Economic Impacts of Shale Gas in the Netherlands

Final Report

Contract details

TEC1048NL Economic Impacts of Shale Gas in the Netherlands

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Executive Summary

The rapid developments in shale gas in the United States over the last few years have stirred a lively political debate about the pros and cons of shale gas, including in the Netherlands. This report aims to contribute to the debate by focusing on the likely economic impacts of shale gas on the Netherlands, while also considering the European context.

Two issues are examined in particular detail:
1. The economic implications of international shale gas developments on the Netherlands; and
2. The economic implications of possible future shale gas production within the Netherlands.

In addition four areas of impact are examined: (I) Impact on gas supply and demand in Europe and the Netherlands; (II) Impact on fuel shifting in the electricity sector; (III) Impact on Dutch state revenues and wider societal costs and benefits; and (IV) Impact on Dutch energy-intensive industries.

The analysis is based on a review of national and international literature on the economics of shale gas. The three IEA World Energy Outlook 2013 scenarios are used as the key source of international economic projections. The results have been verified via interviews with several sector experts.

The key findings of the analysis are:

- ***The impacts of international shale gas developments on the Netherlands and Europe are expected to be limited and gradual, and not similar to the recent shale gas boom in the United States.***

- ***It is not certain that there will be a positive business case for shale gas production in the Netherlands. The potential volume and quality of production can only be estimated after exploratory drilling.***

- ***Current trends in the European and Dutch electricity sector (a shift from gas to coal) and in the chemical industry (deteriorating competitive situation) can only be linked to shale gas developments to a limited extent. Other drivers, such as lower volatility in European gas market prices, a low carbon price in the ETS and geographical shifts in demand for chemical products are likely to be more important.***

- ***If the United States starts exporting shale-gas in larger volumes, the most likely destination for this gas is Asia (and in particular Japan) - as the business case for export to Asia in the foreseeable future is much stronger than for export to Europe.***

Economic impacts of international shale gas developments on the Netherlands

International shale gas developments have economic impacts on the Netherlands in various ways. In this report we distinguish between observed impacts (up to 2013), likely impacts (until 2020) and possible impacts (from 2020 until 2035)

Observed impacts up to2013

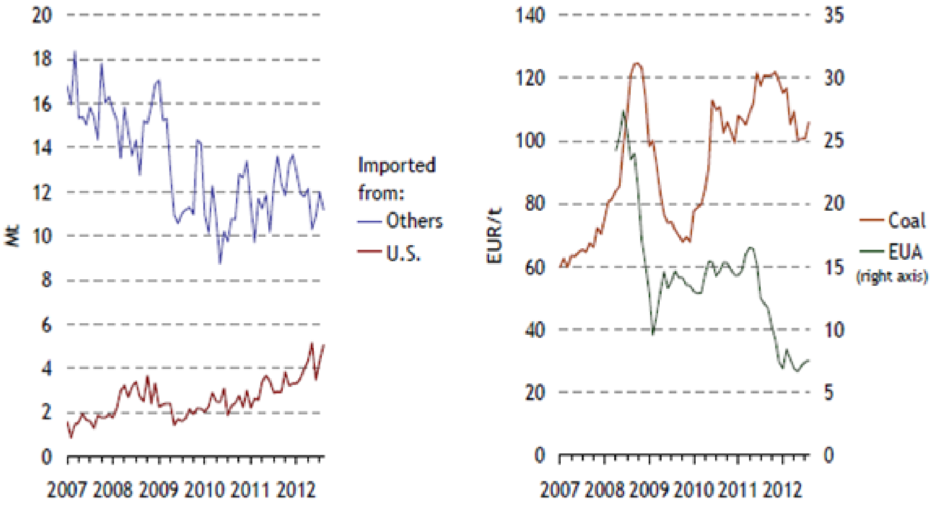
So far the overall impacts of international shale gas developments on Europe and The Netherlands are limited.

The gas price in the Netherlands and Europe is so far not affected by US shale gas. The coal price has slightly decreased over the last three years but over the longer term there has been an upward price trend and overall coal imports to Europe are still declining.

Shale gas is only one of the factors causing a recent fuel-shift from gas to coal in the European electricity sector.

Shale gas developments in the United States have led to a large decrease in gas prices in the United States. Gas prices in the United States and Europe used to be at similar levels, however in recent years the difference has increased, with European gas prices now three times as high as those in the US due to falling US gas prices as well as increasing European gas prices. As a result of the sharp decrease of US gas prices, coal has been replaced by gas in the US electricity generating sector. It has been claimed[1] that the export of the resulting US coal surplus to Europe has led to a shift from gas to coal in the EU electricity sector, however in reality this is not an important factor.

Figure 1: Coal imports by EU-27 in Mt (left); EU coal import price and EU emission allowance price in EUR/t (right) (Source: IEEJ, 2013)



This claim has been examined in more detail. In Europe, in some countries (e.g. the UK, Spain and Germany) the share of coal used in electricity generation has increased substantially over the period 2010-2012. In the Netherlands, in 2012 the share of coal in electricity generation rose by 15%. Across Europe a number of factors play important roles in this very recent shift, these include: the currently relatively high gas prices and the rise of renewables in the EU, the phase-out of nuclear in Germany and the drop of carbon prices in the EU-ETS prices in recent years. In the longer term (2007-2012) European coal imports are still *decreasing*, and coal import prices are still *increasing* (Figure 1). We

1 See e.g. http://www.tyndall.ac.uk/communication/news-archive/2012/us-shale-gas-drives-coal-exports-tyndall-manchester-research

therefore consider the relative importance of US shale gas developments in the gas-to-coal fuel-shift in the European electricity sector as more limited than often indicated.

Likely impacts until 2020 and possible impacts from 2020 to 2035

Impacts of international shale gas developments are expected in Europe and the Netherlands to a limited extent until 2020 though more impacts are expected in the period 2020 to 2035. These impacts are likely to result from increased imports of shale gas and domestic shale production in Europe (in particular in the UK and the Ukraine). This will also lead to increased competitive pressure on the chemical industry. However, we do not expect a 'shale gas boom' in Europe like that recently experienced in the United States, nor is shale gas the most significant problem for the chemical industry.

Political resistance, linked to environmental concerns in many EU Member States will result in a slow and limited development of domestic shale gas production in Europe.
Total technically recoverable resources in Europe are of the same order of magnitude as those in the United States. However, for environmental and safety concerns there is opposition to shale gas development in many Member States. In the Netherlands, this discussion is still ongoing, with a political decision being postponed in 2013. Active governmental support for shale gas production is evident in the United Kingdom, Ukraine and Poland. Given this limited support shale gas production in Europe will be very limited in the near future. In the longer term, Algeria might export shale gas to Europe. Algeria and the Ukraine both have substantial shale gas resources[2] and the Ukraine also has a strong political motive to develop these resources as doing so would reduce its dependence on Russian gas imports.

The majority of LNG export from the United States is likely to go to Japan rather than the EU because it will be more profitable.
Increased imports of shale gas (in the form of LNG) could have a potential impact on the European and Dutch gas market. An analysis of IEA WEO scenarios in combination with delivered LNG processing and shipping costs show that there is a positive business case for exporting gas from the US to Japan and Europe until at least 2025 in all scenarios (Figure 2). The business case for gas exports from the US to Japan is more positive than that for export to Europe. With spot-market based pricing for LNG in the US, this will result in the majority of LNG being exported to Japan in the near and more distant future. Hence, the amounts of US shale gas imported to Europe and the Netherlands will be limited in the near and more distant future. Other major potential future LNG exporters, such as Australia, are likely to export their LNG to Asia and not to Europe due to their geographical position.

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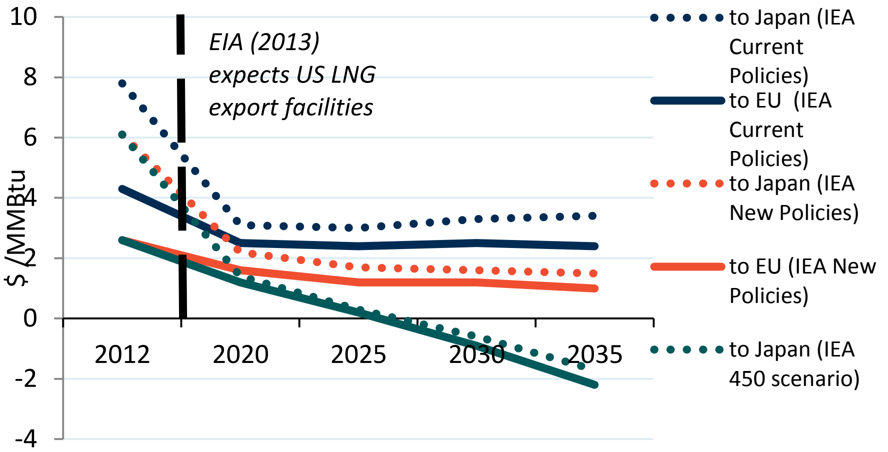
2 Cf. 20.000 bcm in Algeria, 3.800 bcm in Ukraine

Figure 2: Projected US LNG export margins to Europe and Japan under IEA 2013 scenarios



Future shale gas developments are not likely to induce a similar coal-to-gas shift in the European electricity sector (compared to the US). A much higher EU-ETS carbon price could cause such a shift.

We examined the hypothesis that if in the future, a shift from coal to gas in the electricity generating sector could be expected, as has occurred in the US. We did this by comparing IEA WEO price scenarios for coal and gas to the recent coal-gas price ratio in the US, when the shift in the US took place. The assumption is that if a similar relative price level of coal-to-gas occurred in Europe as found in the US it would induce a similar shift. It was found none of the IEA WEO scenarios predicted a price ratio of coal to gas in Europe that came close to the relative price level of coal-to-gas that empirically led to the shift from coal to gas in the US electricity sector in recent years. In three of the IEA scenarios for the ETS price in Europe are considered it can be seen that the price ratios reach a level that would induce a shift in fuel use: i.e. in all three scenarios a shift from coal to gas in the European electricity sector was induced by an ETS price around 35 dollars/tonne.

Shale gas developments in the US come on top of several other global developments that are threatening the world leading role of the European chemical industry.

The overall competitive position of the European chemical industry is threatened by three main structural factors: (1) a shift of global demand for chemical products to Asia, (2) increasing chemical export capacity in the Middle East and (3) a relatively improved competitive position of the US chemical industry due to the relatively low price of shale gas. Shale gas developments in the US have not only led to much lower gas prices there, but also have provided an abundant and cheap feedstock to the US chemical industry in the form of Natural Gas Liquids. As a result, many new chemical plants in the US are planned or under construction and this might negatively affect the position of European producers in the near future. The restructuring towards a more knowledge-intensive, bio-based and specialised chemical sector, which is already envisaged by the Dutch chemical industry, will receive an extra stimulus via these combined developments.

Economic impacts of shale gas production in the Netherlands

The discussion on whether or not to allow shale gas exploratory drilling or production in the Netherlands is still ongoing. A political decision has been postponed until further research has been carried out in 2014.

The cost and revenue assumptions on shale gas production in the Netherlands are very uncertain. Available evidence cannot confirm, nor deny a positive business case for production.
By making costs and revenue assumptions, the Dutch state oil and gas company EBN has arrived at a positive business case for shale gas exploration in the province of Noord-Brabant in the Netherlands. We have compared these figures to those available for the United States and for other locations in Europe and validated these with experts. This comparison indicates that EBN's drilling cost estimates are relatively high, whereas costs per unit of gas are estimated relatively low (Figure 3). An explanation for these figures is found in a high expectation for the yield per well. In addition to this, if NGLs were found to be associated to shale gas in the Netherlands this could account for such figures. Whether these expectations are feasible or not can only be investigated by exploratory drilling. In other locations in Europe, such as Poland and the United Kingdom, the preliminary resource estimations had to be adapted very drastically (downwards and upwards, respectively) as a result of data that became available after exploratory drilling.

Figure 3: Exploration costs per unit of gas ($/MMBtu) (left) and drilling costs per well (mln $)

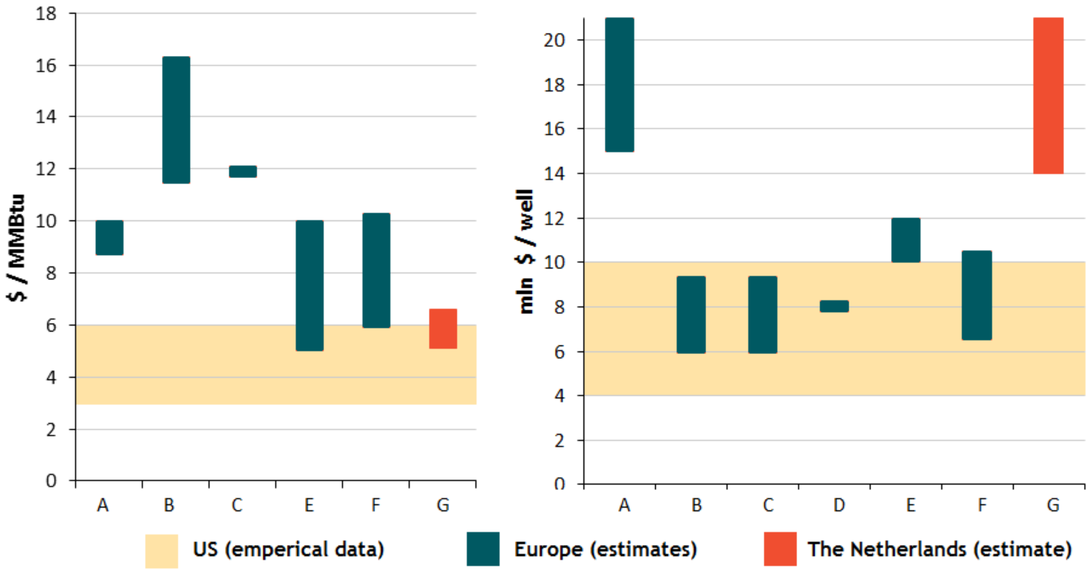


Figure Item	Author	Year	Area	Depth basin
A	Wood MacKenzie	2010	Poland, Austria, Germany	n/a
B	OIES, Gény	2010	Germany	2000
C	OIES, Gény	2010	Poland	2300 - 2500
D	Navigant	2012	UK	n/a
E	IEA	2012	Europe	n/a
F	JRC	2013	Europe	n/a
G	EBN	2013	The Netherlands	3500 - 4000

Shale gas will produce positive short terms incomes for the Dutch state treasury. This income is countered by a variety of potential social costs and the decision of the relative benefits of these is political.
Shale gas production in the Netherlands will have a direct positive impact on the Dutch treasury through the participation of state-owned EBN in any production activities. An indirect positive impact will occur as a result of the taxation of the profits of commercial activities. In addition to this shale gas production will induce some direct and indirect employment, although there is substantial variation between sources on the estimated scale of this. On the other side, shale gas production can lead to additional CO_2 emissions (depending on with which 'baseline' shale gas is compared), as well as to additional land and water use. Also, there are potential risks and disruption to local communities associated with shale gas production, for instance the risk of water pollution or the disruption due to drilling activities. There are large uncertainties regarding the order of magnitude of the benefits as well as of the potential costs. In addition, indirect negative effects might offset the positive effects of shale gas exploration in the Netherlands.

Recommendations

Independent of the decision to allow for drilling for shale gas in the Netherlands itself, the country will be affected by international shale gas developments. Although a similar shale gas boom in Europe as in the United States is most probably not going to take place, an open eye of policy makers for international gas developments, including shale gas, is required. The Dutch government can exert influence on such international (shale) gas developments primarily via the European institutions.

Apart from that, the Dutch government needs to take a sovereign national decision on whether or not to allow shale gas exploration and production in the Netherlands. Such a decision can only be taken in the wider context of energy and socio-economic policies, including considerations about longer-term energy transition and green growth strategies. A more informed decision could also require closely monitoring global and European shale gas developments over the coming three to five years before taking a decision.

Some main recommendations for the Dutch government in this respect are:

1. Allow for (limited) exploratory drilling for shale gas in the Netherlands.
Only exploratory drilling can give an accurate picture of the economics of shale gas production in the Netherlands, which not only serves to get an idea of a possible commercial business case, but also of potential state revenues. Exploratory drilling and commercial production should be seen as separate activities, for which separate permitting decisions can be taken (as has been done in Germany recently, where commercial production was prohibited but scientific research and exploration not).

2. Implement and actively support the European's Recommendation of January 2014 on conditions for environmentally sound shale gas production.

Dutch support for the EU Recommendation could help to create an environmentally sound level playing field for shale gas production within Europe – independent of a decision on shale gas exploration or production in the Netherlands.

3. Develop more detailed scenarios on the fit between a possible 'Dutch Gas Roundabout' and an energy transition to a low carbon economy.

The plans on developing a Dutch Gas Roundabout seem not yet fully integrated with those of a transition to a low carbon economy as envisaged e.g. in the 'SER energieakkoord' of 2013. With or without shale gas, social and economic consequences of gas and other fossil fuels being gradually replaced by non-fossil fuels, or being supplemented by carbon capture and storage activities, should be examined more carefully.

1 Introduction

This chapter provides the policy context (section 1.1) as well as the main objectives of the study (section 1.2). It also briefly outlines the methodology used (section 1.3) and gives an overview of the overall structure of the report (section 1.4).

1.1 Policy context

Shale gas is currently a hot topic in the international energy sector. This is also the case in the Netherlands, where debate is ongoing concerning whether commercial shale gas production should be allowed or not. Environmental issues play an important role in this public debate around "fracking".

Independent of the decision to allow domestic shale gas production in the Netherlands, international shale gas developments are rapidly taking shape. These developments are particularly advanced in the United States, where shale gas extraction has led to a rapid increase in domestic gas production and a sharp decline in gas prices. Other countries might follow this pattern. Within Europe, some countries are now considering allowing production, whereas others have decided to ban domestic shale gas activities.

Apart from the environmental consequences, international shale gas developments might also have an economic impact on the Netherlands by influencing international gas supply and prices. Little is yet known about the potential economic effects on the Netherlands of international, or domestic, shale gas production. TNO has therefore taken the initiative to carry out additional research on this topic, with Triple E Consulting delivering the work. This report presents the results of this research.

1.2 Research questions

The aims of this project are twofold:

1. To examine the potential economic impacts on Europe and the Netherlands of international shale gas developments up to 2030.

2. To explore the potential economic effects of domestic shale gas exploration and production in the Netherlands.

To help define the area of study, the following economic aspects have been chosen:

I. Impact on gas supply and demand in Europe and the Netherlands.
II. Impact on electricity prices and fuel shift.
III. Impact on Dutch state revenues and wider societal costs and benefits.
IV. Impact on Dutch energy-intensive industries.

1.3 Methodology

The research carried out in this project consisted of two phases:

Phase 1: Exploratory research on potential economic effects

This phase comprised of a desk study in which the international situation around shale gas was examined and potential economic effects on the Netherlands were mapped. This included an analysis of economic trends in international gas markets and an examination of the most important recent reports around shale gas. Internal expert knowledge of TNO was used and several external experts were consulted on an informal basis.

Phase 2: Scenarios

In this phase, well-established International Energy Agency scenarios were used to examine potential economic impacts of shale gas in more detail regarding the four key questions posed in this project. Recommendations for Dutch policy makers were formulated based on the results obtained.

1.4 Reading guide

Chapter two of this report discusses international shale gas developments to date and the technical potential of shale gas is. Chapter 3 examines developments around shale gas in Europe within the context of the European gas market. Chapter 4 analyses potential impacts of shale gas developments for Europe. It does so by looking into potential shale gas imports, consequences for the European electricity sector and impacts on European energy-intensive industries. Chapter 5 analyses potential costs and benefits of shale gas production in the Netherlands. Finally, chapter 6 provides conclusions and recommendations.

2 International Shale Gas Developments

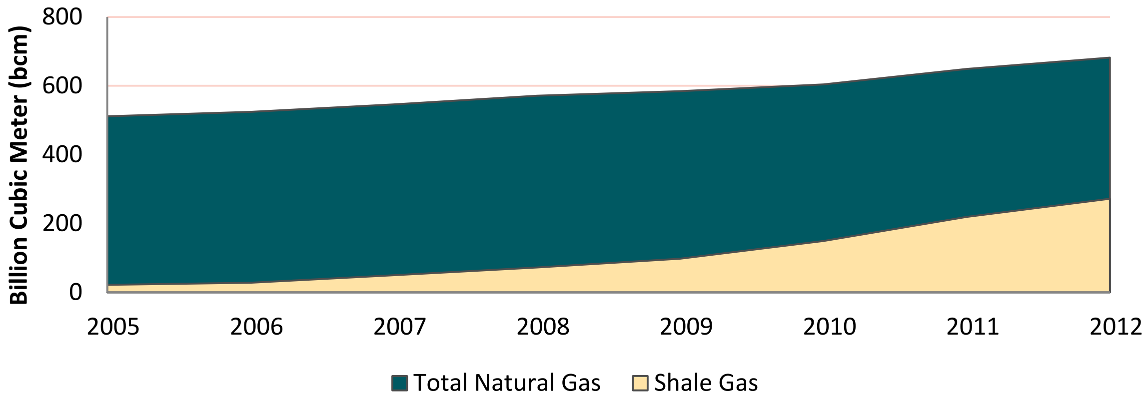
This chapter outlines recent shale gas developments in the US (section 2.1) and the rest of the world, excluding Europe (section 2.2). At the end of the chapter, (section 2.3) a concluding analysis puts the international developments into perspective.

