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Unconventional Means of Oil and Gas Production and Their Influence on International Trade

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Declaration

I hereby declare that I am the sole author of the thesis entitled "Unconventional Means of Oil and Gas Production and Their Influence on International Trade". I duly marked out all quotations. The used literature and sources are stated in the attached list of references.

In Prague on 18.08.2014

_____

Martin Černý

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Most of all, I would like to thank my parents for their endless love, support and encouragement throughout my life. Thank you for being always here for me and believing in me. My younger brother and broader family deserve my thanks as well.

To all my friends, thank you for understanding and supporting me in many ways. I do not have the space to list all names here, but you are always on my mind.

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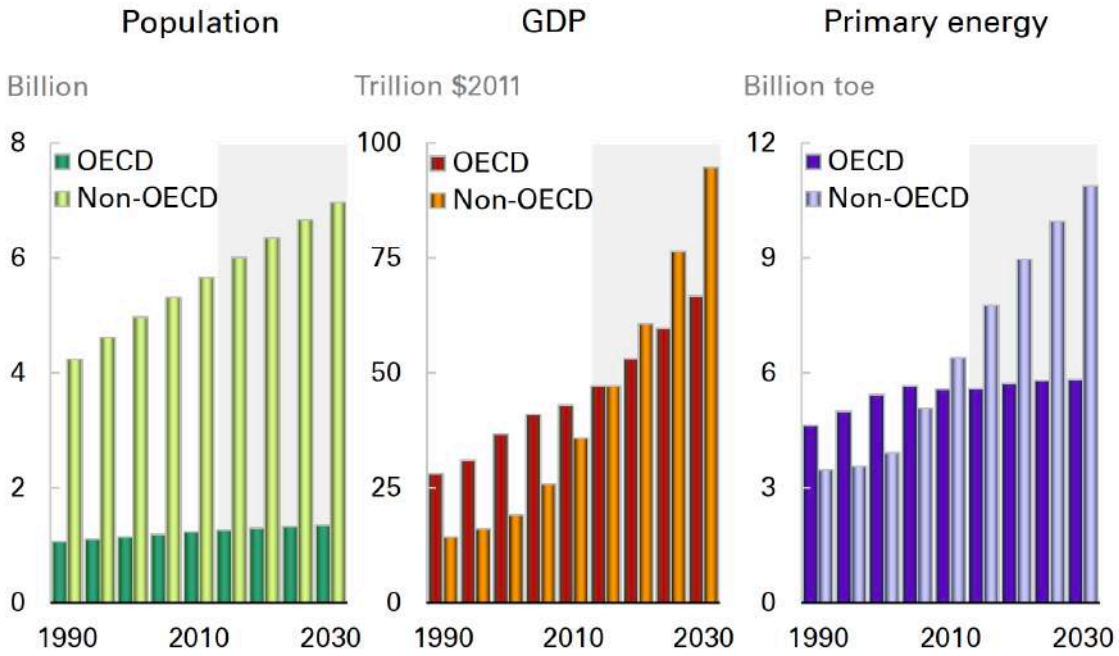
Introduction

The 1990s and the beginning of the new millennium were accompanied by a massive economic growth in developed countries, but more importantly in developing (emerging) markets. Even though the financial and economic crisis of recent years might have slowed down or even put a temporary end to the expansion phase of the world economy, emerging markets continue to grow - at a slower pace. One of the effects of economic growth is also the increase in welfare of the inhabitants. Counting in the radically growing number of people on Earth, one must come to a clear conclusion – mankind will need more resources in order to at least preserve the living standards in developed countries while increasing those in developing. The trends for population, GDP and primary energy production/consumption can be seen in Figure n. 1 bellow.

Figure n. 1: Population, GDP and Primary Energy Production Forecast



Source: BP 2014

Opinions differ however on how to achieve this goal. Some suggest renewable resources to be the solution. Others focus on fossil fuels and particularly on the not very traditional means of oil and gas production, thus called unconventional gas and oil.

The more promising unconventional deposits become, the more the term in publicly available sources appears. Even though mostly mentioned in the connection with North America, the public debate is rising also in Europe. Journalists, economist, government agencies, consulting firms and of course leaders of the industry are publishing analysis on the future of unconventional resources.

After my father introduced me several years ago to the topic I have done extensive research, reviewed pros and cons and analysis both favoring and disagreeing with the use of these new approaches. And I think – if put to use - they may be a game changer for the world economy and will have impact also on international trade and the future of Central Europe. Therefore I made the decision to dedicate my Diploma Thesis to unconventional resources and the impact on the global economy and trade.

Most of analyses available are however focused on one specific area and depending on the source are either in favor or against unconventional resources in general. They do not try to find a balance between both approaches or evaluate both benefits and costs. Most of the time it seemed as if the author adjusted arguments and findings to the desired conclusion. That on the other hand is not as surprising. An environmental protection agency is not going to draft an analysis focusing on the benefits of fracking and a large oil company will not prevalently focus on environmental problems.

The goal of my thesis is therefore not to provide new expert knowledge and estimates – I have neither the means nor the resources to do so, but rather provide a reader who has limited knowledge on the topic with an objective insight, which can be easily read through within a few hours. My goal is to compare, summarize and evaluate facts from various sources and draw an objective conclusion same as provide several of my thoughts on the topic applying knowledge earned during my past five years of studies.

I intend to structure my thesis in three main chapters. The first chapter will open with a brief explanation what actually unconventional resources are, how they

are produced, where they are found and what are the estimates of the reserves. The United States are at time the only evidence of using unconventional resources in praxis in larger amounts. A part of my project will be a typical case study and therefore use descriptive-qualitative approach. I will start from the beginning, describe the evolution of this industry, mention benefits and costs and evaluate the impact on the U.S. economy as a whole. I believe that the most objective sources are international and government agencies in this case, such as the U.S. Energy Information Administration (EIA), International Energy Agency (IEA) and for macroeconomic data the International Monetary Fund (IMF). The EIA and IEA usually provide studies and estimates on an annual basis only and therefore various news websites such as Bloomberg, The Wall Street Journal, CNN and others may be used along with regional media and newspapers. Occasionally also analysis from industry leaders such as Exxon or BP may appear.

The second chapter will evaluate the situation outside the U.S. Especially Europe is deciding what prevails – benefits or costs. I will summarize arguments in favor and against from the point of view of the European Union and try to draw a conclusion. A similar, but shorter analysis will follow for China and Canada. Since different countries within the EU follow different strategies, several will be mentioned also separately along with other countries of the world, which may play a role in the future. I intend to use a meta-analysis comparing both costs and benefits. My sources will be very much similar to the first chapter in addition with materials from the European Commission and occasionally consulting firms. For statistical purposes will serve data either from IMF or the Eurostat.

The last chapter will focus on the impact in the global economy and international trade. I will identify possible future trade routes and discuss possibilities and limitations of them. New resources will usually have an impact on current producers and this is the case of unconventional resources as well – analyzing the influence on current oil and gas producers is necessary. And also – since energy has always been an important factor of political strategies, I will provide an insight in this area as well. Problems in this chapter are usually not covered in analysis provided by governments or international agencies. However companies in the industry (and organizations like OPEC) are usually evaluating opportunities and risks in their outlooks. Most of the ideas and conclusions will

come from my thoughts, which will be backed up by statistical data, estimates of companies in field and news reports.

Certain limitations of my thesis however apply. The lack of academic literature suggests less objective sources. The origin of the given study has to be taken into account and one has to read between lines. Some analysis and facts may not even be available to public given the character of the topic.

Even though I will try to predict certain influences on international trade, based on logical reasoning, in the end humans make decisions, which do not necessarily follow a rational framework and are sometimes influenced by unpredictable or at least uncertain facts.

The industry is growing immensely in recent years and estimates, which are only 2-3 years of age, are today already considered irrelevant. I suspect that this may be the case of sources I am going to work with. The biggest limitation of my study is therefore in the long-term relevance of the conclusions based on given data.

1. Analysis of the current situation

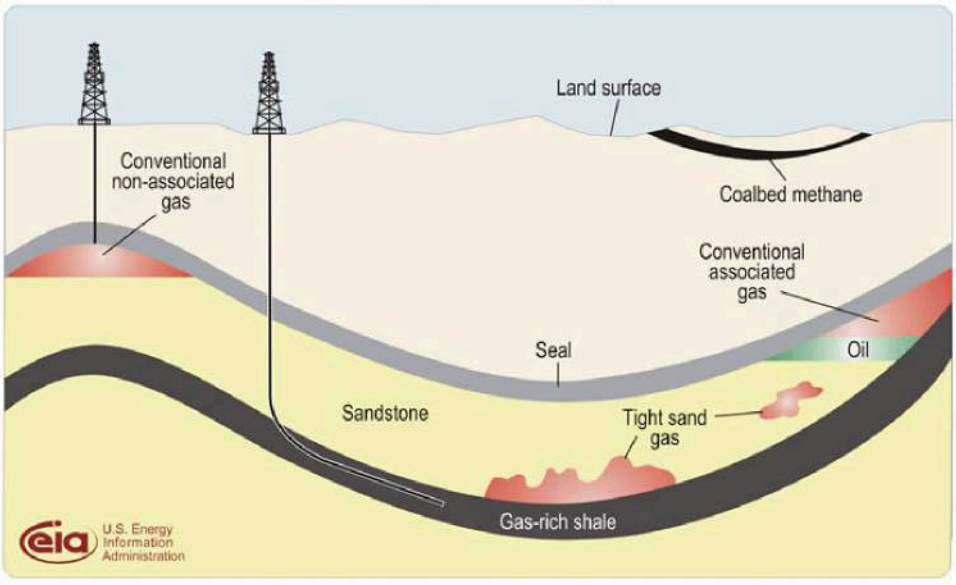
1.1. Unconventional resources in general

Even though the term unconventional resources gained on general knowledge among the population in the recent decade, the most they will probably be able to recall are gas and oil shale. There is however a wider variety of what falls into the term “unconventional”.

As opposed to conventional gas, which is contained in gas reservoirs, unconventional gas is found in geological formations. Regarding unconventional gas, there are four different types:

1. Shale gas, which is actual natural gas but produced from sedimentary shale.
2. Coal bed methane (or coal seam gas in Australian terminology) is generated while transformation from organic materials to coal occurs.
3. Methane hydrates are bound within a crystal structure of water, but are not technically recoverable yet.
4. Tight gas is very similar to shale gas; U.S. authorities have due to taxation reasons set a line regarding permeability and porosity of the geological formation to distinguish tight gas from conventional and shale gas.

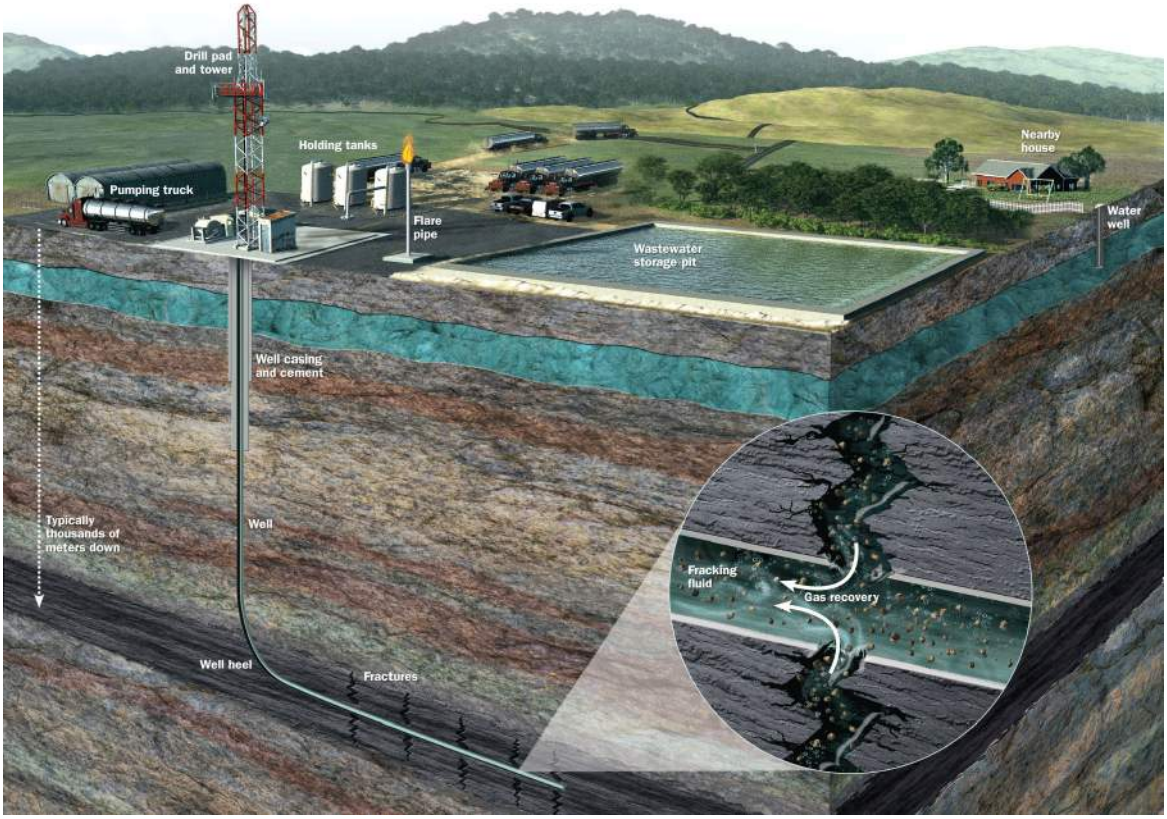
Picture n. 1: Schematic Geology of Natural Gas Resources



Source: EIA 2013

In my thesis I will mainly focus on shale/tight gas/oil, since the impact of these is both significant and relatively foreseeable compared to other sources. In order to avoid future confusion, the word fracking has to be explained. Fracking is a horizontal drilling technique in which usually water with added chemicals is pumped under high pressure into a gas-rich shale in order to fracture it so gas can leak. A typical fracking facility (well) can be seen on Picture n. 2.

Picture n. 2: Fracking



Source: GreenPlug 2013

Regarding oil, the International Energy Agency states: "Conventional oil is a category of oil that includes crude oil and natural gas liquids and condensate liquids, which are extracted from natural gas production… Unconventional oil consists of a wider variety of liquid sources including oil sands, extra heavy oil, gas to liquids and other liquids." (IEA 2013)

1.2. History of unconventional resources

The word unconventional evokes the feeling that the matter has arisen only recently. However the opposite is true. The use of unconventional oil resources reaches back thousands of years ago, regarding gas – hundreds of years. In this chapter I will briefly sum up the history until recent development, the year 2000 being a benchmark.

1.2.1. Gas

Unlike oil, natural gas used to be a not very valuable resource. In fact, it was a side product of oil production and a rather complication. Since there was no market for natural gas it was usually burned directly on the oil fields. It was no sooner than in the 20th century that natural gas came to commercial use. Same development is true for shale gas. According to the New York State Department of Environmental Conservation first time shale gas was extracted was in Fredonia, New York in 1821, even though no commercial use was made of it. Yet, shale gas is just a type of gas, found in geological formations. The technology of horizontal drilling and hydraulic fracking was introduced in the 1930s and 1940s in the United States. Thus - neither of those technologies is completely new (Stevens, 2012). Unconventional gas from Estonian gas shale was used in todays Saint Petersburg as a substitute to traditional gas.

During the 1970s and 1980s the Federal Government of the United States has partnered with private companies and provided tax credits to subsidize shale gas production. Same strategy was followed in the case of another part of unconventional resources - coalbed methane, which led to substantial growth of the industry. However unlike coalbed methane shale gas production was still considered to be uneconomical compared to gas prices at that time.

This changed in 1998, when George Mitchell's company – Mitchell Energy developed the necessary technology to cut down costs – bellow 4 USD per million

BTU[1] (Forbes 2013) – 3.33 USD/Mcf[2]. In perspective – the prices of conventional natural gas ranged from about 2.1 USD/Mcf– 2.4 USD/Mcf in 1998. In the following years gas prices have risen up to 5-9 USD/Mcf. George Mitchell is therefore often considered to be the "father" of shale gas industry, since he made shale gas economically viable and started the revolution, which contributed in the new millennium the most to primary energy production in the United States.

1.2.2. Oil

As mentioned in the previous chapter, unconventional oil has a quit long history of use by mankind, reaching out to ancient times. Great civilizations all over the world – Greeks, Romans, Byzantines, Britons etc. have used oil shale for various on different occasions – starting with fuel to decorative, medical or military (flaming arrows) purposes. The actual extraction of oil from oil shale has likely begun in the Middle East. A local physician named Yahya Ibn Masawaih Al-Mardini has described "oleum de gagatis" (Forbes, 1970, p.41), which is oil obtained from shale by cracking the shale and heating it up. In Europe has exploration of shale oil extraction begun in several regions – Austria, British Islands, Scandinavia and Russia.

Modern use of shale oil could be dated back to the 19th century. Different chemical processes were used to extract oil from the shale. The practice has probably started in France and spread across the continent. Even further – in the United States the process has started a few years later in the Ohio River Valley and the first factory was built in Kentucky. However, cheap petroleum with substantially lower extraction costs was discovered later and the use of oil shale was put to a temporary end in the U.S.

The tension before, during and between the World Wars forced governments all over the world to explore oil shale reserves. The reason was clear – not every nation has had conventional petroleum resources. Mining started in Estonia, Spain, China (under Japanese rule) etc. After World War II was over, most of the countries

[1] BTU is a shortcut for British Termal Units. 1 BTU is defined as the heat required to raise the temperature of 1 pound of water by 1 °F at a constant pressure. Forbes along with other various institutions are using BTU as a measurement, U.S. government organisations use usually cubic feet. Converstion rate: 1 cubic foot = 1020 BTU.
[2] The "M" in Mcf (or mBTU) originates from Roman numbers and represenets thousand. However, mmBTU for example does not follow Roman numbering anymore and does not mean twothousand but million.

have abandoned again the oil shale industry, due to high processing costs compared to conventional resources. Nevertheless most of them remained present in the field, building research factories to evaluate future benefits of oil shale.

In the United States oil shale production was rising due to high petroleum costs in the end of 1970s. Even though substantial investments were made during this time, the prices of petroleum fell again and Exxon was forced to cease a multi-billion dollar project in Colorado. The production of oil from shale fell and the last extraction location was closed in 1991, starting again a temporary break to oil shale development in the United States.

1.3. Present situation in unconventional resources

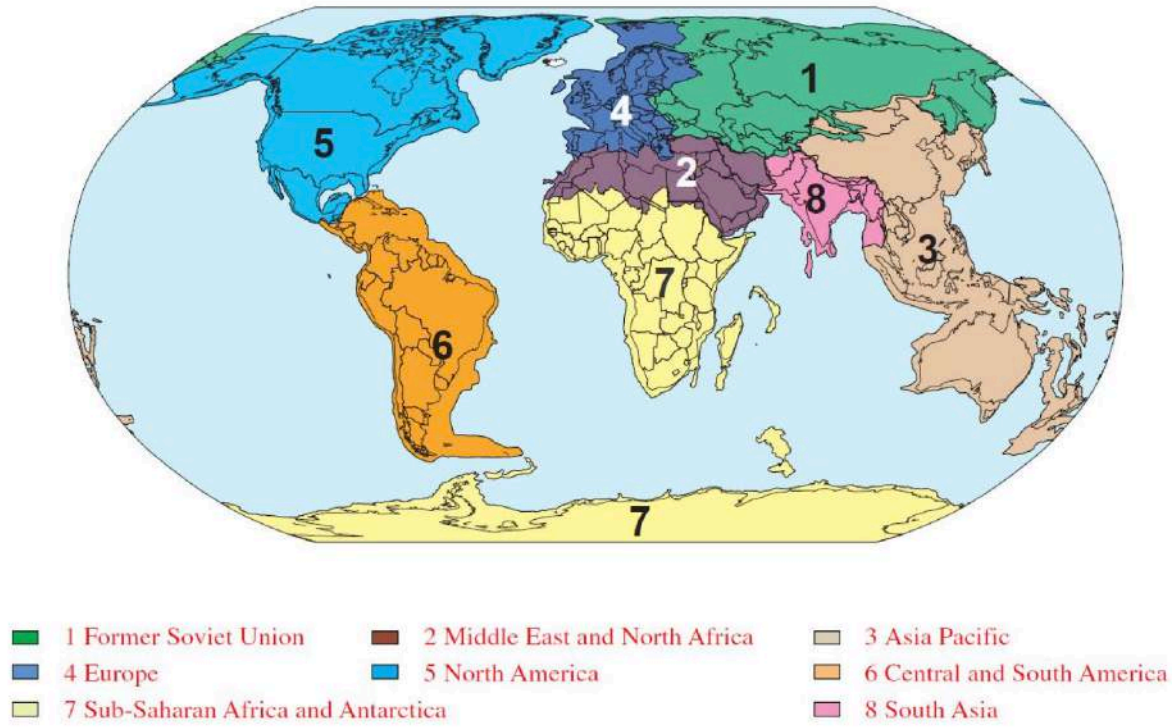
Since the focus of the previous chapter was rather on the past with the new millennium being a benchmark, the following chapter will evaluate the current situation.

