SHALE GAS

Basic Information

ORLEN

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WARSAW, JULY 2010

FOREWORD

Polski Koncern Naftowy ORLEN intends to be actively involved in unconventional gas exploration projects in Poland. This is one of the Group's strategic priorities. ORLEN Upstream, the E&P arm of the Group, has already commenced exploration on five licence blocks in the Lublin region.

This Report attempts, for the first time in Poland, to provide a structured overview of the available knowledge and information on shale gas exploration and production. Our goal is to provide all the interested parties with reliable and comprehensive information on shale gas and PKN ORLEN's activities in this area.

The first section of this Report outlines the basic characteristics of shale gas, such as its geological origin, extraction technology, commerciality criteria, and – the question that stirs up the strongest hopes and emotions in Poland – the potential economic and political consequences.

The first country to launch commercial production of shale gas was the United States, and therefore a whole chapter is devoted to this market. Shale gas currently accounts for approximately 14% of the U.S.'s total natural gas production. As estimated by the U.S. Department of Energy, the majority (60%) of recoverable gas reserves are found in unconventional reservoirs (shale gas and tight gas).

The final section of this Report examines the prospects for unconventional gas exploration and production in Poland. The estimates of potential shale gas reserves published to date have strongly excited the collective imagination. However, it should be noted that the process of appraising the potential shale gas reserves in Poland is still at an early stage.

This Report points out both the opportunities and potential barriers for the development of shale gas exploration in Poland, including geological, economic and administrative factors. It must be emphasised, however, that even if only the most conservative estimates of unconventional gas reserves in Poland prove correct, those resources – assuming their commerciality – may be sufficient to transform the Polish natural gas market.

Jacek Krawiec

President of the Management Board of PKN ORLEN

This Report has been prepared by PKN ORLEN SA on the basis of its proprietary information and publicly available data and opinions. This Report was prepared in the period from May to July 2010.

EXECUTIVE SUMMARY

PART 1: SHALE GAS - KEY FACTS

Shale Gas - Overview

- Depending on the nature of the rocks where hydrocarbon accumulations are found, deposits are divided into conventional and unconventional. Production of unconventional gas is more expensive and more challenging in terms of technology.
- Unconventional gas resources include shale gas, tight gas, coal-bed methane, and gas hydrates.
- The current advanced technology made gas production from unconventional sources commercially possible.

Production Technology

- The development of shale gas production become possible after the cost of horizontal drilling and hydraulic fracturing technology declined.
- In horizontal drilling, a well is first drilled vertically and, after an assumed depth is reached, it is diverted to a horizontal section and continues to be drilled through the target formation zone.
- Hydraulic fracturing consists in pumping high-pressure fluid into a selected section of the borehole. The fluid is composed of a carrier (mainly water), a proppant filling the fractures (mainly grains of sand of particular size and mechanical strength) and chemicals (serving chiefly to improve viscosity). The fluid injected under pressure into the well forms fractures in the shale formation, while the sand prevents the fractures from closing and creates new paths for gas migration to the well.
- The average amount of fluid pumped into one well during a hydraulic fracturing treatment ranges from 7.5 to 11.3 million litres, while the quantity of sand ranges from 450 to 680 tonnes.

Shale Gas – Commerciality: the U.S. Example

- Commerciality of shale gas production depends on numerous factors:
- Mechanical properties and rock composition
- ″Fracability″ depending on natural crack patterns in the rock
- Cost of drilling
- Cost of hydraulic fracturing
- In 2009, Credit Suisse estimated that for the next few years the break-even point for shale gas production will range from USD 0.12 to USD 0.37 per cubic metre of natural gas.
- Due to growing demand for rigs and drilling bits, as well as the spread of the technology, costs can be expected to drop in the coming years.

Shale Gas – Geopolitical Implications

- Growth of shale gas production may significantly affect the areas of influence and energy dependency of many European countries and the United States.
- Thanks to domestic shale gas production, the U.S. has managed to significantly downsize its LNG imports.
- Shale gas production may reduce the EU's dependence on long-term contracts with Russia.
- Due to low CO2 emissions, higher production of natural gas may halt investments in coal or oil-based power generation projects.

PART 2: SHALE GAS PRODUCTION IN THE UNITED STATES

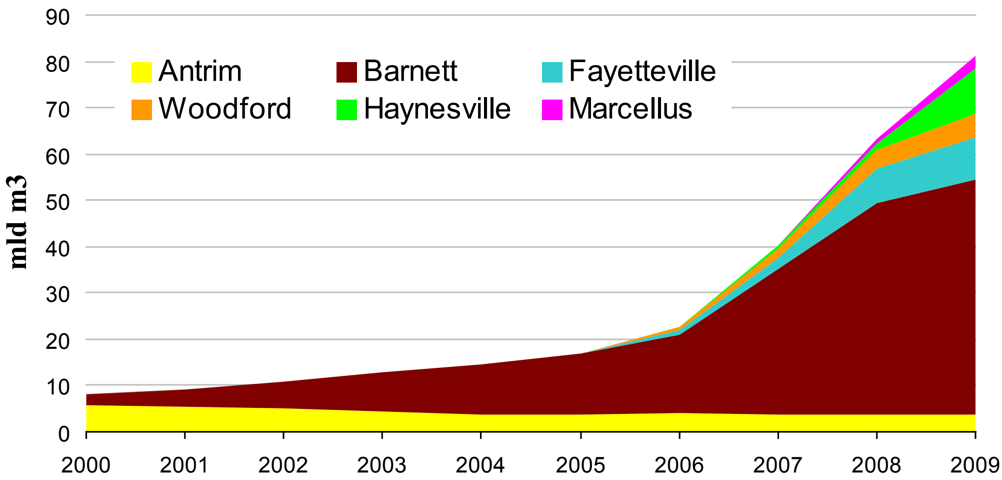
Overview of the U.S. natural gas market

- In 2009, the United States became the largest natural gas producer in the world. The production reached 598.37 billion cubic metres and rose by almost 4% over the previous year. Currently, 50% of the volume comes from unconventional resources, including tight gas (27%), shale gas (14%), and coal-bed methane (9%).
- According to the Energy Information Administration, the U.S. has 50 trillion cubic metres of technically recoverable gas resources, with unconventional sources accounting for roughly 60%.
- At present, shale gas accounts for some 14% of total gas production. In 2008, the shale gas production stood at 57.25 billion cubic metres and was over 70% higher than in the previous year.
- The United States has not yet become fully independent in terms of satisfying its demand for natural gas, but gas imports have been steadily falling.

Overview of the U.S. shale gas market

- The recoverable shale gas resources of the U.S. may be as high as 17 trillion cubic metres.
- Production of unconventional gas is by far the largest in the Barnett Shale, Texas. Other fields, such as Haynesville, Fayetteville, Arkoma/Woodford and Marcellus are still at an early stage of development, but the production is consistently growing (see chart below).

Shale gas production in the U.S. – largest discoveries[1]



- More than 10,000 wells were drilled in the Barnett Shale. One horizontal well covers, on average, an area ranging from 24.3ha to 64.7ha.
- In the U.S., the cost of drilling one vertical well up to the depth of 1,500m ranges from approximately USD 0.8m to USD 2m, while the drilling of one horizontal well with the length of up to 3km may cost as much as USD 6-8m.

PART 3: PROSPECTS FOR SHALE GAS MARKET DEVELOPMENT IN POLAND

- As estimated by the Energy Information Administration, by 2030 shale gas will account for 7% of the global natural gas production.
- According to Wood Mackenzie, Poland's recoverable reserves of shale gas may be as high as 1.4 trillion cubic metres. The estimates of Advanced Resources International are even higher standing at 3 trillion cubic metres.
- Reliable information on the actual resource base will be probably available in four to five years, when the exploration and prospecting activities carried out under the licences granted by the Ministry of the Environment are finalized.
- Poland has awarded 221 licences for exploration and prospecting of hydrocarbon deposits, of which 63 are oriented at shale gas development. Overall, the exploration activities cover 11% of the territory of Poland area, i.e. 37,000 sq km.
- Poland's "shale basin" extends from the coast, in the area between Słupsk and

1 US Department of State, April 2010.

Gdańsk, towards Warsaw, and further to Lublin and Zamość.

- According to projections, potential shale gas reserves are present at the depth of 1,200-2,500 metres in the northern part of the basin and 2,500-4,500 metres in the southern part.
- The cost of one vertical well is estimated at USD 6–13m, depending on the depth.
- Lane Energy Poland Sp. z o.o. was the first company to start drilling (in June 2010, near Lębork).
- No shale gas field has been discovered in Poland to date.

Legal environment in Poland

- Polish geological and mining law does not envisage any special procedures for exploration, prospecting and extraction of gas from unconventional sources. The procedures are the same as in the case of conventional gas.
- In practice, the State Treasury executes mining usufruct agreements and awards licences in two stages: first for exploration and prospecting, and then for production.
- A party that succeeds to discover and validate an unconventional gas deposit, for two years has a priority over other applicants to be awarded a production licence.
- Royalties in Poland range from 1% to 2.5% of revenue from gas production, depending on production volumes. According to the government, this should attract to Poland the largest possible number of foreign players with the relevant expertise in shale gas production. In a similar way, the U.S. administration introduced tax credits and reliefs for companies developing unconventional gas reserves.

Potential barriers to shale gas production in Poland

- At present, Poland does not have any proven shale gas reserves.
- The government has not defined any clear policy that would be reflected in a relevant regulation of the Council of Ministers, to support the the development of the Polish shale gas market.
- Currently, the technology required for shale gas production is not available in Poland on a sufficiently large scale to ensure low cost levels and, consequently, project profitability.
- The number of rigs available in Europe for drilling shale gas wells is insufficient.
- Locally, there may be problems with supplying water in quantities required for fracturing.
- Drilling may show that the profitability of commercial production of shale gas is low under the economic conditions prevailing in Poland at a given time.

Opportunities and benefits offered by shale gas market in Poland

- An opportunity for Poland to rely on its own gas resources for many years and, potentially, to export gas.
- An opportunity for Polish petroleum sector players to grow and expand internationally.
- Acquiring state-of-the-art exploration and production technologies and development of management and engineering staff.
- Development of transport and transmission infrastructure necessary to handle the incremental production volumes.
- Reduction of domestic CO_2 emissions if the share of natural gas in the overall energy output in Poland rises.

Contents

INTRODUCTION

“The world has gone crazy about shale gas. It is said that we are now dealing with a gold fever of the 21st century.”

- Henryk Jacek Jezierski, Poland’s Chief Geologist

The last decade has seen a strong rise in the interest of oil companies globally, and in Poland, in the prospects for the exploration and development of unconventional natural gas resources, namely shale gas, tight gas, and coal-bed methane. This become possible along with the development of advanced technologies, such as horizontal drilling and hydraulic fracturing.

According to recognised international consulting agencies, shale gas reserves in Poland may be as high as 3 trillion cubic metres, which translates to the market value exceeding tens of billions of dollars.

The development of unconventional gas resources has enabled the United States to achieve a substantial decrease in gas prices while significantly reducing the dependence on other producers.

Is Poland now facing a unique opportunity to eliminate its reliance on gas imports and become a major global gas producer? Could the discovery of shale gas in Poland be as groundbreaking for the European energy market as was the start of oil production from the Ekofisk field in the North Sea by Phillips Petroleum on August 30, 1971 ? Within the next five years we should know how big unconventional gas deposits can be found in Poland.

PART 1

SHALE GAS – BASIC INFORMATION

"[Shale gas development is] the most significant energy innovation so far this century" [2]

- Daniel Yergin, IHS Cera's Chair

2 "Sasol-Chesapeake-Statoil apply to explore for shale gas in Karoo", Martin Creamer, Mining Weekly, March19th 2010.

1.1 Shale gas - Overview

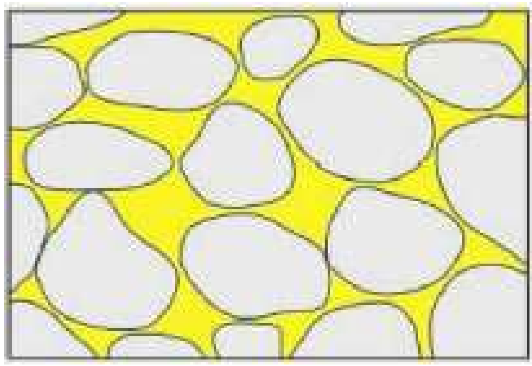
Natural gas can be broadly classified into **conventional** and **unconventional** deposits. People have known how to produce gas from conventional sources since the 19th century and the process has not posed any technological problems for quite some time now. Unconventional gas, on the other hand, is much more difficult and less economical to extract.

The unconventional gas sources include shale gas, tight gas (gas trapped in isolated rock pores), coal-bed methane and gas hydrates.

1.1.1 Origin of shale gas

The processes which gave origin to fossil fuels - including crude oil and natural gas – are extremely complicated. In simplified terms, Silurian shale gas originated from organic matter made up of decaying plant and animal life. For hundreds of millions of years, the organic remains were deposited, along with tiny particles of minerals, on the bottoms of sea basins. Over time, the organic matter, buried under a layer of mud in anoxic conditions, gradually decomposed and was converted into petroleum (natural gas or crude oil) by the combined action of heat and high pressure, which compacted the mud and silt into shale. As a result, the shale became a source rock for conventional gas. Due to its physico-chemical properties, gas generated in the process migrated towards the surface until it encountered various types of geological traps in the form of porous rock formations tightly sealed by overlying layers of impermeable rock. This led to the formation of conventional gas deposits, which resemble a gas-soaked sponge (see Fig. 1.1).

Figure 1.1 – Conventional gas deposit[3]

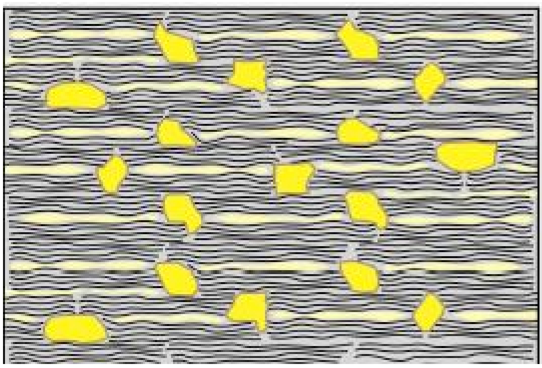


Traps like the ones described above resemble large reservoirs, from which conventional gas can be extracted by means of vertical drilling.

