher capacity of an integrated Spanish-French gas transmission system could be seen as an alternative to the proposed Algerian-Sardinia-Italy (Galsi) pipeline, which is planned for a yearly capacity of 8 bcm/year. This could likewise promote construction of new major gas infrastructure in northern Africa as e.g. the Trans-Saharan Gas Pipeline. By establishing more capacity between Algeria and Spain and between the Iberian Peninsula and France, it will be possible to ensure a high security of gas supply in the entire South-Western part of EU. The issue is at which cost this can be done and to quantify the benefit of this additional security of supply.

Strengthening of the interconnections between the Iberian Peninsula and the rest of EU may open for new supply routes from the South to EU:

- Increased gas import and import flexibility from Algeria – leading to possible installation of the second Medgaz pipeline, with an increased capacity of 8 bcm/year.
- Promote new supply routes like Trans-Saharan Gas Pipeline from Nigeria via Niger and Algeria

The connection may also contribute to improved use of existing infrastructure:

- Use of underutilised LNG receiving terminals in Spain and Portugal
- Increased use of large gas storage facilities in South of France

A new gas interconnector between Spain and France could be constructed in stages as it would to some degree work to alleviate bottlenecks in the two gas transmission networks. The ‘missing link’ itself is no more than approximately 200 km and by having this interconnector in place transhipment of large quantities of piped natural gas across the border could commence. Naturally, the actual use will depend on the use of underground gas storage, LNG terminals and CCGTs.

Better negotiation power and position for European shippers, implying lower gas prices.

An additional larger connection will imply better bargaining position for shippers on both sides of the French Spanish border. South of the border shippers would have the possibility of sourcing gas from the rest of Europe as an alternative to Sonatrach, NNPC, and other LNG suppliers. North of the border in France an upwards shippers and consumers would have the possibility to engage with a larger variety of LNG suppliers, while companies such as Sonatrach, NNPC, and Gas Naturel, could begin competing with other larger wholesale suppliers further up in Europe.

Sustainable transport of natural gas through pipelines than transport of LNG over short distances

Pipeline gas transport over shorter distances is in general more environmentally sustainable than LNG as liquefaction and regasification is more energy intensive than pipeline transportation. The overall use of gas for liquefaction and regasification may be up to 10 per cent of the gas supply. If the short range transportation of LNG from Algeria to France (and Spain) could be replaced by more pipeline transportation, this will have environmental benefits and save gas in Algeria. However, there may be other environmental impact of gas pipelines.

Increased security of gas supply to EU and to the involved countries and regions.

Security of gas supply in EU is mainly organised on national level according to EU regulation 994 on security of gas supply. However, for larger events like disruption of Russian or Norwegian supply or disruption of LNG supply such national approach is insufficient. A main benefit for the EU of increased capacity of pipeline from Iberian Peninsula will be the possibility of increased use of the pipelines from Algeria and the use of idle LNG facilities. These aspects are seen as main drivers for the increased capacity.

3.2.1 *EU and national objectives for gas market and interconnectors*

General – conflicting goals

Transportation of natural gas is a physical activity. Gas can be transported in pipelines or as liquefied natural gas, LNG. The real economic cost of transportation is a.o. depending on the transportation distance, geography, cost of infrastructure, economics of scale etc. However, with creation of single zones, , the cost of transportation does no longer reflect the real cost, which depends on distance and dimensions with a high degree of economics of scale.
On the other hand, it is also a goal to create competition which is the reason for unbundling of the transportation system from supply of gas and creating trading areas with uniform prices.

Some of the contradictions between goals are:

- Creating of one national market place vs. creation of cross border trade
- Creating of one national market place vs. efficiency gains as this may require high investments
- Security of supply vs. competitive prices

Increase of interconnections with firm capacity between the Iberian Peninsula and the rest of EU may make it more expensive to achieve a goal of having only one market zone in France from 2018 by merging the present three zones, PEG Nord, PEG Sud and PEG TIGF.

French gas market – unification of North-South as main priority

France has experienced difference in prices between the different market zones. Since the opening of the gas market in 1998, the number of trading zones has been reduced and in 2012 there were only three zones; PEG North, PEG South and TIGF PEG.

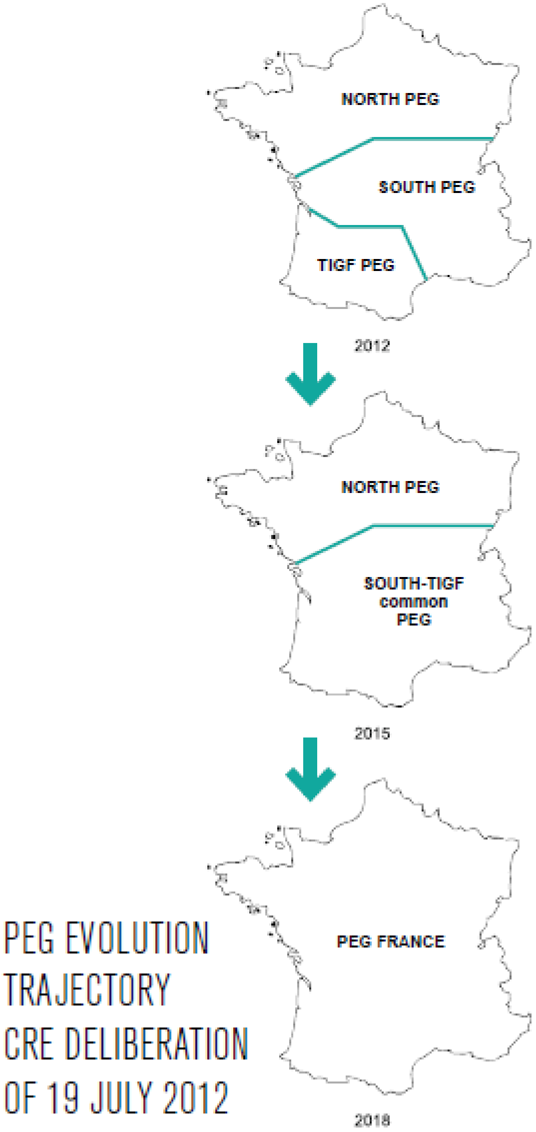

Figure 3-5 Development towards a unified natural gas market zone in France (Source: TIGF)

In order to merge the different zones, it is necessary to invest in new gas infrastructure between the zones, assuming future supply situations. Some of these investments like the Val de Saone pipeline in ongoing. At present there is only limited transit through France to Spain and Switzerland respectively. Despite this situation, congestion has been experienced in the north of France in 2014 when import of LNG was reduced and replaced by import of gas from Norway and Russia via Germany.

Next step could be to create one zone including France, Spain and Portugal. This will require substantial extra investments, which may be close to an extra pipeline from North of France to South of Spain – a distance of 1500 km. The policy of one zone and thus one market price in France will move the price difference to the border to Spain.

The three TSOs in the South region; REN from Portugal, Enagas from Spain and TIGF from France have created two virtual interconnection points, combining the capacity of different physical pipelines. Also, common rules for capacity allocation have been implemented.

Security of gas supply and solidarity

The EU regulation of security of gas supply was implemented in response to the 2009 gas supply crises in Ukraine, when gas transit from Russia was halted for some weeks. The basic principles of the regulation are to ensure a robust system which on national level is sustainable even if the main supply is disrupted and to ensure solidarity between member states. Interconnections play a vital part in the fulfilment of the criteria for security of supply since they facilitate movement of gas in both directions.

Energy Union - Preparation for future change in global market situation

The Energy Union strategy has five mutually-reinforcing and closely interrelated dimensions designed to bring greater energy security, sustainability and competitiveness:

- Energy security, solidarity and trust;
- A fully integrated European energy market;
- Energy efficiency contributing to moderation of demand;
- Decarbonising the economy, and
- Research, Innovation and Competitiveness

The Commission has highlighted 15 action points, of which no 2 concerns gas supply.

"2. The EU needs to diversify its supply of gas and make it more resilient to supply disruptions.

- The Commission will propose a resilience and diversification package for gas in 2015-2016 by revising the existing security of gas supply Regulation.
- The Commission will prepare a comprehensive strategy for Liquid Natural Gas (LNG) and its storage, and
- The Commission will work with Member States to develop access to alternative suppliers, including from the Southern Gas Corridor route, the Mediterranean and Algeria, in order to decrease existing dependencies on individual suppliers."

As part of this package meetings between EU Commission and Algeria and other North African countries have been held.

3.3 Historical use of existing gas interconnectors between Iberian Peninsula and the rest of Europe

The existing French-Spanish interconnector pipelines have in recent years mainly been used for transport of gas from France to Spain. LNG prices have been higher than pipeline gas and as a result there have been no incentive to use the large – partly idle – LNG capacity in Spain for transport of gas to France. Also, Algeria, who has the possibility to export gas as LNG or as pipeline gas, has chosen to stick to oil indexed gas prices, which together with high oil prices have made their pipeline gas relatively more expensive than hub based pricing.

Since the first months of 2015, there has been less flow in the pipelines. This coincides with increased flow in the pipelines from Algeria to Spain. The actual flow from France to Spain also depends on the overall physical balance in the entire EU. With increased production in Norway and increased import from Russia in third quarter of 2015, combined with LNG import to UK and Belgium, there was again a need for more flow from France to Spain.

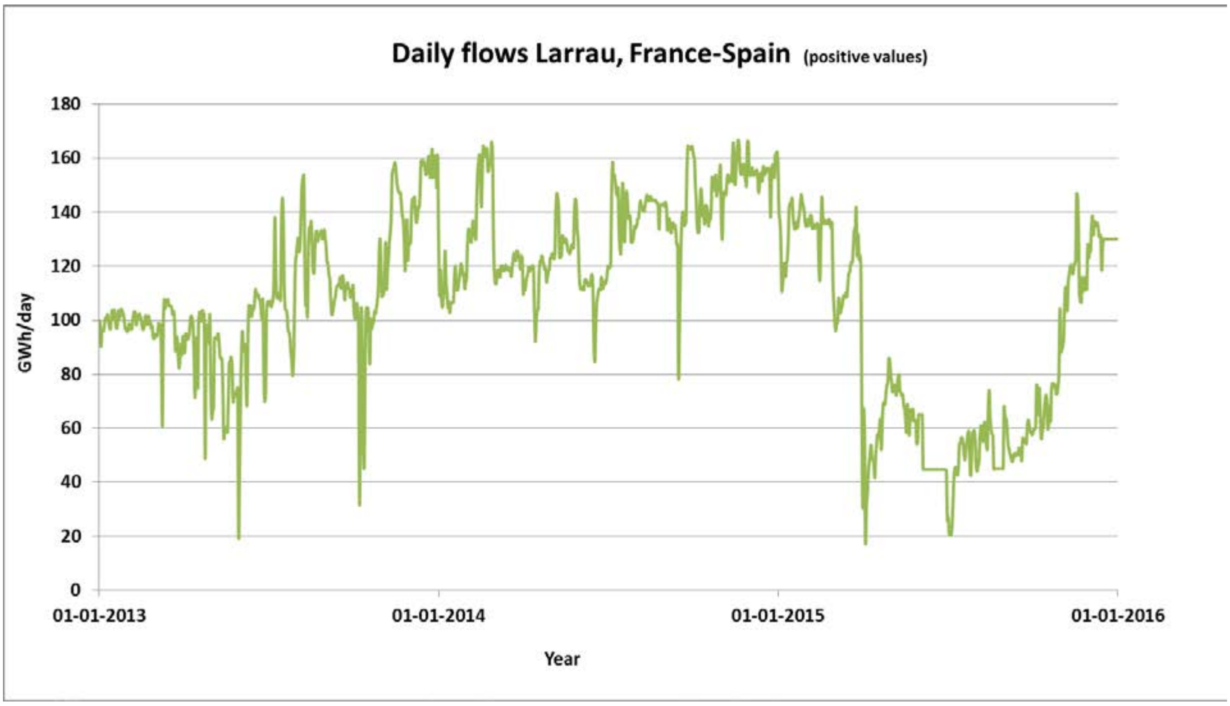

Figure 3-6 Daily gas exports via the interconnector at Port-de-Larrau and Biriatou

In the open season procedure for the MidCat project, highest demand was for the Spain to France flow. <u>Although what has been witnessed is almost entirely flow from north to south.</u> The main reason for the flow from North to South is that the LNG prices have been relatively high compared to pipeline gas from the North, originating mainly from the Netherlands, Norway and Russia. With a weak demand for gas in the EU, the pipeline gas, and take-or-pay obligations, may have pushed gas further to the South.

Long-term contracts for supply of gas to Spain from the North have also favoured the transportation from North to South. Algeria has traditionally used oil indexed gas contracts. With high oil prices this results in higher gas prices than the gas-to-gas competition in North-West Europe could justify, as gas prices has a higher elasticity than oil prices. In a situation with lower oil prices as at present, it is likely to have a more balanced situation with respect to gas prices.

3.4 EU Supply/demand situation

3.4.1 *EU Supply/demand impact on need for increased interconnection*

The overall EU supply and demand balance is impacting the need for increased interconnector between the Iberian Peninsula and the rest of EU. The increased interconnection capacity has been analysed in the ENTSO-G South Region, but the issue is impacted by factors outside the region.

Contrary to electricity, which only can be transported economically over a few hundred kilometres, natural gas can be transported economically over thousands of kilometres by pipeline or even longer as LNG.

It is therefore necessary to take an overall view on the benefits of additional interconnectors between Iberian Peninsula and the rest of Europe, as the present system is not only a bottleneck between Spain and France but also between North Africa – with huge gas reserves – and a Central European gas market, which may be negatively impacted by potentially declining gas supply from Russia, the Caspian Sea and Northern part of Norway.

In this section the overall demand forecasts will be discussed based on the recent published ENTSO-G TYDP 2015 report. Gas supply will be discussed with a focus on indigenous supply sources, main supply sources by pipeline with a particular focus on Algeria and LNG supply, to supplement the ENTSO-G report, which focuses much on Russia and transit countries from Russia. Also, the cut-off time for ENTSO-G was in 2014 which allows us to take some more recent developments into consideration.

3.4.2 *Gas demand in EU*

The ENTSO-G 2015 TYDP demand scenarios are used as the main cases in the present analyses. Since the preparation of these scenarios, the market situation for gas has changed somewhat due to lower oil prices and consequently lower gas prices for the oil indexed contracts. The gas demand in recent year for the entire EU and in particular for the Iberian Peninsula and France has been fluctuating due to impact of the financial crisis, gas prices and also meteorological conditions. In 2014, which was one of the warmest years on record in Europe, the gas demand in France declined more than 16 per cent and in Spain almost 10 per cent. However, this year, where weather conditions have been more normal, the gas demand has picked up rapidly.

The ENTSO-G TYNDP includes comparison of different scenarios for EU gas demand, including their own two main scenarios, the Green and the Grey.

“The global context covers the price of gas and coal as well as the price of CO^2 emissions. The relative levels of these three prices influence the share of gas and coal in the power generation mix. The two considered global contexts are:

Green – the price scenarios correspond to the “Gone Green” scenario from the UK Future Energy Scenarios (FES) document, which is consistent with:	Grey – the price scenarios correspond to the Current Policies scenario from the IEA WEO 2013) document which is consistent with:
• A high price of CO^2 emissions due to the introduction of a carbon tax	• Lower price of CO^2 emissions as no new environmental political commitments are taken
• A continuous reduction in the oil-price linkage mitigating the increase of gas price when oil prices increase	• High energy prices following higher energy demand in absence of new Efficiency policies but with prices still too low to trigger the development of Renewables”

Figure 3-7 Demand scenarios

The two sceanrios are combined with respectively high economic and stagnat economic growth on one side and an electricity system based on renewable and on more traditional fuels.

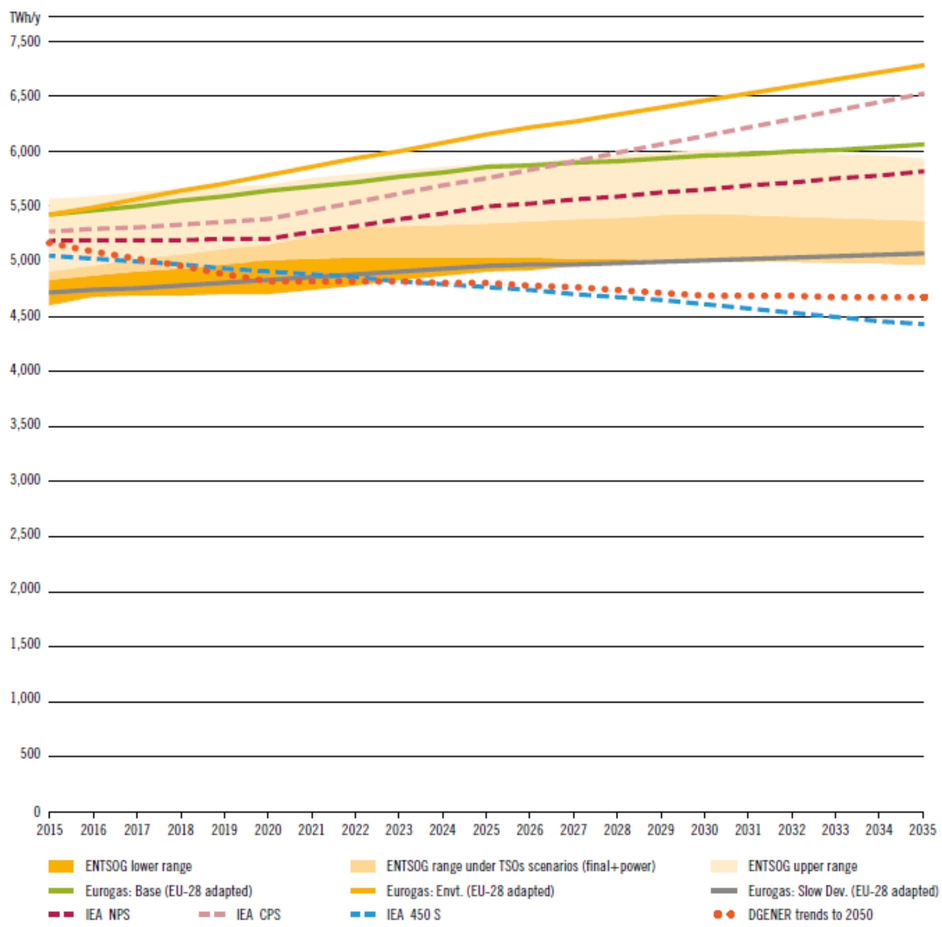

Figure 3: Comparison of gas demand outlooks

Figure 3-8 Comparison of gas demand outlooks (ENTSO-G – TYDP 2015)

The graph shows the uncertainty about future natural gas demand in EU. This uncertainty for natural gas is higher than for energy in general as natural gas is the residual supply after wind, solar, biomass, coal and nuclear in the power and heat sector.

The gas demand on the Iberian Peninsula is forecasted to grow faster than for most of the rest of Europe.

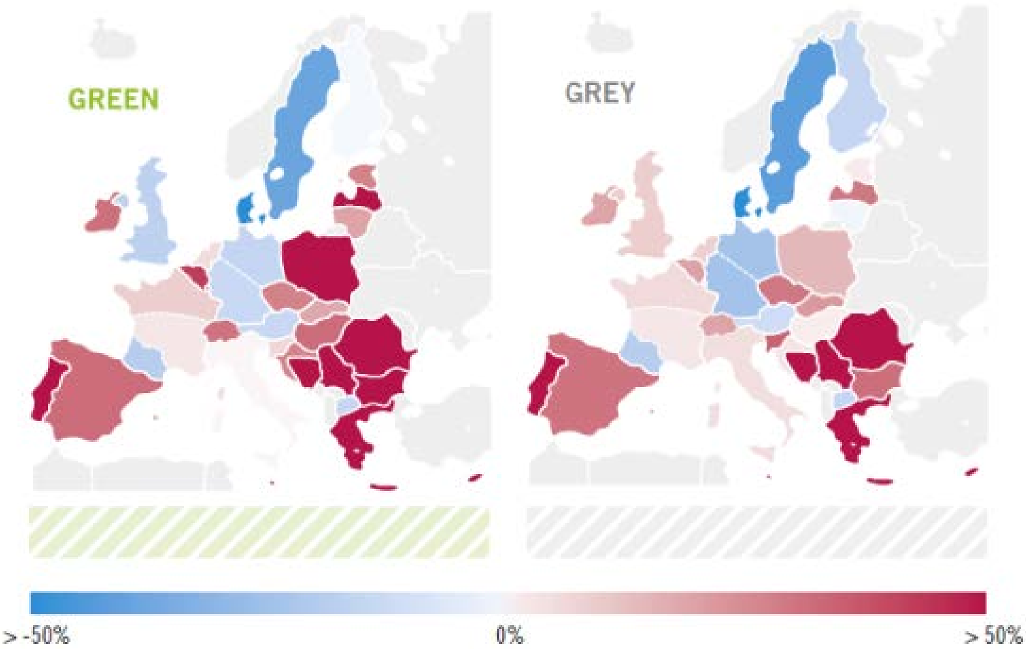

Figure 3-9 Evolution of total annual gas demand on 2015 - 2035 period
(Gas demand for electricity is based on data from ENTSO-E S0&AF 2014 - 2030)

The figures shows the change in natural gas demand in different part of EU, with growth in Iberian Peninsula and East Europe, in particular Poland and decline in wind based energy systems of Germany and Scandinavia

Some of the comments to the ENTSO-G scenarios, which we have not included in the quantitative analyses are:

- Oil and gas prices are high in both scenarios. This may be too optimistic. High oil and gas prices may imply lower demand than what would otherwise be the case.
- The outcomes of the two scenarios – Green and Grey are very similar. This is because the environmental policy adopted in the Green scenario is counteracted by more rapid growth. It could be argued that the cost of green policy would slow down economy and that the Green scenario is optimistic with respect to use of gas as compared to the Grey scenario, as increased use of wind and solar could be accelerated and spread to more EU member states
- Assumptions about use of nuclear energy have previously shown to change rapidly as seen in Germany. Both visions used by ENTSO-G have the same assumptions, which in particular for France and Spain may be a very static picture. For example, the scenarios do not take into account that nuclear policy and implementation could change rapidly?

- Climatic change will by itself change gas demand, as seen in previous years. This is due to the need for heating and cooling, but also impact on hydro-, wind-, solar- and biopower. It is unknown how the gas sector should prepared to be back-up in case of unforeseen climatic conditions. In 2014 the gas demand was particularly weak due to the warm weather, while in the summer of 2015 the electricity sector in countries like Spain and Poland was dependent on the gas sector due to very warm weather and low reservoir levels. In such situation it is easier to move gas than electricity.
- An economic bounce-back from the financial and economic crises in 2008-2013 has not been foreseen in the scenarios. In particular in South Europe there may be room for rapid economic development due to spare capacity in manufacturing and other part of the economy.
- Demographic development inside EU and from outside. In general population is moving from the east to the west and north. Further, there is immigration from outside EU. Population growth is an independent growth factor in addition to the contribution to GDP.

3.5 Gas supply to EU – specific analyses of supply countries

3.5.1 *EU and Norwegian gas production and supply*

EU gas production declined rapidly in 2014 with almost 10 per cent. The main producers are the UK, the Netherlands, Denmark, Germany and Romania. The main reason is the restrictions put on gas production in the Groningen field in the Netherlands emanating from earthquake recently registered around the fieldThe output from the field was in late November 2015 reduced from 33 to 27 bcm/year. Such reduction will stretch the reserves over more years and hereby contribute to keeping up production over longer time.

Germany and Denmark are exposed to a gradually inevitable decline in natural gas production, while the UK is depending on new fields coming into operation in expensive areas like West of Shetland. Further, many old gas fields offshore Denmark and UK are exposed to frequent unplanned maintenance due to ageing. At present it seems unlikely that shale gas will come into operation in EU in the near future. There may, however, be possibilities for drawing upon future new gas supply sources from Romania and Cyprus. These new sources of supply have been discounted in our present forecast, contrary to those by ENTSO-G, since the present reduction in prices has made them less likely. Also, Cyprus has entered into a preliminary gas export agreement with Egypt, and new supply will hence not impact the overall EU supply.

Our gas supply forecasts, based on national publications and own assessments, are shown below.

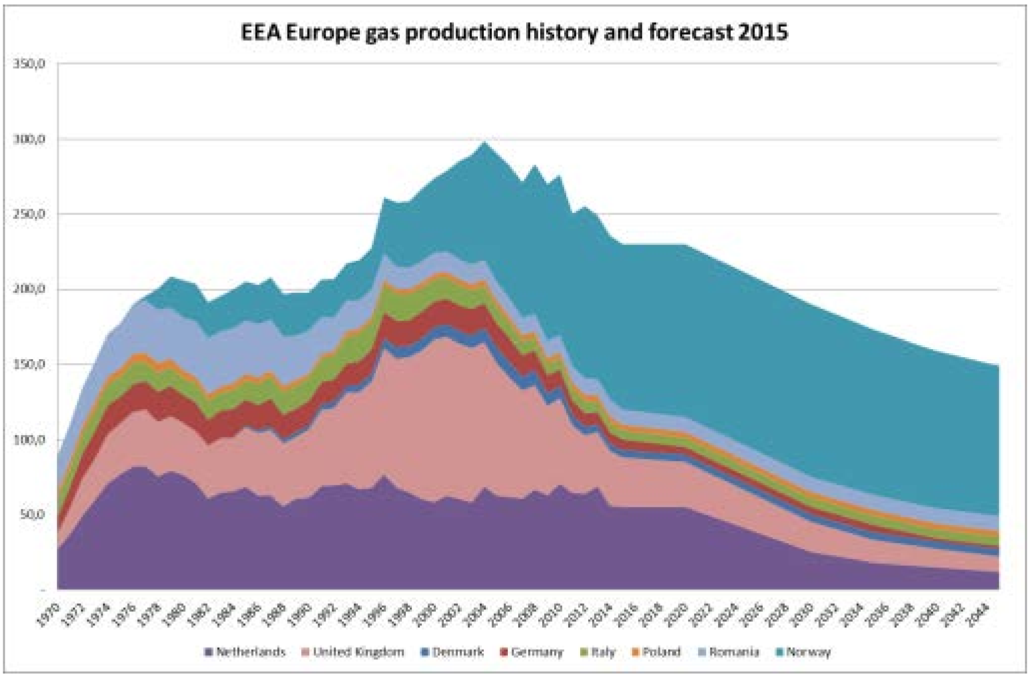

Figure 3-10 Ramboll's gas supply forecasts, based on national publications and own assessments unit bNm3/year

The production profile shows Ramboll combined EU and Norway production profile, showing that production will be on a plateau in the coming years before continuing the fall in production. We have kept the Norwegian supply constant as the natural decline will be replaced by new fields. The graph also shows that the majority of supply will be from the North of EU.

ENTSO-G potential for EU gas production is shown below and includes a.o. Non-FID production from Romania and Cyprus with a combined volume of up to 20 bcm/year, which we have not included.(FID is final investment decision)

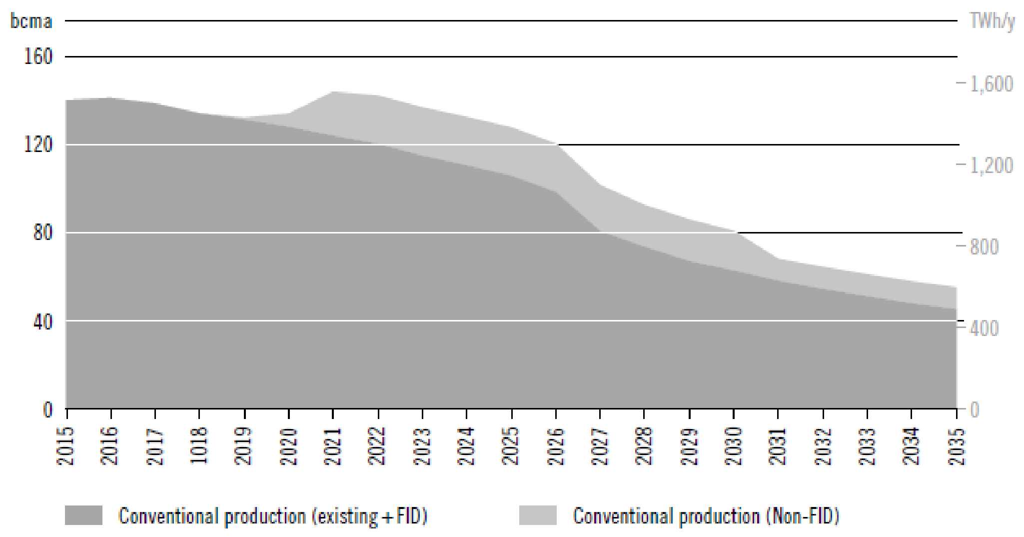

Figure 3-11 Potential of EU conventional production 2015-2035 (ENTSO-G TYDP 2015)

Whereas ENTSO-G expects a plateau in EU gas production around 140 bcm/y until 2025 and a further reduction to 60 bcm/y in 2035, we expect a reduction from the present 120 bcm/y to 115 bcm/y in 2020, and 95 bcm/y in 2025 and 65 bcm/y in 2035.

The Norwegian gas production has been almost constantly around 110 bcm in recent five years. Out of this the pipeline export has been around 100 bcm/y. Today's level is approx.10 bcm lower than assumed only a few years ago, due to delays in project implementation. We expect, based on NPD data, and indications of project prospects, that the pipeline supply to EU will increase with up to 5 bcm/y until 2020 and hereafter stay on this level of 105 bcm/y until 2035. The total forecast is between 15 and 30 bcm lower than the ENTSO-G forecast for the first years, and somewhat higher for the period after 2025. There is a large uncertainty about field developments in Norway but there should be sufficient resources to keep up production.

All in all we expect the supply from EU North-West Europe and Norway to be 230 bcm in 2020 declining to 210 in 2025 and further to 175 bcm/y in 2035, with the majority of supply from Norway in the latter years as the Netherlands and UK will deplete their fields.

In conclusion, we expect that the combined EU and Norwegian gas supply via pipeline will be approximately 20 – 30 bcm/y less than foreseen by ENTSO-G in the 2015 TYDP in the period from 2020 to 2025.

The development in gas supply from EU and Norway is a possible reason for launching of projects like Nord Stream II from Russia to Germany and for a project like Trans Saharan gas pipeline from Nigeria via Niger and Algeria to Spain. Also, the decline can support use of LNG terminals in EU.

