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SELECTED IMPLICATIONS OF SHALE GAS EXTRACTION IN EUROPE

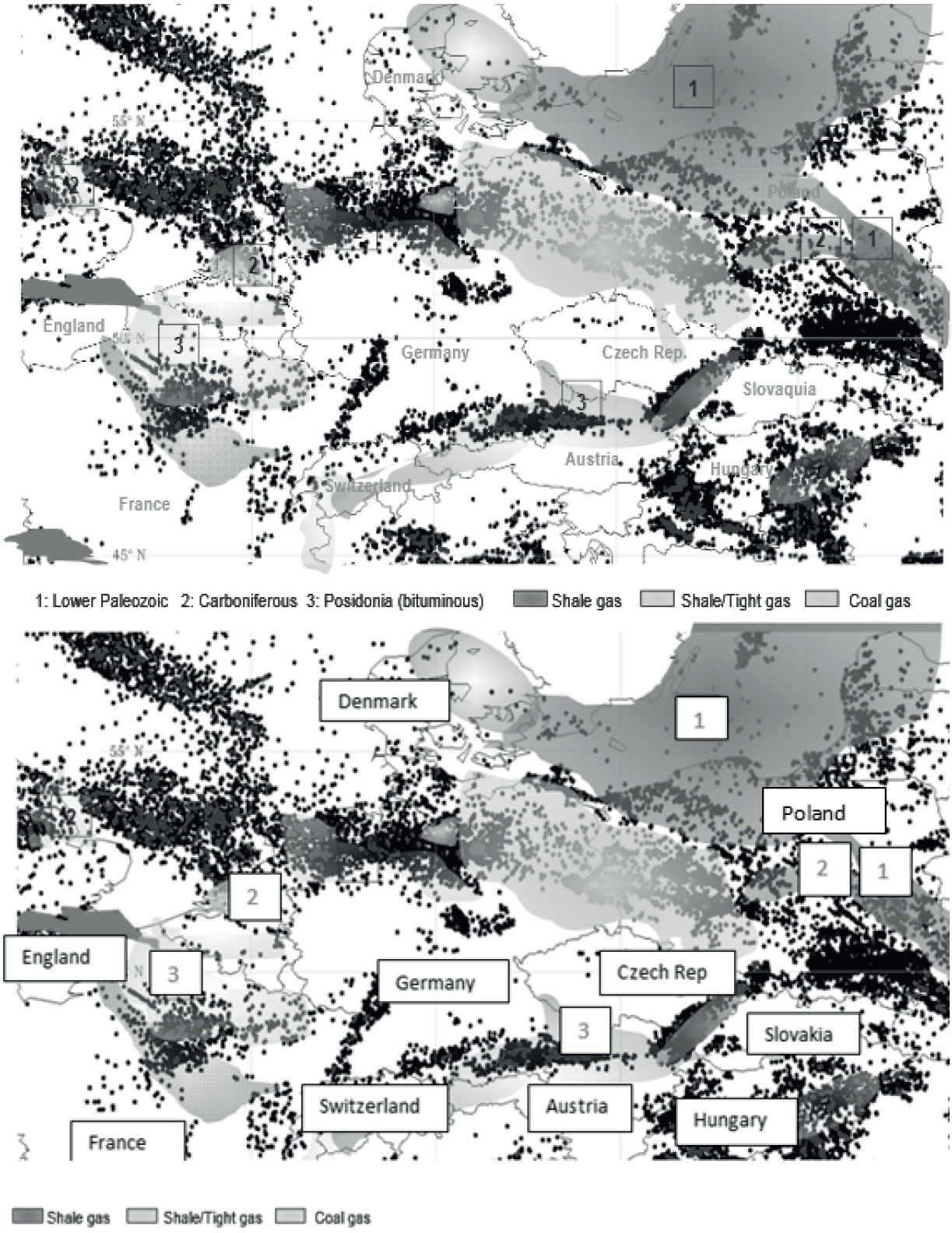
Distribution of unconventional gas in Europe