Historically, gas has been produced chiefly from such traps. There were no technological solutions available to explore the source rocks where hydrocarbons were generated, given that black shale, containing abundant organic matter, is practically impermeable. Black shale occurring on the Earth's surface is usually split into thin laminae, but at a depth of merely one kilometre its structure is concrete solid. Shale gas is trapped in isolated micropores or physically bound with organic matter through adsorption (see Fig. 1.2).[4]

3 "Concession policy and legal regulations for exploration and production of gas", Henryk Jacek Jezierski.
4 "Wyciskanie Gazu" ("Squeezing Gas Out"), Mirosław Rutkowski, Polityka.pl - Nauka, Feb 24 2009.

Figure 1.2 – Unconventional shale gas reservoir rock[5]



In the past, extraction of natural gas from such rocks was sometimes possible, provided that the rock formation contained fractures through which gas could be slowly released. The first shale gas producing well was made as early as in 1821 in Devonian Dunkirk rocks, in the United States. For many years, the 9.5-metre deep well supplied gas to illuminate the nearby town of Fredonia in the state of New York.[6]However, that development was unique and for decades oil and gas companies did not have the technology to produce shale gas.[7]

5 Picture - All Consulting, 2008; Drawing – "Concession policy and legal regulations for exploration and production of gas", Henryk Jacek Jezierski.
6 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, April 2009.
7 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, April 2009.

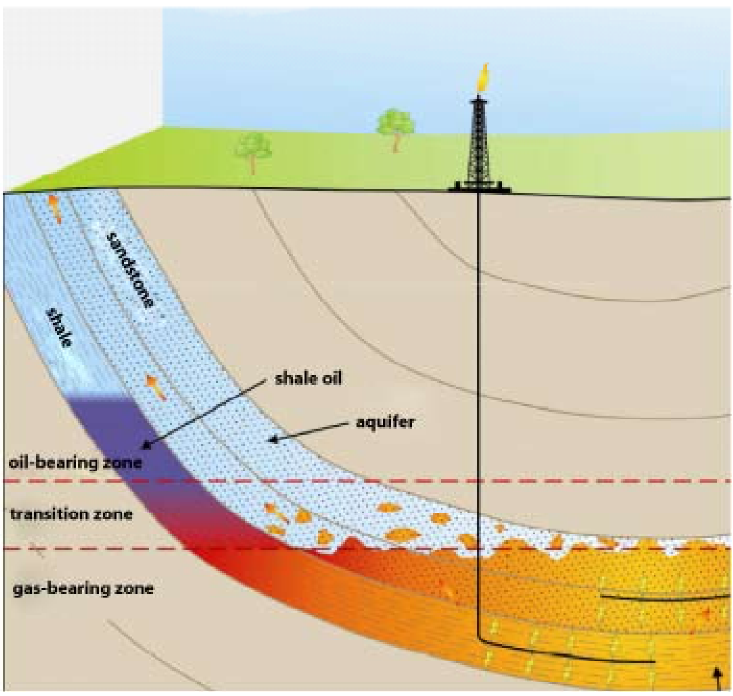
1.2 Shale gas production technology

The shale gas development became possible thanks to advances in production technologies. It was not until horizontal drilling became commonly used and the hydraulic fracturing techniques were improved that commercial production of gas trapped in shale source rocks became viable.

1.2.1 Horizontal drilling

Only two decades ago, horizontal drilling (see Fig. 1.3) was regarded as an extraordinary technology feat. In mid 1990's, it started to be used to enhance recovery from conventional petroleum deposits, as a result of which it soon gained in both popularity and sophistication.

Figure 1.3 – Horizontal drilling - schematic representation[8]



8 Source: R.M. Pallestro (2003).

Horizontal drilling starts with a vertical hole, which, after reaching a specific depth, is diverted to a horizontal trajectory, with a view to penetrating the target rock formation over the distance from one to over three kilometres away from the vertical hole.

Casing is run into the wellbores, and the space between the casing and the rock is cemented in order to stabilise and reinforce the well, and to isolate it from aquifers and other formations containing undesirable minerals (Fig. 1.4).

Figure 1.4 – Well casing – schematic representation[9]

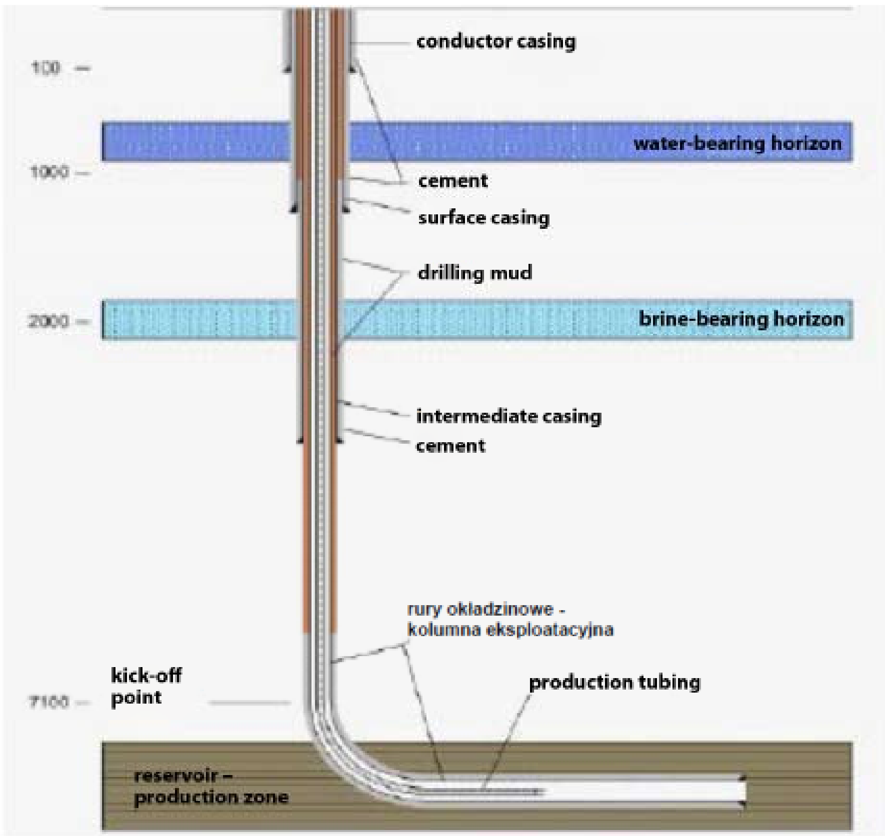


Figure 1.4 – Well casing – schematic representation[109]

The petroleum industry soon realised that horizontal drilling – allowing operators to access a larger area of the reservoir compared with traditional vertical drilling – can

9 "Modern Shale Gas Development in the United States: A primer", US Department of Energy, April 2009.
10 "Modern Shale Gas Development in the United States: A primer", US Department of Energy, April 2009.

be used to produce gas from black shales, thus far considered not to be economically viable. The existing technologies enable vertical drilling to depths of more than seven kilometres and horizontal drilling of sections more than 3 kilometres long.[11] The record of 11 kilometres was set by Maersk Oil.

Thanks to horizontal drilling, reserves can be recovered much more efficiently than in the case of vertical wells. Eight horizontal wells branching off from a single location provide access to a deposit which, if only traditional methods were used, would require drilling of 16 vertical wells.[12]

It should be noted, however, that – due to the extremely low permeability of shale formations – horizontal wells must be more densely spaced than in conventional gas production operations. The average drilling density is 4-8 wells per 2.6 square kilometres.[13]

In the United States, the average cost of drilling and completing a vertical well to the depth of up to 1,000 metres is approx. USD 0.8m, whereas the cost of drilling a well with a horizontal section of up to 1,000m may even reach USD 2.5m.[14]

The use of horizontal drilling alone is not enough to ensure efficient recovery of unconventional gas. To enable production on a larger scale, a network of artificial fractures must be made along the horizontal section of a well, and subsequently filled with sand of the appropriate grain size to create new conduits through which gas can flow from the reservoir into the producing well. The process is called hydraulic fracturing.

1.2.2 Hydraulic fracturing

In 1981 a Texan engineer, George T. Mitchell, experimented with various methods of shale gas extraction. He was the first to apply hydraulic fracturing or, in other words, to pump fracturing fluid under very high pressure into selected sections of a wellbore in order to create new fractures, or enlarge existing ones, in shale rock formations. The technology was patented at the end of the 1990's[15] by Mitchell Energy & Development,

11 "Polish shale gas sparks bonanza hopes", Richard Robinson, Fund Strategy, May 23rd 2010.
12 "Modern Shale Gas Development in the United States: A primer", US Department of Energy, April 2009.
13 "Modern Shale Gas Development in the United States: A primer", US Department of Energy, April 2009.
14 "Modern Shale Gas Development in the United States: A primer", US Department of Energy, April 2009.
15 "The Father of the Bernett", Marc Airhart, Jackson School of Geosciences.

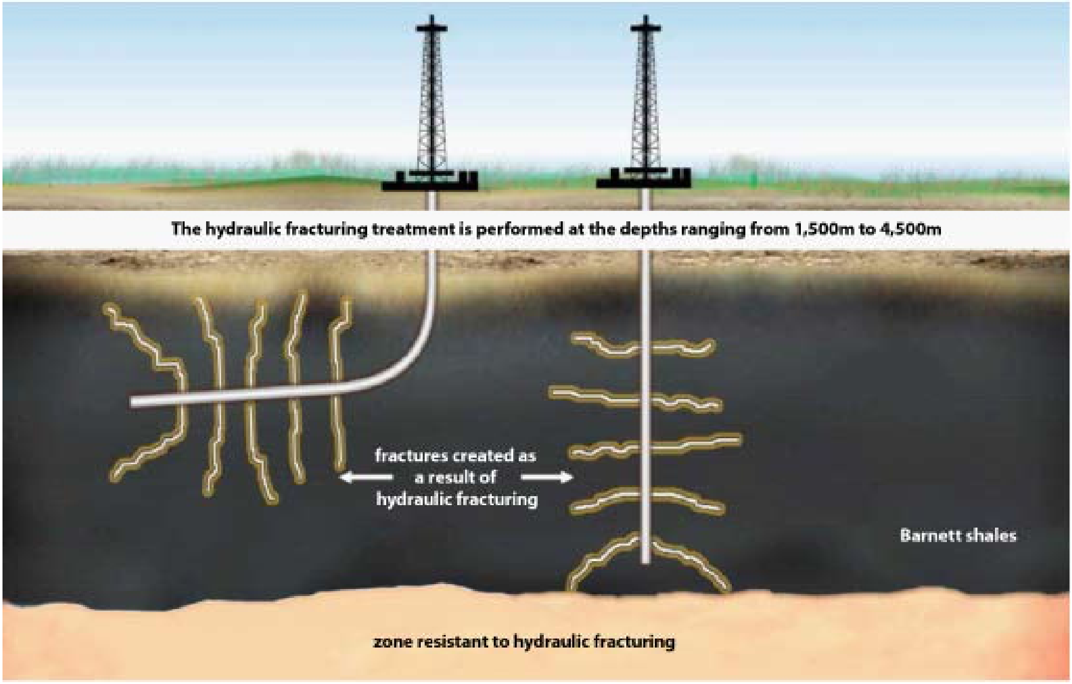
a firm founded by George T. Mitchell, which was acquired in 2002 by Devon Energy for the price of USD 3.5bn.[16]

Modern hydraulic fracturing (Fig. 1.5) is a strictly controlled process, tested in laboratories and in tens of thousands of wells, which draws on both the scientific knowledge and hands-on experience, and is frequently protected by patents. It is also a fairly expensive treatment, which may account for as much as 25% of total well costs. In its basic version, it involves the injection of so-called fracturing fluid (a mixture of water and various additives) into a wellbore at a pressure that may even exceed 600 bar. Once the target zone is cracked with a sufficient number of fractures, water mixed with sand of the appropriate grain size (so-called proppant) is pumped into the well. The sand is carried into the fractures and prevents them from closing while providing migration paths through which gas can flow into the wellbore. There is a broad variety of hydraulic fracturing options. Fracturing fluids of controlled viscosity, humidity and gravity are mixed with small quantities (up to a few percent) of chemicals which allow the treatment to be properly executed. Apart from sand, other filling materials may include ceramic materials, metal and plastic pellets as well as polymer fluids, which get transformed into networks of tangled fibres. The quality of the fractures is diagnosed using microseismic logging. Most importantly, however, the costly work is usually preceded by an analysis of rock samples, aimed at determining their geomechanical properties as well as stress conditions in the rock mass. Based on the results of such analyses, the choice of fluids is made, and other key parameters such as the pressure levels and the duration of individual stages of the fracturing treatment are defined. The entire process is preceded with a digital simulation. While painstaking and costly, the laboratory stage of the process is also highly effective, as it allows to achieve precisely spaced, concentric fracture zones with a radius of up to 900 metres (up to 200 metres in sandstones).[17]

16 Devon Energy's corporate website- www.devonenergy.com.

17 "Wyciskanie Gazu" ("Gas Extrusion"), Mirosław Rutkowski, Polityka.pl - Nauka, Feb 24 2009.

Figure 1.5 – Hydraulic fracturing – schematic representation[18]



Once the hydraulic fracturing treatment is completed, the fracturing fluid is withdrawn from the well and a production test is performed. For some time, in addition to natural gas, the well continues to produce flowback frac fluid.