2.1 The United States

The United States are the biggest consumer of natural gas in the world. With a total annual gas consumption of 700 bcm, gas is responsible for 25% of US primary energy demand. The most important sectors are power plants (31%), industry (28%) and residential (19%). Somewhat more than half of all housing uses natural gas as its primary source of heating[3].The US has historically played a dominant role in the production of unconventional gas reserves such as tight gas, coal-bed methane, and more recently shale gas.

Even in the US, shale gas has only been on the radar for a few years – although its history is longer and more complex than widely assumed[4]. Between 2007 and 2012 annual production levels increased on average by about 40% per year[5]. Because of this recent production boom, the share of shale gas within the total indigenous gas production has risen from 9% in 2007 to over 40% in 2012. Current annual production levels are around 300 bcm[6].

Figure 2.1: Annual production levels of Natural Gas and Shale Gas in the US[7]

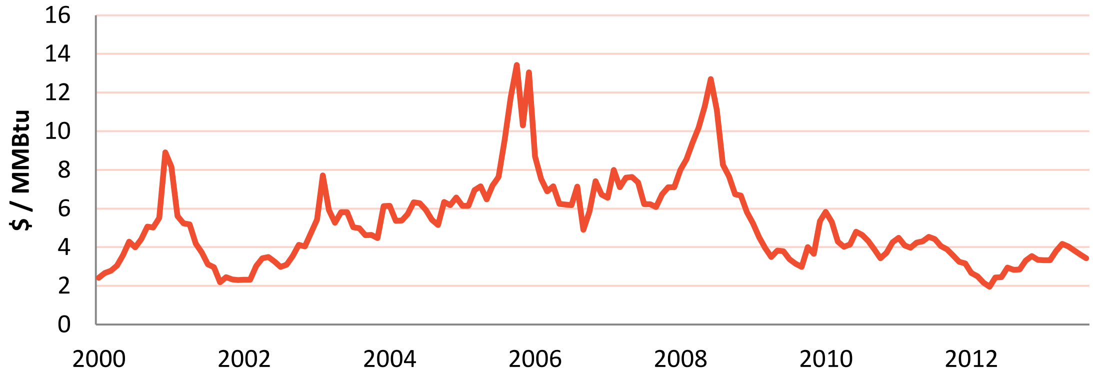


[3] EIA (2013) Coal and Gas Competition in Global Markets
[4] OiD (2013) Getting Shale Gas Working
[5] EIA (2013) Shale Gas Production
[6] The surge in the production of shale gas somewhat slowed in 2012, as current low gas prices led to fewer rigs drilling gas wells
[7] EIA (2013) Shale Gas Production

Reasons for the shale gas boom in the United States

One of the important reasons for the sudden boom in the production of shale gas has been the upward trend in natural gas prices since 2002, together with the development of new techniques for horizontal drilling and hydraulic fracking 'fracking'. This has made the production of unconventional gas such as shale gas economically attractive, as can be seen from the figure 2.2. Subsequently, the surge in the supply of (shale) gas from 2008 onwards has resulted in a very steep drop in US gas prices. With a price of around 3 to 4 dollar per MMBtu, prices have returned to levels that were last seen around the year 2000.

Figure 2.2: US (Henry Hub) Natural Gas Spot Price[8]



Apart from high gas prices and technological developments, there are also other explanations for the recent pace of shale gas development in the US, one being the favorable geological conditions. Shale gas resources in America are usually located in relatively shallow layers and in unpopulated areas. Environmental concerns and public acceptance therefore often play a less prominent role than is currently the case in parts of Europe. A majority of American citizens describes themselves as neither an explicit advocate nor as an opponent of the production of shale gas[9].

Another reason why the production of shale gas has evolved at such a rapid pace is the fact that in the US, any minerals found underground belong to the particular surface landowner. Private landowners therefore directly receive financial benefits, in the form of royalties from the production of minerals such as shale gas. Consequently, thousands of small-scale private oil and gas companies seized this opportunity to quickly close deals with local landowners for the production of shale gas. This has also meant that the lion's share of shale gas production in the US is done by these small-scale oil and gas companies. Larger oil and gas companies, such as Shell, have only become involved after the more promising basins were already taken. Consequently, they paid very high prices for drilling sites that turned out to be less productive than expected. A final reason that contributed to the shale gas boom in the United States is the high prominence given to fuel independence in American energy policy. Shale gas offered a perfect opportunity to substantially reduce the US fossil fuel import dependence, and was therefore strongly promoted by policy makers.

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[8] EIA (2013) Natural Gas Price Data
[9] Linda Steg (2013) Maatschappelijk acceptatie van schaliegas

Shale gas exports

Due to the recent growth in the production of shale gas, the United States are expected to become the largest producer of natural gas in the world. If the current production growth trend continues, the US will become, a net exporter, instead of a net importer of natural gas around 2015 - 2020. The EIA expects that this will happen in 2016[10]. At this moment, preparations for such an event are being made, as the plans for a number of LNG export facilities are becoming concrete. As of January 2014, the U.S. Department of Energy (DOE) has approved five applications (94 bcm / annum) for permits to export liquefied natural gas (LNG) from the east coast to non-free trade agreement nations. There are further currently 21 pending applications, covering 19 discrete facilities (282 bcm/ annum) where U.S. businesses are seeking to build and operate terminals to process LNG for export[11]. However, the actual future export capacity, that will come on-line is likely to be much lower – as not all business case will be found profitable in further planning stages.

The pricing model for US LNG export projects, at least for the initial projects, is based on ongoing Henry Hub prices, plus a liquefaction fee which is based on long-term contracts[12]. There are no destination restrictions, which mean that LNG is effectively free to seek markets which promise the highest export margins. Based on recent figures, this is expected to be in Asia. However, the question remains how many of the current applications will actually be approved by the DOE and to what markets LNG will finally be exported.

The importance of Natural Gas Liquids

Due to the low domestic gas prices in the US (3 – 4 dollar per MMBtu), gas exploration in the United States is increasingly being determined by the price of oil and natural gas liquids (NGLs) such as ethane, propane and butane. These NGLs are used as feedstock for the chemical industry. Due to this development, profit pools are shifting from gas producers and refineries to petrochemical manufacturers. If NGL prices are high enough, energy firms will drill for these, treating the gas as a by-product. Tight oil[13] production in the US ramps up. Since 2008, tight-oil production in America has soared from 600,000 to 3.5 million barrels per day[14]. This is already 1/3 of total conventional oil production in the United States, and 19% of oil demand[15].

Whether US gas prices can remain at their current level, will depend greatly on whether their liquids-rich gas plays start to deplete or not. The Economist even reports that, due to a lack of adequate infrastructure to get gas affordably (e.g. below current prices) to the market, locations in North Dakota instead choose to flare their gas, making profits only on the associated NGLs. Fracking for oil and NGLs is profitable when oil is trading on American exchanges at above 80 dollar a barrel, as it

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[10] EIA (2013) Annual Energy Outlook 2013. Newer information suggests a start post 2018, Timera Energy (2014) Transition from JCC Pricing in Asian LNG Markets

[11] API (2013) Proposed U.S. LNG Export Terminals

[12] IEA (2013) World Energy Outlook 2013, p.127

[13] Tight oil is crude oil stored in shale deposits, Major tight oil locations in the US cover Bakken, Eagle Ford, and the Permian Basin).

[14] The Economist (2014) The economics of shale oil, February 15th 2014

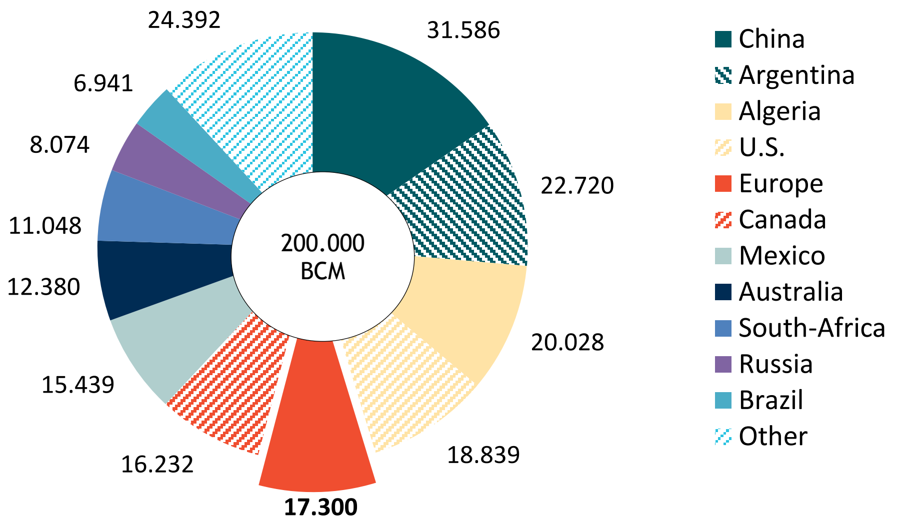
[15] EIA (2013) Country: Oil consumption

mostly has done for the past four years. As long as energy firms expect this to continue, drilling will remain, and thus large amounts of gas, as well as oil and NGLs will be produced[16].

2.2 Rest of the world

Apart from the US, there are a number of countries that have considerable estimated technically recoverable resources of shale gas. As can be seen from Figure 2.1, the largest resource estimates are currently located in China, Argentina and Algeria. Together these three account for 37% of the currently estimated technically recoverable resource. In comparison: resources in Europe are currently estimated at 17.300 bcm, or 8% of the global technically recoverable resource[17]. These resources are almost equal to those in the United States.

Figure 2.3: Worldwide technically recoverable resources[18]



Resources vs Reserves

The **technically recoverable resources (TRR)** are the volume of (in this case) gas that can reasonably be expected to be recovered through the application of current technologies under current regulations. It is the estimate of the amount of gas that might be technically recovered if the production were not constrained by economics.

Reserves refer to an estimate of the amount of gas that can be both technically and economically recovered. They are usually categorised as proven, probable or possible in order to allow investors to better appreciate the risks associated with a company's discoveries of natural gas.
Most of the European geological institutes do not consider that there is currently sufficient understanding of the geology, or experience of the engineering or costs of production to yet make a reliable reserve estimate about their national shale gas basins. Estimates of shale gas reserves can become more accurate by exploratory drilling.

[16] The Economist (2013) Capitalist not just greens are now questioning how significant benefits of shale gas; Box "Importance of NGLs made use of: PLATTS (2013) Special Report: Petrochemicals - Can shale gale save the naphtha crackers? and PLATTS (2013) How will US shale gas affect the future of global polyethylene supply?, 7 November
[17] The"Resources vs Reserves" box made us of DECC (2013). Resources vs Reserves: What do estimates of shale gas mean?
[18] EIA (2013) U.S. Crude Oil and Natural Gas Proved Reserves

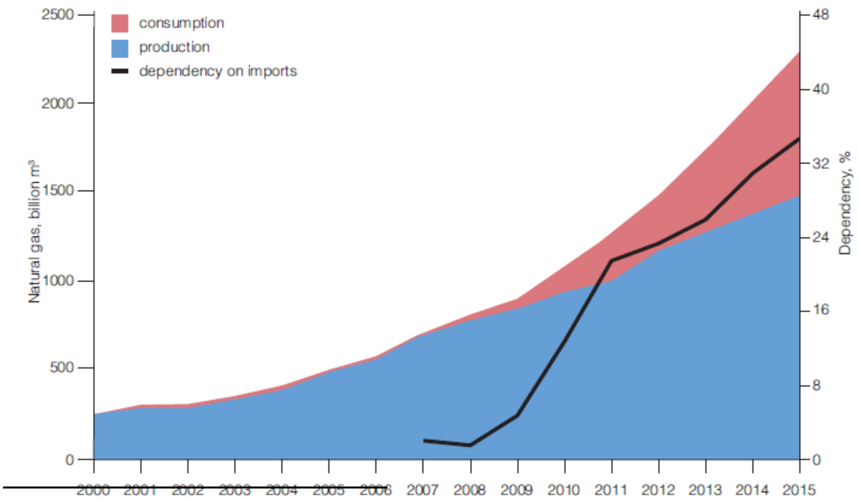
China

With a total of 32.000 bcm, the world's largest technical recoverable resources of shale gas are located in China. If these estimates represent the resources accurately, further shale gas development in China will be very important for world gas markets. According to Francis Egan, the CEO of the oil and gas exploration company Cuadrilla, the start of significant shale gas production in China could have a significant downward impact on gas prices[19]. China's latest national five year plan for unconventional natural gas development has set a shale gas production target of 6.5 bcm for 2015 increasing to an annual production of 60 – 100 bcm in 2020. This additional indigenous production of gas is first needed to fulfill rising domestic demands (Figure 2.3).

China's targets can be seen as ambitious, as there are of couple of serious bottlenecks that need to be addressed. Most of its promising shale gas deposits are located in remote mountainous and desert-like areas deep underground (up to 4—5 km). The installment of the required equipment together with the transportation of gas to where there is demand for it will therefore be a complicated and expensive long-term process which could well be a delaying factor in the development of shale gas. The water scarcities that the shale gas areas face act as an additional constraint – since the process of hydraulic fracturing requires large quantities of water. Given these constraints the latest EIA report notes that the so far anticipated increase in commercial production is unlikely to get China close to the official target of 6.5 bcm of shale gas production by 2015[20].

To support exploration and production activities, the Chinese government offers tax breaks, as well as exploration and mining rights free of administrative charges. On the national level, the Ministry of Finance offers a subsidy of 7 US cents per cubic meter of shale gas produced, effective from 2012 to 2015. Currently, foreign investors are allowed to compete for exploration licenses under the condition that they partner with Chinese companies. This has led to three Western oil majors, Royal Dutch Shell, Hess and Chevron, collaborating with Chinese partners in the exploration of shale gas in the country[21].

Figure 2.4: Evolution of natural gas production and consumption levels in China[22]



[19] House of Lords (2013) The Economic Impact on UK Energy Policy of Shale Gas and Oil, Meeting 5 November 2013
[20] IEA (2013) World Energy Outlook 2013, p.122
[21] China Announces New Guidelines for Shale Gasz
[22] NEA (2012) The Policy on Natural Gas Utilisation. Beijing, China, National Energy Administration

While China's shale gas resources are the largest in the world, location specific conditions imply that production costs are expected to be high. State-owned oil and gas company Sinopec stated that the cost of drilling one shale gas well is now around $14.7 million, including costs for drilling, fracturing and procurement of services from technical service companies[23]. These costs are significantly higher than those currently achieved in the United States which are on average $8 million lower.

China's domestic supply of gas has not been sufficient to meet demand since 2007. Additional imports of LNG have therefore been needed. Any increase in future shale gas production levels would therefore be absorbed by domestic demand which will continue to far outstrip all domestic production. Additional supply could however lead to price shifts on a local or national level[24]. From an international perspective these price shifts could lead to a competitive advantage for energy-intensive firms which are based in China, as energy costs in the country may decline. Even under an optimistic IEA shale gas scenario, gas imports would still amount to nearly 120 bcm in 2035, about 20% of the country's gas demand. In a low unconventional case, imports would amount to over 260 bcm or nearly 60% of demand[25].

Mexico

Mexico has large resources of shale gas (15.000 bcm) and first test drilling sites are operational. The political climate is seen as a key factor in determining if production levels will increase. Historically, PEMEX, the Mexican state-owned oil and gas company, has had a full monopoly in the supply chain of oil and gas in Mexico. Any initiative concerning the development of shale gas therefore rests on their shoulders. However, Pemex is seen as lacking the equipment, technology and the financial means to explore and exploit shale gas[26]. Hence, a legal reform has been put forward by the government to open up the oil and gas market to foreign investors. This reform has just been passed and ends the 75-year monopoly of PEMEX[27]. Now that foreign investors are allowed access to the Mexican market, this offers new opportunities to North-American players that are already active in the US and are therefore experienced in the exploration and production of shale gas. However, the question remains of how new investors will be regulated, since adequate regulation is not in place due to the previous monopoly of PEMEX.

Argentina

In March 2013, the Argentinian state-owned oil and gas company (Yacimientos Petrolífero Fiscales) signed a contract with Chevron to drill over 100 wells in Vaca Muerta, the largest shale gas deposit in the country. Although foreign investors are excited about the prospects in Argentina, they are sizing up the political and economic environment before committing significant funds, with concerns over a recession and possible resource nationalism[28]. In addition, in April 2013 the government decided to freeze gas prices for six months due to spikes in inflation. These recent developments are currently deterring foreign investors from becoming active in the Argentinean market.

[23] PLATTS (2013) Chinese oil companies attempt to slash shale gas drilling costs, 25 October 2013
[24] WRI (2012) Testimony: China's Prospects for Shale Gas and Implications for the U.S.
[25] IEA (2012) Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas – International Energy Agency (May 2012)
[26] Los Angeles Times (2013) Helping Pemex help Mexico. Los Angeles Times. August 22, 2013.
[27] Wall Street Journal (2013) Mexico Congress Passes Historic Energy Bill, 12 December 2013
[28] KPMG (2013) Shale Development: Global Update Focus on US, China, Argentina, Australia, Indonesia and UK

Algeria

Algeria plays an important role in the production and supply of natural gas from Africa to Europe. In 2011 Algeria supplied 52 bcm of natural gas to Europe, of which 27 bcm was in the form of LNG. It seems likely that these volumes will increase. One of the reasons for this expectation is the enormous potential shale gas resources. According the EIA, Algeria holds 20.000 bcm, which is the third largest national recoverable shale gas reserve after China and Argentina. However, these figures are questioned by some experts. For example Professor Chems Eddine Chitour, the director of the fossil fuel energy laboratory at the Polytechnic Institute in Algiers argues that the 2013 EIA report is no more than a copy of the 2004 version, rather than an update with more recent figures[29].

Australia

According to several sources Australia has the most attractive shale gas prospects outside North-America[30]. Australia has a strong legacy of mining and sits on vast (estimated) resources of shale gas (12.000 bcm). Given its favorable location, the Cooper shale gas basin has lured significant amounts of investments and is currently the only region outside North-America commercially producing shale gas[31]. The Cooper basin is located in a mature onshore region with production of conventional oil and gas over the last 40 years[32]. This implies that an extensive pipeline network is already in place. It is however unclear how big the shale gas resources in this play really are and how fast they could be developed in the next few years.

Other shale basins in Australia are still under exploration. The depth and relative remoteness of these basins poses a disadvantage of these basins in terms of drilling costs and available infrastructure. Next to this, Australia is a high-cost country which implies that overall wage and resource costs could stall further production levels or even hamper eventual export. On the other hand, Australia is well positioned to provide shale gas to South-East Asia and in particular to Japan.

2.3 Conclusion

The chapter illustrates that shale gas has already had a very important impact on the gas and oil outlook for the United States. In only five years' a shale gas boom has taken place in the United States that has reduced domestic gas prices to one third of the previous price. Various factors have driven this boom, including technological development, high gas prices, a legally secured private ownership of underground resources and a long-existing drive for resource independence in US policy.

The continuation of US shale gas development might lead to the United States becoming a gas exporter instead of importer by 2015-20. Preparations for such exports are already ongoing, with LNG liquefaction capacity now at various stages of legal and operational preparation. However, it is unclear what fraction of these projects will ultimately get export licences and become operational.

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[29] Platform London (2013) Shale Gas Exploitation in Algeria: Interview with an Algerian Journalist and Anti-Fracking Campaigner
[30] Bloomberg (2014) Shale's 'Next Big Play' Draws U.S. Gas Producer to Australia and Lux Research (2013) Uncovering Further Opportunities in the Booming Frac Market
[31] The Australian (2013) Cooper Basin only region outside US commercially producing shale gas
[32] KPMG (2013) Shale Development: Global Update Focus on US, China, Argentina, Australia, Indonesia and UK

The role of so-called ‘Natural Gas Liquids’ (NGLs) is crucial for further shale gas development in the United States. These NGLs are often associated with shale gas deposits and can be marketed separately. An important factor in the importance of NGLs is that their price is linked to oil prices. Commercial production of shale gas wells is often only possible due to the sale of the associated NGLs (for example to the chemical industry where they serve as a feedstock for many petrochemical processes) because of the currently low gas prices in the United States –.