The distribution of unconventional gas resources in Europe is uneven. As outlined in Figure 1, there are three major basins in Europe: the Lower Paleozoic play (reaching from the east of Denmark down to Gdansk), the Carboniferous marine basin (spreading from North West England through Germany to western Poland), and the Lower Jurassic basin (south of England, France, the Netherlands, Lower Saxony and Switzerland[1]). This means that not all European countries have unconventional gas potential. According to the IHS Cambridge Energy Research Associates (IHS CERA) report 'Gas from Shale – Potential outside North America?', the biggest basins of recoverable shale gas resources are located in Germany and the Netherlands followed by the northern German-Polish, French and the Anglo-Dutch basins, which are in line with the geographical estimations[2].

[1] F. Geny, *Can European Gas Be a Game Changer in European Gas Markets?*, The Oxford Institute for Energy Studies, December 2010, p. 48–54.

[2] L. Smith, *Gas from Shale: Potential Outside North America?*, IHS CERA, February 2009, p. 1–5.

Figure 1. Map of unconventional deposits in Europe



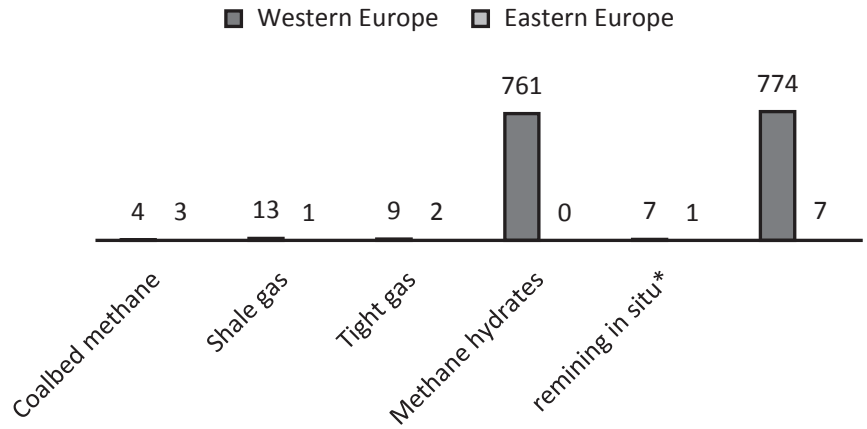
1: Lower Paleozoic 2: Carboniferous 3: Posidonia (bituminous) – Green dots symbolise active wells.
Source: Oxford Institute For Energy Studies (IHS EDIN-GIS May 2010, Schlumberger 2009), p. 49.

Resource estimations

There is a degree of uncertainty regarding the amount of recoverable shale gas resources in Europe, as different methodologies have been applied to measure it. The Join Research Centre, the European Commission's research body, approximate that for geological estimation of unconventional gas sources there is between 15 and 40 per cent of uncertainty of whether the sources are recoverable. There is also a difference between technically recoverable and economically recoverable resources. For instance, KPMG[3] estimates that there are substantial resources of shale gas in Eastern Europe, however, it points out that that there are different geological settings in different gas formations. In addition, shale gas resources in Europe are located 1.5 times deeper than those in the US[4]. Lack of precise data about the availability of unconventional gas in Europe is one of the main challenges for European operators.

In 1997 H. H. Rogner estimated that Central, Eastern and Western Europe combined have 14 gigatonnes of oil equivalent (Gtoe) of shale gas (Figure 2). In comparison, according to the same estimations, the US have 7 times more shale gas resources than Europe. Rogner's work was one of the first comprehensive estimations of shale gas resources worldwide and the best international study available at the time; however, his methodology is not perfect. While all available data was used in the study, the remaining gaps were filled with estimates[5].

Figure 2. Estimates of unconventional natural gas in place by type, unconventional gas in Gtoe



[3] *Central and Eastern European Shale Gas Outlook*, KPMG, Global Energy Institute, 2012, p. 9–18.

[4] F. Geny, op.cit.

[5] J. Williams, L. Field, L. Ericson, *The impact of Unconventional Gas on Europe: A report to Ofgem*, Pöyry, June 2011, p. 28–34.