1.2.3 Water used in hydraulic fracturing

The amount of water and sand that needs to be injected into a single wellbore during a hydraulic fracturing treatment is 7.5 to 11.3 million litres and 450 to 680 tonnes, respectively. To compare – an Olimpic-size swimming pool holds 2.25 million litres of water.[19]

The water needed for shale gas development is usually stored in artificial reservoirs or in mobile tanks deployed close to the well to ensure connection during the treatment. In order to secure water beforehand, wells are drilled locally or water is delivered from a spring. This forms a closed circulation system where water is treated on an ongoing basis and reused for other purposes during drilling or hydraulic fracturing of wells at the

18 "Shale Gas Development in the U.S.", Mark Smith, Interstate Oil & Gas Compact Commission, April 2010.
19 "Preparing a Well for Production - Hydraulic Fracturing", Fayetteville Shale Natural Gas.

same location or elsewhere. Some water volumes may be reused in other production processes.[20]

1.3 Stages of shale gas development: the U.S. Example[21]

This section describes the steps of a typical shale gas development process in the United States.

1. **Acquisition of rights.** Unlike in other countries, in the U.S., companies planning to acquire rights to hydrocarbon exploration and production in a given area negotiate contracts for the lease of a site with the landowners (private owners, a state, the federal government). These are complex contracts providing for appropriate compensation for the use of the land and development of reserves (in the U.S. the landowner's title includes also the minerals underground).

2. **Permits.** An operator is required to obtain a permit for any exploration and production activities, including well drilling . The application for the permit should be usually accompanied by the results of studies, analyses, drilling designs and other technical information. Before a permit is approved, operators may be required to take special measures to protect the environment.

3. **Drilling.** In selected sites, horizontal wells are drilled. Typically, four to eight wells are designed per site, usually in pairs, going in opposite directions. The well design depends on the rock characteristics, recovery enhancement planned for the future, and the selected production approach.

4. **Hydraulic fracturing**. Creation of factures in rock formations by means of specially prepared fluids.

5. **Development**. To prepare a field for exploitation it is necessary to design the necessary surface infrastructure for the preparation of the gas for transport (treatment, dehydration, gathering from wells to a common send-out point, etc.) and its subsequent export (gathering pipelines, distribution pipelines, metering equipment, etc.) to the transmission pipeline system.

20 "Modern Shale Gas Development in the United States: A primer", US Department of Energy, April 2009.
21 "Modern Shale Gas Development in the United States: A primer", US Department of Energy, April 2009.

6. **Production.** Once extracted from the well, gas undergoes adequate processing and is eventually offered to the market (production can last for decades).

7. **Production enhancement**. Gas production rate usually decreases over years. Operators normally apply various methods to maintain the level of production. These may include simple treatments, such as well purging, flushing the rock at the point of contact between the well and the reservoir, or additional fracturing.

8. **Well abandonment**. Once the recovery rate falls below the economic profitability limit, a gradual well abandonment process is commenced. Individual wells are permanently plugged (cemented at the bottom of the hole), the well site is restored to its original condition. Then, the entire surface infrastructure is gradually removed.

1.4 Shale Gas – Environmental impact of shale gas production

Thanks to the development of horizontal drilling, the impact of shale gas production on the land environment in the production area is much smaller than in the case of conventional gas production.[22]Devon Energy Corporation has announced that one horizontal well can replace three to four vertical wells.

In the United States, some environmental organisations have been claiming that hydraulic fracturing may cause damage to the natural environment, and demanding that the organisation of the process should be subject to governmental regulation. It should be noted, however, that shale gas wells are properly protected (see Fig. 1.4) to prevent chemicals from getting into groundwater. On the other hand, if well casing is faulty, there is some risk of chemicals permeating to groundwater.

In addition, there are no laws currently in force which would require corporations to disclose precisely what chemicals they inject into boreholes to make fractures in rock formations.[23]In practice, however, basically no production company in the United States conceals the chemical composition of fluids used in hydraulic fracturing.[24]

22 "Modern Shale Gas Development in the United States: A Primer", US DOE, April 2009.
23 "EPA begins study on shale gas drilling", Tom Doggett, Reuters, March 18th 2010.
24 "Modern Shale Gas Development in the United States: A Primer", US DOE, April 2009.

Production companies assert that modern hydraulic fracturing methods make it possible to produce gas in a manner that is completely safe for the natural environment. They also add that there is no evidence that hydraulic fracturing in any way affects the resources of drinking water.[25]

On March 18, 2010, the U.S. Environmental Protection Agency[26]announced the launch of a study into the environmental impact of shale gas production. The study will cover mainly the impact of hydraulic fracturing and, specifically, the effect of the chemicals used in the process on drinking water. According to EPA representatives, the study could take even two years to complete.[27]

Similar studies are also carried out by the Energy and Commerce Committee[28]and the Penn State University (final report to be released in 2011).[29]The general public voices growing concerns and doubts over the impact of chemicals used in hydraulic fracturing on the environment and human health.

The oil spill in the Gulf of Mexico after the BP oil rig sinking in April 2010 fuelled further concern over the effect of hydraulic fracturing on the environment and human health. One or two more years of research are needed to precisely identify the potential impact. This may be the reason why the Pennsylvania State Senate is preparing a proposal to impose a one-year moratorium on drilling in the Marcellus shale. The most reasonable opinion seems to have been voiced by George Mitchell, the pioneer of hydraulic fracturing, who considers his invention as sound, but not foolproof: "You've got to do a good job, or you'll have trouble."[30]

People's imagination is stirred by the seemingly huge amounts of water needed for hydraulic fracturing in one well (from 7.5m to 11.3m litres of water, equivalent of three to five Olympic pools).

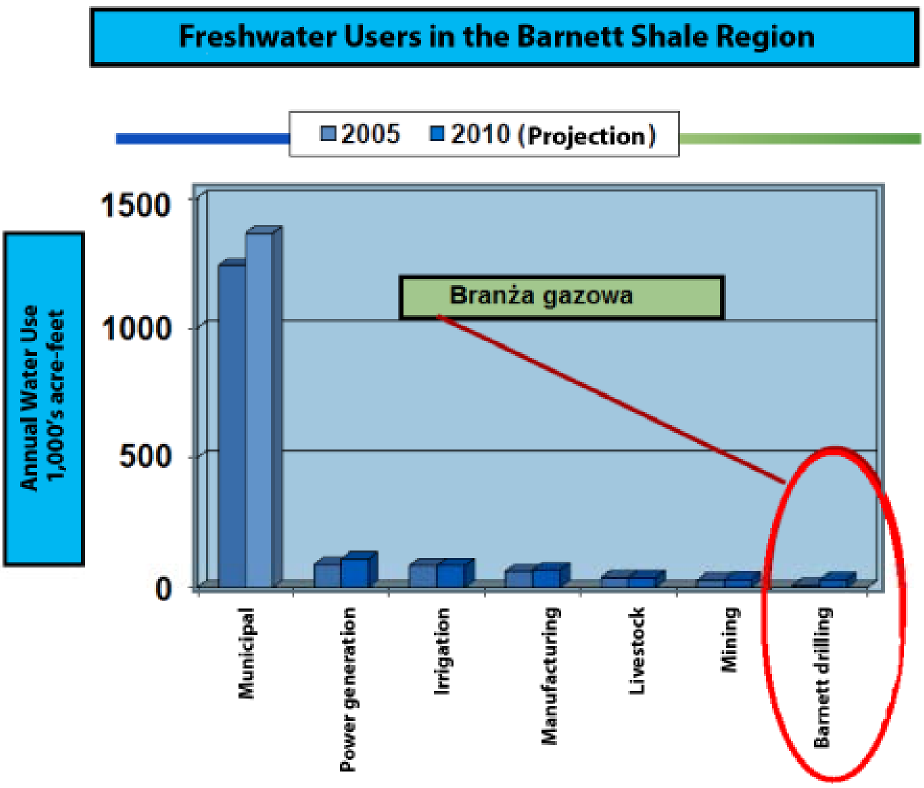
However, it should be noted how much freshwater is used (or wasted) for other purposes. A comparison of the largest freshwater users in the Barnett Shale region (Fig. 1.6) prepared by Gas Technology Institute shows that the largest amounts of

25 "EPA begins study on shale gas drilling", Tom Doggett, Reuters, March 18th 2010.
26 US Environmental Protection Agency, www.epa.gov.
27 "EPA begins study on shale gas drilling", Tom Doggett, Reuters, March 18th 2010.
28 Committee on Energy and Commerce.
29 "Shale Pioneer sees bright future of technology", Eric Lidji, greeningofoil.com, June 30th 2010.
30 "Shale Pioneer sees bright future of technology", Eric Lidji, greeningofoil.com, June 30th 2010.

freshwater are consumed in for municipal purposes[31]. Shale gas production is one of the least water-consuming branches of the local economy. The greatest savings can still be made by making more efficient use of water in everyday life.

Also in terms of the relation between the occupied area and energy output, shale gas is more efficient than alternative energy sources. Energy output (measured in British Thermal Units) from one Marcellus well on 0.25 acre of land is equivalent to energy produced by a windmill farm occupying the area of 500 acres.[32]

Figure 1.6[33]



31 Guy Lewis, Gas Technology Institute, presentation at "US/Poland: energy roundtable June 2010".
32 Source: Ray Walker, Range Resources, at Guy Lewis, Gas Technology Institute, presentation at "US/Poland: energy roundtable June 2010"
33 1 acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot, approximately 1,233,489 cubic metres.

1.5 Shale Gas – Commerciality: the U.S. Example

Commerciality of shale gas production depends on the existence of a natural network of fractures and the effectiveness of hydraulic fracturing. Since the reservoir conditions differ significantly, even within a single formation, the commerciality can vary extent lot. In 2009, Credit Suisse estimated the break-even point for shale gas production as ranging from USD 0.12 to USD 0.37 per cubic metre of natural gas, with the average of USD 0.28 per cubic metre. The internal rate of return (IRR), with the price at USD 0.26 per cubic metre, was estimated at 1% to 48% (5% on average). In order to stimulate unconventional gas development, tax credits for producers of unconventional fuels were introduced in the United States in 1980 and remained effective until 2002.[34]

Similar calculations were made by Ben Dell, an analyst from Bernstein Research. According to his estimates, in order to cover all costs of exploration, development and exploitation of shale gas, and arrive at an average return on equity, the required price should range around USD 0.26 – 0.28.[35]

It should be noted that recent years have seen a strong drop in costs of shale gas production. At the end of 1990s, the cost of production from the Barnett Shale still exceeded USD 5 per million BTU[36].[37]

1.6 Geopolitical implications of of the development of unconventional gas resources

1.6.1 End of gas and oil dependence?

By developing domestic production of shale gas, western countries and China will gain access to less remove sources of the fuel, and thus undermine the position of key gas exporters. Before shale gas was discovered, it was expected that domestic production of natural gas in the U.S., Canada and North Sea would fall, which at the time when gas was becoming increasinglyy import ant as a source of energy, strengthened the

34 „Shale Gas – Extraction Technology", węglowodory.pl, May 4th 2010.
35 "The true cost of shale gas production", John Dizard, Financial Times, March 7th 2010.
36 British Thermal Unit – see Glossary.
37 "How shale gas is going to rock the world", Amy Meyers Jaffe, Wall Street Journal, May 9th 2010.

dependence on imports. More than a half of known natural gas resources was found in Iran and Russia, i.e. regions perceived as relatively unpredictable. The Russian Federation openly used its position to create a cartel of gas producers. The discovery and development of substantial shale gas reserves will bring stability to industrialised countries and could undermine the effectiveness of oil and gas supply as a tool political influence.[38]

1.6.2 Chain Reaction

The growth of LNG supply, i.e. liquefied natural gas that may be transported by tankers, has exposed the heavy reliance of many countries on gas imports. However, the developments in shale gas production are transforming the gas trade market. Previously, LNG was expected to account for half of the international gas trade. Now it seems that share is most likely to be around one-third.[39]

A downtrend in LNG imports is already evident in the U.S. Import terminals for LNG are almost empty as cargoes of LNG from Qatar are going to European buyers, contributing to a drop in the price of natural gas in Europe. Russia has had to accept far lower prices from customers.

Tension could be felt among the traditional suppliers of LNG to the European and U.S. markets during the Gas Exporting Countries Forum held in Oran, Algeria. According to Chakib Khelil, the Algerian Minister of Energy, demand for gas will return to the 2008 pre-crisis level no earlier than in 2013, while Jurij Trutniev, the Russian Minister of Natural Resources, confessed to Reuters *"We have a problem with shale gas. And it is not only my point of view but Gazprom's as well."*[40]

Factors such as the self-sufficiency of the U.S. gas industry, growth in the volume of LNG imported by the European countries from sources other than Russia, and sagging natural gas prices have developed into a problem which for the Russian Federation is primarily an economic one. *Kommiersant*, the Russian daily, disclosed that according to a management report for Gazprom's board of directors the energy giant is set to lose billions of euros. All this put pressure on the economic viability of Gazprom's

38 "Shale Gas Will Rock the World", Ann Meyers Jafe, Wall Street Journal, May 10th 2010.
39 "Shale Gas Will Rock the World", Ann Meyers Jafe, Wall Street Journal, May 10th 2010.
40 "Gas Cartel Set to Push Up Prices for Europe", Andrzej Kublik, Gazeta Wyborcza, April 20th 2010.

project involving the development of the Shtokman field in the Barents Sea, which was originally conceived as the source of LNG supplies for the U.S. and Canada.

1.6.3 Russia, Iran and Venezuela

Leveraging their resource potential and the power to dictate prices, Russia, Venezuela and Iran could effectively use these tools in their policy to resist Western interference in their foreign and internal affairs while exporting their own ideologies along with the fuels. Handicapped by international sanctions, the Iranian energy sector develops at a sluggish pace. Hence, by the time Iran can get its natural gas ready for export, the marketing window to Europe will likely be closed by launch of shale gas production in the potential customer countries. In the long run, as crude oil is gradually replaced by natural gas as the primary energy source, the position of OPEC countries on the international arena is likely to weaken.[41]

1.6.4 China

Shale gas development could also mean big changes for China. In order to satisfy its ever-growing demand for energy, China engaged in cooperation with nations such as Iran, Sudan and Burma, making it harder for the West to address the problems those countries create. But if China can tap on its domestic resources of natural gas, partnership with those countries may no longer be so vital. Domestic shale may bring China closer to the U.S., especially in the context of the latter being virtually the only provider of shale gas expertise and innovative exploration and production technologies. Signs of the rapprochement are already emerging. Talks held during a recent visit of the U.S. President in China in May 2010 were focused on a potential bilateral agreement to embark on joint projects involving the development of shale gas technologies and production.[42]

41 "Shale Gas Will Rock the World", Ann Meyers Jafe, Wall Street Journal, May 10th 2010.
42 "Shale Gas Will Rock the World", Ann Meyers Jafe, Wall Street Journal, May 10th 2010.

