Implications of European Shale Gas Developments for the EU Gas Market: A Model Based Analysis

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Background

The shale gas boom in the U.S. in the past decade has led to expectations and fears in Europe: expectations with respect to the possible contribution shale gas deposits in Europe can make to European gas needs in the future and thereby ease Europe's security of supply concerns, and fears with respect to the risks attached to European shale gas developments based on incidents in the U.S. (e.g., local ground water pollution, safety hazards) and the sustainability of shale gas activities at large. In response, some EU countries have imposed a de facto moratorium on shale gas developments (e.g., France) whereas others have welcomed a large number of test drillings for shale gas (e.g., Poland).

Estimates of the presence of shale gas deposits in Europe vary and similarly, there is large uncertainty exists regarding the costs of bringing this gas to market. The possible risks involved in producing shale gas deposits across Europe needs to be thoroughly assessed, and also the degree to which shale gas is a sustainable energy source in comparison with alternatives needs to be analyzed. But irrespective of these issues, also the desirability (or need) to develop shale gas resources from an economic market perspective needs to be addressed. Without proper information on this aspect policy maker's decisions on shale gas developments across Europe are bound to be flawed.

Based on the scarce available information, and for the moment ignoring political decisions that are or may be made across different EU member states, this article tries to assess the possible implications of shale gas developments in Europe for the EU gas market. How do shale gas developments contribute to security of supply in the EU and its member states in next decades? How may developments affect the sourcing of gas consumption across the EU? And: what are the implications for infrastructure use and investment requirements? These are the type of questions addressed in this contribution.

Methodology and Assumptions

In order to quantify the possible impact of future shale gas developments in the EU we use an economic optimization model that covers the EU gas market and its neighboring regions. The use of market models to simulate (future) gas market developments is not new, but an application to the potentially high-impact development of large-scale shale gas production has not been researched thus far. The lack of an application to the case of shale gas prospects may be explained by the scarce availability of commercially recoverable shale gas estimates and production cost data. We use an existing multi-complimentarity problem (MCP)-based model of the European gas market that features endogenous investment decision-making, distinguishes between different demand periods within a year, has a timeframe until 2050 and is able to reflect different degrees of upstream market power.[1] The model endogenously determines required investment in new gas infrastructure over time using a net present value based rule. However, assumptions need to be made regarding investment in new gas production capacity over time. The model simulates market operations given available gas resources and gas demand nodes across Europe and provides optimal market outcomes in terms of matching supply and demand. In doing so it takes into account the fact that the natural gas market is not a fully competitive market: it allows gas suppliers room for exercising market power. This leads to gas prices across Europe lying above the level of total costs of delivery. In order to simulate future gas market developments various assumptions need to be made.

First of all, an existing scenario framework that is developed in the European research project SUSPLAN[2] provides a suitable context for assessing shale gas developments (Auer et al. 2009). This project assessed the energy infrastructure implications of different energy transition paths to 2050. The most relevant aspect of this framework for the analysis on shale gas is the range in gas demand projections derived from the scenarios. We particularly use the high gas demand scenario that shows a continuing increase in gas demand in Europe until 2050, and the low gas demand scenario where gas demand peaks around 2030 and steeply declines until 2050[3]. With climate policy being one of the key drivers for the future role of gas in the energy mix it is important to mention here that long-term sustainability targets are not met in this particular high gas demand scenario, but are met in the low gas demand scenario. As will become clear, the impact of shale gas penetration in the markets is different for both scenarios. Figure 1 presents the two gas demand trajectories until 2050 used