I intend to start with a brief overview of the global territorial structure. The case of use of unconventional resources in the United States is the only available case study in the field and my analysis will go more in deep. Therefore I will not mention the United States in the opening chapter. Also, to evaluate the potential impact on international business one should have an idea about the future of the industry. Therefore this chapter will close with an estimate of resources available worldwide.

1.3.1. Global territorial structure

The U.S. Geological Survey (USGS) divides the world into 8 different regions, when assessing the structure of petroleum allocation. I intend to follow this division as well. A map displaying the regions can be seen bellow, on Picture n. 3.

Picture n. 3: USGS World division map.



Source: USGS 2000

Region 1 comprises the former Soviet Union with most currently known sources being allocated in Russia, prevalently in the West Siberian Region, which is also a primary source of conventional oil, delivering 60% of Russia's annual oil production (EIA 2009). Another estimated source in this region is the Dnieper-Donets Basin in eastern Ukraine and Carpathian Foreland Basin in western Ukraine and Moldavia. Other areas, prevalently in Eastern Siberia may also contain perspective sources, however current information are not sufficient for an estimate.

Region 2 stretches from northwest Africa to the borders between Iran and Afghanistan/Pakistan, comprising the whole Arabian Peninsula and Turkey. Even though certain resources may be present in Morocco, Jordan, Turkey, Tunisia or Egypt, it is Libya and most of all Algeria that play the primary role. Also Saudi Arabia may have substantial gas resources, declared the Saudi Minister of Petroleum and Mineral Resources (Reuters 2014). However it is unclear on what these estimates rely, since no analysis was provided to the public so far.

Region 3 on the USGS map includes not only China but also Southeast Asia and Australia. Both Australia and China do have substantial resources. In Australia

the most promising area includes the Maryborough, Canning and Cooper Basin. In China several basins are located in the Sichuan province and practically all over southeast of the country. Indonesia is also estimated to have some deposits.

Western Europe, as region number 4 on the map, France is so far the country with the highest estimated resources, followed by the UK, Netherlands, Denmark and Germany.

Even though the United States are excluded from this overview, both Mexico and Canada have substantial resources of both shale gas and oil. Several projects in Canada, mainly Alberta (but also in British Columbia, Ontario and others) are already in development with more planed. Most of Canada's reserves are located in rural areas, yet in more densely populated provinces, like Quebec a temporary moratorium was declared until environmental concerns are resolved. In Mexico the industry is developing rather in a slow pace. The national company decided to focus on conventional (that means higher return) resources and put shale gas/oil on hold.

Region 6 includes Central and South American states, with Argentina having by far largest deposits, followed by Brazil, Venezuela, Paraguay and Chile.

Number 7 contains sub-Saharan Africa and Antarctica. Antarctica is only a formal part of this region since international treaties have banned any economic activities on the continent. Worth mentioning is only South Africa, with the Karoo Basin stretching over a big part of the country. Several companies have already been given licenses for exploration of the potential, including Shell, Falcon Oil&Gas and others.

The last region on the map – number 8 – includes mainly India and Pakistan with both countries having rather moderate resources. India has expressed interest in cooperation with the United States. The issue is a rather densely populated country, the lack of technology and bureaucratic obstacles.

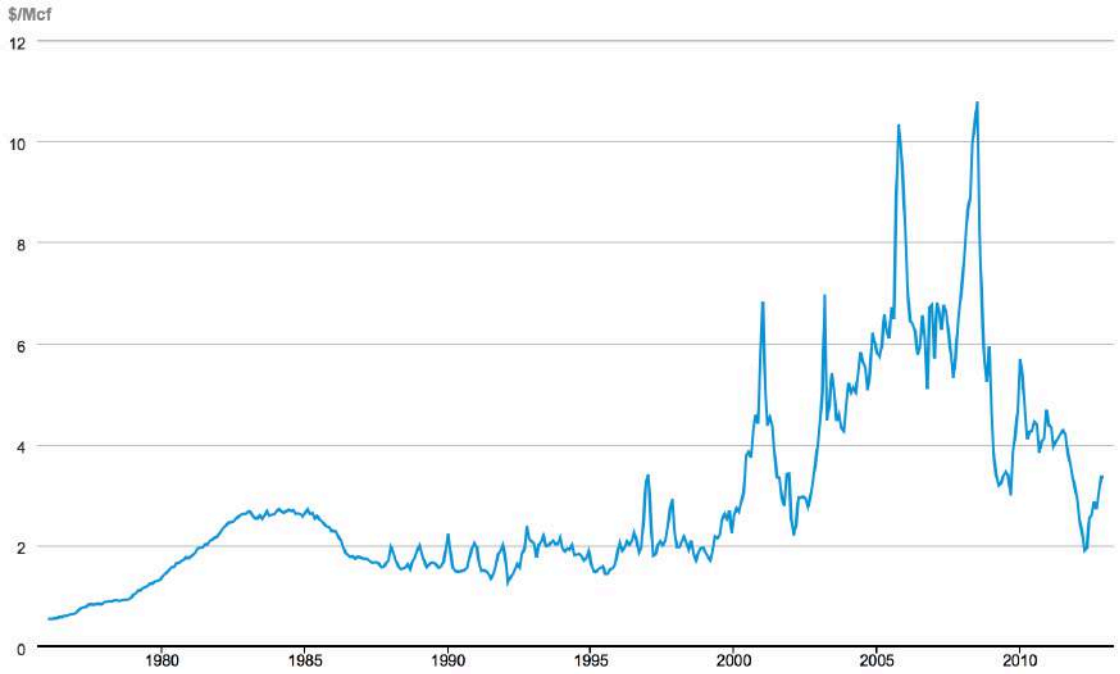
1.3.2. Situation within the United States

Gas

The U.S. government believed into the future of unconventional resources, particularly shale gas in the 1970s and 1980s, providing tax credits to companies involved in new technology development and experimental testing. Despite that, shale gas accounted only for about 1.6% of the production of natural gas in the United States in 2000. (Wang, Krupnick 2013) At the beginning of the new millennium several factors created a favorable environment for shale gas development.

As mentioned earlier, Mitchell Energy has found a way to substantially lower horizontal fracking costs, yet not enough to match prices at the level of 2USD/Mcf. Figure n. 2 shows natural gas prices.

Figure n. 2: Natural Gas Prices on the U.S. market (in Mcf)



Source: EIA 2012

This picture depicts that rising gas prices at the beginning of the new millennium provided economically feasible conditions for shale gas production.

The company has chosen the Barnett shale in Texas as one of their testing sides earlier. Nowadays we know that a certain amount of luck was also present – the Barnett shale is one of the most favorable shale formations from the geological stand of view – compared to other formations around the world. A thing Mitchell Energy could not have known at that time. The investment advisory company Tudor, Pickering, Holt & Co has suggested in their 2012 report that the Barnett shale is the third most profitable shale formations in the U.S. – for a 10% rate of return, gas prices have to be above 4USD/Mcf, whereas the average for other sites lies above 5.5USD/Mcf.

Another factor was the structure of the U.S. market. Big oil/gas companies did not invest in the shale industry, dedicating resources to more economically feasible projects in the conventional industry. There were however also medium sized companies, like Mitchell Energy, Devon Energy etc. that could usually not compare themselves in the amount of capital available to the biggest companies and compete with them. The market structure has forced these companies to take the way of innovations and focus on finding an opportunity, which eventually will prove itself profitable in the future. The presence of a strong capital market in the country was crucial as well. Big financial institutions provided loans or bought out companies involved in R&D and supplied them with enough resources to continue testing.

The structure of the landscape was important from two points of view. Even though close to Dallas/Fort Worth, the Barnett shale is located in a not very densely populated area of Texas and the same applies to other shale formations with the exemption of formations in Pennsylvania. Since horizontal drilling is very water demanding (in millions of liters per one well), the availability of sufficient water resources was important. Therefore, the proximity of nearby water reservoirs has played an important role.

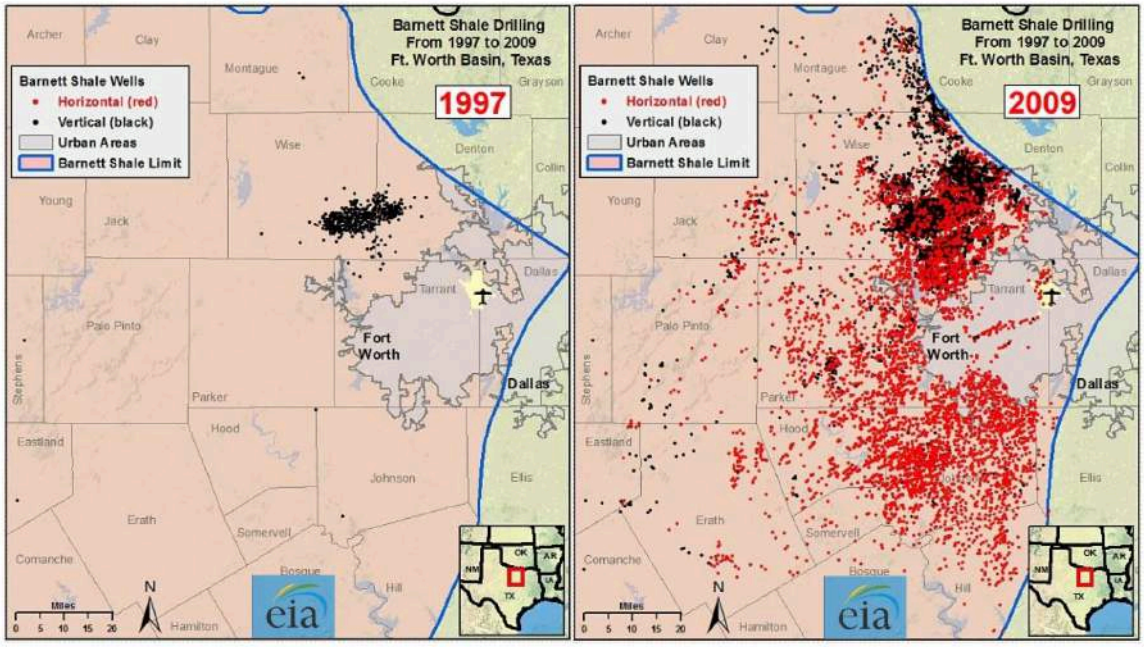
Also, it is important to note that the United States have had a developed (and from large companies independent) gasoline infrastructure, based on a first-come-first-serve principle, which allowed smaller companies easy access to transportation.

The circumstances in the United States were very favorable and created basis for innovation, which arguably could not have taken place in densely populated

areas in Europe, places with water-shortage such as most of the OPEC countries or the former Soviet bloc, where capital endowment or legislation do not provide the necessary background for innovations.

As for the Barnett Shale the development was very intense. The amount of drilling wells in the formations has increased from approximately 750 in 2000 to almost 18,000 in 2012 (EIA 2012). The map on Picture n. 4 provides a better explanation. Red dots are new-build horizontal wells in the Barnett shale over the given time period 1997-2009. Gas production from the Barnett Shale reached 60 billion m^3 in 2012, which is ~7 times more than the gas consumption of the Czech Republic in the same year and covers 6% of the gas production of the United States.

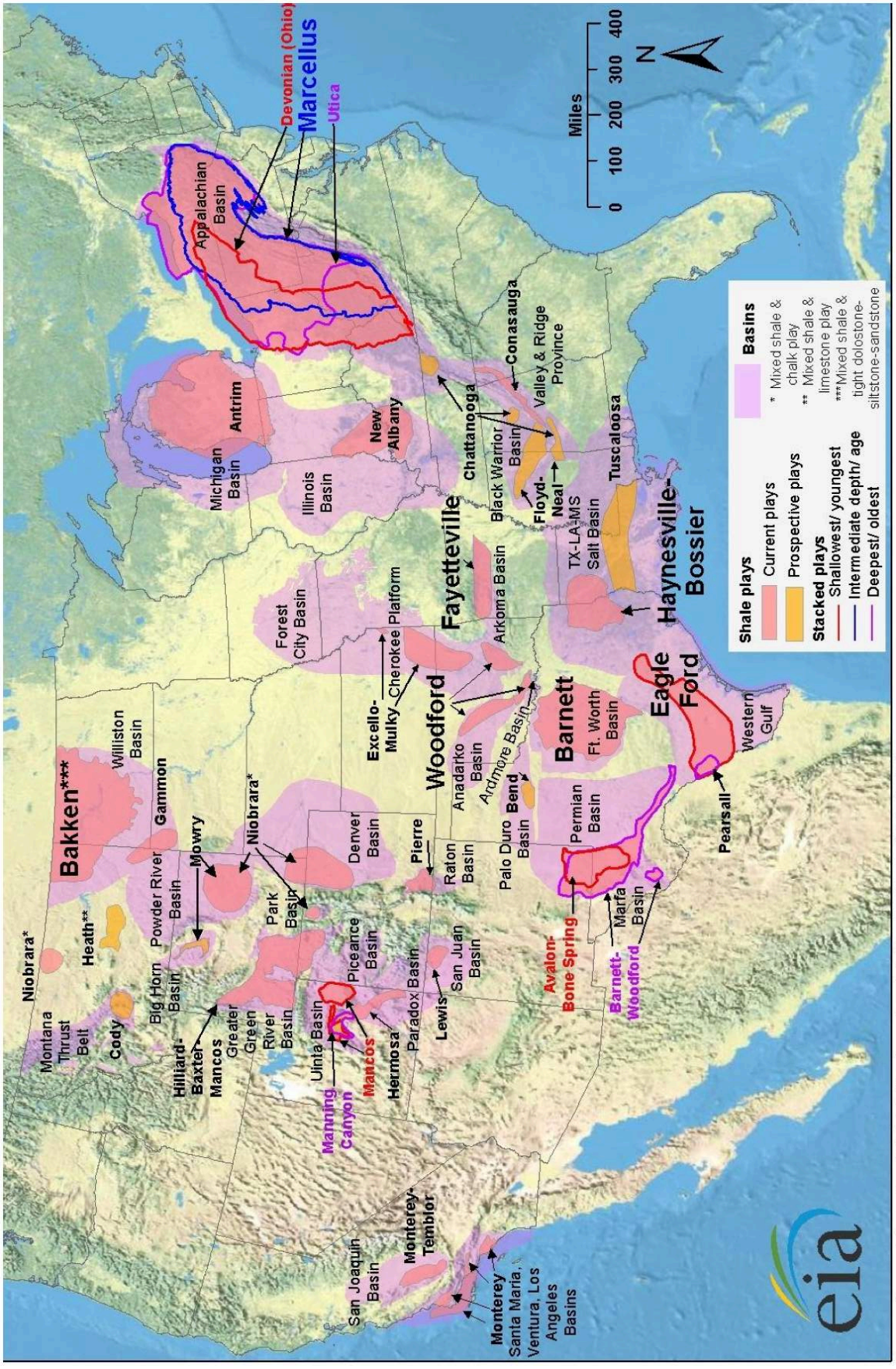
Picture n. 4: Barnett Shale Wells.



Source: EIA 2012

After the success of fracking at the Barnett shale, development has started in the last decade on several other locations. The EIA provides a good overview of these areas on Picture n. 5.

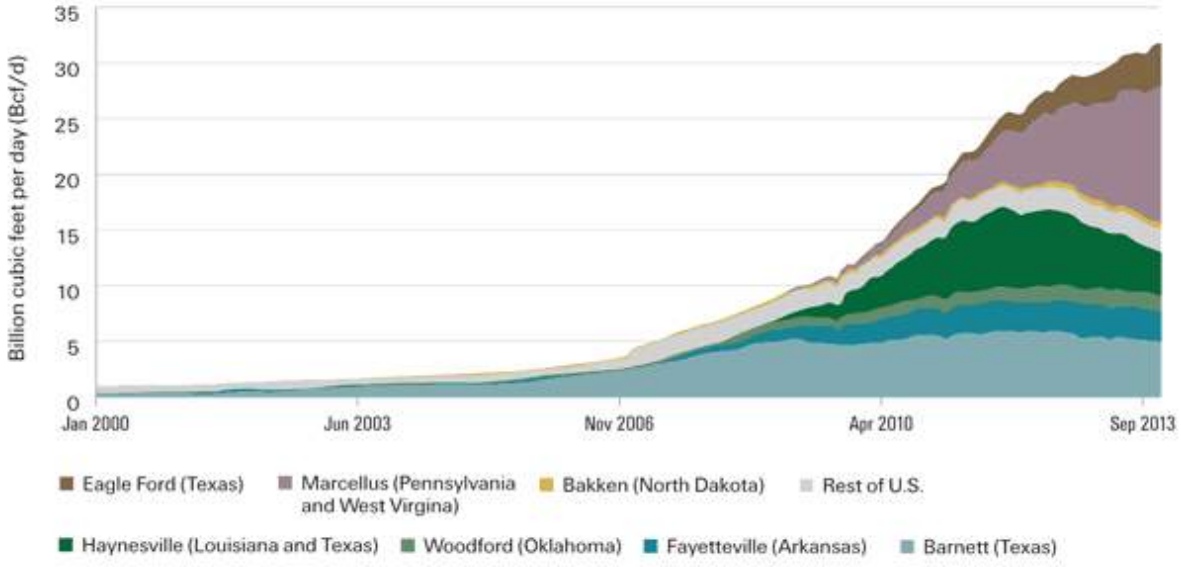
Picture n. 5: Shale Formations in the U.S.



Source: EIA 2013

Most of them are currently explored and production either has already begun or is scheduled to begin shortly. Likely the biggest known deposits are in the Marcellus and Devonian formations in the northeast of the country, which are together with the Haynesville basin the most promising. Also in Woodford, Oklahoma the current capacity of 12 billion m^3 a year has already been reached and further development is in progress. A graphic depiction of the development and importance of each shale formation can be seen bellow, on Figure n. 3:

Figure n. 3: Daily U.S. shale gas production by formation[3]

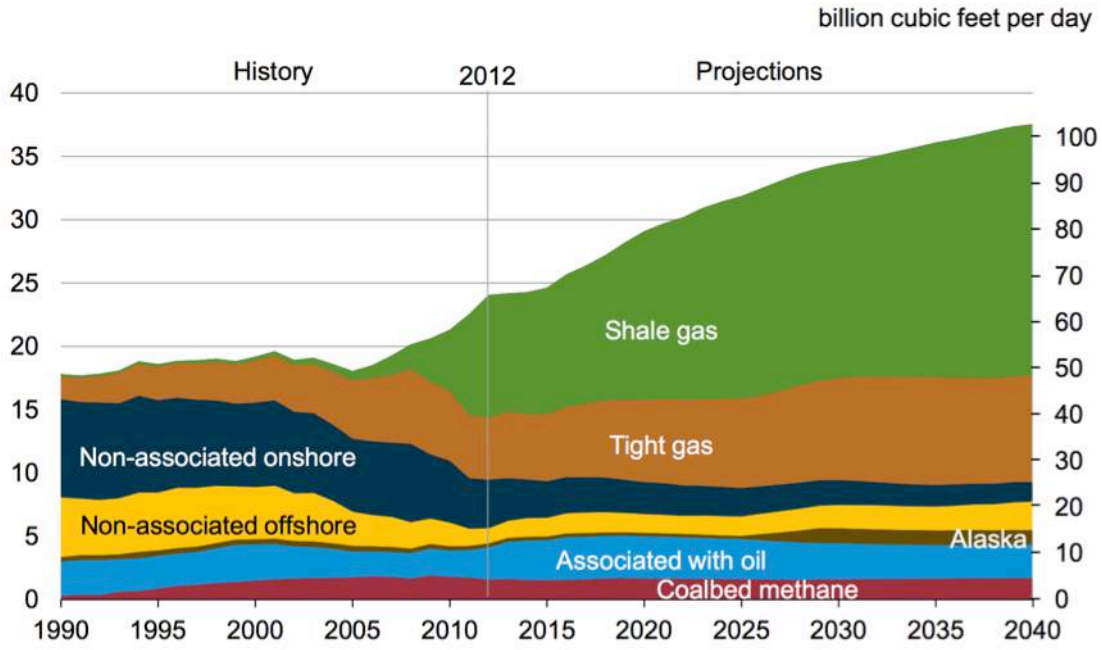


Source: Lord Abbett 2014

The yearly shale gas production is nowadays approximately 300 billion m^3, which accounts for 40% of the gas production of the U.S. – a jump compared to 2007, when shale gas accounted only for 5%. Projections are that gas production from unconventional sources will continue to rise and combined with tight gas (which is also produced by hydraulic fracking, the only difference between shale and tight gas is the porosity and permeability of the reservoir – an administrative approach) will account for 75% of U.S. gas production by 2040, as depicted on Figure n. 4.