Substantial shale gas resources exist in many parts of the world. Resources in China, Argentina and Algeria are larger than those in the United States, with those in Europe (including Ukraine) are of about the same magnitude as those in the United States. Other countries with important resources are Australia, Mexico and Canada. If, and when, these resources will become available on the world market is still very uncertain. However, in some countries (e.g. China), domestic demand is likely to absorb all future production for many years to come. In other countries (e.g. Mexico, Argentina, Ukraine) regulation and the political situation are still important issues. Other countries (e.g. Algeria, Russia, Mexico) still have important conventional resources, limiting the need for a fast development of unconventional gas such as shale gas. Those countries which do not have these constraints, such as Australia and Canada, will be the first to follow the United States in the export of shale gas to the world market[33].

[33] Japan Times (2013) Canada agrees to begin exporting shale gas to Japan

3 European Shale Gas Developments

This chapter describes shale gas developments in Europe. To understand these developments, it first considers key features of the European gas market as a whole (section 3.1). After that, specific aspects of European shale gas are examined (section 3.2). The chapter ends with an overall analysis of shale gas development in Europe in an international context (section 3.3).

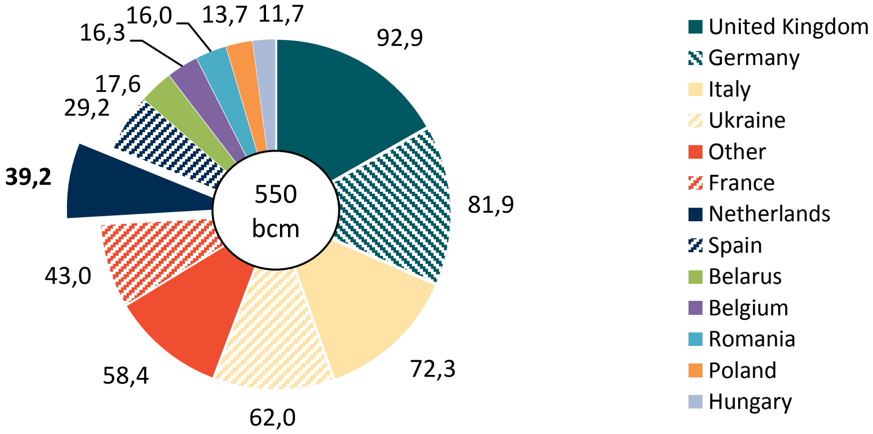
3.1 The European Gas Market

Before one can comprehend and assess the potential impact of shale gas production in Europe, one needs to get an overview of the European gas market. Therefore in this section the key characteristics (demand, supply, prices and price mechanisms) of this market are described. European LNG developments are also described as they are crucial for future European shale gas imports.

3.1.1 Demand

The 2000 - 2011 average annual gross inland consumption of natural gas within Europe is about 550 bcm[34] (Figure 3.1). With an annual consumption level of 45 bcm, the Netherlands consumes about 8% of total gas demand in Europe. Other economies that consume significant quantities of gas within Europe are the UK, Germany, Italy, Ukraine and France. The IEA expects that the demand for natural gas will only slowly rise to 2035[35]. The underlying arguments for this expectation are that the strong penetration of renewable energy sources in the power sector in Europe is expected to continue. In addition to this, the EU energy policy targets for 2030 could also herald a new effort on energy efficiency and CO_2 emission reductions.

Figure 3-1: Natural gas demand in Europe in 2012[36]

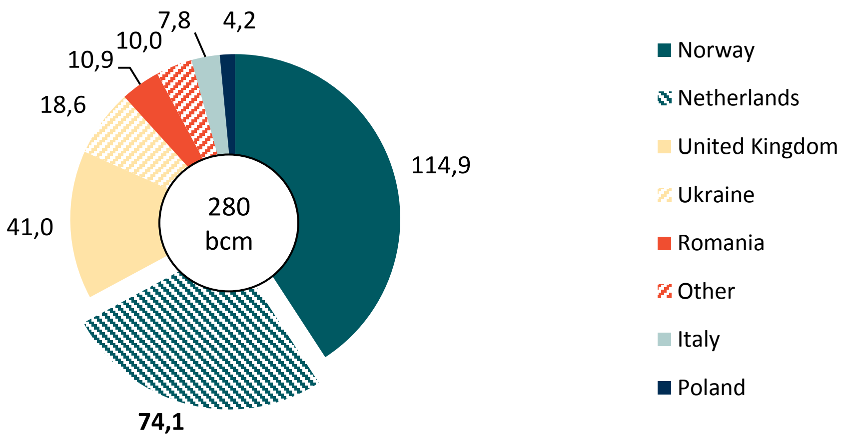


[34] BP (2013) Statistical Review of World Energy 2013
[35] IEA (2013) World Energy Outlook 2013
[36] BP (2013) Statistical Review of World Energy 2013

3.1.2 Supply

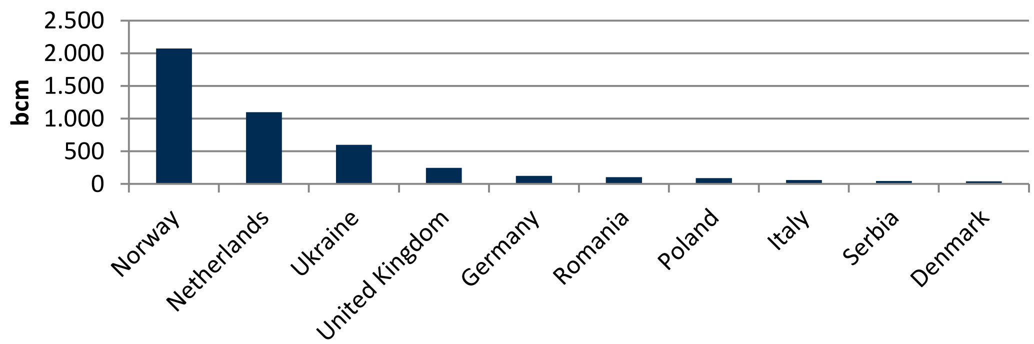
The production of natural gas in Europe gas remains stable at around 300 bcm, but rests more and more on the shoulders of gas producing countries such as Norway and the Netherlands (Figure 3.2). Norway is the largest gas producer in Europe, and is expected to remain so for the years to come[37] (Figure 3.3). Other gas producing countries in Europe have declining gas reserves and production rates. Even Dutch production levels, which lie currently at 75 bcm, will decline to 60 bcm in 2020 and to 40 bcm in 2025[38].

Figure 3-2: Natural gas production in Europe in 2012[39]



If Norway is left out of the equation, conventional gas production in Europe is in significant decline. When considered at the EU-28 level, declining production levels become more apparent and important. EU-28 import dependency levels for gas have been steadily increasing, from 49% in 2000, to 58% in 2005 to 62% in 2010 %[40]. This imported gas reaches Europe either by pipelines or by transport of LNG. In 2012, Europe imported most gas from Russia (100 bcm), Algeria (45 bcm), Qatar (30 bcm) and Nigeria (10 bcm).

Figure 3-3: Proven natural gas reserves in Europe in 2013 [41]



[37] IEA (2013) World Energy Outlook 2013
[38] Nlog (2013) Aardgasvoorraad en toekomstig binnenlands aanbod
[39] BP (2013) Statistical Review of World Energy 2013
[40] EC (2013) Statline database
[41] EIA (2013) ; BGR (2012) ; BGS, DECC (2013) ; PGI (2012) ; ACIEP (2013) ; TNO (2012)

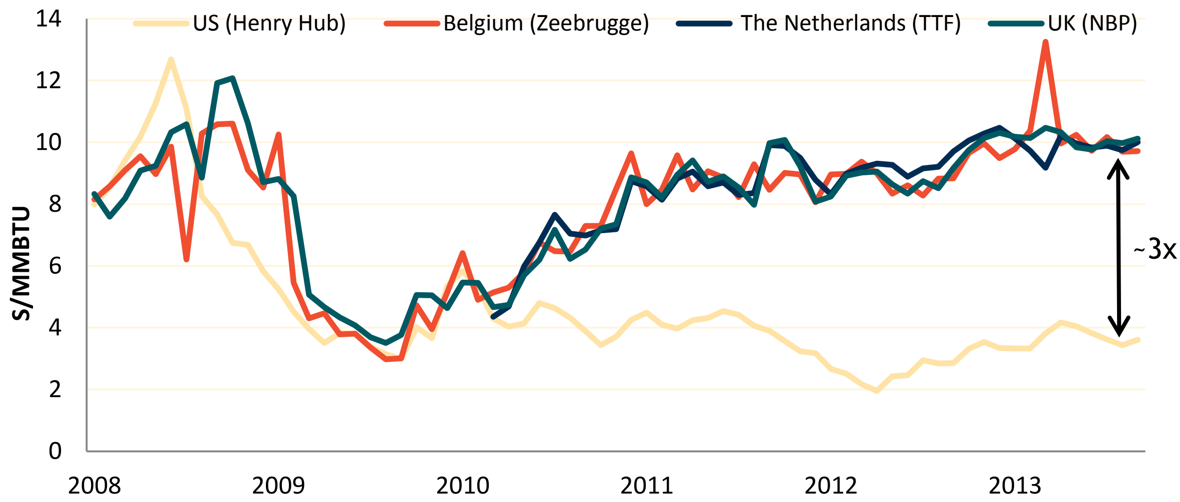
3.1.3 Gas prices

In the last few years, a record divergence in regional gas prices has been observed between the United States and Europe (Figure 3.4). This development was driven by both supply and demand factors (e.g. US shale gas boom, historical mild winter in US 2012, European financial crisis, Fukishima nuclear disaster). Currently, European gas prices range between the 8 and 10 $ per MMBtu.

Continental European gas prices are now around 3 times higher than US gas prices. Prices in Europe have risen due to a combination of factors:

- The prevalence of oil-price indexation in Europe at a time of persistently high oil prices - whereas in the US, gas prices are based on spot market pricing via the Henry Hub;
- A different demand and supply balance. In the US, the sudden surge in shale gas resulted in lower gas prices as the excess of supply could, and still cannot be exported. Conversely in Europe, there was no supply boom but an increased reliance on growing production levels in Norway and the Netherlands. In addition, the continent remains highly dependent on the import of gas from Russia and import via LNG.

Figure 3-4: Gas prices in the US and Europe in real 2010 dollars[42]



3.1.4 Pricing mechanisms

Until a few years ago natural gas prices in Europe were set via two main mechanisms: oil-product linkage and spot market pricing. Oil-product linkage was established shortly after substantial gas reserves were discovered in Europe in the sixties. The mechanism is based on the principle that the price of gas should generally be based on that of alternative (non-gas) fuels which were commonly used at that time[43]. The lion's share of gas contracts that European states currently have with Gazprom and Sonatrach (Algeria) are still based on traditional oil-indexation[44].

[42] EIA (2013) Natural Gas Price Data ; Intercontinental Exchange (2013) Market Data, TEC data
[43] JRC (2012) Unconventional Gas: Potential Energy Market Impacts in the European Union
[44] KEMA (2013) Study on the LT-ST Markets in Gas

However, there is a movement towards more short-term (< 5 year) hub-based pricing (gas-to-gas), and it seems that this will become the dominant market mechanism for specifying gas contracts in Europe., Hub prices have become the benchmark for supply contracts and gas portfolio optimisation[45] especially in North-Western Europe. This trend is to a certain extent comparable with historical developments in the US, where oil-based contacts now only play a marginal role. A recent analysis by the Oxford Institute for Energy Studies indicates that 55% of the European gas contracts in 2012 were oil-indexed. According to Timera Energy, 2013 could become a turning point, in which the majority of the gas contracts in Europe become hub-indexed[46]. More recently, these predictions have been backed up with data. The proportion of Europe's gas bought in the spot market rose from 15% in 2008 to 44% in 2012. The most recent data indicates that it is now more than 50% and in North-West Europe it is around 70%[47]. If this trend continues, which appears likely, it will contribute to lower overall gas prices in Europe in the near future.

One of the important reasons for this trend can be traced back to the price-difference that has occurred between oil-indexed and spot market (short-term) contracts in recent years. Hub-based prices for gas have been substantially lower than oil-index contracts due to a sudden reduction in European gas demand from 2009 onwards as a result of the economic crisis. On a yearly basis, hub-prices since 2009 became between 1.5 and 3.7 $ per MMBtu cheaper. These arbitrages created momentum for European customers to renegotiate their long-term contracts in order to introduce more flexibility by means of hub-indexation. To a certain extent new price- and volume adjustments have been renegotiated with Gasterra and Statoil, as there have been concessions made by Sonatrach and Gazprom[48].

However, in Asian markets long-term oil-indexed contracts are still expected to remain an important factor. Here a substantial part of LNG will still be sold under long-term, oil-based contracts of up to 20 - 30 years, as this is necessary to finance the capital-intensive liquefaction terminals.

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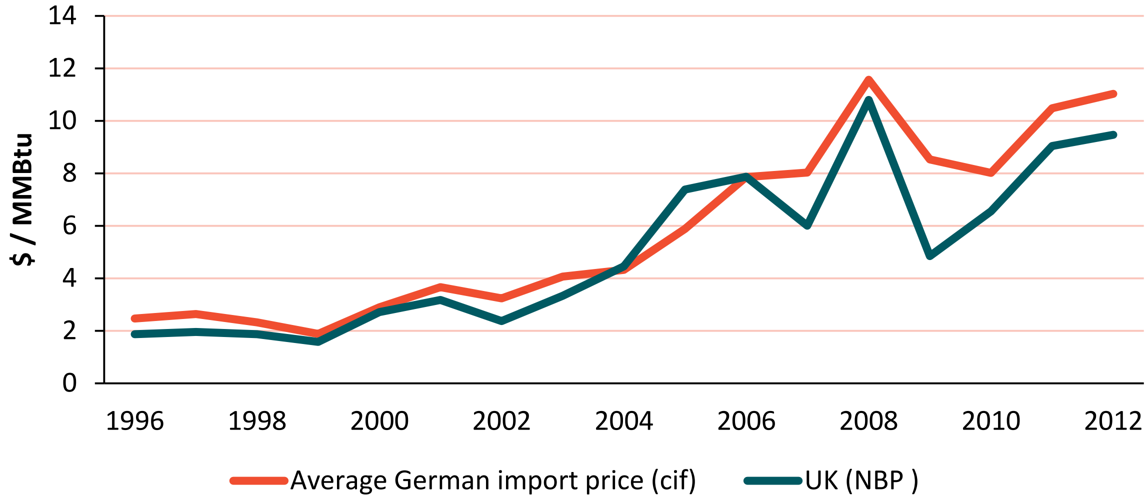
[45] Timera Energy (2013) Gas hub price evolution: applying the framework
[46] Timera Energy (2013) Gas indexation in Europe – a tipping point?
[47] The Economist (2014) Paying the piper, accessed 8 January 2014
[48] Timera Energy (2013) Gas hub price evolution: applying the framework

Figure 3-5: European long-term contracts (German import cif) vs UK (NBP) hub prices[49]



3.1.5 LNG

Europe imported an average 80 bcm of LNG in 2010, 2011 and 2012[50]. This accounts for 15% of total European gas demand. The biggest LNG customers were Spain and the UK. These countries are also the most reliant on imports as a percentage of their total gas demand (Spain 60%, UK 20%). In Europe 23 LNG import terminals already exist (179 bcm; Table 3.1). Seven facilities are currently under construction (35 bcm) and 32 are planned (>160 bcm)[51]. These figures indicate that Europe is preparing infrastructure to deal with increasing volumes of LNG. Additional LNG supplies – if they arrive, which is dependent on contracts and geopolitical developments – will reduce European import dependencies from exporters like Norwegian Statoil and the Russian Gazprom. At the same time, the additional supplies might improve the negotiation position for European customers when specifying conditions for new gas contracts.

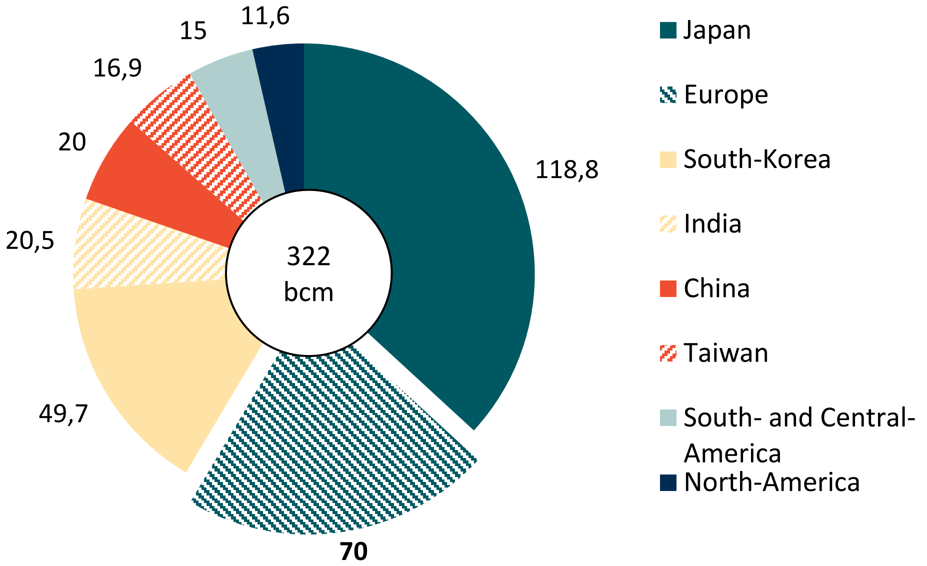
[49] BP (2013). Statistical Review of World Energy
[50] Ibid.
[51] GLE (2013). LNG map

Table 3.1: Operational LNG terminals in Europe[52]

Country	Number of Terminals	Operational since	Capacity in bcm / a
Belgium	1	1987	9
France	3	1972, 1980, 2010	23,75
Greece	1	2000	5,3
Italy	2	1971, 2009	10,96
The Netherlands	1	2011	12
Norway	2	2011, 2011	10,65
Portugal	1	2004	7,9
Spain	6	1968, 1988, 1989, 2003, 2006, 2007	60,1
UK	3	2005, 2009, 2009	46,5
Total	**23**		**179**

Total demand for LNG will not only increase in Europe. European markets mainly compete for LNG with markets in Asia, such as Japan and South-Korea. As an illustration, Japan imports more LNG than the total European continent[53] (Figure 3.6). With a share of 75% of the total imported LNG volumes, the center of LNG trade lies in Asia. This is expected to remain so in the coming years, as the nuclear disaster in Fukushima (March 2011) substantially raised Asian LNG import prices relative to European prices. On average, Asian LNG import prices are 35 – 50% higher than the corresponding figures for European markets. Countries such as Japan therefore remain more financially attractive markets for the import of LNG compared to Europe.

Figure3-6: Worldwide LNG import in 2012 (bcm)



[52] GLE (2013) LNG map
[53] EC (2013) Quarterly Report Energy on European Gas Markets

3.2 The European Shale Gas Market

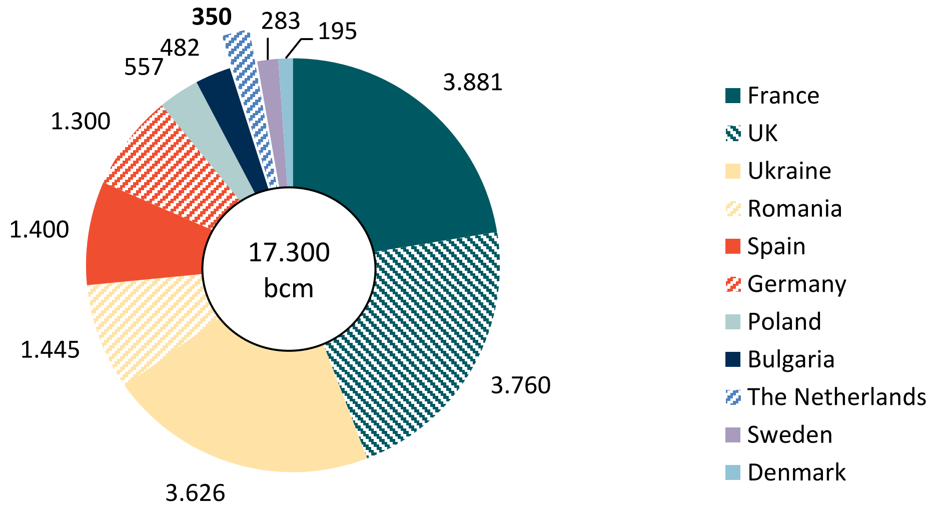
In order to understand the European shale gas market, technical resources as well as political developments regarding shale gas need to be considered.

3.2.1 Technical resources

Shale gas resource estimates have been down- and upgraded substantially over the years (up to a factor of 10) due to the lack of sufficient and reliable geological data for the shale formations already identified. For example, Norway's shale gas resources, were originally estimated at 2.400 bcm in 2011, but are non-existent in the latest EIA (2013) report due to the disappointing results obtained from three Alum Shale wells drilled by Shell. Similarly, the EIA reported in 2011 that Poland's shale gas resources were among the largest in Europe, with 4.100 bcm. In 2012, however, the Polish Geological Institute downgraded these resources to 500 bcm. On the other side of the spectrum, the UK's latest resource estimates rose from 700 bcm to 3.800 bcm[54].