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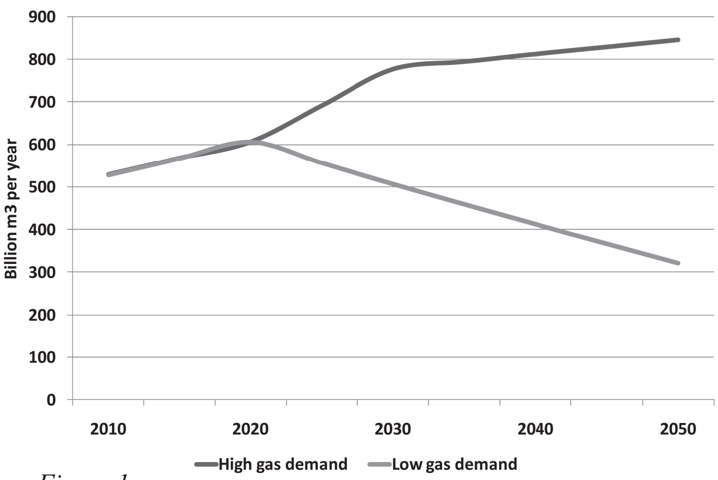

Figure 1
Scenarios for EU gas demand until 2050 (Source: SUSPLAN, De Joode et al. (2011))

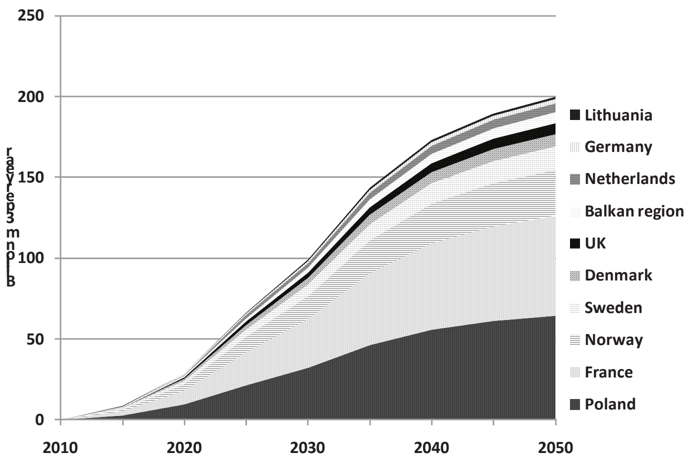

Figure 2
Installed shale gas production capacity across EU (Source: own calculations based on EIA (2011) and Geny (2010))

in this analysis. We refer to De Joode et al. (2011) for a full description of scenario assumptions and data input.

Second of all, we need to make assumptions on the availability of shale gas deposits, the rate of investment in shale gas production assets, and the cost of producing shale gas across Europe. Firstly, we use EIA estimates (EIA 2011) for technically recoverable shale gas resources to identify the potential shale gas producing countries in Europe. Secondly, we use *high but not totally unrealistic production levels* for shale gas in 2010 and 2030 provided by Gény (2010) to construct a possible trajectory for investments in shale gas production capacity for Europe in total for the time period until 2050. Total realized capacity is allocated to the countries with shale gas potential as estimated by EIA (2011) on a pro-rata base. Figure 2 illustrates the shale gas production capacity that is assumed to come on stream over time, which is exogenously fed into the simulation model. Thirdly, we assume that the cost of producing shale gas is in the range of 7-12 €-cent per m^3 (IEA 2010), with the higher end of the range applicable to shale gas produced at maximum production capacity. These cost assumptions are uniform across all countries and are about 3 to 4 times higher than the cost of conventional gas production.

In this analysis we focus on the *substitution-effect* of shale gas developments, and not on the *demand-side-effect*. In other words, while keeping gas demand at the level of, respectively, the high and low gas demand scenarios we analyse shifts on the supply-side. Theoretically, the increased availability of (shale) gas resources could give rise to lower (local) gas prices and an increase in demand, but this effect is not assessed in this article.

Results

Decrease of EU Import Dependency

The impact of the increasing shale gas production capacity can be derived from comparing simulation results for the high and low gas demand storylines with and without the assumed trajectory of investment in shale gas production assets. As may be expected this leads to an increase in indigenous shale gas supplies that replaces gas supply previously contracted outside the EU. Regardless of the gas demand scenario the level of import dependency of the EU as a whole is reduced both in absolute import volumes and percentage wise. This result is illustrated by Figure 3. This observation can be explained by a substitution of the most expensive external gas supplies (reflecting production as well as transportation costs) for local unconventional gas supplies: this varies across EU member states as becomes clear below. However, with the assumed realization of shale gas production capacity the EU will still be largely dependent on external gas suppliers in the future.