Since H.H. Rogner, there have been several attempts to estimate resources, including attempts made by the IEA, the Energy Information Administration (EIA), IHS CERA, Wood Mackenzie, Cedigas and scholars.

For example, to illustrate differences in shale gas estimations, the EIA's 'World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States' estimates that there are around 17 trillion cubic meters[6] (tcm) of recoverable unconventional gas resources in Europe, with Poland having the highest amount of shale gas resources[7]. IHS CERA estimates that there could be between 3 and 11.9 trillion cubic meters[8] of recoverable shale gas reserves in Europe.

Shale gas exploration in Europe is still at a very early stage and the industry still needs to determine the real geological potential of this resource. The European Commission acknowledges that there is uncertainty as to what is the precise volume of technically recoverable shale gas, however its potential could be at a level of 16 trillion cubic meters (tcm)[9].

To conclude, studies acknowledge that there is a considerable shale gas potential in Europe; however, there is a degree of uncertainty as to how much recoverable resources are available. Methodology of calculating shale gas potential depends on several factors, including geological, social, environmental and economic challenges, which are further described in this paper.

Factors influencing shale gas prospects

There are several factors which could potentially influence prospects of shale gas in Europe.

Among other factors, the IEA[10] mentions public concerns regarding the environmental and social impact of shale gas as an obstacle for its development in Europe. Indeed, shale gas has caused a certain degree of social unrest among local communities affected (or that potentially might be affected) by exploration activities. The most recent protest took place in the UK in January 2014, following the announce-

[6] Original estimation outlined in the paper is 624 trillion cubic feet (tcf) and has been converted into cubic meters.

[7] Energy Information Administration, *World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States*, April 2011, p. 15.

[8] Original estimation: 106 and 423 trillion cubic feet (tcf).

[9] *Communication from the Commission and the Council and the European Parliament on unconventional hydrocarbons*, European Commission, 2014, p. 4.

[10] *2012 World Energy Outlook*, International Energy Agency, p. 142.

ment of investment of 29 million pounds by French oil and gas company Total into shale gas[11] activities in the UK.

Environmental concerns related to the use of hydraulic fracturing[12] and horizontal drilling have been one of the issues debated both on national and European level. In fact, several countries, including France, Germany and Bulgaria have banned hydraulic fracturing. In addition, the fact that in Europe landowners have a very limited right to the resources in comparison to the US is not contributing to gaining more social acceptance on the issue.

Although EU Member States have each individually adopted a set of mining, geological and environmental regulations which apply to shale gas exploration and exploitation, there is no single EU law which regulates this issue. In fact, in the past years the European Commission has looked into the environmental impact of shale gas and in January 2014, it published 'Recommendations providing minimum principles for the exploration and production of hydrocarbons'. The recommendations tackle, inter alia, regulatory issues related to exploration and production, provide guidance on monitoring requirements and outline procedures regarding inspections and sanctions. Although it is a non-binding document, after the evaluation of the impact of Commission recommendations planned for 2015, it might lead to more stringent laws[13].

Legal policy frameworks which are not supportive of shale gas, will increase cost and limit the number of drilling locations. IHS CERA model shows that lack of supportive policy framework will increase production cost and might push the industry into a position where the development of shale gas will no longer be profitable. For instance, the lack of such supportive framework in Germany would make shale gas profitable only if the price of gas was higher than 21 euro per megawatt hour (MWh). With favourable policy in place the amount of recoverable gas in Europe could reach 106 billion cubic meters (bcm) per year (in comparison with 61 bcm if such framework is not put in place)[14].