These substantial shifts in shale gas resource estimates indicate that current figures are still rather unreliable and that new data from test drilling sites have yet to give more accurate and reliable resource estimates. Current figures show that the UK, France and Ukraine have the largest technical resources of shale gas in the continent (Figure 3.7). The basis for the estimated technical resources as presented in this report is EIA (2013). However, when available, more recent figures from national geological institutes have been used. Romania, Denmark, Poland and the Netherlands follow at a distance. These figures add up to a total technical resource estimate of about 17.300 bcm, which is comparable to US resource estimates. If these technical resources could be translated into economic reserves, which is rather unlikely given the widely diverging results of exploratory drillings so far, they would fulfill European demand for about 30 years under current annual consumption levels.

Figure 3.7: Technical resource estimates for shale gas in Europe[55]

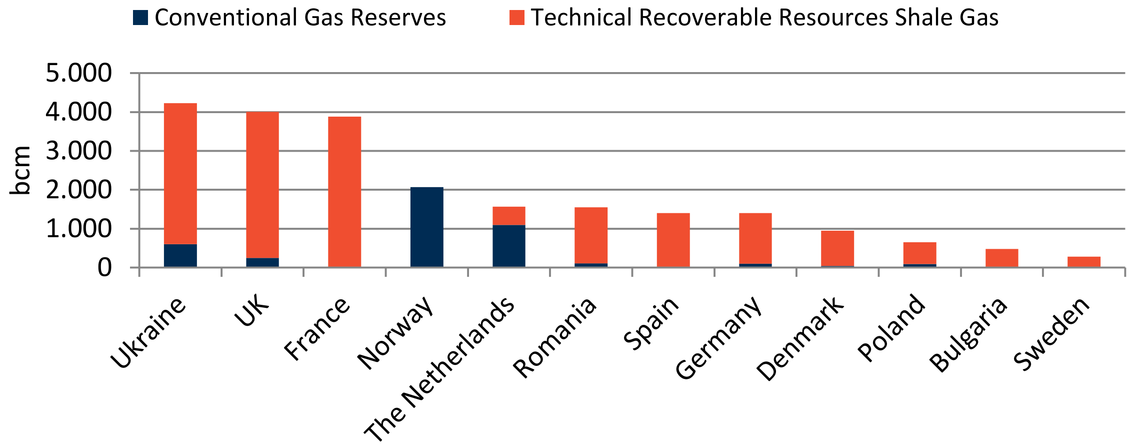


[54] BGS, DECC (2013) The Carboniferous Bowland Shale gas study: geology and resource estimation

[55] EIA (2013); GIEP (2013); BGR (2012); BGS, DECC (2013); PGI (2012); ACIEP (2013); TNO (2012) ; For the Netherlands an average of TNO estimates is used.

The Figure 3.8 combines proven natural gas reserves in Europe with technical shale gas resources. As can be seen, proven conventional gas reserves in Europe are rather low compared to estimated shale gas resources. This implies that, in theory, for most MSs the extraction of shale gas in Europe could substantially contribute to European energy security. The only exception is the Netherlands, where proven natural gas reserves appear to be much larger than estimated shale gas resources. However, due to the uncertainties in turning technical resources into proven reserves, restrictions posed by national politics in several member states and the open question if proven reserves can also be explored economically, the figure has to be regarded with some caution.

Figure 3.8: Proven natural gas reserves and technical shale gas resources in Europe in 2013[56]

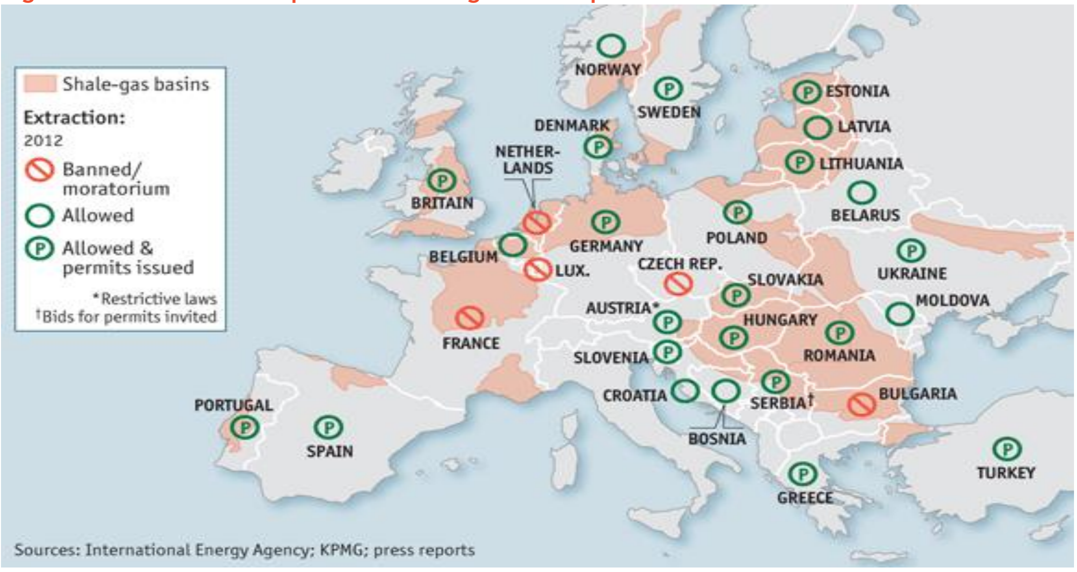


3.2.2 Country specific political developments

Due to a relative high gas price and a well-developed West-European gas infrastructure, Europe could be an interesting business case for the development of shale gas. However, future production of shale gas in Europe should not be assumed to be self-evident, as national views on whether the production of shale gas is desirable still differ substantially (Figure 3.9). The figure reflects the situation of 2013. In 2014, in addition Germany has issued a ban on commercial drilling for shale gas, while scientific research for shale gas exploration is still allowed[57]. In the following sections, the situations in the countries with the largest potential for shale gas production in Europe are discussed.

[56] EIA (2013) International Energy Statistics ; BP (2013) Statistical Review of World Energy 2013; BGR (2012) ; BGS, DECC (2013) ; PGI (2012) ; ACIEP (2013) ; TNO (2012)
[57] Spiegel (2014) Atommüll: Umweltministerin Hendricks drängt bei Endlagersuche

Figure 3.9: Political standpoints on shale gas in Europe[58]



Poland

Poland has issued exploration licenses relatively early compared to other European countries, driven by their wish to be less dependent from gas imports from Russia. Partly for this reason, Poland has already made substantial revisions to its initial resource estimates when new data from test drilling sites became available[59]. Based on these figures, the Polish Geological Institute downgraded the EIA's initial resource estimates from 4.100 bcm to 500 bcm. Out of 43 exploration wells currently drilled, shale gas has only been found in 12 locations. Several investors have therefore stated to withdraw from further exploration[60]. Public support however remains positive. Lena Kolarska-Bobinska, Polish member of the European Parliament, states that 70% of the Polish population still supports shale gas production, even in drilling areas.

France

Together with the UK, France has the largest estimated shale gas resources in Europe. The French government had therefore initially issued three exploration licenses, but due to public opposition these permits were withdrawn in 2011. Later that year, France imposed a moratorium on hydraulic fracturing. On the 14th of September 2012, President Hollande reaffirmed the ban on hydraulic fracturing in France for the remainder of his presidential term. This ban has been reconfirmed in October 2013 by the France constitutional court, via a decision after a complaint by the American exploration company Schuepbach Energy LLC. Hollande has promised that the ban will remain in place for his entire term, which officially ends in 2017[61].

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[58] In September 2013, the Dutch Minister of Economic Affairs postponed all exploration drilling in the Netherlands until additional research on the regional and local impacts of shale gas production could be conducted. It is expected that this research will be concluded before the summer of 2014.
[59] EIU (2011) Breaking new ground, A special report on global shale gas developments
[60] NOS (2013) Schaliegas tegenvaller voor Polen, http://nos.nl/artikel/504824-schaliegas-tegenvaller-voor-polen.html
[61] The Economist (2013) Unconventional Gas in Europe: Frack to the future

Ukraine

Ukraine controls the transit of a large part of Russian gas to Europe, which makes Ukraine's pipeline infrastructure a highly-prized strategic asset. Ukraine recently signed a 50-year production-sharing agreement with Chevron to extract shale gas in Western Ukraine[62]. In addition to this, Royal Dutch Shell signed a production-sharing agreement for extraction in Eastern Ukraine earlier in 2013. Potential shale gas production figures could advance up to 5 - 15 bcm per year. Whether this potential supply would actually affect EU member states depends on how the new trade association contract with the EU looks.

Russia

Russia has the largest shale gas resource in Europe, but any activities in this field in the near future are not expected. Gazprom stated: "*Shale gas production in Russia would be inexpedient due to the abundance of conventional gas reserves with their recovery cost being considerably lower than the estimated cost of shale gas production*"[63]. Therefore Russia is not expected to exploit any shale gas in the coming 5 – 10 years[64]. In the longer-term, however, Russia might well become a serious player in the shale gas field.

United Kingdom

In 2013 the technical recoverable resources of shale gas in the UK were upgraded by the British Geological Institute to a central estimate of 3.760 bcm. These new estimations put the UK resources in the top three in Europe. Shale gas production could therefore be of significant importance in securing the UK's future energy needs. Currently, domestic demand for gas is expected to remain high. Over 90% of UK homes use gas for heating and 34% of primary energy demand is fulfilled by gas[65].

Shale gas production in the United Kingdom is supported by the government but, unlike in the US, where private landowners receive royalties from shale gas production, in the UK the mineral rights belong to the Crown. This could partly explain greater opposition to fracking by local communities in the UK than in the United States.

In June 2013, in order to mitigate such opposition, the UK Onshore Operators' Group proposed benefits for local communities of £100,000 per fracked well site during exploration/appraisal stage, and a share of proceeds at production stage of 1% of revenues – potentially up to 10 million pounds, allocated approximately 2/3rd to the local community and 1/3rd at the county level[66].

Governmental support to investors also appears to be in place with the fiscal regime for shale gas currently under reform. State royalties have been lowered from 62% for conventional oil and gas, to 30% for shale gas. This has been done to encourage early investments in the exploration for shale gas in the UK. In addition, the government committed to extend the Ring Fence Expenditure Supplement

[62] RT (2013) Ukraine ramps up shale revolution, signs $10bn gas deal with Chevron,
[63] Gazprom (2013) Gazprom to continue shale gas market investigation
[64] Articgas (2013) LNG market overview looks at supply and demand
[65] House of Lords (2013) ; BP (2013) Statistical Review of World Energy
[66] HM Treasury (2013) A fiscal regime for shale gas: Summary of Responses.

(RFES) for shale gas projects from six to ten accounting periods. RFES allows companies without profits in oil and gas to ring fence tax regime to uplift their losses by 10 per cent to maintain their time value until they can be set off against future profits. This extension was designed to ensure a shorter payback period for these projects[67].

Despite the proposal to involve local communities in shale gas developments, local support remains a barrier. Shale gas concerns have in particular focused on seismicity in Blackpool induced by hydraulic fracturing. This, together with a heightened public awareness, has led to 1,5 – 2 years of delay in the obtaining the required permits. Whether the potential employment benefits of a suggested 74.000 direct jobs induced by production would sufficiently address recent concerns remains an open question[68].

Cuadrilla expects that it will be at least a decade before the UK sees any shale gas production and that, even then, it would not be the gamer changer we have seen in North-America[69]. Unlike the North American market, the UK and European gas market is not isolated. Regardless of how much shale gas is produced in the UK, the price for gas in the UK will be determined by the pan-European supply and demand balance. The cost of marginal supply, predominantly flexible Russian pipeline volumes, will continue to be the key driver of prices across the interconnected network of European gas hubs until well into next decade[70]. On the other hand, if significant amounts of NGL's were found to be associated with shale gas, the business case for shale gas production might show better – probably leading to more rapid development.

3.3 Conclusion

Shale gas is a much debated and explored topic in the European gas market. Nevertheless, whereas technical resources of shale gas in Europe are of a similar magnitude as those in the United States, the European context is fundamentally different from that in the United States. Most importantly, while the United States are relatively isolated in terms of gas supply, in and around Europe there are several major suppliers of conventional gas (e.g. Russia, Algeria, Norway) that can set the marginal gas price at any time if desired for geopolitical or economic reasons. Therefore any European shale gas development has to compete with the abundant conventional supply in the decades to come.

LNG developments will substantially influence the position of shale gas in Europe, directly and indirectly.
Directly, the many European LNG terminals under construction can enable increasing LNG imports in Europe in the future, including shale gas imports from the United States. A combination of bilateral relations, geopolitics and market conditions will determine whether these facilities will indeed attract LNG flows. From an economic perspective, however, Europe will have to compete with Asia for LNG imports from the global market (in particular with Japan and South Korea). Given this, it is

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[67] Ibid.
[68] IoD (2013) Getting Shale Gas working
[69] The Telegraph (2013) Centrica to unveil shale gas drilling plans with Cuadrilla
[70] House of Lords (2013) The Economic Impact on UK Energy Policy of Shale Gas and Oil, Meeting 5 November 2013

likely that any rise of LNG imports into Europe , will be gradual. The following chapter will explore this in more detail.
Indirectly, LNG is likely to exert influence on the dominant pricing mechanism in Europe and therefore on the European gas price. Whereas the current dominant method of gas pricing in Europe is still linking gas prices to those of oil via oil-indexed long-term contracts, LNG gas pricing is often spot-market based. Through this spot-market pricing, the rise over time of LNG in Europe is likely to put a downward pressure on European gas prices. This in turn might negatively affect the competitive position of domestic shale gas production in Europe, as European shale gas deposits are often located much deeper than the US counterparts, and therefore need higher gas prices to be exploited in a commercially attractive way.

There are other differences in circumstances for shale gas in Europe compared to the United States. European shale gas resources are spread divided over a large number of countries, each with different legislation and public opinion regarding shale gas. Underground resources are not legally owned by private land owners in any of these countries. In this way shale gas in Europe misses one of the key drivers of the US shale developments. General public opinion in Europe is not as positive towards shale gas as in the United States: Whereas in many European countries exploration is going on in initial or further stages, there are also countries where shale gas production has already been legally prohibited (France, Bulgaria) and in other countries (e.g. Netherlands, Germany) the public discussion about shale gas is still going on.

4 Potential Impact of Shale Gas in Europe

Following on from the literature review of international and European shale gas developments in the previous chapters, this chapter goes into more detail on the potential economic impacts of shale gas developments on Europe and the Netherlands. It does so by making illustrative calculations on some of the most likely impacts using the 2013 IEA WEO scenarios. These scenarios cover projections up to 2035. Section 4.1 introduces the economic scenarios used and their underlying assumptions and limitations. Section 4.2 discusses impacts of shale gas developments on shale gas flows in Europe. Section 4.3 analyses likely impacts of shale gas on a fuel shift in the European electricity sector. Section 4.4 examines impacts on the European chemical industry. Finally, section 4.5 provides an overall analysis based on the calculations made.

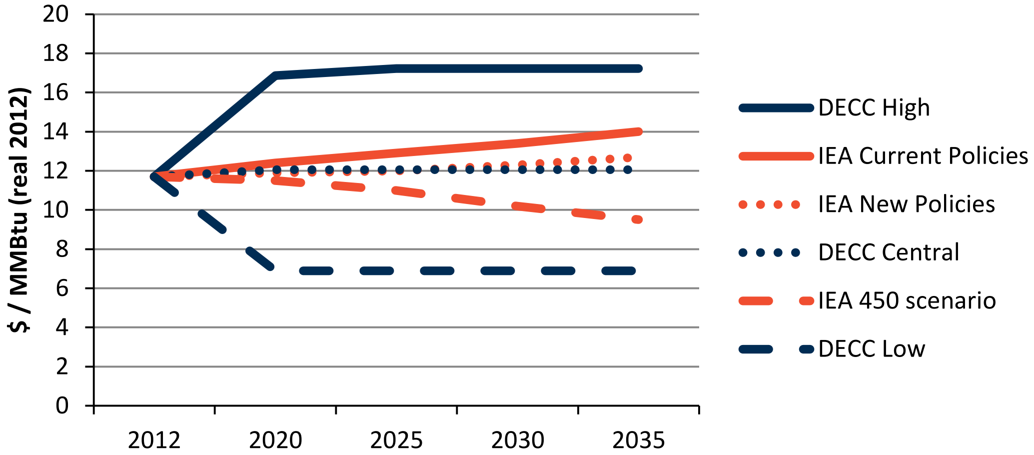
4.1 Economic scenarios used

To assess the potential economic impact of shale gas, recent IEA international energy scenarios are used. These scenarios are from the latest World Energy Outlook, published by the International Energy Agency (IEA) in November 2013. The IEA describes three scenarios (New Policies, Current Policies, and 450) for the US, Europe and Japan.

These scenarios are chosen as authoritative sources as they take into account the main recent worldwide energy price developments. The IEA distinguishes between three key regions relevant for international shale gas developments in relation to potential LNG flows: the US, Europe and Japan. According to the IEA, these regions represent the three major regional markets – North America, Asia-Pacific and Europe – with prices established by different mechanisms.

The core variables in this analysis are the projected long-term gas prices for the US, Europe and Japan (Figure 4.1). As a reference, in Figure 4.1 recent scenarios from the UK Department of Energy and Climate Change (DECC) are also used. It is clearly visible that, whereas DECC scenarios span a relatively wide range of potential gas prices, IEA scenarios are centered in a smaller area of potential gas prices. This signals a potential limitation to the IEA scenarios: i.e. gas prices are notoriously hard to predict, and future gas prices could possibly fall outside the range spanned by the three IEA scenarios. On the other hand, the IEA scenarios represent the best available knowledge from an authoritative source, with a relatively well-defined set of publicly available data. We therefore consider the use of the IEA scenarios as appropriate for this analysis. The underlying key assumptions and energy prices that belong to each of the IEA scenarios are given in the overview in Table 4.1.

Figure 4-1: Projected natural gas import price Europe (in real 2012 $ / MMBtu)



Macroeconomic effects of European (EU-28) Shale Gas Production

Pöyry (2013) examine the macro-economic effects of shale gas production in Europe. The main findings are that shale gas could add a total of 1.7 trillion to 3.8 trillion euros to the European economy between 2020 and 2050. Wholesale gas prices could decline by 6 to 14% as a result of shale gas developments in Europe and wholesale electricity prices fall by 3 to 8% until 2050.

Differences of the findings of the Pöyry report with those of this report are mainly due to differences in methodology used, the two main differences are:

- **Period examined.** This report examines the period until 2035, Pöyry until 2050.
- **Scenarios used.** Pöyry used three self-developed scenarios (No Shale, Some Shale, Shale Boom) in which very high assumptions are made regarding shale gas production in Europe compared to the IEA scenarios used in this report. Whereas IEA assumes a shale gas production of at best 18 bcm in Europe by 2035 in the New Policies Scenario, Pöyry assumptions for production are 60 bcm in 2035 in the Some Shale Scenario, and 135 bcm in the Shale Boom Scenario.

Table 4-1: Underlying assumptions for WEO 2013 scenarios (with a focus on Europe)

		Current Polices Scenario	New Policies Scenarios	450 Scenario
Building Blocks	Economic growth	Global GDP increases at an average rate of 3.6% per year (Europe 1.7% per year)		
	Population growth	Based on latest UN projections, population will rise by 0.9% per year, to 8.7 billion in 2035 (Europe 0.3% per year)		
Other relevant parameters	Energy pricing	Policies adopted to reduce the use of fossil fuels are limited. This leads to higher demand and, consequently, higher prices, although prices are not high enough to trigger widespread substitution of fossil fuels by renewable energy sources.	Crude oil import price reaches $128 barrel in 2035. A degree of convergence in natural gas prices occurs between the three major regional markets of North America, Asia and Europe. Coal prices remain much lower than oil and gas prices on an energy-equivalent basis.	Lower energy demand means that limitations on the production of various types of resources are less significant and there is less need to produce fossil fuels from resources higher up the supply cost curve. As a result, international fossil fuel prices are lower than in the other two scenarios.
	Power generation policies	Continuation of policies that had been legally enacted as of mid-2013 plus cautious implementation of announced commitments and plans.	Early retirement of all nuclear plants in Germany by the end of 2022; Support for renewables sufficient to reach 20% share of energy demand in 2020.	ETS strengthened; Reinforcement of government support in favour of renewables.
	CO_2 pricing	Price levels gradually increase from 15 dollar per tonne in 2020, 20 in 2030 and 35 in 2035	New schemes that put a price on carbon are gradually introduced, with price levels gradually increasing from 20 dollar per tonne in 2020, 33 in 2030 and 40 in 2035	Price levels substantially increase from 35 dollar per tonne in 2020, to 95 in 2030, to 125 in 2035
	Production of shale gas	No specifications are given	Worldwide shale gas production will rise from 232 bcm in 2011 to 745 bcm in 2035. Due to unfavourable geological conditions, high public and political opposition, European production levels will only be marginal within 2011 to 2020. From 2020 onwards, annual production levels can increase to 20 bcm in 2035.	No specifications are given

4.2 Impacts on shale gas flows

Shale gas can have a direct impact on European gas markets either via the import of LNG from the United States or via domestic production in Europe. These two options are discussed below.