1.6.5 Proactive U.S. foreign policy

The Obama administration shows interest in promoting shale gas development in China and elsewhere. According to State Department officials, the U.S. has approached about a dozen countries (including China and India) offering them the assessment their potential shale gas resources. Thereby, Washington seeks to protect the interests of the U.S. energy companies, which at present are the only ones to possess adequate technology and funds necessary for commercial shale gas production. On the other hand, such involvement would enable the U.S. to expand its influence in the potential shale gas-producing regions and undermine the position of countries exporting fuels to such regions.[43]

1.6.6 Impact on renewable energy sources

Shale gas is also likely to decelerate the implementation of some renewable energy projects whose economic viability may be threatened by the abundant supply of natural gas, a fuel offering low carbon emissions and, potentially, low prices. It should be noted, however, that this may be seen as an opportunity for the renewables as well. The funds earmarked for technology implementation projects may be poured into R&D initiatives aimed at improving the efficiency of energy sources such as wind, solar, hydro and biomass.

43 "US Pitches Shale Gas Studies Overseas", Ian Talley, Dow Jones, April 7th 2010.

PART 2

U.S. SHALE GAS PRODUCTION MARKET

"The shale gale has shifted natural gas from a constrained resource to an abundant one with wide-ranging implications for the energy future in North America"

- David Hobbs, Chief Energy Strategist, IHS CERA[44]

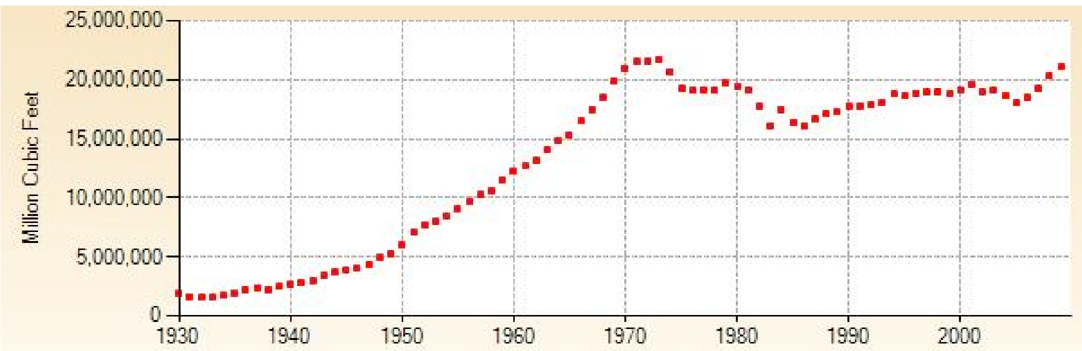
44 Sasol-Chesapeake-Statoil apply to explore for shale gas in Karoo", Martin Creamer, Mining Weekly, March 19th 2010.

2.1 Overview of the U.S. gas market

In 2009, the United States became the world's largest natural gas producer. New technologies which enabled shale gas recovery turned out to be a ground-breaking factor that caused a shift in the structure of energy sources in North America in the last decade. In 2009, the natural gas production volume reached 598.37bn cubic metres, which represents a 3.9% growth over the previous year (576.95bn cubic metres). Between 2007 and 2008, production rose by 6.7%.[45]To compare, gas production in Poland totalled 4.11bn cubic metres in 2008.[46]

Natural gas covers approximately 22% of the U.S. energy demand. It is expected that the share will remain at a similar level for the next 20 years.[47]According to estimates by the Energy Information Administration, the United States has some 50 trillion cubic metres of technically recoverable natural gas, of which approximately 60% are unconventional resources (shale gas, tight sand, coal-bed methane). Combined with the estimated shale gas reserves, this makes a sufficient gas volume to last for the next 116 years.[48]

Figure 2.1 – Natural gas production in the U.S. [49]



A vast majority of the natural gas produced in the U.S. comes from conventional sources. Unconventional gas (including shale gas, tight gas and coal-bed methane) accounted for 50% of the country's total production in 2008.[50]Shale gas currently represents some 14% of the total natural gas production.[51]Particularly evident is

45 U.S. Energy Information Administration.
46 Polish Geological Institute - the figure is also quoted in the Ministry of Economy's reports.
47 "Modern Shale Gas Development in the United States: A Primer", US DOE, April 2009.
48 "Modern Shale Gas Development in the United States: A Primer", US DOE, April 2009.
49 U.S. Energy Information Administration.
50 U.S. Energy Information Administration.
51 U.S. Energy Information Administration.

the growing production rate of shale gas: its output in 2008 came to 57.25bn cubic metres, compared against 33.52bn cubic metres in 2007, which represents a growth of 70.8%.[52]

It should be noted that the United States has not yet become fully self-sufficient considering the country's demand for natural gas. In 2009, gas imports totalled 105.75bn cubic metres, as compared to 112.81bn cubic metres in 2008 (a decline of 6.7%) and 130.47bn cubic metres in 2007.

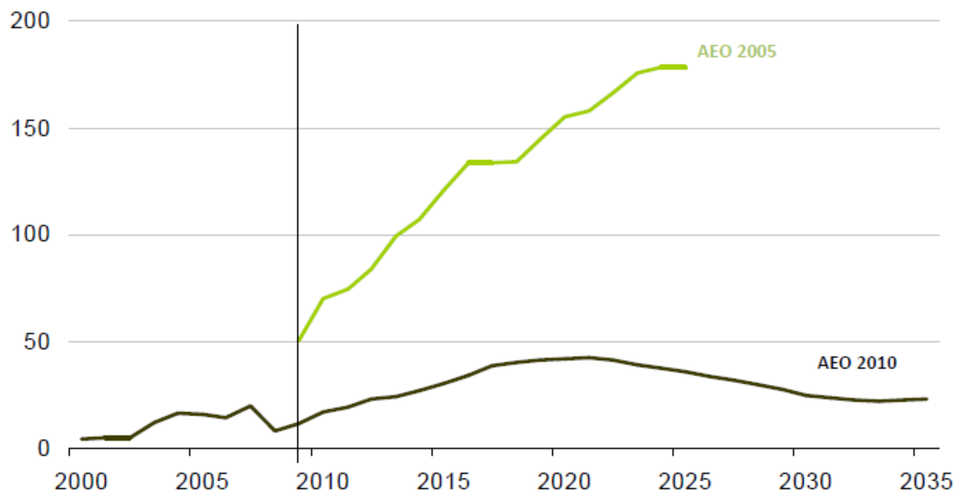
For the last 2 years, there has been a significant drop in demand for LNG in the U.S., caused primarily by a rise in unconventional gas production, which also affected gas prices globally. An excellent example of the trend is the LNG terminal at Sabine Pass, built in 2005-2009. Since its completion, only 10 gas cargos arrived at the terminal. Over a half of the American East Coast's handling capacity was unutilised in 2008.[53]

However, the actual impact of the factor on the price movement is difficult to measure, owing to the financial crisis, which had a material effect on the total gas demand. Figure 2.2 shows differences between forecasts (Annual Energy Outlook) of LNG imports developed in 2005 and 2010.

52 U.S. Energy Information Administration.

53 Gaz łupkowy w USA a sytuacja rynku ("Shale gas in the U.S. and market situation"), weglowodory.pl, May 14th 2010, after US Energy Information Administration.

Figure 2.2 – U.S. LNG import forecasts (in billions of cubic metres) [54]



A massive rise in unconventional gas production was made possible by three primary factors:

1. Improvements in horizontal drilling technology
2. Improvements in hydraulic fracturing technology
3. A surge in natural gas prices on the American market around the mid-point of the previous decade, driven by significant growth ofdemand for gas.

2.2 Overview of the U.S. shale gas market

Shale gas is present in most of the states in the U.S.. Map 2.1 shows approximate locations of the currently exploited and prospective shale gas reservoirs.

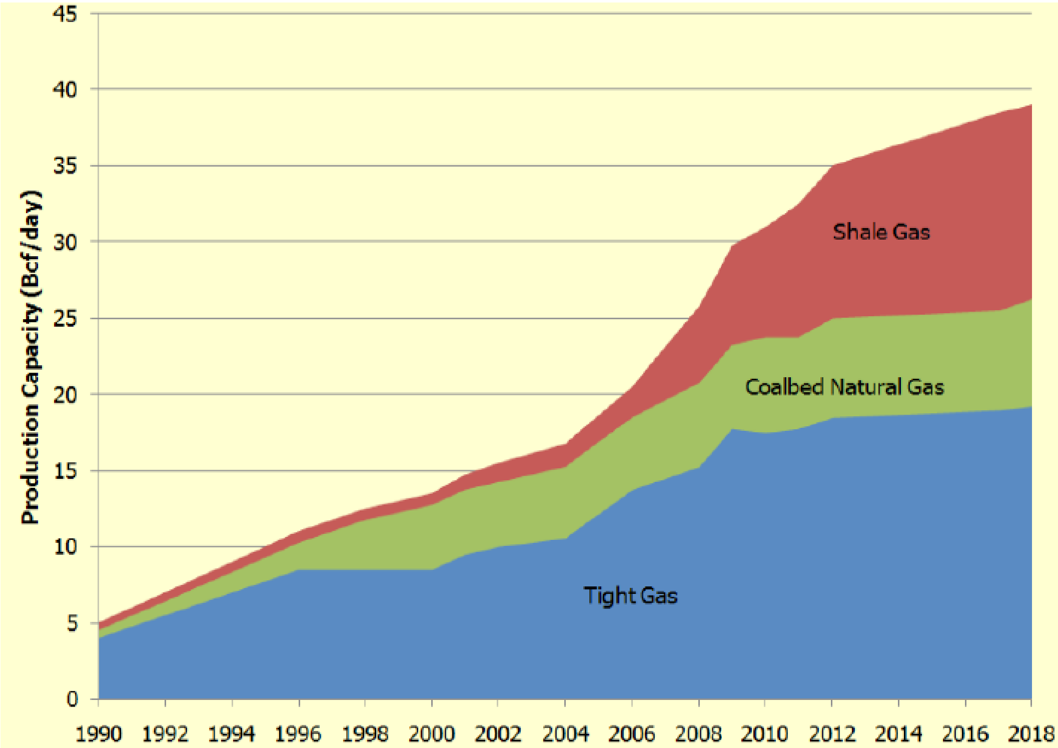
54 "The Shale Gale in the United States and Global Gas Markets", Douglas C. Hengel, US Department of State.

Map 2.1 – Proved shale gas reserves in the U.S. [55]

According to the report published by the Colorado School of Mines in July 2009, the United States' resources amount to 17 trillion cubic metres of shale gas.[56]Figure 2.2 shows the shale gas production growth over the next 8 years as projected by the Energy Information Administration. The estimates by the International Energy Agency, on the other hand, indicate that production from unconventional gas sources will rise from 360bn cubic metres to 630bn cubic metres in 2030.[57]

55 Energy Information Administration.
56 "Betting Big on a Boom in Natural Gas", Seve LeVine, Adam Aston, Bloomberg Businessweek, October 8th 2009.
57 "Shale Gas Estimates Perhaps Optimistic", The Oil Drum, October 14th, 2009.

Figure 2.3 – Development prospects for the U.S. unconventional gas market [58]

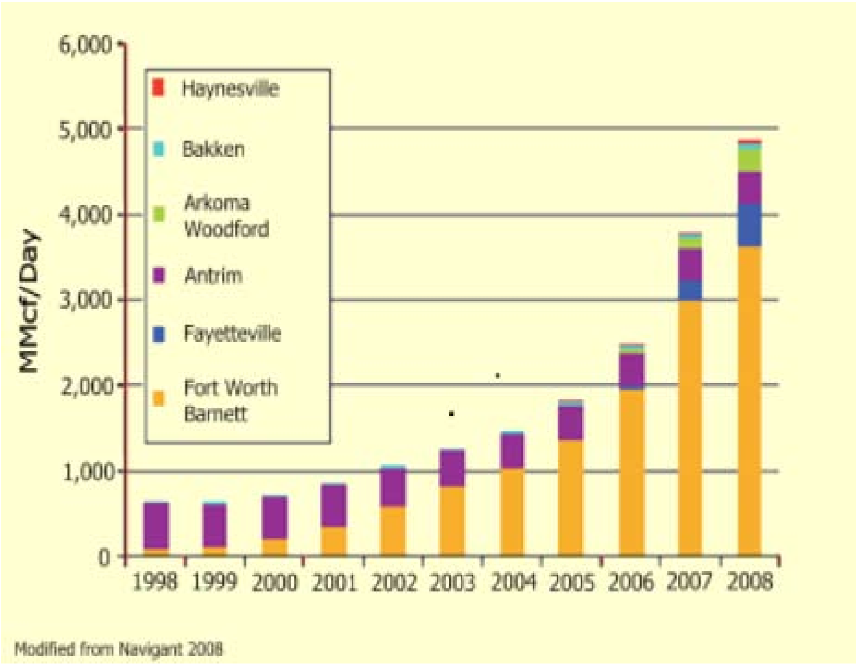


A growing interest in unconventional gas production is also evident when analysing the growth in the number of drilling rigs used for onshore development of unconventional gas. Towards the end of the 1990s, there were 40 such rigs, while in May 2008 their number was already 519.[59]

Locations where most intense work is in progress are Fort Worth Barnett, Fayetteville, Antrim, Arkoma Woodford, Bakken and Haynesville (Figure 2.3). Importantly, those shale gas reservoirs differ considerably amongst themselves in terms of production characteristics, thus requiring different approaches to development.

58 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, Apr 2009.
59 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, Apr 2009.