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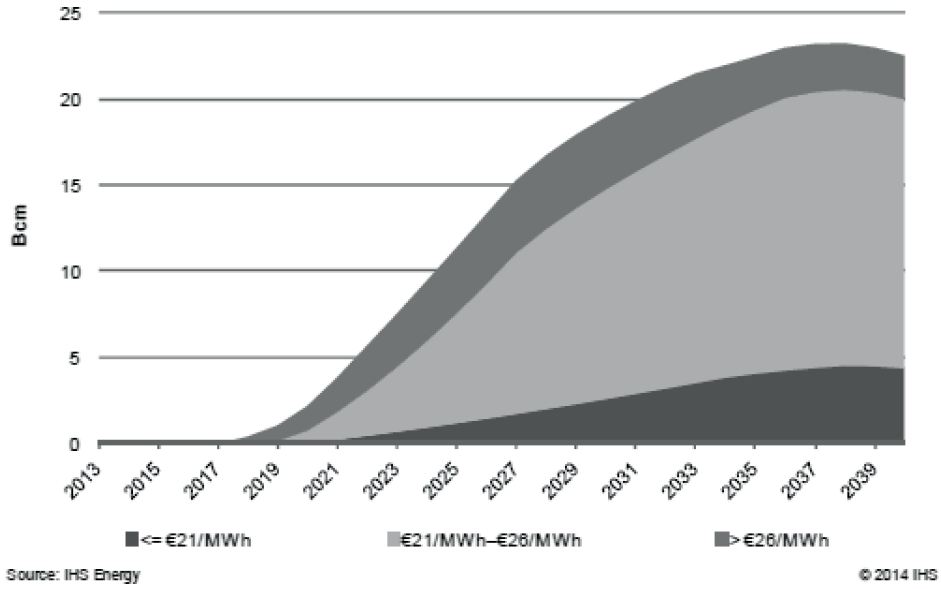
[11] T. Macalister, *Anti-fracking protests fail to halt interest in shale gas*, Reuters, 12 January 2014.

[12] Hydraulic fracturing is a process, which involves pumping a pressurised mixture of water, sand and chemical additives down the wellbore and into the tight rock formations that contain natural gas (source: www.europeunconventionalgas.org).

[13] *Commission Recommendation of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing*, European Commission, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32014H0070:EN:NOT

[14] *A More Competitive Energiewende: Securing Germany's Global Competitiveness in a New Energy World*. IHS CERA, Main Report, p. 47.

Figure 3. Germany resource potential at price levels without supportive policy



Source: *A More Competitive Energiewende: Securing Germany's Global Competitiveness in a New Energy World*, IHS CERA, Main Report, p. 47.

Social and political issues are not the only constrains to shale gas development. Other difficulties include limited access to pipelines, shortage of expertise in the EU with regard to technology, different geological formation compared to that in the US, location of shale gas basins in highly populated areas, water access (hydraulic fracturing needs large amounts of water). Finally, the cost of development of shale gas will also have an impact on its prospects.

The current state of the European gas infrastructure is another potential bottleneck to the development of shale gas as the transmission infrastructure requires significant investments. Moreover, more cross-border gas infrastructure connections need to be further developed, if the production of shale gas reaches level when it could be exported to other countries[15].

Shale gas also affects other issues such as the development of road infrastructure, traffic management, access to water supplies, wastewater treatment and gas storage.

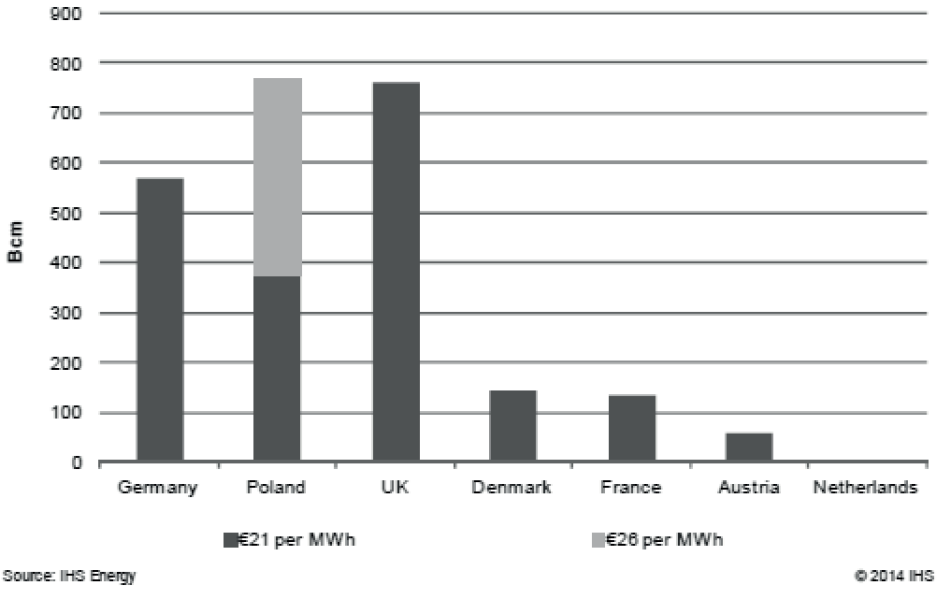
Furthermore, shale gas resources in Europe are located much deeper than those in the US, raising the cost of extraction. For instance, according to A.T. Kearney, the cost of drilling in Germany could reach between 11 and 44 euros per MWh, while in