4.2.1 LNG imports

Of all the countries having substantial shale gas resources, only the US has the short-term possibility to become a net exporter of shale gas. As of 2012, the United States is set to become the world's largest gas producer (boosted by expanding supply of shale gas) and is expected to remain so through to 2035[71]. According to the OIES[72], US LNG export could happen as early as 2015. The latest IEA report expects that US LNG export facilities can begin operation as early as 2016.

The gas import dependency of Europe and Japan, is expected to continue to rise. Given that both European and Japanese markets are exhibiting increasing gas demands, the US can either export shale gas as LNG to Europe or Japan. Two hypothetical business cases are therefore calculated, one for LNG export from the US to the EU, and another for LNG export from the US to Japan.

It will be favourable for the US to export LNG to Europe when the difference between European and US gas prices compensates for transporting shale gas as LNG to Europe. The same holds for shale gas exports to Japan. According to the OIES (2012) and the BNEF (2013) these costs amount to 4,70 $ / MMBtu for Europe and 6,40 $/MMBtu for Japan[73] (Table 4.2). Note that the transport costs to Asia assume use of the Panama Canal which will have been widened sufficiency to accept LNG vessels from 2014 onwards.

Table 4-2: Additional cost of US LNG to Europe and Asia[74]

	US Liquefaction	Transport	Regasification	Total	Difference
Exports to Europe	3,00	1,30	0,40	4,70	1,70
Exports to Asia	3,00	3,00	0,40	6,40	

The second condition which needs to met for US export terminals to ship their LNG to Europe instead of to Japan is that the difference between the price of gas in Japan and Europe is less than the transport costs difference between these two regions, assuming regasification costs are equal. As can be inferred from the table above, this implies that LNG will be exported to Europe when the price difference is less than 1.70 dollar per MMBtu. If the price spread between the Japanese and European market exceeds 1.70 dollar per MMBtu, US LNG exports will go to Japan rather than to Europe.

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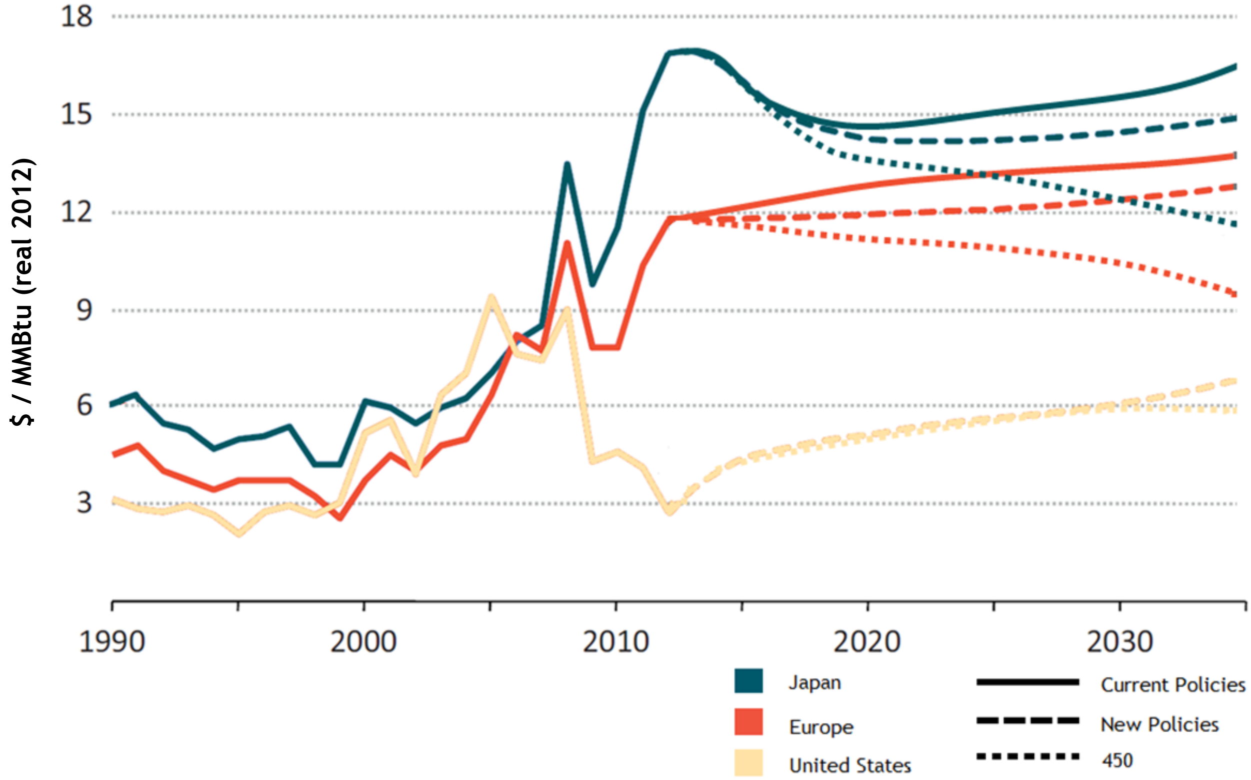
71 IEA (2013) World Ebnergy Outlook 2012

72 OIES (2012)The potential impact of North American LNG exports, p.3

73 Ibid ; OIES (2012) The potential impact of North American LNG exports, p. 46; BNEF (2013) The Economic Impact on UK energy policy of shale gas and oil, p. 4

74 OIES (2012) The potential impact of North American LNG exports, p. 46 ; BNEF (2013) The Economic Impact on UK energy policy of shale gas and oil, p. 4

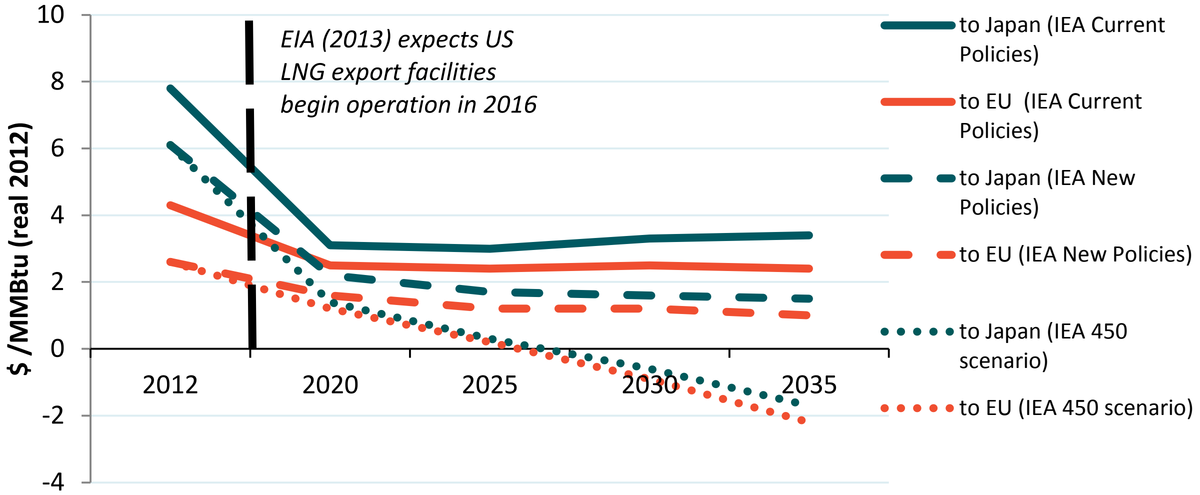
Figure 4-2: Historical and expected gas prices in the US, Europe, and Japan (adapted from IEA WEO 2013)



Historically, Japanese gas prices have been higher than gas prices in Europe due to the lack of gas resources in Japan. This can be seen by Japanese gas import dependency rates which are higher than European rates (90% vs 60%). Recent Japanese supply shocks, related to the Fukushima disaster, have only amplified widening price spreads between European and Japanese markets (Figure 4.4). If we look at the trend of the last 5 years, which corresponds with the start of the shale gas boom in the US, Japanese LNG import prices were more than $1,70 higher compared to gas prices for the European continent. This implies that during the last years it was more favourable to export LNG to Japan than to Europe due to higher net export margins.

Using IEA scenarios for price projections in the three regions, together with the additional costs of US LNG shipment to Asia and Europe, results in a positive business case for US LNG exports to both Japan and Europe in most scenarios (Figure 4.5). However, in all scenarios, the net export margins are expected to decline substantially until 2020. This is because all IEA scenarios expect US natural gas prices to rise, which brings down the business case for US LNG export. Furthermore, in all scenarios the business case for exports from US to Japan is more positive than for exports from US to Europe, suggesting that with hub-based pricing the majority of potential LNG exports from the US will go to Japan. What will be interesting for Europe is to investigate whether the LNG left over after Chinese and other Asian requirements are fulfilled will end up in Europe or not.

Figure 4-3: Projected US LNG export margins to Europe and Japan under IEA 2013 scenarios



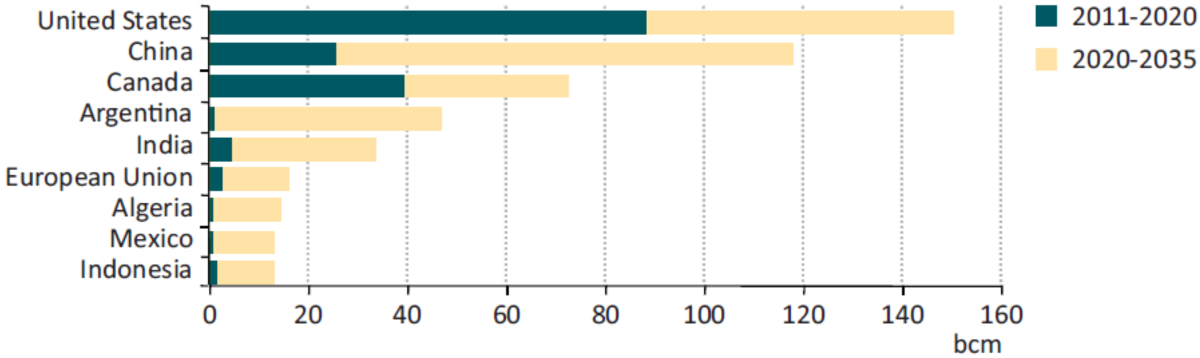
4.2.2 *Shale gas production in Europe*

In an optimistic case, European countries such as the UK or Poland can start- economic production of shale gas within 5 to 10 years. But even then, it is likely that no significant quantities of shale gas will be produced and marketed within Europe[75]. This seems to be confirmed by the latest New Policies scenario by the IEA[76].

Due to unfavourable geological conditions, high public and political opposition, European production levels will only be low within the 2011 – 2020 timeframe (Figure 4.6). From 2020 onwards, annual production levels can increase to 20 bcm in 2035 (compared to a current annual European gas demand of 550 bcm). Production will take place in Poland (8 bcm), Ukraine (8 bcm) and the UK (3 bcm).
The IEA expects a global increase of shale gas production under the New Policies Scenario of 232 bcm in 2011 to 745 bcm in 2035. In the more distant future, additional shale gas resources to those from the US could be imported by Europe from shale gas production in Algeria. Although it remains unclear how Algeria is going to solve its current scarcity of water, the IEA estimates that the Algerian shale gas output will reach 15 bcm near the end of 2035.
However, in the light of current political events, these figures seem rather optimistic. Fiscal and political-economic regulations for oil and gas in Algeria are currently not attractive for foreign investors.

[75] House of Lords (2013) The Economic impact of UK energy policy of shale gas and oil, Written Evidence E.ON
[76] The other two IEA scenarios do not elaborate on shale gas developments.

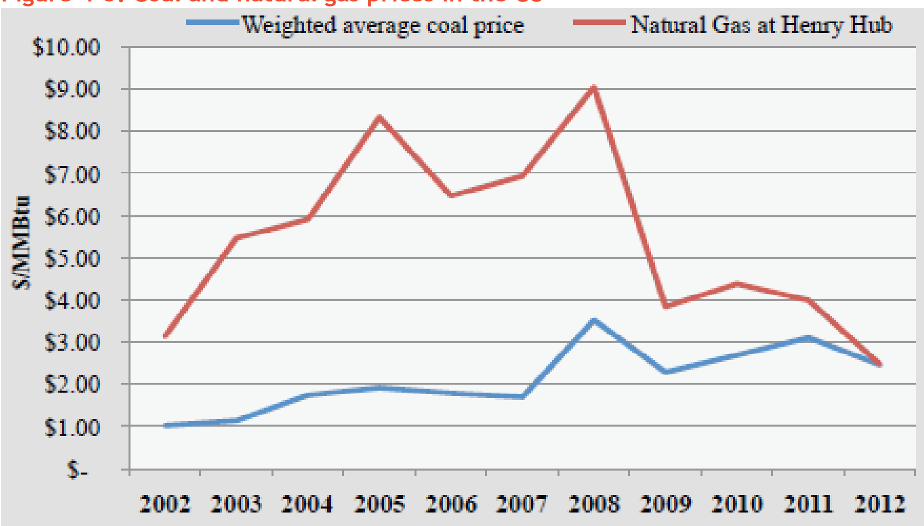
Figure 4-4: Growth in shale gas production in the New Policies Scenario



4.3 Impacts on fuel-shift in the European electricity sector

In power systems which have sufficient spare capacity (e.g. in the United States), competition between coal-powered plants and combined-cycle gas turbines (CCGTs) can result in fuel switching between coal and gas[77]. Fuel switching is mainly a result of changes in the relative prices in the underlying coal and gas markets. The recent increase in the production of unconventional gas, especially shale gas, has put a downward competitive pressure on coal in the United States. This can be seen from the figure below (Figure 4.7). This sudden surge in the supply of gas resulted in lower domestic prices for gas in the United States which led to higher gross margins for gas-fired power plants (spark spread). At the same time, old coal plants needed to be retrofitted with expensive scrubbers[78]. To some extent these developments led to a displacement of coal by gas in US power generation.

Figure 4-5: Coal and natural gas prices in the US[79]

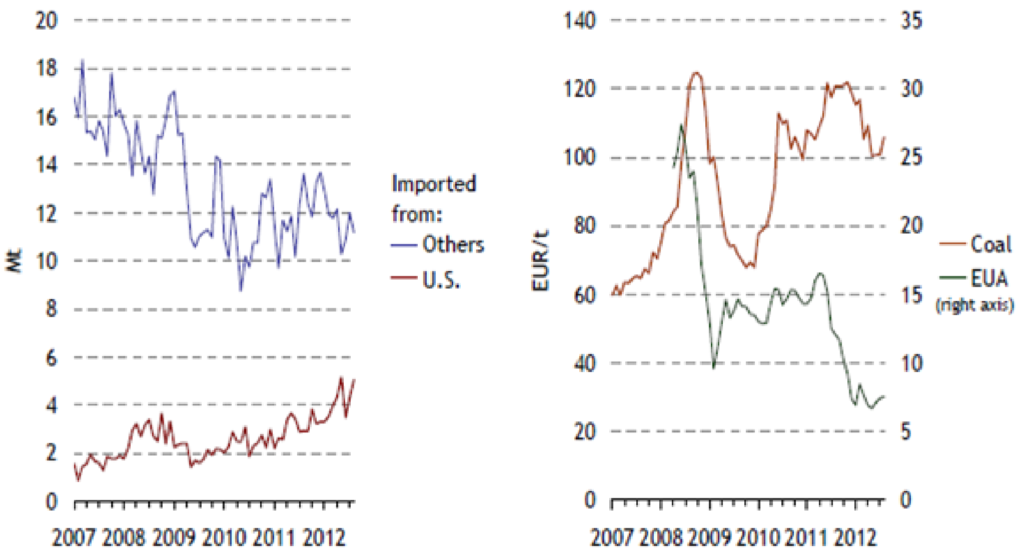


On a global level the consequence of this shift from coal to gas was that more US coal became available on world markets. It has been suggested that an increase in US coal exported to Europe, and the resulting declining coal prices in Europe, were the main reasons for a shift from gas to coal in the

77 IEA (2013) World Energy Outlook 2013
78 Centre for Policy Studies (2013) Why every serious environmentalist should favour fracking
79 Navigant (2013) The Phenomenon of Coal-to-Gas Switching

European power sector. It is true that such a shift has taken place: Gas-fired power generation in Europe decreased by 25 per cent between 2010 and 2012, while coal-fired power generation increased by 10 per cent[80]. But it is not clear if this is the result of shale gas developments in the United States.

Figure 4-6: Monthly coal imports by EU in Mt (left); EU coal import price and EU emission allowance price in EUR/t (right) (Source: IEEJ, 2013)



As can be seen from the left part of Figure 4.6, monthly EU coal import volumes from the US increased, as did overall coal imports, from 2010 to 2012, corresponding with the rise of shale gas in the US. However, over the last five years total coal imports have decreased. The right figure suggests a small decrease in coal import price between 2010 and 2012, but an overall increase over the period 2007-2012. Given these figures, the extent of the 'US shale gas effect' on the European electricity market can be questioned. Another factor that will have played an important role in the decline of gas and the increase in coal might be the large reduction in EU ETS prices that has taken place (EUA on the right side of Figure 4.8). In addition, the decline of gas can be partly attributed to the increase in the use of renewable energy sources in electricity supply in Europe over the same period[81]. European gas prices have also increased substantially since the 1990s, which is another reason why a shift to coal has been attractive.

Another question that can be posed is if increasing levels of shale gas in Europe might lead to a similar development as in the US electricity sector, i.e. a future shift from coal to gas in electricity supply. According to a sensitivity analysis done by IEEJ (2013), who based their analysis on empirical data gathered in the US between 2007 and 2012, a certain "threshold level" or point exists where the relative price of natural gas compared to coal is such that a substantial substitution effect of coal by gas will be induced. In the United States this level can be empirically derived as being on average

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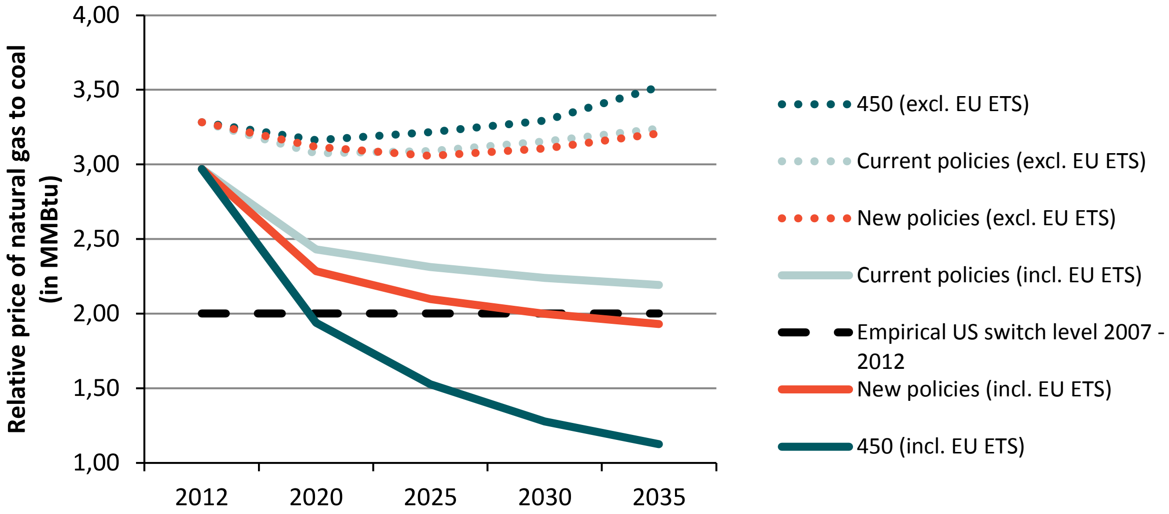
[80] Financial Times (2013) Russia and shale can solve Europe's energy problem, accessed on 13-11-2013

[81] For example in February 2014 RWE announced that the Dutch Claus C power plant will be, until further notice, closed from July onwards. The Dutch power market has currently overcapacity due to additional power supply form German renewables which have decreased overall profit margins for gas-fired power plants.

two: i.e. gas has replaced coal in the electricity supply in the United States when the ratio of the gas to coal price became lower than two.