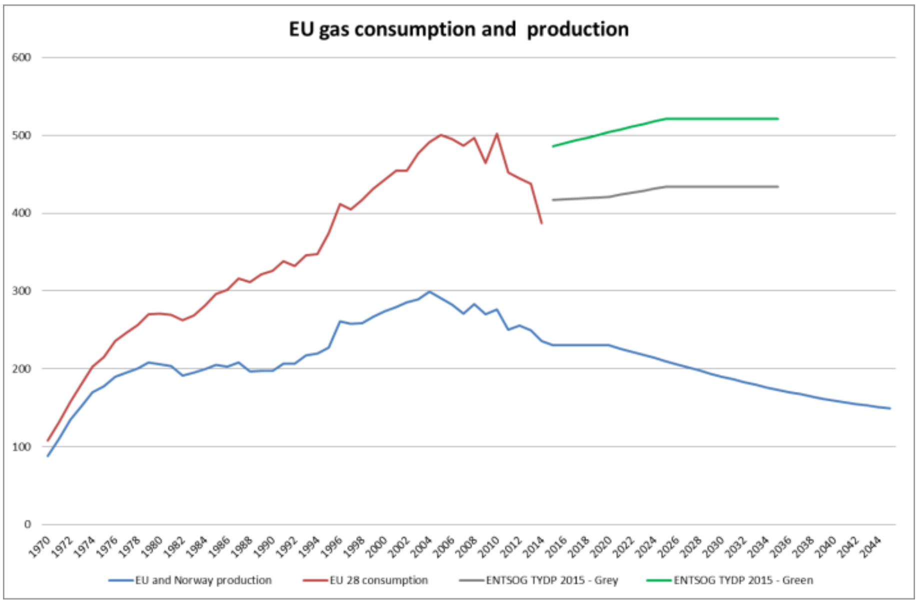

Figure 3-12 EU gas consumption and production from EU and Norway (BP Statistical review and ENTSO-G and own assessment of production)

In any case there is a substantial gap for external suppliers to cover. In the following, a brief review of the assumptions with respect to gas infrastructure and supply to the EU is presented.

3.5.2 *EU Gas supply routes from outside EU*

The EU gas supply situation is described in the ENTSO-G TYDP with the following existing import routes.

EXISTING IMPORT ROUTES OF GAS

Source	Route	Sub-route
LNG	United Kingdom	
	The Netherlands	
	Belgium	
	France	
	Spain	
	Portugal	
	Italy	
	Greece	
	Poland	
NORWAY	United Kingdom	
	Germany	
	The Netherlands	
	France	
	Belgium	
RUSSIA	Finland	
	Germany	
	Estonia	
	Latvia	
	Belarus	Lithuania
		Poland
	Ukraine	Poland
		Slovakia
		Hungary
		Romania
ALGERIA	Spain	
	Italy	
LIBYA	Italy	

Table 5.1: Existing import routes of gas[1)]

Table 3-2 Existing import routes of natural gas to Europe (ENTSO-G TYDP)

This description does not include the transit countries for Algerian gas supply. Here we will use the following more precise description:

Source	Route	Sub-route
Algeria	Spain	Morocco
		Direct – Medgaz
	Italy	Tunisia

Table 3-3 Export routes of natural gas from Algeria

From a security of supply as well as from a market point of view, it is important to recognise that a major part of the Algerian gas is transported via transit countries. It is expected that a transit tariff is paid for use of transmission lines in the transit countries, which may impact shippers' choice of transportation: by LNG or pipeline and also between the direct pipeline and via transit.

With respect to security of supply, the gas supply situation in Algeria and Libya has been impacted by civil war and terrorists' attack on gas infrastructure. This has not yet been experienced in the transit countries but cannot be ruled out.

In addition to the existing pipeline routes, it is likely that the Trans Adriatic Pipeline, TAP, will be built. However, no decision has been made so far on the TurkStream, although recent development makes it more uncertain which could increase the likelihood of Nord Stream 2 The new development in Iran may open for new supply sources. New supply routes also includes Nord Stream II from Russia to Germany and PCI projects like GIPL, Baltic Pipe and Balticconnector, which may turn some Norwegian gas supply to Eastern Europe.

The overall conclusion is that there is not a firm frozen picture of which boundary conditions will exist for the increased interconnection between the Iberian Peninsula and the rest of EU. This also tends to favour a stepwise development of a new Spanish-French interconnection. A stepwise development would ensure that the capacity matches the market situation.

3.5.3 *Algerian supply to EU via pipeline and LNG*

Algerian gas supply has most impact on the gas supply to Spain, Portugal, Italy and partly France as a combination of pipeline supply and LNG.

Figure 3-13 Algerian gas fields and supply routes to southern Europe (Sonatrach)

Algeria is one of the most important gas producers and suppliers to the EU with a total production of 130 bcm/y according to Sonatrach annual report. However, a large part is used for re-injection, fuel use on fields etc. and only around 80 bcm/y is eventually marketed. The indigenous consumption outside the oil and gas sector is around 40 bcm/y leaving another 40 bcm/y for export to Tunisia, Morocco, Spain, Portugal and Italy by pipeline and as LNG.

Algeria has potential for developing gas production substantially with a gas reserve base of 4500 bcm conventional gas and potentially large volumes of shale gas. At present some volumes of gas are flared and a programme is being implemented to reduce this and recover the gas.

Development of Algerian gas supply has been delayed due to security problems. Most visible was the terrorist attack on the BP/Statoil facilities in Amenas in 2013, which resulted in several fatalities. The consequence of the event has been increased focus on security and associated cost, which has delayed some field developments. It is likely that these fields will come into operation within a few years, again depending on the security situation.

Algeria has potential for development of new resources as shale gas. The potential is big, but still it needs to be proven if the resources can be produced technically and economically viable. It is possible that shale gas production could start already within the next five years.

The Trans Saharan Gas Pipeline is a potential new import route of Nigerian gas via Algeria. When the national gas system in Nigeria is being developed to Kano and the Algerian gas network stretches to the south, the missing link between the two systems will only be around 2600 km.

The Algerian gas export system includes three main pipeline routes. Transmediterranean I and II via Tunisia to Italy, Maghreb-Europe via Morocco to Spain and further to Portugal and Medgaz directly to Spain. Further, a fourth pipeline, Galsi, is planned for direct connection to Italy and via Sardinia with a spur line to Corsica. The present capacity and use of the pipelines are as follows:

Pipeline / LNG	Capacity (bcm/y)	Use 2014 (bcm(y)	Possible upgrade
Transmediterranean	32.0	6.1	32
Maghreb-Europe	11.6	7.1	20
Medgaz	8.0	6.3	16
Morocco and Tunisia	4.0	4.0	
LNG	40	17.3	
Total	95.6	40.8	

Table 3-4 Gas exports from Algeria 2014

The daily use of the systems is shown in the graph below.

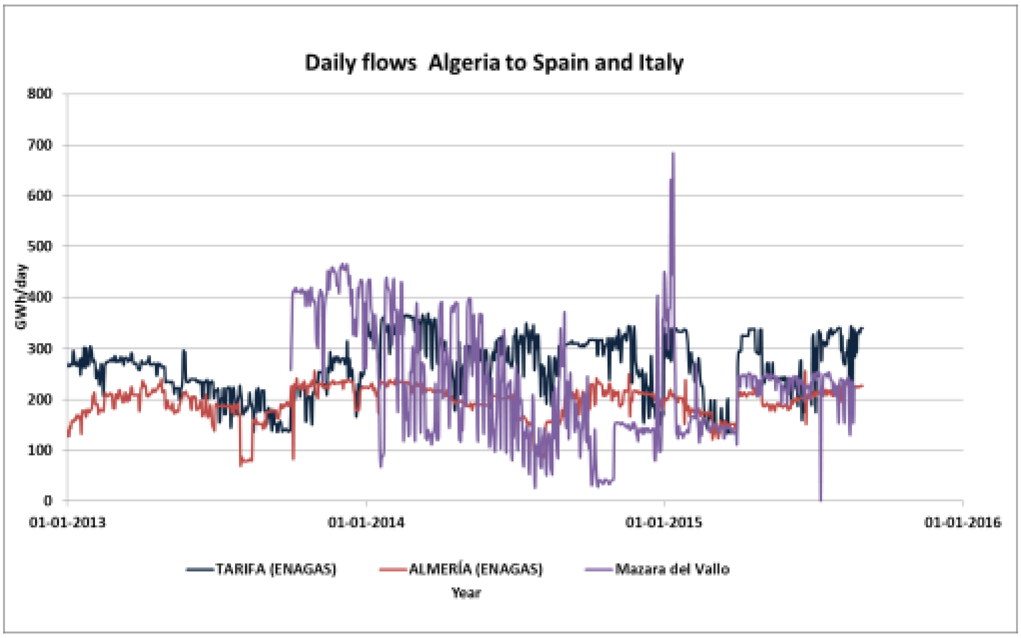

Figure 3-14 Gas flows from Algeria to Spain and Italy (Source: Enagas and Snam Rete Gas)

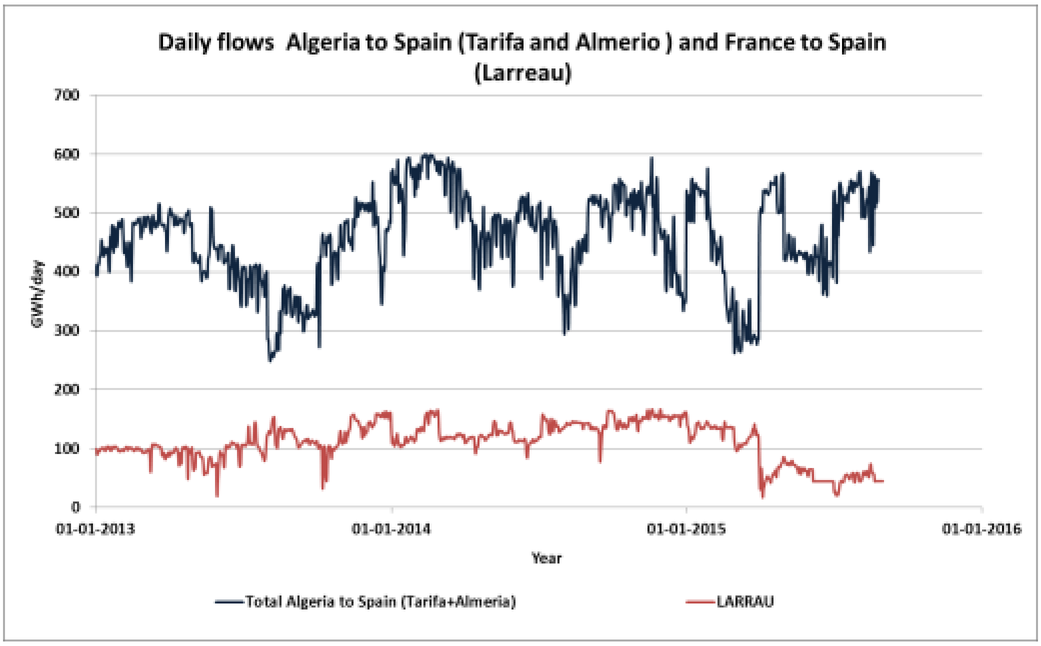

Figure 3-15 Daily flows Algeria to Spain (Tarifa and Almerio) and France to Spain (Larreau) (Source: Enagas)

The Trans-Mediterranean and Maghreb-Europe pipelines both go via transit countries. It is assessed that the transport tariff is more than 5 per cent of the transported volumes, paid either in gas or cash. In particular with high gas prices such transit tariff will favour the use of LNG export or direct pipeline.

Technically it will be possible to increase the capacity of the Maghreb-Europe pipeline by adding additional compressor stations as the diameter of the pipeline is large enough for transporting up to 20 bcm/y. The dual pipeline crossing of the Straits of Gibraltar also has sufficient capacity for such transport. The Medgaz pipeline is planned for an additional pipeline as landfalls have already been made for the second line.

Algeria has two main LNG export facilities; Arzew and Skikda. The country was the first to use LNG from early 1960´ies as pipeline export was not possible at that time.

The overall capacity of the two terminals is about 30 mt/y, including a rebuild Skikda terminal with a capacity of 4.5 mt/y which was brought into operation in 2013. This terminal is a replacement of the one which was destroyed by a fire back in 2004.

Algeria has a very flexible system and can make decisions about export or use of gas. In recent years, while oil prices were high, high priority was given to indigenous consumption which increased rapidly. In 2014 the LNG export was around 17.3 bcm, including 2.6 bcm to Asia. The pipeline export was 23.5 bcm, of which 4 bcm to Morocco and Tunisia, while indigenous consumption increased by 12 per cent to 38 bcm.

Due to the fall in oil prices in 2014, Algeria has moved from a solid surplus on trade and current account to a sharp deficit. In the short run this may be acceptable due to the large financial reserves. On the longer run, we consider that Algeria may give priority to increased gas export to support the economy.

3.5.4 Norwegian gas supply to EU via pipelines and LNG

Norway became the main gas supplier to EU in 2014. The majority of gas supply takes place via the integrated gas pipeline system.

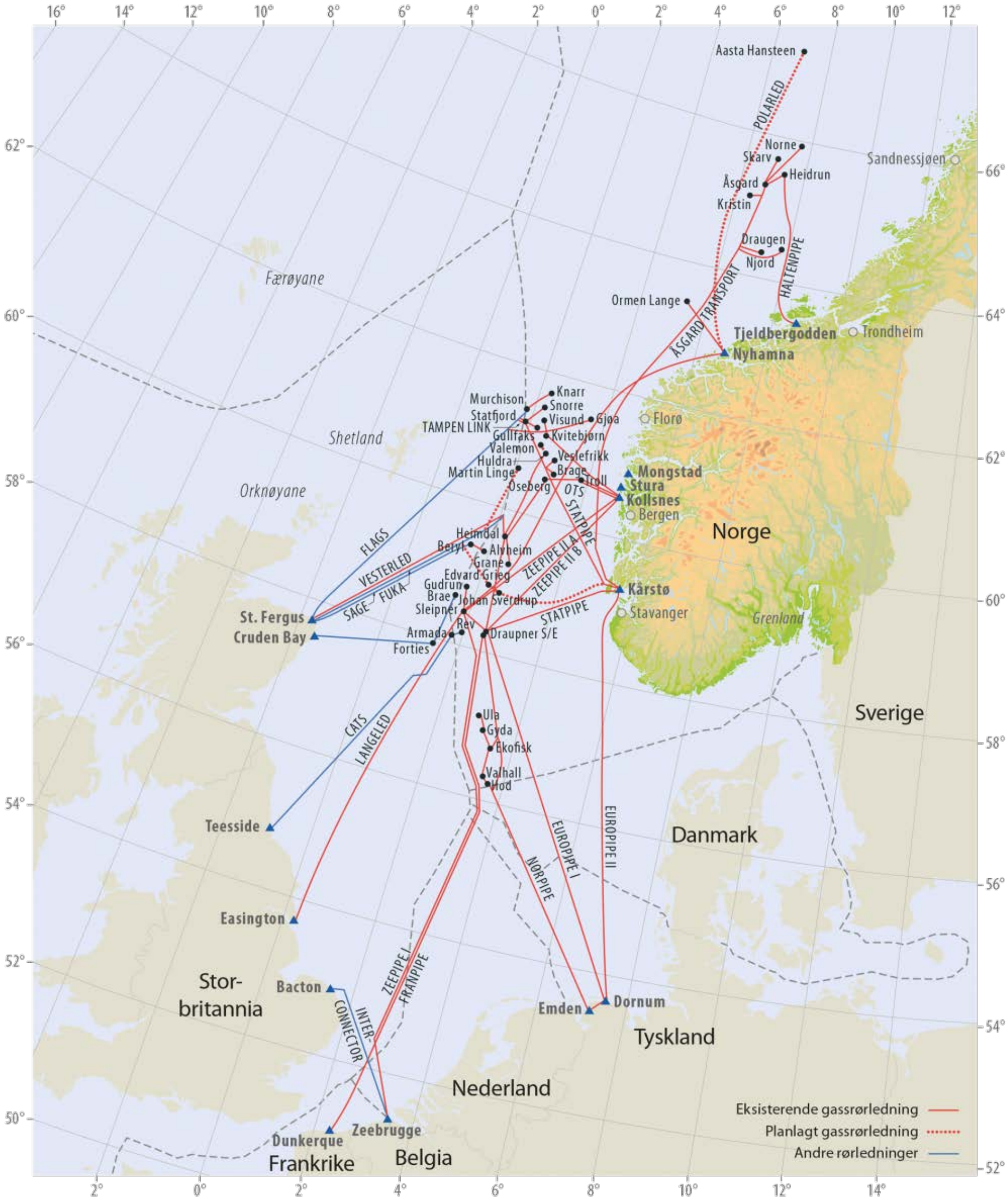

Figure 3-16 Norwegian gas supply routes to EU (Source: NPD)

The capacity of the system is more than 350 mcm/day, which was the maximum delivery in 2014. In 2014, the total delivery of gas was 101 bcm, corresponding to an average of 275 mcm/day. The present utilisation of the system is hence less than 80 per cent in average. However, when taking into account the need for repair and maintenance, the utilisation is approx. 85 per cent. With the planned increase in use, the utilisation will be close to 90 per cent. This means that there will be little flexibility to reduce supply to France and submit to Germany and further to the East.

The capacity of the individual pipelines can not necessarily be added as it may be gas treatment plants and compressor stations which determine the overall capacity.

The Franpipe pipeline to Dunkerque has a capacity of 55 mcm/day, corresponding to more than 18 bcm/y. The technical capacity of the five pipelines to the Continent is 246 mcm/day. In 2014 the total export by pipeline to the Continent was 75.2 bcm, corresponding to an utilisation of the system of more than 85 per cent in average.

Gassco has analysed possibilities for additional capacity to the Continent to respectively the Netherlands and Denmark from where the gas could be sent to Poland via the PCI project Baltic Pipe, which is being analysed. So far these projects have not been decided. Also, it is presently analysed to build a new pipeline to the Barents Sea and connect to the existing system in order to prolong the plateau production for the entire sector.

We therefore anticipate in the following analyses that Norway will have to deliver at least 10 bcm/y via Franpipe to France to maintain production. Of this, some volumes will be exported to Italy via Switzerland.

Norway is exporting LNG from the Snöhvit terminal. The capacity is approximately 5.5 bcm/y. Gas is sold to many countries as the original market; USA, has replaced LNG import by shale gas. Norway has started to supply LNG to the new terminal in Lithuania. This is one of the first examples that Norwegian gas is replacing Russian gas close to the Russian border. Hereby, the previous sharing of the EU market has been broken, which may also open for new pipelines to the east.

3.5.5 *Russian gas supply to EU via pipeline and LNG*

Russia is the second largest gas supplier to EU after Norway overtook as the leader in Q4 2014. The Russian gas supply impacts the possible need for additional capacity from Iberian Peninsula via the overall gas balance between pipeline and LNG supply and delivery to specific entry points.

The Russian gas strategy changed in late 2014 after the Ukraine crisis when the South Stream pipeline was replaced by TurkStream and later by announcement of the Nord Stream II pipeline to Germany. It is still unclear if the TurkStream will go ahead and with which capacity especially following the increased tensions between Turkey and Russia.

Further, Russia is developing the arctic Yamal LNG where Europe is the main goal as reloading from ice class vessels to the European system or reloading of LNG is expected to take place in Zeebrugge or other LNG facilities. Also, Russia is planning for new LNG export facilities in the Baltic Sea.

On a global scale, the Russian – Chinese agreements on pipeline supply from Russia to China may change the overall LNG supply/demand balance by reducing the need for LNG in China and reduce the available gas for pipelines to EU.

The Russian gas supply system is used for indigenous use and export. As the gas consumption in Russia is high during winter, it will be beneficial to export and store gas in Europe during summer. This is the reason why Russian companies have invested heavily in storage facilities. As Ukraine gas storage may no longer be available there will be some changes in supply situation.

Traditionally, Ukraine has been the major transit route to EU. Further, the Yamal-Europe is supplying gas to Poland and Germany, and since 2012 the Nord Stream has been a major supply route with a capacity of up to 55 bcm/y directly to Germany.

In the summer 2015, Russia launched the Nord Stream II project, consisting of two new pipelines in parallel to the existing two Nord Stream pipelines. The capacity would be the same, around 55 bcm/y. It is still uncertain what should be the gas sources for these two pipelines. It could be that gas presently supplied via Ukraine, and/or Belarus/Poland via Yamal-Europe pipeline is re-routed, or that there be new sources like the shelved Schtokmann field. As Russia is presently moving into recession, probably to be followed by lower growth than foreseen before the Ukraine crisis, there may also be some gas available as indigenous consumption will be lower than foreseen so far.

The Nord Stream II pipelines are not included in the ENTSO-G-TYDP and can change the North/South balance in gas supply in EU and hereby also increase the supply of gas via Germany to France. Generally the more gas is being supplied by Russia in the east and central Europe the higher the likelihood for gas being flowed from north to south in the Iberian interconnector.

3.5.6 *Libyan and Egyptian gas supply to EU via pipeline and LNG*

Libya was one of the first suppliers of gas to Spain, as LNG to Barcelona. In recent years, the main supply has been via pipeline – Green Stream – to Italy. The LNG supply stopped after the change in government and the ongoing civil war.

Egypt was exporting up to 15 bcm LNG per year before the Arabic Spring, mainly to USA and EU, particularly Spain. One of the results of the Arabic Spring was to give priority to indigenous demand and Egypt has now turned to become an LNG importer.

Egypt is now considering to import gas also via pipeline from Cyprus and Israel. The other obvious alternative would be to import gas from Libya, where there is large reserves. Due to the civil war and lack of stability in Libya this option has so far been postponed.

The developments in Libya and Egypt show that North African countries may not be as stable as originally anticipated. This can be seen as a treat for gas supply to the two Iberian countries, Portugal and Spain, which is highly depending on gas supply from Algeria. Also transit via Tunisia and Morocco may be exposed to risks. Plans to develop interconnections between the Arabic countries have so far not materialized. The interconnector will be able to ensure increased security of supply to the Iberian Peninsula.

3.5.7 *TAP/TANAP pipelines and Shah Deniz gas*

The Shah Deniz II filed in Azerbaijan will be the initial source of gas to the Trans Adriatic Pipeline – TAP – which will transport gas from the Turkish/Greek border to Italy via Albania. The initial volumes will be 10 bcm from year 2020 with possibility to increase capacity to 20 bcm/y.

Russia is planning the TurkStream from Russia to Turkey. This could also be a source for the TAP and other pipelines from South-East Europe to the rest of EU. However, there is considerable uncertainty about the progress of this pipeline and capacity as solutions with one up to four offshore pipelines are being considered.

With the present development in Iran, it is likely that gas export to Turkey will be increased via the existing 56" pipeline between Iran and Turkey.

If TAP will supply 20 bcm/y to Italy, it is likely that the import from Algeria will be reduced as the north-south capacity in Italy to a certain degree will be utilised by the TAP pipeline gas. This is illustrated by the figures below.

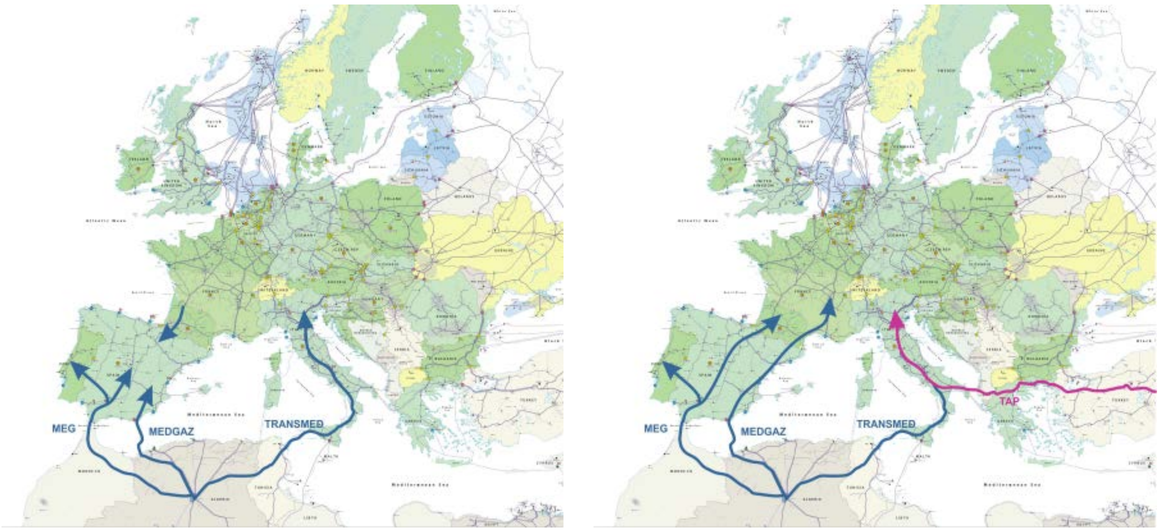

Figure 3-17 Present and future main gas transmission lines to southern Europe

3.5.8 *LNG supply from other sources without pipeline connections to EU*

LNG has the flexibility of technically free combination of supply sources and regasification via ship transport. In recent years a market for reloading has further developed as already known from the oil market, allowing for temporary parking of LNG, changing of ship size and even use of trucks for transportation of LNG to off-grid end users. The use of very large LNG vessels brings down the cost for long distance transportation. Contractually there is still a lot of constraints including long term contracts, destination clauses etc.

The advantage of LNG transport is that the marginal cost of longer distance is small which allows for re-loading of LNG and regasification close to the end-users and hereby also to be flexible in case of rapid change in demand. This was most clearly shown in response to the Fukushima accident in Japan in 2011, which resulted in re-routing of LNG from the European market to Japan. The missing LNG to Europe was replaced by pipeline gas and coal as LNG prices increased, resulting in a low utilisation of LNG import facilities.

The LNG market was until a few years ago divided into two main markets; the Atlantic and the Pacific. In the Atlantic market, LNG was shipped to North America and Europe, mainly from Middle East and Africa. Hereby, it was possible to re-route vessels to Europe from North America in case of a short term shortage. In line with the increase in US shale gas production there was no more a need for import of LNG to USA. Hereby the possibility for meeting a short term shortage in Europe also disappeared as shown in the cold spell of early 2013.

As a replacement of the US import market, a South American import market has developed in recent years which due to the opposite seasonality than in Europe can replace the need for storage of gas.

Seen from a security of supply point of view, LNG has the advantage of many suppliers and the disadvantage that geopolitical events can influence the market on the supply as well as the demand side. Examples on this is the change of Egypt from being LNG exporter to become importer, the stop of LNG supply from Yemen and on the demand side the sudden increase in LNG import to Japan.

For the interconnector between the Iberian Peninsula and the rest of Europe, the LNG market influences the projects in several ways;

- Algeria preference to sell LNG or pipeline gas
- The cost of new re-gasification facilities compared to new interconnector
- Coincidence between gas supply by pipeline and/or LNG – can the same general infrastructure be needed to transport gas to different sub-markets and storages – example is the Eridan pipeline project which will create more choices between LNG and pipeline gas
- Price of LNG on the world market and flexibility in contracts
- Preference for different suppliers and use of LNG for diversification of supply

Answers to these questions do not necessarily follow a mathematical optimisation, and a number of paradoxes can be observed in the European gas market also impacting the use of the existing and possible new interconnector between the Iberian Peninsula and the rest of EU:

LNG is supplied to North-West Europe and UK, while at the same time there is spare capacity in Spain and at the same time gas flows from France to Spain via pipelines Gas pipelines from Algeria to Spain are not fully utilised, but instead LNG is supplied to Spain and France.

In 2014, the total LNG supply globally was around 333 bcm, divided on approximately a dozen export countries. Qatar was the largest supplier with more than 100 bcm, followed by Malaysia, Australia, Nigeria and Indonesia with between 20 and 35 bcm in the second tier. Trinidad & Tobago, Algeria, Russia, Oman, Yemen, Brunei, UAE, Peru, Norway and Equatorial Guinea were in the third tier between 5 and 20 bcm/y. Of these countries Oman and UAE has a combined LNG export similar to their pipeline import from Qatar. It could as such be claimed that the Qatar export is in reality 120 bcm/y. In 2015 and 2016 it is expected that substantial new capacity will be available from Australia. USA will slowly become an exporter by conversion of previous import terminal to export, while it is more unlikely that green field projects become viable. On the longer term, East Africa may become a new exporter as new major gas fields are found and planning of LNG export facilities is ongoing.

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LNG supply to Europe was around 50 bcm and was hence less than 20 per cent of the world market. The supply to Europe mainly took place from Qatar and Algeria with a combined export of almost 40 bcm. In practise the possible diversification of supply to Europe is not taking place. This is partly because counties like Egypt, Yemen and Libya have halted LNG export temporarily or permanent.

ENTSO-G TYDP does not consider LNG supply a possible security of supply concern. The recent development in Egypt, Libya and Yemen shows that it may be a too optimistic approach. Apart from supply problems like in Egypt and political unrest as in Yemen there may be technical and nature problems which may impact supply on shorter or longer term.

The fact is that three of the LNG suppliers to EU; Egypt, Libya and Yemen, have halted LNG supply. This may be an overseen reason for the decline in LNG import to Europe.

In the security of gas supply analyses we will include a scenario with lack of LNG supply from Qatar for technical or other reasons.

LNG vessels are becoming larger and more diversified. LNG from and to new arctic terminals requires special ice-class vessels. Smaller vessels are normally used for short range transport.

The cost of transportation will depend on the availability of vessels and the day rates for vessels. It may take one week extra in transport to deliver a cargo to UK or Belgium instead of to Fos in France or Barcelona in Spain if a cargo arrives from Qatar. In case of supply crisis to Europe, which shall be covered by large volume LNG import, the availability of vessels may impact the prices for vessels and hereby also the choice of LNG re-gasification terminal.

The recent widening of the Suez Channel will probably improve the LNG supply situation from Qatar. However, it also highlights the importance of this route. The route south of Africa is approximately 10,000 km longer than via Suez. This corresponds to an extra sailing time of almost 4 weeks per load from Qatar, which shows that disruption of the Suez Channel may constitute a risk for LNG supply as well as for oil supply. Whereas there are oil pipelines in parallel with the Suez Channel, such pipelines does not exist for LNG transportation.

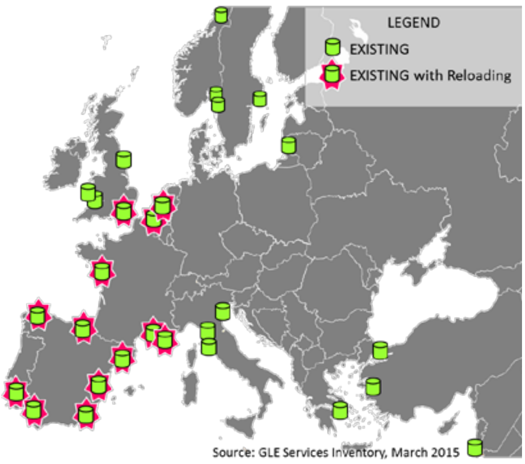
There are at present more than 20 large scale LNG terminals in operation in EU with a combined capacity of 195 bcm/y. Consequently, the average utilisation of the LNG import capacity is only around one third.