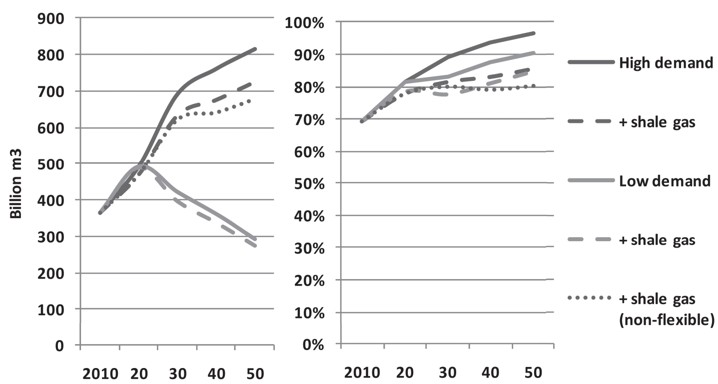

Figure 3
EU import dependency in absolute and relative terms across scenarios (Source: own calculations)

The supply countries that experience a decline in gas exports in particular are LNG producing countries such as Nigeria, Qatar and Egypt, and, to much lesser extent, Algeria and Russia. In the low gas demand scenario there is considerable less substitution of imported gas with indigenous shale gas as the much lower gas demand gives rise to relatively lower prices, which already pushed the high supply cost options out of the supply curve in the situation without shale gas.

Significant Changes in Gas Flow Patterns in Some Parts of the EU

Since a large part of the European shale gas prospects are located in countries with previously little or no gas production the increasing penetration of shale gas across the EU significantly affects EU internal gas flows as well. Figure 4 illustrates the impact of shale gas production in a high gas demand scenario in 2050 by depicting the incremental changes in net yearly gas flows compared with the situation with no shale gas production at all. Note that the incremental changes in gas flows may vary across seasons. Below we sketch some of the implications for infrastructure investment..Whereas increased production from the relatively more limited shale gas deposits in the UK, the Netherlands and Norway basically (partly) compensate for the declining conventional gas production, the large presence of shale gas in Poland and France gives rise to changing gas flow patterns in those regions. Whereas French shale gas is partly exported to Italy, Belgium and the Netherlands, Polish shale gas is exported to other central and eastern European countries that previously relied mostly on Russian gas imports. In order to accommodate these gas flows new gas pipeline investments are required for French interconnections with Italy and Germany, and Polish interconnections with Central Europe and the Baltic states. In the low gas demand scenario the little gas produced from shale gas deposits hardly affects infrastructure investment requirements since shale gas is predominantly consumed within the borders of the producing country.

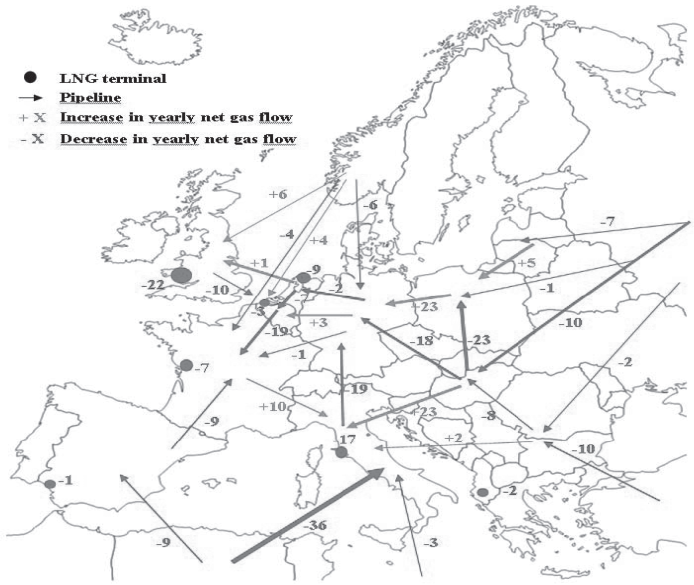

Figure 4
Incremental changes in yearly net gas flows in 2050 due to shale gas production in a high gas demand scenario (in billion m3 per year) (Source: own calculations)