Figure 2.4 – Shale gas production trends in the U.S. by location [60]



An undisputed leader in unconventional gas production is Barnett Shale, Texas. Although production from the Fayetteville and Arkoma/Woodford fields is still at an early development stage, it is gradually rising (Fig. 2.3).

2.3 Barnett Shale – case study

Barnett Shale is located in the Forth Worth Basin in north-central Texas. Shale deposits are buried at depths ranging from 1,950m to 2,600m below the ground level, with calcareous rocks below and above.[61]

Over 10,000 have been drilled wells in the area. One horizontal well covers an area from 24.3 to 64.7 hectares.[62]Production from the Barnett Shale is a genuine breakthrough in unconventional gas recovery. The activities of the companies operating in that area represent a roadmap of how to produce gas from shale deposits.

60 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, April 2009.
61 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, April 2009.
62 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, April 2009.

Barnett Shale occupies an area of approximately 13,000 sq km, whereas the thickness of the gas-bearing layer varies from 30 to 185 metres. Gas resources there range from 8.5 cubic metres to 10 cubic metres per tonne of rock.

Map 2.2 Barnett Shale deposits in the Forth Worth basin [63]

63 "Modern Shale Gas Development in the United States: A Primer", US Department of Energy, April 2009.

2.4 Top players in the U.S. shale gas market (Table 2.1)[64]

NAME	HQ	NET REVENUE (USD)	NOTES
Andarko Petroleum Corporation	Texas	3.29bn (2008)	
Burlington Resources	Texas	1,5bn (2005)	Acquired by ConocoPhillips in 2006.
Carrizo Oil & Gas Co.	Texas	-66.2m (2008)	
Chesapeake Energy Corp.	Oklahoma	723m (2008)	StatoilHydro is a strategic partner
Contango Oil & Gas Co.	Texas	55.9m (2008)	
Devon Energy Corp.	Oklahoma	2.48bn (2008)	Licences shared with Total S.A. in France.
EnCana Corp.	Alberta Canada)	749m (2009)	
EOG Resources Inc.	Texas	1,089bn (2007)	
Infiniti Oil & Gas	Colorado	-8m (2008)	
Mainland Resources, Inc.	Texas	13m (2009)	
Marathon Oil Corp.	Texas	3.53bn (2008)	
Murphy Oil Corp.	Arkansas	767m (2007)	
Noble Energy Corp.	Texas	944m (2007)	
Newfield Exploration Co.	Texas	524m (2009)	
Nexen Inc.	Alberta Canada)	536m (2009)	
Parallel Petroleum Corp.	Texas	210m (2008)	In 2009, acquired by Apollo Global Mngmt.
Penn Virginia Corp.	Pennsylvania	114m (2009)	
Petrohawk Energy Corp.	Texas	1.55bn (2009)	
Questar Corp.	Pennsylvania	393m (2009)	
Quicksilver Resources Inc.	Texas	557m (2009)	Collaborates with ENI since May 2009
Royal Dutch Shell	Hague (the Netherlands)	12.52bn (2009)	Holds production sites at Barnett
Range Resources Corp.	Texas	53m (2009)	
Southwestern Energy Co.	Texas	960m (2007)	
Talisman Energy Inc.	Alberta	437m (2009)	
Occidental Petroleum Corp.	California	5.4bn (2008)	
XTO Energy Inc.	Texas	1.92bn (2008)	Acquired by ExxonMobil in 2009

64 Corporate websites and press releases by the respective companies.

PART 3

DEVELOPMENT PROSPECTS FOR SHALE GAS MARKET IN POLAND

3.1. Potential shale gas resources in Europe and current developments

In 2009, Realm Energy International Corporation, in a collaborative effort with Halliburton Consulting, commenced the appraisal of shale gas resources worldwide. The initial survey covers Europe, and the results are due in 2011.[65]

As estimated by the Energy Information Administration, shale gas production will account for 7% of the global natural gas production by 2030.[66]

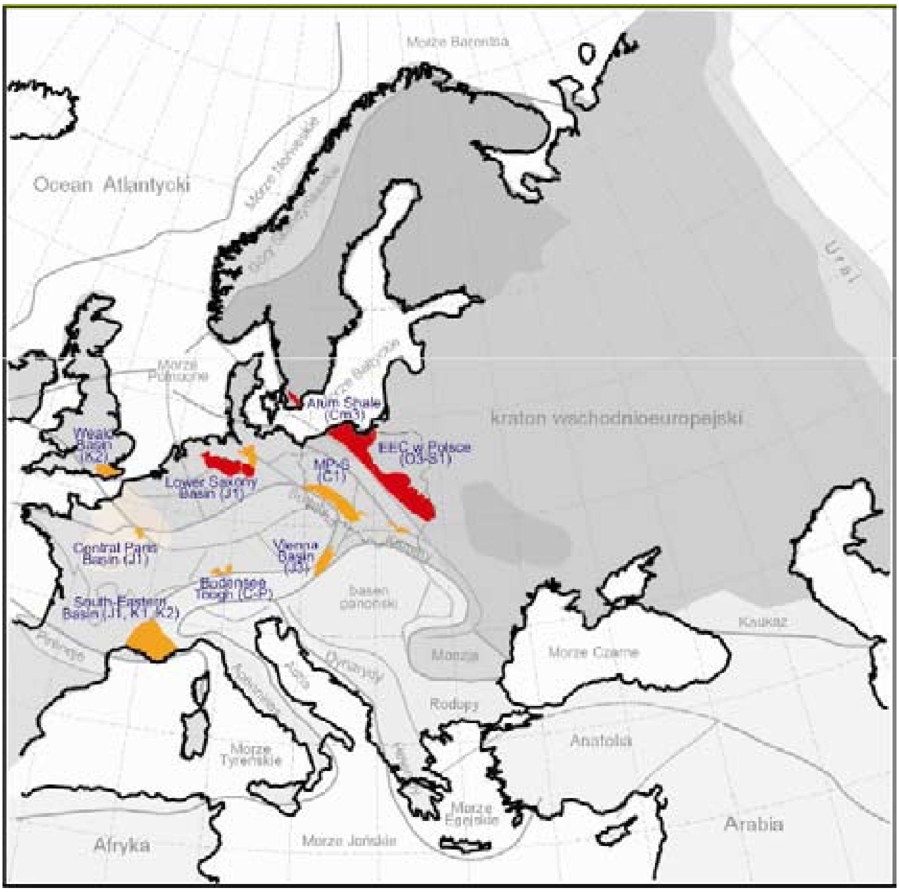
The table below (Table 2.2) shows shale gas volume estimates for the selected regions of the world.

Table 2.2 Estimates of world shale gas reserves[67]

Region	Reserves (trillions of cubic metres)	Source
World	184	IEA 2009 WEO
Outside North America	140-450	CERA 2009
OECD in Europe	3	EIA 2010
Poland (licence areas)	3	ARI 2009
Austria (licence areas)	0.85	ARI 2009
Sweden (licence areas)	0.3	ARI 2009

65 http://realm-energy.com/
66 "The shale gale in the United States and Global Gas Markets", Douglas C. Hengel, U.S. Department of State, April 8th 2010.
67 "The shale gale in the United States and Global Gas Markets", Douglas C. Hengel, U.S. Department of State, April 8th 2010.

Map 3.1 – Unconventional gas resources in Europe [68]



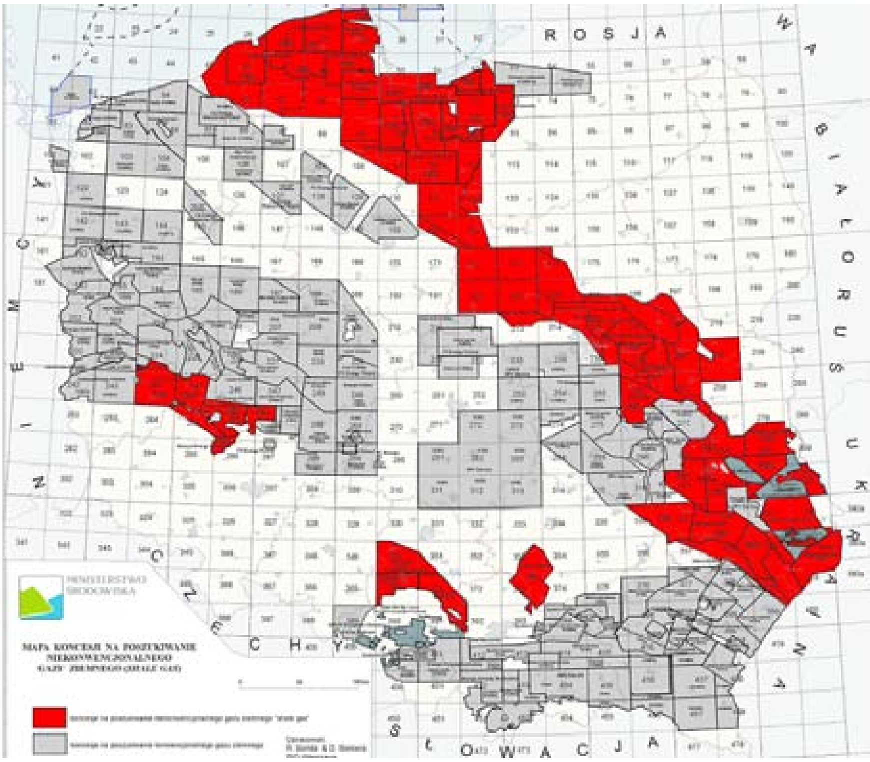
Similarly to the rest of Europe, Poland seeks to attract international corporations to invest in the exploration for, and then production of gas from unconventional sources.

3.2. Potential shale gas reserves in Poland

According to the estimates by various consulting firms, natural gas resources in Lower Palaeozoic shale formations in Poland may range from 1.4 trillion cubic metres (Wood Mackenzie) to 3 trillion cubic metres (Advanced Resources International).[69] At the moment, it is difficult to validate the estimates in a reliable way.

68 “Concession policy and legal regulations for exploration and production of gas”, Henryk Jacek Jezierski, April 2010.
69 “Poland ‘Bubbles Up”, Bloomberg.com, December 9th 2009.

Map 3.2 – Shale gas exploration licences [70]



The actual volume of the resource base will be determined in the course of work under the licences granted by the Ministry of the Environment.[71] The questions whether shale gas is present in Poland and in what quantity should be answered within the next 4 years, which is the average period for which the exploration licences have been granted. Areas covered by shale gas exploration licences are highlighted in red on Map 3.2.

The shale basin in Poland extends from the coast, in the area between Słupsk and Gdańsk, towards Warsaw, and further to Lublin and Zamość. According to forecasts, potential shale gas reserves in Poland lie at the depth of 2,500 to 3,000 metres in the eastern part of the basin, and from 4,000 to 4,500 metres in its western part.[72]

At present, considering the depth of deposits as stated above, the cost of a single vertical well may range from 6 to 13 million dollars on average.

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70 Ministry of the Environment.

71 See chapter 3.2. Current situation in the Polish shale gas market.

72 "Gaz z łupków nie szkodzi elektrowni atomowej", (Shale gas does no harm to nuclear power plant) Bankier.pl, interview with Henryk Jezierski, PhD, Piotr Siekański, April 22nd 2010.

3.2. Exploration and Appraisal of Shale Gas in Poland

As at July 1st this year, there were 224 active licences for exploration for and prospecting of crude oil and natural gas in Poland[73] (see Exhibit 1: List of licences for exploration for and prospecting of oil and gas deposits in Poland). The figure comprises exploration and prospecting licences for both conventional and unconventional hydrocarbon deposits. Exploration areas currently cover 11% of Poland's territory, that is 37,000 sq km.

Under 11 licences granted by the Ministry of the Environment, two companies with American equity participation, i.e. ExxonMobil Exploration and Production Poland Sp. z o.o. and Mazovia Energy Resources Sp. z o.o., and one with Australian equity participation, i.e. Strzelecki Energia Sp. z o.o., conduct exploration projects for unconventional natural gas only. Further 14 Polish, American, Canadian, British and Australian-owned entities hold 40 licences for exploration of and prospecting of both conventional and unconventional hydrocarbons.

One company with British equity participation (Energia Zachód Sp. z o.o., in which the majority stake is held by Aurelian Oil&Gas) carries out exploration and prospecting projects under a single licence, focused solely on tight gas deposits. Additionally, with respect to the licence areas located within prospective tight gas regions (e.g. some licences awarded to PGNiG S.A.), the licensees do not report their intention to explore for this type of deposits, and plan shale gas exploration only.[74]

As argued by numerous experts, it is not possible to precisely estimate the volume of unconventional natural gas reserves in Poland at the present stage of the exploration process. The actual size of the resources will be determined as a result of the work programmes implemented under the awarded licences. Exploration and prospecting licences for shale gas were granted in 2007-2010. The scope of work under the licences primarily covers analysis of historical data, its interpretation, seismic field work, as well as exploration and appraisal drilling.

In June 2010, Lane Energy, in collaboration with ConocoPhillips, started drilling on the Lębork prospect. The rig has been provided by Poszukiwania Nafty i Gazu "Nafta"

73 Koncesje na poszukiwanie i rozpoznawanie złóż węglowodorów w Polsce w tym shale gas i tight gas (Exploration and appraisal licences for hydrocarbon deposits in Poland, including shale gas and tight gas), Ewa Zalewska, Przegląd Geologiczny,vol. 58, No 3, 2010.