[3] 10 billion cubic feet per day is ca. 103.3 billion m^3 a year.

Figure n. 4: U.S. Natural gas production by its origin[4]



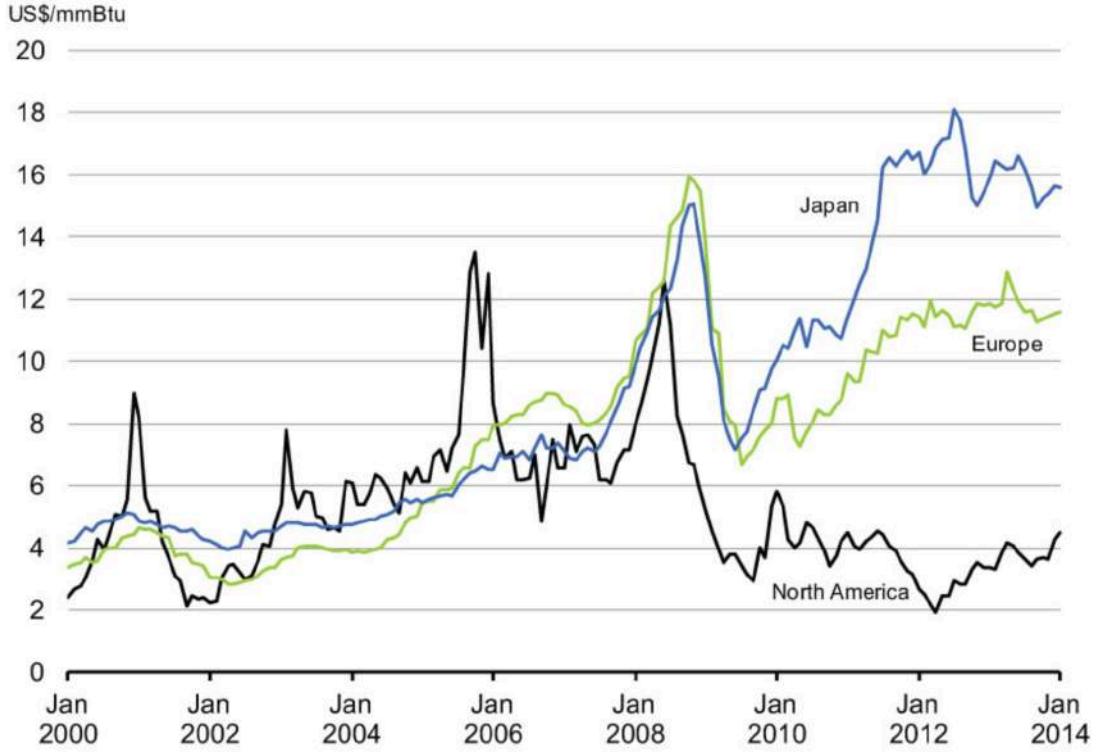
Source: EIA 2013

A rapid development of a new industry may have a positive impact on the economy and a potentially negative on the environment. Let us first discuss the impact on the economy.

The industry by itself does create a quite significant amount of new jobs; it is, however, the lower gas price that provides the United States with a competitive advantage compared to the rest of the world. Until 2008 the development of gas prices in the United States, the European Union and Japan has been very similar. It was only during the last 5 years that prices in Europe and Japan have started to rise, while the prices in the United States were kept stable on a low level. The depiction can be seen on Figure n. 5 bellow.

[4] 100 billion cubic feet per day is ca. 1033 billion m^3 a year.

Figure n. 5: Comparison of gas prices in North America, EU and Japan



Source: Government of Canada 2014, based on World Bank data

America's Natural Gas Alliance (ANGA) estimates that by 2015 almost 1.5 million new employment opportunities will be created either directly, indirectly or induced by the unconventional gas industry with a positive outlook for the future. The industry is expected to generate in federal and state taxes additional 36 billion USD on government revenue and the yearly disposable household income should increase by 1,100 USD on average in 2015 thanks to lower gas prices for households compared to 2010. The study also estimates that over the period 2007-2015 the shale gas industry has added approximately 0.93% per anum to the growth of GDP.

Some industries are very sensible on the price of energy, mainly the petrochemical and steel industry. Again, the ANGA expects that investments directly linked to gas prices will top 100 billion USD in the next years. And the companies confirm the direct impact. A German company Linde has announced an investment of 200 million USD in Texas - „directly to be linked to the price and accessibility of natural gas". Also Incitec, an Australian company has recently announced an investment worth 850 million USD in Louisiana, Sason from South Africa in the worth of 5-7 billion USD and another planned investment for up to 14 billion USD.

(Patria 2013). The CEO of E.ON Johannes Teyssen has also concluded that the United States have achieved a "comparative advantage, and there is nothing we can do about it right now". The former German Federal Minister of Economics and Technology Philip Rösler agrees – "more and more German companies have chosen to move to the U.S. due to high energy prices in Germany" (Patria 2013).

Often cited by environmental protection agencies – the negative environmental impacts supposedly outweigh economic benefits. They also accuse the industry of wasting water supplies. These accusations are however usually not based on rational background, since all areas, where current shale gas production takes place are very well endowed with water reservoirs and are therefore more ideological in my opinion. What has to be taken seriously though is the concern about ground waters. Several studies conducted in Texas and Pennsylvania do actually show higher levels of dangerous chemicals of arsenic nature in tested private drinking wells. The Massachusetts Institute of Technology comes to a conclusion that even though these problems are present, they do not prove the danger of the industry, but rather a need for more regulation and are thus "challenging, but manageable".

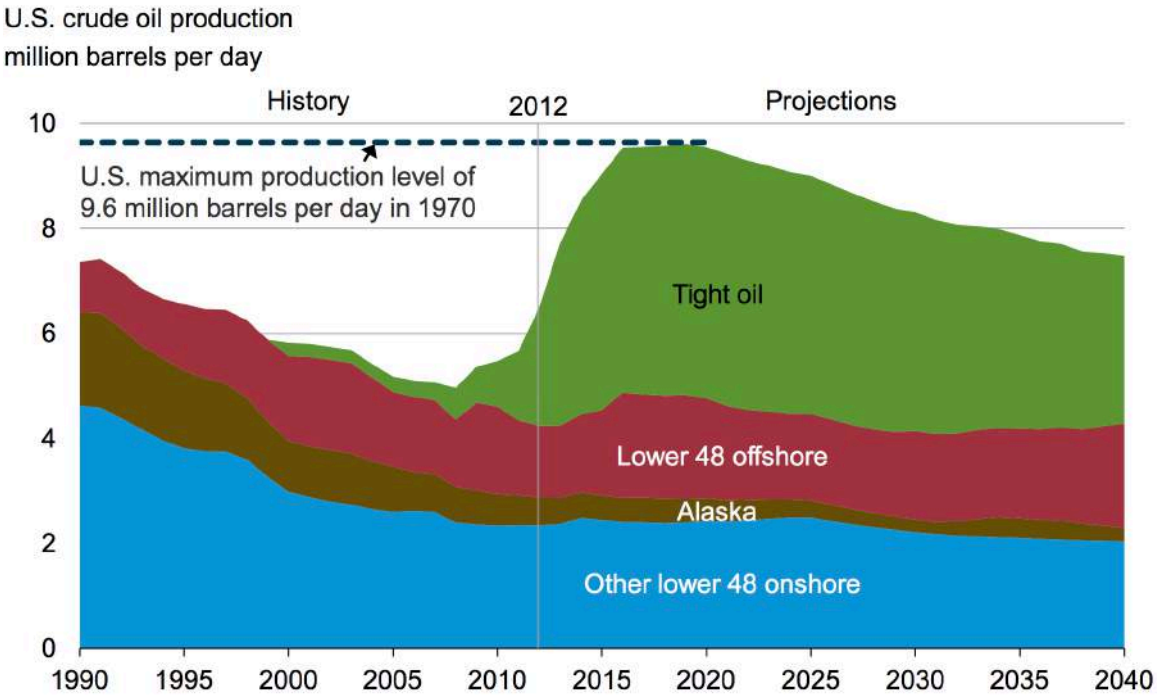
Also air pollution is often mentioned as being influenced by shale gas. On the one hand a positive impact on the amount of carbon dioxide emitted into the atmosphere is without discussion – estimates show that CO_2 emissions will drop in 2020 by 10% compared with the peak level in 2005. A widespread opinion blames carbon dioxide produced by the mankind for global warming. However methane is also a powerful greenhouse gas and a study conducted by the Environmental Protection Agency yields that 1.4% of shale gas produced leaks directly into the atmosphere. Whether this leakage outweighs the downturn of coal-supplied power plants is currently under discussion. In my laic opinion – even if so, the leakage issue is probably easier to address than the structural pollution problems caused by coal-based power plants.

Oil

Same as in the case of gas, unconventional oil in formations can be divided into shale and tight. Tight oil accounts for the vast majority of the production though. The biggest issue with oil production as for now is the large decline in

effectiveness in the production wells. Leonard Maugeri has conducted a study, which shows that just to maintain the same level of production North Dakota's Bakken-Three Forks (at 770,000 barrels per day), 90 new wells have to be installed per month. Despite this fact, production continues and predictions are quite favorable, as depicted on Figure n. 6.

Figure n. 6: Oil production in the U.S.



Sources: EIA 2013

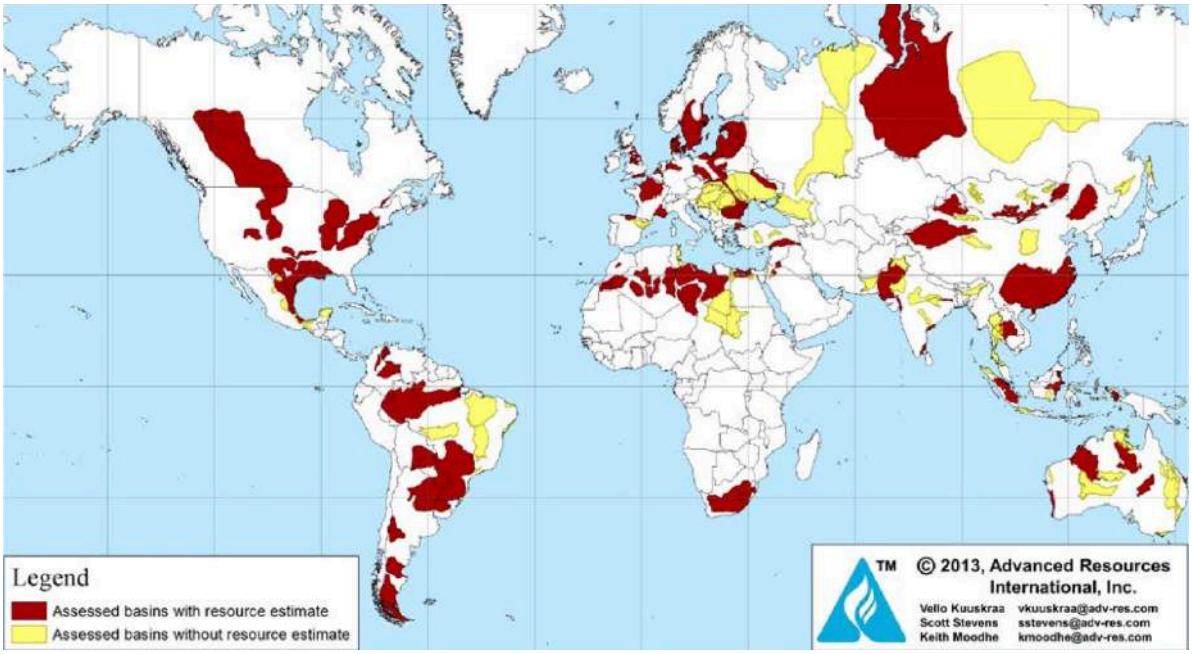
Compared to shale/tight gas, the future of unconventional oil resources is hard to predict and will depend on the technological progress made. They key question is here also the development of oil prices worldwide.

1.3.3. Estimates of unconventional resources

To put the estimates in this chapter into perspective let's first discuss the estimates of conventional resources. The EIA estimates the world conventional reserves of natural gas to be 187×10^{12} m^3 and the oil reserves to be around 1480 billion barrels.

In their most recent study the EIA has assessed 95 shale basins all around the world. The territorial division can be seen on Picture n. 6.

Picture n. 6: Shale basins around the world



Source: EIA 2013

Natural Gas

The 2013 estimates are quite promising. The currently technically recoverable shale gas resources amount for as much as 220×10^{12} m^3, which is more than the estimate of conventional reserves of the planet. Yet it is very likely by far not the final count. The estimate went up by 15% compared to a similar report in 2011. Introduction of new technologies in the recent years allowed to access more resources and also new perspective basins were added. Ten countries with the highest recoverable shale gas resources up to date are listed in Table n. 1.

Table n. 1: Countries by technically recoverable shale gas resources

(Data in $x10^{12}$ m^3)	
1. China	32
2. Argentina	23
3. Algeria	20
4. USA	19/33[5]
5. Canada	16
6. Mexico	15
7. Australia	12
8. South Africa	11
9. Russia	8
10. Brazil	7
Others	43

Source: own elaborations based on EIA/DOE data

If the European Union was considered one country, it would rank 7th in the table with estimated deposits of $13x10^{12}$ m^3.

In perspective and based on my calculations – the currently recoverable shale gas resources within the U.S. would be sufficient to cover the whole domestic gas consumption for another 46 years, in case of the EU and its resources for 27 years (no modifications made to estimates whatsoever and gas consumption constant at 2013 level).

However the study also estimates the in-place resources, which are not technically recoverable yet and go even further. The estimate puts these numbers as high as $1{,}010x10^{12}$ m^3. Also put into perspective under the same assumptions – the U.S. could cover domestic demand for another 160 years, the EU for another 140 and the world combined for more than 300 years. The question is, whether these will become both technically recoverable, as innovations proceed and economically feasible to produce.

Oil

In the opening chapter we have seen that even though mankind is aware of shale oil for a long time already, out of several reasons it had failed to use it – mostly

[5] EIA estimates U.S. recoverable shale resources to be 19 trillion m^3, the estimate of the U.S. Department of Energy puts the estimate higher, to 33 trillion m^3, which would rank the U.S. first in the table.

because of economical unfeasibility. This has changed however in the recent years and the industry starts to develop again. Yet, compared to the shale gas it is in their beginnings. It was only in 2013 that the EIA has included shale oil in their estimates. It has estimated that around 345 billion barrels of shale oil are technically recoverable, allocated mostly in Russia, the U.S., China, Argentina and Mexico.

Same as in the case of shale gas, estimates of in-place deposits are significantly higher. The EIA believes the currently known oil shale/tight oil deposits outside of the U.S. to be around 5,800 billion barrels, almost four-times more than the proven conventional oil reserves.

The USGS has published a study assessing three most important basins within the United States – the Piceance Basin, Uinta Basin and Green River Formation and estimated the in-place reserves to be another 4,300 billion barrels, by far the largest in the world. However the issue is that even though technically recoverable in the future, the extraction may not be economically feasible. This may change though as oil becomes more expensive.

Another source of unconventional oil are oil sands, found mainly in Canada, in lesser quantities also in Venezuela, Kazakhstan, the U.S. and Russia. Rough estimates show approximately 2,000 billion barrels of petroleum in-place, according to the study by the U.S. Department of Interior.

For other types of unconventional resources, like coal bed methane, methane hydrates etc. are either no qualified estimates available or the reserves are negligible compared to shale/tight gas/oil and oil sands.

2. Potential of unconventional resources outside North America

2.1. Europe

2.1.1. General approach and regulations

The previous chapter has focused on the position of the United States in the market of unconventional resources. Europe is however a different case in many ways. Estimates of unconventional oil resources in Europe are at time very inaccurate and the reliability of studies focusing on unconventional oil is questionable. Therefore the main focus of this chapter will be on unconventional gas, namely shale gas. The main question to ask is, whether the boom, as we have experienced it overseas can be repeated in European conditions. And if not, is it still viable to produce shale gas in the European Union?

If the European Union was one state, it would have the 7th largest deposits on the planet. IEA determines several factors (IAE: Golden Age 2011), which have to be assessed in order to answer the viability question. The first condition – the geological question, whether there are actually resources present – is mostly answered. The real question is what is the amount of technically recoverable resources. This cannot be answered without further exploration, which currently takes places on many European locations.

The IEA sets the second criterion as to whether the necessary technology is accessible and whether the infrastructure is sufficient. To the first part I tend to answer yes, the technology is present – it is usually global oil companies, which have already experiences from the Unites States that are interested in the European deposits. The countries in the European Union and in North America are countries, where rule of law governs and property rights are honored. The risk of loosing technological know-how due to for example nationalization is very limited compared to 3rd world countries. Another issue is however the capacity of the service industry. Since the EU imports most of its gas either from the Northern Sea, North Africa or Russia, the pipelines are adjusted to these conditions. The density is

significantly lower in the EU – 29 km of pipelines for 1,000 km^2 of land, compared to 55 in the U.S. (EIA: Natural Gas Pipelines 2012) and regions, with potential for unconventional resources are not covered. If production was to take place, this would require significant investments into the existing pipeline infrastructure.

Arguably the greatest challenge companies have to face is the regulatory framework in the EU. From this point of view, we can discuss difficulties in assigning spacing units to companies for exploration, legal issues, noise regulations and also environmental problems.

In most European countries there are some regulations for natural gas extractions present, mainly in countries, where conventional gas is produced. Furthermore regulatory challenges specific to unconventional gas may also come up. Once a possible mining site is seen as preliminary viable, at-place research has to be conducted by the company to either confirm the presence of shale gas or not. Florence Gény from the Oxford Institute for Energy Studies claims that while in the United States are blocks assigned to companies for research usually around the size of 3500 km^2, in Europe they range from as little as 2.6 km^2 to several hundreds. Therefore companies experience difficulties when trying to research various sites and having to go through the whole administrative procedure again for a new assigned zone. It is also often argued that the population density in Europe is higher than in the United States. In my opinion, the problem with this argumentation however is that it is too general and cannot be applied to all areas in Europe in the same manor – one would need an analysis for areas as small as possible in order to be judgmental whether population plays a role or not. However a different issue – a legal one arises.

Gény argues that while in the United States ownership of land is usually connected with a claim to minerals/resources being found under that particular land, in Europe these rights are separated. This means that even though a company may be the legal owner of a block of land, it does not automatically gain ownership of the resources beneath it, which are claimed by the state authorities. And it also works the opposite way - what are the options of those, who own rights for resources/minerals, but do not own the land above it directly? The European Commission does not provide a clear answer – Philip & Partners, who have analyzed various legal documents argue that some of them say that land owners have to be

compensated for the use of their land, others claim, the rights to minerals are owned by the state and therefore - if license granted, companies do not have to negotiate with every single land owner in order to explore the potential of the resources.

Likely the greatest barrier is the current public opinion, which is based on two approaches – people do not want to live close to a drilling pad and are concerned about the environmental impact.

Truth is that the actual building process of a horizontal well is accompanied by noise and will impact the quality of life in that period. However various studies and reports (NTC Consultants 2009; IFC International 2009; Anderson 2009) show that the land preparation process and the drilling phase take 1-4 months with a well lifespan of 20-40 years. Taking in account that some kind of construction work with noise will always take place around peoples home, (and judging without prejudice against shale gas) this would be in my opinion an acceptable construction time/lifespan ratio. However I agree that shale wells may not look aesthetic to everyone (Picture n. 7.) and also – people tend to think more rationally when it does not directly concern them. The author of this thesis would also have objections against a shale well in the proximity of his house – for example because of the likely decrease in market value of the estate.

The previous paragraph implied that the temporary noise may not be the actual problem, but rather an excuse and that the issue is indeed more general. The environmental concerns were mentioned already in the previous chapter. Europeans tend to be more concerned with environmental protection in general and therefore watch very closely the experience overseas. Which on the other hand is not necessarily a wrong approach.