Annual regasification capacity of large-scale LNG import terminals per country

billion m^3(N) / year

	operational	under construction	planned
Belgium	9		3
Croatia			6
Estonia			7
Finland			3
France	22	13	23
Greece	5	2	11
Ireland			3
Italy	15		37
Latvia			5
Lithuania	4		
Malta			2
Netherlands	12		4
Poland		5	3
Portugal	8		
Romania			8
Spain	69	3	7
UK	52		26
EU-28	**195**	**23**	**146**
Albania			8
Turkey	12		6
Ukraine			10
Europe	**208**	**23**	**170**

LNG import terminals offering reloading



Number of LNG import terminals per type

	operational	under construction	planned
Large-scale	24	4	22
FSRUs and others	3	0	7
Small-scale	4	4	4
Total	**28**	**8**	**26**

Figure 3-18 European LNG import terminals – an overview

The figure shows that most LNG regasification plants are located in Western and South-Western Europe, while there are few plants in Eastern Europe. More and more LNG plants have possibility for reloading, which means that LNG can be re-exported to destinations elsewhere globally

An additional 23 bcm import capacity is at present under construction, mainly projects that were decided before the financial crisis and the following decline in gas consumption.

The capacity of projects in Spain and Portugal is 77 bcm per year, which can be compared to the actual use in 2014 of around 16 bcm. The utilisation for these plants is hence only around 20 per cent. This opens for the possibility of using the terminals for import of gas for France and other parts of Europe, in particular when the import plants are fully utilised which is not the case at present. A large number of new LNG import terminals are planned, with most put on hold due to the lack of utilisation of existing plants.

A main question for the additional interconnector capacity between Iberian Peninsula and the rest of Europe is if it will be more economical to develop new LNG facilities close to the end use market or to use the Spanish terminals combined with additional investments in pipeline and gas storage.

The Dunkerque LNG plant in France is the largest ongoing expansion of LNG capacity in EU. With a capacity of 13 bcm/y, the plant may become an alternative to use of the UK and Spanish LNG import terminals. The investment cost is around [1250] MEUR. As this is the most recent green field project, the average investment cost of a new terminal can be assessed to around 100 MEUR/bcm/y capacity.

There are plans to expand the Fos-Cavaou LNG terminal with an additional 8.25 bcm/y. This will be an alternative to use the Spanish LNG terminals and transporting from Spain to France. The Fos-Cavaou will also be an alternative to the North West European LNG terminals as the shipping distance will be shorter for gas arriving from Qatar. The expansion cost for the Fos-Cavaou is estimated by to 350 MEUR. Hereby, the marginal cost of expansion is less than 50 MEUR/bcm/y capacity.

3.6 EU security of gas supply – major cases and events

3.6.1 *Disruption cases*

In the 2015 ENTSO-G TYDP report the focus is on the overall supply/demand balance and two specific cases for disruption:

- Disruption of Ukraine transit of gas from Russia
- Disruption of Belarus transit of gas from Russia

ENTSO-G does not consider LNG supply disruption as a security of supply concern as it is assumed that the market will ensure supply from different sources, although at a higher price.

The French N-1 criterion is disruption of the supply point from Germany Obergailbach. This implies disruption of gas supply from Russia. For Portugal the main criterion is disruption of supply to the LNG terminal in Sines for technical reasons or due to failure of the main supply countries Algeria or Nigeria. For Spain, Algeria constitutes a major risk.
The following disruption cases have been identified as creating a supply situation where gas supply to Europe could benefit of having access to increased capacity between the Iberian Peninsula and the rest of EU.

For supply from South to North this includes:

- Russian disruption of gas supply or disruption of transit via Ukraine or Belarus or technical disruption of Nord Stream pipeline
- Norwegian technical disruption, in particular Troll or Sleipner fields or Draupner platform or Franpipe
- UK-Belgium interconnector failure – isolating UK from Continent as the BBL pipeline can only supply in one direction from The Netherlands to UK
- Groningen field decline in gas supply – escalation of earth quake problem
- Disruption of Algerian supply via Tunisia to Italy for technical or other reasons
- Disruption of Fos LNG import terminal in South of France

On the demand side the following two events can be considered:

- Extreme cold weather in North and East Europe and consequently empty storage
- Nuclear incident in France, closing nuclear power and increase use of CCGT in France and Germany to maximum capacity for existing plants

The sources of gas may differ in the specific cases depending on duration and time of the year. Initially it could be full use of the pipeline capacity via Medgaz and hereafter use of LNG or import via Maghreb-Europe pipeline.

From North to South the following events have been identified:

- Algerian gas supply disruption in general
- Qatar or Nigeria LNG failure – technical or other reasons
- Technical fault on Medgaz, or Strait of Gibraltar pipelines/compressors
- Morocco transit disruption
- LNG accident in Spain

On the demand side the following event can be considered

- Sudden demand increase on Iberian peninsula (nuclear disruption, cold/warm weather, combination)

Some of these events will also impact the rest of EU, while some are specific for the Iberian Peninsula.

In the following is given a more detailed description of cases with impact on the interconnection between Iberian Peninsula and the rest of Europe,

3.6.2 *LNG supply disruption and reduction of supply*

As ENTSO-G does not include disruption or reduction of LNG supply in the TYDP report, it is worth to discuss this event in more details. Historical events which have disrupted LNG supply include a combination of political unrest, change in priority for resources and technical events:

Country	Event	Year and Duration	Volume bcm/year
Egypt	Priority given to indigenous use of gas after Arabic spring	2012 - ongoing	15
Yemen	Civil war. Security and attacks on pipelines	2014- ongoing	7
Libya	Civil war. Priority to pipeline supply	2011- ongoing	5
Algeria	Explosion on LNG liquefaction plant, Skikda	2004 - 2013	6

Table 3-5 Historical events having disrupted LNG supplies

This means that 3 out of 17 major LNG suppliers; Libya, Egypt and Yemen have stopped export during the last 5 years. Empirically this is a very high frequency, but it could be argued that the Arabic Spring was the root course for the events.

Most important is the reliability of LNG supply from Qatar and Algeria. The probability of disruption of LNG supply from Qatar is a combination of technical and political factors. Different indices place Qatar as a political stable country, despite the fact that the last two emirs have come to power by bloodless coup. Technically, much of LNG from Qatar is shipped from Ras Laffan in the Northern part of the country. The probability of disruption is probably low, but as seen by the Skikda accident in Algeria, cannot be ruled out.

3.6.3 *France – increase in demand due to nuclear incident*

Majority of electricity in France is produced on nuclear power plant. Hereby, there are some similarities between the energy system of Japan and France. The consequence of the Fukushima incident in Japan was that all nuclear power plants were closed for 4 years and only recently the first one was opened.

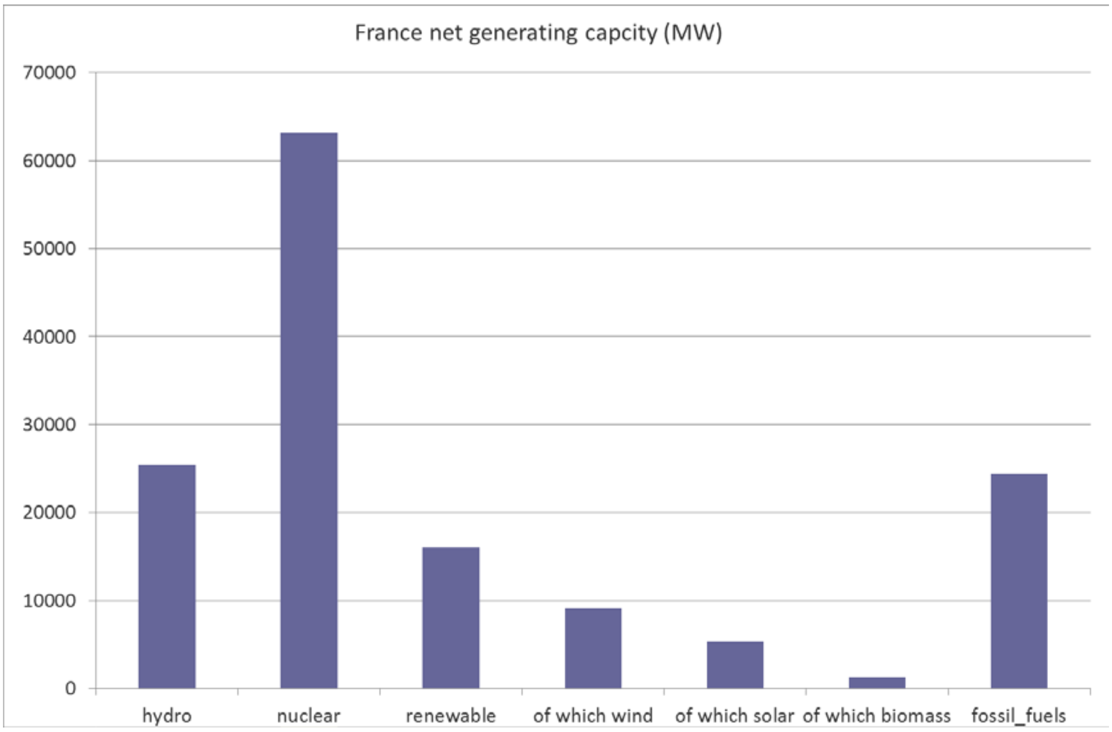


Figure 3-19 French net generating capacity 2014 (MW)

Normally, gas for power generation in France is only used for approximately 1000 MW. In case of a nuclear incident it can be assumed that gas will be used for 10000 MW as base load. This will require about 50 mcm/day in additional gas consumption, or 15 bcm/y.

The probability of the event is low. But with many nuclear power plants in France, the accumulated probability for an event on one plant will be higher than in most other countries. Historically there have been two main accidents internationally, out of approximately 200 power plants. 4 out of around 450 reactors have experienced melt down. So purely based on empirical statistics, globally there is approximately 1 per cent risk for a major (category 7) event during the entire life time of each reactor. .The risk in France is probably much lower, but it cannot be ruled out. Also, lower category events may create a public opinion which requires closing of some reactors. The probability of such events in France cannot be assessed in this study, although the events are still relevant.

In the following we will use an event with additional 50 mcm/day gas consumption corresponding to around 15 bcm/year.

3.6.4 *Tunisia as transit for gas from Algeria to Italy*

Tunisia is a transit country for all pipeline gas from Algeria to Italy. In recent years, the gas flow has been reduced. The capacity is up to 33 bcm/y

Risk-wise Tunisia is ranked in different indexes on the same level as Belarus but better than Algeria and Russia in the following index from Fund for Peace. Recent events may increase the risk rating of Tunisia.

The gas flow from Algeria to Italy has declined in recent years as Algeria has increased the flow to Spain via the direct Medgaz pipeline.

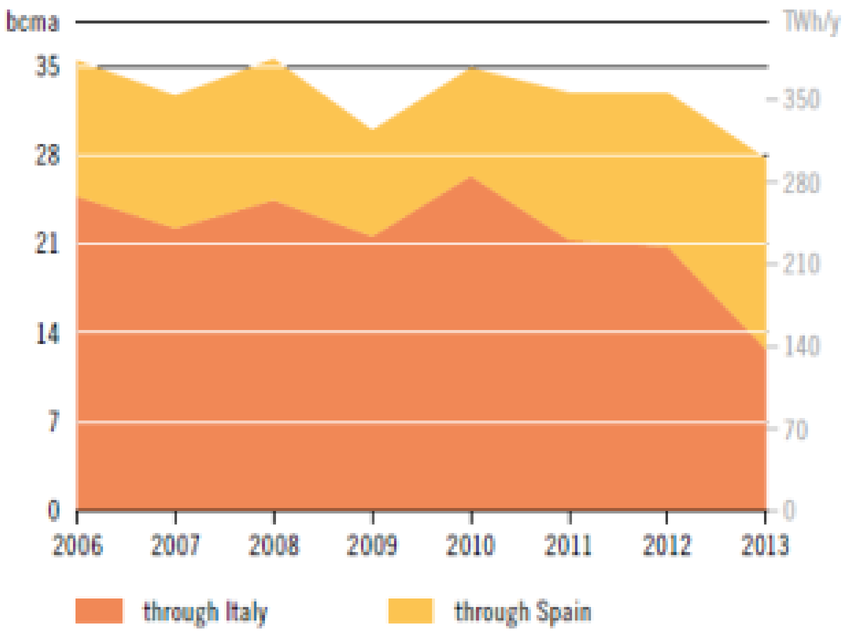


Figure 3-20 Algerian pipeline gas exports to Europe 2006-2013 (Source BP Statistical Review 2014)

In 2014 the gas transit via Tunisia was reduced to only 6.2 bcm. This could indicate that some gas may already have been re-directed to Medgaz or to LNG supply. Consequently, the consequences of a disruption will be in the order of 5 to 10 bcm/y which would need to be redirected.

3.7 Spain, Portugal and France demand and supply

3.7.1 *Demand forecasts have been uncertain – create wrong signals and decisions*

Gas demand forecasts for Spain, Portugal and France have been uncertain in recent years, mostly because of the fluctuations in the use of gas for power generation in CCGT. This is caused by a combination of new sources of renewable, use of coal as gas prices became relatively high and less increase in electricity generation. Further, there have been large fluctuations in the climatic conditions which have impacted the use of gas in the power sector, as gas is mainly used as peak load.

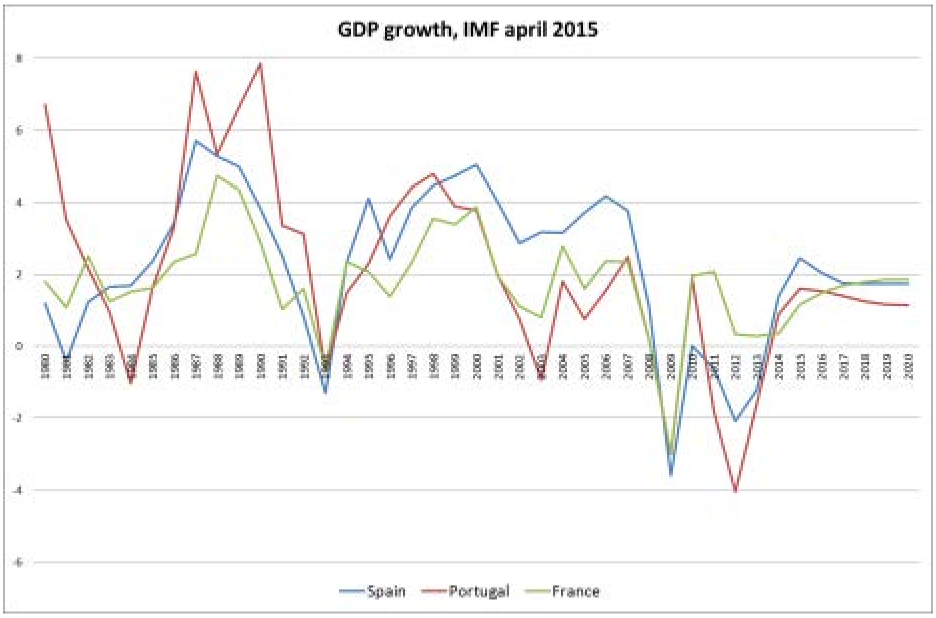


Figure 3-21 GDP growth, (Source: IMF WEO data base April 2015)

The long term development in GDP growth shows how severe the financial crisis hit Spain and Portugal with a double dip recession. France had avoided the double dip, but has in return been struggling to accelerate the economy. Due to general energy efficiency gains, the total energy consumption will need a GDP growth of around 2 per cent to create growth. As natural gas together with oil is marginal fuels, they will be even more sensitive to growth. This was the main reason for the decline in gas consumption during the financial crisis.

Population growth is by itself an independent driver of energy and gas consumption. During the financial crisis, the population started to decline in Spain and Portugal as people migrated to other parts of EU and abroad. In France there is still a rapid growth, even though natural growth is combined with net emigration. In general there is a net long term migration from the East Europe to West Europe, also impacting the energy consumption. Recent migration from outside EU may also impact the demand outlook.

Economic and population growth is extremely difficult to predict on the longer term. However, as most of Europe has a natural ageing with declining work forces, there is room for bounce back of the economy in South Europe with a large idle work force.

The figure below shows the sharp decline in gas consumption in Spain and a milder decline in France and Portugal. In particular the Spanish consumption is much lower than predicted before the financial crisis, which partly explains the decision to build many LNG terminals.

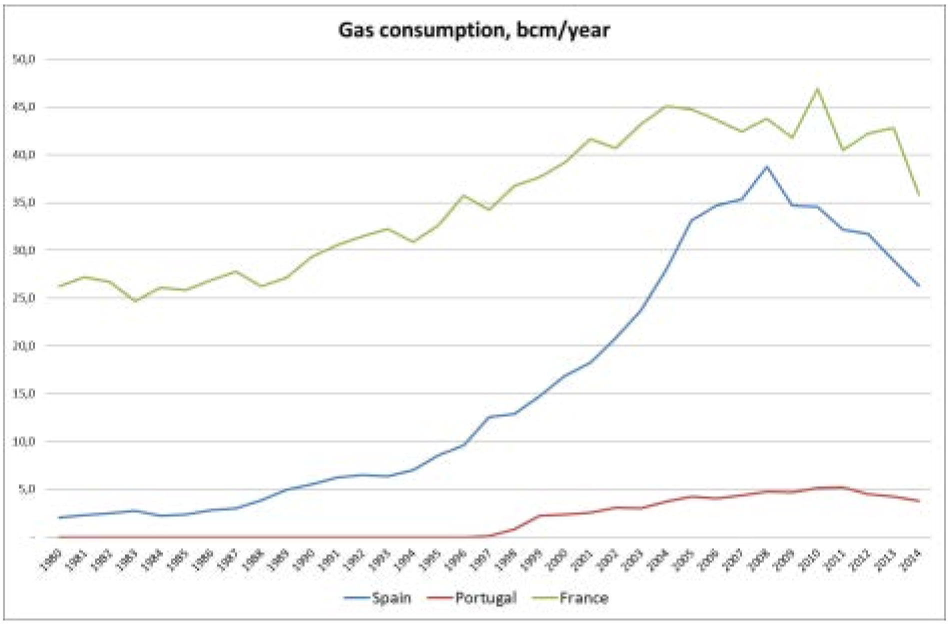


Figure 3-22 Gas consumption, bcm/y (Source BP, 2015)

The sharp decline in gas consumption in 2014 was due to a combination of extremely warm weather and high gas prices.

3.7.2 *Gas demand forecasts Spain, Portugal and France*

Ramboll expects a recovery in the Spanish gas consumption as there is possibility for a bounce-back effect. Our estimate is that the gas consumption will reach a plateau of 40 bcm. This is in line with ENTSO-G two scenarios. However, we foresee that a very high focus on climate issues may hurt gas consumption as Spain has tradition and space for wind power and also for solar energy. However, at present the development of wind power in Spain is very slow.

We foresee an increase in natural gas consumption in Portugal to between 6 and 8 bcm per year. This is in line with ENTSO-G scenarios between 8 and 9 bcm/y. Portugal has been particularly hard hit by the financial crisis and the decline in population. There is hence good potential for recovery. The conditions for increased use of renewable imply that extreme focus on climate issues may hurt gas consumption.

Our scenario for France depends very much on the use of nuclear power and use of renewables. We foresee gas consumption between 40 and 55 bcm/y in 2035 under the present assumptions and use of nuclear and renewables, depending on economic growth. This is in line with ENTSO-G scenarios. However, as France has amble possibilities for wind, solar and bio energy we foresee that it will be the green focus which will result in lowest gas consumption. An extreme focus on climate change and renewables can bring gas demand further down than described above. The extreme high use of nuclear power in France gives the risk of rapid changes, if new political decision is made to reduce use of nuclear energy. This could be due to accidents or cost. In such scenario, the gas demand may increase up to same level as seen in UK, Germany and Italy of up to 80 bcm/y. To reach such level it will be necessary to construct new CCGT power plants. The total LNG capacity can cover a large part of such increase in demand.

France still has a very low gas consumption per capita compared to other countries. It cannot be ruled out that there will be a rapid increase in gas consumption as more CCGTs are being built. Also, large fluctuations can be expected from year to year due to use of weather conditions and use of renewables.

3.7.3 *Supply – sources and concentration*

The concentration of suppliers is to a certain degree determined by the physical possibilities for import. Below in Figure 3-23 the concentration calculated as the herfindahl-hirschman index, which is a general methodology for measure of competition, on the imports from the period 2005-2013 is presented, with the exporting country as a proxy for the supplier. It shows that the concentration of imports in Spain has increased over the past 4 years. The concentration has increased in France. While Portugal, although having a much higher concentration of importers, has seen a larger diversity in suppliers since 2005.

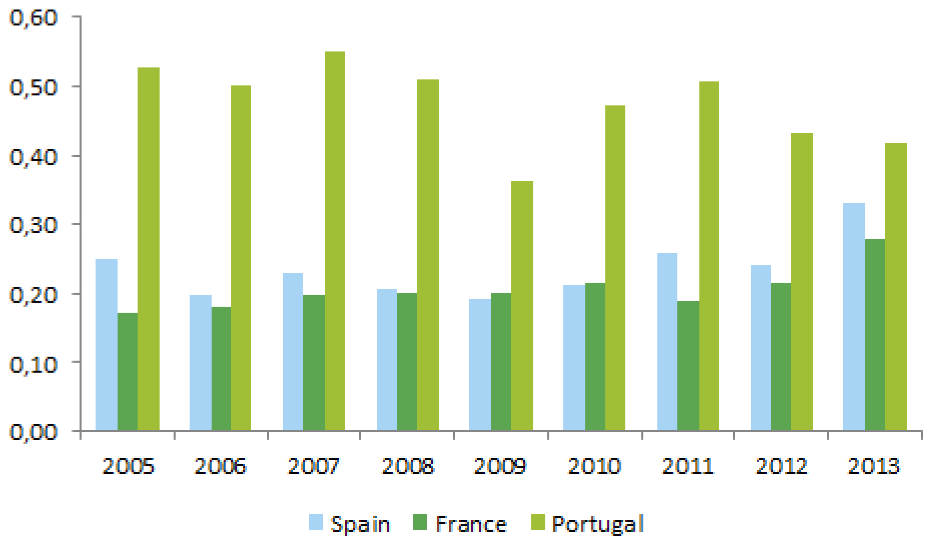


Figure 3-23 Gas market concentration South-West Europe by supply countries Source: Eurostat

Spain has traditionally received most gas from North Africa, initially from Libya, later on from Algeria. Further, Spain was pioneer to develop the global LNG market. At present there are many suppliers also from South America and Sub-saharan Africa.

Norway is an important gas supplier with more than 3 bcm/y as part of the Troll agreement.

Figure 3-24 The Spanish and Portuguese natural gas network (Source: Entso-G)

Most gas to Portugal was originally supplied via Spain with the construction of an interconnector pipeline as part of the Maghreb-Europe system. Later one additional interconnector has been established and an LNG import terminal in Sines with a capacity of more than 5 bcm/y.

France has a diversified system and most gas is supplied by pipeline from Norway and from Russia. Further, gas is supplied by pipeline from the Netherlands via Belgium, some as low calorific gas. LNG is mainly supplied from Algeria, Nigeria and Qatar. Some of this supply is associated with suppliers participating in upstream activities in particular in Nigeria.

In the overall French gas balance it is assumed that there will be high flow into the system from Norway in Dunkerque as there is insufficient capacity in the Norwegian system to move gas to other points. The minimum expected input from Norway is more than 10 bcm as Norway would otherwise have to reduce production from their offshore fields.

Figure 3-25 The French natural gas network (Source ENTSO-G)

The French system uses odorisation in the gas transmission system, while Germany has odorisation in the distribution system. This means that it is not at present possible to have physical flow from France to Germany. However, a new pipeline has been constructed to connect France and Belgium allowing for flow of gas before odorisation.

The overall balance of the French gas transmission system is shown below.

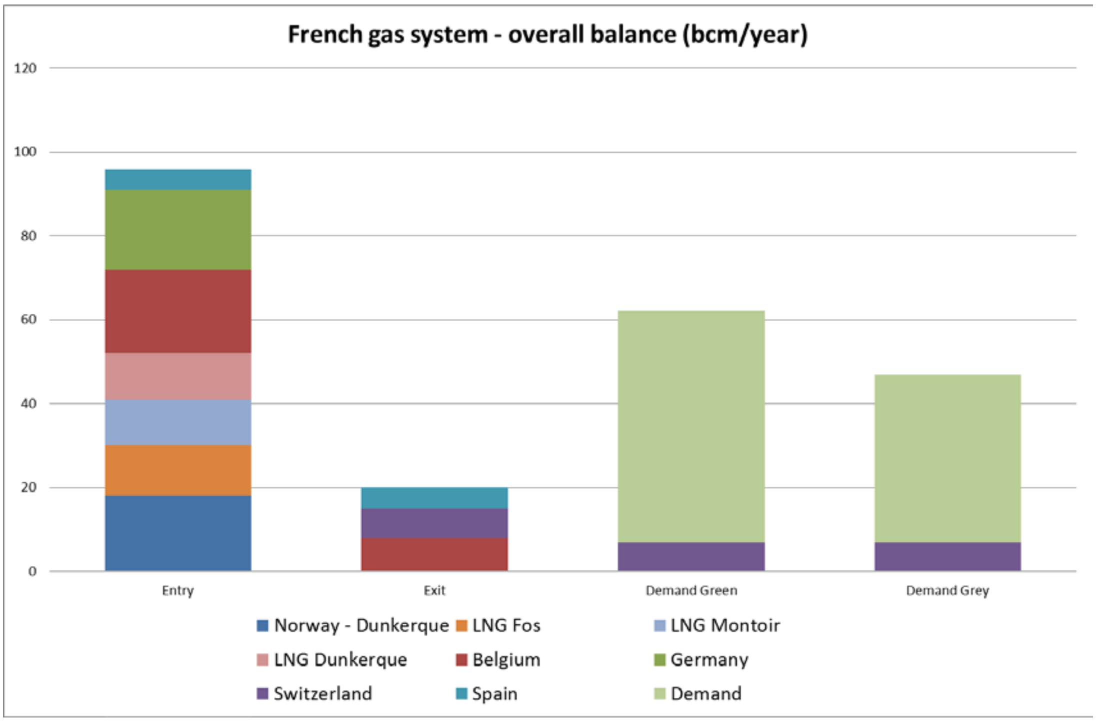


Figure 3-26 The French gas system - overall balance (bcm/y)

Import from Dunkerque via Franpipe is assumed to be fixed as there is no alternative possibility for export of Norwegian gas with the present Norwegian system.

With maximum use of the LNG import facilities, there will be surplus capacity for the Grey demand scenario, without import from Germany (Russia) and Belgium (The Netherland, Norway or UK).

In the Green demand scenario, there will be space for more than 5 bcm even in a situation with maximum use of the French LNG import. Hence, the demand situation in France is important for the possible use of interconnector from Iberian Peninsula.

3.8 Gas prices and contracts

Different gas prices, transportation fees and contractual obligations are influencing the physical and contractual flow of the gas transmission systems. Some of these prices are publically available, while some are kept confidential such as long term gas supply contracts including indexation and take-or-pay obligations.

Natural gas prices internationally diverged from 2010 due to oversupply of shale gas in USA and from 2011 due to the Fukushima nuclear accident in Japan. From 2014, the difference between Asian and European prices disappeared to converge fully in 2015. However, still more than the double of US prices.

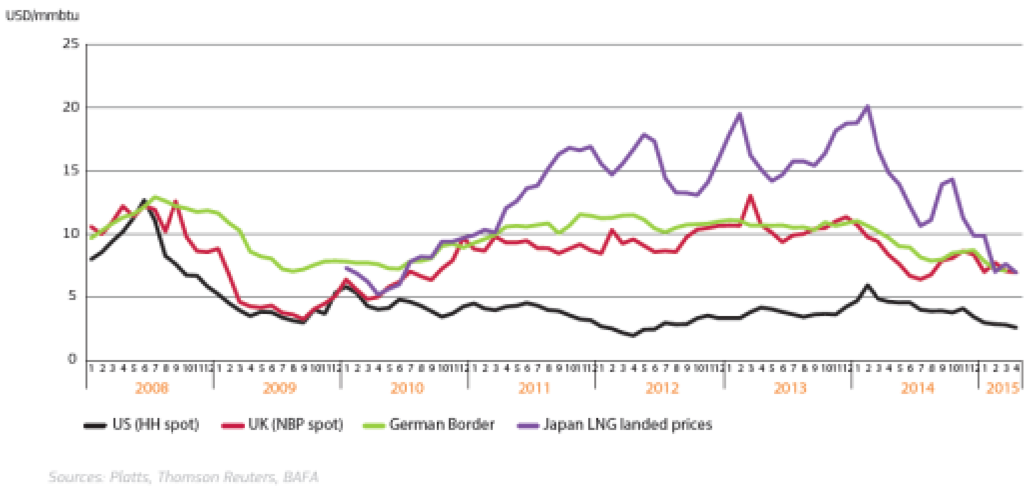


Figure 3-27 International gas prices – comparison and impact (sources: Platts, Thomson Reuters, BAFA)

Without difference between Asian and European prices, it is more likely that gas LNG will be shipped to Europe.

The spot prices for gas in EU are shown below. The high Spanish LNG prices is one reason for low utilisation of the Spanish LNG terminals and net flow from France to Spain.