Higher Level of Gas Supply Diversification and Smaller Import Dependency at Member State Level

The presence of shale gas resources across Europe leads to new dynamics in European gas trade with new gas producers not solely producing for domestic consumers but also for neighboring countries: gas producing countries may at the same time import and export gas, just as is the practice on the current gas market. The newly added shale gas production capacity significantly impacts the import dependency of countries – as measured by the gap between national gas demand and production – varies largely across countries (see Figure 5). Shale gas production in Germany reduces German import dependence somewhat, while UK shale gas production is by no means capable of compensating for declining conventional UK gas production. However, shale gas production in Poland and France proves a *game changer*: Poland could become self-sufficient in the second half of the period until 2050 in a high gas demand scenario and France reduces its import dependency by more than 40%. In a low gas demand future the impact becomes negligible since the little gas demand that

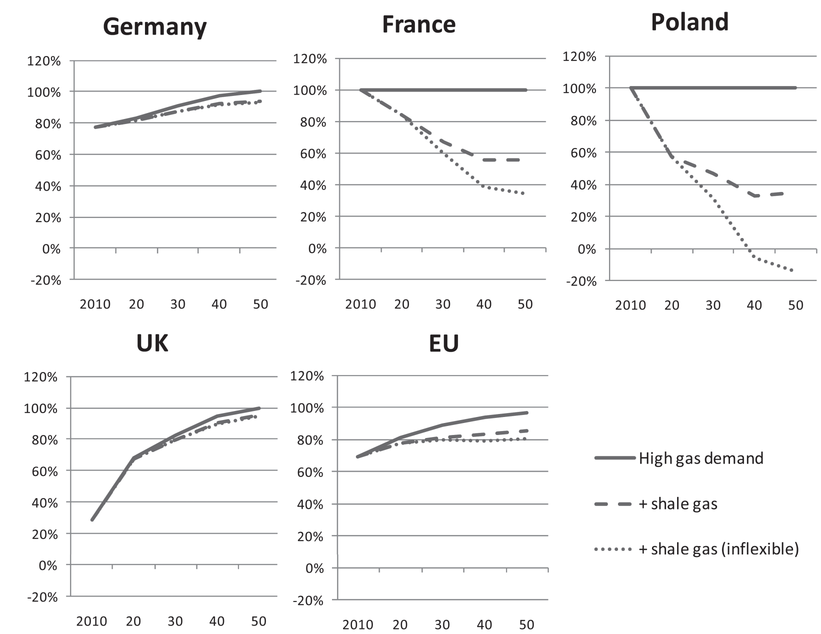

Figure 5
Import dependency of selection of EU member states and the EU (Source: own calculations)

still needs to be served is accommodated by relatively cheaper conventional gas supplies from Norway or Russia. The general message that may be taken from these results is that the figures for the EU as a whole cannot tell the whole story for individual EU member states.

Assumptions on Shale Gas Production Flexibility Matter for Simulated Market Outcomes

Although the above results show a significant impact of shale gas developments on the gas demand/ supply balance in the EU we find that the total amount of shale gas produced over the years is less than what actually could be produced based on the assumed development of shale gas production assets over the same period. When simulating the impact of shale gas it turns out that in the low demand periods it is cheaper to import gas from outside Europe than to use available shale production capacity. This is explained by the higher level of production costs for shale gas, which is not sufficiently compensated by the relatively higher costs for transportation incurred when importing gas from outside the EU (i.e., no substitution of imported gas with shale gas in summer). This obviously poses the question whether the investment in shale gas production capacity as assumed is realistic. Generally, gas production fields need to produce at a relatively constant rate throughout the year and are not capable of providing high levels of seasonal flexibility – some exceptions exist, of course. Although the model is not capable of simulating endogenous investment in production assets we instead assessed the impact of the assumed shale gas production investments on the market while imposing a limit on the production flexibility of shale gas production throughout the year. Assuming an 80% minimum production level – which may still be considered quite flexible compared with conventional gas fields – we find the level of shale gas production to significantly increase. This basically strengthens the substitution effects and consequences for gas supply diversification and import dependency at the member state level as described above. The dotted lines in Figures 3 and 5 show how this imposed limitation affects results.