The more the public debate continues, the more studies are being published which evaluate the possible impact on the European economy depending on the estimated shale gas production. A vast majority of them agrees that a revolution comparable to the United States is not going to happen. Apart of the already mentioned environmental concerns, missing infrastructure and regulations, also drivers for development are missing. The European Union is still experiencing an economic growth close to zero and the demand for gas is stagnating. Also, the whole gas industry has to face strong price competition from LNG importers (at least in some countries).

Picture n. 7: Shale gas well

Source: National Geographic 2010

2.1.3. Possible future benefits and costs

Companies interested in exploring shale gas resources in Europe have not only to adjust to new circumstances but are facing difficulties with the lack of proper infrastructure, various regulations on national level (will be mentioned later) and public opinion. To be able to evaluate, whether it is actually worth to overcome all difficulties present and launch shale gas production under European conditions, we should know, what are the benefits and costs of any decision.

Let us start with natural gas in general. Out of several reasons it may be the key to sustainable growth and not harming the environment. Natural gas is affordable and the technology is constantly improving. According to the UK Department of Climate Change and Energy the construction costs of power plants fired on natural gas are only half of a coal-based power plant and around a fifth of a nuclear power plant. From the environmental point of view, burning natural gas produces only a very low amount of nitrogen oxides responsible for smog and acid

rain and almost no solid waste, compared to coal. CO_2 emission remain three-times lower than in the case of coal and in a theoretical example of transforming all coal- and oil-powered power plants in Europe into gas-powered power plants, CO_2 emission could be cut by 58% compared to 1990, thus by far surpassing the Kyoto Protocol goals (IHS CERA 2011). Gas-fired power plants consume 60% less water than coal plants and 75% less than nuclear plants for the same amount of energy produced (US Department of Energy 2010). Therefore may be viable also for countries, which are not very well water-endowed. In comparison with renewable sources – natural gas power plants need twenty-times less land to produce the same amount of energy than solar panels or wind turbines. And not to forget – natural gas is abundant – the consumption has strongly increased in the past decades, nevertheless proven resources have increased much more.

Agreeing that the European shale gas industry will not be an absolute game changer and cause revolution, but more likely an evolution, different scenarios have been modeled by various institutions and consulting firms. Most of them work with 3 different approaches – each based on different level of public and political support; the amount of actually recoverable resources in place (20% in the most positive scenario). Most studies I have read are discussing the future until 2050, yet none of them has actually even mentioned the fact that technology is developing and the amount of recoverable resources may change over the next 30-40 years due to it. Estimating the future benefits is therefore much more complicated. Nevertheless, even with the current approach, where no improvement of mining technology is expected gives a reason to consider the benefits.

It is estimated that in 20 years shale gas could cover for 12-30% of Europe's gas consumption (2013 level). This would require 30,000 to 60,000 wells being drilled by then (compared to existing 40,000 shale gas wells in the U.S. in 2014) (Fracktracker 2014; Pöyry 2013).

We can divide the impact on Europe into two categories – on energy markets and macroeconomic effects. Pöyry estimates that shale gas production will lead to 6-14% lower gas prices, compared to a situation with no shale gas production. This would translate to annual savings on gas and electricity of up to 50 billion EUR, a total of 1.7 trillion until 2050. With the words of James Fazzino, CEO of Incitec: "If you think about the competitive advantages of an economy, low energy prices are

almost the most important thing." (Patria 2012). Also Johaness Teyssen, CEO of E.ON claimed that the "U.S. advantage has come to the point, where we cannot afford it to continue". (Patria 2013). The Boston Consulting Group has estimated that the United States will receive investments of up to 50 billion USD in the next 5 years thanks to low gas prices, most of them from European companies, who choose either to relocate or to expand their production plants oversea. The EU may not achieve a competitive advantage in cheap energy anymore; however decreasing the difference as much as possible should be the aim of European governments.

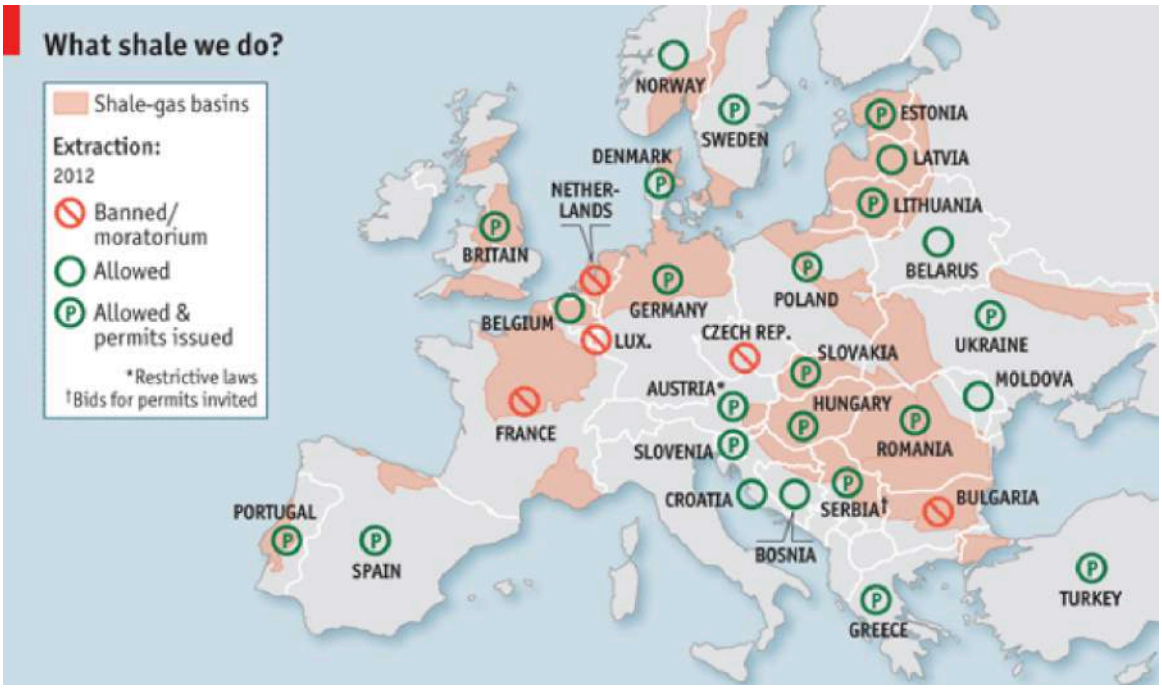
Pöyry also projects that while no shale gas production will lead to an increase in gas imports dependency (up to 95% in 2050), shale gas would decrease this dependency to about 62% from the current 74% level. The firm moreover suggests that shale gas would be a substitute to coal in the European electrical mix and not to renewable sources – effectively decreasing pollution and CO_2 emissions.

It is however the macroeconomic data, which could better translate into real life. Shale gas production would add to the annual GDP growth of the EU 0.6%-1% (combining lower energy prices, higher investments and lower imports) accompanied by an annual increase in tax revenues of 40-70 billion EUR, partially originating in VAT and corporate tax, partially in income tax of workers – the industry may create up to 1.2 million new jobs until 2050.

2.1.4. Allocation on national level an approach of local governments

After defining the common regulatory framework and discussing the advantages of active production same as costs of not producing, I would like to take a closer look at several EU countries. I have accessed all 42 countries of the world, for which the EIA prepared estimates in its 2013 Outlook and have regarded two criteria – a significant estimated amount of technically recoverable shale gas and the position of the local government. European countries I have chosen for a closer analysis fulfill at least one of these criteria - France, the UK, Germany, Spain, Poland and Romania. Out of personal reasons I will also take a look at the situation in the Czech Republic and Slovakia. A graphic overlook of the deposits in Europe and also the position of the local government can be seen in Picture n. 8 below.

Picture n. 8: Shale gas in Europe

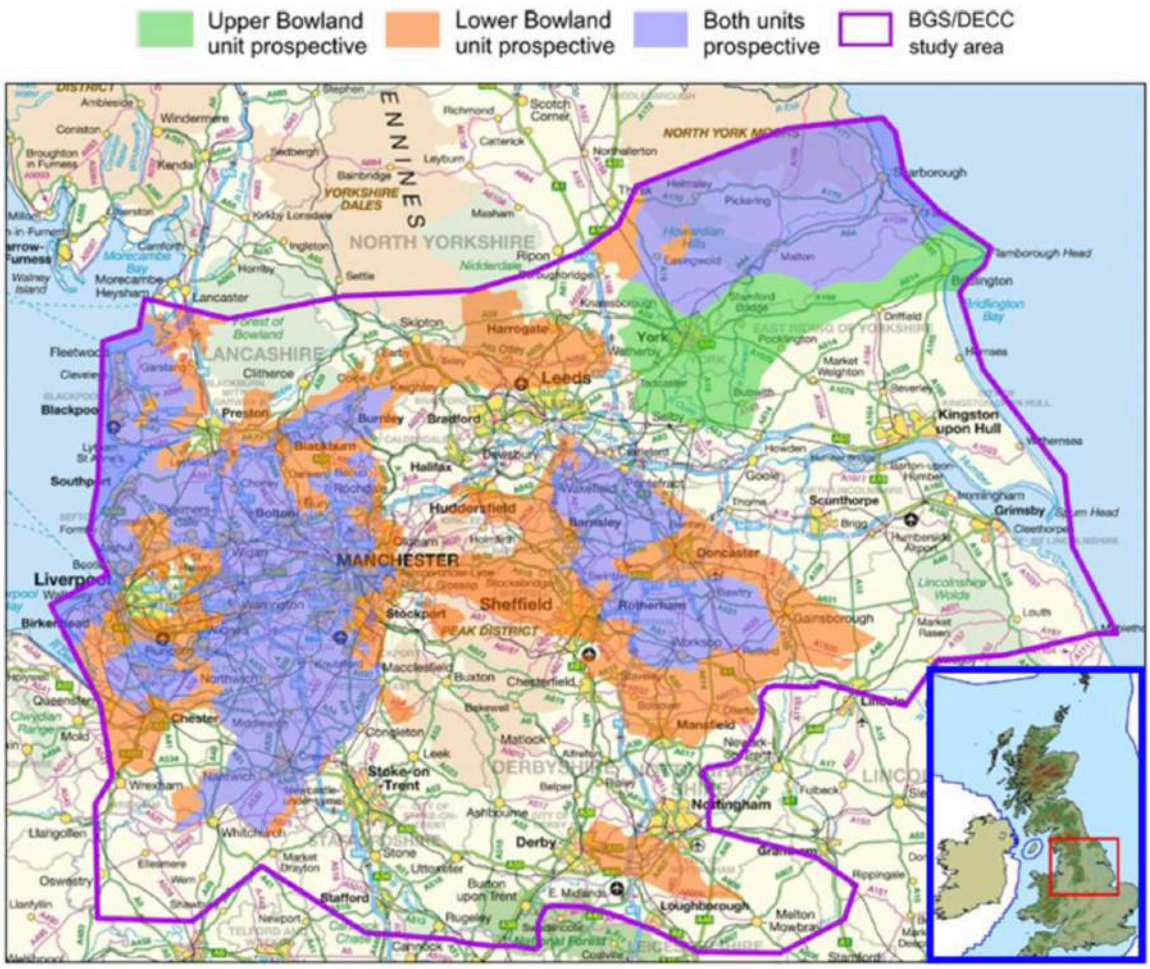


Source: The Economist 2013, based on IEA, KPMG and press reports

United Kingdom

The House of Commons Library of the Parliament of the UK has published a paper, which provides an interesting overview of the shale gas in the UK. Being aware of the potential is quite important. Domestic gas production in the UK is steadily declining and in 2013 imports have reached the highest level since 1970s, climbing up to 50% of consumption (EIA 2013; House of Commons 2014). The country may hope to reverse the trend by producing more natural gas from its shale resources. The current estimates of technically recoverable shale gas put the numbers up to 700 billion m^3 although recent discoveries in northern England suggest that the Bowland and Hodder shale (Picture n. 9) could have more than $35x10^{12}$ m^3 in place. This would be one of the largest deposits in the world. However the question is, how much will be actually recoverable. The densely populated area with cities like Liverpool and Manchester may pose a difficulty as well despite the fact that the region has a history of intense mining.

Picture n. 9: Bowland-Hodder Shale Formation



Source: British Geological Survey 2013

Currently several licenses for exploration have been issued, active production has not yet begun. Should the country proceed to production in the upcoming years, the impact on the economy could be quite significant. The Institute of Directors has estimated in 2013 that the shale gas industry may create more than 74,000 jobs, particularly in regions with higher unemployment. The UK government seems to be aware of the possible benefits and does not stand against shale gas out of ideological reasons. The UK Energy Minister Michael Fallon has stated that shale gas "will provide a welcome boost for communities" (Reuters 2013), David Cameron, the PM said that in light of the Ukraine crisis "Europe should pursue shale gas development" (Reuters 2014). Also a committee of the House of Commons has stated in 2011 that there was no evidence that hydraulic fracking poses a threat to underground water and a moratorium is unjustified (House of Commons 2011).

France

France is a completely different case. Even though exploration permits have been issued in the past, a moratorium on fracking is in place since 2011 due to environmental concerns and the future is uncertain. The country does not depend on natural gas to a high level, considering nuclear power plants produce 75% of its energy. The French President Francois Holland has however pledged to cut the share down to about 50% (Reuters 2013), leaving the question open, how to cover for the difference. The debate will likely continue though, since the Ministry of Industry seems to favor at least a public discussion and the fact that the industry may create around 100,000 new jobs by 2020 (SIA Partners 2013), which is a strong argument in the hands of trade unions, who traditionally have great power in France.

Germany

Germany's position is likely somewhere in the middle between the UK and France. On the one hand, the country strongly depends on gas imports (86% in 2013 according to Eurostat) and decreasing imports may be seen even as more beneficial than the actual economic advantages. There is no moratorium in place and Lower Saxony is planning on issuing the first exploration permits in 2014. The Ministry for Environment has however concluded that fracking in water protection zones should be banned and also an assessment of environmental impacts should be mandatory for each well.

Poland

Poland is considered by many to be the most promising country of the EU when it comes to hydraulic fracking. According to different estimates the country holds deposits, which would cover its needs for 30-200 years. The motivation to become less dependent on Russia is strong and also the need to switch to more ecological sources of energy may come up, considering that the country produced up to 85% of its energy by burning coal (Eurostat 2013). Poland has also issued exploration permits for 21 companies and intends to start production in 2015. The governmental policy is very in favor of shale gas development, exempting the

industry from taxation until 2020 (WSJ 2014). A graphic depiction can be seen on Picture n. 10 on the next side.

Spain

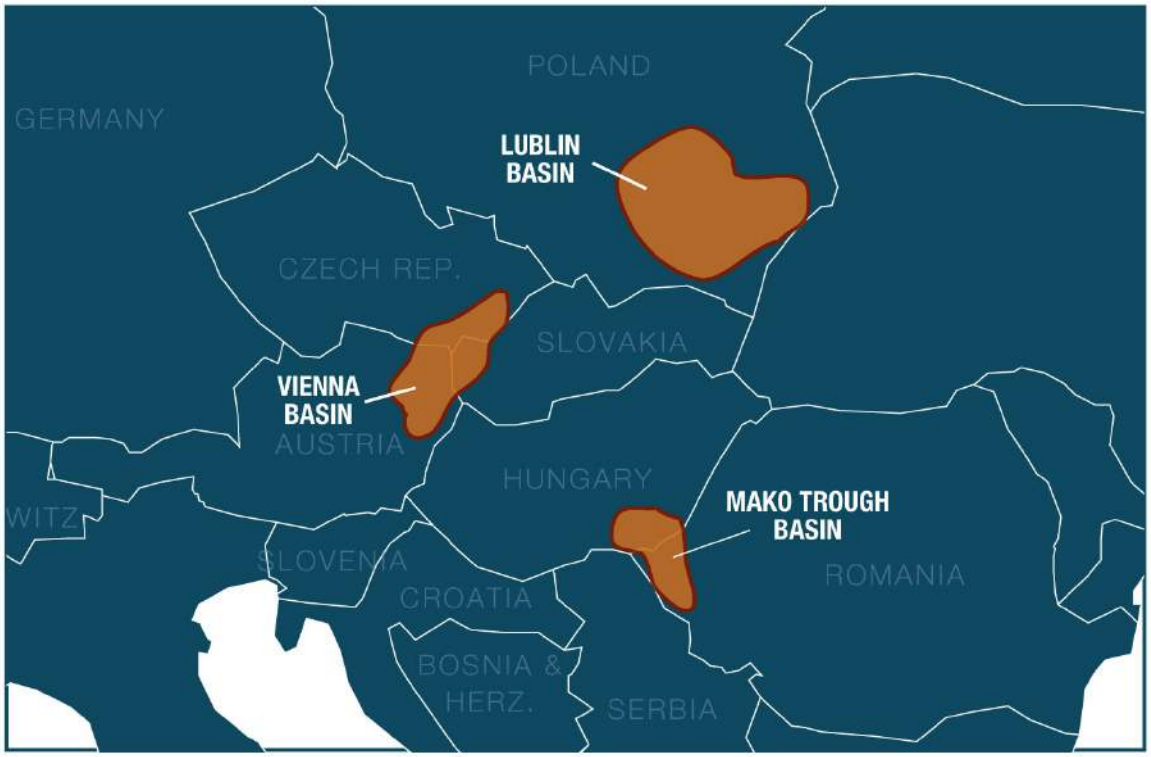
Spain is not a country usually mentioned in connection with shale gas, yet there are several reasons, why it is worth to comment on it. The country may have high deposits, which are already being explored and at the same time Spain is strongly dependent on energy imports and was severely hit by the economic crisis when unemployment skyrocketed. This increases the motivation of the government to support shale gas, with the Spanish PM repeatedly stating that he supports exploration and production in the future.

Romania & Czech Republic & Slovakia

Romania may rank in the top 3 EU countries by shale gas resources. The country is strongly dependent on natural gas imports from Russia. Combined with the motivation to boost its economy, this may be a major driver for production. In fact, the local government has already issued exploration permits and believes that production will start soon.

Concerning the Czech Republic, a moratorium is currently placed on production. Several companies have applied for exploration permits for an area incorporating about 3,000 km^2 in total, including protected areas like Český kras. After a petition by local residents exploration in natural reservoirs was denied. At time, the only expected deposits are located in southern Morava (Picture n. 10). The geology is however a complication and production would me much more expensive than in the U.S. Therefore for example the Czech Academy of Science has estimated that the price of shale gas produced in the Czech Republic would be the same as long-term import contracts. The only motivation may be therefore to decrease dependency on foreign imports.

Picture n. 10: Shale gas deposits in Central Europe



Source: PacWest Consulting Partners 2013

Slovakia in contradiction is trying to evade the debate in general. The Ministry for Environment has stated that no deposits have been proven until now and therefore it is too soon for any discussion (SME 2012). In 2012 there were some controversies, since an English company has invested about 30 million Euros in exploration in northeast of Slovakia, claiming that they are searching for conventional sources of oil and gas. The location is however usually mentioned in connection with possible shale gas deposits. Whether they have found something or not remains unclear, towns in proximity of the potential deposits have expressed interest in the industry though, citing high unemployment.

2.1.5. Summary for Europe

At the beginning of this chapter I have set a question, whether it is possible to repeat the American shale revolution elsewhere in the world. After considering the case of the European Union, its geological conditions, differences in the legal, regulatory framework, economic situation and the overall public opinion, one has to

conclude that it is not possible to speak about a revolution, but rather of an evolution of the gas industry in Europe.

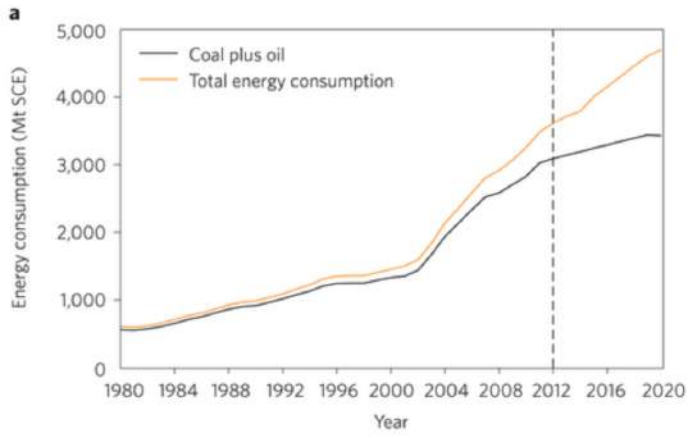
I tend to think that one of the downsides of regular elections is that it forces politicians to plan in a rather short-term horizon, leaving out the long-term interests of the country (such as lower energetic dependency) and focusing on getting re-elected. Therefore arguments based on macroeconomic data, especially the GDP increase and new jobs could motivate leaders to consider support for the shale gas industry, which would be based on a clear and simple regulatory framework and possible tax exemptions to boost investments. Listening to environmental concerns, I believe rules have to be set in a more clear way and an acceptable compromise would include a ban on fracking in natural reservoirs while permitting it elsewhere.