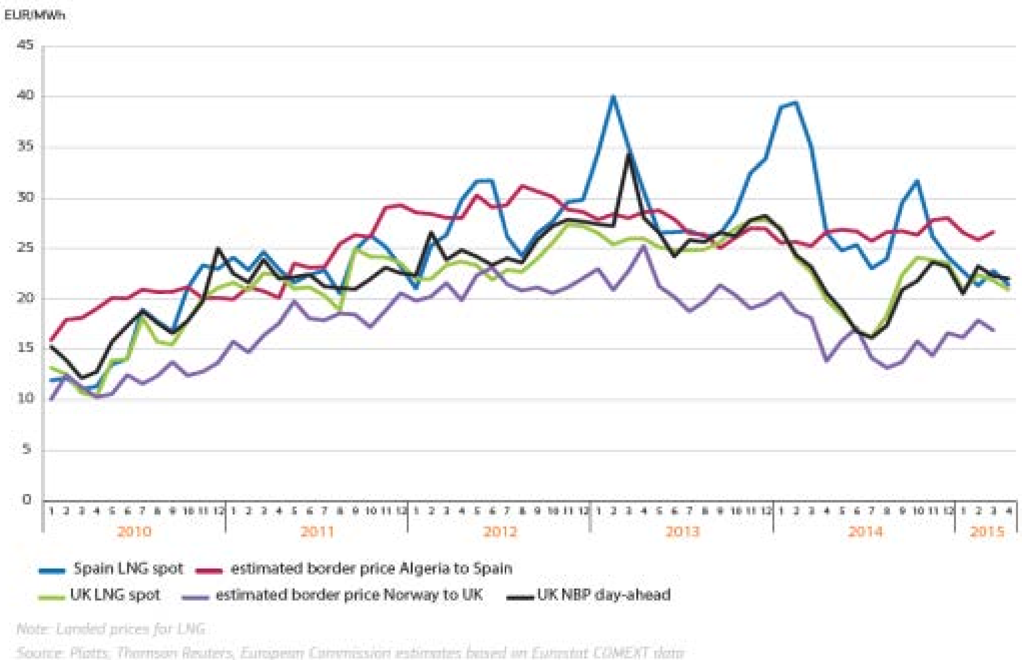


Figure 3-28 Landed prices for LNG (source: Platts, Thomson Reuters, European Commission)

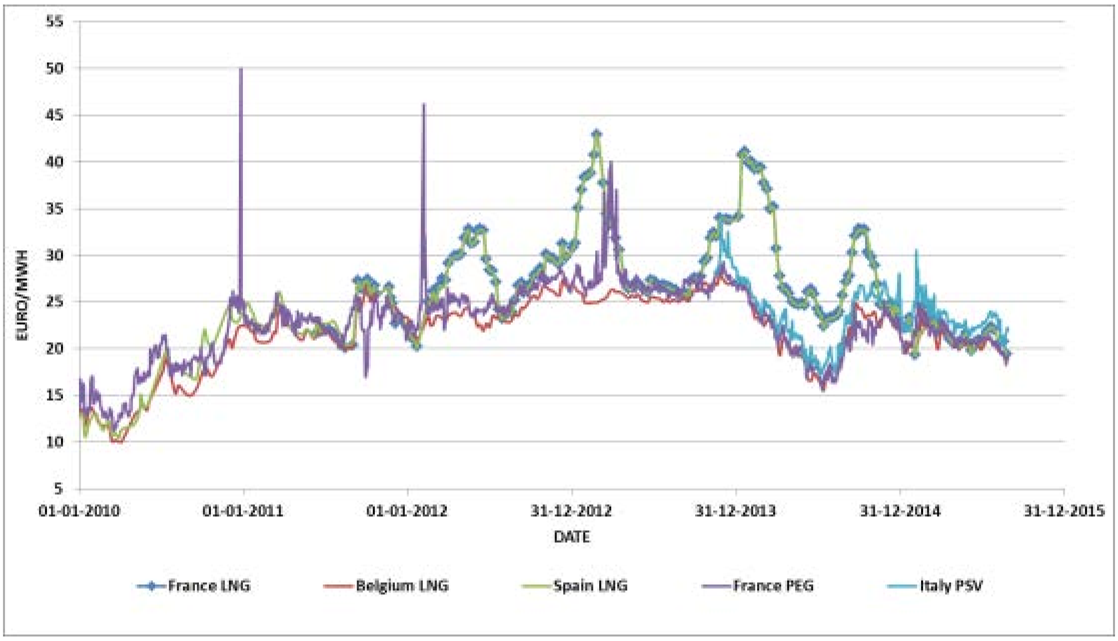


Figure 3-29 Energy prices converge in South Europe

From mid-2015 the prices converge in South Europe. One of the consequences has been that the net flow in the interconnector between Spain and France has been reduced.

4 Transportation tariffs

4.1 French regulated transportation tariff overview and comments

4.1.1 *Overview*

The tariff system in France is based on an entry exit system with regulated tariffs as basis. The exit points to the system are located on the borders. The system is divided into two transmission systems, GRTGaz and TIGF. With respect to transmission tariffs the system is divided into a North and a South zone, where the South zone from 2015 is merged between GRTGaz Sud and TIGF. It is planned that entire France will be merged into one zone from 2018.

The entry points to the French system are pipeline connection points from Norway, Belgium, Germany and Spain. From 2018 there will also be an entry point from Switzerland when the TENP system will have reverse flow capability and open for delivery of gas from TAP via Italy.

The exit points are towards Switzerland and Spain. From 2015 there will further be an exit point towards Belgium to be used for gas from the new Dunkerque LNG terminal and Franpipe, before adding odorant. The policy for odorisation is the reason why there is no exit possibility towards Germany. There are no direct connections between France and Italy.

At some entry and exit points it is possible to have reverse flow. The general tariff for reverse flow is 20 per cent of forward flow, except for the new connection to Belgium in Alveringem.

The tariffs are as follows for yearly products:

Point for entry or exit of gas	Country	Entry/exit	Tariff EUR/MWh/day/year	Interruptible coefficient
Taisnières B	Belgium	Entry	88.82	50%
Taisnières H	Belgium	Entry	114.19	50%
Taisnières H	Belgium	Reverse flow	22.838	
Dunkerque	Norway	Entry	114.19	50%
Obergailbach	Germany	Entry	114.19	50%
Obergailbach	Germany	Reverse flow	22.838	
Montoir	LNG	Entry	107.84	N/A
Fos	LNG	Entry	107.84	N/A
Dunkerque GNL	LNG	Entry	107.84	N/A
Oltingue	Switzerland	Exit	398.39	75%
Oltingue	Switzerland	Reverse flow	79.678	
Oltingue	Switzerland	Entry	From 2018	
Jura	Switzerland	Exit	98.61	75%
Jura	Switzerland	Reverse flow	19.722	
Alveringem	Belgium	Exit	45.00	N/A
Alveringem	Belgium	Reverse flow	56.25	
PIRINEOS	Spain	Entry	114.19	75%
PIRINEOS	Spain	Exit	496.39	75%
North to South	France		208.04	50%
South to North	France		50.00	50%
Exit main network	France	Exit	93.75	50%

Table 4-1 Entry and exit tariffs in France 2015

For monthly and daily products there are different rules. In general, the monthly entry tariff is 1/8 of the yearly tariff, this is also the case for the PIRINEOS, the interconnection point between France and Spain. For exit from the main network, the monthly tariff depends on the season with the highest payment during winter.

4.1.2 *Impact of establishing one zone in France from 2018*

The French gas transmission system will be unified into one zone from 2018. This will most likely result in an increase in the border tariffs for the exit to Spain.

The French regulator will start a process to establish the future tariffs, but the process is only being started. A future network code is expected in 2017.

One of the main issues is the allocation of cost for new infrastructure. As an example, the Eridan pipeline was assumed to be split equally between the North-South merger and the Midcat during the open season in 2010. Now the regulator assumes that the full cost is allocated to MidCat, as it has not been found necessary to establish the Eridan project as part of the creation of one zone.

4.1.3 *Assessment of French transmission system*

The French tariff system is a pure capacity based system. The tariffs system has an almost uniform entry tariff from pipelines and LNG for firm capacity. However, for interruptible capacity the PIRENEOS tariff is higher than for others as the factor on firm capacity is 75%, while it is 50% for other entry points. This means that the tariff for interruptible capacity is quite high which may hinder use of capacity.

For exit tariffs the PIRENEOS has by far the highest tariff, which is around 400 EUR/MWh/day/year higher than delivery to exit points inside France and for delivery to the Jura exit point towards Switzerland. This is a substantial difference, which with a constant flow results in transportation tariff of more than 1 EUR/MWh. If only monthly products are used with a load factor of 50%, the transportation cost will be more than 3 EUR/MWh.

As the historical gas transmission via the PIRENEOS has been from North to South it could be argued that the reverse flow tariff used for other entry points of 22,838 EUR/MWh/day/year should be used at this point instead of the normal entry tariff of 114,19EUR/MWh/day/year. This would make it more attractive to import gas from Spanish LNG plants and pipeline towards France, and hence also reduce the congestion in the French system.

The tariffs for using the Iberian pipelines in the French system are clearly very high as compared to use of the system for ingenious use, and the system hereby counteracts the use of the interconnectors.

The French system is very large with few entry and exit points towards neighbouring countries and limited transit volumes. The gas consumption per area is low compared to countries like the Netherlands, Belgium, Italy and UK. With a wish to create very large exit zones, only two zones from 2015 and only one zone from 2018, there will be cross subsidies among gas consumers. If the same principles are used when the one zone principle is introduced in 2018 there may be even higher barrier for use of the Iberian pipelines than today.

The entry-exit system of France will by far be the largest in the EU in terms of area. Although the ultimate goal of the EU may be to create a single zone, it is well known from the literature that very large entry-exit zones may create problems. Reference can be done to a recent paper by Dr. Harald Hecking http://www.naturalgaseurope.com/images/ewi%20Policy%20Brief%20-%20Rethinking%20entry%20exit.pdf

When long-term bookings have been made for gas transmission, the shipper may choose only to make a short term marginal cost consideration, at least when he has spare capacity. However, there is no reason for him to do so if competitors have to book short term capacity at a higher cost.

To our knowledge correct that the unified French gas transmission system will be in accordance with the European Gas Target Model (EGTM). However, it should be kept in mind that EGTM also says that “As a general rule, entry-exit zones should not be defined on the basis of national boundaries, but based on physical realities and market needs.”

In “Network Code on Harmonised Transmission Tariff Structures for Gas” July 2015, it is as a general rule said that “Where the entry-exit split is used as a parameter of the reference price methodology, it shall be equal to 50/50, unless otherwise set or approved by the national regulatory authority”.

4.2 Spanish regulated transmission tariffs overview and comments

The Spanish gas transmission system is an entry exit system with regulated tariffs. The tariffs were most recently updated in 2014 and no update took place in 2015.

Figure 4-1 Spanish gas transmission system (Source: Enagas)

The main entry points to the system are the Tarifa and Almeria pipeline with gas from Algeria and the VIP PIRENEOS (Larrau and Irun pipelines) from France and the six LNG terminals. There are exit points to Portugal, where the most important is Badajos and the northern point of Tuy, regulated as a virtual exit point VIP Portugal.
The entry tariff is 1.0848 cent/kWh/day/month Gas in kind (applied at entries): 0.2%. If we recalculate this to the same unit as for the yearly capacity used in France, this will with a load factor of 100 per cent be 130 EUR/MWh/day/year plus a commodity charge of 0.2%.

For the export there is a capacity element of 2.0060 cent/kWh/day/month and a commodity term 0 cent/kWh, which corresponds to 240,72 EUR/MWh/day/year. For export there are special favourable conditions with a factor 0.7 on the normal exit tariffs and zero commodity charge. The normal exit conditions for systems with a pressure above 60 bar are 2,8658 cent/kWh/day/month plus a commodity charge of 0,0615 cent/kwh, corresponding to 343,9 EUR/MWh/day/year plus 0,0615 cent/kwh.

The Spanish tariff system with only one zone has the same problem as the French system; that a very large zone will give relatively high entry and exit tariffs to the system. The Spanish system has given some incentives to export by having a factor of 0.7 on the export and no commodity charge.

The entry tariff to Spain is a little higher than the corresponding French tariff, while the exit for export is substantially lower than the French tariff.

4.3 Tariff barrier for use of interconnection between Spain and France

To illustrate the tariff barrier for use of the interconnector between Spain and France, a number of calculations have been made for firm capacity:

- Supply of gas from Northern Europe with pipeline entry into France to and including exit from the main transmission system in respectively TIGF area and in Spain and including regional transmission and delivery
- Supply of gas from Algeria with pipeline entry into France to and including exit from the main transmission system in respectively TIGF area and in Spain and including regional transmission and delivery
- Supply of gas from respectively LNG terminals in France and Spain to and including exit from the main transmission system in TIGF area

The main results for a load factor of 100 per cent are as follows:

	Capacity	Capacity	Commodity		Transport of 1 MWh/day, 100% load factor			
	cent/kwh/day/m	EUR/MWh/day/yea	percent	EURO/MWh	France-Spa	France-Fra	Spain-Spai	Spain-Fran
Entry France - pipeline		114,190			114,190	114,190		
North-South		208,040			208,040	208,040		
Exit PIRENEOS, France		496,390			496,390			
Exit Spain	2,0060	240,720	0,00%	0,0000				240,720
Entry PIRENEOS, France		114,19						114,19
Entry Spain	1,0848	130,176	0,20%	0,0400	144,776		144,776	144,776
Exit main system TIGF		93,750				93,75		93,75
Regional transmission		62,740				62,740		62,740
Delivery, France		23,690				23,690		23,690
Exit main system Spain (1.3)	2,8657	343,884		0,615	568,359		568,359	
Total					1531,755	502,410	713,135	679,866
Per MWh					4,20	1,38	1,95	1,86

Table 4-2 Transportation tariffs for delivery to Spain and France for pipeline supply (Source: own calculations)

	Capacity	Capacity	Commodity		Transport of 1 MWh/day, 100% load factor			
	cent/kwh/day/m	EUR/MWh/day/yea	percent	EURO/MWh	South LNG	Spain LNG		
Entry France LNG		107,84			107,840			
Entry Spain	1,0848	130,176	0,20%	0,0400		144,776		
Entry PIRENEOS, France		114,19				114,19		
Exit Spain	2,0060	240,720	0,00%	0,0000		240,720		
Exit main system TIGF		93,750			93,750	93,75		
Regional transmission		62,740			62,740	62,740		
Delivery, France		23,690			23,690	23,690		
Total					288,020	679,866		
Per MWh					0,79	1,86		

Table 4-3 Transportation tariffs for delivery in France from LNG terminals in respectively France and Spain (Source: own calculations)

This high exit tariff from France at PIRENEOS result in a tariff difference for pipeline gas delivered from respectively France and Spain in Spain of 2.25 EUR/MWh. In the opposite direction, the difference is smaller 0.48 EUR/MWh.

For LNG delivery from regasification plants in respectively Spain and France, the difference in tariffs is 1.07 EUR/MWh. Here the difference in regasification itself has not been included.

The high tariff in particular from French to Spain creates a competitive advantage for e.g. industrial users north of the border, who will receive indirect subsidies from other French consumers due to the large zones. With unification of the French system this will be even larger. The high tariff from France is reflecting the cost of long transportation distance from the Northern entry points in Northern France

4.4 Auctioning of capacity, CAM, Capacity Allocation Mechanism

In addition to the regulated tariffs there will be auctioning according to the EU CAM rules which officially came into force from 1 November 2015. According to the CAM rules, bundled capacity will be offered at the border point securing access on both sides of the border. Auctioning will be held for yearly, quarterly, monthly, daily and within-day products. The payment of transportation will be the regulated tariffs plus the result of the auctioning.

4.5 UBI (Use-it-and-Buy-It) capacity offer

According to TIGF "The "Use-It-and-Buy-It" (UBI) offer allows a Shipper to request additional capacities over and above its subscriptions (firm and interruptible). These capacities can be allocated to it (in whole or in part) if another Shipper does not use all of its capacities on a given day." UBI is only offered in the forward direction of the PIRENEOS border point from France to Spain and not in the opposite direction.

4.6 Use of gas storage in South of France for Spanish gas

Spain has only very limited gas storage of 2.5 bcm, while France has more than 12 bcm of storage facilities. It would hence be obvious to use the large storage in the TIGF area in France for storing Spanish gas.

However, the average cost of crossing the border from south to north during injection and from north to south during withdrawal adds up to very high level depending on the actual use.

With a load factor of 50 per cent, which is high, this would add up to more than 5 EUR/MWh.

	Capacity cent/kwh/day/m	Capacity EUR/MWh/day/yea	Commodity percent	EURO/MWh	Withdrawa	Injection		
Entry PIRENEOS, France		114,19				114,19		
Exit Spain	2,0060	240,720	0,00%	0,0000		240,720		
Exit PIRENEOS, France		496,390			496,390			
Entry Spain	1,0848	130,176	0,20%	0,0400	144,776			
Total					641,166	354,910		
Per MWh					1,76	0,97	2,73	
Load factor 50%					3,51	1,94	5,46	

Table 4-4 Tariff calculations for use of gas storage in South of France from Spain

4.7 Enagas examples on impact of LNG terminal and transportation tariffs

Enagas has carried out a number of calculations of transportation tariffs and use of LNG terminals in respectively France and Spain. One example for supply to the TIGF area is shown below. It can be seen that it will be cheaper to supply gas from the French LNG terminals than from Spanish terminals due to the transportation tariffs, even though Spanish LNG terminals are cheaper than French terminals.

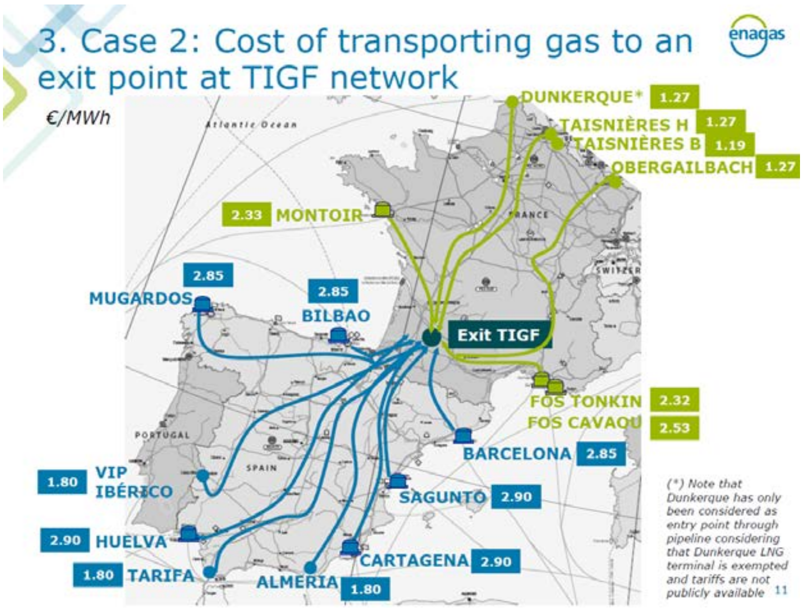


Figure 4-2 Tariff calculations for delivery in south-west of France from different delivery points in France and Spain, including LNG regasification – (source: Enagas)

The example also illustrates that is may be an advantage to reload LNG from Spanish terminals rather than to use the pipeline systems, even as reverse flow.

4.8 Conclusions on tariffs

- The present tariff system in France and Spain constitutes a major barrier for transportation of gas and creation of competitive market for gas on the Iberian Peninsula
    - The transmission tariffs with high cost for crossing the border from France to Spain creates a barrier for transportation of gas from North to South and consequently there will be impact on the price formation.
    - The south-north tariffs are establishing cost differences for import of LNG from Spanish and French LNG terminals and may hereby limit the transportation across the border from south to north. This is one reason for bypassing Iberian LNG terminals.
    - Use of gas storage in South of France for Spanish LNG is made impossible due to the transportation tariffs across the border
- The one zone policy in France will further increase the border tariffs
- The tariff system result in competitive advantage for e.g. industrial users north of the border as compared to Iberian users during situation with flow from North to South, which has been the situation for the last years.
- Tariffs for interruptible capacity across the border between France and Spain have a smaller rebate than for entry tariffs and for exit tariffs from the main system in France.
- Possibility for an integrated entry-exit system between France, Spain and Portugal should be evaluated to create full integration.

5 Interconnectors – identifications and technical solutions

5.1 Technical solutions for additional interconnectors

The present chapter describes the identified technical solutions for additional interconnectors between the Iberian Peninsula and the rest of Europe. During the inception phase, it was decided to focus on the already identified projects as described in the open season in 2010. Focus of the description is to identify cost and time as input to the cost benefit analyses and comparison of technical solutions.

The basis for the description is a shared technical report between the three gas transmission companies Enagas, TIGF and GRTGaz. In addition, Ramboll has made own technical estimates, but no full pre-feasibility for the identified projects have been made by the promoters. The shared study has been made based on already existing technical solutions, which in some cases are back to 2010. Consequently, there is a need for updating such work with respect to technical solutions, environmental impact and authority approval.

Eventually the goal with increased interconnector are to be able to transport gas from the LNG terminals and pipelines in Spain to France and further on to Germany and Central European countries, which are now depending on import of Russian gas without direct access to the global LNG market and to transport gas from the integrated EU gas system to Spain and Portugal and hereby integrate these two countries fully into the EU system.

5.2 Existing interconnectors between Spain and France and agreed network additions

At present there are two pipeline interconnectors between France and Spain:
- Larrau, DN650 mm pipeline (26”) with a design pressure of 80 bar
- Biriatou, DN600 mm pipeline (24”) with a design pressure of 80 bar

Figure 5-1 Existing pipeline interconnectors with indicative route for MidCat first phase

The combined capacity of the two pipelines are 170 GWh/d (14.8 mcm/d) from Spain to France and 165 GWh/day (14.3 mcm/d) from France to Spain. From 1 December 2015, the capacity was increased to 222 GWh/day from Spain to France. The first pipeline was built back in 1990´ies to transport gas from Norway to Spain under the Troll agreement.

Gascogne-Midi project

It has been decided to strengthen the connection by the Gascogne-Midi project, with TIGF as promoter.

Figure 5-2 Prospective development programme for TIGF's gas transmission network 2014-2024 (source TIGF)

After the implementation of this project the capacity of the existing pipelines can be increased and there will be more flexibility between West and East of France, which may also impact possible solutions for strengthening of the French gas transmission system.

Merger between North and South Zone in France – Val de Saône pipeline

The merger between the North and South zones in France is on-going by establishing the Val de Saône pipeline.

The project consists in the looping of the Burgundy pipeline (189 km, DN 1200) between Etrez and Voisines in Eastern France. The cost of the pipeline is estimated to 744 million EUR, corresponding to an average cost of almost 4 million EUR per km, illustrating the relative high pipeline construction cost in France.

Figure 5-3 Val de Saône pipeline (Source GRTGaz and Ramboll)

The project is now being approved by authorities, and it is assumed that the pipeline will be constructed during 2015 and 2016 and taken into operation in 2017.

5.3 France-Spain interconnector - Eastern corridor - definitions

5.3.1 *MidCat definitions*

An eastern corridor has been evaluated for decades between France and Spain. Initially this goes back to the development of the Maghreb-Europe pipeline from Spain in the early 1990´ies. In recent years, the MidCat name has been used for this pipeline although the definitions have not always been clear.

In the regional development plan GRIP 2010 report the following definition was used: “The MidCat Project involves the development of a full corridor (Eastern) between Spain and the North of France, by the association of a new interconnection point (Le Perthus sub-project), the GRTgaz South-TIGF subproject and the expansion of the interconnection capacity between GRTgaz North and GRTgaz South (GRTgaz North-GRTgaz South subproject).”

In 2015 the three companies Enagas, TIGF and GRTGaz carried out a common study for the MidCat project. Here two steps were considered:

- MidCat first step
- Full MidCat

The following parts were included in the definitions.

TSO	Infra nbr	Pipeline / Compression	Diameter / Power	Length	Cost (M€) **
GRTgaz	1	Midi	DN1050 - PMS 80b	200 km	
	2	CS St-Martin (new)	30 MW		
	3	Eridan	DN1200 - PMS 80b	220 km	591,51
	4	CS St-Avit	+15 MW		
	5	Arc Lyonnais	DN1200 - PMS 80b	150 km	435,57
	6	CS Palleau (new)	50 MW		
	7	Perche	DN900 - PMS 68b	63 km	
TIGF	8*	Barbaira - Border	DN900 - PMS 80b	120 km	320,00
	9	Midi	DN1050 - PMS 80b	40 km	
	10	CS Barbaira	7 MW		
ENAGAS	11*	Figueras - Border	DN900 - PMS 80b	25 km	29,06
	12*	Hostalrich - Figueras	DN900 - PMS 80b	79 km	80,69
	13*	CS Martorell	36 MW		41,75
	14	Loop Tivissa - Arbos	DN740 - PMS 80b	114 km	96,77
	15	CS Tivissa filters			0,38
	16	CS Arbos	+5 MW		0,43
	17	Loop Villar de Arnedo - Castelnou	DN640 - PMS 80b	214 km	160,63
	18	CS Zaragoza	+21 MW		4,50

(*) : infrastructures related to 1st Step MidCat
(**) : Cost information extracted from ENTSOG 2015 CBA completed by information from ENAGAS

Figure 5-4 The full set of infrastructures as defined by the TSOs in the context of the study (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF)

The table illustrates the pipeline dimensions in mm, operational pressure in bar and power of the compressor stations in MW. Further cost estimates are included for some sections.

It can be seen that the first step of the pipeline will only include the 224 km long section from Hostalrich via Figueras to the border and further to the compressor station in Barbaira close to Carcassonne.

The other parts of the project as defined in the table partly have as an objective to transport gas from/to the interconnector partly other purposes such as generally develop the gas systems in the two countries.

In the shared report the following influence zones are given together with possible pipeline routes in France and Spain. However, other alternative routes are also possible.

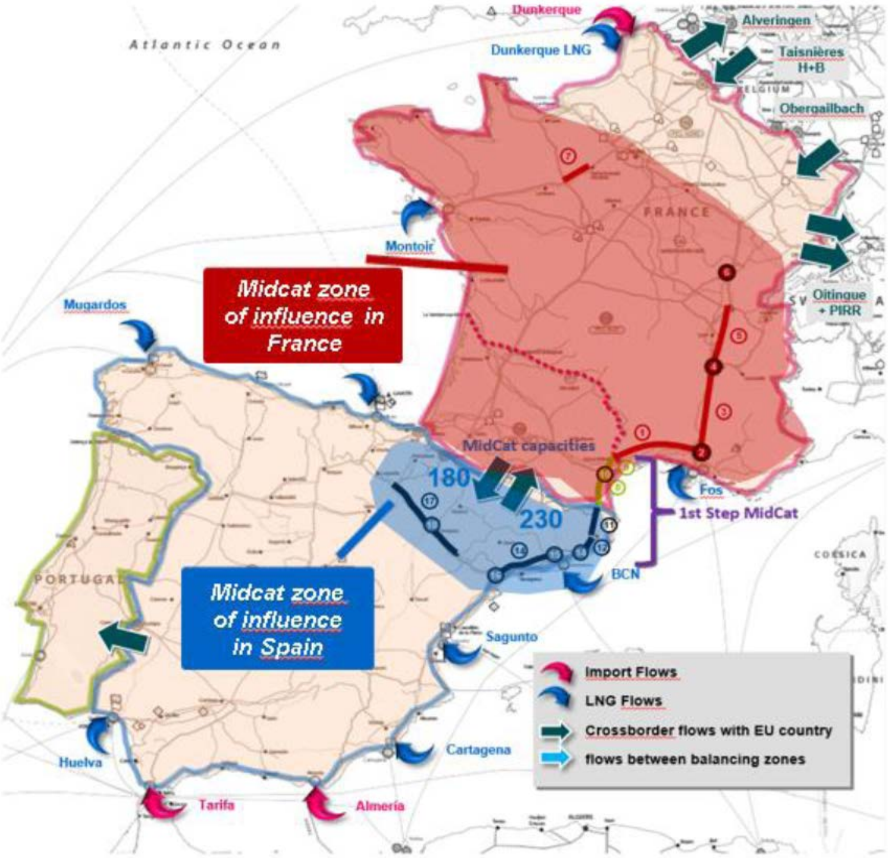


Figure 5-5 Zones of influence of the MidCat project in Spain and France according to the understanding of each TSO, and the phased infrastructures considered (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF)

The original definition of MidCat goes back in time and may create misunderstandings among stakeholders and uncertainty about technical solutions, purpose and cost. This is because some of the elements of the original definition have already been implemented. Further elements like Eridan pipeline can be used together with the interconnection to Spain, but as well to supply South Eastern France instead of supply from LNG terminal. Also, more options are possible for transportation of gas from South to North of France, and for the one shown above there is only one possibility. No detailed routing for the first phase has been made available.

We will therefore recommend renaming the pipeline and defining the first stage of MidCat without necessarily using the original capacity, size or routing. To make the project easily understandable, we suggest renaming the section with a unique name which can be understood by stakeholders and the public: Girona-Carcassonne gas interconnector.

5.3.2 *MidCat – first phase – Girona-Carcassonne*

MidCat First phase – Girona-Carcassone – description and assessment

In the joint study between Enagas, TIGF and GRTGaz the following elements are included in the project:

On the French side, a 120 km long pipeline between the existing compressor station of Barbaira, close to Carcassonne, and Le Perthus at the border to Spain. On the Spanish side the MidCat consists of a 104 km pipeline between Hostalric, south of Girone, via Figueras to Le Perthus, and a 36 MW compressor station in Martorell close to Barcelona.

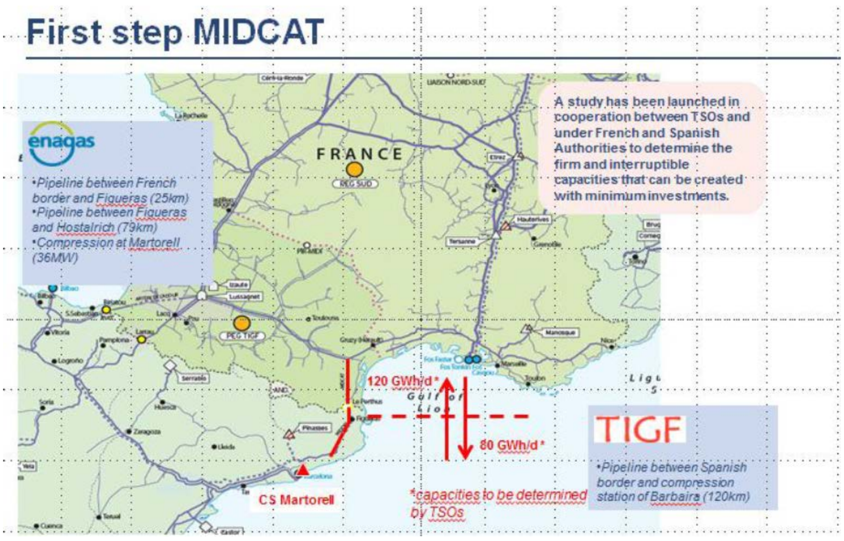


Figure 5-6 First step MidCat – (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF)

The pipeline diameter is 900 mm, which is a medium size transmission pipeline with a design pressure of 80 bar similar to the design pressure of adjacent pipeline systems in France and Spain.

The costs of the pipelines are estimated by the two TSOs; TIGF on the French side and Enagas on the Spanish side to 429 MEUR and further 42 MEUR for the compressor station. Review of the cost estimates is ongoing.

The route selection, dimensioning and cost estimation is based on existing information carried out by Enagas and TIGF as part of an open season 2010 project. Optimisation of dimensions and alternative routing, including offshore, has not been carried out.