[15] Considering the regional shale gas estimations, shale gas resources would most likely be consumed within the region where it is produced.

the US the same cost is between 7 and 17 euros per MWh[16]. Pöyry, an international consulting and engineering company, argues that high estimations of extraction costs in Europe do not take into account the "likely economy of scale and technical ingenuity"[17].

Figure 4 (below) outlines IHS CERA's estimation of recoverable shale gas at various price levels in different EU Member States. Assuming that the price will stay above 21 euro per MWh[18], the recoverable potential in seven EU Member States (Germany, France, Poland, the United Kingdom, Austria, the Netherlands, and Denmark), could reach 2,086 bcm[19]. Interestingly, Poland seems to be most price sensitive and if the price reached 21 euro per MWh, Poland could produce as much as 70bcm per year in 2035, a production comparable to current pipeline exports from Norway (100 bcm)[20].

Figure 4. Recoverable resources at price levels



Source: *A More Competitive Energiewende: Securing Germany's Global Competitiveness in a New Energy World*, IHS CERA, Main Report, p. 47.

[16] A.T. Kearney, *New A.T. Kearney Study on Shale Gas Production in Europe*, http://www.atkearney.com.tr/news-media/news-releases/news-release/-/asset_publisher/00OIL7Jc67KL/content/new-a-t-%C2%A0kearney-study-on-shale-gas-production-in-europe.

[17] J. Williams et al., op.cit., p. 34.

[18] The same report estimates that with the price of 26 euro per MWh the recoverable potential could reach 2,494 bcm.

[19] bcm – billion cubic meters.

[20] J. Williams et al., op.cit., p. 47.

Europe is not expected to experience a shale gas boom comparable to the one that has happened in the US. In fact, Europe is not heading the same path as the US and will not be faced with a shale gas revolution, because of a number of factors which disrupt the speed of shale gas development. However, while shale gas is not expected to transform European markets as a whole, it has a potential to influence regional markets and help them in reducing their dependence on gas imports. Such impact will of course not be the same in every European market; however, those EU Member States where shale gas will be produced could potentially benefit from taxes, and increased job market.

Potential benefits of shale gas in Europe

According to the International Association of Oil and Gas Producer (OGP), shale gas can provide a number of economic benefits on the local, regional and national level. OGP lists potential benefits such as lower import costs, employment, and development of supply industry in Europe. It also notes that governments would be able to benefit from royalties and tax revenues on shale gas[21].

A report on 'Macroeconomic effects of European shale gas production', prepared by Pöyry for OGP, outlines that shale gas could contribute to lower gas and wholesale electricity prices. For the purpose of its analysis, Pöyry developed three scenarios: 'No Shale', 'Some Shale' and 'Shale Boom' production levels in the EU. The 'Some Shale Scenario' assumes 15 per cent of shale gas can be technically recoverable. In addition, there are adequate levels of political and public support towards enabling extraction of shale gas resources, however some restrictions are still in place and not all shale gas can be produced. The 'Shale Boom Scenario' assumes around 20 per cent of resources are recoverable and there is a widespread political and public support[22].

The scenarios outline that an average wholesale gas price reduction could be as much as 6 to 14 per cent compared to 'No Shale Scenario'. This may bring from 36 billion to 51 billion euro savings by 2050. Such scenarios could particularly benefit the power sector and development of gas-fired power plants and would reduce production costs for the industry.