2.2. China

China is along with the United States, Canada and Argentina the only country, which at time produces gas from shale formations for commercial use. The volumes are at the moment very small, it is however the amount of possible resources and the interest of the government, which make the case interesting.

The country's energy consumption is strongly increasing and has nearly doubled in the past 10 years. As shown on Figure n. 7, China has covered its energetic needs mainly with fossil fuels.

Figure n 7: Energy consumption in China.



Source: Nature 2014

Burning coal and oil results in an increase of air pollution, which has become unbearable in the last decade. Burning natural gas is much more environmentally friendly. Also, the country strongly depends on oil imports. According to EIA the natural gas consumption will raise in the following years and the gap between domestic production and consumption will continue to widen. China seems aware of the dependencies on foreign supply, which these cause. Being aware of the success of shale gas in the United States, China sees the chance as well.

The country has along with the United States the biggest proven shale gas deposits on the planet, is however only at the beginning of commercial use. Compared to the United States, where 40,000 wells are operational, in China it is fewer than 100 (Wall Street Journal 2014) and the current production of 200 million m^3 annually accounts for about 0.2% of natural gas production. It has to be noted that the only production plant at time is the Fuling shale in Central China of an area of about 200km^2. Due to different porosity and depth of the shale (the shale layers are heavily faulted and deformed as a result of seismic activity, which allows only shorter horizontal drills), currently the costs of a new well are much higher than in the U.S. and the later production rate lower. (South China Morning Post 2014). The key challenge will be therefore to decrease the drilling costs. Considering how successful has Chine become in lowering production costs across other industries, I tend to believe that they will succeed in their goal.

China's ambitions however go further – this year (2014) the estimated production will reach 1.5 billion m^3, the goal set for the year 2015 is 6.5 billion m^3 and Chinese leader believe they should be able to produce around ten times more by the year 2020 (which is still incomparable to the U.S. production though). There are two main companies, which are interested into shale gas production in China. First it is China National Petroleum Corp. partnered with Royal Dutch Shell. The focus of PetroChina seems to be somewhere different – according to The Wall Street Journal they devote currently less than 1% of their total budget to shale/tight gas development. The second company – China Petroleum & Chemical Corp. (Sinopec) is already working on the earlier mentioned pilot project in Fuling and aims to add the most amount of production to fulfill the goals set by the government.

The circumstances in China slightly differ from Europe in favor of shale production. China is not a country with a rule of law and does not respect property

rights of inhabitants to land in the manor European countries do. Also, public awareness is limited and so is the discussion about the benefits and costs. Environmental concerns are also ignored and will likely be overlooked in the future as well, effectively decreasing costs. Thus, the given regulatory conditions offer shale producers a favorable position. Even though deposits are located across the country, the ones, with the greatest potential are located in the densely populated Eastern part of the country – Picture n. 11.

Picture n. 11: Shale gas deposits in China

Source: PacWest Consulting Partners 2013

In 2009 U.S. President Barack Obama agreed to share some American know-how in the area with the Chinese quoting "clean energy goals" and promote investments among U.S. companies (The White House, 2009). Also the cooperation of PetroChina with Royal Dutch Shell seems to boost technology exchange and will spare the country years of development.

Two major difficulties however arise – the water supply in China is lower than in the United States and the shale gas development is water-intense. Also, due

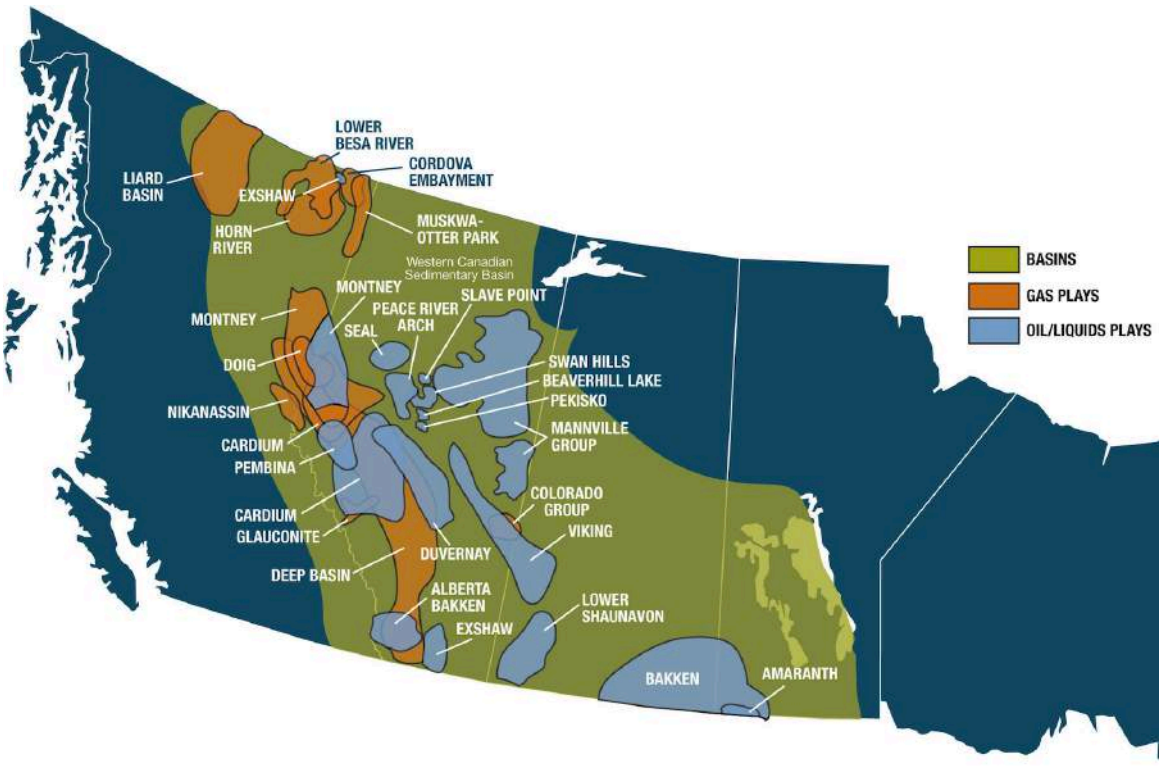
to the current energy structure, which favors oil and coal, the gas pipelines are underdeveloped and will require high investments in the future.

If however the pilot project should turn out to be a success, the "[reserves] of the Sichuan and Tarim basins are potentially enormous and could rival the Marcellus in terms of absolute scale" (Bernstein Research for Wall Street Journal 2014). China may be able to repeat the shale gas revolution as we have seen it in the United States.

2.3. Canada

Canada is already a large producer of both conventional natural gas and oil. Along with conventional resources, Canada has a considerable amount of unconventional resources – both shale gas (Table n. 1) and oil. Starting with shale gas, the EIA estimates that shale/tight gas accounts for about 15% of Canada's natural gas production. A graphic depiction of both shale gas and unconventional oil basins can be seen on Picture n. 12.

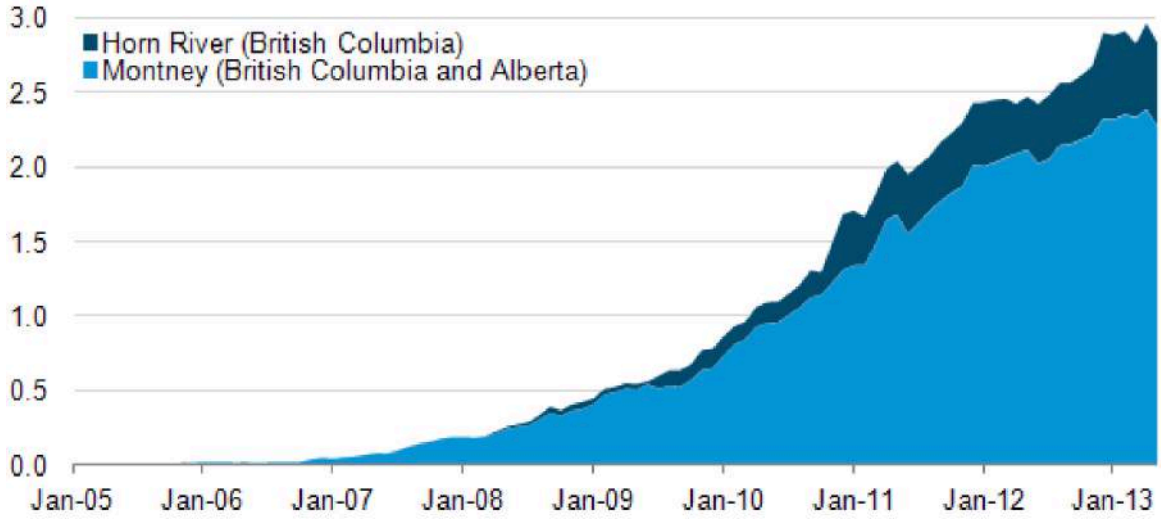
Picture n. 12: Unconventional resources in Canada



Source: PacWest Consulting Partners 2013

Production is concentrated in the western part of the country, mainly in British Columbia. It is estimated that about 60% of Canada's shale gas resources are located in the province (Canadian Natural Gas Initiative 2013) with several places also in Alberta and Quebec – the recent development of shale gas production is depicted on Figure n. 8.

Figure n. 8: Shale gas production in Canada 2005-2013[6]



Source: EIA 2013

The province of Quebec has however banned shale gas exploration in 2011 and asked a government committee to conduct a research on environmental impact. This report has been released in 2014 and a decision should be made later this year as well. Canada, being already a natural gas exporter is mainly interested in exporting shale gas.

Canada has however large reserves of unconventional oil as well. It is estimated that currently technically recoverable oil deposits in Canada peak at 174 billion barrels, out of which 169 are unconventional resources – light shale oil or oil from oil sands (Oil and Gas Info Canada 2013). Most of Canada's oil sands are located in Alberta. Economic benefits of oil sand mining are significant. The Department of Energy of Alberta estimates that every dollar invested in oil sands will generate 8

[6] Data in billion cubic feet per day. 1 billion cubic foot a day equals 10.33 billion m^3 a year

dollars of economic activity, resulting in additional almost 80 billion USD in federal and provincial government revenue over the next 20 years (Conference Board of Canada Report 2012). The local government also estimates that more than 120 thousand jobs are directly connected to the industry in the province. Apparently Alberta is quite convinced about the feasibility of production and several large projects are either in approval process or already under construction (Department of Energy Alberta 2014).

2.4. Other countries

Some countries around the world are in the process of exploring their own shale reserves; most of them however still wait to see the long-term outcome in the United States and potentially Europe. The ones, where significant basis are expected are already at the beginning of production.

2.4.1. Argentina

Argentina is believed to have the 3rd largest shale gas reserves worldwide. The reasons why the government is pushing production to start may be economy in the first place. The country went bankrupt in the previous decades several times (the last time only a few weeks ago, in August 2014) and constantly has difficulties paying of their debts. According to the IMF Argentina fights one of the highest inflation rates in the world. Also, the country's oil and gas imports equal 10 billion USD a year, which is virtually the whole trade deficit (EIA 2014; IMF 2014).

The most promising basis seems to be on the border to Chile – Vaca Muerta, which serves as a major conventional oil bases as well. The pilot program has begun in 2011, when the first horizontal well was drilled; currently the number has risen to more than 150. (E&P Magazine 2011). Since the region is still being explored and some drills were also a failure, the average gas prices from the Vaca Muerta basin are as high as 4-6 USD/mmBTU, compared to only 2USD for conventional gas, which is subsidized by the government and artificially kept low. To attract foreign investors such as Exxon, Total or Chevron the Argentinian government has granted

the shale gas a temporary exception, so the prices could meet the costs. During the past 2-3 years, the Argentinian petroleum company – YPF has signed joined ventures with Chevron and Shell. Chevron has promised to invest about 1.5 billion USD into several dozens horizontal wells and supposedly plans an investment of about 16 billion USD, should the initial program prove to be a success (Bloomberg 2013). The company also hopes to start shale oil production, with the initial target of about 50,000 barrels per day. Repsol, the Spanish oil & gas company has estimated in 2012 that about 77% of the resources in the basis belong to shale oil instead of shale gas, which is a rather rarity in the world.

Also Royal Dutch Shell announced (Bloomberg 2013) an increase in capital spending to 500 million in 2014 compared to 170 million the previous year for shale gas projects in Argentina. Various other companies, such as Petronas, Petrobras, Wintershall etc. are also involved either in exploration of the area or are in the process of negotiating a partnership with YPF.

A problem Argentina is facing is the trust issues from big companies. The government has decided in 2012 to nationalize the activities of Repsol, citing too slow development; paying out a rather small amount of compensation. Considering that the industry requires large investments, I believe most of the companies are facing a hard decision – invest money in one of the most promising basins around the world, which could bring great profits in the future but also risk that one day they will lose their property and know-how out of a made-up reason, or do not take the risk?

However also in Argentina, local residents are concerned with environmental problems. Most of the residents and organizations argue that no technology for treatment of waste is present in the region. The reason is that companies are not required to do so by law (compared to the U.S. for example), which only underlines the lack of proper regulations.

2.4.2. Algeria

On the other end of the world, Algeria is believed to be also in the top 5 countries with the most shale gas reserves. Unlike Argentina, Algeria is already an exporter of both oil and gas. Exports, which are an important part of the land's

income, are declining steadily (EIA 2014). The country has only recently (May 2014) granted license for exploration purposes and test drilling is about to follow in the next years. Especially European companies are interested in the resource, due to the proximity of import-heavy countries like Italy and Spain. These companies will also be able to invest financial resources and bring expertize to build the necessary infrastructure. The areas, where estimates place the reserves are deserted and not inhabited, which leaves out the environmental concerns. Despite that, according to he presidency of the country, exploration is to be carried out "with a view to preserving water resources and protecting the environment" (Algerian Press Service 2014). Another issue comes up as well – being a desert country, Algeria will have to find a solution to deliver the immense amount of water needed for horizontal drilling to the shale wells placed in the desert (Forbes 2014). A graphic depiction of shale gas resources in North Africa can be seen below, on Picture n. 13.

Picture n. 13: Shale gas deposits in North Africa

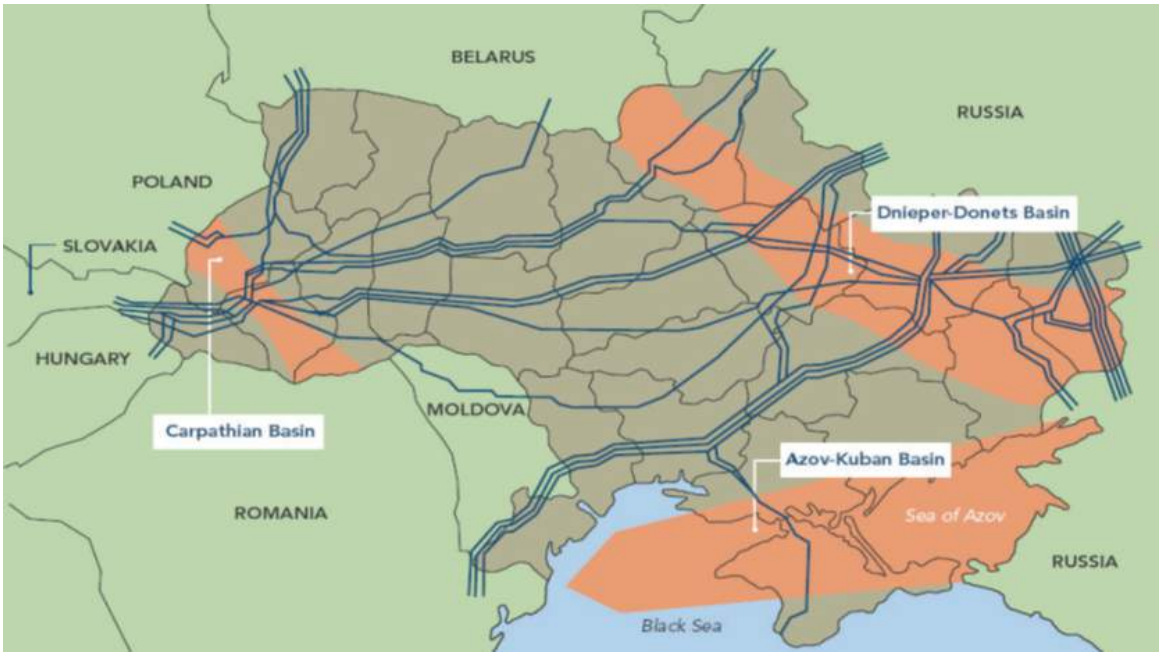
Source: PacWest Consulting Partners 2013

2.4.3. Ukraine

In Europe, Ukraine is believed to have the 3rd largest shale gas deposits. The previous government, led by Viktor Yanukovich, has already signed an agreement with the Italian consortium led by Eni to explore unconventional resources in the

Black Sea over the next years (Eni 2013). It was also in the process of negotiating a joint venture with Chevron to start exploration on large shale gas deposits in the eastern part of the country. Also Royal Dutch Shell was negotiating an agreement for exploration in the same area. When it comes to Crimea, several companies including Chevron, ExxonMobile, Repsol, PetroChina and Shell showed their interest in developing offshore deposits. In November 2013 the then President of Ukraine Viktor Yanukovich said that "we have attracted investors which will within five to seven years maximum double Ukraine's domestic gas production" and added that by 2020 the country hopes to cover for their gas consumption by itself (Financial Times 2013). Locations of on-shore shale gas deposits are below, on Picture n. 14.

Picture n. 14: Shale gas deposits in Ukraine



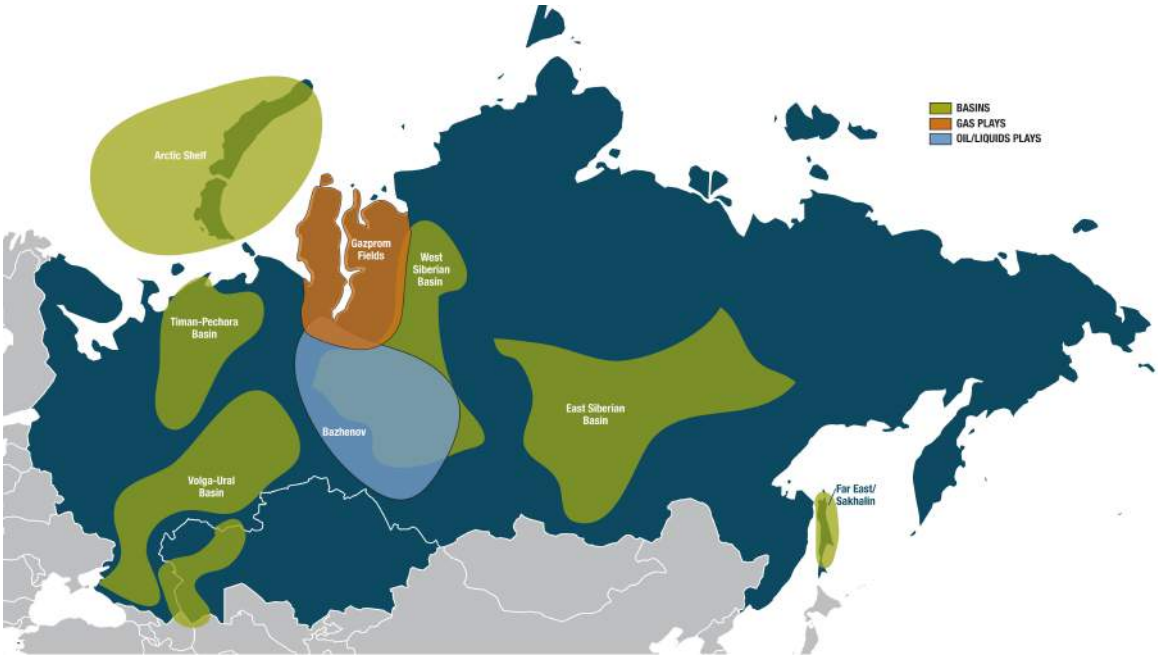
Source: Týden.cz 2014

Ukraine will however not be able to use its potential resources on the Crimea due to recent evolvement. War in the eastern part of the country will likely result in postponing of shale gas exploration projects as well. I will abstain from speculations, whether Russian aggression towards the peninsula and funding of terrorism and separatism might have been partially motivated by Ukraine's aim to become independent on gas imports, or whether it was just a coincidence.