Using this ‘fuel shift ratio’ with the IEA scenarios for European gas and coal prices leads to Figure 4.9. The dashed lines show that, if EU ETS prices are not taken into account, the price ratio of gas to coal is not projected to come near to the shift ratio in any of the three scenarios, i.e. a fuel shift is not induced in any of the three scenarios.

Figure 4-7: Relative price of natural gas to coal in Europe (with and without projections of EU ETS CO2 emission price)



However, if the IEA projections for ETS prices in the three scenarios ate taken into account (Figure 4.10) this gives a completely different picture. Including these figures in the IEA price projections and taking into account the relative carbon content of gas and coal leads to the solid lines in Figure 4.9. It can be clearly seen that in this case in the New Policy scenario a coal to gas shift in European electricity supply will be induced around 2030 (at an ETS price of around 33 dollars). In the IEA 450 scenario, this shift would be induced in 2020.

Figure 4-8: IEA CO2 price assumptions in dollars per ton (WEO 2013)

	2012	2020	2025	2030	2035
IEA current policies	5	15	20	25	30
IEA new policies	5	20	27	33	40
IEA 450	5	35	65	95	125

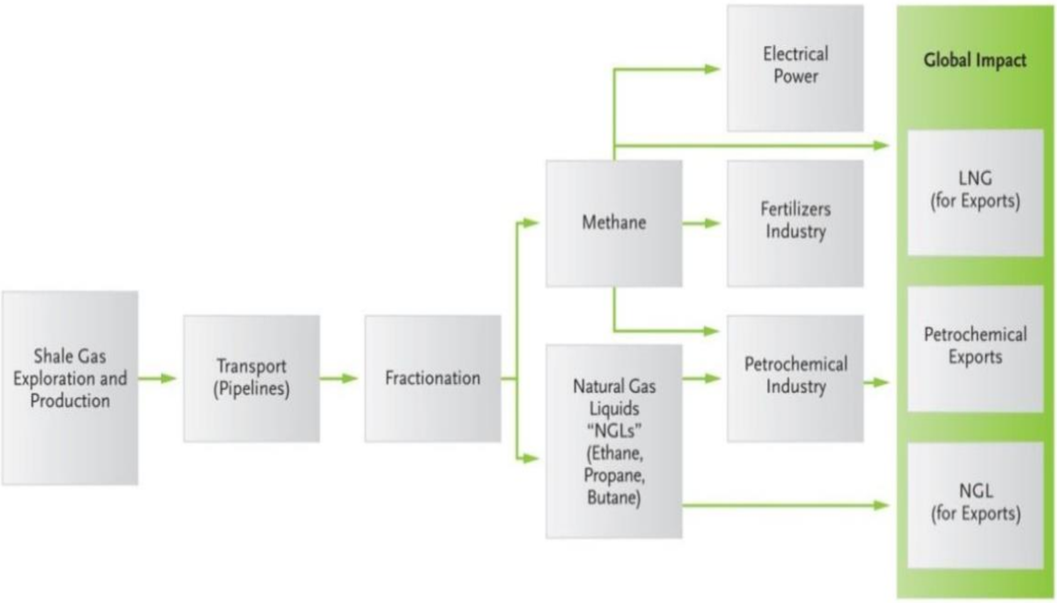
4.4 Impacts on the chemical industry

European energy-intensive industries have expressed their concerns about the change in relative energy prices that has been occuring between the US and Europe. Increasing price gaps between these two regions results in a comparitive disadvantage for European energy-intensive firms. The Dutch chemical industry is particulary concerned about its competitive position due to the fact that the chemical sector represents one of the most important sectors in the Netherlands as well as internationally.Total annual revenues are about 60 billion euro, which represent 3% of Dutch GDP.

About 80% of total chemical output is exported and around 8% of total jobs in the Netherlands are linked to the chemical sector according to the Dutch financial newspaper FD[82].

The concerns of the chemical sector are based on the fact that shale gas developments not only affect the relative fuel prices between the US and the EU, but even more importantly the feedstock prices. As can be seen from Figure 4.8 the petrochemical industry not only depends on low gas prices in terms of energy benefits, but also relies on gas since it is their basic building block. NGLs associated with shale gas in particular provide feedstock, such as ethane, propane or butane, so the industry is especially keen to understand the exact nature of any shale gas deposits (i.e. what kind and quantity of NGLs can be expected)[83].

Figure 4-8: Possible impact of shale gas on the chemical industry[84]



The current abundant availability of chemical feedstocks in the United States due to shale gas developments has led to the construction of several new petrochemical plants. The fear of the European chemical industry is that these new plants will lead to an oversupply in the United States, that will subsequently be exported to the European Union leading to competition with European petrochemical plants that derive their feedstocks from (currently much more expensive) oil-based naphta crackers. Of the large European petrochemical units— the crackers that make basic petrochemicals of which ethylene is the most important - only four (out of 40 in total) are actually gas-based, the rest are all oil-based (naphta).

Ethylene

The concerns of the European chemical industry are illustrated by current developments regarding ethylene. Ethylene is one of the most valuable petrochemicals produced as it is one of the key

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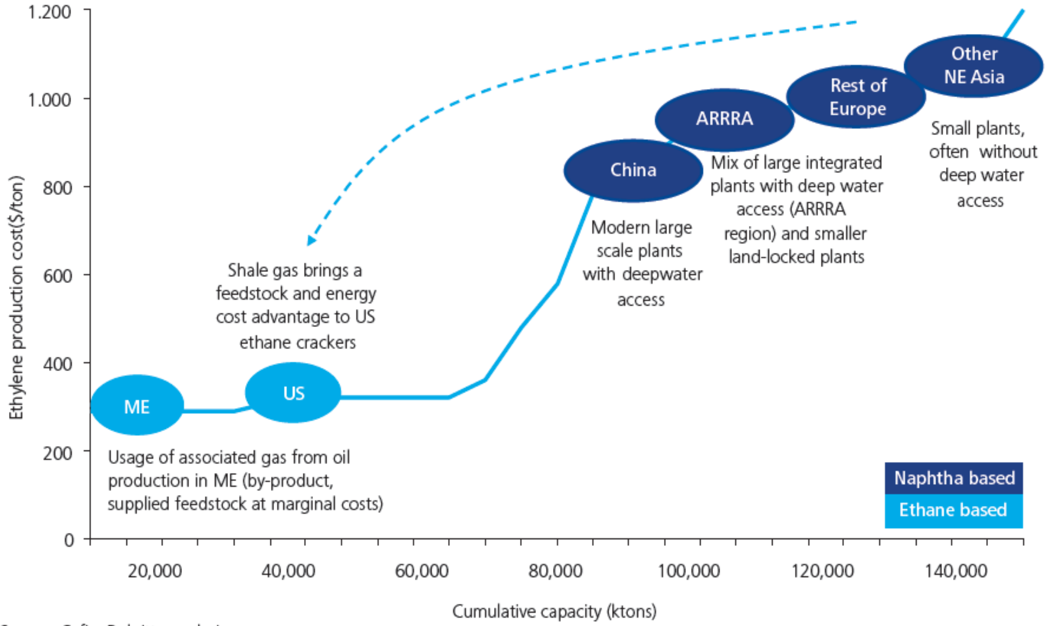
[82] FD (2013) 4 December
[83] House of Lords (2013) The economic impact on UK energy policy of shale gas and oil, Evidence session no. 7
[84] Ibid.

chemicals that is used in tens of thousends of products througout our economy. About 70% of the costs of producing ethylene are related to energy[85]. In 2005 the production costs of ethylene (ethane based) were approximately the same in the US as for Europe (500 dollar per ton). Seven years later, the difference in production costs between Europe and the two other major competitors for the manufacture of petrochemicals (Middle East and US) have risen by up to 700 dollar per ton (Figure 4.9). In comparison, transport costs between the US and Europe are about 300 dollars per ton[86], showing that the business case for exports of ethylene from the US to the EU is good.

Figure 4-9: Costs of ethylene production in different regions



Source: Cefic, Deloitte analysis

As a result of the lower gas prices in the US, American companies are planning to develop six new ethylene crackers or 7 to 10 million tons of additional capacity for the manufacture of ethelyne in the next 3 to 5 years. These figures correspond to 35 – 50% of the total European demand. When these facilities are operational US supply will exceed US demand. Is is possible that some of this supply will compete with the ethylene production of Europe[87]. Large European-based petrochemical companies such as INEOS are therefore now in the process of making plans to import US shale-based ethane into Europe. INEOS has established long-term contracts in the US to bring ethane in Europe and dedicated tankers are currently being built to do this[88].

Is shale gas a decisive competitive factor?

It remains an open question whether the serious concerns of the Dutch industry regarding shale gas are justified and to what extent the recent shale gas developments are responsible for a shift in the

[85] Elsevier (2013) A Shale Gas Primer, webinar
[86] Ibid.
[87] Ibid.
[88] House of Lords (2013)The Economic Impact on UK Energy Policy of Shale Gas and Oil, Meeting 5 November 2013, Mr Tom Crotty, Director INEOS (the fourth largest chemicals company in the world measured by revenues)

global competitive positions of chemical industries . At this moment, the worldwide market share of energy-intensive products in Europe is about 36%, much larger than the relative share of the EU global demand for these products. The latest IEA World Energy Outlook expects that the share in supply will decline to 25% by 2035[89].

Two additional key factors that are responsible for the decrease foreseen in the competitive position of European industry, which are completely independent of shale gas developments in the United States, are the shift in global demand to Asia and the surge of the Middle East petrochemical industry. The competitive position of the Middle East petrochemical industry is even better than that in the United States, as can be seen in Figure 4.9, which shows that production costs in the Middle East are still lower than those in the United States. This fact in combination with the strategic position of the Middle East plants (relatively near to the growing Asian markets), underlines that the EU chemical industry will not solve its structural problems by addressing shale gas alone. It appears that the strategic focus that the Dutch chemical industry has already planned, a switch on towards more specialised, biobased chemicals might be accelerated by the rise of shale gas in the United States[90].

4.5 Conclusion

The more detailed calculations and discussions that were made in this chapter using IEA WEO 2013 scenarios, underpin the overall picture of shale gas impacts to Europe that has arisen in the previous chapters.

Using these scenarios, a positive business case for LNG imports from the United States to Europe can be calculated in the years to come. This holds for all three WEO scenarios. Only in the IEA 450 scenario, with very strict climate policies, there will be no positive business case after 2025, in the other two scenarios a positive business case is likely to remain until 2035. However, in all scenarios the business case for exports from the US to Japan is more positive than the US-EU business case. Most of the LNG available for export from the United States will therefore be directed towards Japan. In this way, only a very gradual expansion of US-EU exports is expected.

IEA figures also confirm limited domestic shale gas production figures in the EU until 2035. According to the IEA, the United States, China, Canada and Argentina will be the largest producers of shale gas. Whether all these countries become exporters of shale gas might be doubted. As discussed in the previous chapter, rising domestic demand and regulatory and political issues might prevent countries such as China and Argentina from becoming substantial exporters in the decades to come.

We also examined in more detail the fuel shift in the electricity sector from coal to gas that has taken place in the United States in recent years due to shale gas. We draw two conclusions regarding this fuel shift.
First, our examination leads us to question the importance of the often claimed relationship between the current shift in the EU electricity sector from gas to coal and shale gas developments in the

[89] IEA (2013) World Energy Outlook 2013
[90] See Routekaart Chemie 2030 (routekaartchemie.nl) and Letter Minister of Economic Affairs to Parliament (2013) ‘concurrentievermogen chemische industrie’, DGBI-TOP / 13178936

United States. In our view other factors, such as the persistently high gas prices in Europe, very low ETS prices, the rise of renewables in the EU and the German nuclear exit, rather than low coal prices might be more important factors for this shift than US shale gas developments.
Second, based on IEA WEO figures, future EU gas and coal prices are not forecast to get near to the spread which induced the coal to gas shift in the US. However, if relatively high ETS prices, as envisaged by the IEA, are taken into account, this might induce a coal to gas shift in the EU electricity sector. Therefore, we do not consider shale gas as the key driver for change in the EU electricity sector until 2035.

Finally, we examined claims made by the chemical industry concerning the importance of shale gas in the deteriorating competitive position for the European chemical industry on the world market. Although we recognize the importance of shale gas in the competitive position of the European chemical industry in comparison with that in the United States, according to our analysis addressing shale gas alone is not likely to solve the structural problems of the European chemical industry. Shale gas might lead to an even faster transition towards a more knowledge-intensive, bio-based sector, as is already envisaged e.g. in the roadmap of the Dutch chemical industry.

5 Potential Costs and Benefits of Shale Gas in the Netherlands

The previous chapters have focused on the impacts of international shale gas developments on Europe and the Netherlands. This chapter will examine the potential impacts of shale gas production in the Netherlands itself. First, the business case for shale gas production in the Netherlands will be analysed (section 5.1). Then, likely benefits and costs to society as a whole are explored (sections 5.2 and 5.3). The chapter ends with an overall discussion and conclusions (section 5.4).

5.1 The Business Case: Shale Gas Production Costs

Production of shale gas resources in the Netherlands by a commercial party will only take place if there is a positive business case for it. In this section, we examine what is known about the business case for shale gas production in the Netherlands. We do that by first looking at European and US figures, then to those available for the Netherlands.

On a European level, cost estimates are available from drilling wells. These can give an indication for Dutch costs and are therefore discussed first. Then, the available data for the Netherlands, where no such drilling has taken place, are examined.

5.1.1 European production cost estimates

From the initial exploration phase to the decommissioning of the site a number of stages in which shale gas production can be divided exist. These are outlined in the table 5.1 below. Costs can be attributed to each of these phases. Often, a distinction is made between overall drilling costs in mln $ per well (capital investment), and production costs in $/MMBtu (operational costs).

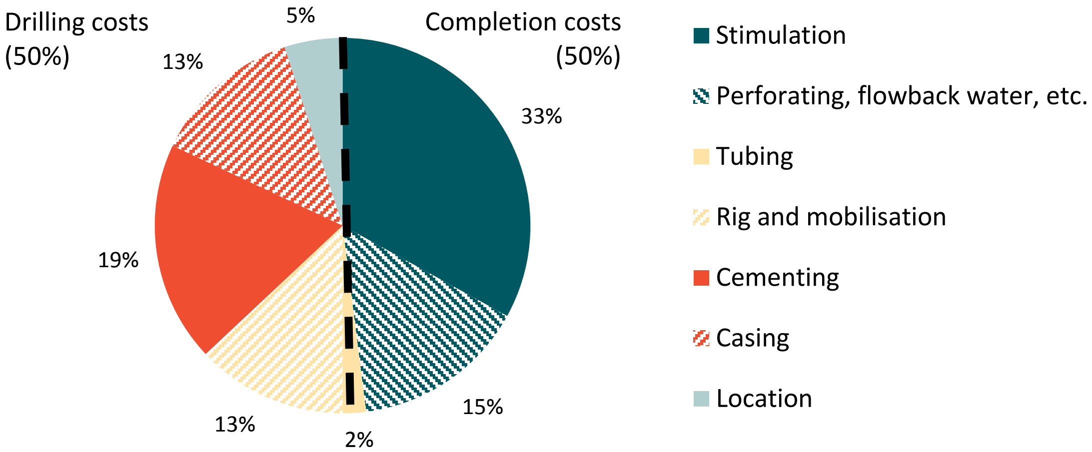
Table 5-1: Production stages[91]

Stage	Time frame
Exploration (literature study and geophysical research)	Several years
Planning and permits	2 – 3 years
Well preparations	6 – 18 months
(Test) Drills, data logging, casing/cementing	2 – 6 months (per well)
Well completion and the installation of the production facilities	1 – 3 months (per well)
Hydraulic fracking and flow-back of liquids	4-6 weeks (per well)
Production	10-30 years
Decommissioning	6-9 months

[91] Witteveen en Bos (2013) Aanvullend onderzoek naar mogelijke risico's en gevolgen van de opsporing en winning van schalie- en steenkoolgas in Nederland

Figure 5.1 also gives some insight into the cost structure of unconventional gas exploration and production. As a rule of thumb, well costs are split 50/50 between drilling and completion costs (see figure 5.1). Drilling costs include costs for the preparation of the location, casing, cementing, directional drilling and the hire of rigs. Directional drilling and cementing captures the largest share of drilling expenditures, followed by rig costs (i.e. day rates). Stimulation costs (i.e. hydraulic fracking and flow-back of liquids) account for the highest share of completion investments[92].

Figure 5-1: Simplified well costs breakdown between drilling and completion costs the Haynesville (US)[93]



Because of the lack of available European production data, little has been published regarding the cost of shale gas production in Europe. More recently however, there have been a number of reports which published economic estimates based on datasets derived from test drilling sites in Poland and Germany. Based on these newer reports costs estimates for short-term shale gas sites for Poland/Germany and the UK have become available. Compared to the costs of shale gas production in the US, which on average lie between 5-6 $ /MMBtu, costs in Europe seem to lie at least 50% to 100% higher (Table 5.2 and Figure 5.2).

US shale gas plays vary in production costs due to their difference in location (depth of the shale formation) and whether natural gas liquids are present. In wet plays (with associated NGLs) such as Marcellus and Eagle Ford, production costs lie in the lower range (3-4 dollar per MMBtu), while dry plays (without NGLs) such as Haynesville and Barnett lie in the upper range (5-6 dollar per MMBtu). Well costs have an even bigger costs spread. For example, a typical onshore shale gas well in the Barnett shale in Texas may currently cost $4 million to construct, while a similar well in the Haynesville shale costs on average $10 million, because of the depth and pressure[94]. These figures can

[92] Figure 5.1 is based upon data available from approximately 2000 wells drilled in the Haynesville during the period between 2009 and 2012 . The Haynesville formation is a layer of sedimentary rock with lies at depths of 3 to 5 km depth in the area of northwestern Louisiana and eastern Texas . Based on the empirical cost data that has been gathered between 2009 and 2012, for this source the well costs were split 48/52 between drilling and completion costs and averaged to 10 million dollars.

[93] OIES (2010) Can Unconventional Gas be a Game Changer in European Gas Markets?

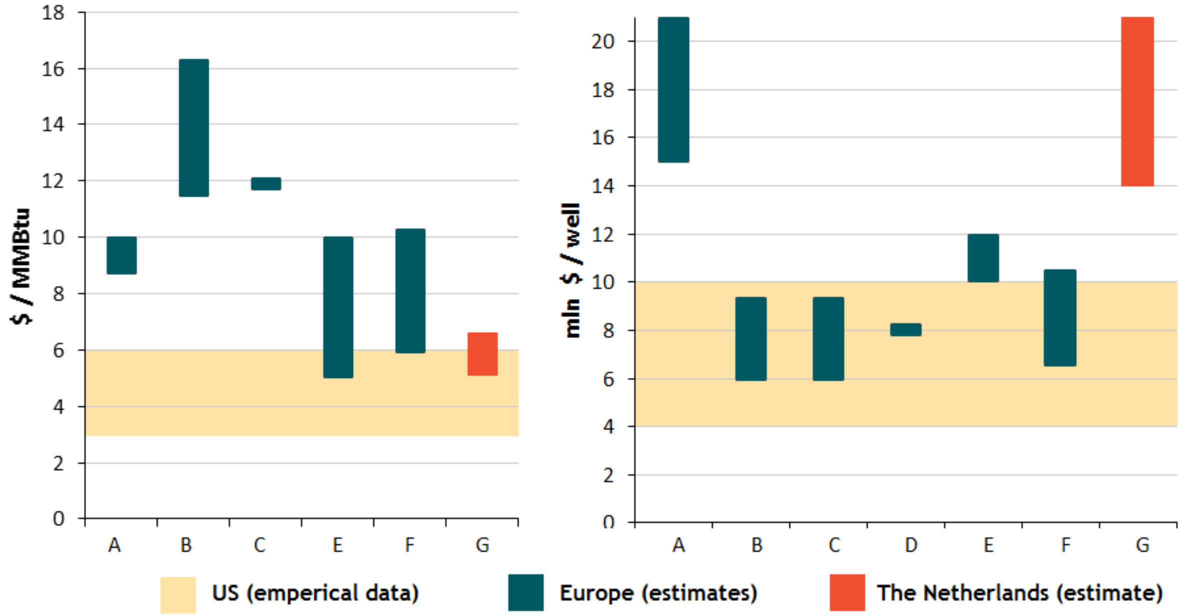
[94] Oil and Gas Journal (2013) Haynesville Update: North Louisiana drilling costs vary slightly 2007 -2012

be traced back to figure 5-2 below. European cost estimates on shale gas production are also available, although no data from exploratory drilling has yet become publicly available.