TSO	No	Component	Diameter/Power	Pressure (bar)	Length	Cost (MEUR)
TIGF	8	Barbaira-Border	DN900	80	120 km	320
Enagas	11	Figueras-Border	DN900	80	25	29
Enagas	12	Hostalrich-Figueras	DN900	80	79	81
Enagas	13	Compressor	36 MW	80		42
						472

Table 5-1 First phase of infrastructure, MidCat Girona-Carcassonne

It has not been possible to obtain detailed routing of the pipeline as only preliminary studies have been performed to the identification of several alternatives. Additional field work and analysis need to be conducted in order to select the final route. Also, the cost estimates are based on work done before the open season in 2010 and has not been updated as part of the shared study.

On the French side, the route may include crossing of wine yards and is exposed to severe environmental constraints. This may impact the cost of the pipeline.

It is Ramboll´s assessment that the cost estimates for the pipeline is very high on the French side, which may be because of cost or right-of-way. On the Spanish side, the cost seems to be very low. As can be seen from the table above, the average cost per kilometre of pipeline varies between 2.7 MEUR in France and 1.0 MEUR/km in Spain. The difference in terrain should not justify such large difference in cost. Also, the cost of the compressor station in Spain seems low. This demonstrates that additional technical maturing of the pipeline system is necessary. This should also include a unified approach to cost estimation.

Capacity share study by Enagas, TIGF and GRTGaz

Whereas the infrastructure of the MidCat first phase is located entirely on the territory of respectively Enagas in Spain and TIGF in France, the capacity will also depend on the conditions of the GRTGaz system in France.

The available capacity will depend on the climatic conditions and hereby indigenous gas consumption, use of gas fired power plants (Combined Cycle Gas Turbines), underground gas storage injection and withdrawal levels and input from LNG terminals and pipelines. Some of these parameters are natural variations, while some are market based.

For assessing the capacity, a number of scenarios were developed. For climatic conditions this included a peak demand (defined as the coldest day in 20 years in Spain, respectively 50 years in France) and average winter and average summer conditions. For use of CCGT it includes use of 50% of the French plants and in Spain a number of plants used to meet climatic conditions.

For the output from underground gas storage and LNG plants there are favorable and unfavorable patterns for the increased interconnector capacity. As an example, high flow on the interconnector from Spain to France simultaneous with output form underground gas storage and LNG in South of France will create bottlenecks in the French system. On the other hand, such a flow pattern will require input from LNG plant in Barcelona in Spain. For some unfavorable cases there will be no available capacity.

The shared study was based on peak demand, average winter climate and average summer climate, respectively. In the study, a best and worst case analyses were made, resulting in full capacity of the pipeline or zero capacity, respectively. Further intermediate assumptions or conditions were made. This can be summarised as shown in the table below:

GWh/day	Spain to France	France to Spain
Best case	230	245
Worst case	0	0
Intermediate case	120	80

Table 5-2 MidCat capacity under different assumptions first phase (Source: Shared study)

The capacity for the intermediate case for first phase in the shared study is 120 GWh/day (10.5 mcm/day) from South to North and 80 GWh/day (7 mcm/day) from North to South. This capacity has been identified as capacity based on bottlenecks and assumptions for future use of the existing and planned systems, including the following conditions for flow from Spain to France:

- Barcelona LNG to supply at least 63 % of capacity in peak demand and 25% during average winter conditions
- Limitation of output from Fos LNG terminal in France, Lussagnet and Mansque underground gas storage to less than 75% of their nominal capacity in summer situation during injection.

To meet the capacity of 80 GWh/day from France to Spain there may be congestion at the entry of the network in the North of France. This will in particular be the case during summer, when there is only a very small consumption along the network in France and when there is high injection to gas storage. Here the use of MidCat will compete with capacity for filling underground gas storage in the south. The following conditions need to be met:

- Balanced entry to France from North (Germany, Belgium and Dunkerque) with entry into the LNG terminals Fos and Montoir, or
- Reduction of injection in the underground gas storage of Lussagnet, Manosque and Chemery to less than 58 per cent in case of no input from Fos, as compared to a limitation of 71% without the MidCat, or
- Barcelona LNG to supply less than 95% of nominal capacity

Technically, the ultimate capacity of the pipeline will be around 230 GWh/day (20 mcm/day), if there was sufficient capacity of the gas networks and compressors in France and Spain.

Furthermore, Enagas has carried out probability analyses of their system showing that probability to reach the 120 GWh/day is more than 98 per cent, while the full capacity of 230 GWh can be achieved for more than 80 per cent of the time. This means that the full capacity may be available as interruptible capacity even without investing in the further strengthening of the systems in Spain. The probabilistic calculations are based on historical data for use of the Spanish system. The analyses showed that the scenarios used in the shared study were very conservative.

On the French side it has not been possible to do similar probabilistic simulations as the conditions will change as part of the unification of the system and the implantation of new infrastructure. The main uncertainty about capacity is hence on the French side of the interconnector. This will be further discussed and analysed in the final report.

Capacity calculations comments and proposed additional analyses

The methodology and the assumptions used in the shared study are deemed by the TSOs to be quite conservative. We agree with this conclusion and the large variation shown between best and worst cases show that there is a need for more technical clarity and loosening of some of the constraints to fully use the capacity.

Our main comments to the assumptions and scenarios are:

- The scenarios and climatic conditions used are very conservative. By only assessing the peak winter day, average winter and average summer conditions only a small part of the year is covered. The spring and autumn seasons are not covered at all and it may be that there is most flexibility in the use of the European gas system, depending on the actual use of storage etc.

- The peak winter condition is defined differently in Spain, one in 20 years, and France once in 50 years. This implies that higher priority is given to supply in France than to the interconnector points. The choice of probability is a political issue, but in this case it gives higher security of supply for France than for other countries. We will recommend reviewing the peak demand cases to identify additional capacity not least in view of the recent years' warmer climate.
- The use of CCGT is treated differently on the French and Spanish side. In France an average use of 50 per cent of the CCGT is assumed. This seems to be rather arbitrarily and does not reflect the dynamics of the electricity market.
- No link has been established between the use of CCGT and injection and withdrawal from storage. In practise there will be less injection in storage if CCGTs are used or higher withdrawal. It does not seem as if correlation between storage use and CCGTs are used in the calculations.
- Simultaneous use of gas storage and interconnector is used in the calculations. This will most likely not be the case in practise.
- The conditions for use of existing UGS and LNG give priority to these facilities over the interconnector. As an example in the summer case it is assumed that there will be full injection in gas storage in South of France. However, the overall market incentives for use of the interconnector may be situations where the storages are already full. The actual use of storage and LNG facilities are not used in analyses only the capacities. We would recommend using hindcast analyses on how they have been used in the past, adjusted for the creation of one zone in France from 2018. This will allow for a probabilistic approach rather than the deterministic used in the shared study. Enagas has performed such analyses on the Spanish side. We would recommend doing the same on the French side.

Sensitivity of cost and capacity to pipeline diameter

One of the basic fundaments of pipeline design is the strong economics of scale. In the present case it seems as there will be large costs connected with right-of-way in France due to crossing of wine yards, complicated environmental constraints etc. Such cost will be (almost) independent of pipeline dimensions. This will also be the case for design and supervision. The main difference in cost will hence be steel material and excavation as well as pipeline transport and installation.

The cost of a DN1200 pipeline compared to a DN900 is estimated to be roughly proportional to the diameter, which means that the cost will be around 33% higher for the DN1200. The technical capacity of a DN1200 is more than the double of a DN900 pipeline - an increase of approximately 110 per cent.

The marginal cost of transportation of gas in a DN1200 versus a DN900 pipeline is hence only 30 per cent of the cost of a DN900 pipeline. Therefore, it should be considered to establish a large diameter pipeline for the first section.

MidCat - First phase - Girona-Carcassonne – offshore alternative

The initial cost indication from the French part of the first phase from Barbaira to the border is very high due to environmental constraints and compensation to landowners.

As an alternative to the traditional crossing of the eastern part of the Pyrenees with wine yards, it could be considered to choose an offshore pipeline for a certain section. Examples of such solutions are shown on the map below, also indicating that the water depth is not a problem. The main problem would be the landfalls.

Offshore pipeline for increased capacity has according to information from the TSOs not been studies as part of the ongoing shared studies or previously. However, offshore solutions are part of the electricity connection study carried out in parallel to this study.

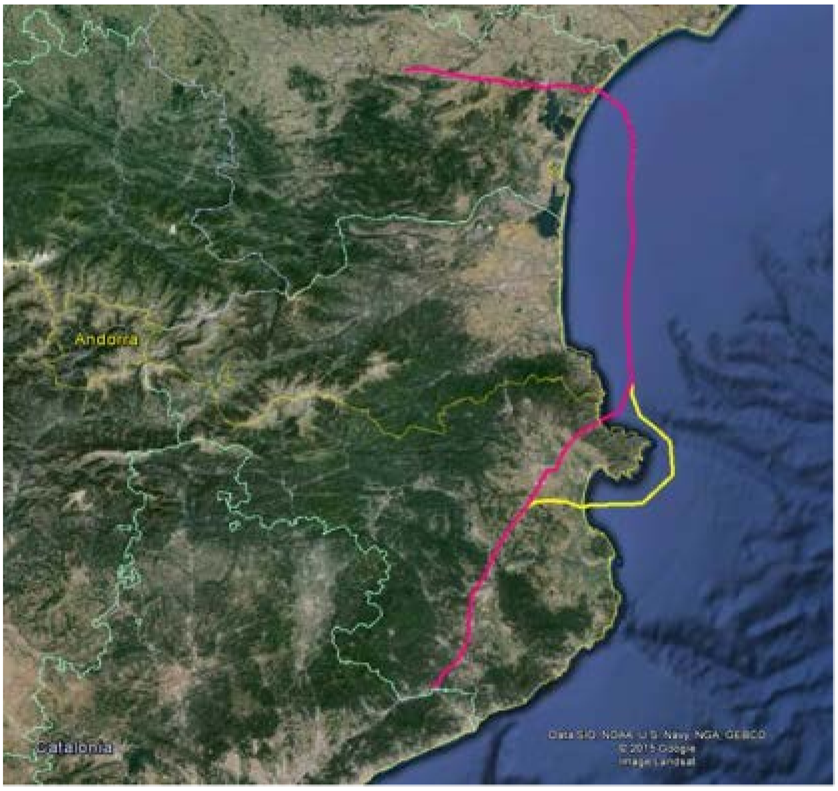


Figure 5-7 First phase of MidCat Girona-Carcassonne – offshore alternative (Source: Ramboll)

The figure above shows a possible solution with an approximately 120 km offshore section, having the same function as the proposed MidCat pipeline and connecting between Enagas and TIGF system. However, it would also be possible to have a longer offshore pipeline stretching all the way from Spain to the Fos terminal in France, bypassing the TIGF system and connecting to GRTGaz system.

The water depth in Gulf of Lion is less than 100 metres and there should probably not be any technical problems which could not be overcome. For comparison the water depth of the Medgaz pipeline is more than 2000 metres. Also, a pipeline has been constructed from the Spanish mainland to Belearic Islands. Technically an offshore pipeline has the advantage of allowing higher operational pressure and hereby higher capacity than traditional onshore pipelines.

Environmentally, offshore pipelines have been favoured in Norway instead of crossing of mountains. Typical environmental problems with offshore pipelines are associated with landfalls, flora and fauna, historical heritage as ship wrecks, ammunition. However, in most cases such issues have been overcome by detailed planning and surveys.

Economically, one advantage of offshore pipelines is that only limited land owner compensation is requested. Typically, fishermen and others with direct losses are compensated.

5.4 Full MidCat

5.4.1 *Internal strengthening of Spanish and French system*

The utilisation of the first phase of the MidCat project from Girona-Carcassonne will be restricted by the existing pipeline systems, including pipelines, LNG terminals, underground gas storage compressor stations and off-take points in Spain and France.

In the shared study, the bottlenecks have been identified, and based on different scenarios the firm capacity has been determined used a conservative approach to ensure firm capacity.

5.4.2 *Definition of full MidCat and alternative solutions in France*

The following definition of the full MidCat project is used in the shared study.

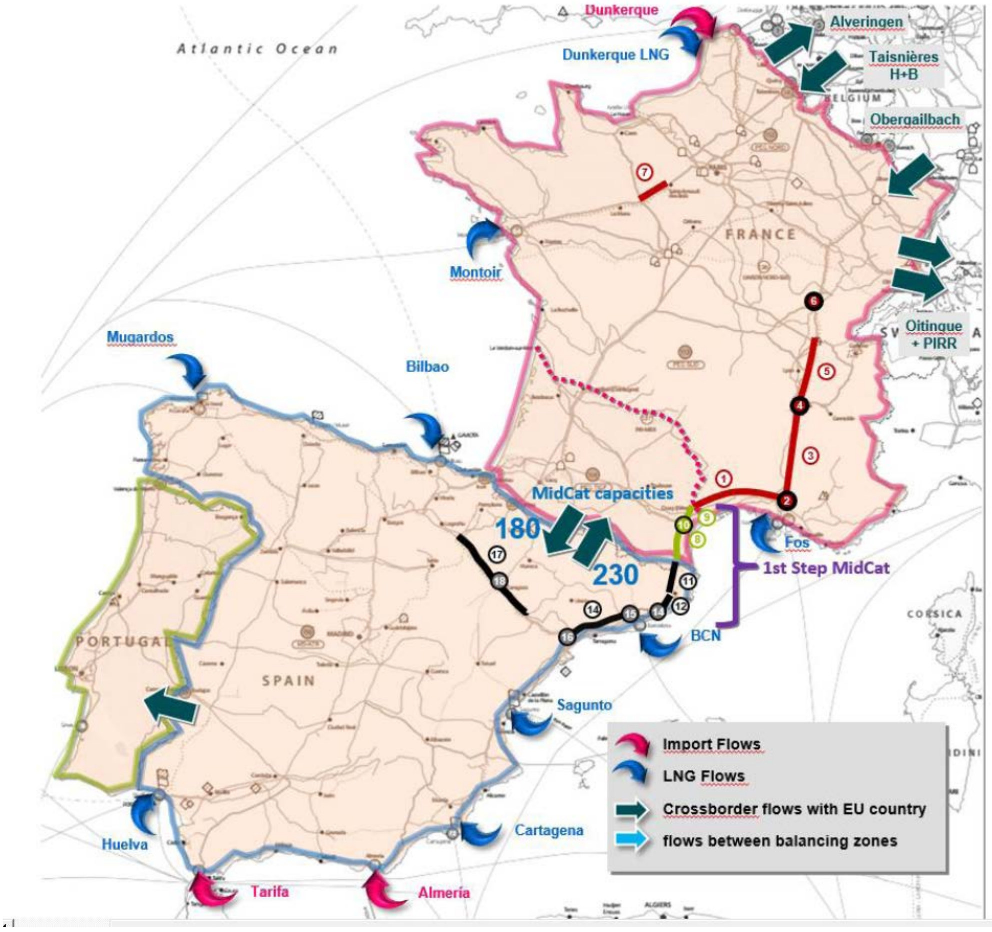


Figure 5-8 Full set of phased infrastructures considered by the TSOs in the context of the study (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF)

This definition is used to achieve a firm capacity of 230 GWh/day (20 mcm/day) from Spain to France and 180 GWh/day (16 mcm/day) from France to Spain. Further, it is assumed that the French policy of maintaining one zone as expected from 2018 is still enforced.

This eastern alternative in France was chosen because GRTgaz proposed to focus on the Eastern corridor solution, mainly for the two following reasons:

- This is the solution for which GRTgaz has already achieved several studies and obtained ministry approval for Eridan ;
- The Western corridor seems less scalable: at this preliminary stage of analysis, it seems more difficult to phase the development as the different infrastructures reach saturation almost simultaneously.

However, a western alternative is also possible as indicated below.

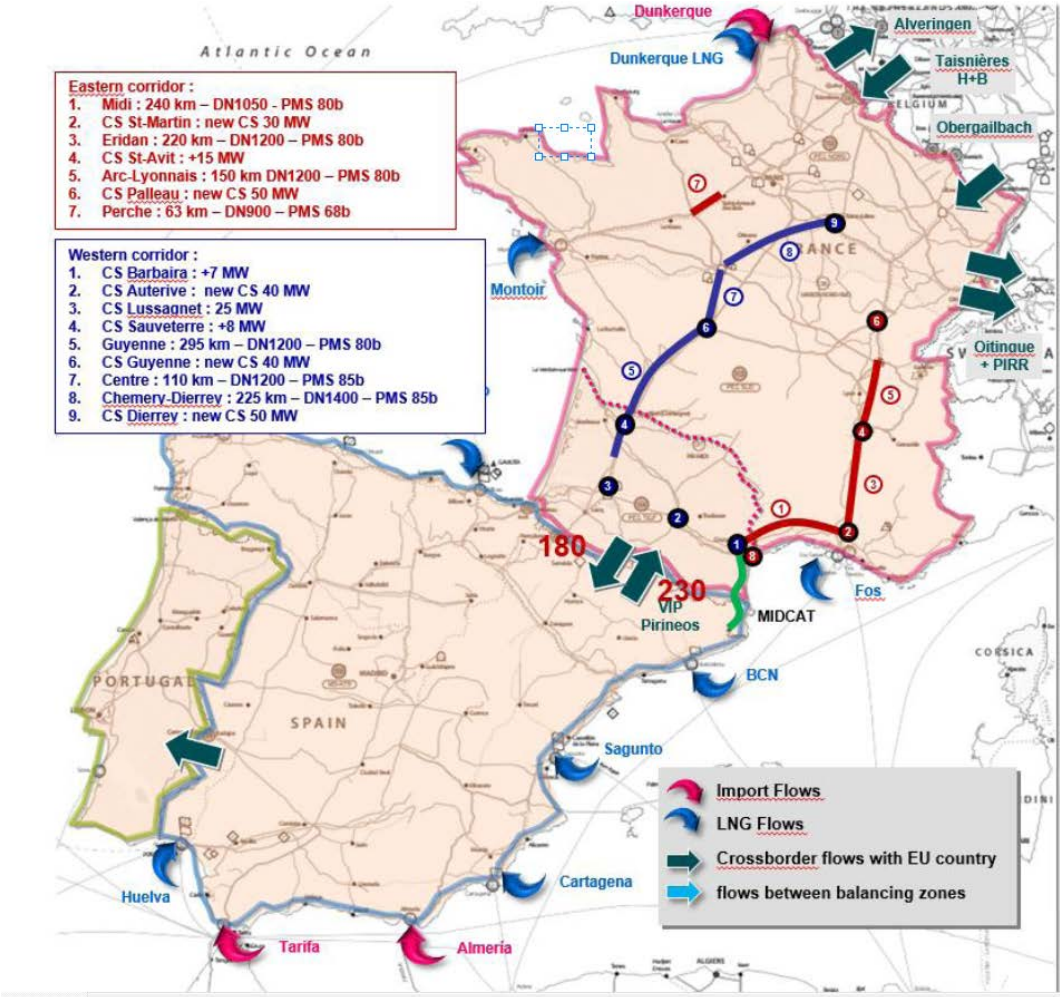


Figure 5-9 Two main corridors identified in order to achieve integration of MidCat: a) The Eastern corridor, flowing through the Rhone Valley to connect the Val-de-Saone artery; b) The Western corridor, using the western route to the Arc-de-Dierrey

The proposed solution for the full MidCat includes differences in dimensions of the different sections. The proposed large investments Eridan and Arc Lyonnais are proposed to be DN1200 pipelines which will have a capacity of more than the double as the proposed capacity of the border crossing. It is hence evidently that cost for these lines should be shared by other users in the socio-economic comparisons. This could be the expansion of the Fos LNG terminal.

Alternatively it is possible to establish the new pipelines only for some sections as this will increase the overall capacity even without a full pipeline. Here, the gas velocity in the existing parallel pipelines would set the limit for capacity.

Capacity calculations based on decremental approach

The analyses in the shared study are based on a decremental approach. It means that the starting point is the full MidCat as described above. Hereafter different parts of the full MidCat are omitted to see which limitations there will be in the system.

The target capacity is in all cases 180 GWh/day from North to South and 230 GWh/day from South to North.

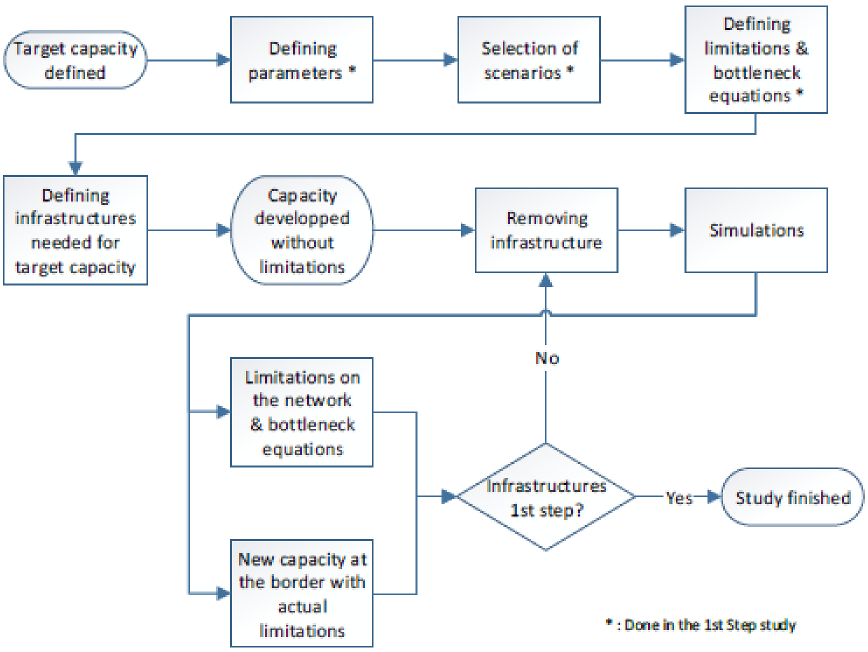


Figure 5-10 Procedure for capacity calculation full MidCat (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF)

TSO	Infra nbr	Pipeline Compression	Diameter Power	Length	Full MidCat	Decrement #1	#2	#3	#4	1st Step MidCat
GRTgaz	1	Midi	DN1050 PMS 80b	240 km	X	DN900	CS Montpellier	CS Montpellier		
	2	CS St-Martin (new)	30 MW		X	X				
	3	Eridan	DN1200 PMS 80b	220 km	X	X	X	X	X	
	4	CS St-Avit	+15 MW		X	X				
	5	Arc Lyonnais	DN1200 PMS 80b	150 km	X	X	X			
	6	CS Palleau (new)	50 MW		X					
	7	Perche	DN900 PMS 68b	63 km	X					
TIGF	8	Barbaira - Border	DN900 PMS 80b	120 km	X	X	X	X	X	X
	9	Midi	DN1050 PMS 80b	40 km	X	X				
	10	CS Barbaira	7 MW		X	X				

Figure 5-11 Elements included France in the different decrement steps (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF)

TSO	Infra nbr	Pipeline Compression	Diameter Power	Length	Full MidCat	Decrement #1	1st Step MidCat
ENAGAS	11	Figueras - French border	DN900 PMS 80b	25 km	X	X	X
	12	Hostalrich - Figueras	DN900 PMS 80b	79 km	X	X	X
	13	CS Martorell	36 MW		X	X	X
	14	Loop Tivissa - Arbos	DN740 PMS 80b	114 km	X	X	
	15	CS Tivissa filters	?		X	X	
	16	CS Arbos	+5 MW		X	X	
	17	Loop Villar de Arnedo - Castelnou	DN640 PMS 80b	214 km	X		
	18	CS Zaragoza	+21 MW		X		

Figure 5-12 Elements included in Spain in the different decrement steps (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF)

The main limitations of the flow cases are shown in the table below:

	From Spain to France		**From France to Spain**	
	French side	**Spanish side**	**French side**	**Spanish side**
Peak demand scenario	Same infrastructure as LNG and UGS. Need for outlet capacity as Eridan if simultaneous entry	Certain production in Barcelona Local constraints	Production from UGS and LNG needed due to bottlenecks from northern entry points.	Limitations to Barcelona entry Local constraints
Average winter	Same infrastructure as LNG and UGS. Need for outlet capacity as Eridan if simultaneous entry. Additional bottleneck before Paris area. Limits Montoir.	Certain production in Barcelona Local constraints	Production from UGS and LNG needed due to bottlenecks from northern entry points Bottleneck around Lyon	Limitations to Barcelona entry Local constraints
Average summer	UGS injection creates room for gas import from Spain Few constraints.	Local constraints	General constraints at Northern entry points Limitations on Lussagnet UGS filling	Limitations to Barcelona entry Local constraints

Table 5-3 Bottlenecks in different scenarios and flow situations

As for the first step on MidCat, the simulations give certain constraints when less than the full MidCat is included.

The sizing of the different components of the full MidCat means that the full MidCat will contribute to other goals than the planned capacity for MidCat. It is obvious that the use of a DN1200 (48") pipeline for Eridan compared to a DN 900 (36") for the border crossing means that Eridan will not only contribute to capacity for MidCat but also for other purposes, such as increase of the overall North-South capacity. According to the shared study the full MidCat infrastructure provides 600 GWh/day of which only 230 GWh/day will be allocated for MidCat. If there is no need for such increase in North-South capacity, there is a mismatch between dimensions of the different pipelines.

In the shared study it has not been analysed if an even larger crossing between Spain and France could be included in case of the Full MidCat, which could contribute to bringing down average cost.

The conclusions on the shared study based on worst case scenarios are that the most severe constraints are on the French side. Even with the full MidCat there will be constraints in case of flow from North to South, due to the entry point constraints in the North. For gas flow from South to North the main constraint is the lack of simultaneous outlet from MidCat, UGS in the South and Fos, which could be partly lifted by Eridan and fully with a combination of Eridan and Arc Lyonnais.

Comments to shared analyses for full MidCat

The comments given above to the first stage MidCat also apply for the full MidCat.

Further the additional findings are made concerning the full MidCat analyses:

- No optimisation of the first step MidCat and full MidCat with respect to dimensions have been made, which means that Eridan and Arc Lyonnais could serve other purposes than the interconnector due to the larger dimensions than the first step MidCat.
- The analyses are based on a normal year with respect to weather only. Also, the analyses do only cover a few months of the year (summer and coldest winter month). This underlines that a very conservative approach has been used.
- Possibility of significant increase in gas import from North of France to the French market has not been analysed. This could be the case if Nord Stream 2 will provide significant new volumes of gas to France instead of LNG import to France and Spain.
- Significant increase in gas from Algeria to Spain, such as Medgaz II has not been analysed. The influence zone of MidCat in Spain may be too small in such case.
- The flow calculations are only preliminary and it is not clear how the creation of one zone in South of France from 2015 has impacted the use of the system.
- The analyses are based on the Eastern corridor; However, it is not clear if a western or combined expansion would be more favourable.

Conclusions on Eridan and Arc Lyonnais

The shared study shows that the Eridan pipeline and Arc Lyonnais contribute significantly to the insurance of capacity from the interconnector between France and Spain. However, the capacity of the Eridan and Arc Lyonnais is 600 GWh/day which is more than the double of the target for MidCat. Also, the estimated cost of the Eridan and Arc Lyonnais of more than 1 bEUR is more than the double of the cost of the first phase of MidCat.

We do not find that Eridan and Arc Lyonnais should be justified only be increased interconnector capacity between Iberian Peninsula and rest of EU. During the open season for MidCat 2010 only half of the cost for Eridan was allocated to MidCat.

Factors which can influence the need for Eridan and Arc Lyonnais are in addition to flow to/from Spain:

- Increase entry of gas from North, e.g. Nord Stream 2 and/or reduced LNG import to Fos
- Lower gas demand in France in general, which will spread the supply from the North to a larger part of the country
- Location and use of CCGTs. In the shared study only 50% use was anticipated
- Use of underground gas storage as it may be possible to choose between supply to and from UGS and the interconnector

Conclusion on Artere de Midi, Compressor Montpellier

The choice between a new pipeline parallel to the exiting Artere du Midi or a new compressor station is mostly a question about the load factor for the anticipated flow. With large uncertainty it can be argued that a compressor station gives more flexibility and lower investment cost. With the lack of complete overview over the daily use, this will be the preferred solution.

As illustrated with the offshore solution for an interconnector between Spain and France, it would also be possible to connect such offshore pipeline close to Montpellier and bypass some of the bottlenecks in the TIGF area.

5.4.3 *Firm or interruptible capacity – probability calculations*

The definition of the full MidCat shown above is based on achieving the capacity at the border without limitations. A conservative approach is used based on combinations of the following four parameters:

- Climatic conditions / Domestic demand
- Underground storages injection and withdrawal levels
- Use of combined cycle Turbines
- LNG terminals production level

France and Spain have traditionally used a conservative approach for firm capacity with a very high probability for guaranteeing the capacity.

Different countries have different traditions and use of force majeure can impact the firm capacity.

Security of gas supply is also unclear in some cases. Regulation 994 on security of gas supply on Member State level focusses much on capacity of the systems during winter situations and less on an overall supply crisis in one or more Member States:

- extreme temperatures during a 7-day peak period occurring with a statistical probability of once in 20 years;
- any period of at least 30 days of exceptionally high gas demand, occurring with a statistical probability of once in 20 years; and
- for a period of at least 30 days in case of the disruption of the single largest gas infrastructure under average winter conditions.

In a general supply crisis, such as disruption of one of EU´s main suppliers for longer time, it may be worth also to focus on long term reduction of supply. Here, interruptible capacity between Member States can be used to slowly move gas when there is available capacity.

Enagas has made probability analyses for the Spanish system for use of MidCat.

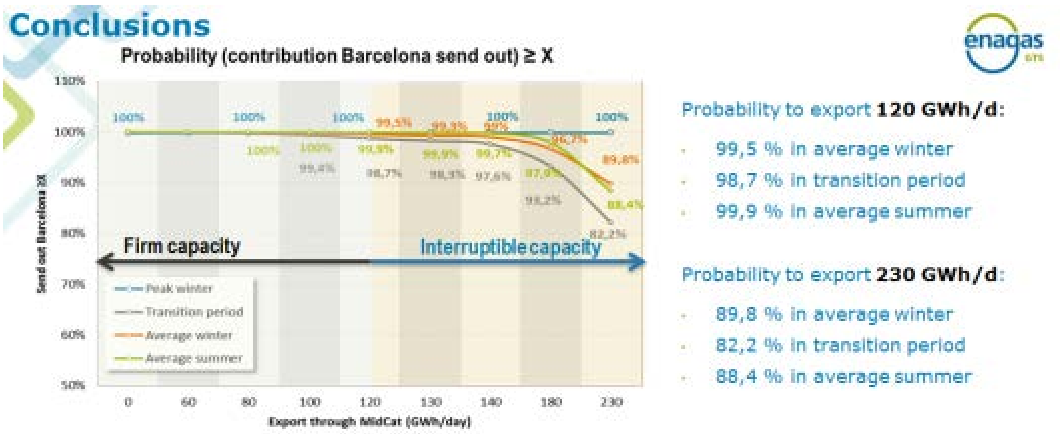


Figure 5-13 Probability analyses for the Spanish gas transmission system for use of MidCat

TIGF and GRTGaz have not carried out similar probability calculations.