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[21] *EU domestic shale gas production could add a million jobs, new study shows*, OGP, http://www.ogp.org.uk/news/press-releases/eu-domestic-shale-gas-production-could-add-a-million-jobs-new-study-shows/.

[22] J. Williams, Ph. Summerton, *Macroeconomic effects of European shale gas production. A report to the International Association of Oil and Gas Producers (OGP)*, Pöyry, November 2013, p. 1.

Pöyry estimates that the average wholesale electricity price could drop by 3 per cent in 'Some Shale Scenario' and 8 per cent in 'Shale Boom Scenario'. This will bring from 28 to 42 billion of savings in 2050. In addition, shale gas could reduce spending on the household level by 8 to 11 per cent in 2050 and it could increase EU28 GDP from 57 to 145 billion euro in 2035 and from 138 to 235 billion euro in 2050. Pöyry believes that lower gas and electricity prices would benefit consumers and would drive overall consumption at the household level[23].

The European Commission Communication on unconventional hydrocarbon outlines only a moderate direct price impact on the regional gas markets in comparison with the US, due to smaller volumes of shale gas in Europe and because prices are calculated to a large extent based on oil-indexed contracts[24].

A study, by Ernst&Young, shows that availability of cheaper gas could lead to replacing the coal generation with gas. However, it also points out that lower gas prices could potentially lead to decreasing investments in renewable energy. Ernst&Young estimates that gas alone will not be able to help reduction of greenhouse gas emissions to be in line with EU targets, hence EU Member States would have to offer heavy incentives in order to attract investments into this technology. In addition, the EU would have to apply legislation which will be protecting the development of renewable energy sources. Ernst&Young also states that the drop in prices of gas in Europe will not be as extensive as in the US[25].

A similar view is supported by the European Renewable Energy Council (EREC), which outlines that shale gas might cause a diversion of investments away from renewable energy. However, EREC also outlines that at the same time, additional gas-fired power could be beneficial from 'an overall system perspective'[26].

The report 'Macroeconomic effects of European shale gas production' showcases a different scenario. It outlines growth in the renewables sector between 2020 and 2035. At the same time it forecasts an increasing gas generation[27] (Figure 5).

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[23] Ibidem, p. 2–41.

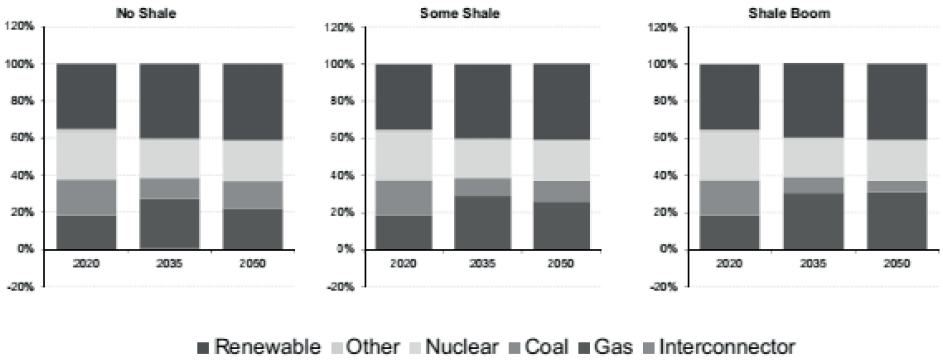
[24] *Communication from the Commission to the council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU*, European Commission, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52014DC0023:EN:NOT.

[25] N. Dale, *Shale gas in Europe: revolution or evolution?*, Ernst&Young, 2013, p. 1–4.

[26] *Shale Gas and its impact on Renewable Energy Sources*, EREC Factsheet, June 2013, p 1–7.

[27] J. Williams, Ph. Summerton, op.cit., p. 38.

Figure 5. EU28 generation mix



Source: J. Williams, Ph. Summerton, *Macroeconomic effects of European shale gas production, A report to the International Association of Oil and Gas Producers (OGP)*, Pöyry, November 2013, p. 38.