Concluding Remarks

Although the overall impact of possible shale gas developments on EU security of gas supply in terms of import dependency is intuitive, the performed modelling analysis shows that due to the particular distribution of technically recoverable shale gas resources across EU member states, the impact on the individual member state can vary largely.

The fact that a considerable share of shale gas resources is located in countries that previously had little or no gas production may have large implications for gas flow patterns across Europe, especially in France and neighbouring countries and Poland and Central/Eastern Europe. This has consequences for future gas infrastructure investment requirements on specific cross-border interconnections that would not generally attract attention in scenarios where shale gas resources are excluded.

Results on the market impact of shale gas developments are to a large extent dependent on the overall level of gas demand and the gas demand trajectory towards 2050. Whereas a high demand trajectory allows for a significant penetration of shale gas in the market, a low gas demand trajectory gives rise to an unfavourable position for shale gas due to the relatively stronger competition from *cheap* supplies.

This points to an aspect that is to be researched further: the *demand-effect* of the large-scale availability of shale gas deposits. The availability of large volumes of shale gas may itself trigger more demand for gas and thus make a higher gas demand scenario more likely in the future (i.e., the *demand effect* of shale gas). However, no conclusions can be drawn here since the analysis focussed on the *substitution effect* of shale gas.[4]

Finally we would like to stress that this analysis is based on very scarce information on shale gas resource availability and EU shale gas production cost estimates. Planned test drillings, predominantly in Poland, in the next years will need to provide more and better information that can then be used to analyse larger gas market implications. Furthermore, although we ignored non-economic issues such as environmental pollution, safety risks, sustainability features of shale gas and public acceptance at large we do acknowledge that these are crucial for the possibility of shale gas developments in Europe in the future. We refer to Gény (2010) for a comparison of a number of these issues for the case of the U.S. and Europe. However, it is likely that even with all relevant information concerning the key aspects of shale gas activities on the table, future political choices across EU member states will still differ due to different prioritisation of public policy goals.

Acknowledgement

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Footnotes

[1] A more elaborate description of the model is provided in de Joode and Özdemir (2010) and de Joode et al. (2011).

[2] We refer to www.susplan.eu for further information. The project is financed by the European Commission (EC) under the 7th Framework Programme, grant agreement no 218960.

[3] The SUSPLAN scenario framework consists of four different 'storylines' that are labelled by different colours. In this shale gas analysis we have used the 'Red' storyline (high gas demand scenario) and the 'Green' (low gas demand scenario) respectively.

[4] This has been analysed in a report from Resources for the Future (Brown et al. 2010) for the US case. They find that especially climate policy plays an important role when analysing the impact of shale gas on investment choices in the energy mix.

References

Auer, H, K. Zach, G. Totschnig, and L. Weissensteiner (2009) Storyline Guidebook: Definition of a Consistent Storyline Framework, SUSPLAN Guidebook Deliverable D2.1.

Brown, S., S. Gabriel, and R. Egging (2010) Abundant Shale Gas Resources: Some Implications for Energy Policy, Resources for the Future, April 2010.

De Joode and Özdemir (2010) Demand for Seasonal Gas Storage in Northwest Europe until 2030: Simulation Results with a Dynamic Model, Energy Policy, Vol. 38, Issue 10, pp. 5817-5829, October 2010.

De Joode, J., Ö. Özdemir, K.Veum, A. Van der Welle, G. Migliavacca, A. Zani, and A. L'Abbate (2011) Trans-national Infrastructure Developments on the Electricity and Gas market, SUSPLAN Deliverable D3.1.

EIA (2011) World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States, US Energy Information Agency (EIA), April 2011.

Gény (2010) Can Unconventional Gas be a Game Changer in European Gas Markets?, Oxford Institute for Energy Studies, NG 46, December 2010

IEA (2010) Medium-Term Oil and Gas Markets 2010, International Energy Agency (IEA).