2.4.4. Russia

As for Russia itself, the country could have immense shale oil reserves on Siberia – rough estimates put the currently recoverable amount using technology developed by American companies somewhere between 22-360 billion barrels possibly surpassing the country's conventional resources. The advantage of Russia is however that it has already a developed gas pipeline infrastructure and sufficient amounts of water in Siberia. Complications may pose the arctic climate and permafrost, which makes explorational drilling expensive. Also, the geological conditions of the reserves seems to be different – "the Bazhenov crude, much of it locked under Siberia's permafrost, may not have undergone the immense heat and pressure that produced the shale oil in the U.S., so it may not be "mature" enough to have commercial value." (Washington Post 2014). Russia's deposits can be seen on Picture n. 15.

Picture n. 15: Unconventional gas & oil deposits in Russia



Source: PacWest Consulting Partners 2013

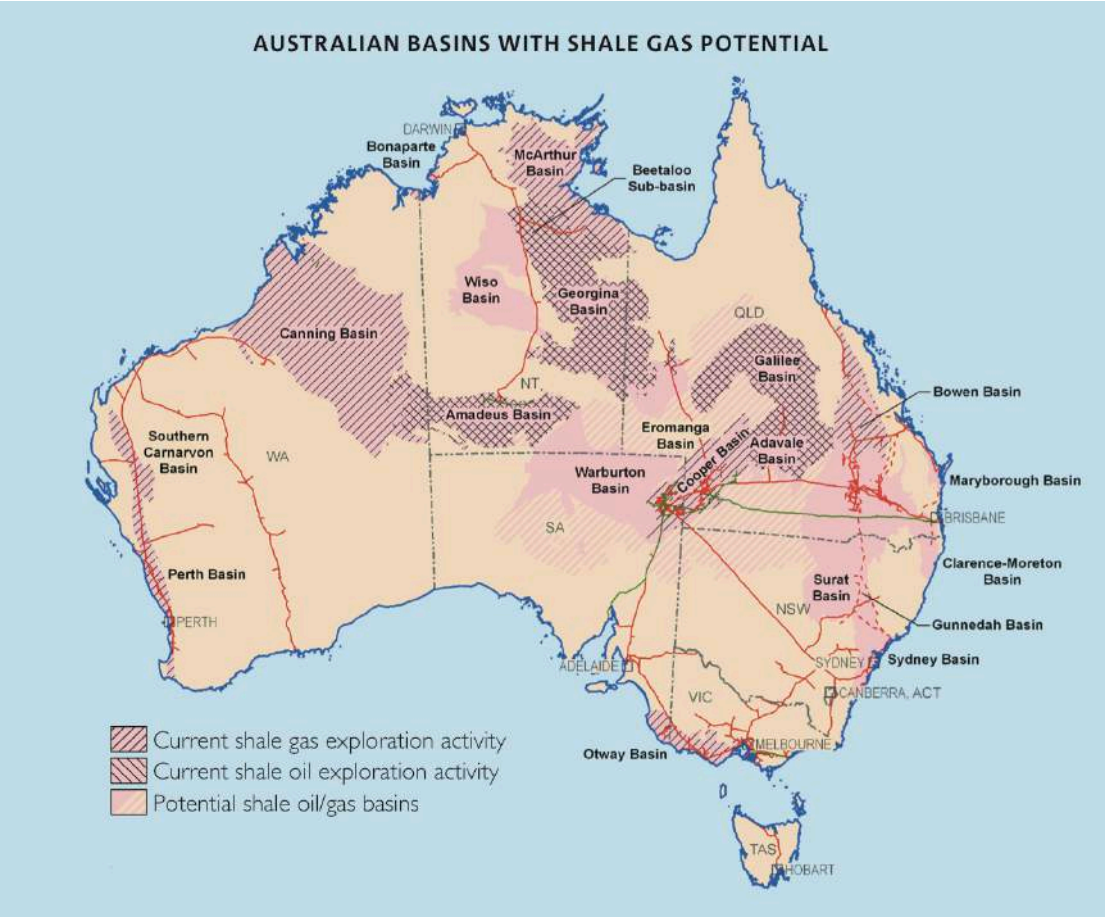
Russia, being one of the biggest conventional oil & gas producers has also seen the shale revolution and its possible repetition in Europe as a threat and did not consider shale resources to be of high importance until now – the local company

Rosneft has entered earlier in 2014 a partnership with Exxon Mobile and Gazprom with Shell to drill the first horizontal wells in the country. Only recently – in reaction to Russia's involvement in Ukraine, the United States and the European Union have issued sanctions, including specifically on passing know-how for shale/tight gas and oil to Russian companies. Without these, Russia is neither able to produce nor explore potential deposits.

2.4.5. Australia

Australia is believed to have a great potential. The country's deposits are quite large, located in remote areas and a positive government approach is present. Picture n. 16 shows more closely the areas believed to have unconventional resources.

Picture n. 16: Shale gas basins in Australia



Source: CSIRO – National Science Agency 2012

Australia is however a country with a rather small domestic population, which covers for its energy needs by itself and exports raw materials. However the current infrastructure is not meant for additional gas-export purposes and the country will have to build LNG facilities and terminals, which would likely require tens of billions USD. Some of them are already under construction and will be mentioned later (CSIRO – National Science Agency 2013)

2.4.6. South Africa

The last country, I would like to take a closer look at is South Africa. Already mentioned earlier – South Africa has granted right for exploration to domestic and foreign companies. In 2013 the moratorium on horizontal drilling was lifted and test drills have already taken place. The country is now in the process of creating a legal framework as the president of the country - Jacob Zuma has said: "Having evaluated the risks and opportunities, the final regulations will be released soon and will be followed by the processing and granting of licences." (South Africa Government Portal 2014). The question is, whether fracking in the earlier mentioned Karoo basin is economically viable. Royal Dutch Shell has done some exploration and was not able to confirm the actual amount of shale gas in place and slightly doubts the economic viability (Global Research 2014)

3. Influences on International Trade

At the beginning of the new millennium, the EIA has forecasted that the United States are close to the edge. The organization believed that while gas demand would continue to rise, domestic production would stagnate and the gap between production and consumption would widen. This and other similar forecasts have moved American companies to enter contracts on LNG imports. By the end of the decade, the shale gas revolution proved EIA's estimates to be "slightly" incorrect. The country was not anymore in need of such an amount of LNG imports and companies have requested authorization to re-export the contracted gas. These were the first firms to experience difficulties. Right after them, operators of LNG terminals suffered. Importing LNG was not necessary anymore and law prohibited export of domestically produces gas at that time (originating from the oil shocks in the 1970s).

Currently there is a discussion ongoing in the United States to what extent should be permits issued for gas exporters. Critics argue that this will raise the low gas prices in the United States and the country may loose its competitive advantage. Supporters believe that the classical model does not apply, since no completely free trade will be permitted and issues can be managed by exporting only the surplus over consumption. They also argue that exporting gas will decrease influence of other countries in the world and at the same time increase the power of the U.S. Meanwhile two notable regions seem to be interested in gas originating in the U.S. – Europe and East Asia.

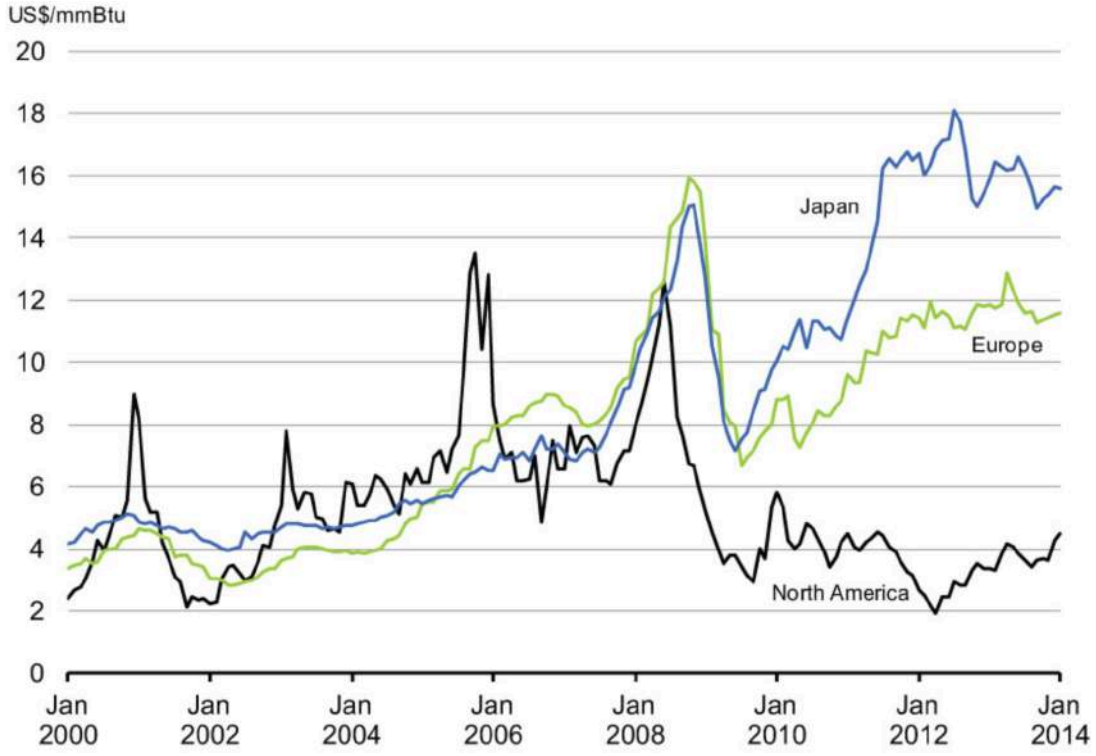
3.1. Possibility of new trade routes

3.1.1. North America to Asia

The decision on exporting North America's gas will depend on 2 main factors, which are connected together: on the gas prices in potential markets (mainly Japan, South Korea and Taiwan) and the competition. Reusing Figure n. 5 from earlier, one

can see that until approximately 2011 prices in Europe and Japan have been similar. The 2011 increase can be explained by the earthquake and the Fukushima disaster. Before that, Japan has produced 13% of its energy with nuclear power plants (EIA 2010). After the earthquake public pressure has led to a production cease in most of Japan's nuclear power plants resulting in higher demand for natural gas and therefore an increase in prices in the short-term.

Figure n. 5: Comparison of gas prices in North America, EU and Japan



Source: Government of Canada 2014, based on World Bank data

Prices in the long-term depend on several important factors – exporting costs and again – competition. The process of liquefying natural gas (for example shale gas in the U.S.) into LNG and exporting it (to for example Japan or South Korea) is a rather long and extremely expensive process. The United States have basically two options – either transport natural gas via Rocky Mountains to the West coast or build LNG terminals in the Gulf of Mexico and widen the Panama Canal, so it can accommodate large tankers. Taking into consideration that North America might be interested into exporting LNG to Europe as well, the Panama Canal would require widening without regard of the location of LNG terminal. The expansion project has

already begun in 2007 and is expected to be completed in 2015, doubling the capacity at a cost of more than 5 billion USD (Bloomberg 2013).

Also, an LNG export terminal cost up to 20 billion USD (Bloomberg 2014) and currently 6 are approved in the U.S. (International Business Times 2013). The initial investments and the fact that the gas has to be transported at -260 degrees Celsius to the other side of the Pacific Ocean have to mirror in the prices. Vice president of Tokyo Gas - Shigeru Muraki has estimated that it will not be economically feasible to sell gas under 10-11 USD/mmBTU. Nevertheless – this is still lower than the current prices (Washington Post 2014).

It is however not only North America, which is interested in the Asian market and the United States should act quickly. According to EIA, the U.S. will not be able to export LNG in large amounts until 2016 due to construction processes at the terminals. Also the bureaucracy when issuing export permits slows the progress down. At the moment South Korea is the only country interested in importing LNG from the U.S., which has a free-trade agreement at the same time. The process of receiving an approval is therefore more automatic, since the Department of Energy believes it is in "public interest". For non-FTA countries the process takes significantly longer with periods when objections and protests can be received and have to reviewed. Also, public interested has to be proven by the applicant. This results in delays, and motivates competition. Japan, not having a FTA with the U.S. has already agreed with Canada on closer cooperation on gas deals (Washington Post 2013). Meanwhile Australia is also starting commercial shale gas production and may prove to be a strong competition out of several reasons (to be assessed later). The American Council for Capital Formation has come up recently with a study, which underlies the fact that in order to be competitive, the Department of Energy has to speed-up the approval process in the future.

Canada in general is making rather bold plans to turn into an LNG exporter. Even though the west coast of Canada (notably British Columbia) has up to 14 proposed LNG terminals, no final decision has been made and construction work has not even started yet. Closest to an actual start are projects by Petronas, Chevron and Apache Corporation. The reasons for delays are mainly administrative – long approval process, environmental concerns, insufficient tax rules etc. Natural Gas Development Minister of British Columbia Rich Coleman has noted that the

province's "window for opportunity will close in the next 5-7 years." (The Globe and Mail 2014).

As stated earlier, exporting LNG will require significant investments, which are best covered by long-term contracts. The LNG industry is at the time based on long-term contracts, however a new approach becomes visible – the international market based model, where short-term trading is preferred. Bain & Company noted that even though currently only 15% of LNG is traded outside of long-term contracts, the process is similar to how coal has become traded on the spot-market. It is a paradox that the main driver of this so called gas-on-gas pricing is the actual construction of LNG terminal in the U.S., which will provide the Asian buyers with a good choice of the source – no company will have a monopoly to export gas from the U.S. and they will not only face competition from other countries, but also compete between themselves. The market in Singapore, where all main players of the world like Shell, BP etc. have already established their trading desk, is an indicator of "the growing market for spot and short-term LNG contracts both in Asia-Pacific and globally" (Bain & Company 2011)

3.1.2. North America to Europe

Since it will likely take a while until Europe will be able to fully benefit from its shale gas reserves and even then the impact will be likely smaller than in the U.S., the continent is trying to find other sources of energy. The consumption of the EU is about 450 billion m^3 (Eurostat 2012), production about 164 billion m^3 (+ Norway 115 billion m^3). The main pipeline import source differs around the continent. For Western Europe it is Norway, for Central Europe Russia and for Southern Europe Algeria and Libya. At the same time, the EU has an advanced LNG import infrastructure with Qatar, Nigeria and Algeria playing the main role and Spain, the UK and France being the main destination.

Energy security is in case of Europe the most prevalent reason for being interested into gas imports from North America. Mainly countries in Central Europe are suffering under lack of diversity, with Bulgaria importing 99%, Slovakia 98%, the Czech Republic 72% and Poland 60% from Russia. The lack of competition and the monopoly power of Russia are reflected into gas prices for Central Europe – for

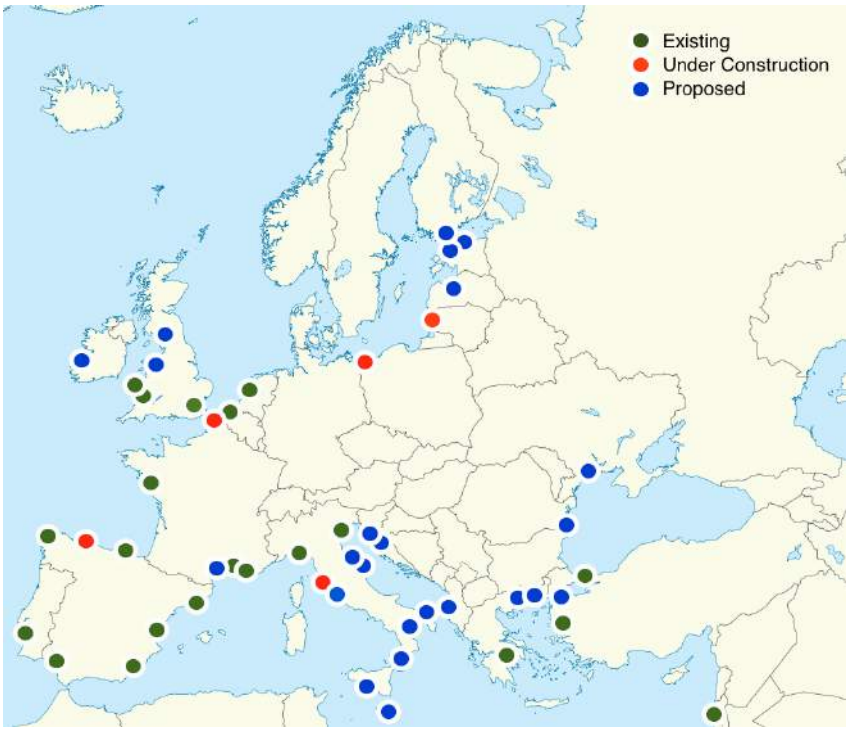
example Poland has paid in 2012 a 28% price premium compared to Germany and 40% more than the UK. Also, in past Ukraine and Russia were not able to come to an agreement and the region had to face outages in imports. Counting in the complicated relationship at time and the bad historic experience with Russia, it comes as no wonder that it is mainly Central Europe and Baltic countries, which are prevalently interested in diversifying their import sources.

It seems to me that despite the current presidency of Barack Obama, which is (or rather was) accompanied by a number of concessions and "restarts" towards Russia, the U.S. are interested into helping their allies. Currently a legislation, which would make gas exports to non-FTA but NATO member countries easier, is being considered (The Economic Times, 2013). Central European countries are also not passive regarding potential imports and are lobbying in the U.S. for an approval and a soon beginning of American gas exports to Europe, especially after recent events. (National Journal 2014). Earlier this year, the U.S. President Barack Obama met in Brussels with the President of the European Council Herman van Rompuy and the President of the European Commission Jose Manuel Barosso to discuss Europe's energetic security. The summit made a joint statement: "The situation in Ukraine proves the need to reinforce energy security in Europe and we are considering new collaborative efforts to achieve this goal. We welcome the prospect of US liquid natural gas exports in the future since additional global supplies will benefit Europe and other strategic partners" (The Guardian 2014).

Similar to Asia, Europe is well prepared for importing LNG from the United States. Speaking general from the technological point of view, there is no difference between importing LNG from Qatar and the United States.

Picture n. 17 shows the locations of LNG terminal across Europe. It is quite easy to distinguish which countries are large LNG importers already and which countries are trying to find a new source of natural gas – by the number of present, U/C or proposed terminals.

Picture n. 17: LNG terminals in Europe



Source: own elaboration, based on publicly available data

Closest to actual shipments is the UK thanks to an agreement between the British company Centrica and Cheniere Energy, the owner of a Louisiana LNG terminal, which is currently undergoing a 20 billion USD reconstruction to serve as an export facility. Shipments are to begin in 2015 (BBC 2013)

A difficulty however arises. The prices in Europe are around 12 USD/mmBTU, lower than in Asia (14-18 USD). Asian customers, especially in Japan are willing to pay a higher premium than Europeans and motivate American export companies to prefer Asian customers. American gas will likely cost on the European market 8-9 USD/mmBTU compared to 10-11USD on the Japan Market (Washington Post 2013). The difference cannot be explained only by the fact that Japan is "further away" from the Gulf of Mexico than Europe. Economic theories would suggest that prices have to drop in Asia and rise in Europe in order for exports to Europe to be competitive. There may be two influences: The political and regulatory, where the U.S. Government will favor exports to Europe to a certain degree. The FTA Agreement between the U.S. and Europe, which is currently under negotiations may prove important, since it will decrease bureaucracy and speed-up the process of

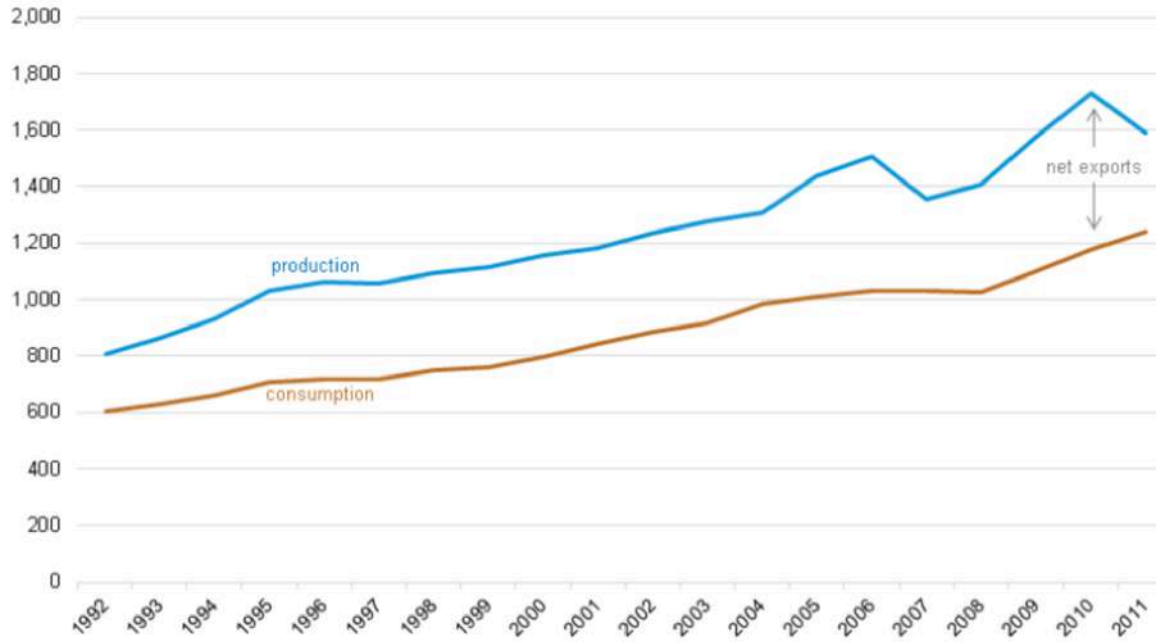
getting exporting permits, thus making export less expensive and better for long-term planning.