European publications also link increasing European competitiveness with the development of shale gas. An interesting example is the impact of shale gas on the chemical industry, which in 2012 generated 558 billion euro revenues. The chemical industry in Europe employs circa 1.1 million people and in 2012 created a trade surplus of 49.5 billion euro, although in 2012 it faced a decline in the overall share of global demand. According to CEFIC[28], the European Chemical Industry Council, shale gas could have a potential beneficial impact on the chemical industry, as 35 per cent of energy used by the petrochemical industry is gas. This industry would therefore benefit from indigenous and less costly gas. CEFIC believes that shale gas could potentially have an impact on petrochemicals and their value chain as well as fertilisers production.

Shale gas could also lead to the development of the oilfield services sector in Europe, which has grown in the US in parallel with the growth of shale gas, and which currently focuses on other regions than Europe, i.e. Middle East. However, as Ernst&Young noticed, there will be only little rush to invest in a new capacity, as long as there is uncertainty about the potential of shale gas. This could require investments into new high-specification equipment such as drilling rigs or pumps. For instance, such support has been provided by BGK Bank to Nafta Piła, which could buy new rigs. E.ON, a German energy company, also notes that European service industry is not as mature as the service industry in the US. Moreover, E.ON estimates that the cost of drilling and simulation could be as much as four times higher in Europe, in comparison to the US[29].

[28] J. Mosquera, *Position Paper: The implications of the shale gas revolution for the European chemical industry*, CEFIC, 15 March 2013, p. 1–10.

[29] A. Korn, *Prospects for unconventional gas in Europe*, 5 February 2010, slide 9.

Shale gas and European import diversification

According to the EIA, natural gas consumption in Europe will be steadily increasing until 2040, making shale gas an attractive option to rising demand.

Around 67 per cent of EU natural gas imports originate from Russia, Norway and North Africa[30]. Central European Countries (CEE) are particularly dependent on gas imports. According to KPMG in 2010, on average 69 per cent of natural gas consumption in the CEE region came from import[31].

This import dependency is predicted to rise in view of declining indigenous production of natural gas in Europe. According to the report on 'Macroeconomic effects of European shale gas production', the EU's dependency on gas from outside Europe could reach as much as 89 per cent between 2020 and 2050, if no shale gas is developed in Europe. Indigenous shale gas could also help Europe to reduce dependency on foreign gas to 62 per cent by 2050, if the 'Shale Boom Scenario' is applied.

The European Commission outlines that shale gas would be able to meet around 10 per cent of the EU's gas demand in 2035, helping to maintain European gas import dependency at a stable level[32]. In particular, it could help with offsetting the declining North Sea production.

The 2014 IHS CERA[33] report estimates that more than 20 billion cubic meters of shale gas production per year is possible in Germany by 2030. Domestic energy production (both conventional and unconventional) could meet more than 35 per cent of today's gas demand[34]. This could modify Germany's import dependence, and stabilise the increasing supply of Russian gas to the country.

Indigenous shale gas production in Europe could also help EU member states negotiate gas prices and gas contracts with Russia. Overall, shale gas could make EU member states less dependent on foreign gas and help counter decreasing gas production in Europe.

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[30] *EU Energy in Figures 2011. EU-27 Energy Import Dependency*, European Commission, p. 22.

[31] *Central and Eastern European Shale Gas Outlook*, op.cit., p. 18–20.

[32] *Communication from the Commission and the Council and the European Parliament on unconventional hydrocarbons*, European Commission, 2014.

[33] R. Wiegert, *A More Competitive Energiewende: Securing Germany's Global Competitiveness in a New Energy World*, IHS CERA, p. 48–52.

[34] Today's consumption level of natural gas in Germany, according to IHS CERA is 10 bcm.

Conclusions

Future prospects of shale gas and its potential economic impact are still to be determined. There are several factors which need to be taken into consideration when estimating potential recoverable resources of shale gas in Europe. The European market is complex and while geological issues play a role in those estimations, in fact, regulatory framework, social acceptance and environmental impact are equally important.