Enagas calculations show that there is a high probability of more than 80 per cent for use of the full capacity of the pipeline even without strengthening of the other parts of the network in France and Spain. However, this capacity cannot be offered as firm capacity. There is no uniform definition of probabilities required to distinguish between firm and interruptible capacity. However, for the present interconnector we consider the yearly capacity most important as France, Spain and Portugal all have LNG and underground gas storage available to ensure peak load.

5.5 Cost and comparison

Based on the shared study supplemented with own estimates of capacity and using the same diameter pipeline for the direct crossing between France and Spain as for the Eridan pipeline, the following preliminary estimates are made. The firm capacity is based on the assumptions described for MidCat first phase.

Dimension	Cost	Firm capacity GWh/d	Interruptible capacity GWh/d		
DN900	472	120	230	Midcat 1st phase	
DN1200	627	120	500	Midcat 1st phase	
DN900	2075	230	230	Full Midcat incl. Eridan	
DN1200	2230	500	500	Full Midcat incl. Eridan	

Table 5-4 Cost comparison for different capacity and dimensions

The interruptible capacity will be different with respect to probability for the different cases.

The cost comparison will be further evaluated in the final report.

5.6 Line pack and reduced energy consumption

Establishing a large diameter pipeline will reduce energy consumption for compressors and will further contribute with line pack capacity which will ease balancing. The line pack capacity of a DN900 pipeline with 80 bar pressure will be more than 10 mcm.

5.7 Connection between France and Germany, Reverse flow and odorisation problem

It has previously been considered to establish reverse flow between France and Germany.

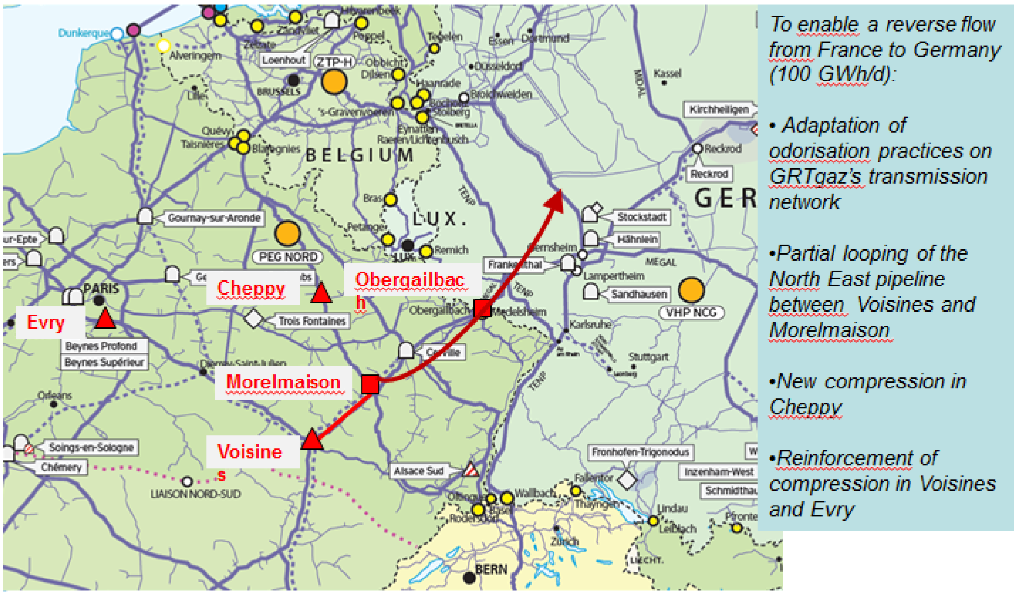


Figure 5-14 Reverse capacity from France to Germany at Obergailbach (Source: GRTGaz)

However, it has been considered to be very expensive because of the difference in odorisation practises between France and Germany. In France, natural gas is odorised in the transmission system, while this is only done in the distribution system in Germany. Therefore, there is a need either to change the practise in France or to establish a process plant for removing the odorant, which will be expensive in terms of investment and operational cost. No information about the cost is available, but it is assessed to be in the order of 500 MEUR including pipelines and deodorisation plant.

TENP and Transitas in Switzerland have recently decided to invest in reverse flow between Italy and Germany from 2018 by changing compressor stations in Switzerland and Germany and by building Europe´s first deodorisation plant. The impact of this decision may be that gas can flow from France to Switzerland and further to Germany and utilise the Transgas deodorisation plant. The investment will consequently create more flexibility between all countries in the region.

Figure 5-15 TENP reverse flow illustration (Source: TENP)

Historically the flow direction in the TENP pipeline has been from the Netherlands via Germany and Switzerland to Italy. Further a branch from France can also supply gas to Switzerland to Italy. With establishing the TAP pipeline from Turkey to Italy there is a possibility to import gas from Azerbaijan and in order to make this gas available in Germany, Belgium, France and UK there is a need for reverse flow.

According to GRTGaz, it will be possible to physically import 100 GWh/day of gas from Italy via Switzerland from 2018 with the possibility of increasing this level with 100 GWh/day of extra capacity. Today, more than 220 GWh/day of gas can already flow from France into Switzerland through Oltingue.

5.8 Portugal - Spain – 3rd interconnector

5.8.1 *Description of 3rd interconnector*

The 3rd gas interconnector between Portugal and Spain consists of three phases according to REN. The first phase, which is a precondition for the following two phases consist of a 250 km pipeline with a dimension DN700 (28"). The major part, 162 km, of the pipeline will be in Portugal, while the remaining part will be in Spain. In addition, there will be meter station at the border.

The second phase will be the addition of a compressor station in the existing system. The third phase will be 67 km in parallel to an existing pipeline in Portugal and according to Enagas also a number of additional pipelines in Spain 148 km 30", 170 km 26" and 307 km 32".

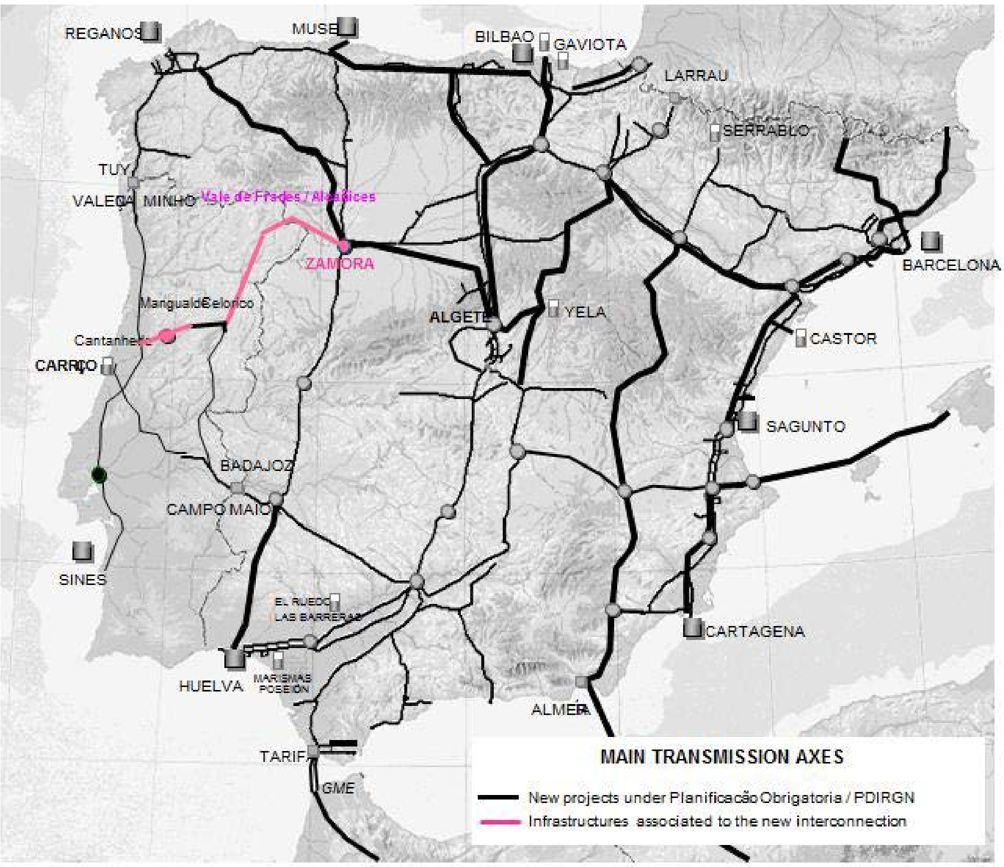


Figure 5-16 New interconnector between Portugal and Spain (Source: REN)

In addition to provide further connection between the two countries, the new pipeline will also provide gas supply to the North Eastern part of Portugal, which is presently not served by natural gas.

5.8.2 *Portugal capacity of interconnectors, LNG and storage*

The capacity of the new pipeline connection will be as follows:

GWh/day	From Spain to Portugal	From Portugal to Spain	LNG import	UGS
First phase	75	50		
First plus second phase	107	97		
All three phases	141	141		
VIP Iberico	*144*	*80*		
Bajoz/Campo Kaior	134	30		
Valenca do Minho/Tuy	30	25		
LNG Sines			223	
Underground gas storage				80

Table 5-5 Portugal capacity overview for new and existing supply sources (Source: REN and ENTSO-G)

The Portuguese system is today consisting of the two pipeline connections to Spain, LNG import terminal in Sines and underground gas storage. The main capacity is from the LNG receiving terminal, which is hence seen as the determining factor in the N-1 calculations for security of supply.

The overall peak demand in Portugal is expected to be around 400 GWh/day in both scenarios, Green and Grey. Under normal situations, the present system will have sufficient capacity. However, during a disruption of the LNG terminal in Sines there will be lack of capacity.

In Portugal, a major part of gas is used for power generation. Some of the CCGTs have been built with back up facilities and use of gas oil in emergency situations. This was the case because initially there was only one pipeline connection to Spain and no LNG or underground gas storage.

Due to the use of renewable energy like wind and hydro there are substantial variations in the use of gas for power generation in Portugal. This will potentially result in low utilisation of the LNG import facility. The increase in pipeline capacity from Portugal to Spain can hence potentially be used for increased import of LNG to the Iberian Peninsula and hereby to the rest of Europe if the bottleneck between Spain and France is removed.

Portugal is today very much dependent on import of gas from Algeria via pipeline and from Nigeria as LNG. New connections will contribute to less market concentration.

5.8.3 *Portugal drivers behind the 3rd interconnector*

The use of the existing pipelines between Spain and Portugal is shown in the figure below.

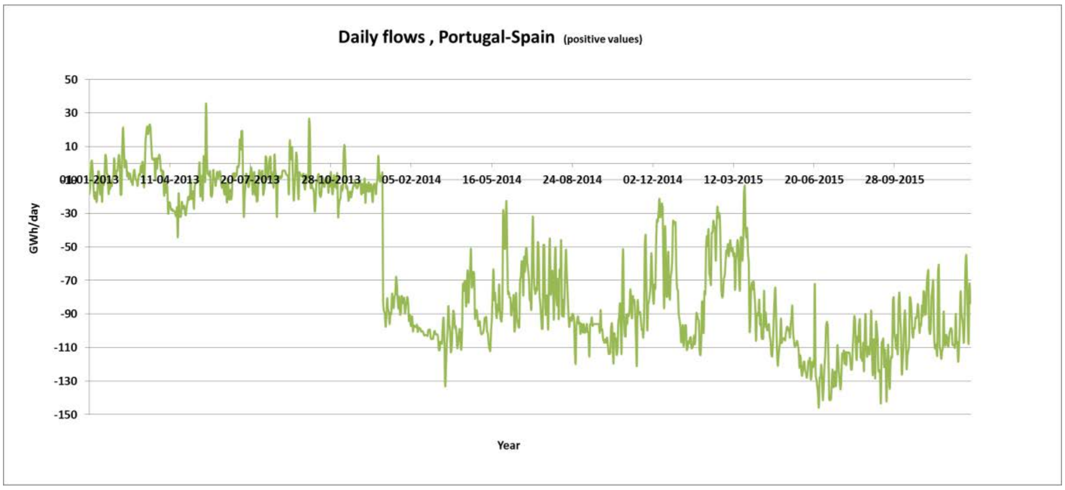


Figure 5-17 Actual use of existing pipelines between Spain and Portugal

The historical use of the interconnectors shows that there has been an increase in use, reaching a high level in 2015.

Portugal is supplied from Algeria and Nigeria based on long term take-or-pay contracts for almost 6 bcm/year. These contracts will expire in the period from 2020 to 2026. In this situation there is a risk that Portugal will be entirely linked to the global LNG market and consequently have higher prices than seen in other countries in Europe. By connecting to Spain at a location closer to the entry point from France, it may be possible to link some of the gas supply to the rest of EU.

A main driver behind the 3rd interconnector is security of supply. Here, the following 9 risks were identified in the Portuguese reporting on security of supply regulation:

1. Infrastructure failure at the Sines LNG terminal
2. Failure in the Campo Maior link
3. Failure in the third link with Spain
4. Failure in the Valença do Minho link
5. Failure in the infrastructure at the underground storage in Carriço
6. Failure of the compression station at Carregado
7. Disruption in the main gas pipeline transporting gas in the RNTGN
8. Disruption in supplies by third country suppliers
9. Correlated risks

In particular the supplies by third country, mainly Algeria and Nigeria were seen as potential long term risks.

Further, the use of gas in Portugal differs from other EU member states as there is less use of gas for heating. Instead, gas is used for industries and for power generation as well as for cooking in the households. For industries the price of natural gas is the most important compared to other countries in EU and elsewhere to maintain the industry competitive.

The use of gas for power generation differs wildly from year to year due to the high dependence of hydro and wind power in Portugal. In years with less hydro and wind power, there is a need for natural gas for back-up fuel in CCGT plants. Out of the 4 CCGT plants in Portugal at least two can use gasoil as back up, but no storage is available. Further, the existing coal power plants which are old may be decommissioned within the next years.

The dilemma for Portugal is consequently that the focus of gas use of industries and power result in a much more fluctuating gas demand than seen in countries with use of gas for heating.

5.8.4 *Cost benefit consideration for Portugal-Spain 3rd interconnector*

As long as the bottleneck between Spain and France is not removed, the 3rd interconnector between Portugal and Spain will mostly contribute to the following benefits:

- Ensure gas at a price level linked to the rest of EU rather than only to the global LNG market
- Security of supply for Portugal in case of LNG failure
- Increased use of Sines LNG and hereby more competition between different LNG receiving terminals
- Increased competition and reduced market concentration in Portugal

Portugal is in particular vulnerable to the country risk of Algeria. In case of failure of Algerian pipeline supply via Morocco, supply of LNG from Algeria may also be reduced.

In order to fully assess the need for the interconnector it is needed also to assess the electricity grid interconnection between Portugal and Spain as a major part of gas is used for power generation in Portugal.

The underground gas storage in Portugal is not used at full capacity. It may be possible to increase the use of the facility.

If the bottleneck between Spain and France is removed, it may be possible to use the Sines LNG terminal in a wider European context, which will require increased capacity from Portugal to Spain. Further, it may be possible to import gas from France in some cases with high LNG prices.

In conclusion, the removal of bottleneck between Spain and France is seen as the most urgent and should have first priority. The 3rd interconnector between Portugal and Spain will only have full value when this has been done.

5.9 MidCat cost summary including Eridan, Arc Lyonnais, 3rd interconnector to Portugal

The overall investment cost is showed in the table below.

	MidCat Investments	Diameter	Length	First step	**Total cost**	**Unit cost**	**First step**	**Cost allocated to MidCat**		**48" MidCat**
	Pipelines		km	km	MEUR	EUR/m/mm	MEUR		MEUR	MEUR
GRTGaz	Midi	1050	200		*470*	*2,24*		50%	235	470
	Eridan	1200	220		591	*2,24*		50%	296	591
	Arc Lyonnais	1200	150		435	*2,42*		50%	218	435
	Perche	900	63		*125*	*2,20*		50%	63	125
TIGF	Barbaira-border	900	120	120	320	*2,96*	320	100%	320	427
	Midi	1050	40		*100*	*2,38*		50%	50	100
Enagas	Figueras-Border	900	25	25	29	*1,29*	29	100%	29	39
	Hostalrich-Figueras	900	79	79	80	*1,13*	80	100%	80	107
	Loop Tivissa Arbos	740	114		97	*1,15*		50%	49	97
	Loop Villar de Arnedo-Castelnou	640	214		160	*1,17*		50%	80	160
	Celorico da Beira to Zamora	700	85		70	*1,18*		30%	21	70
REN	Celorico da Beira to Zamora	700	162		137	*1,21*		30%	41	137
	Cantanhede-Mangualde	700	67		58	*1,24*		30%	17	58
	Total		1539	224	2672		429		1498	2815
	Compressors	MW		MW	MEUR		MEUR		MEUR	
GRTGAz	St-Martin	30	New		*60*			50%	30	60
	St-Avrit	15	Exp		*30*			50%	15	30
	Palleau	50	New		*100*			50%	50	100
TIGF	Barbaira	7	Exp		*15*			50%	8	15
Enagas	Martorell	36	New	36	*42*		42	100%	42	42
	Arbos	5	Exp		*1*			50%	1	1
	Zaragoza	21	Exp		5			50%	3	5
REN	Portugal	12	New		*30*			30%	9	30
	Total	176			283		42		157	283
	Investment total				**2955**		471		**1654**	**3098**
	OPEX	25%			739		118		414	775
	Grand total				**3694**		**589**		**2068**	**3873**

Table 5-6 MidCat and associated pipelines in France, Spain and Portugal (source: Joint Technical Study Between ENAGAS, GRTgaz and TIGF and REN with own additions)

The table includes the cost for the first step of MidCat at less than 500 MEUR. The full MidCat will reach a cost of almost 3000 MEUR. With allocation of only half of the MidCat and ArcLyonnais and the rest for the North-South integration and to increased import from Switzerland, Germany and other sources from the North, and 30 per cent of the 3rd interconnector, the cost will be 1650 MEUR. Finally, the cost for a full 48" solution for the MidCat including all other pipelines will be 3100 MEUR. The additional investments for Spanish part of the final stage 3rd interconnector between Spain and Portugal has not been included.

As described above the cost estimates are mostly based on information from the TSOs. It can be seen that the unit cost for pipeline, which as a proxy is calculated as cost per metre and mm is also the double in France than in Spain and Portugal. This may reflect that no recent design has been made as well as difference in terrain and not least right-of-way compensation. It is recommended that more updated cost estimates are made based on conceptual design.

5.10 Fos LNG extension – Capmax project

At present there are two LNG terminals in Fos close to Marsailles; the older Fos Tonkin terminal and a new Fos Cavaou commissioned in 2010. Both terminals are operated by Engie, who also owns the Fos Tonkin terminal. Fos Cavaou is owned by Fosmax, a cooperation between Engie and Total.

The Fos Tonkin terminal is the oldest terminal and is mostly used for import of gas from Algeria as the terminal can receive medium size LNG carriers (medmaxup to 75,000 m3 LNG). The Tonkin terminal is also used for truck delivery of LNG. The Fos Cavaou terminal can receive large LNG carriers (Q-max up to 267,000 m3 LNG) and is as such an attractive terminal not least for receiving gas from Qatar and other Middle East sources via the Suez channel as the sailing time will be less than for terminals in Northern Europe.

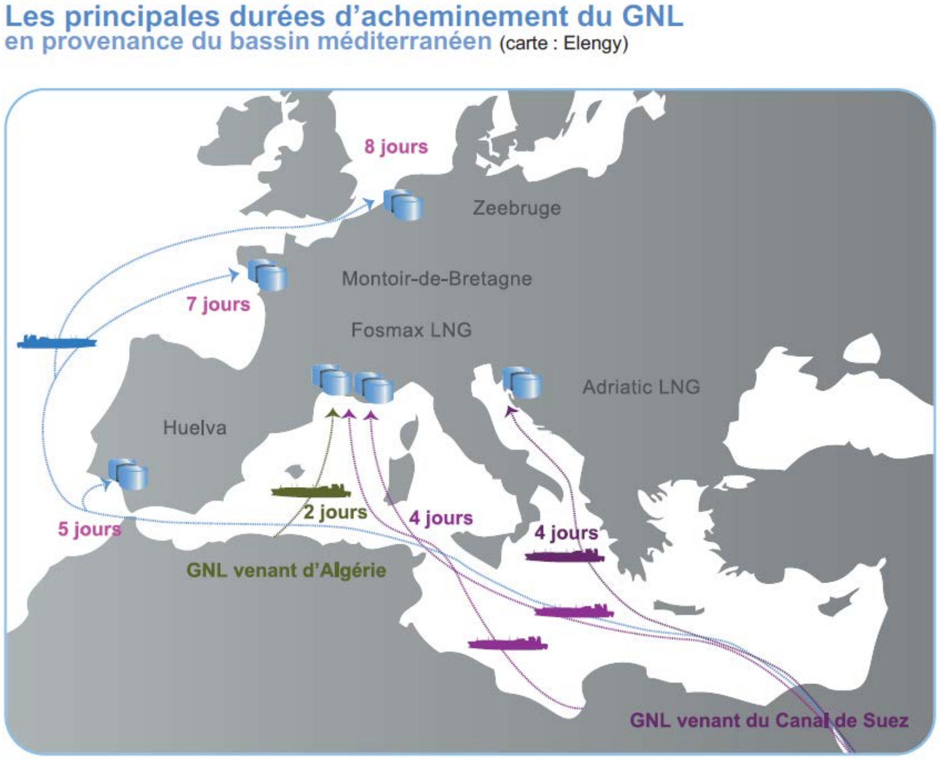


Figure 5-18 Fos LNG strategic location (Source: Elengy)

The present capacity of the Fos Cavaou and Fos Tonkin entry into the French system is 410 GWh/d equivalent to approximately 13 bcm per year.

The capacity of Fos Tonkin is 3000 GWh/month or around 3 bcm/year, while the capacity of the Fos-Cavaou LNG terminal is 8.25 Gm3 per year in a full year, i.e. around 96.9 TWh per year. 10% of the terminal's capacity is reserved for all shippers, on the basis of short-term contracts, while 90% of capacities have been subscribed on a long-term basis.

The CAPMAX projects aim to boost the capacity of the current Fos Cavaou terminal, increasing its gas send-out capacity from 8.25 Gm3/year to 16.5 Gm3/year. The increase involves expanding LNG storage capacity by building one or two additional storage tanks and doubling regasification facilities.

An open season for the Capmax project was held in 2013, but so far no final investment decision has been made. With the present low utilisation of LNG terminals in Europe a final investment decision is probably not imminent.

The cost estimate for the Capmax is according to Elengy around 350 MEUR. However, no details are given for this estimate and it will probably depend on the selection of one or two storage tanks.

The capacity of the Capmax project is almost the same as the technical capacity for the MidCat pipeline with a DN 900 mm pipeline (36") and the cost is in the same order of magnitude.

The Capmax and the MidCat projects have the same challenges with respect to capacity of the North-South connection in Eastern France and possible need for the Eridan project and the Arc de Lyonnais pipeline.

5.11 Baltic Sea LNG terminals

An alternative to increasing the interconnector capacity between Iberian Peninsula and France is to establish new LNG terminals close to the East European EU member states most exposed to single supplier issues. This includes LNG terminals in the Baltic Sea region.

At present there are two major LNG terminals in the Baltic Sea area; the FSRU in Klaipeda, Lithuania which became operational in 2014, and the Polish LNG terminal in Świnoujście which received the first LNG cargo late 2015. New terminals are also being planned in Estonia and possibly Finland.

The capacity of the Lithuania LNG is up to 4 bcm, but at present the outlet is restricted to 47 GWh/day due to pipeline capacity limitations, corresponding to 1.5 bcm. The pipeline system is being expanded to supply gas to Latvia and further connect to Estonia from here. The ship size is restricted to 160,000 m3 LNG, preventing the terminal to receive the largest LNG ships.

The Polish LNG terminal has a yearly capacity of up to 5 bcm and can take ships up to 216,000 m3 LNG. The terminal capacity can be expanded up to 7.5 bcm. Expansion above this size will probably require a completely new terminal and additional pipelines to reach the markets, which could a.o. include the Baltic Pipe to Denmark.

New terminals in Finland and Estonia are being planned and can contribute to security of supply and diversification of the market. The overall capacity of the East Baltic gas market is limited by size of the overall market of only 6 bcm. When the pipeline between Lithuania and Poland is established there may be an additional outlet.

LNG terminals in Germany, Sweden or Denmark are also a possibility. So far only a small LNG terminal in Gothenburg, Sweden is progressing. The import capacity of this capacity is limited by the pipeline from Denmark to Sweden to less than 1 bcm.

An LNG terminal in the middle of Denmark could contribute with up to 10 bcm as it could serve Sweden, Denmark, Germany and indirectly the Netherlands by redirecting Danish production. The plans for such facility are still on pre-feasibility level.

The shipping time for LNG vessels is found to be approximately 5 days extra for vessels from Qatar via the Suez channel than compared to Mediterranean terminals, resulting in a total of 10 days extra vessel days per cargo.

5.12 KRK LNG terminal in Croatia and terminals in Greece

The KRK terminal in Croatia is presently in the binding open season phase. The terminal can serve the Central and Eastern European market. The terminal is based on onshore tanks and vaporizers. The planned capacity is 4-6 bcm/year, tank capacity (full containment): 2x180.000 m^3 and size of LNG supply ships: 75,000 - 265,000 m^3. The KRK terminal can supply gas to Croatia, Hungary and possibly to other countries in the region. No information about cost is available.

In Greece there are plans for a new terminal in the Northern part of the country as well as increasing capacity of the existing terminal close to Athens. Such terminals can in case of disruption of Russian supply be used for supplying gas to Bulgaria also. However, with the establishment of the TAP pipeline it may also be possible to redirect gas from Azerbaijan towards Bulgaria. Romania is almost self-sufficient and will have less use for import of LNG, although possibilities for terminals in the Black Sea have been evaluated.

5.13 GALSI pipeline

The Galsi pipeline directly from Algeria to Italy is planned for a capacity of 8 bcm/year. The proposed route is via Sardinia and with a possible connection to France by a link to Corsica.

Figure 5-19 GALSI pipeline (Source: ENTSO-G)

The pipeline will create access to the two islands, Sardinia and Corsica, and hereby to a new market which is presently not served. It will consequently only be a smaller part of the capacity which will reach Italy.

The major impact on the Iberian interconnector is that less gas may be available for Spain via pipeline or LNG and there may be more gas supply to France via Switzerland, resulting in additional flow from North to South.

5.14 Technical Conclusions

- The capacity of the MidCat will depend on how the French, Spanish and Portuguese gas systems are used, including pipelines, underground gas storage and LNG terminals. This varies day by day and year by year depending on the balance. The available capacity analyses do only cover a few snap shots of such situation and is considered very conservative. To unlock further capacity of the existing systems it is recommended to carry out probabilistic analyses based on historical data also for the French system as it has been done for the Spanish.
- The cost estimates for the different pipeline systems are only based on preliminary design and routing. There seems to be high estimates for the French components. No documentation has been available to support the estimates. It is recommended to carry out at least technical feasibility and routing studies, but preferable conceptual or FEED design.
- A full 48" interconnector between France and Spain should be evaluated by the TSOs in addition to the 36" included in their technical study. The capacity could be 20 bcm instead of 8 bcm, which would allow for full integration of Iberian Peninsula
- LNG terminals have been identified which from a security of supply point of view can be an alternative to the interconnector from Iberian Peninsula. The terminals in the Baltic Sea region will have relatively long sailing distance compared to terminals in the Mediterranean Sea coast for gas supplied from EU´s main supplier, Qatar. If the terminals are used for import they will replace Russian gas, which will then have to move further west and south, and hereby create a north to south flow in the Iberian interconnector.
- The Galsi project could contribute to ensure further supply security for gas from Algeria. However, hereby it would also create additional need for north to south flow in the Iberian interconnector.

6 Cost benefit analyses

6.1 Benefits of increased interconnection between Iberian Peninsula and rest of EU

The drivers for benefits of increased interconnections between Iberian Peninsula and the rest of EU are summarised in the table below.

Direction	Market driven	Security of supply driven
South-North	- Pipeline supply from Algeria increases, conventional, shale or TSGP - LNG supply via Iberian receiving terminals if other LNG terminals in France and Northern Europe are fully utilised - Price differences between oil indexed prices from Algeria and market based prices in North-West Europe. In particular the case with low oil prices - Increased LNG supply in case of decline in gas production in the Netherlands, Germany, Norway and Denmark reducing pipeline supply to Europe - Improvement in the bargaining position. Possibility to engage with a larger variety of LNG suppliers, while companies such as Sonatrach, NNPC, and Gas Naturel, could begin competing with other larger wholesale suppliers further up in Europe.	- Russian disruption of gas supply, or Ukraine or Belarus transit - Norwegian disruption, in particular Troll field or Draupner - UK-Belgium interconnector failure - Nuclear incident in France, closing nuclear power and increase use of CCGT in France, Germany etc. - Fos LNG terminal disruption - Disruption of Algerian supply via Tunisia to Italy for technical or other reasons - Groningen field disruption - Extreme cold weather in North and East Europe and consequently empty storage
North-South	- Ensure full integration of Spain and Portugal into EU market and avoid price differences - Increased Russian supply, e.g. Nord Stream 2 - High LNG prices globally compared to gas market prices on North West Europe - Qatar or other LNG suppliers prefer to use UK and other LNG terminals outside Iberian Peninsula keeping the price high in Spain by isolating it from the rest of Europe - Contract differences between oil indexed prices from Algeria and market based prices in North-West Europe. In particular the case with high oil prices - Take-or-pay obligations for EU suppliers in case of demand, warm weather, high gas prices - South of the border shippers would have the possibility of sourcing gas from the rest of Europe as an alternative to Sonatrach, NNPC, and other LNG suppliers.	- Algeria gas supply disruption or Morocco transit - Qatar, Algeria or Nigeria LNG Failure - Technical fault on Medgaz, or Strait of Gibraltar pipelines/compressors - Sudden demand increase on Iberian peninsula (nuclear disruption, cold/warm weather, combination) - LNG accident in Spain

Table 6-1 Flow drivers normal market situation and security of supply

Quantification of these benefits are very dependent on the development in gas demand in EU, but also in neighbouring countries like Ukraine, Belarus, Morocco, Tunisia, Turkey as well as in the producing countries Russia, Algeria and Libya as this will impact the overall need for LNG import to EU.

In particular the EU gas demand uncertainty impacts the benefit, as EU could move from being almost completely supplied by pipeline gas to needing more than 100 bcm import as LNG.