74 Koncesje na poszukiwanie i rozpoznawanie złóż węglowodorów w Polsce w tym shale gas i tight gas (Exploration and appraisal licences for hydrocarbon deposits in Poland, including shale gas and tight gas), Ewa Zalewska, Przegląd Geologiczny,vol. 58, No 3, 2010.

of Piła, whereas Schlumberger was contracted to perform supervision services, as well as all the logging and stimulation activities. The project is due to continue until the end of 2010. Lane Energy is the first company to start drilling to explore for shale gas in Poland. As reported by other companies, their seismic and drilling work is due to start by the end of this year.[75]

Until now, no shale gas deposits have been discovered in Poland. Experts agree that the presence of shale gas in Poland will be verified within the next 4 to 5 years, that is the period for which many exploration and prospecting licences were granted. As a prerequisite for gathering the relevant information, licensees will need to carry out the necessary geological surveys, including specifically well drilling in the most prospective areas.[76]

In Poland, these are the Lublin Region, Pomerania, Mazovia, and Greater Poland. If exploration confirms the presence of shale gas, and its production proves economically viable, the development of new deposits could begin in approximately 10 years.[77]

75 State Geological Institute, website on May 24th 2010.
76 Koncesje na poszukiwanie („Exploration licences"), Ewa Zalewska, etc.
77 Koncesje na poszukiwanie („Exploration licences"), Ewa Zalewska, etc.

3.3 Licensing Procedure for Companies Exploring for Shale Gas Accumulations in Poland[78]

Pursuant to the Polish Geological and Mining Law of February 4th 1994 (Dz.U. of 2005, No. 228, item 1947, as amended), operations involving exploration and appraisal of hydrocarbon deposits (including unconventional sources) require a licence, which is granted by the Minister of the Environment. The application for the licence to conduct such operations may be filed by any entrepreneur who operates under the Freedom of Economic Activity Act of July 2nd 2004 (Dz.U. of 2007, No. 155, item 1095, as amended), including an entrepreneur with foreign equity participation.

Requirements concerning the licence application are set forth in the Polish Freedom of Economic Activity Act and Geological and Mining Law. A geological work programme should be attached to the application for the licence for exploration for and prospecting of mineral resources. Specific requirements to be met by the geological work programmes are set out in the Regulation of the Minister of the Environment of December 19th 2001 on geological work programmes (Dz.U. 153, item 1777). Parties applying for a licence for exploration for or prospecting of mineral deposits are entitled to use, free of charge, geological data in the State Treasury's possession for the purposes of the preparation of geological work programmes.

Since the Polish Act on the provision of information on the environment and its protection, public participation in environmental protection and environmental impact assessments, dated October 3rd 2008 (Dz.U. No. 199, item 1227), and secondary legislation thereto (the Council of Minister's Regulation of November 9th 2004 on types of undertakings which may exert a significant impact on the environment and detailed conditions regarding classification of undertakings as requiring environmental impact reports (Dz.U. No 257, item 2573, as amended), projects which involve exploration and prospecting of natural gas, crude oil or its derivatives from deposits may be classified as having a significant impact on the environment, and thus requiring environmental impact reports. If this is the case, the competent environmental protection authority (e.g. head of commune, town mayor, or regional environmental protection directors) conducts the environmental impact assessment procedures pursuant to the said Act, which leads to the issuance of the environmental decision.

78 Based on answers provided by the Geology and Geological Licences Department at the Ministry of the Environment.

In the course of the procedure for award of an exploration and prospecting licence, the licensing authority (Minister of the Environment) consults other competent authorities, as relevant for the location of the licence area, that is heads of communes or town mayors. Their opinions are not binding on the licensing authority, but play an auxiliary rolein the licensing procedure.

Pursuant to Art. 11.2 of the Polish Geological and Mining Law of February 4th 1994, making areas available for e.g. hydrocarbon deposit exploration and prospecting (including unconventional deposits) takes the form of a tender for the mining usufruct right. The successful bidder applies for the exploration and/or prospecting licence regarding the mineral resource in question.

Importantly, mining usufruct encompassing exploration and appraisal of natural gas (including shale gas), coal-bed methane, crude oil and its natural derivatives, may also be established in a non-tender procedure, pursuant to Art. 11.2a of the Polish Geological and Mining Law of February 4th 1994, if at least one of the following conditions is met:

1) list of areas where the non-tender procedure may be applied was communicated to the general public and published in the Official Journal of the European Union;
2) the area to be covered by the proposed mining usufruct has been subject to a tender procedure but no mining usufruct was granted.

In view of the above, the list of areas where the mining usufruct can be established in a non-tender procedure was notified to the European Commission, with a request for publication in the Official Journal of the European Union, on October 7th 2005. On April 26th 2006, the European Commission published in the Official Journal of the European Union the *Communication from the Government of the Republic of Poland concerning Directive 94/22/EC of the European Parliament and of the Council of May 30th 1994 on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons and the competent authorities specified pursuant to Article 10 of Directive 94/22/EC (OJ C 98 of 26.4.2006, pp. 22-24).*

Accordingly, as of April 26th 2006, the Minister of the Environment as the licensing authority had the right to establish mining usufruct rights for exploration for and prospecting of natural gas (including unconventional gas), crude oil and its natural derivative products, as well as coal-bed methane, to the areas specified by the Minister, following a tender-based or non-tender procedure.

It is important to note that licences for exploration for and prospecting of unconventional (shale) gas deposits granted by the Minister of the Environment to date are not equivalent to licences for production of gas from the deposit.

Under the Polish Geological and Mining Law, an entrepreneur who was granted a licence is required to pay the licence fee. Pursuant to Art. 85 of the Law, in the case of exploration for and prospecting of mineral resources the fee is a product of the fee rate (PLN 217.76 in 2010) and the number of square kilometres of the area where the operations are conducted. The amount, date and method of payment are indicated in the licence. 60% of the fee represents revenue of the municipality where the operations are conducted, and 40% is revenue of the National Fund for Environmental Protection and Water Management (Art. 86. 1 of the Polish Geological and Mining Law).

On being granted a licence for exploration for and prospecting of mineral resources, the licensees sign a mining usufruct agreement with the State Treasury. The fee for the establishment of the mining usufruct varies depending on the size of the area where the operations are conducted. The entire fee represents the State Treasury's revenue (Art. 83 of the Polish Geological and Mining Law).

Importantly, in the course of their exploration and appraisal operations, entrepreneurs obtain geological data owned by the State Treasury. Furthermore, they are required to submit to the licensing authority reports on geological surveys conducted, samples of drilling cores, as well as results of work specified in the licence. This data contribute to the development of the knowledge of the geology of our country and is stored at the Central Geological Data Bank (Centralne Archiwum Geologiczne). Each licence provides for a specific scope of exploration and prospecting activities (e.g. number and depth of wells to be drilled, scope of seismic work, etc.) and other non-financial obligations, if any. All licences are disclosed in the public data register pursuant to the Act of October 3rd 2008 (Dz.U. of 2008 No 199, item 1227, as amended).

In the event that obligations under the licence are not fulfilled or are performed in gross breach of the relevant laws, the licensing authority may, under Art. 27 of the Polish Geological and Mining Law and Art. 58 of the Freedom of Economic Activity Act, withdraw the licence or modify its scope. Further, under Art. 85a of the Polish Geological and Mining Law, an additional charge may be levied on exploration and prospecting activity conducted in gross breach of the licence conditions, totalling three times the fee indicated in the licence.

3.4 Legal Aspects of Shale Gas Exploration and Production in Poland[79]

Before becoming involved in any natural gas exploration, prospecting and production projects in Poland, an investor must first of all assess the attendant legal risks. The Polish Geological and Mining Law does not provide for any special procedures with respect to exploration, prospecting and production of gas from unconventional sources. Accordingly, investors should proceed as in the case of other hydrocarbons.

As a first step, an investor interested in obtaining a licence should enter into a mining usufruct agreement with the State Treasury (under which it will have the right to use the a specific mineral deposit owned by the State Treasury) and then apply for the license (under which it will be permitted to carry out specific operations within the area). Mining usufruct and licences may cover both phases, i.e. exploration for and prospecting of minerals, or to just either of them.

Another stage of the process, entailing the execution of another agreement, is the production of approved reserves. In line with the regulations currently in force, an entity which appraised a natural gas deposit, evaluated its reserves and prepared the relevant geological documentation may – within two years of a written notification of acceptance of the geological documentation by the competent geological authority – demand the establishment of mining usufruct for its benefit, claiming priority over other applicants. What it means in practice is that within such two-year period the entity in question may also claim priority to be awarded a gas production licence.

An investor looking to become involved in exploration for and prospecting, and subsequently production, of natural gas from unconventional sources in Poland may consider several legal ways of entering that market.

79 "Prawne aspekty poszukiwania, rozpoznania i wydobycia gazu łupkowego (shale gas) i gazu zamkniętego (tight gas) w Polsce" ("Legal Aspects of Exploration, Appraisal and Production of Shale Gas and Tight Gas in Poland"), Ewa Rutkowska-Subocz, the Wierciński Kwieciński Baehr Law Office, 2010.

First of all, it may step into the place of an entrepreneur which already holds the relevant mining usufruct and licence. In such a case, the mining usufruct and the licence may be assigned to another entity. Typically, detailed conditions under which mining usufruct may be assigned are set out in the agreement establishing the mining usufruct, which may include the obligation to seek the State Treasury's approval of the assignment. As for a licence, it may be transferred by the licensing authority, upon the consent of the entrepreneur to whom it was originally granted, after the transferee fulfils certain statutorily defined conditions. The licensing authority may refuse to transfer a licence only in circumstances specified by the Law (e.g. where this would be in conflict with an overriding interest of the national economy).

An option which some investors might find worth considering involves the transfer of only a part of mining usufruct rights and rights under a licence. The new practice of transferring an interest in mining usufruct emerged in Poland as a response to expectations expressed by some investors. However, Polish law precludes the possibility of transferring an interest in a licence.

Another way for an investor to become involved in activities related to unconventional gas resources and carried out by another entrepreneur is by gaining corporate control over the entrepreneur being party to a mining usufruct agreement and a licence holder, through acquisition of shares in the entrepreneur, merger or transformation of the licensee. Given a wide range of available options, it is possible to develop and explore a number of different entry scenarios.

Yet another option involves the creation of legal and contractual links equivalent to a farm-out agreement, well known and commonly used in Anglo-Saxon countries. It is a civil-law agreement whereby one party acquires the right to a share in the production profits in return for financial and technological support of the exploration and appraisal (and subsequently the production) of minerals. The implementation into Polish law of the legal and contractual framework equivalent to a farm-out agreement may prove difficult (due to differences between the two legal systems) but is permitted by law and achievable.

In Poland, royalty payments range from 1% to 2.5% of gas production revenues, depending on production volumes. Elsewhere, royalties are several times higher – for example in the United States they amount to twenty odd percent. The government in Warsaw has strategic reasons for offering such uniquely attractive conditions. According to the government's representatives, this will attract to Poland the largest possible number of firms with know-how in the area shale gas production.[80]

In the United States, development of the unconventional hydrocarbons market was spurred by a package of tax credits and reliefs, which had the effect of encouraging investors, who were able to spend more on exploration work as well as on new technologies. A factor that also mattered was the awareness that the system of government charges was stable, which helped investors properly assess the business risk involved.

In Poland, royalties are set as a percentage of volumes produced, rather than a percentage of sales. Given the market prices of natural gas, proceeds from royalties based on production volumes are much lower than proceeds from sales-based royalties. For instance, in 2009 the royalty fee for 1,000 cubic metres of high-methane gas produced amounted to PLN 5.63 (PLN 4.68 in the case of other gases, except for coal-bed methane). To compare – in the same year, the average price paid by households for one cubic metre of gas was PLN 2.41 (including transmission charges).[81]

Although the currently applicable statutory royalties are low[82], no assurance can be given that they will not be significantly raised in the future if the wells yield promising results.[83]

The state is equipped with certain tools designed to counteract potential abuses which may occur during the process of acquiring production licences:

According to Art. 26b. of the Polish Geological and Mining Law:

The grant of a licence may be refused if the contemplated activity would violate the environmental protection requirements, including standards pertaining to sustainable management of mineral resources, also with respect to production of associated minerals, or would prevent the use of the properties in accordance with their intended purpose. The grant of a licence for storage of waste in the rock mass, including in underground mine workings, may also be refused if the waste can be utilised or neutralised otherwise than through storage, with the use of technically,

80 The Ministry of the Environment's announcement of March 11th 2010.
81 Energy Regulatory Office, May 2009.
82 News wire by RMF FM, May 14th 2010.
83 News wire by RMF FM, May 14th 2010.

environmentally and economically feasible methods.

Despite the fact that the existing laws seem to provide a stable, albeit rather poorly developed, legal framework for activities related to unconventional gas resources in Poland, it needs to be borne in mind that a draft amendment to the Polish Geological and Mining Law is now passing through Parliament. The draft provides for a number of changes, e.g. by implementing into Polish law the provisions of the so-called Hydrocarbons Directive (No. 94/22/EC), of which the most consequential one is the requirement to hold an open tender procedure for granting authorisations to explore, prospect and produce hydrocarbons. The current wording of the draft Law (as opposed to the Law being currently in force) does not warrant the conclusion that an entrepreneur who discovered a mineral deposit will still enjoy priority (and a guarantee) with respect to the establishment of mining usufruct (and granting of a production licence).

3.5 Potential issues on the way towards shale gas production in Poland

- Lack of clear policy of the government that would be reflected in a relevant regulation of the Council of Ministers with respect to activities aimed at the development of the Polish shale gas market.
- The drilling costs alone are much higher in Europe than in the U.S. In Europe, prospective shale formations are often buried deeper underground than similar shales in the U.S., which means higher drilling costs.[84]
- Polish companies do not have the necessary technology to produce shale gas in a relatively cost efficient way, while their position and presence on international markets is insignificant.
- According to Baker Hughes, a U.S.-based oilfield services company, in May 2010 there were 88 operational drilling rigs in Europe, of which 46 were onshore rigs, whereas the remaining ones were offshore rigs. At the same time, the number of operational drilling rigs in the U.S. was over 1,500.[85]According to estimates, in Poland there are 27 drilling rigs, but only some of them are currently operational. Meanwhile, importing such equipment from overseas may pose difficulties due

84 "Poland's paltry shale gas indicators" Kate Mackenzie, Financial Times, April 19th 2010.
85 Baker Hughes, June 2010.

to the fact that the U.S. and Canada rely on different computation and certification methods than those used in Europe.

- Exploration and production may present a considerable challenge, given that the land which is to be covered by such operations is heavily developed.[86]
- Little is known about the actual resources – only five wells have been drilled so far within the Baltic Sea basin in north-western Poland.
- It is conceivable that after millions of zloty have been invsted in the technology and test wells, production will prove to be not viable in economic terms.