Table 5-2: Current European production cost estimates, in real 2010 dollars

					$ / MMBtu		Mln $ / well	
Author	Year	#	Area	Depth basin	Low	High	Low	High
Wood MacKenzie	2010	A	Poland, Austria, Germany	n/a	8,7	10,0	15	21
OIES, Gény	2010	B	Germany	2000	11,45	16,3	5,94	9,35
OIES, Gény	2010	C	Poland	2300 - 2500	11,7	12,1	5,94	9,35
Navigant	2012	D	UK	n/a			7,75	8,25
IEA	2012	E	Europe	n/a	5	10	10	12
JRC	2013	F	Europe	n/a	5,9	10,3	6,5	10,5
EBN	2013	G	The Netherlands	3500 - 4000	5,1	6,6	14	21

Figure 5-2: Current production costs per unit of gas ($/MMBtu) (left) and well costs in mln $ (right)



There are a number of reasons why it is more expensive to produce shale gas in Europe compared to the US. These are:

1. **The geological depth of the shale basins in Europe.**
   On average, European shale depths are about 1,5 to 2 times deeper than in the US, the Netherlands being at the upper end (3000 – 3500 meter). This translates to a need for deeper wells, more powerful rigs and pumps, and the need for additional fracking fluids, water, etc.

2. **European fiscal, environmental and safety regulations are stricter.**
   Shale gas production within Europe falls under both national and European legislation. The relevant EU legislation focuses on environmental aspects, including the protection of water,

air and soil quality, the use of chemicals and the associated liabilities for any eventual environmental damage. In October 2013 EU environmental legislation of direct relevance was extended when the European Parliament called for a mandatory environmental impact assessment for hydraulic fracturing. For initial exploration, such an assessment is not needed. The fact that for well design European law requires four programs whereas under US law only one is required, is a good example of European regulations being more demanding than those in the US.

In January 2014, the European Commission adopted a recommendation which lists a number of non-binding principles such that hydraulic fracturing techniques are done safely and without confusion over conflicting environmental regulations among the member states. From December 2014 onwards each member state has to report annually about the execution of the recommendation. The Commission will aggregate and list these country assessments by a publishing a scoreboard that will compare and rank the situation in each of the member states[95]. When the approach appears to work ineffectively, the EC will propose revisions after 18 months.

3. **Less developed onshore oil and gas service industry.**

   Initial costs for developing shale gas in Europe would be expected to be very high because there is no (mature) supply value chain. OIES (2010) reports that the European service industry can even be seen as oligopolistic, with very few specialist oil and gas companies compared to the US[96]. For example, at the high end, rig rates would be up to 120.000 dollar /day compared to US rates of only 20.000 dollar as of 2010. Due to a lack of supply, mobile rigs have to be hired and imported via the US which brings additional costs. As of January 2014, Europe only has about 87 onshore rigs actively exploring for or developing oil and gas, compared with up 1711 in the US[97]. In time, when shale gas production in Europe starts to take off, these costs would be expected to reduce due to changes in supply and demand and economies of scale.

4. **Lower public support**

   A majority of American citizens do not consider themselves as either explicit advocates or opponents of the production of shale gas[98]. For this reason, issues related to public awareness and acceptance play a less prominent role in the US than they currently play in (parts of) Europe. In the UK, it has been reported that the cost of policing the protests at Cuadrilla’s drilling site at Balcombe are currently about $6m dollars. To put this in perspective, the security of conventional gas sites (for the rig site and camp) averages around $300k per well. Although the costs of policing may reduce when the public debate on shale gas cools down it is not possible to predict what future policing costs will be. Low future public support may also prove a significant hurdle to replicating US production costs.

[95] EC (2014) European Commission recommends minimum principles for shale gas
[96] OIES (2010) Can Unconventional Gas be a Game Changer in European Gas Markets
[97] Baker Hughes (2014) International Rig Count for January 2014
[98] Linda Steg (2013) Maatschappelijk acceptatie van schaliegas

In the production phase, learning effects should lead to at least a 50% reduction of drilling and competition costs within 5 to 10 years[99]. However, the gap in costs between the US and Europe is likely to continue in the long-term due to a lower potential for economies of scale in Europe. There are lower recoverable volumes of shale gas in Europe per member state, smaller surfaces to drill and a larger number of concession holders in a given area. This also implies that there is a reduced scope for standardisation due to more heterogeneous and smaller-sized shale deposits plays throughout Europe.

5.1.2 *Dutch production cost estimates*

In collaboration with Halliburton, Tetra Tech, and Royal HaskoningDHV, EBN has produced a case study (Noord-Brabant) for shale gas production in the Netherlands. An overview of the cost calculations in this report can be found in table 3.3. EBN estimates that 4.5 to 4.9 billion euro (price level 2011) of investments are needed for shale gas production in Noord-Brabant[100]. For a total of 319 wells (3 to 4 rigs per site), this implies that on average 14,1 to 15,3 million euro of investments are required per well (17 to 19 million dollar; see also Figure 5-2). These costs are rather high in comparison with the estimates given for other European countries. The main explanation for this could be that the shale basins in Noord-Brabant are on average 1 to 1,5 km deeper than sites in Germany and Poland. In addition to that, EBN has assumed that each well include a (relative large) horizontal section. These horizontal legs are expensive and therefore the total costs of 17 – 19 million dollar lie on average 50% higher than other estimates that can be found in table 2.2.

EBN also published calculations for potential operational and decommissioning expenses. According to EBN, these amount to 2.5 - 3 billion spread across the lifetime of the well. The lifetime is set to 30 to 40 years. For a total of 319 wells, operational expenses amount to 195.000 to 321.000 euro per well, per year.

When these estimates are translated into costs per MMBtu, production costs (excluding land acquisition and exploration costs) they amount to 5 to 6 dollar per MMBtu (Figure 5-2). This is about the same order as US production costs, and much lower than estimates for other sites in Europe. EBN does not provide an explanation for this low estimation, but an important factor might be very high expected revenues.

Table 5-3: Estimated production costs of shale gas in Noord-Brabant, not taken into account inflation (source EBN, 2013)

Capital expenses per well	Million euro
Drilling costs	8.4 – 9.4
Fracking costs	3.8
Construction of above-ground installations and pipelines	1.9 – 2.2
Total investments per well (million euro)	***14.1 - 15.3***

[99] House of Lords (2013) The Economic Impact on UK Energy Policy of Shale Gas and Oil, Meeting 5 November 2013, quote Francis Egan, CEO of Cuadrilla
[100] EBN (2013) Conceptueel veldontwikkelingsplan schaliegaswinning in Noord-Brabant

Annual operational expenses per well	Euro
Operational costs	180.000 – 300.000
Decommisioning costs	15.000 - 21.000
Total operational and decommissioning costs per well per year (million euro)	***195.000 - 321.000***

5.1.3 Is there a business case for shale gas production in the Netherlands?

According to EBN calculations, using the production costs and assumed revenues as indicated in Figure 5-2, the pay-back time for investments in Noord-Brabant will be 18 years at the current gas price of 10$/MMBtu (0,26 euro/bcm). However, there are many uncertainties in this.

Some crucial uncertain factors are:

- Will exploratory drilling confirm the high revenues that are now assumed? Compared to other European sources, the assumptions made seem rather optimistic.
- Will there be NGLs associated with the shale gas found in Noord-Brabant? Cuadrilla expects that the shale gas in Noord-Brabant will be of similar content as compared to conventional gas in Groningen (no NGLs)[101]. If this holds true, no additional revenues could be created by selling NGLs to the chemical industry at oil-based prices.
- How fast can the currently very high estimates of drilling costs be reduced by learning effects?
- What will the gas price development in Europe be? Two out of three IEA scenarios assume an increase of gas prices in Europe until 2035, but the IEA 450 scenario, with strict climate policies, assumes decreasing prices.
- Will Dutch government introduce supportive instruments to improve the regulatory or fiscal conditions for shale gas, such as has been done in the UK?

Therefore, a positive business case for shale gas production in the Netherlands is far from certain. It depends on many, very uncertain factors that can have either a positive or a negative effect on the economics of production. One of the most important issue is to determine the exact amount and quality of the shale gas resources in the Netherlands, and the only way to get more certainty on this is via exploratory drilling.

5.2 Societal Benefits

A political decision on allowing shale gas production in the Netherlands will need to take the balance of benefits and costs to society as a whole into account. The following two sections examine the most important benefits and costs to the Netherlands society.

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[101] Petrochem (2013) Vermoedelijk enkel methaan in schaliegas Brabant

5.2.1 *Gas and the Dutch treasury*

The Dutch treasury benefits from the production of natural gas. Currently these benefits amount to a figure of around 15 billion per year. As the state participates as a 40% shareholder in the gas concessions, 40% of both the costs and benefits of gas production accrue to the state. The remaining 30% is received via corporate taxes and dividends. This implies that for every euro that is earned from the production of gas, about 70% flows directly to the Dutch treasury; the remaining 30% is earned by the NAM[102]. Within the last decade, the share of natural gas revenues in the total Dutch public budget has varied between five to ten percent (see Figure 4.1). This resulted into a total sum of 14.5 billion euro in 2012[103], or 850 euro per capita. Hence, over the last decade the Dutch treasury has made substantial gains as a rsult of the gas price hike.

Natural gas revenues are largely determined by the production of natural gas, the price of gas on wholesale markets (e.g. TTF, Zeebrugge, NBP) and the exchange rate. Previously, Dutch gas revenues also depended on oil prices (due to oil-indexation of gas contracts), but for new production oil-indexation is no longer relevant. As can been seen from Figure 4-1, during the last couple of years state revenues derived from the production natural gas have increased substantially. This can be mainly attributed to relatively higher gas prices in these years.

In addition, the gas industry provides over 16.000 direct and 10.000 indirect jobs[104]. Natural gas fulfils 42% of total primary energy demand in the Netherlands in 2012[105]. About 60% of electricity is generated from gas and 98% of Dutch households use gas to heat their homes and cook their meals. Compared to other European countries, only Luxemburg has a higher gas demand per capita.

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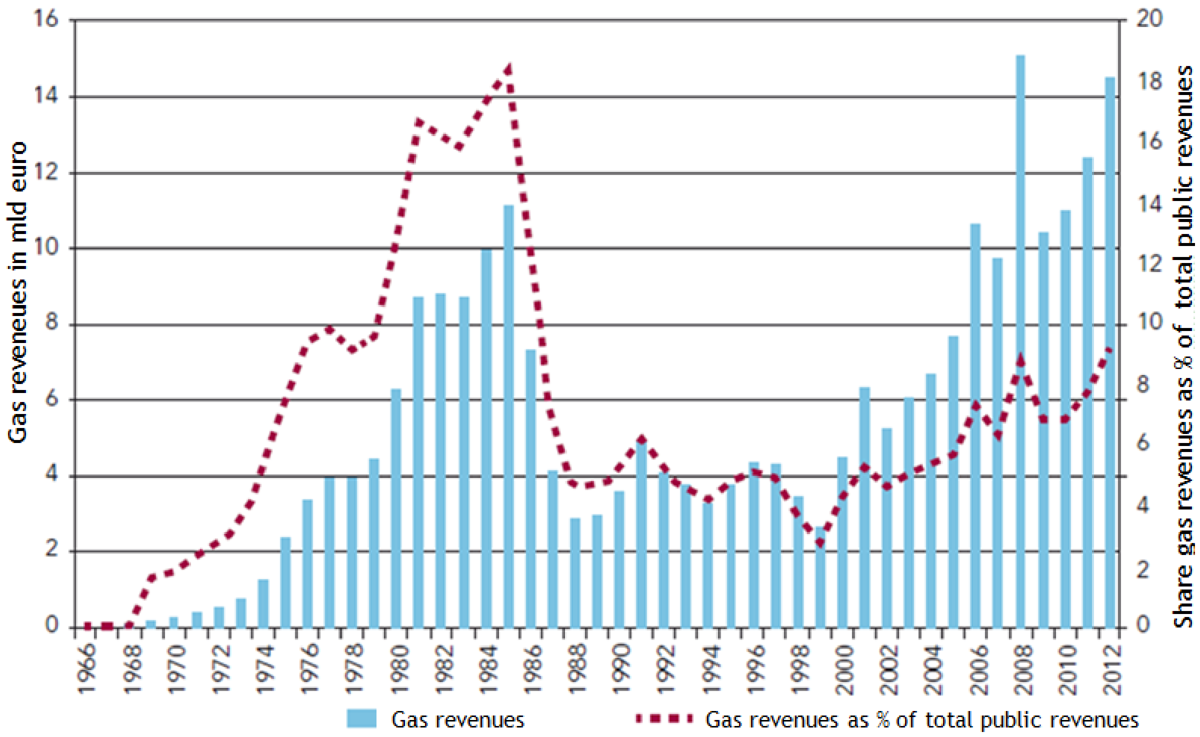
[102] EBN (2013) Conceptueel veldontwikkelingsplan schaliegaswinning in Noord-Brabant

[103] Rijksoverheid (2013) Miljoenennota 2014

[104] NOPEGA (2011). Achtergrond schaliegas in Nederland (bijlagen)

[105] Aardgas in Nederland (2013). Aardgas en de economie

Figure 5-2: Absolute natural gas state revenues in the Netherlands, relative to public budget[106]



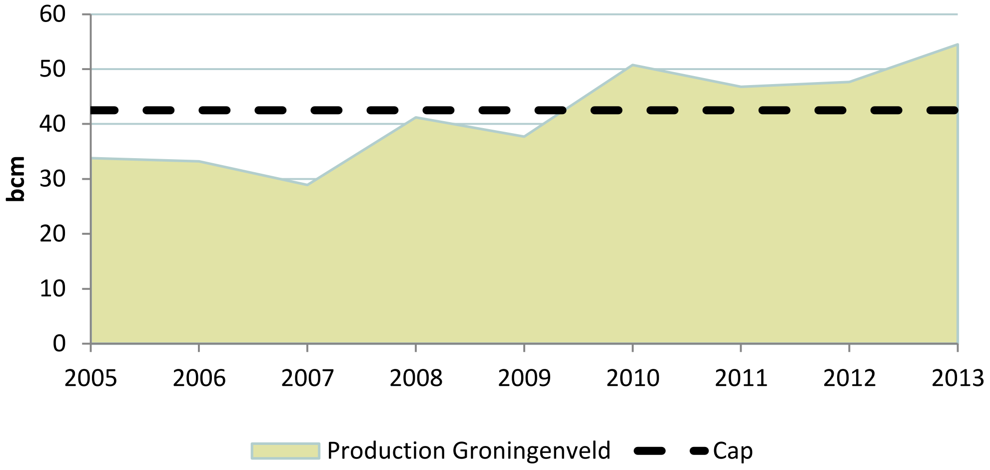
The Netherlands currently has 1.100 bcm of conventional gas reserves remaining (Groningen field ~700 bcm and 'small fields' ~ 400 bcm[107]). Based on an average indigenous gas demand of 45 bcm, current conventional gas reserves could meet demand for an additional 25 years. When export contracts are taken into account, the Groningen field can sustain its balancing function up to 2020. From 2020 – 2025 onwards, the Netherlands loses its role as exporter of natural gas and needs to import gas to meet future domestic gas demands.

5.2.2 *Shale gas and the Dutch treasury*

If shale gas was to be commercially exploited in the Netherlands, this could possibly extend the balance function of the Groningen field[108]. However, it is unlikely that shale gas production in the Netherlands could start before 2020. The Dutch government agreed in 2005 that no more than 425 bcm of natural gas should be extracted from the Groningen field in ten years' time. This translates to putting a cap in place for 42,5 bcm per annum. Since 2010 production levels from the Groningen field have exceeded this cap as can be seen in figure 5.3.

[106] CBS, Min. EZ, 2013.
[107] NLOG (2013) ; EZ (2013). Delfstoffen en aardwarmte in Nederland: Jaarverslag 2012; TEC calculations
[108] Rijksoverheid (2013) 'Gaswinning en gasinfrastructuur: Gas exploratie en gasproductie'.

Figure 5-3: Annual production levels Groningen field [109]



To calculate the effects on the longevity of the Groningen field estimates on technical shale gas resources are needed. Currently both the U.S. Energy Information Agency and TNO have reported resource estimates for shale gas in the Netherlands. The EIA estimates that the Netherlands currently holds 735 bcm of shale gas resources; TNO estimated a lower range of 200 – 500 bcm. This report uses the numbers of TNO, as the EIA figure lack their detailed geological underpinning[110]. Based on the TNO estimates for shale gas resources in the Netherlands, together with current gas price of 0,26 euro / cm[111], potential state benefits are significant. EBN participates as a 40% shareholder in the concessions of Cuadrilla Brabant[112]. Assuming that 70% benefits directly go to the state treasury, this amounts to a total figure of 14 to 17 billion euro. These figures should however be interpreted with great care. There is still much uncertainty concerning the accuracy of the technical resources figures, since no exploratory drills have yet been sunk. In addition to this, a gap exists between technical resources and economic reserves (see explanation paragraph 2.2). In the EBN Noord-Brabant case, annual state benefits are stated to amount to between 0,5 and 0,7 billion euro per operational year.

5.2.3 *Shale gas and job creation*

The economic contribution, in terms of jobs, from upstream shale gas activity in the US is currently 600.000 jobs (127.000 direct, 186.00 indirect, 292.000 induced). The British IoD assumes that every million euro of capital and operational expenses leads to the creation of 17 jobs (direct + indirect + induced) in the shale gas industry[113]. This rule of thumb is based on the situation in the North Sea, where 20 billion euro of capital and operational expenses supports 339.000 jobs[114]. This also reflects

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[109] NLOG (2013) Productiedata
[110] TNO (2013) bijdrage hoorzitting schaliegas, 19 september 2013,
[111] European Commission, DG Energy (2013) Quarterly Report on European Gas Markets, Vol 6, Issue 2, 2nd Quarter 2013
[112] Cuadrilla has concession agreements in different areas in the Netherlands, including North Brabant and the “Noordoostpolder” region, and pending applications for “De Kempen” (in the provinces Limburg, North Brabant and Zeeland) and “Breda-Maas” (in the provinces North Brabant and Limburg). Plans have been submitted for exploration drillings in the municipalities of Boxtel, Noordoostpolder and Haaren. It remains uncertain whether the permits for actual drilling in these three municipalities will be granted to the company.
[113] IoD (2013) Getting Shale Gas Working
[114] Oil & Gas UK (2013) Economic Report 2012

the situation in the US, where, according to the models developed by HIS, each $1 million of capital expenditure in the oil and gas sector leads to the creation of 19 jobs[115].

When we apply this rule of thumb to the potential shale gas production figures in the Netherlands - which amount to a total capital and operational expenditure of approximately 7.3 billion euros over 15 years[116] – a total of 8.000 additional jobs (direct + indirect + induced) could be created. It should however be noted that jobs created for the development of shale gas might be different from offshore, as the onshore gas industry is not as labour intensive as the offshore gas industry. The logistics onshore are more straightforward and efficient and integrated teams can look after a large number of wells.

Focusing solely on the Noord-Brabant business case developed by the EBN, the following approximate figures might give a more accurate picture. Drilling 10 wells a year involves at least two rigs, with two shifts, which approximately means 100-150 site jobs and another 300 associated jobs. Managing on average 200 producing wells at any time and up to 40 stretches of pipeline will involve 200-250 jobs. Managing the production plant will involve another 100 jobs. Employment during the construction phase will be much higher. In totalthese figures would add up to some 1000 direct jobs for this case – much lower than the above assumptions.

5.2.4 *Benefits for local communities*

The UK Onshore Operators' Group proposed benefits for local communities of £100,000 per drilling / fracked well site during the exploration/appraisal stage where hydraulic fracturing takes place, and a share of proceeds at production stage of 1% of revenues – potentially up to 10 million pounds, allocated approximately 2/3rd to the local community and 1/3rd at the county level. A similar scheme could be proposed for the Netherlands. Currently there is an ongoing debate as to whether the NAM should release extra funds to compensate inhabitants of the North-Eastern part of Groningen due to the damage done by the increased seismicity due to conventional gas production. The commission Wijers recently released a report in which they propose a share of 1% of production stage proceeds[117]. They refer to the proposed benefits by the UK Onshore Operators' Group, but falsely claim that the British government already has this regulation in place. Nevertheless, Cuadrilla Brabant has indicated they would be open to discuss such a proposal[118].

5.3 Societal costs

Apart from potential societal benefits, there are also many potential societal costs that have to be taken into account when taking a policy decision about shale gas production in the Netherlands. These include in particular additional costs of mitigating risks, greenhouse gas emissions and air quality, water usage, land use and potential disruption of local citizens.

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[115] IHS (2013), America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy, Volume 1: National Economic Contributions

[116] EBN (2013)

[117] Commissie Wijers (2013) Vertrouwen in een duurzame toekomst: Een stevig perspectief voor Noord-Oost Groningen

[118] Petrochem (2013) Cuadrilla: Vermoedelijk enkel methaan in schaliegas

5.3.1 Additional costs of mitigating risks in the Netherlands

Shale gas production is different from conventional gas production. Additional expenses are needed to mitigate the different risks. Since environmental regulation differs per country, these expenses also vary per country.