There is a degree of uncertainty around all aspects of shale gas development. Geological estimations are not precise, and moreover, there are several factors such as depth of resources and density of population in Europe. The issue of underdeveloped infrastructure to accommodate shale gas will also play a role in further development of this resource.

The regulatory framework around shale gas will play as important role, as without supportive laws, the costs will rise and the number of available drilling locations will decrease. Moreover, uncertainty regarding how legislators will handle the issue of shale gas may influence investors' confidence and decrease the level of interest among energy companies in the European market.

As long as Europe does not face a shale gas boom, shale gas might have an impact on certain aspects of the European economy. Firstly, it might have an impact on long-term wholesale gas and electricity prices, however the level of impact is not estimated to be high. Secondly, it could stabilise the increasing levels of Europe's dependency on natural gas. Thirdly, it might have an impact on regional markets helping them to give up coal generation and increase the declining national production of gas.

Finally, shale gas could help in development of the oilfield companies in Europe and could boost the chemical sector. It might also have an impact on job creation, however the impact will be minimal and will not be comparable with the situation in the US, where millions of jobs were created due to the development of shale gas resources.

Selected implications of shale gas extraction in Europe

According to the 2011 International Energy Agency data, 60% of natural gas production in the US comes from unconventional sources. Currently in Europe the commercial production of shale gas has not yet been developed. However, the European Commission estimates that conventional production in those countries which have already made some progress could already start as early as 2015. The 2013 A.T. Kearney report outlines that European resources constitute 7% of world resources, but the success of shale gas exploration in Europe will depend on a series of economic, political and geographical factors. This paper analyses the potential impact of the development of the shale gas industry in Europe, particularly recoverable potential of shale gas, its impact on the economy, overall EU energy mix, energy prices and the European job market. In addition, the paper briefly discusses the potential impact of shale gas extraction on gas imports and security of supply.

Keywords: natural gas, shale gas, energy, security of supply, gas import, gas prices

Certaines conséquences de l'extraction de gaz de schiste en Europe

Selon les données de l'Agence internationale de l'énergie de 2011, 60% de la production de gaz naturel aux États-Unis provient de sources non-conventionnelles. Dans un même temps, en Europe, la production de gaz de schiste n'est pas encore développée. Toutefois, la Commission européenne estime que la production conventionnelle de gaz dans les pays qui ont déjà fait des progrès dans ce domaine pourrait commencer en 2015. Le rapport de 2013 par AT Kearney souligne que les ressources européennes constituent 7% des ressources mondiales, mais le succès de l'exploration du gaz de schiste en Europe dépendra d'une série de facteurs économiques, politiques et géographiques. Cet article analyse l'impact potentiel du développement de l'industrie du gaz de schiste en Europe. L'objectif est de montrer l'impact des gaz de schiste sur l'économie européenne, ainsi que son impact potentiel sur le mix énergétique, les prix de l'énergie et le marché du travail. En outre, le document aborde brièvement le problème de l'impact potentiel de l'extraction de gaz de schiste sur les importations et la sécurité d'approvisionnement de gaz.

Mots-clés: le gaz naturel, le gaz de schiste, l'énergie, la sécurité d'approvisionnement, l'importation de gaz, les prix du gaz

Добыча сланцевого газа в Европе – Избранные последствия

По данным Международного энергетического агентства за 2011 год, 60 процентов природного газа в США добывается из нетрадиционных источников. В настоящее время в Европе коммерческая добыча сланцевого газа пока не ведется. Тем не менее, Европейская комиссия считает, что в некоторых странах Европейского Союза она может начаться уже в 2015 году. По мнению A.T. Kearney, европейский сланцевый газ составляет 7 процентов мировых ресурсов, но успех его добычи будет зависеть от ряда экономических, политических и географических факторов. В данной статье анализируется потенциальное воздействие развития отрасли сланцевого газа в Европе, в частности, его влияние на экономику, энергетический баланс ЕС, цены на энергоносители и европейский рынок труда. Кроме того, дано краткое описание потенциального воздействия добычи сланцевого газа на импорт и безопасность поставок газа.

Ключевые слова: природный газ, сланцевый газ, энергетика, безопасность поставок, импорт газа, цены на газ