3.6 Opportunities and benefits arising from the growth of the shale gas market in Poland

Poland stands a unique chance to completely remodel its energy market. If Wood Mackenzie's or Advanced Resources International's estimates are confirmed, Poland may turn from a gas importer into a net exporter.

Polish firms that will become actively involved in exploitation of unconventional gas deposits will stand a chance of strengthening their position on international arena.

Acquisition of state-of-the-art exploration and production technologies will provide a springboard for a "technology leap" of Poland's upstream sector.

Production of unconventional gas will boost the development of transport and transmission infrastructure across almost the whole of Poland. In addition, fees and taxes levied in connection with natural gas production will contribute to the municipal budgets.

A potential rise in natural gas consumption will help Poland meet the EU-imposed requirements sooner than it might otherwise have done, by reducing carbon emissions.

86 "Poland's paltry shale gas indicators" Kate Mackenzie, Financial Times, April 19th 2010.

SUMMARY

The continuous improvement of production technologies has enabled access to unconventional gas resources present in source rocks.

Whether Poland is going to see a gas revolution depends chiefly on the geological conditions. At this point, it is difficult to estimate the actual size of Poland's shale gas resources and commerciality of shale gas production. First results will be known in the next four or five years, when operators complete the work under exploration and prospecting licences granted to them by the Ministry of the Environment. Polish government is offering licences on exceptionally favourable terms as an incentive for research on unconventional gas resources. Such an approach is driven by the strategic objective to reduce Poland's reliance on foreign sources of natural gas in the future.

Shale gas will not change Poland's and the region's energy landscape instantaneously. As in the case of all commodity and energy revolutions, changes occur slowly, but shale gas development offers huge opportunities for a permanent shift in the Polish and European energy sectors. Poland stands a chance of becoming fully independent on natural gas imports, and Polish companies – a chance of improving their international standing.

EXHIBIT 1

LIST OF LICENCES FOR EXPLORATION FOR AND PROSPECTING OF OIL AND GAS DEPOSITS IN POLAND (as at July 2010)[87]

87 "Koncesje na poszukiwanie i rozpoznawanie złóż ropy i gazu ziemnego w Polsce (na dzień 1 lipca 2010 r.)" ("Licences for Exploration and Appraisal of Oil and Gas Deposits In Poland (as at July 1st 2010)") – Ministry of the Environment.

Company	Number of all licences for exploration and prospecting of conventional and unconventional hydrocarbon deposits*	Number of licences for exploration and prospecting of conventional hydrocarbon deposits only*	Number of licences for exploration and prospecting of both conventional and unconventional hydrocarbon deposits	Number of licences for exploration and prospecting of unconventional hydrocarbon deposits only
CalEnergy Resources Poland Sp. z o.o.	4	4	-	-
Celtique Energie Poland Sp. z o.o.	3	3	-	-
Chevron Polska Exploration and Production Sp. z o.o.	3	-	3	-
Chevron Polska Energy Resources Sp. z o.o.	1	-	1	-
Cuadrilla Polska Sp. z o.o.	2	-	2	-
DPV Service Sp. z o.o.	21	21	-	
Energia Cybinka Sp. z o.o. Sp. kom. (Aurelian Oil & Gas Poland Sp. z o.o.)	1	1	-	-
Energia Kalisz Sp. z o.o. Sp. kom. (Aurelian Oil & Gas Poland Sp. z o.o.)	1	1	-	-
Energia Karpaty Wschodnie Sp. z o.o. Sp. kom. (Aurelian Oil & Gas Poland Sp. z o.o.)	2	2	-	-
Energia Karpaty Zachodnie Sp. z o.o. Sp. kom. (Aurelian Oil & Gas Poland Sp. z o.o.)	4	4	-	-
Energia Torzym Sp. z o.o. Sp. kom. (Aurelian Oil & Gas Poland Sp. z o.o.)	1	1	-	-
Energia Zachód Sp. z o.o. (Aurelian Oil & Gas Poland Sp. z o.o.)	3	2	1	-
ExxonMobil Exploration and Production Poland Sp. z o.o.	5	-	2	3
FX Energy Sp. z o.o.	21	21	-	-
Gas Plus International Sp. z o.o.	1	1	-	-

Helland Investments Sp. z o.o. (Realm Energy International Co.)	1	-	1	-
Indiana Investments Sp. z o.o. (BNK Petroleum)	3	-	3	-
Joyce Investments Sp. z o.o. (Realm Energy International Co.)	1	-	1	-
Lane Energy Poland Sp. z o.o. (3Legs Resources Plc)	6	-	6	-
Lane Resources Poland Sp. z o.o. (3Legs Resources Plc)	3	-	3	-
Liesa Investments Sp. z o.o. (San Leon Energy)	2	-	2	-
Marathon Oil Poland Sp. z o.o.	7	-	7	-
Maryani Investments Sp. z o.o. (Realm Energy International Co.)	1	-	1	-
Mazovia Energy Resources Sp. z o.o. (EurEnergy Resources Corporation)	7	-	-	7
Oculis Investments Sp. z o.o. (San Leon Energy Plc)	3	-	3	-
LOTOS Petrobaltic S.A.	8	8	-	-
PGNiG S.A.	89	82	7	-
Orlen Upstream Sp. z o.o. (PKN Orlen S.A.)	5	-	5	-
PL Energia S.A.	2	2	-	-
RWE Dea AG S.A.	5	5	-	-
Saponis Investments Sp. z o.o. (BNK Petroleum)	3	-	3	-
Strzelecki Energia Sp. z o.o.	1	-	-	1
Vabush Energy Sp. z o.o. (San Leon Energy Plc)	1	-	1	-
Total	221	158	52	11

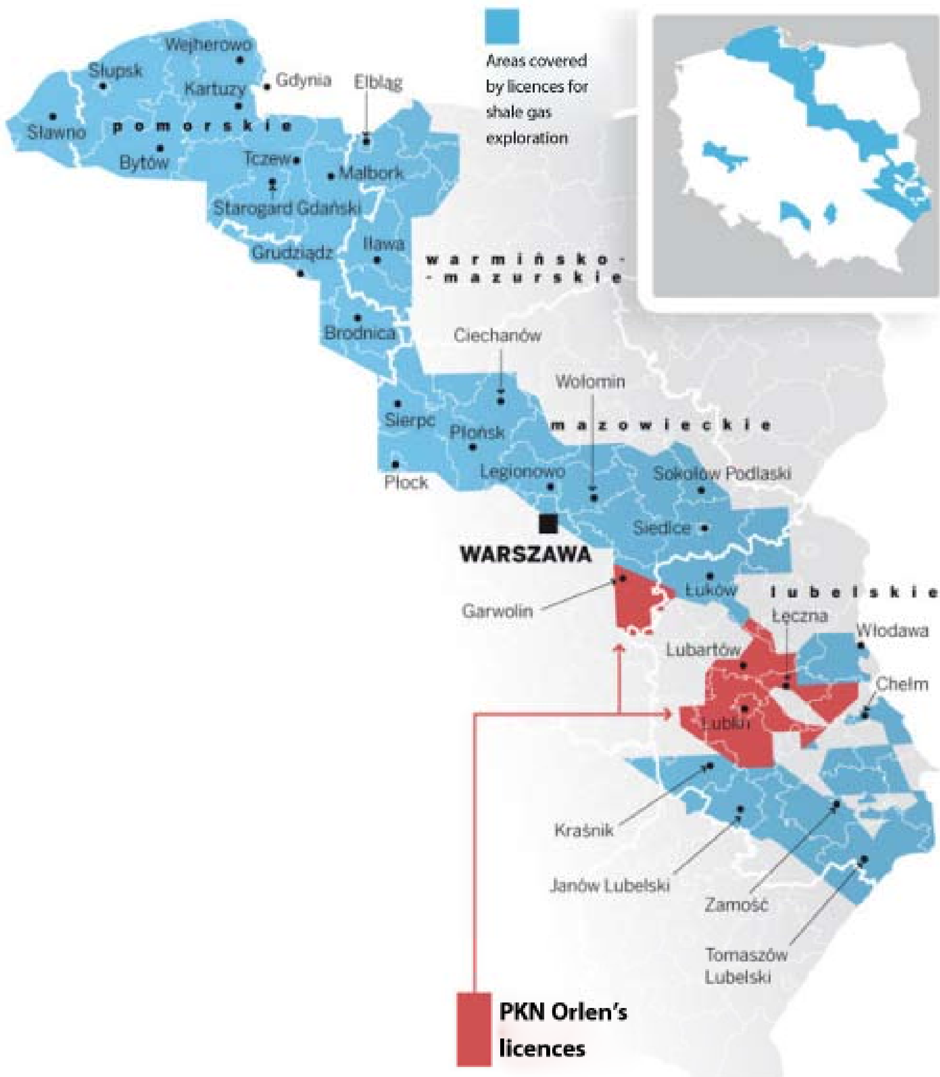
EXHIBIT 2

CASE STUDY – EXPLORATION FOR SHALE GAS ON THE PKN ORLEN EXAMPLE[88]

88 Information sourced from PKN Orlen.

PKN Orlen holds five licences for exploration and appraisal of hydrocarbons in the Lublin region, obtained in November 2007. The licence area is approximately 5,000 sq km. Areas of presence of conventional resources potentially overlap with areas of presence of unconventional resources. PKN Orlen's subsidiary responsible for fuel exploration, including shale gas exploration, is Orlen Upstream.

Map – Areas covered by PKN Orlen's Licences[89]



89 Source: Dziennik Gazeta Prawna, February 25th 2010.

Completed surveys[90]

PKN Orlen has completed the first phase of surveys under the licences for the Lublin basin. PKN Orlen analysed historical geological data, well data, including geophysical and seismic measurements. The surveys covered prospects within Carboniferous and Devonian formations. Some work was also carried out with a view to documenting the current understanding of early Palaeozoic formations (late Ordovician and early Silurian shale formations) in the most prospective sections of PKN Orlen's licence blocks.

Following the surveys, the most prospective conventional resources and potentially prospective unconventional resources were selected for further seismic studies. Initial estimates of recoverable reserves have also been made.

The main horizons which seem the most prospective and where the largest conventional resources were discovered are sand and siltstone Carboniferous formations at 1,500 to more than 3,000 metres below the ground level and Early Palaeozoic shale formations at 1,500 – 4,000 metres below the ground level.

New seismic surveys were carried out on the Garwolin licence block. The surveys included field 2D seismic reflection surveys along preselected seismic lines. The general contractor for the seismic studies - Geofizyka Kraków Sp. z o.o. - has the necessary equipment and long-standing experience in carrying out such surveys in Poland and around the world.

The first interpretation of the seismic surveys will probably be possible in August 2010.

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90 As at June 8th 2010.

Further surveys

At present[91], further seismic surveys are underway. By the end of October 2010 a total of 2,300km of 2D seismic lines will have been analysed. Tests will be carried out to determine the shale's susceptibility to hydraulic fracturing to stimulate gas migration into the wellbore. At the same time, all gathered data will be analysed to confirm the depth of prospective resources, and the location of the first exploration wells will be identified.

The budget which PKN Orlen plans to allocate for the first phase of shale gas exploration exceeds PLN 100m.

Planned drilling

By 2012, well drilling will be undertaken to confirm the physical and mechanical properties of the rock and to determine the composition and maturity of organic material. These characteristics predetermine the amounts of recoverable gas.

In 2012–2013, first wells are planned to test production capabilities. The years 2014–2016 will see the drilling of first horizontal wells with the length of 1 to 2km, which will serve for future production.

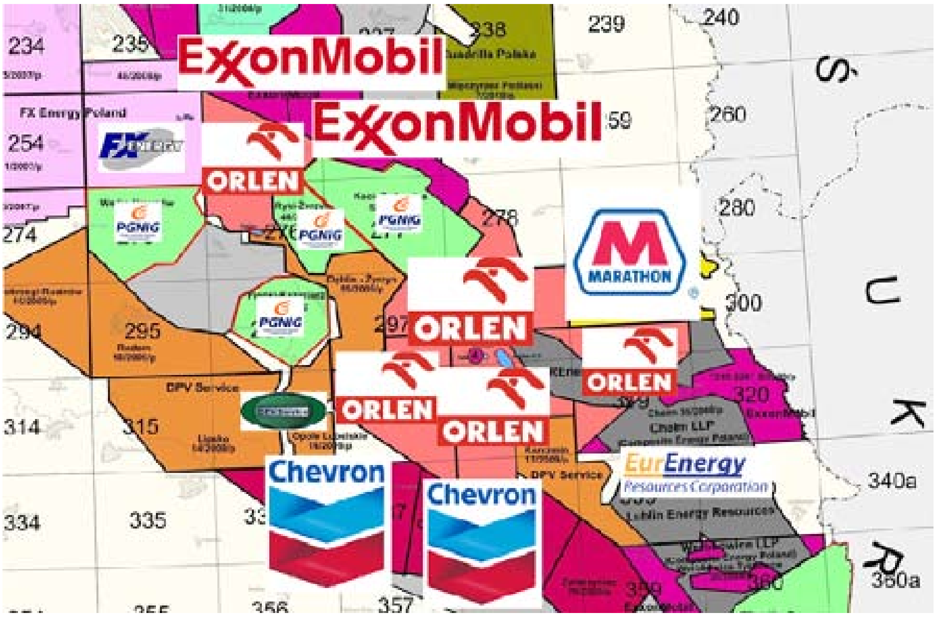
Financing of surveys and future development

Orlen Upstream is financing the exploration work with its own funds. At present[92], talks are underway with partners potentially interested in cooperation, who have the technology and experience required for exploration and development of shale gas. At a later stage, the investment will be most probably implemented on a project finance basis.

Natural partners for potential cooperation are companies whose licence areas are adjacent to the borders of PKN Orlen's five licence areas in the Lublin region, namely ExxonMobil, Chevron, and Marathon Oil. Orlen has signed 15 agreements with other companies, based mainly in the U.S., but also in Italy, Canada, Austria, the Netherlands, and the United Kingdom (including Lane Energy, South West Energy, Eni, Shell).