6.2 North-South or South-North supply assessment and methodology

6.2.1 *Normal market situation – ENTSO-G green and grey scenarios for demand – revised supply from North-West European production*

Historically, the net flow on the France to Spain interconnector has been from France towards Spain. However, commercially there is flow in both directions.

With the forecasts for gas production in North-West Europe (UK, The Netherlands, Germany, Denmark, Norway), there will be a tendency to have less supply to Northern Europe and hence to shrink the area directly supplied from this direction. This may indicate that the flow direction between Spain and France may change or become fluctuating depending on yearly changes.

However, the overall balance will also depend on new gas infrastructure. This could be pipelines like Nord Stream 2 or Trans Saharan Gas Pipeline or new LNG import terminals. TAP project will tend to move Algerian gas from Italy to Spain and Portugal via existing infrastructure.

If no new gas infrastructure is established, the use of LNG terminals will become decisive for the flow direction. There seems to be a tendency that Qatar is delivering LNG to terminals in the UK and Belgium rather than to terminals on the Iberian Peninsula and France. The reasoning for this can be the Qatar ownership of terminals in UK or it can be to isolate the Iberian Peninsula from the rest of EU gas market. This factor will have most impact in the low demand scenarios as there will be amble LNG receiving terminal capacity.

Transportation and LNG terminal tariffs will also influence the use of the interconnector. In particular the creation of a single zone in France will probably increase the tariffs at the border points.

6.2.2 *Security of supply*

For security of supply the Iberian Peninsula is very much depending on the situation in Algeria and on the global LNG market, in particular Qatar. In such cases, supply by pipeline from the North, e.g. gas storage in France will be necessary if the impacts shall be smoothening out. Portugal is in particular exposed to country risk for Algeria and Nigeria, the two major suppliers.

For EU as a whole, the main concern is the disruption of supply from Russia or one of the main transit countries, Ukraine or Belarus, or from Norway. The French dependency of Russian gas is not clear as a large proportion according to GRTGaz has unknown source. Most LNG import terminals are located in the West or South of Europe.

The use of LNG receiving facilities in UK is restricted by the UK-Belgium interconnector, as the BBL pipeline has no capacity from UK to the Netherlands. Even assuming that the most Northern and Eastern terminals are used first, there will be a potential for flow from Spain and Portugal to the North in case of a Russian disruption.

Disruption of Trans-Mediterranean gas supply, e.g. due to technical reasons or due to disruption of flow in Tunisia will move gas to the North via Spain, assuming that the GALSI project has not yet been established.

A particular case for France is event with nuclear power supply. In such case there will be a need to increase supply from all sources, including LNG supply from Spain and Portugal.

6.2.3 *Quantification of supply cases – methodology*

The different supply cases have been quantified as yearly balances in 2025. Many possible supply situations will be possible, mainly depending on the gas policy in gas exporting countries and by gas supply companies. The yearly quantifications illustrate possible situations taking into account the historical behaviour of gas suppliers and our assessment of the competitive situation.

The quantification is made for the two demand scenarios, grey – with low demand, and green with high demand. However, as recent years have shown, there may be quite abrupt change in gas demand in EU in general and in individual countries.

The supply cases have been made for normal years with respect to weather and climate. In reality such year is very seldom and reality will most often differ. This could include warm weather as the start of the 2015/2016 winter, high or low hydro power on Iberian Peninsula and rest of EU, difference in wind power. Such differences will significantly impact the need for gas and as pipeline and storage supply is faster to react than LNG supply it is likely that the initial impact will be on pipeline supply, possible followed by a later impact on LNG for filling of gas storage.

The following infrastructure is assumed to be commissioned before 2025:

- Dunkerque LNG terminal
- Artere des Flandres, which allows gas from Dunkerque (LNG and Franpipe) to be turned to Belgium before odorisation
- Arc de Dierrey
- Val-de-Saône pipeline
- TAP pipeline between Greece and Italy with possibility for reverse flow
- Polish LNG import terminal
- TENP reverse flow allowing gas from Italy (TAP) to Germany and France
- Greece to Bulgaria pipeline
- Poland to Slovakia, Lithuania and Czech Republic

Contrary to this it is assumed that the following projects have not been implemented before 2025:

- Medgaz II (the pipeline is prepared with landfalls etc.)
- GALSI pipeline between Algeria and Italy
- Nord Stream 2
- Denmark-Norway and Baltic Pipe
- Trans Saharan Gas Pipeline
- East Ring pipeline from Greece to Slovakia
- Turk Stream
- East Mediterranean pipelines
- KRK LNG
- Fosmax

It is assumed that all the EU producers, Norway and Algeria will produce at full capacity in both scenarios and that the supply system will be the same in both scenarios. The overall difference in EU supply will hence be between LNG import, mainly from Qatar, and pipeline gas from Russia. Due to the limitations in the Norwegian gas system to the Continent there will consequently always be import via the Franpipe to France.

It is assumed that the present supply of Russian gas via Ukraine and Belarus will be possible as at present. Supply of gas from EU to Ukraine has not been explicitly included in the normal supply situations or security of supply situations.

The purpose of the overall balance is to create a frame around the possible need for increasing the interconnector capacity between the Iberian Peninsula and the rest of EU, including need to internal investments in the three countries and need for creating possibility for reverse flow with Germany. Due to the difference in policy with respect to odorisation, such reverse flow will require investments. It is assumed that commercial reserve flow will be possible, which means that the following balances are only based on net yearly flow.

6.3 Supply cases and balances for France, Spain and Portugal combined – yearly balances 2025 – Green and Grey scenarios

In the following is given a description and possible quantification of gas balance in the three countries for respectively the green and the grey scenarios. The balances are made for respectively normal market situation and security of supply situations.

The purpose of the yearly balances is to quantify the possible use of the overall interconnector capacity between the Iberian Peninsula and the rest of Europe. The quantifications are based on yearly assessments rather than models, as insufficient information about long term contracts and commercial behaviour of main players is available.

6.3.1 *Normal supply situation – Grey and Green scenarios – different prices*

In the Grey scenario the consumption of gas will only grow very modestly compared to the present situation in the three countries and the combined EU and Norway production will only decline with approximately 20 bcm. The case is hence very similar to the present flow in 2015.

France, Spain and Portugal yearly gas balance			Normal market situation GREY					Normal market situation GREEEN			
2025	bcm/year		LNG=TTF	LNG=TTF	"+5 EUR/MW	"+5 EUR/MW	"-5 EUR/MWh"	LNG=TTF	"+5 EUR/MW	"-5 EUR/MW	"-5 EUR/MW
	Maximum			Qatar to UK		Elastic	Elastic		elastic		
France	Entry	Exit									
Norway - Dunkerque	18		15	15	15	15	5	15	15	5	10
Belgium	20	8	7	20	7	17	5	7	7	5	10
Germany	19		10	15	15	19	0	10	15	0	0
Switzerland	3	7	-5	-5	-5	3	-5	-5	-5	-6	-6
Spain Pipeline	7	5	0	-12	-5	-17	1	0	0	17	7
LNG Fos	12		5	3	5	1	12	10	9	12	12
LNG Montoir	11		4	2	4	1	11	9	7	11	11
LNG Dunkerque	13		4	2	4	1	11	9	7	11	11
Demand France			-40	-40	-40	-40	-40	-55	-55	-55	-55
Total France	103	20	0	0	0	0	0	0	0	0	0
Spain											
Algeria pipelines	22		15	15	10	10	18	15	10	18	18
Pipeline Portugal	3	5	-4	-4	-4	-4	-2	-4	-4	-2	-2
France pipeline	5	7	0	12	5	17	-1	0	0	-17	-7
LNG Barcelona	17		8	3	8	3	8	9	12	15	10
LNG Bilbao	7		3	2	3	2	3	4	5	5	5
LNG Mugardos	4		2	1	2	1	2	3	3	3	3
LNG Huelva	12		4	2	4	2	3	5	5	8	5
LNG Cartegena	12		4	2	4	2	2	5	5	7	5
LNG Sagunto	9		3	2	3	2	2	4	5	4	4
Demand Spain			-35	-35	-35	-35	-35	-41	-41	-41	-41
Total Spain	91	12	0	0	0	0	0	0	0	0	0
Portugal											
Spain pipeline	5	3	4	4	4	4	2	4	4	2	2
LNG Sines	7		3	3	3	3	5	4	4	6	6
Demand Portugal			-7	-7	-7	-7	-7	-8	-8	-8	-8
Total Portugal	12	3	0	0	0	0	0	0	0	0	0
Total	186	15									
EU balance											
Demand EU			-427	-427	-427	-427	-427	-513	-513	-513	-513
EU production	95		95	95	95	95	95	95	95	95	95
Norway pipeline	115		115	115	115	115	95	115	115	95	115
Russia pipeline			115	115	130	145	95	140	155	95	125
Algeria pipeline			25	25	20	20	30	25	20	30	30
TAP pipeline			10	10	10	10	10	20	20	20	20
Libya pipeline	10		10	10	10	10	10	10	10	10	10
LNG import	218		57	57	47	32	92	108	98	168	118
LNG France, Spain, Portuga	115		40	22	40	18	59	62	62	82	72

Table 6-2 Yearly supply balance 2025 normal market situation for grey and green scenarios, SW Europe and EU (bcm/year)

For illustration of the flow cases, please see the following maps.

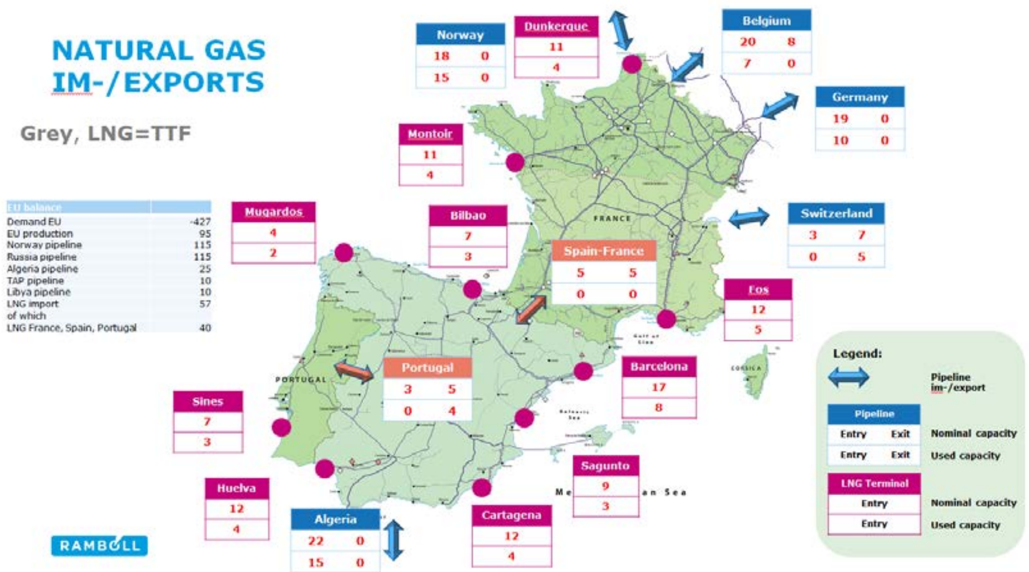


Figure 6-1 Yearly flow pattern 2025. Grey scenario. LNG=TTF prices

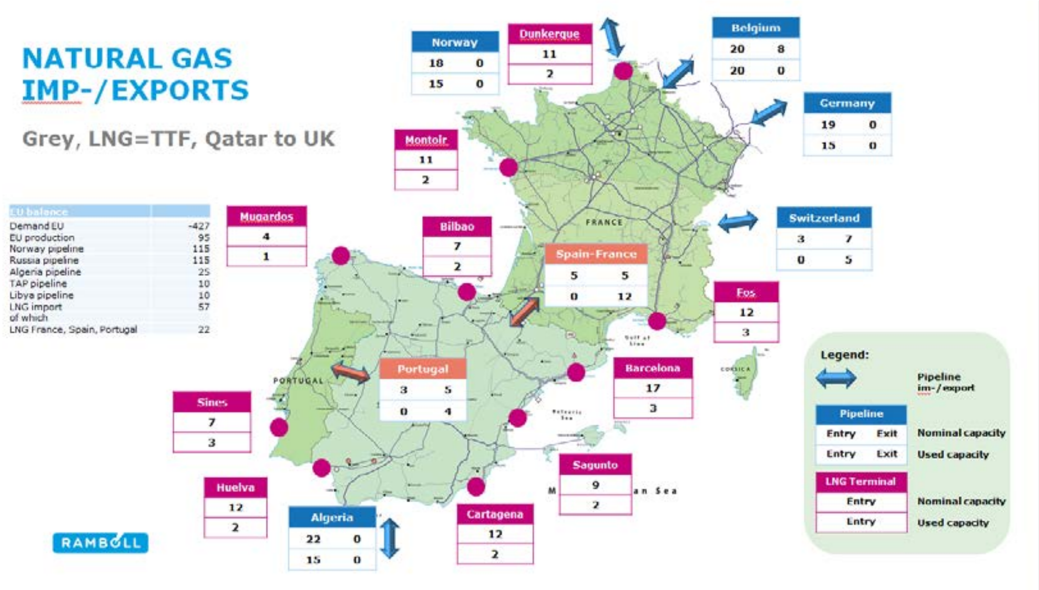


Figure 6-2 Yearly flow pattern 2025. Grey scenario. LNG=TTF prices, Qatar preference for UK LNG import terminals creates need for interconnector

Three price assumptions are assessed. 1) The base case where LNG price is equal to the North West European market price, 2) a higher LNG case where LNG is 5 EUR/MWh more expensive than the pipeline gas, and 3) a low LNG case with 5 EUR/MWh less. The variations are less than seen in previous years.

When international LNG prices are low, it is assumed that gas buyers prefer to buy LNG than pipeline gas. On the seller's side the situation will be very different between countries connected to EU by pipeline, as Algeria, and countries like Qatar who do not have any direct outlet for gas. We assume that Algeria will prefer to sell gas via their pipeline system in a situation with low LNG prices to save operational cost for liquefaction.

In the grey scenario we have further used two variations on the behaviour of the two main gas suppliers acting as swing suppliers Russia and Qatar, as it is assumed that Norway will keep an almost constant supply. The first variation is with respect to Qatar preference of delivery as this will significantly impact the need for gas interconnector. If LNG from Qatar is mainly delivered to UK, Belgium, Italy and Poland there will be a net flow from north to south exceeding the present capacity of the pipeline. The second variation is in a situation with higher LNG prices, where Russia could use this opportunity to supply additional gas and hereby significantly reduce the need for LNG. Also in this situation there will be a need for gas supply from France to Spain exceeding the present capacity.

In the Green scenario where gas demand increases, the situation will be different depending on delivery location of LNG and how the Russian and Norwegian suppliers will react in situations with low LNG prices as there may be south to north flow in such situations. When prices for pipeline and LNG gas are the same or LNG prices are highest, there will be little flow in the pipeline. With low LNG prices there may be flow from south to north. As there will be capacity of LNG terminals in France and Northern Europe it will only be in cases of significant reduction from Russia and Norway that the full capacity of a new MidCat will be used. .

The flow cases illustrate that the need for interconnector will mainly depend on the demand and the behaviour of the two main suppliers Qatar and Russia.

6.3.2 Security of supply – disruption of gas supply from Russia or Norway

The main scenario is disruption of the Russian supply over a year and a loss of 100 bcm/y from this source. Such a long disruption could happen as a consequence of political actions. Shorter disruptions could be due to technical faults or problems with transit countries. Further, a situation with loss of 50 bcm/y from Norway is considered. This could be because of a technical break down of the Troll field or the Draupner platform, which may take years to replace.

France, Spain and Portugal yearly gas balance			Security of supply situations				
2025	bcm/year		Russia -100 bcm			Norway - 50 bcm	
	Maximum		Grey	Green		Grey	Green
France	Entry	Exit					
Norway - Dunkerque	18		8	9		5	5
Belgium	20	8	0	0		-5	0
Germany	19		0	0		0	0
Switzerland	3	7	-7	-7		0	0
Spain Pipeline	7	5	5	19		6	16
LNG Fos	12		12	12		12	12
LNG Montoir	11		11	11		11	11
LNG Dunkerque	13		11	11		11	11
Demand France			-40	-55		-40	-55
Total France	103	20	0	0		0	0
Spain							
Algeria pipelines	22		0	0		10	10
Pipeline Portugal	3	5	-1	-1		-1	-1
France pipeline	5	7	-5	-19		-6	-16
LNG Barcelona	17		12	17		10	12
LNG Bilbao	7		5	7		5	7
LNG Mugardos	4		3	4		2	4
LNG Huelva	12		8	12		5	8
LNG Cartegena	12		8	12		5	8
LNG Sagunto	9		5	9		5	9
Demand Spain			-35	-41		-35	-41
Total Spain	91	12	0	0		0	0
Portugal							
Spain pipeline	5	3	1	1		1	1
LNG Sines	7		6	7		6	7
Demand Portugal			-7	-8		-7	-8
Total Portugal	12	3	0	0		0	0
Total	186	15					
EU balance							
Demand EU			-427	-513		-427	-513
EU production	95		95	95		95	95
Norway pipeline	115		115	115		65	65
Russia pipeline			15	40		115	140
Algeria pipeline			30	30		25	25
TAP pipeline			10	20		10	20
Libya pipeline	10		10	10		10	10
LNG import	218		152	203		107	158
LNG France, Spain, Portuga	115		81	102		72	89

Table 6-3 Yearly flow balances, security of supply with disruption of Russian or Norwegian supplies (bcm/year)

In all cases, this gives a potential for flow from Spain to France which exceeds the present capacity considerably in the high demand green scenario. For the grey scenario, it will be sufficient capacity.

In case of disruption of Russian supply it is assumed that the European gas system will be used in the following way:

- Algerian pipeline gas is sent to Italy instead of to Spain and further into the TAP pipeline to supply Greece, Bulgaria and partly Romania. Also the West Balkan countries can be supplied in this way by re-directing the Shah Deniz gas away from Italy.
- Norwegian gas is sent to Germany and Belgium by fully utilising the supply system to its limit and reduce the flow to UK and France if there is not sufficient total capacity redirecting some of the gas from Dunkerque to Belgium
- Use French LNG import terminals to the limit
- Uses Spanish and Portuguese LNG import terminal to also supply France when necessary.

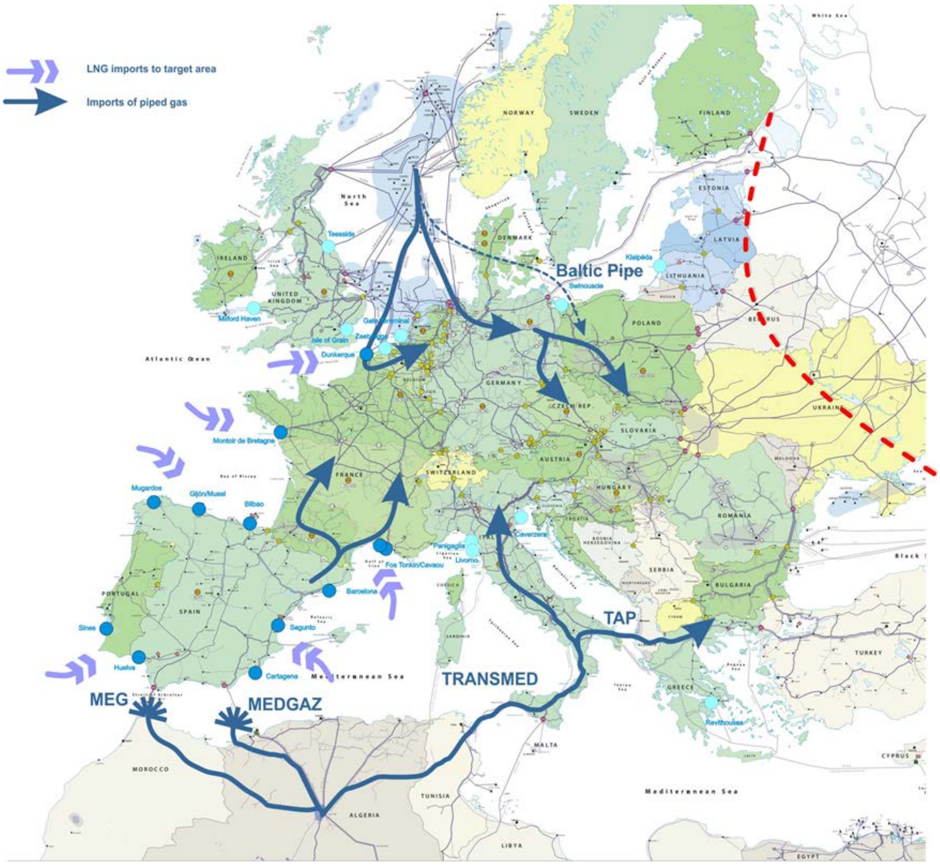


Figure 6-3 Possible flow situation in case of disruption of Russian supply to EU and use of French, Spanish and Portuguese LNG terminals

The flow volumes are shown on the figure below:

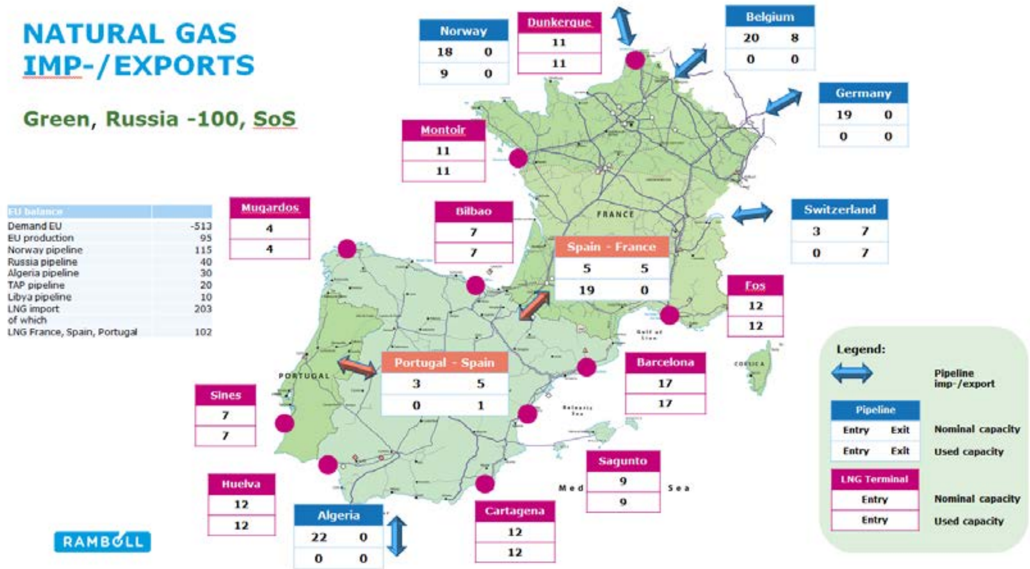


Figure 6-4 Security of supply situation. Green scenario. Russian supply reduced by 100 bcm/year.

A disruption of some of the Norwegian supply will have a number of similar impacts as disruption of Russian supply. However, in such case we assume that the Algerian pipeline supply will continue as normal and Italy can be supplied by TAP gas as normal. It may be that Norwegian supply to France will be completely stopped as priority will be given to Germany and Belgium.

6.3.3 *Disruption of LNG supply from Qatar, Algerian supply or transit via Tunisia*

For the Iberian Peninsula, in particular Portugal, the main security of supply situation is a disruption of supply from Algeria. Further, disruption of LNG supply from Qatar will impact the situation on the Iberian Peninsula as in the rest of EU.

France, Spain and Portugal yearly gas balance								
2025	bcm/year		Algeria - no gas		LNG default (Qatar - 100bcm)		Tunisia transit closed	
	Maximum		Grey	Green	Grey	Green	Grey	Green
France	Entry	Exit						
Norway - Dunkerque	18		15	15	18	18	15	15
Belgium	20	8	5	5	15	20	7	7
Germany	19		10	10	19	19	10	10
Switzerland	3	7	-7	-7	-5	-5	-7	-7
Spain Pipeline	7	5	-5	-2	-15	-5	5	7
LNG Fos	12		10	12	4	4	2	5
LNG Montoir	11		6	11	2	2	4	9
LNG Dunkerque	13		6	11	2	2	4	9
Demand France			-40	-55	-40	-55	-40	-55
Total France	103	20	0	0	0	0	0	0
Spain								
Algeria pipelines	22		0	0	10	10	22	22
Pipeline Portugal	3	5	0	-1	-5	-5	-4	-4
France pipeline	5	7	5	2	15	5	-5	-7
LNG Barcelona	17		8	9	3	10	7	10
LNG Bilbao	7		5	7	2	3	5	5
LNG Mugardos	4		2	4	2	3	2	4
LNG Huelva	12		6	7	3	6	2	3
LNG Cartegena	12		6	7	3	6	3	4
LNG Sagunto	9		3	6	2	3	3	4
Demand Spain			-35	-41	-35	-41	-35	-41
Total Spain	91	12	0	0	0	0	0	0
Portugal								
Spain pipeline	5	3	0	1	5	5	4	4
LNG Sines	7		7	7	2	3	3	4
Demand Portugal			-7	-8	-7	-8	-7	-8
Total Portugal	12	3	0	0	0	0	0	0
Total	186	15						
EU balance								
Demand EU			-427	-513	-427	-513	-427	-513
EU production	95		95	95	95	95	95	95
Norway pipeline	115		115	115	115	115	115	115
Russia pipeline			115	140	125	150	115	140
Algeria pipeline			0	0	25	25	22	22
TAP pipeline			10	20	10	20	10	20
Libya pipeline	10		10	10	10	10	10	10
LNG import	218		82	133	47	98	60	111
LNG France, Spain, Portuga	115		59	81	25	42	35	57

Table 6-4 Possible flow situation in case of disruption of Algerian or LNG supply to EU and use of pipeline connections from North

Disruption of Algerian supply can be compensated by increased LNG supply. It is assumed that some Norwegian gas will be sent to Spain in such case. It is also assumed that the Portuguese LNG terminal will have highest priority.

In case of disruption of LNG supply from Qatar, there will be a need to maximise pipeline import. However, it is assumed that Algeria in such case will maximise their LNG production which will limit pipeline export. In this case it is assumed that pipeline import from Norway and Russia via Germany will be maximised. However, due to the UK dependency of LNG this may not be possible.

Tunisia is the only transit route for Algerian gas to Italy. In case of an interruption, it is likely that the gas will be re-routed to Spain via the existing pipelines. Instead, Norwegian gas flow to Germany and further to Italy via Switzerland can be maximised and hereby there will be a sharp reduction in direct import from Norway and import from Germany.

6.3.4 *France – increased demand for power sector in case of nuclear reduction*

In case of a decrease of nuclear power production it will be possible to use the existing CCGT plants in France as base load. This will give an additional consumption of up to 15 bcm/y. There may also be additional gas power production in Spain, but this is not included in the following case.

France, Spain and Portugal yearly gas balance				
2025	bcm/year		France nuclear + 15 bc	
	Maximum		Grey	Green
France	Entry	Exit		
Norway - Dunkerque	18		15	15
Belgium	20	8	10	13
Germany	19		10	10
Switzerland	3	7	-7	-7
Spain Pipeline	7	5	5	5
LNG Fos	12		8	12
LNG Montoir	11		7	11
LNG Dunkerque	13		7	11
Demand France			-55	-70
Total France	103	20	0	0
Spain				
Algeria pipelines	22		15	15
Pipeline Portugal	3	5	0	-1
France pipeline	5	7	-5	-5
LNG Barcelona	17		7	7
LNG Bilbao	7		4	6
LNG Mugardos	4		2	4
LNG Huelva	12		4	5
LNG Cartegena	12		4	5
LNG Sagunto	9		4	5
Demand Spain			-35	-41
Total Spain	91	12	0	0
Portugal				
Spain pipeline	5	3	0	1
LNG Sines	7		7	7
Demand Portugal			-7	-8
Total Portugal	12	3	0	0
Total	186	15		
EU balance				
Demand EU			-442	-528
EU production	95		95	95
Norway pipeline	115		115	115
Russia pipeline			115	140
Algeria pipeline			25	25
TAP pipeline			10	20
Libya pipeline	10		10	10
LNG import	218		72	123
LNG France, Spain, Portuga	115		54	73

Table 6-5 Possible flow situation in case of increased use of LNG in case of nuclear disruption in France

In both scenarios the French LNG terminals and existing terminals in EU will be sufficient together with the existing pipeline between Spain and France.

6.3.5 *Conclusions on the yearly flow cases*

The yearly flow cases show that the need for increased interconnector capacity in normal market situation will mostly be present in the grey scenario with low demand if Qatar continues to supply LNG to EU via the UK and Belgium terminals rather than via Iberian terminals.

If the LNG prices are high there will also be a case if Russia decides to increase supply as such gas will almost replace all LNG to EU.

In the Green – high demand scenario and a situation with low LNG prices there will also be a need for additional capacity if Russia and Norway reduce their supply. Such golden age for gas situation may become the case if there will be global oversupply of gas.

The strongest need for increased interconnector between the Iberian Peninsula and the rest of Europe will be in the green scenario in the case of a major disruption from the North European suppliers, Russia and Norway.

6.4 Comparison of interconnector cost with new and expanded LNG terminals

One of the benefits of increased interconnector between the Iberian Peninsula and the rest of EU is that the existing overcapacity of receiving terminals in Spain could be utilised. It can be argued that new LNG terminals can be established closer to the end user market in France and rest of EU.

A simple comparison of cost indicates the possibility for use of Spanish LNG terminals if this was the only benefit of an interconnector.