Another influence may be the price-drop in Japan and Asia. If it is quite significant, for example due to a strong competitor on the export market, the motivation for American companies to export to Europe will increase.

3.1.3. Australia do Asia

The competitor for American exports, which I have hinted on in the previous paragraph, will likely be Australia. The country has a long-term history for producing more natural gas than consuming, as depicted on Figure n. 9

Figure n. 9: Production and consumption of natural gas in Australia[7]



Source: EIA 2012

Since Australia has no pipelines, which could be used for exporting gas, it is exported in the form of LNG – with Japan (77%) and China (17%) being the main destinations (EIA 2014). This in turn means that Australia has an existing and well-developed know-how for LNG exports and is ahead of the United States. Australia

[7] Data in billion cubic feet. 1.6 trillion cubic feet = 45.32 billion m^3

has already several LNG terminals and invested in the construction of other LNG projects 180 billion USD since 2012. It is to rival Qatar by 2017 as the biggest natural gas exporter (LuxResearch 2014). Moreover Australia has already signed export contracts with Korea Gas Corp., Malaysia's Petronas, Japan's Kansai Electric and China National Offshore Oil Corp. Noting the Asian mentality, which is focused on long-term and stability, this may prove important.

On the other hand, Australia's production has not yet even started and therefore the country may pose a competition to the United States not sooner than in a couple of years. It appears to me that Australia, motivated by the shale revolution in the United States, has made a decision to exploit shale gas mainly out of commercial reasons and has also adjusted the development of the infrastructure, so it can be directly exported. Which is quite logical, considering that there is no actual use for shale gas on the domestic market. That in turn means that the discussion whether to export gas or not will not be as heated in Australia as it is in the United States right now. Australia has to pay attention though on not "over-investing" – the immense amount of investment in the recent years has driven up the Australian Dollar and meanwhile construction and labor costs have risen as well. The more countries invest into exporting facilities, the more they will be able to export gas, likely decreasing worldwide LNG prices and that may pose a threat to the return of Australia's investments. A vicious circle indeed and finding balance may prove crucial.

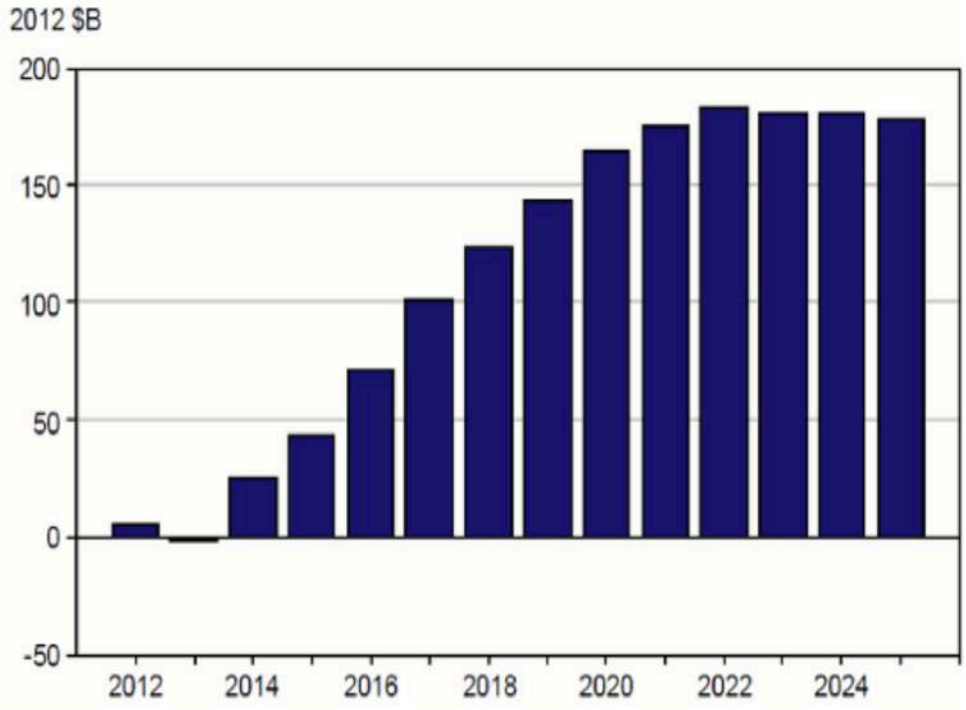
3.1.4. Influence on the trade balance

Energies are a quite significant item on the trade balance sheet and the vast majority of oil and gas exporting countries are in trade surplus. On the other hand, deficits in energy-importing countries must be present (Germany being an exception). I will explain the basic principles and impact on the trade balance on the example of the United States.

An increase in natural gas and oil productions will influence the balance of trade in two ways. A direct impact is a decrease in imports of the commodity, which in turn will decrease the trade deficit. Shale gas, being relatively cheap in the U.S. attracts investments in the area of manufacturing, petro chemistry, metallurgy and

others, which are energy intensive. In fact these industries have outperformed the average growth in manufacturing already in 2012 and even though the growth rate of manufacturing should increase to 3.5% in 2020, energy-intensive industries will grow by 6-7% per annum (IHS 2013). The final products are however not intended for domestic use only, but also for export. This is an indirect boost caused by shale gas, which will have impact on the trade deficit. In fact, the U.S. trade deficit should decrease in 2020 by 164 billion USD, by a third compared to the current state as it is seen in Figure n. 10.

Figure n. 10: Forecast of the U.S. trade deficit decrease



Source: IHS 2013

As stated in the second chapter shale gas production will have an influence on gas prices for households and the disposable income will rise. This may cause a counter-effect, since the higher income will be at least partially spend on higher consumption and therefore increase imports and raise the trade deficit. I have not found any estimates and it is hard to predict exact values, which is beyond the scope of this thesis, but considering the number of households in the United States (115 million according to CNN 2013) and the average rise, even if the whole increase in

disposable income was invested into imported products, it would not outweigh the decrease of trade deficit.

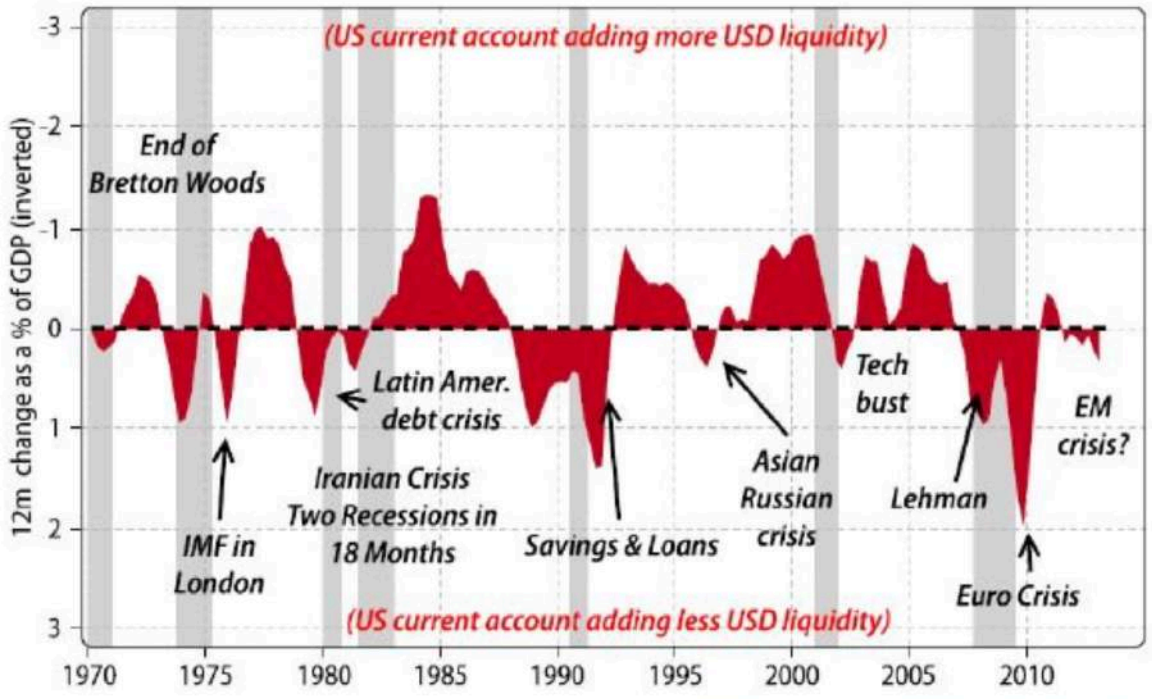
The estimates for the United Kingdom are very similar. Considering a theoretical case, of the UK becoming self-sufficient that would mean that 27 billion USD would remain in the economy. If circulating they would generate a value of 150 billion. The newspaper wanted to prove that shale gas would have influence on the balance of trade and payments.

3.1.5. Impact on the USD as the world reserve currency

The impact on the trade balance noted in the previous paragraphs could have in turn an impact on the USD, which serves as the world reserve currency at time. In my opinion the amount and availability of the currency in the world makes a specific currency the world currency. The United States have been running a trade deficit for most of the time due to two reasons: imported oil and manufactured goods from Asia, both paid for in USD. Both, oil producing and manufacturing countries have in turn invested the acquired dollars in government bonds. So are the first three places in countries with the highest foreign exchange reserves given out to China, Japan and Saudi Arabia (IMF 2014). Importing less energies and exporting manufactured products will decrease the trade deficit of the United States, thus decreasing the supply of USD overbroad. Logically, since the trade balance of the world will always be evened up, a lower trade deficit in the U.S. will have impact somewhere else, given there is no adjustment of the exchange rates (which is not present, even though the trade deficit is declining already).

Empirical studies, have shown that most of the time when the U.S. added less liquidity to the world economy, it has led to a crisis somewhere around the world, as shown on Figure n. 11. The question is, whether history will repeat itself and where. Considering that most of the liquidity did flow to emerging markets and they have benefited from it and build up external debt denominated in USD, they may also suffer, when the supply of USD is reduced. As noted by John Mauldin, the exact same situation has happened in the 1990s, where these Asian and Latin American markets "took a beating (…) because of boom-and-bust credit cycles caused by hot capital inflows followed by rapid capital outflows." (Mauldin 2013)

Figure n. 11: Changes in the U.S. current account balance & financial crises



Source: John Mauldin 2013

There are two possible solutions. Number one, as suggested by the Monetary Authority of Singapore, which serves as the local Central bank is that "the US Federal Reserve [System – author note] should consider its role to be that of central banker to the world and that it should thus make sure there is a sufficient supply of dollars to facilitate global trade." Which translated is nothing else than quantitative easing over an unlimited time period. Possibly, if the Federal Reserve System does not meet the expectations of players, who are using the USD as currency in international business, they may look for other solutions. I will abstain from an analysis, whether the Chinese Yuan is a suitable reserve currency or not and will instead close up again with John Mauldin, who believes that while the CNY may become "a" reserve currency, it will certainly not replace the USD as "the" reserve currency.

3.2. Impact on the oil and gas market

The oil and gas markets have been unchallenged for years – countries were either endowed with natural resources or not. Shale gas and oil are indeed game changers and several issues come up, connected with the impact of unconventional

resources on oil/gas prices worldwide. Also, questionable is the impact on current producers.

3.2.1. Oil

Our focus in the previous chapter was more on shale gas, since it offers a much higher potential for export and has a significant impact on international business. Switching to oil, it may not be exported from the U.S. (yet) but a lower demand would nevertheless have influence on prices. Oil is prevalently sold based on spot/forward prices than on long-term contracts like natural gas and therefore fluctuations have bigger impact. In my analysis I will focus on 2 areas – OPEC countries, and non-OPEC countries, meaning mainly Russia and Central Asia.

OPEC countries

The Organization of Petroleum Exporting Countries (OPEC) is basically a cartel of oil producing countries founded in 1960, which have set their goal to influence world-oil prices and securing a steady income to its members, achieved through hindering competition between themselves. OPEC was aware of the possible potential of unconventional sources around the world for quite a time, yet did not have to fear competition due to past low oil prices, which made use of those resources economically unfeasible. For years, OPEC countries have used spare capacity and the amount of oil produced to influence prices worldwide. If they believed the prices were low, producing less meant a rise and vice-versa. The situation has however changed – the recent decade has seen an increase in oil prices (with a break during the worst phase of the financial crisis).

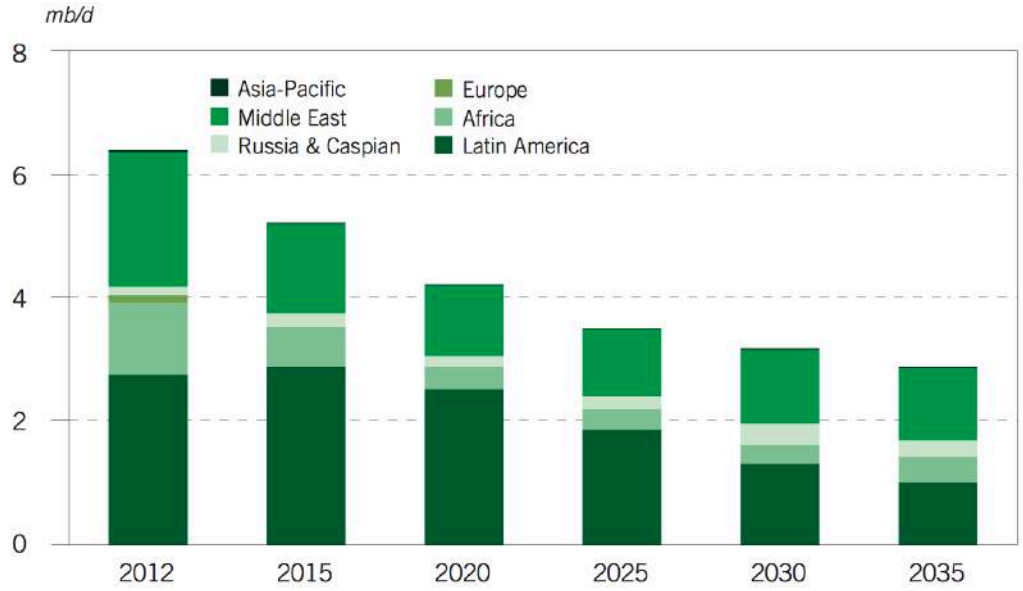
Canadian oil sand producers need stable prices above 70 USD per barrel (Financial Post 2012) and American shale oil producers of more than 80 USD per barrel (International Association for Energy Economics 2013)

Worries that OPEC countries will crush the unconventional industry by substantially lowering oil prices seem impossible to me out of a very prosaic reason – they cannot afford it. In most of OPEC countries oil-income is the prevalent part of the state budged. For example Saudi Arabia, fearing the revolutions of Arab Spring has announced to spend 630 billion USD (International Association for Energy Economics 2013) on social welfare and building projects. The break-even price for

the country lies at 88 USD per barrel and it was always prevalently Saudi Arabia, which has a massive spare capacity and was (is) able to influence up and down oil prices. BP does not agree though and forecasts a reaction of OPEC countries to rising non-OPEC supplies (BP 2013).

OPEC issues every year its World Oil Outlook, which is an extensive summary of forecasts how the oil market is going to evolve based on the organizations opinion. OPEC agrees that shale/tight oil will have influence on its business in the next decade or so. The organization however does not consider unconventional oil resources a danger. Which is quite understandable for now, taking in account that apart from North America no commercial shale/tight oil production has taken place yet. The position of OPEC on the U.S. market has been traditionally weaker. OPEC accounts for about 40% of world's oil production. The United States consume about 18.5 million barrels a day out of which about a half is imported and only approximately one third of all imports is covered for by OPEC members, bringing the dependency of the U.S. economy on OPEC's oil to not more than 18% (EIA 2013). They also believe that the daily oil output of Northern America is going to rise significantly over the following years from about 1 million barrels a day in 2010 to about 5 million on 2017. The organization therefore counts on decreasing imports in the U.S. market, as seen on Figure n. 12.

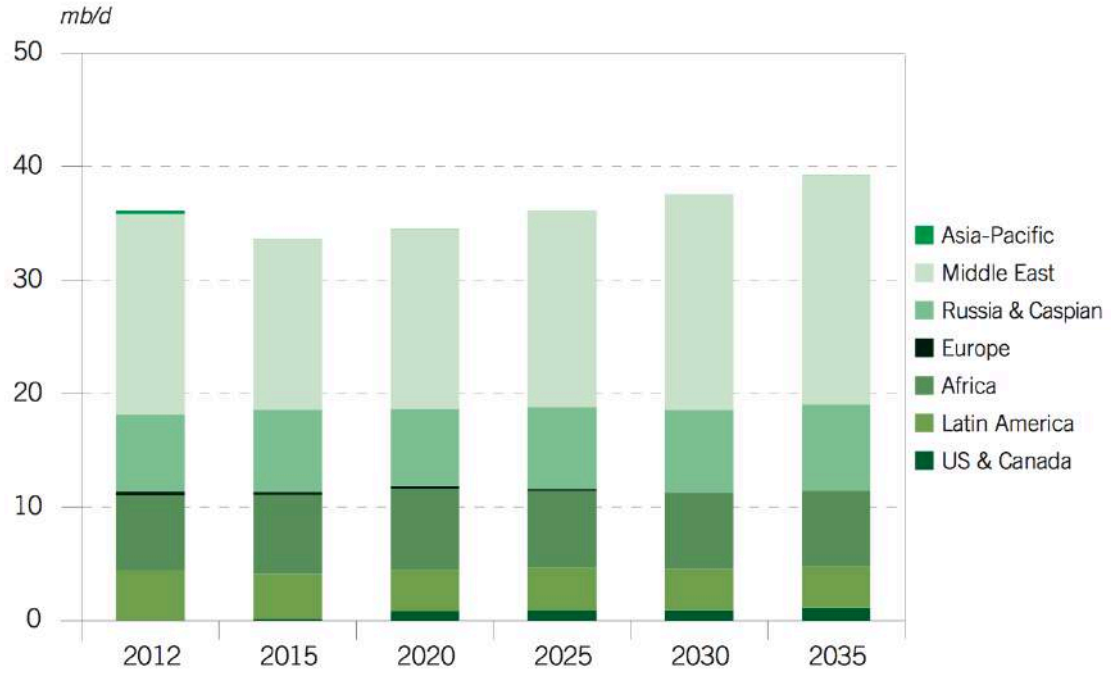
Figure n. 12: Crude oil imports to U.S. and Canada by region of origin.



Source: OPEC 2013

Taking in account the importance of the U.S. market for OPEC it may be a loss but in my opinion not a very dramatic one. OPEC believes that unlike shale gas, tight oil from the U.S. and Canada will never be meant for export in high amounts (Figure n. 13) and therefore is not going to harm the cartel on other important markets, mainly Asia.

Figure n. 13: Global oil exports by origin in 2012-2035.