91 As at June 8th 2010.
92 As at June 8th 2010.

Map – Licensees in the Lublin region[93]



Implementation of such innovative projects in cooperation with experienced partners offers tangible benefits:

- Access to know-how and appropriate technologies
- Minimised exploration risk, with priority over other applicants to be granted rights to produce from the discovered reserves.

Further licences

Currently[94], studies are being performed in order to identify further potentially prospective areas of unconventional gas resources in Poland.

93 Source: PKN Orlen.
94 As at June 8th 2010.

EXHIBIT 3

COAL-BED METHANE BOOM OF 1990s

In 1990s, a great uproar was raised by photographs taken by an American satellite, showing clouds of methane over Silesia. Methane in the atmosphere came from coal-bed methane resources. Proved coal-bed methane reserves are present in 51 fields in the Upper-Silesian Coal Basin.

Coal-bed methane resources according to AGH University of Science and Technology of Kraków (Akademia Górniczo-Hutnicza w Krakowie):

- proved, recoverable, reported methane reserves – 89.5 billion cubic metres
- methane in producing fields – approximately 26 billion cubic metres
- methane in developed fields – 3.6 billion cubic metres
- methane in undeveloped reserves or more than 1km below the ground level – approximately 60 billion cubic metres
- potentially recoverable coal-bed methane – approximately 350 billion cubic metres.

Foreign concerns, like Amoco, Texaco, McCormic, made in 1990s more than a dozen wells testing flow of gas directly from coal deposits, but the results were not satisfactory and further work was abandoned. As in the case of shale gas, the problem of thight rock has to be overcome to extract methane from coal beds . Polish coal deposits are characterised by low fracture density and low permeability, which means that a large number of wells is required to extract methane from a small area. Due to these characteristics of Polish coal deposits, foreign players abandoned their plans to extract methane in Poland through drilling.

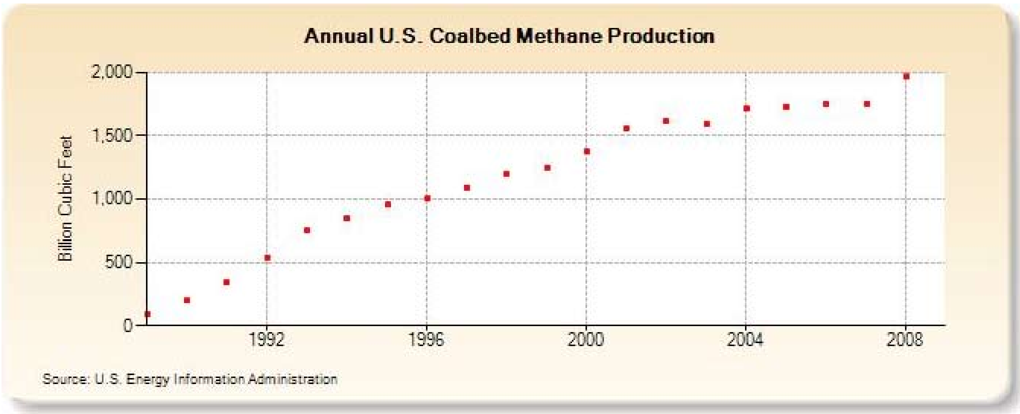
The largest producers of coal-bed methane are currently the following coal mines:

1. KWK Brzeszcze – 109.80 million cubic metres annually (Kompania Węglowa)\
2. KWK Krupiński – 99.72 million cubic metres annually (Jastrzębska Spółka Węglowa)
3. KWK Zofiówka – 52.63 million cubic metres annually (Jastrzębska Spółka Węglowa)

To compare, the U.S. resources of coal-bed methane are estimated at 588.9 cubic metres. The annual U.S. production of coal-bed methane in 1990–2008 rose ten-fold: from 5.55 billion cubic metres to 55.67 billion cubic metres.[95]

95 www.eia.doe.gov.

Figure 4.1 – Annual U.S. coal-bed methane production (billions of cubic feet)



Clouds of methane photographed by the American satellite were created by gas flowing into the atmosphere from ventilation systems of coalmines and through rock mass cracking. The methane is there but it is difficult to extract.

Now, the quantities of extracted methane depend on coal production. Methane is extracted to ensure miners' safety and serves as a source of energy for coal mines.

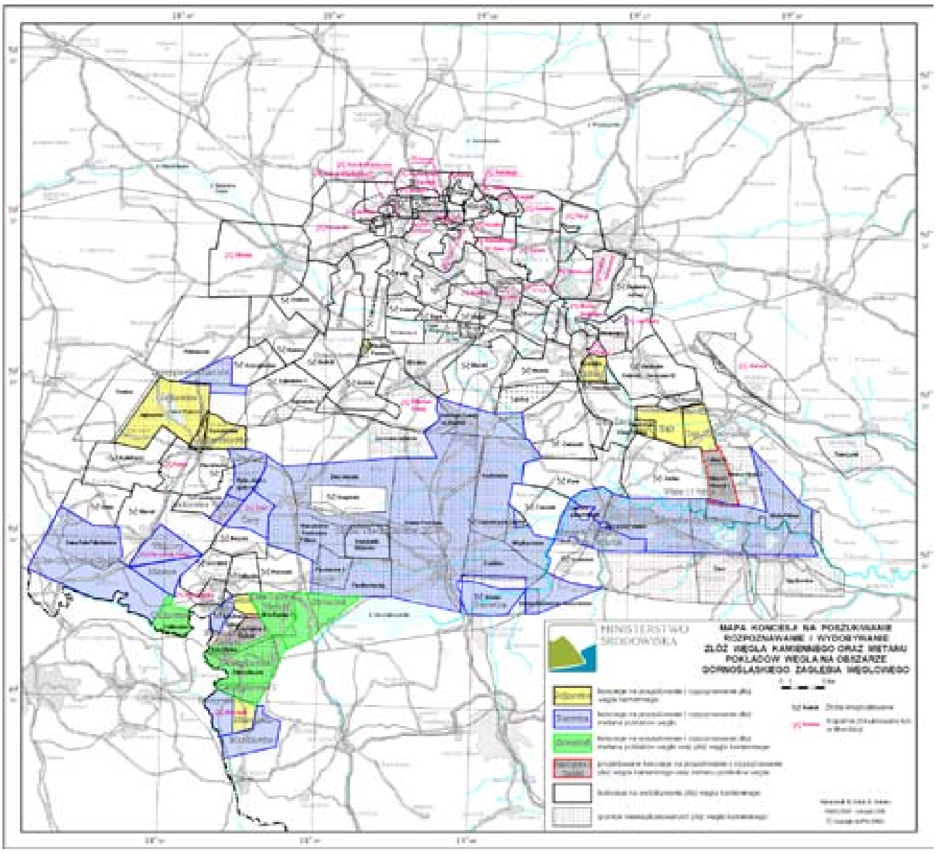
In Poland, methane is used chiefly by coal mines, to produce heat and power and to provide electricity for coal dryers and air-conditioning systems.

Alternatively, methane can be used for municipal purposes. Jastrzębska Spółka Węglowa, whose mines are assigned the highest (4th) category in terms of methane bearing capacity, plans to launch a pilot project in the Moszczenica coalmine, closed down in 2000. Jastrzębska Spółka Węglowa also wants to sell methane in cylinders. The project is to be launched in 2011 by CNG Jastrzębie. Methane would be sourced from the Budryk, Pniówek and Krupiński coal mines.

The only company whose sole business is methane production is KARBONIA PL, a subsidiary of New World Resources, owned by Zdenek Bakala, a Czech coal magnate. Methane is produced in the former Morcinek coal mine in Kaczyce (near the Czech border) and sent mainly to Czech consumers (smaller quantities to Polish market, including municipal consumers).

An additional source of revenue from methane production comes from allowance trading. Methane's global warming potential is 21 times higher than that of carbon dioxide. By expanding methane degassing facilities and using gas for industrial purposes Polish companies obtain CO_2 Emission Reduction Units (ERUs), which can be traded on the international market. First such transaction was carried out by JSW, when it sold ERUs to Chugoku Electric Power, a Japanese power corporation (its annual revenue from sale of ERUs is approximately PLN 1m). A similar multi-year contract, valued at approximately PLN 30m, was signed with Chugoku by Kompania Węglowa.

Map 4.1 – Licences for exploration, appraisal and production of coal and coal-bed methane in the Upper-Silesian Coal Basin [96]



96 Polish Geological Institute.

Why does the shale gas market stand a better chance to develop than the coal-bed methane market?

- access to shale gas deposits is easier (methane is found in coal beds that in a majority of cases are controlled by coal mining conglomerates)
- over the last decade, the cost of exploration and production has fallen
- stronger emphasis is placed on environmentally friendly technologies and implementation of international climate standards

Table 4.1 – Companies holding licences to produce methane as the main mineral[97]

Company	No. of licences	Capital	Licence type
Fiten Gaz Sp. z o.o. (Cetus - Energetyka Gazowa Sp. z o.o.)	6	PGNiG	Licences for exploration and appraisal of methane
Werbkowice LLP, Chelm LLP Composite Energy (Poland) Sp. z o.o.	2	Owned by UK-based exploration company Composite Energy Ltd., which holds licences in England, Scotland and Poland (the province of Lublin, areas in the vicinity of Chełm and between Tomaszów Lubelski and Hrubieszów) www.composite-energy.co.uk	same as above
EurEnergy Resources Poland Sp. z o.o.	3	A subsidiary of U.S.-based exploration company EurEnergy Resources Corporation, which holds licences in the U.S., Bulgaria, Poland, Romania, Ukraine, Kazakhstan, Libya, the Caribbeans and Columbia.	same as above
European Diversified Resources Sp. z o.o.	1	A private company registered in Poznań, whose shareholders are Ian Macgregor Thom, Bolesław Kozyrski and Anthony Scott Veitch.	same as above
Pol-Tex Methane Sp. z o.o.	2	Owned by Consolidated Seven Rocks Mining (whose shareholders include Polish engineer Bohdan Żakiewicz, PhD, and Przemysław Koelner).	same as above (including one "combined" licence, currently in the exploration and appraisal phase)
Urządzenia i Konstrukcje S.A.	1	Construction of machinery for the coal industry, including Katowicki Holding Węglowy; www.uiksa.pl	Licence for exploration and appraisal of methane

97 www.mos.gov.pl

NWR Karbonia PL Sp. z o.o.	1	New World Resources (Zdenek Bakala) www.newworldresources.eu	(Licence for exploration, appraisal and production; currently in the production phase)
Metanel S.A.	1		Licence for production of methane from "Silesia Głęboka"
CH4 Sp. z o.o. (Pol-Tex Methane Sp. z o.o.)	2	Licences for production of coal and methane ("Strumień").	Licences for exploration and appraisal of coal and methane
Jastrzębska Spółka Węglowa S. A.	3		same as above
NWR Karbonia Sp.z o.o.	1	New World Resources (Zdenek Bakala) www.newworldresources.eu	same as above

EXHIBIT 4

LIST OF FIGURES, MAPS AND CHARTS

EXHIBIT 5

GLOSSARY OF NAMES AND TERMS

ARI - Advanced Resources International Inc. (www.adv-res.com) - a U.S.-based research and consulting firm which has provided services related to geologic studies since 1970s. It specialises in unconventional petroleum resources, enhanced oil recovery and carbon sequestration.

BTU - British Thermal Units (BTU) - units of energy used predominantly in the U.S. One BTU corresponds to the amount of energy needed to heat one pound of water by one degree Fahrenheit. 1 BTU equals about 1,054 J to 1,059 J.

CERA - Cambridge Energy Research Associates (more precisely: IHS CERA) - a renowned U.S.-based consulting and business intelligence firm specialising in energy resources, having its seat in Cambridge, Massachusetts. The company's founder and president is Daniel Yergin, a recognised expert in geopolitics and economics of energy resources (mainly oil) and a Pulitzer Price winning author of *The Prize: The Epic Quest for Oil, Money and Power.* CERA is a member of IHS (Information Handling Services) Inc., a publishing (e.g. Jane's Defence Weekly) and business intelligence group listed on the New York Stock Exchange.

EIA - Energy Information Administration (www.eia.doe.gov) - a unit of the U.S. Department of Energy. EIA collects information and publishes analyses on energy resources, as well as on the U.S. and global energy markets.

IEA - International Energy Agency (www.iea.org) - an organisation of 28 countries, including Poland (since 2008), established in the wake of the oil crisis of 1973-1974. Initially, it was dedicated to coordinating actions at times of oil supply disruptions, but its current role is to develop common energy security policies and to promote economic development and environmental protection.

HORIZONTAL DRILLING – a technique involving the initial drilling of a vertical wellbore, deviating it at a pre-determined depth to a horizontal trajectory and drilling on into the target rock formation for a distance which may exceed one kilometre from the vertical well (the record length was 11 kilometres).

DRILLING MUD – a fluid used in well drilling which has a number of important functions, such as removing and carrying out drill cuttings, cooling and lubricating the drill bit and the drill pipe, securing the stability of the borehole walls in drilled intervals, controlling subsurface pressures, and providing information on drilled rocks. In horizontal drilling, it also provides hydraulic power to the drill bit and sets it in a rotary motion.

HYDRAULIC FRACTURING – once a sufficient number of fractures are created within the target zone, a mixture of water and sand with the grain size suited to the rock porosity is pumped into the wellbore, invading the fractures and preventing them from closing, while providing natural passageways for gas flowing into the wellbore. Hydraulic fracturing may be performed in a variety of ways. A fracturing fluid of controlled viscosity, humidity and gravity may be mixed with a small quantity (up to a few percent) of chemical additives which enable proper execution of the treatment. Apart from sand, alternative filling materials may include ceramic materials, metal and plastic pellets and polymer fluids, which get transformed into a network of tangled fibres. The opening of the fractures is controlled by means of microseismic probes and fibre-optic cables.

Tcf - trillion cubic feet (U.S.), 1 cubic foot equals 0.028316846592 cubic metre.