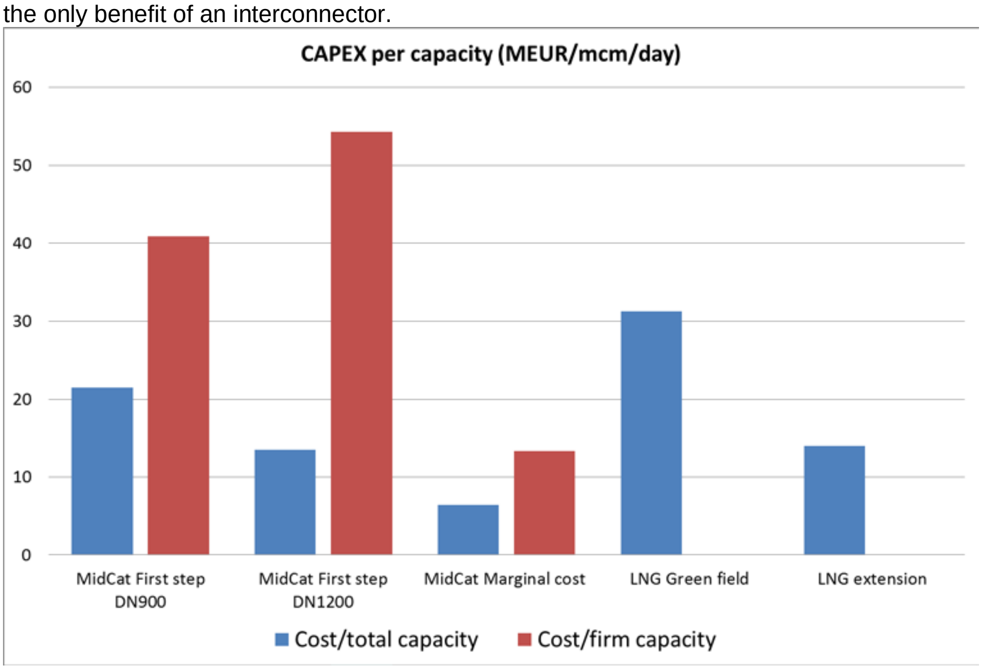


Figure 6-5 CAPEX per capacity for MidCat and LNG terminals (MEUR/mcm/day)

The graph shows the economics of scale for pipeline as well as for LNG terminals. The LNG extension can only be used in a few cases where there is space for increase of capacity in the port facilities and by establishing new storage. It can be considered as the marginal cost for pipelines by choosing a larger diameter. Also, in such cases there may be additional cost to bring the gas to the market as there may be saturation close to the terminal.

Similarly for the pipeline there is a huge advantage for choosing a large diameter pipeline if there is no need for additional investment at the end of the pipelines. The marginal cost is the difference between the DN900 and DN1200 solution assuming that there were other reasons for the initial investment.

6.5 Price differences between Iberian Peninsula and rest of EU

6.5.1 *Price differences historical*

The interconnector could and should be used to even out potential price differences arising from bottlenecks between the countries.

Spain has for many years been regarded as a high price area due to a combination of dependency on LNG, supply on oil indexed contracts from Algeria, and limited possibilities for sourcing of gas from the rest of Europe. Below in Figure 6-6 the price developments between the French PEG and estimates by Waterborne on the LNG prices in Spain are presented. The graph shows significant differences between the areas in some periods during the year, typically during the winter months.

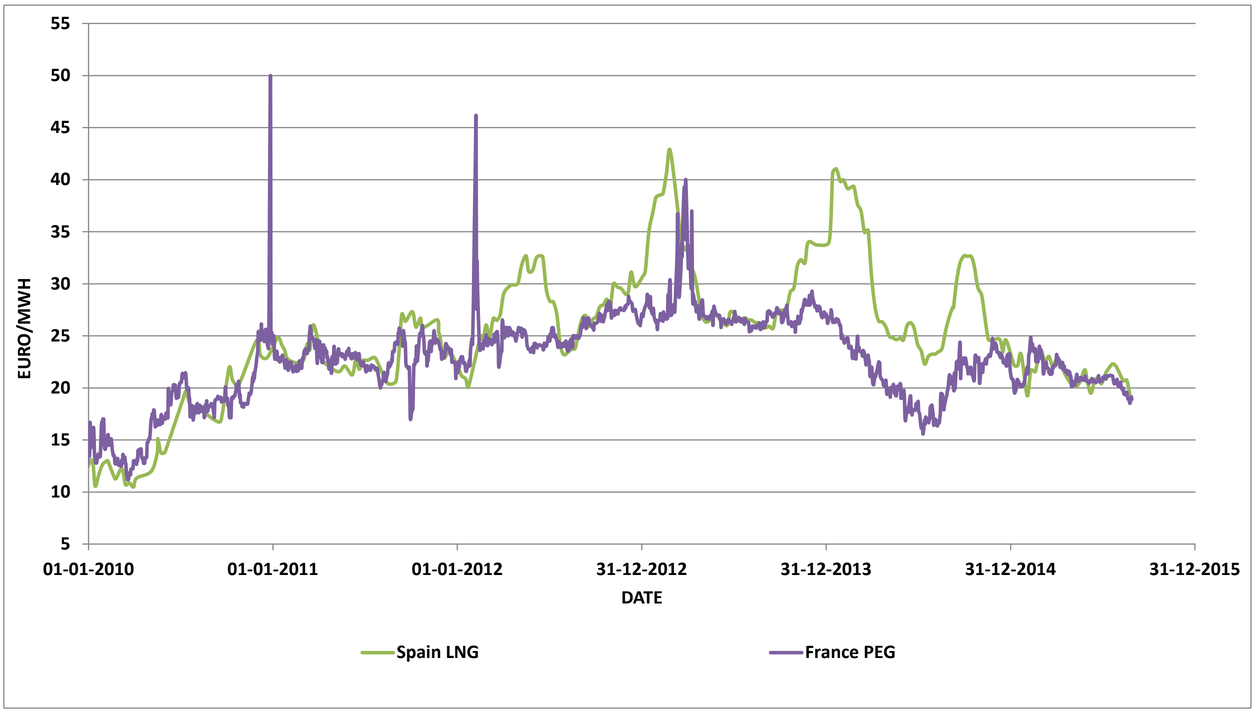


Figure 6-6 Historical gas prices, France and Spain (Source: Reuter)

In a perfectly competitive environment price differences between areas would be adjusted “quickly” by arbitrage leaving only the transportation cost as the difference between the areas. From the figure below it can be seen that large price differences main arise during winter and are relatively long lived.

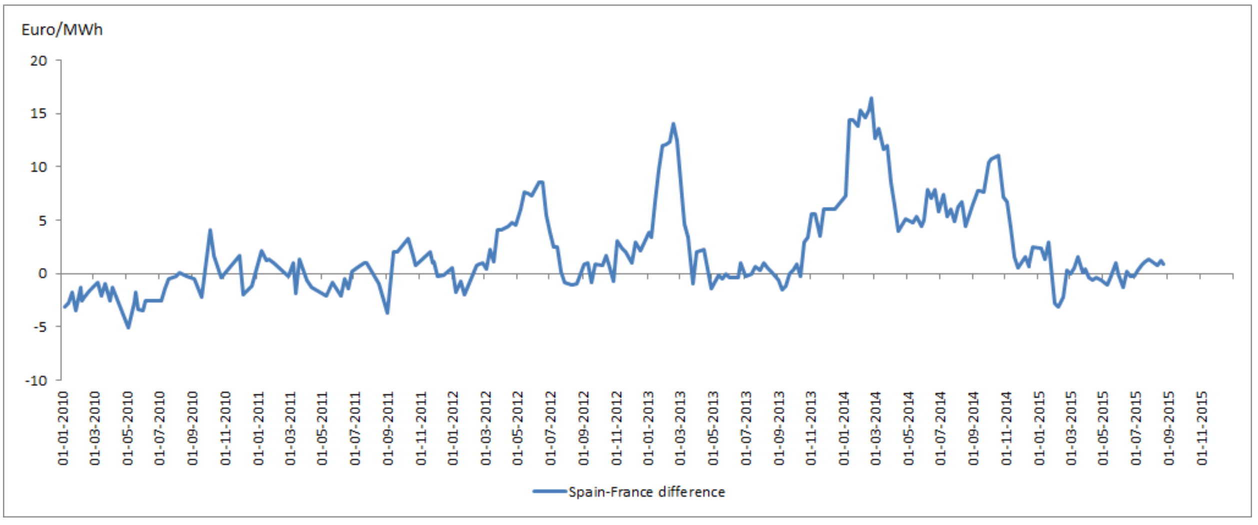


Figure 6-7 Gas price difference Spain and France (Source: Reuter)

Assuming that the transportation cost amounts to 2.5 euro/MWh, it can be concluded that there are no bottlenecks from the south to the north. On the other hand bottlenecks seem to appear at least in some periods from France to Spain. Looking at the actual capacity utilization during these periods shows that the interconnector has been used to the maximum capacity during these periods.

Thus, there is reason to believe that additional capacity could alleviate potential bottlenecks at the border. The welfare gain from this is not easily deducted as future prices can be affected in many different ways. However, as an example, the months which are “overpriced” have an average consumption of 2.5 bcm assuming uniform distribution of demand over the year (conservative assumption as the winter months constitute a larger share of demand). Below the price differences corrected for transportation costs are illustrated showing a minimum of 5-6 Euro/MWh and a maximum of up to 18 Euro/MWh.

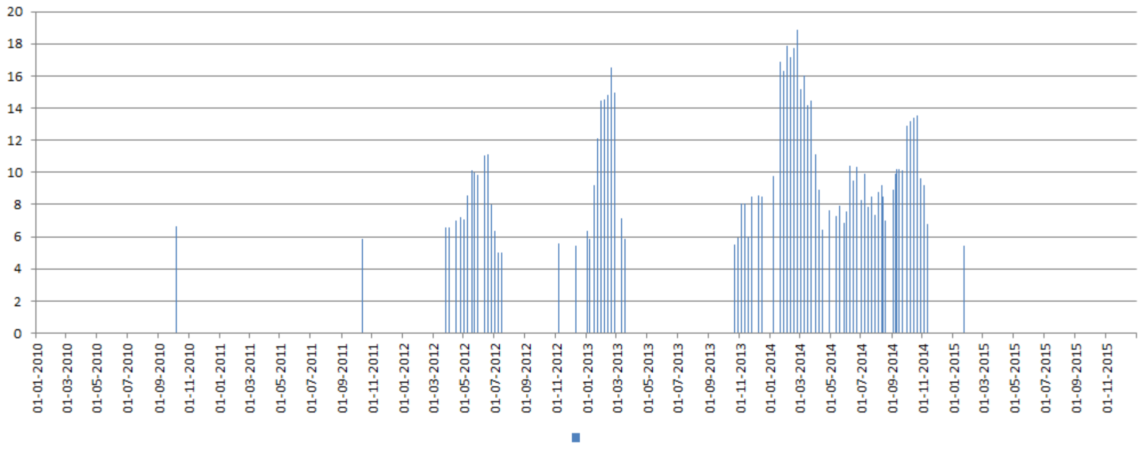


Figure 6-8 Price difference Spain-France

Assuming bottlenecks over a period of a month in aggregate and with a price difference of 5 Euro/MWh gives annual saving of up to 143 MEUR per month.

6.5.2 *Benefits of interconnector to limit price differences in green and grey scenario*

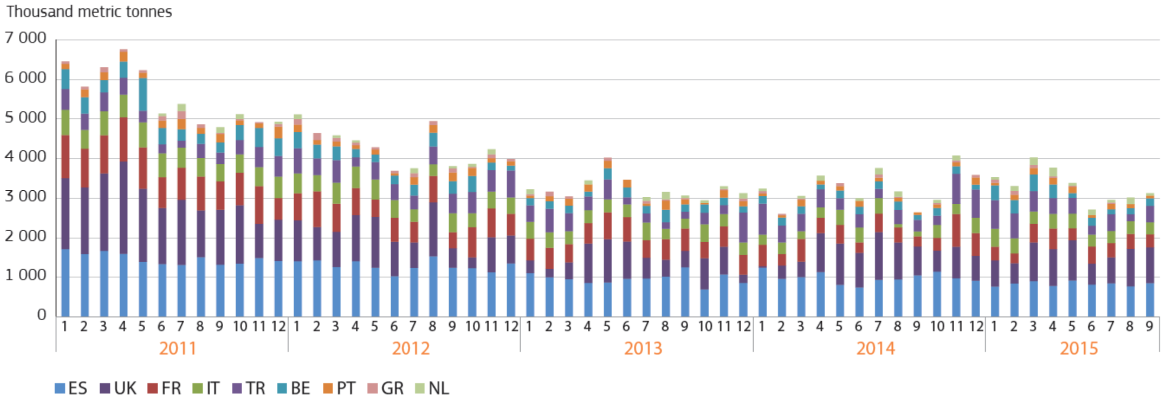
With the creation of a single market place in France from 2018, the differences in prices between the present North and South zone in France will disappear. Instead the price difference will move to the border between France and Spain.

When Spain, Portugal and France all import large volumes of LNG, and when global LNG prices are equivalent to the European pipeline prices, there will in a liquid market be a possibility to change import locations and hereby avoid large price differences.

The yearly gas balances indicate that with the selected scenarios, there will during normal years only be a need for use of the Iberian LNG facilities to supply the rest of EU in cases with low LNG prices compared to pipeline gas and high demand in EU (Green scenario). The volumes will depend on the Russian policy and response to competition from lower LNG prices.

In recent years gas prices on the Iberian Peninsula and South of France have been higher than in North Western Europe and there has been a net flow from North to South. This has to a certain degree been due to long term contracts and preference of Qatar to deliver LNG to the UK and Belgium market rather than to France, Spain or Portugal. The figure below shows the decline in LNG supply in general and the preference for supply of LNG to UK.

FIGURE 7 – IMPORTS OF LNG INTO EUROPE BY COUNTRY



Source: Thomson-Reuters Waterborne
Lithuania is not included

Figure 6-9 LNG supply to Europe (source EU Quarterly Report Energy on European Gas Markets Market Observatory for Energy DG Energy Volume 8 (issue 3; third quarter of 2015))

During recent years the European LNG import has decreased due to declining demand. To create a situation where pipeline gas should entirely replace LNG, there will be a need for very high supply from Northern Europe compared to demand. This can be because of new supply from Nord Steam 2 or due to significant decline in demand, e.g. due to years with warm and windy weather (climate change) or financial crises. Mandatory use of LNG in countries like Lithuania and Poland as part of security of gas supply policy may also redirect Russian gas to Western Europe. In such case, the Iberian Peninsula can be isolated and LNG prices can be increased in case of high global LNG prices or lack of competition.

With high LNG prices and high gas pipeline import there will only be between 10 and 15 per cent LNG import to EU. To illustrate this, the capacity of the Nord Stream 2 will be larger than the present overall LNG import to EU.

The price difference between LNG and North-West European gas prices may also impact the price setting of pipeline gas from Algeria as this gas will only be competing with LNG on the Iberian Peninsula, while it is competing with pipeline gas in Italy. It could be assumed that Algerian pipeline gas on the Iberian Peninsula can follow the LNG price.

To illustrate the order of magnitude of the value of price difference, the yearly capacity and a price difference of 5 EUR/MWh is used. However, such high price differences may not be sustainable over longer periods. For a capacity of 8 bcm the value will be around 500 MEUR per year. With 20 bcm capacity the yearly savings can be 1200 MEUR. For the situation with equal LNG and TTF prices a price difference of 2.5 EUR/MWh is used equal to the tariffs for using the existing system from France to Spain.

Short term arbitrage advantages will occur such as delivery of gas from underground gas storage in South of France to Spain in warm years with high storage level.

The beneficiary of the arbitrage between LNG and pipeline gas will be the consumers, while the losers will be gas suppliers and the producers. Further, the owners and users of LNG terminals and pipelines will be losers and winners, respectively.

Spain and Portugal are the most vulnerable to high LNG prices as the lack of competition from pipeline gas from the rest of EU makes the country dependent on internal competition between LNG exporters to obtain reasonable prices. This situation can only be changed by adding additional pipeline capacity.

6.5.3 *Conclusion on benefit of price differences*

In the Grey scenario it is likely that there will be a continuous flow from France to Spain as Qatar prefers to use UK and Belgium LNG terminals. Even when international LNG prices are equal to TTF price there will be benefits of increased capacity as the high tariffs for using the existing system from France to Spain is assumed to result in a price difference of 2.5 EUR/MWh. The yearly benefit is assessed to 200 MEUR.

With high LNG prices there will be further benefit of additional interconnector capacity up to 500 MEUR yearly for an additional capacity of 8 bcm/year.

In years with lower LNG prices than pipeline prices, it is found that there will be less use of the interconnector as it will be favourable to use LNG import as close to the end consumers as possible. This will result in higher LNG import in France, Belgium, Italy, UK etc., while the Spanish and Portuguese terminals will primarily be used for indigenous consumption.

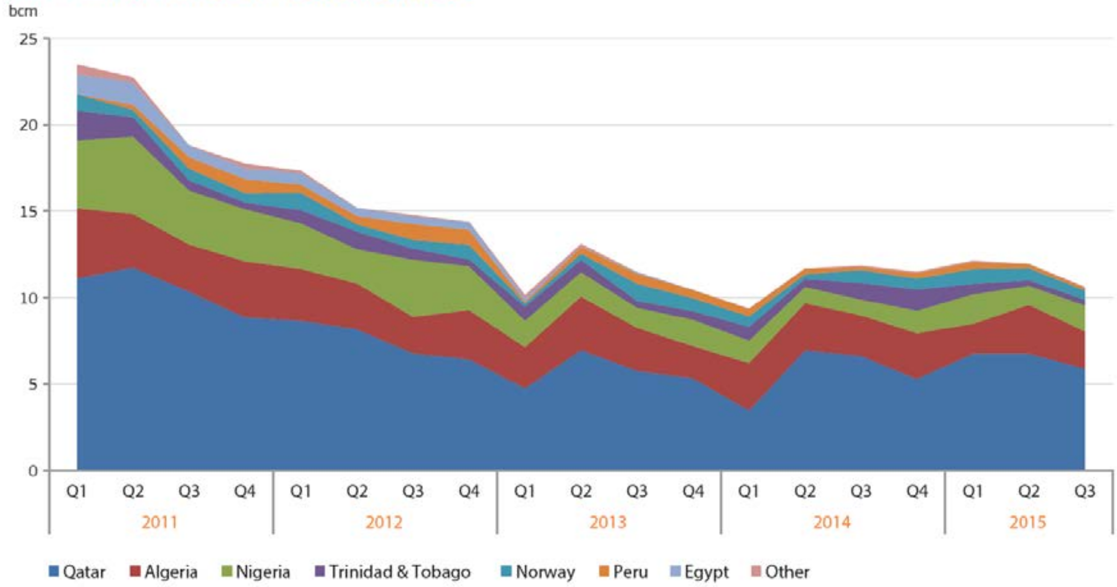
Assuming that years with high and low LNG price outweigh each other, the average yearly benefit will be 200 MEUR for an additional capacity of 8 bcm/year. The NPV of this over 40 years will be 4000 MEUR.

In the Green scenario the benefit of additional interconnector will primarily be to use the Iberian LNG terminals in situation with low international LNG prices as it is assumed that other terminals in Europe will be fully used in such situation. Assuming that this will be the situation for one in five years the average yearly benefit will be 100 MEUR.

6.5.4 *Qatar gas to UK, Belgium creates higher prices in Spain, Portugal*

Qatar and Russia are the two swing producers to the EU gas market at present, and it is expected to be the case for years ahead, unless new LNG players as Australia and USA decide to enter the market with very large volumes. As Egypt, Yemen and Libya have left the LNG market, there are in practice only three players in the European LNG market; Qatar, Algeria and Nigeria. The figure below shows the dominance by Qatar with a rising market share which is now more than 60 per cent.

FIGURE 8 - LNG IMPORTS TO THE EU BY SUPPLIER



Source: Bloomberg/Poten & Partners
Imports to Lithuania are not included

Figure 6-10 LNG supply to EU by country (Source: Eurostat)

By exporting the Qatar LNG to UK and Belgium, it is possible to split the EU gas market into two main price areas, the Iberian Peninsula and the rest of EU. This is due to the limited capacity of the present gas interconnector between France and Spain. On the Iberian Peninsula there will be no competition between Qatar and Russian gas supply to EU as Russia has no access to this market. Hereby it will be possible to keep the Iberian gas prices at the global LNG prices or at least at the level of rest of EU plus the transportation cost to Spain from France. As a result, UK has now overtaken Spain as the largest EU importer of LNG.

If Qatar instead supplied large volumes of gas to the Spanish LNG terminals and changed the pipeline flow from Spain to France, the price would fall to the price in France minus the transportation cost from Spain to France. As Qatar partly owns the LNG terminal South Hook in UK, there is further incentive to use this terminal rather than Spanish terminals, despite the longer sailing distance.

By exporting LNG to UK and Belgium, Qatar has to compete with Russian gas, assuming that the EU producers and Norway produce at full capacity.

If additional pipeline capacity is established between Iberian Peninsula and the rest of EU there will also be such competition between Qatar gas and Russian gas on the Iberian Peninsula.

6.5.5 *Russian pipeline gas to Iberian Peninsula*

Today, Spain is importing gas via pipeline from Algeria via two pipeline systems of which one via Morocco, and from Norway, as part of the Troll field development.

The existing gas interconnectors between France and Spain are fully booked, or there are bottlenecks inside France. There are therefore not any possibilities for export of Russian gas to Spain and Portugal via pipeline. The Iberian Peninsula is hereby the only part of EU without access to Russian pipeline gas. Increased capacity of the interconnector will open for such import and hence a more competitive market.

As Russian gas is being replaced by new sources in Lithuania and Poland when LNG import starts and in Italy with the start of TAP, Russia will need to find new markets to maintain its market share as the traditional markets may also decline. The political change in Ukraine has also resulted in a dramatic decrease in gas consumption and import from Russia, allowing for increased export to EU.

6.5.6 *LNG price increase in Security of Supply situations*

In the following Security of Supply situation, we will use a price elasticity of 10 per cent, implying that an increase of European LNG from 70 to 170 bcm/year would result in an increase of 25 per cent. This corresponds to using the LNG import prices for Japan instead of Europe in the WEO New Policy scenario.

6.6 Security of gas supply to rest of EU

6.6.1 *SoS cases, probabilities and quantification of cost savings from Iberian interconnection*

The benefit of increased capacity of the interconnector for security of gas supply is a combination of possibility for increased use of the new capacity, probability and duration of events and the value of avoiding disruption of supply in the rest of EU. In many cases it will primarily be countries outside Iberian Peninsula and France which will benefit from the increased flexibility, as the existing LNG facilities in South Western Europe is already creating security of supply towards e.g. Russian supply disruptions.

In the following the upper value of contribution of security of supply is calculated by assuming that the alternative to delivering gas via the interconnector would be to use gas oil in e.g. power plants in Germany, France, UK, Portugal etc. Only long term incidents considered as short term incidents will typically be covered by use of gas storage facilities. The main driver behind the use of the interconnector for security of supply will be to use the idle LNG capacity in Spain, after idle capacity has been used in France. One of the uncertainties in such situation is how much the LNG prices would increase in such security of supply situations. We have assumed an increase in gas import price to Europe of 25 per cent, and using the WEO forecasts this corresponds to LNG prices in Japan.

The security of supply events are described elsewhere in this report. By combining probabilities for the events with the use of interconnector and duration of each event of one year, the following value can be calculated.

Oil_prices: IEA new policies scenario, flat after 2040 **End_year** 2060 **Start_year** 2020 **Discount_rate:** 0,04				Gasoil price = Crude oil + refinery m 6,6 EUR/MWh = 12,0 USD/bbl NPV of price difference between gasoil and natrual gas price LNG i **6,32** bEUR/bcm/year over 40 year 0,16 bEUR/year							
Event	**Probabaility**	**Capacity 8 bcm**		**Capacity 20 bcm**		**Flow direction**	**NPV (bn Euro) Capacity 8 bcm**		**NPV (bn Euro) Capacity 20 bcm**		**Duration (year)**
		Grey	**Green**	**Grey**	**Green**	**Grey and Green**	**Grey**	**Green**	**Grey**	**Green**	
Russian disruption of gas supply, or Ukraine or Belarus transit	1,00%	0	8	0	12	North	0,00	0,51	0,00	0,76	1
Norwegian disruption, in particular Troll field or Draupner	1,00%	0	8	0	9	North	0,00	0,51	0,00	0,57	1
UK-Belgium interconnector failure	0,50%	0	2	0	2	North	0,00	0,06	0,00	0,06	1
Nuclear incident in France, closing nuclear power and increase use of CCGT in France, Germany etc.	0,00%	0	0	0	0	North	0,00	0,00	0,00	0,00	1
Disruption of Algerian supply via Tunisia to Italy for technical or other reasons	1,00%	0	0	0	0	North	0,00	0,00	0,00	0,00	1
Groningen field disruption	0,50%	0	0	0	0	North	0,00	0,00	0,00	0,00	1
Algeria gas supply disruption or Morocco transit	1,00%	0	0	0	0	South	0,00	0,00	0,00	0,00	1
Qatar or Nigeria LNG Failure	1,00%	8	0	10	0	South	0,51	0,00	0,63	0,00	1
Technical fault on Medgaz, or Strait of Gibraltar pipelines/compressors	0,50%	0	0	0	0	South	0,00	0,00	0,00	0,00	1
						TOTAL (bn EURO)	**0,51**	**1,08**	**0,63**	**1,39**	
North							0,00	1,08	0,00	1,39	
South							0,51	0,00	0,63	0,00	

Table 6-6 Summary of security of supply probability, additional capacity for interconnector, duration and economic value NPV

In the table the value of security of gas supply is calculated based on a unit value taken as the difference between price of gas oil and imported LNG multiplied by a probability of the event, the need for additional flow in the interconnector and the duration of the event. In this way the focus is entirely on events with long duration as short term events will be mitigated by use of underground gas storage etc. In the calculations a duration of one year disruption is used as an average. It could, however, be as well be ½, 1, 2 or 5 years.

6.7 Shorter shipping distance

The duration of an LNG round trip from Qatar to NW Europe is approximately 7 days than for unloading on the Iberian Peninsula or in South of France. With a cost of LNG vessel of 50.000 USD/day the corresponding extra cost of transportation will be approximately 0.3 EUR/MWh.

With an additional interconnector capacity of 230 GWh/day, this corresponds to a yearly saving of 25 MEUR, corresponding to an NPV of 500 MEUR over 40 years.

6.8 Algerian short range LNG supplied by pipeline

LNG liquefaction requires around 5-10 per cent of the gas for compression and cooling. For short distance this is much more than pipeline transportation for which a distance of less than 1500 km as for transportation from Algeria to Spain and south of France the energy consumption will be around 1 per cent. In the following a 5 per cent saving by using pipelines instead of LNG is used.

The yearly LNG export from Algeria to France was 4.4 bcm in 2014. Assuming that all this volume was changed to pipeline transportation, the savings would correspond to around 200 mcm of gas.

Assuming a gas value equal to a price of 20 EUR/MWh the savings will be around 1.8 EUR/MWh in pure energy consumption. The value of the gas will be around 45 MEUR per year, corresponding to a NPV of 900 MEUR. However, it can be argued that this benefit will mostly be a benefit for Algeria and that the value should be determined as the production cost and not the price. Assuming production cost of 6 EUR/MWh, the NPV of benefit will only be 270 MEUR.

6.9 Storage uses in South France

The Iberian Peninsula has only small underground gas storage capacity. With increased capacity across the Spanish-French border there will be a possibility for using the gas storage facilities in the South of France. This could open for a more flexible use of the LNG import terminals on the Iberian Peninsula.

Due to the high tariffs for crossing the border with the present pipelines, it is not possible to use historical data to assess the need for use of storage. It is outside the scope of the present study to carry out very detailed storage analyses.

The benefit of gas storage use has consequently not been quantified in the present analyses.

6.10 Increased gas production in Algeria and Trans Saharan Gas Pipeline

Increased interconnector capacity may contribute to increased gas production in Algeria. As described, Algeria has large conventional and unconventional gas reserves. Further, Algeria has committed itself to reduce or stop flaring in association with oil production. Easier access to the entire EU gas market may contribute to decisions among national and international producers to invest in increased production. So far, Algeria has had focus on the Galsi project to bring additional volumes of gas to the EU market. With more direct access such major investment will not be necessary.

The benefit for EU of increased gas production from Algeria will be increased competition and less need for security of supply if gas can be moved freely around. The benefit for Algeria of increased pipeline connection will be saved gas for liquefaction and increased value of production.

The Trans Saharan Gas Pipeline (TSGP) is a pipeline connection between Nigeria and Europe via Niger and Algeria. The pipeline connection could be an alternative to LNG export from Nigeria. This is in particular the case because such pipeline may be cheaper than a full LNG chain. However, the safety situation in the countries involved also holds back the project. Uncertainty about capacity in Spain and between Spain and France is one of the other factors holding back the project.

6.11 Comparison of cost and benefit

The following table shows the comparison between cost and benefit.

	Grey scenario		Green scenario		
Benefits	Yearly	NPV 40 yea	Yearly	NPV 40 yea	Beneficiary
Price difference					
North to South	200	4000			Spain, Portugal, France (transit)
South to North			100	2000	France (transit), Germany rest of EU
Security of supply					
North to South		500			Spain, Portugal
South to North		0		1080	Germany, Poland, Czech Republic,EU
Shorter shipping distance	20	400	20	400	Qatar or LNG buyers
Algerian short range LNG supplied by pipeline	45	900	45	900	Algeria or France
Storage use in France		?		?	France
Algerian gas production or TSGP		?		?	Algeria, Nigeria
Grand Total		**5800**		**4380**	
Price and security of supply		**4500**		**3080**	
Cost (Capex and Opex)					
MidCat first step		**589**		**589**	
MidCat incl Eridan etc (50%) and 3rd interconnector to Portugal (30%)		**2068**		**2068**	
MidCat full - incl all cost		**3694**		**3694**	

Table 6-7 Cost-benefit comparison

It can be seen that the overall cost of the full MidCat weighted with the part of the capacity which will be used for the MidCat is around 2 BEUR.

The total benefits are considerably larger than the cost. However, some of the benefits may be overlapping and some of the beneficiaries are outside the EU. Also, it should be highlighted that there are considerable uncertainty in the assessments.

6.12 Conclusions

- The combination of price advantage and security of supply creates benefits higher than cost for the grey as well as the green scenario. However, the contributions differ with benefits of north to south flow in the grey scenario and south to north in the green scenario, with a considerable part from security of supply.
- The benefits of the interconnector are uncertain as they will depend on:
  - Gas demand in EU
  - Gas supply policy and actions by the two main external suppliers Russia and Qatar
  - Tariff system in France and Spain

- Establishing new LNG terminals for security of supply purposes in Northern and Eastern Europe will create an increase in the North to South flow from France to Spain as such terminals will not only be used for security of supply but also for diversification

- TAP, and potentially Galsi, will with the possibility for reverse flow from Italy to France via Switzerland create further north-south flow in France and towards Spain.

- The uncertainty about the actual gas demand in EU (and not only the countries involved) results in high uncertainty of the results and how the actual flow would be in case of establishing the full MidCat system, including a stronger internal connection in France and a new connection between Spain and Portugal could favour a step wise development with the first step of MidCat to be built before deciding on the other elements.

- There is a difference in where the benefit and costs are located in the EU. Some of the benefits even fall outside the EU.
  - Security of supply benefits: Eastern Europe and Germany
  - Price benefits: Spain and Portugal

  For France the main benefit will be the income created by the transmission system and sharing of cost.

- The proposed solution with a DN900 mm for the MidCat crossing of the border and DN1200 mm for the Eridan and Arc Lyonnais implies that only a part of the Eridan and Arc Lyonnais should be allocated to MidCat project. Alternatively, the first step of MidCat should also be established with a DN1200 dimension.

7 References

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