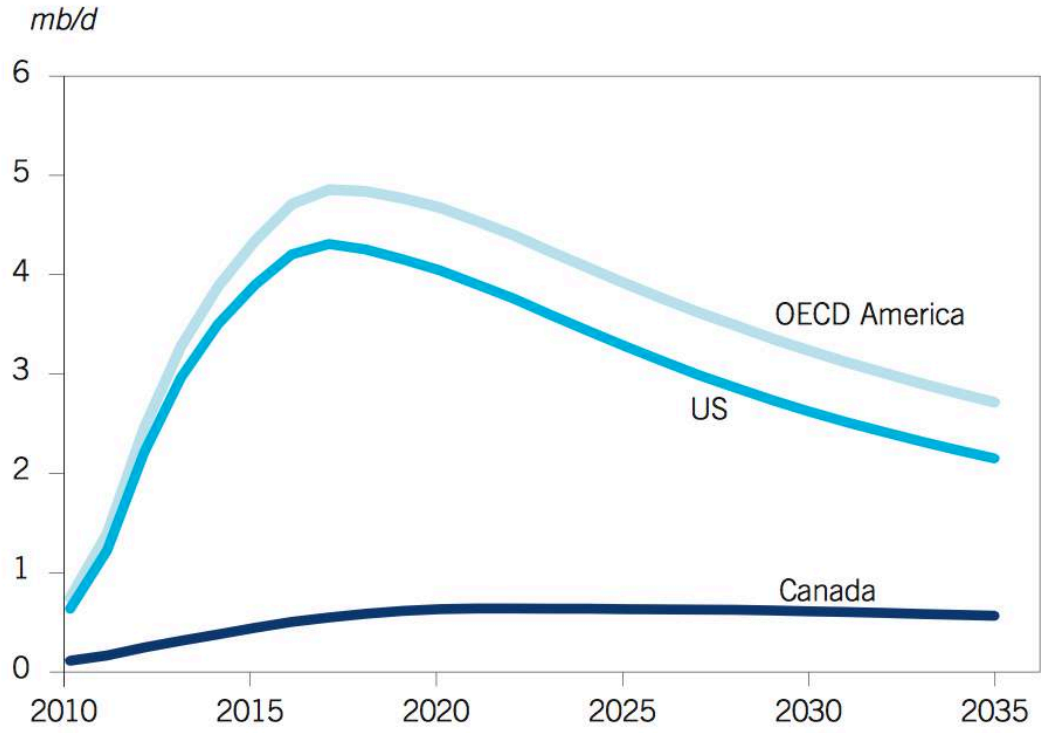


Source: OPEC 2013

Furthermore, OPEC believes that the unconventional oil boom in the U.S. is only temporary and production will start to decline by 2017 – "The rapid acceleration of tight oil supply in the U.S. (…) is not thought to be sustainable over the long term" (OPEC: World Oil Outlook 2013). OPECs estimates can be seen on Figure n. 14. These expectations are similar to those of EIA on Figure n. 6.

Overall, the negative impact, OPEC is expecting is a decline in production by 1 million barrels a day, slipping just under the cartels production target of 30 million barrels a day.

Figure n. 14: Unconventional oil supply in the U.S. and Canada in 2010-2035.



Source: OPEC 2013

The IEA is of same opinion as the cartel, pushing the beginning of decline in production to 2025 according to its Word Energy Outlook. The forecast is that even though the U.S. may become the biggest oil producer in the world by 2020, the trend will be only temporary and Saudi Arabia will take over later in the decade due to a decline of U.S. production.

The problem however with the OPEC forecast is that it is subjective to a certain degree and tends to see the situation in a more positive light. Even though it counts also with a scenario, when U.S. production is not going to decline, it hesitates to openly admit that this is a relevant option and marginalizes it. The shale/tight oil and gas industry has undergone significant changes and the relevance of reports and studies is a rather short-term thing. So, for example, OPEC has forecasted in their 2011 outlook that shale/tight oil will remain a marginal source and will not have any influence on the cartel exports to North America. 2 years later OPEC openly admits the situation has changed, opening up the question to what degree will the estimates differ in the next year's outlook.

Non-OPEC countries

As already hinted in the previous paragraphs, shale/tight oil is likely to remain a domain of North America in the next years and will not be exported in significant amounts out of the region. Therefore I see direct impact neither on OPEC countries nor on Russia and producers in Central Asia.

If however 3rd countries with large shale oil resources like for example Argentina should engage in production in the future, they would likely opt for export. Estimating production costs is however difficult and depends on various aspects of the specific basin. The real impact on world oil prices remains therefore unclear at this time.

3.2.2. Gas producers

The shale gas boom in the United States on the other hand may hit gas producers quite hard. Only a few years ago Qatar, the world's largest LNG exporter, was planning on exporting LNG to the U.S. and built in cooperation with Exxon an import facility in Louisiana and also bough new ships in order to be able to transport the gas overseas. The changes in the U.S. have forced the country to reconsider plans. The import terminal is being converted into an export terminal, so the owners can at least earn profits on exporting natural gas from the U.S.

Similar to oil, the current impact on traditional producers is limited to a decrease in imports to the United States. However, shale gas may pose unlike oil a potential threat to traditional producers in the long term in two different ways. According to Bloomberg, Qatar (along with Malaysia) is now charging a price premium of 6 USD/mmBTU for Asian customers, driving Asian prices up to 14-18 USD/mmBTU. As mentioned earlier, prices of American shale gas on the Asian market, moving around 10-11 USD (Australian being likely even lower) would cost Qatar quite a significant amount of money. This theoretical 30-40% drop would according to my calculations cost the Qatar economy about 20-25 billion USD a year and also likely decrease government savings. North America and Australia will not only directly compete with Qatar and Malaysia over the Asian customer, but also decrease prices of natural gas and profits of current producers.

There is however also an opportunity for Qatar. The country is after Iran the largest producer of natural gas in the region (Iran will not be taken into consideration now due to international sanctions and hostility of the Arab world). Even though a paradox, Kuwait and the UAE have recently become net importers of natural gas, especially during hot summer months, when the need for electricity rises. I see an opportunity for Qatar to engage more into international trade with countries in the region. However, most of the countries in the Gulf region are investigating their own shale gas resources, out of the reasons mentioned above. The consulting firm A. T. Kearney for example argues that Saudi Arabia is being crushed between two rocks – on one hand, the increased demand for electricity is forcing the country to burn oil, lowering exports on the other hand and decreasing profits of the government. Saudi Arabia may have significant deposits of shale gas and seems to be strongly interested in exploring them. The consultants also believe that the role of unconventional resources in the region will be cleared up in the next 3-5 years.

A country seriously hit by the shale gas revolution may be Russia in the future. LNG producers around the world have the advantage that they can export their product to virtually any country, which has access to an import terminal, significantly increasing the range of potential customer. In Russia natural gas travels from the country to its customers solely via gas pipelines. Thus, if the end customer finds another (closer, cheaper, more reliable) source, the producer will have it difficult to sell the product elsewhere. Russia's federal budget strongly depends on income from gas & oil sale – estimates ranging from 50% as given by President Putin to 80% according to sources from Russia's Accounts Chamber (Natural Gas Europe based on RT 2012). A "worst nightmare" scenario for Russia would be therefore a shale gas revolution in Europe and China, striking both - the key market and the potential future big market down. We have already concluded though that this scenario is rather unlikely to happen. Exports from the United States to Europe (and the goal of Central European countries to diversify suppliers) and China developing its own capabilities at the same time will pose a threat to Russia. Especially now, when both, the U.S. and the European Union have forbidden the export of advanced technologies for shale gas exploitation to Russia as a reaction to Russia's

involvement in Ukraine, effectively hindering the country to make use of its shale gas deposits in the following years.

3.3. Political aspects

Natural resources have always influenced strategic decision of world leaders. Current exporters of oil and gas were presented with an immense amount of financial resources and power came along with the money. The United States have based their foreign policy partially also on energetic security. Becoming more and more self-sufficient may have an influence on the political strategies and landscape.

3.3.1. Middle East

A few decades ago, the United States agreed under the Carter doctrine and Reagan Corollary to defend the Gulf States against aggression from other countries and committed to the stability of region. They have seen the region as crucial for the energetic security of North America and also, they have hoped that allying with the region will support the position of the USD as the world currency due to investments of petrodollars into U.S. treasury bonds. The U.S. have managed to acquire support of the regional governments (maybe except Iran after the 1979 revolution and its regional allies). They have proven their determination by entering the first Gulf War, after Iraq invaded Kuwait. U.S. troops have stayed in the region permanently since then, opening large military bases in Saudi Arabia and making Bahrain the basis of the 5th fleet.

It seems to me though that the United States are less committed to keep stability of the region in the recent years. Iraq was abandoned in 2011 and is currently falling apart. The Obama administration was against direct involvement of U.S. troops in the fight against Islamic terrorism in the country and only recently engaged into limited air strikes. There is a question left open who is going to be in charge of oil production – considering that both Kurds in the north and IS (Islamic State of Iraq and the Levant) claim to have partial control over oil fields. Weather this has something to do with the fact that the U.S. are less dependent on the regions

oil or it is just a principal philosophy of the current President is up for discussion. My personal opinion is that if the U.S. were strongly dependent on Iraqi oil production (like some people tend to believe that invading Iraq was because of its oil), they would much more engage into keeping stability of it. Other sources argue that currently only 10% of the Gulf's production is exported to North America. They believe that American strategy is still based on the principle that oil should serve the global economy, its growth and wellbeing and has to be an important part of the U.S. foreign policy (Middle East Online 2013).

Another influence, hinted already in the previous chapter may be a drop of prices of oil due to increase of domestic production in North America and surplus of oil on the world markets. If Asia will not be able to cover for this fallout, budgets of Gulf States may be severely hit. Certain fiscal adjustments may prove necessary and as we have seen elsewhere in the region, inhabitants not exactly accept them with pleasure, especially since saving on social welfare has never been necessary before. Questionable is, whether this will influence funding of various interests of these countries around the world. Ranging from donations that promote Islam in Europe (Saudi Arabia and Qatar support constructions of mosques) to funding of terrorist organizations like Taliban in Afghanistan and Pakistan or Hamas in the Palestine territories. Wealthy individuals from Saudi Arabia also might have made significant donations to Al-Qaeda in Iraq or Yemen or IS in Syria and Iraq.

3.3.2. Americas

The shale gas and oil revolution may have also impact on NAFTA - the free-trade agreement in North America between the U.S., Canada and Mexico. Mexico is currently trying to reform its energy policy and may be successful in regaining its position as an exporter of energy. Currently the most of the U.S. foreign policy towards Mexico is limited to a fight either against immigration or drugs production and trafficking. If the region should become a net exporter of energy, this may shift the focus of the U.S. and boosts the importance of Mexico in their foreign security policy.

In Southern America recent decades have seen a decrease of U.S. influence in the region and rise of openly anti-American politicians. Even though Venezuela has

the largest proven conventional oil reserves in the world, social experiments, disrespect to property rights (especially those of foreign companies) and dilettantish economic policy have led to a situation that the break-even price for the country lies at 100 USD per barrel (AboutOil.com 2014). Considering that 43% of Venezuela's oil export headed for the U.S. in the past (EIA 2010), the country may be particularly hard hit by both, the possible drop of oil prices and by the decrease of U.S. imports. It can hope to find new customers in South America and face tough competition from Argentina, once it becomes an unconventional oil producer. Importing American technology and know-how that is necessary for any South-American country, which is thinking about exploring its unconventional deposits will furthermore strengthen U.S. influence.

3.3.3. Asia

In case of Asia, shale gas will play a prime role. The U.S. will become an exporter and a significant amount will find its customer in Asian countries. Being a reliable and politically stable source, this will lead to stronger U.S. influence in the region. In case of China on the other hand, the U.S. may be equipped with a new argument in diplomatic negotiations – technology and know-how exports. Even though these are mostly held by private companies, I think it is very unlikely that the U.S. government will stand by and miss the opportunity to support its arguments. Other than that, increasing influence in Asian countries like Japan, South Korea and Taiwan (along with other countries as well) might effectively reconfirm the current alliance and help control Chinese influence in the region.

Meanwhile in Central Asia, Azerbaijan, Uzbekistan and Turkmenistan are exploring possible shale gas deposits. Since conventional deposits in Central Asia are abundant and rather cheap to produce, the speed of developing shale resources is rather slow. In the future both conventional and unconventional deposits might find its customer on the European and Asian markets.

3.3.4. Africa

Africa may play a role in connection with China. China is not going to achieve energetic self-sufficiency in the foreseeable future and will cover for 70% of its oil needs by importing it (EIA 2013). EIA also predicts that imports from Africa to China will rise. China will try to diversify suppliers and is already strongly investing in oil projects on the continent, mainly in Sudan and Angola and has signed an exploration agreement with South Africa in the hope to find shale/tight oil deposits (CNN 2013). So even though the direct impact on Africa will be very limited, it may become a valuable source for other countries. This in turn will lead to conservation of the current political situation. China unlike the U.S. and Europe does not look at human rights in their aid and development programs. A greater Chinese involvement will likely therefore keep current governments intact and push reforms and changes on the political landscape far in the future.

3.3.5. Europe

In Europe possible exports of shale gas from the United States and also development of local deposits will help diversificate energy sources. The continent and especially its central part will become less dependent on natural gas from Russia. Russia has a long history of misusing energy and different prices for different countries as a political weapon to spread its influence by either hindering strong opposition (from Germany) or keeping its influence in the former communistic countries. Even the possibility of diversifying sources will cut Russia's monopoly and weaken its ability to set different prices. A final medium-term impact may be even a decrease in imports from Russia.

Currently Europe is the only possible customer for Russia's natural gas exports. There are no operational pipelines to potential Chinese customer and relevant LNG export terminal are also not present in the country. Even though it is often heard that Russia is able to choose its gas customer and may just "stop" sending gas to Europe, the truth is, there is no other choice at time. Russia is not physically able to export large amounts of natural gas to other destinations than in Europe.

The dependency is therefore mutual and same as European leaders try to diversificate their suppliers, Russian leaders are well aware of the situation and are working on diversifying its customers as well. Only recently Russia has signed a multi-billion dollar deal with China to export natural gas, which includes also the construction of the first (except for Turkey) gas pipeline heading to Asia. The downturn is that while relatively small Central European countries are hardly able to put pressure on Russia to lower prices, China is a different league and according to sources (Bloomberg 2014) negotiations were tough and the Chinese will pay less than for example Poland for the gas. Nevertheless, this may strengthen the political bond between Russia and China. Even though China will not be able to substitute Europe as the main export destination in my opinion, so will not North America be able to take over Russia's position in Europe's natural gas imports. Also, Russia will likely have to deal with the fact that long-term contracts may start to be substituted by spot prices. Considering that the U.S. may be motivated to support their allies in Europe with shale gas exports (ideological reasons) while China is motivated by negotiating as low prices as possible, I believe that the process will be in the end more beneficial for the Europeans. Decreasing export profits will have impact on the Russian economy. Nevertheless I do not believe this will lead to a regime change or significant reforms in the country.

Conclusion

My goal in this thesis was to provide a brief and objective overlook of unconventional resources and the impact on international trade. I did not aim to come up with new research data but rather analyze and compare different sources. I believe I have achieved my goal. I have analyzed studies conducted by international organizations, government agencies, consulting firms, environmental agencies and firms from the industry. These were often in contradiction to each other, with a too positive or too negative approach. I believe I was able to compare arguments provided in each study and have found a balance. Moreover I was able to conduct personally several analyses and present opinions based on the knowledge I have earned during my past five years of studies.

The first chapter started with an explanation what actually unconventional resources are. I did try to be as precise as possible without going too much into technical details. The basics had to be explained, so the reader can understand upcoming chapters. I have continued with a short history of unconventional resources and a brief overlook of the global territorial structure. The United States served as the only case study present at time and a descriptive-qualitative approach was used to access the development and impact of the industry. My sources included prevalently the U.S. government agency EIA, but also literature about natural gas in general. A study conducted by the Massachusetts Institute of Technology on ecological issues was already a very objective source. Apart from that I have also cited several news media sources, such as Patria.cz.

The second chapter aimed to access unconventional resources outside of the United States, focusing mainly on the European Union. To analyze, whether conditions are in favor of possible production or not I have followed a framework set by the IEA. After evaluating benefits and risks with the addition of statistics provided by the European Commission, IMF, Eurostat or consulting firms I was able to access several countries separately. Based on two criteria seven EU countries were selected and discussed with the use of mainly local sources – both government analysis and newspaper reports. Furthermore other world countries with large

amounts of recoverable shale gas and oil were mentioned. Again, I have worked with local analyses and also information provided by companies active in the industry.

The last chapter was dedicated to the influence on the global environment. Most of the thoughts in this chapter came from my analyses, which were backed by statistical data from various sources – EIA, government departments, Eurostat, news reports, consulting firms and also well regarded experts. I have not only evaluated the possibility of new trade routes and the influence on trade balance, but also the impact on current producers of both oil and natural gas. The chapter closed up with a brief overlook of possible political impacts.

At the beginning of my thesis I have expressed the opinion that unconventional resources could be a game changer. After completing this paper I can only confirm this claim. It does not happen every day that mankind discovers a significant and abundant source of energy. In fact I believe the use of unconventional resources might be the most important event in the energy field since the peaceful use of nuclear power. The U.S. case study has shown, what happens, when a technologically advanced economy with significant capital resources stumbles across an opportunity. Of course, several other conditions, including luck were in favor. The production from unconventional resources is growing and the U.S. have become the biggest natural gas producer and soon will surpass Saudi Arabia to rank as the biggest oil producer as well. Within 10-15 years, the country may be energetically self-sufficient. Moreover, thanks to natural gas prices, which are 3-4times lower in the U.S. than elsewhere in the world, the country has attracted investments in the amount of tens of billions USD, adding billions in tax revenues and hundred thousands of jobs while decreasing the trade deficit possibly by a third.

The U.S. success-story was closely watched by the European Union, where several member states are facing difficulties with declining production and the whole union is having difficulties with diversifying resources and becoming more and more dependent on imports. After evaluating various aspects – starting with the actual presence of unconventional resources in the EU and coming down to legal aspects, missing infrastructure, ecological issues and public opinion I have concluded that a revolution will most likely not happen. Depending on various aspects and decision, the EU may at least be able to decrease the competitive advantage of the U.S in the future while creating additional tax revenues and jobs.

The public debate is however still not resolved, with member states opinions ranging from very supportive like Poland to completely opposing like in France.

It is however not only the EU, who would like to benefit from unconventional resources, but also other countries – some driven by the desire to import less from abroad, like China, others intend to boost export, like Canada or Australia.

The shale industry will create various prospective trade routes. Closest to actual export are the United States and Australia, both fighting for the Asian customer, where currently prices for natural gas are the highest. Their fight will decrease the price of natural gas in the following decade, making exports to Europe, where prices are lower than in Asia also economically feasible. This will in turn have influence on the trade deficit of the U.S. and the role of the USD in the world economy. It may sound a paradox, but U.S. exports may actually lead to a decrease in use of the USD and it is up to the Federal Reserve System how it will deal with this situation.

Declining world prices and tougher competition will influence current producers. Qatar may lose its leading position to Australia as the largest LNG exporter and the OPEC countries may in turn lose the U.S. oil market. Whether they will be able substitute this fallout by increasing exports to Asia will strongly depend on the economic development there. In Europe we may witness a race between the EU and Russia on who is going to diversify its importer/customer first.

Having significant impact on the global economy, unconventional resources will have impact also on the political landscape, changing strategies and doctrines of the U.S. and forcing current producers to adjust to new conditions. While analyzing political impacts I came to a conclusion that even though this topic is rarely mentioned in other studies, yet I have had enough thoughts to probably write a sole new Master's Thesis on this influence. Also, the empirical connection between the amount of USD in the world economy and crisis worldwide, hinted my John Mauldin would pose an excellent topic for a further analysis.

At the beginning I have mentioned several limitations, which I expected to appear during my work. I have to admit, even though the lack of proper academic resources was understandable – the topic is rather new; this fact made the writing more complicated. While one can rely on data from the MIT, other sources, especially company analysis had to be double-checked. I found that the EIA, IAE and

surprisingly consulting firms provided a very comprehensive amount of relevant information backed up by either own research or reliable macroeconomic data. Mentioned several times both at the beginning and while writing the thesis, my biggest concern is the relevance of the data in the medium and long-term. As technology and methodology will improve, so will the estimates be more precise and it can easily happen that this paper will in light of new information be in 2-3 years irrelevant.

However, as for now I believe my goals were met and this paper provides an extensive analysis of unconventional resources that will shape the global economy in the next decade.

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