Witteveen and Bos (2013) identified the following additional risks for shale gas production[119]:

- Increased risk of (ground)water and soil contamination due to the use of additional chemicals needed for hydraulic fracking;
- Increased external safety risk due to the fact that more drilling sites are needed compared to conventional gas productions. This results in higher policing costs. In the UK, it has been reported that the cost of policing the protests at Cuadrilla's drilling site at Balcombe are about 6 million dollars[120].
- Higher carbon dioxide emissions.

It is also stated that compared to conventional gas, there is a lower risk for shale gas of seismicity induced by hydraulic fracturing. Although hydraulic fracking can induce seismicity, the magnitude of these instances is reported to be lower.

All together, the extra costs that are needed to limit these risks of shale gas are estimated to amount to 1 to 2 million euro[121] (Figure 5.4). The costs associated with regulation and incident response management are not taken into account.

Figure 5-4: Indication of the extra costs to limit the additional risks of shale gas production (per well)

Action	Costs (million euro)
Policing	1,0
Water treatment	0,05 - 0,95
Decommisioning of well	0,05 - 0,08
Regulation	Not included
Incident response management	Not included

5.3.2 Greenhouse gasses and air quality

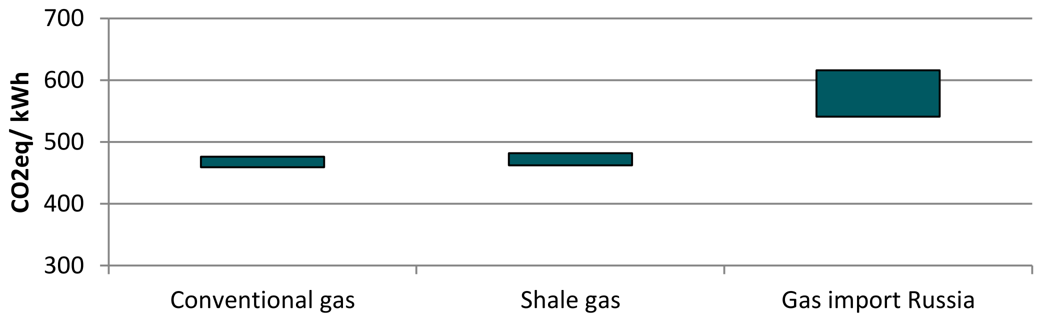
In 2012 the University of Utrecht, in collabation with EBN, performed an LCA to map the GHG emissions of shale gas compared with conventional fossil fuels and renewable energy sources (Figure 5.5). This research was complemented a year later when Royal HaskoningDHV released their climate footprint analyis of Dutch shale gas production [122]. Additional sensitivity analyses were performed to compare the climate footprint of conventional gas and shale gas production in the Netherlands.

[119] Witteveen en Bos (2013) Aanvullend onderzoek naar mogelijke risico's en gevolgen van de opsporing en winning van schalie- en steenkoolgas in Nederland, Eindrapport onderzoeksvragen A en B, p.107
[120] Offshore Energy Today (2013) DW: Offshore Security Is an Expensive Headache
[121] Witteveen en Bos (2013)
[122] Royal HaskoningDHV (2013) Klimaatafdruk van schaliegas; Louwen (2012) Comparison of Life Cycle Greenhouse Gas Emissions of Shale Gas with Conventional Fuels and Renewable Alternatives

The results showed that, based on the assumed production profiles, the climate footprint of shale gas compared to conventional gas is on average 1% higher. The earlier study performed by the University of Utrecht and EBN concluded that the GHG emissions of shale gas are about 4.4% higher, at 485 gCO_2-eq/kWh compared to conventional gas at 465 gCO_2-eq/kWh. The difference is mainly explained by higher well costs (+0,85 gCO_2eq/kWh). Shale gas wells are less productive than conventional gas, and shale wells are generally 1,5 times longer, as they extend not only vertically but also horizontally. This results in more energy and material usage during the production process. These findings are also offset against the import of Russian gas, which appears to have a 15-30% higher climate footprint due to methane leakage from pipelines.

It is a matter of perspective (e.g. which energy source is the comparison) how the additional greenhouse gasses emitted by potential shale gas production could be judged. In the case of the United States the recent shale gas activities can be seen as a positive development. This is due to the fact fact that coal is being displaced by gas, giving the US the fastest- falling CO_2 emissions of any developed country in the world. Compared to coal, shale gas results in a 400- fold reduction of PM2.5, a 4,000-fold reduction in sulphur dioxide, a 70-fold reduction in nitrous oxides (NOx), and more than a 30-fold reduction in mercury[123]. In Europe, however, due to the maturity and size of the gas market, it is not expected that shale gas woulsd replace coal in the same way it has done in the United States, unless very strict climate policies – with very high ETS prices – are introduced.

Figure 5-5: Comparison of upstream emissions of gas production situations in gCO2-eq/ kWh



5.3.3 *Water*

Water use can be seen as a potential (societal) costs and barrier to the production of shale gas. There are separate issues connected with water use in the production of shale gas:

- Availability of water
- Potential costs of water contamination

Whether the availability of water is an issue depends on the location. Contrary to parts in China and Algeria, water availability in the Netherlands of is not an issue. The Netherlands currently has a groundwater reserve of 500 billion cubic meter and annually consumes about 1,1 billion cubic meters of drinking water. A fractured well site consumes annually about 15.000 to 20.000 cubic meters of

[123] EIA (2009) Modern Shale Gas Development in the United States – A Primer. United States Energy Information Administration.

water[124]. Most of that water can be recovered through water purification; however this process cannot be repeated indefinitely. After some cycles the water is too costly to purify and has to be stored elsewhere. When it is assumed that 15.000 cubic meter of water can be used for up to three wells, about 1,5 million cubic meter of water is required in the Noord-Brabant business case as developed by the EBN. This water footprint would be relatively high compared to the use of a 'tight' gas well which uses 1.000 cubic meters[125], but low when compared to other forms of energy production (e.g. nuclear, coal or biofuels)[126].

Risks of water contamination and their prevention and containment costs are difficult to quantify. What can be said is that shale plays in the Netherlands are located at a depth of 3500 up to 4000 meters. This is considerably deeper than common aquifer layers in the area which lie at 100 – 300 meters. Even considering the possibility of induced fractures, which may penetrate 100 meters vertically, there are still more than 3000 meters of isolation between them[127]. Nevertheless, suitable well and casing requirements need to be implemented to protect groundwater reserves and operators need to prove that casings can cope with any micro-seismic activities[128].

What is therefore perhaps more important, in terms of risk management, is minimizing the risk for surface water contamination. This implies that flowback- / wastewater streams needs to be treated carefully to prevent pollution. Water purification by means of filtration techniques is hereby key. Any wastewater discharge (by underground injection or by dilution to other water steams) needs to be strictly monitored and regulated such that water quality is maintained and guaranteed. Certified companies that can treat wastewater streams should be employed to handle any excess of wastewater that can't be dealt with. Fracture fluids that are spoiled at the surface shouldn't be able to exit the site and penetrate trough the surface. When sites are decommissioned, an important question is how casings will be removed such that water quality is maintained and soil subsidence is prevented.

5.3.4 Land use

With respect to land use EBN estimates that a production site, which includes 6 to 10 wells, occupies an area of 50 x 150m, up to a maximum of 150 x 150 meters. Gas will be transported from each production site via pipelines to a central processing facility. When the economic or technical lifetime of the production site ends, it needs to be decommissioned and the site should be returned to its original condition. For 319 wells, 38 production locations are needed. A total of 0.86 km^2 of land would need to be acquired for this.

[124] Downstream Strategies et al. (2013) Water Resource Reporting and Water Footprint from Marcellus Shale Development in West Virginia and Pennsylvania and Cuadrilla Resources (2013) Waste Management Plan: Anna's Road Exploration Site, Issue 3.3, 9 January 2013

[125] Nogepa (2011) Achtergrond schaliegas in Nederland (bijlagen)

[126] Navigant (2012) and Chesapeake (2012) Water Use in Deep Shale Gas Exploration, Wilson Center (2013) The Thirsty Triangle: The Water Footprint of Energy Trade Between China, Canada, and the United States

[127] Accenture (2012) Water and shale gas development

[128] Vitens (2012) Zorgen schaliegas drinkwaterwinning

5.3.5 *Disruption to local citizens*

Finally, an important, but difficult to quantify, economic cost of shale gas production is the disruption caused to local citizens in the form of noise due to site preparation, drilling and fracking, increased traffic from e.g. trucks, visual impacts or fears about possible impacts like seismic activity, accidents or drinking water pollution. Despite the intangible character of these costs, they are very important in any political decision as they are often closely related to local resistance to shale gas development.

5.4 Conclusion

Shale gas production in the Netherlands will only take place if there is a positive business case for a commercial party that is technically able to carry out the production. Figures available for the Netherlands are limited. Calculations of the Dutch state-owned oil and gas production company EBN suggest a positive business case for shale gas in the province of Noord-Brabant, with a pay-back period of 18 years. However, putting these calculations in perspective and comparing them to other available European and US sources, shows that the assumed drilling costs are in the upper range compared to other European and US locations. This is compensated by assumptions about resources to be found that are also high compared to available figures for other locations. Verification of these assumptions can only be achieved by exploratory drilling.

A political decision about whether or not to allow shale gas production in the Netherlands should take into account the balance of benefits and costs to society as a whole. A fully fledged social cost-benefit analysis was not the aim of this study; however, some of the most important benefits and costs to society have been explored. On the benefits side, substantial direct revenues for the state treasury would be likely to arise, together with job creation and, depending on the details of how production was regulated, potential benefits for local communities. On the cost side, mitigation of various risks, including possible contamination of ground water and safety risks has to be taken into account, as well as additional water use, land use and potential disruption to local citizens.

That exact calculations for a social cost benefit analysis are difficult and will be very sensitive to the assumptions made, as is illustrated by the case of CO_2 emissions. Whereas shale gas production represents limited additional emissions compared to the production of conventional natural gas, the additional emissions are large if shale gas is seen as a substitute for renewable energy sources. On the other hand, if shale gas is regarded as a substitute for coal (like in the United States), the net CO_2 balance of shale gas is positive.

6 Conclusions and Recommendations

The final chapter presents the overall conclusions and recommendations of this study. First, conclusions are given regarding the main research questions posed at the outset of this research project (section 6.1). Based on these conclusions, recommendations to Dutch policy makers are formulated (section 6.2).

The aim of this research project was to examine potential economic effects of international and European shale gas developments on the Netherlands, as well as the potential economic effects of shale gas drilling and exploration in the Netherlands.

Overall, it was found that there are still many uncertainties around these effects. Reliable production cost figures are only available for the United States, where shale gas drilling on a commercial scale is already taking place. In Europe, cost estimates are based on evidence from exploratory drilling in a limited number of places. In the Netherlands, cost figures are even more uncertain, as no exploratory drilling has taken place. This has to be taken into account when reviewing the results of this research project.

Four questions regarding shale gas developments were selected to be examined in more detail in this research project:

I. Impact on gas supply and demand in Europe and the Netherlands
II. Impact on electricity prices and fuel shift
III. Impact on Dutch state revenues and wider societal costs and benefits
IV. Impact on Dutch energy-intensive industries

In this chapter, first conclusions regarding the main research questions are given. After that, based on the findings some general recommendations for Dutch policy makers regarding shale gas are discussed.

6.1 Conclusions

I. Impact on gas supply and demand in Europe and the Netherlands

The impact of international and European shale gas developments on gas supply and demand in Europe and the Netherlands is likely to be very small in the period until 2020, and slowly expanding but still small in the period 2020-2035.

Motivation

Impacts of shale gas on the EU can occur either via import of shale gas as LNG to the EU, or via shale gas production within the EU.

- ***Shale gas exploration is much more expensive in the EU than in the United States in the short and medium term. In Europe, shale gas also has to compete with abundantly available pipeline gas.***

  Whereas drilling costs in the US vary from 3 to 6 mln dollars per well, present figures for the EU indicate costs of 8 – 16 mln dollars per well. The main reason is the much deeper location of the shale gas in most parts of the EU. Likewise, while production costs in the US are typically some 3 – 6 $/MMBtu, in the EU corresponding figures currently available show costs ranging from 5 – 16 $/MMBtu. . In the Netherlands currently available figures for drilling costs indicate a range of 14 to 21 mln dollars per well, and production costs of 5 - 6 $/MMBtu. These figures are approximations only, as experience with shale gas in Europe is limited to some exploratory wells. Whereas drilling costs seem within a logical range, the expected overall production costs in the Netherlands (as expected by EBN) seem to be at an unlikely low level – as they are in the same range as US figures. In addition to this the dominant gas supply to the EU is currently via pipeline from countries like Russia, Norway, Algeria and others. EU shale gas developments have to compete with these readily available resources, of which prices can be readily adapted if competitive considerations make this appropriate

- ***Shale gas exploration in the EU is likely to take off in Poland and the United Kingdom. In many other EU countries, however, shale gas exploration faces public and political resistance.***

  Current shale gas developments in Europe suggest that shale gas exploration will take off first in the United Kingdom and Poland. Outside the EU this might be the case in the Ukraine. Exploratory drilling has led to a downward adaption of estimated resources in Poland, while in the UK resources were adapted upwards after first explorations. Nevertheless, shale gas in the UK will be used first for domestic demand and will therefore not have a major impact on gas supply to mainland Europe. In several other EU countries, public resistance to shale gas drilling exists. This has led to a ban or moratorium on further shale gas developments in France and Bulgaria.

- ***Shale gas import as LNG to the EU will be limited until 2020, due to limited export capacities in the US. From 2020-2035 this will probably no longer be a limiting factor.***

  Until 2020, shale gas imports to the EU could come predominantly from the United States. Export of shale gas as LNG from the US to the EU will only be technically and administratively possible from 2016 onwards at the earliest, when LNG liquefaction capacity in the US will become available. The current limiting factor is a lack of LNG export capacity in the US (4 terminals with 65 bcm have received conditional approvals so far, equalling at maximum 5% of EU demand). Many additional LNG terminals are planned in the US, and these are expected to come online after 2020, thereby resolving export and import bottlenecks.

- ***There is a positive business case for LNG exports from the United States to the EU, but the business case for exports from the US to Japan is better over the whole period until 2035.***

  Although a positive business case of up to 3$/MMbtu for US-EU LNG exports is calculated until 2035, in all scenarios the business case for export to Japan is calculated to be better (up to 5 $/MMBtu). Hence, spot market based allocation of LNG would lead to the majority of available production going to Japan rather than to the EU.

II. Impact on electricity prices and fuel shift

> Shale gas will probably not lead to a similar shift from coal to gas in the electricity sector in Europe as in the United States. Such a shift in the EU could rather be induced by high ETS prices.

Motivation

- ***Shale gas developments in the United States have contributed to a shift from coal to gas in the United States electricity sector and from gas to coal in the EU electricity sector.***
  In the last three years, the reduction of gas prices in the United States as a result of the shale gas boom there has led to a replacement of coal by gas in the US electricity sector. Coal reserves that became redundant in the United States were partly exported to the EU, which has led to decreasing coal prices in the EU and a replacement of gas by coal in the EU electricity sector. Over the longer term however, coal import prices to the EU have not decreased, neither has overall coal import to the EU increased. Therefore, the exact contribution of US shale gas developments to the gas-coal fuel shift in EU electricity supply is not proven. Instead, higher European gas prices (due to lack of supply boom and oil-indexed-contracts) together with historically low EU ETS prices are more likely to have contributed to the gas-to-coal shift within Europe.

- ***Price projections of gas and coal in Europe do not suggest that in the future shale gas in Europe will lead to a similar shift from gas to coal in the electricity sector as in the United States. Rather, high ETS prices might induce such a shift.***
  Examination of IEA coal and gas price scenarios for the EU shows that until 2035 the price ratio of coal-to-gas in the EU does not comes near to the ratio which induced the recent coal-to-gas switch in the US in any of the scenarios. . However, w if the projected ETS prices in the three scenarios are taken into account , in two out of three scenarios a coal-to-gas shift in the EU would be induced somewhere between 2020 and 2030.

III. Impact on Dutch state revenues

> Shale gas exploration in the Netherlands could lead to substantial state revenues and societal benefits. However, these potential revenues and benefits are still very imprecise and have to be balanced carefully against potential societal and environmental costs.

Motivation

- ***Various potential societal benefits and costs have to be taken into account when considering shale gas development in the Netherlands.***
  Potential benefits of shale gas development in the Netherlands consist of state revenues of up to 11 billion euros, some 8.000 direct and indirect related jobs and an expansion of the Dutch gas reserves by up to 11 years. This has to be weighed against various potential

societal and environmental costs, such as additional CO_2 costs, water extraction costs and land use costs - as well as costs related to societal resistance, possible financial compensation and delayed transition to a low-carbon energy sector. The insecurity in local communities on real or perceived risks related to shale gas extraction, and the real or perceived environmental risks are difficult to weigh in just an economic way and therefore require a well-motivated political decision. Furthermore, if large-scale shale gas production leads to lower overall gas prices, it has to be taken into account that these would have a longer term counteractive effect on the initially increased revenues from domestic shale gas.

- ***A more exact figure regarding potential revenues can only be obtained via exploratory drilling.***
  Present figures around revenues are still very imprecise. There are particular, uncertainties over whether or not there are NGLs associated with the shale gas, as these might have an important impact on the economics of shale gas exploration in the Netherlands. Further information about whether or not NGLs are associated with shale gas in the Netherlands can only be obtained through exploratory drilling. This can also give better indications about flow rates and energy content of the gas, which are also important for the revenue. In this way, a more informed decision could be taken about whether or not to allow commercial shale gas production in the Netherlands.

IV. Impact on Dutch energy-intensive industries

Shale gas developments in the United States negatively affect the competitive position of energy-intensive industry in the EU. This is particularly true for the chemical industry, where shale gas can not only be used fuel but also feedstock. However, addressing shale gas effects only would not solve the wider structural problems of EU energy-intensive industry, which are caused by wider world market developments.

Motivation

- ***A deteriorating gas price ratio with the United States has led to comparative disadvantages for energy-intensive industry in the EU competing with the US. This holds in particular for the chemical industry, where shale gas can also serve as a feedstock.***
  Whereas five years ago US and EU gas prices where on a similar level, current gas prices in the EU are some three times higher than those in the US. This gives significant comparative disadvantages to US energy-intensive industries such as steel, aluminium and the chemical industry where energy prices can make up more than half of the total production costs. For the chemical industry, comparative disadvantages are even larger due to the fact that shale gas can also serve as a feedstock. As a result, overall ethylene production costs in the EU are now 2,5 times higher than in the United States. IEA future scenarios suggest that the gas prices between the US and EU will partially converge again, relieving part of the present comparative disadvantages.

- ***Gas prices are only one of the comparative disadvantages currently faced by EU energy-intensive industries.***
  Policy measures influencing the gas price ratio between US and EU, cannot resolve the wider structural problems of EU energy-intensive industries. Other important factors to be considered are the impact of the EU ETS, the wider consequences of global demographic changes and demand shifts that are leading to relocation of production growth to non-OECD countries.

6.2 Recommendations

Independent of the decision to allow for drilling for shale gas in the Netherlands itself, the country will be affected by international shale gas developments. Although a similar shale gas boom in Europe as in the United States is most probably not going to take place, an open eye of policy makers for international gas developments, including shale gas, is required. The Dutch government can exert influence on such international (shale) gas developments primarily via the European institutions.

Apart from that, the Dutch government needs to take a sovereign national decision on whether or not to allow shale gas exploration and production in the Netherlands. Such a decision can only be taken in the wider context of energy and socio-economic policies, including considerations about longer-term energy transition and green growth strategies. A more informed decision could also require closely monitoring global and European shale gas developments over the coming three to five years before taking a decision.

Some main recommendations for the Dutch government in this respect are:

1. Allow for (limited) exploratory drilling for shale gas in the Netherlands.
Only exploratory drilling can give an accurate picture of the economics of shale gas production in the Netherlands, which not only serves to get an idea of a possible commercial business case, but also of potential state revenues. Exploratory drilling and commercial production should be seen as separate activities, for which separate permitting decisions can be taken (as has been done in Germany recently, where commercial production was prohibited but scientific research and exploration not).

2. Implement and actively support the European's Recommendation of January 2014 on conditions for environmentally sound shale gas production.
Dutch support for the EU Recommendation could help to create an environmentally sound level playing field for shale gas production within Europe – independent of a decision on shale gas exploration or production in the Netherlands.

3. Develop more detailed scenarios on the fit between a possible 'Dutch Gas Roundabout' and an energy transition to a low carbon economy.
The plans on developing a Dutch Gas Roundabout seem not yet fully integrated with those of a transition to a low carbon economy as envisaged e.g. in the 'SER energieakkoord' of 2013. With or without shale gas, social and economic consequences of gas and other fossil fuels being gradually replaced by non-fossil fuels, or being supplemented by carbon capture and storage activities, should be examined more carefully.

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