ACTIVITIES IN SHALE GAS AND SHALE OIL EXPLORATION IN POLAND

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PRESENTATION OUTLINE

- PGNiG SA – COMPANY INTRODUCTION
- ENERGY SITUATION IN POLAND
- SHALE GAS RESOURCES ESTIMATION FOR EUROPE AND POLAND
- SHALE GAS/OIL EXPLORATION ACTIVITY IN POLAND
- PGNiG SA SHALE GAS/OIL EXPLORATION ACTIVITY
  - EXECUTED AND PLANNED WORKS
  - OVERVIEW OF THE DRILLED WELLS
- RISK RELATED TO THE UNCONVENTIONAL HYDROCARBON EXPLORATION IN POLAND
PGNiG (Polish Oil and Gas Company) is a leader in natural gas segments in Poland that contain trade, distribution, oil and gas exploration and production as well as gas storage and processing. The company is also the largest importer of natural gas to Poland.

PGNiG provides nearly 100% of gas production in Poland and up to 70% of oil production in Poland.

PGNiG produces from fields in Poland (2011):
- 4.33 bcm of natural gas
- 468 ths tons of crude oil

The production is also from fields abroad:
- Norwegian Shelf - the production started at the end of December 2012
- Pakistan – the production is planned to start in 2013
PGNiG SA - EXPLORATION & PRODUCTION ACTIVITY IN POLAND

93 Exploration Concessions
with total acreage of 60.9 ths sq. km

225 Production Concessions
with total acreage of 1.5 ths sq. km

- oil 40
- oil and gas 32
- gas 153
OIL AND GAS FIELDS IN POLAND

**Discovered:**
- 110 oil fields
- 231 gas fields
- 8 oil and gas fields
- 5 Petroleum Provinces

**Main Exploration Targets**

![Map of Oil and Gas Fields in Poland](image)

**Oil and Gas Fields in Poland**
- **Oil fields**
- **Gas fields**

**Legend:**
- OIL - Cenozoic Foredeep (sandstones)
- OIL - Flysch Carpathians (sandstones)
- OIL GAS - Flysch Carpathians (sandstones)
- OIL GAS - basement of Carpathian Foredeep (sandstones and carbonates)
- OIL GAS - basement of Cenozoic Foredeep (carbonates)
- Oil GAS - Jurassic Trough (carbonates)
- Oil GAS - Jurassic Trough (sandstones)
- Oil GAS - Flysch Carpathians (sandstones)
- Oil GAS - Flysch Carpathians (sandstones)
- OIL - Baltic Syncline (sandstones)
PGNiG SA - CONCESSION AREAS OUTSIDE POLAND

**Norway**

**Participation**
- PGNiG SA 100%

**Acreage**
- 5,494.0 km sq

**Geographic site**
- Province Awbari, Murzuq Basin

**Obligations**
- 3,000 km 2D seismic, fulfilled
- 1,500 km sq 3D seismic, fulfilled
- 8 exploration well

**Estimate stocks**
- 146.2 bcm natural gas
- 15.4 MM tons condensate

**Pakistan**

**Participation**
- Pakistan Petroleum Limited 30%
- PGNiG SA 70%

**Acreage**
- 956.22 km sq

**Geographic site**
- Province Sindh, Folded belt Kirthar

**Obligations**
- 1 well, 100 km 2D seismic, fulfilled

**Reserves**
- 11.6 bcm of natural gas

**Pakistan**

**Participation**
- BG Norge AS 40.00%
- Idemitsu Petroleum Norge AS 20.00%
- Norwegian Energy Company ASA 20.00%
- PGNiG Norway AS 20.00%

**Acreage**
- 1,197.96 sq km

**Structures**
- PL599

**Location**
- Norwegian Continental Shelf
ENERGY SITUATION IN POLAND – FUEL CONSUMPTION SHARES

- Poland is consuming 14.4 bcm of gas per annum (comparable to Romania and three times less than Spain, France or the Netherlands);
- Gas share in Polish energy market is much lower than an average in the EU (14% against 26%);
- It is a consequence of the extensive usage of coal (hard/brown) as the source of primary energy.

EU natural gas sales by sector in 2010**

PGNiG natural gas sales breakdown in 2011

** Source: EuroGas Statistical Report 2011
Polish energy policy is determined by directives and requirements of European Union, which assume natural gas will remain the fuel of choice and will continue to make a growing contribution to energy supply in Europe, because of “its green properties” and highly efficient application technologies.

Energy security is the main priority in Polish energy policy. This is the result of high dependency on imported hydrocarbons. To meet the demand, Poland is forced to import 95% of oil and more than 70% of gas. More than 94% of oil and 80% of gas is imported from Russia by Friendship and Yamal pipelines. The governments goal is to diversify the import sources and transport ways.
In gas sector crucial Polish government activities include:
- Construction of LNG terminal in Świnoujście to diversify delivery sources
- An increase in capacities of underground gas storages
- Extention of transmission and distribution system and network
- An increase of domestic gas production

In oil sector the crucial Polish government activity is an extention of Odessa-Brody oil pipeline from Ukraine to Polish refineries in Płock and Gdańsk.

Poland is willing to have high resources of unconventional oil and gas. The confirmation of that could change the energy situation in Europe. What is important for Poland, it would decrease the country dependancy on the import of these energy sources.
### EUROPEAN SHALE GAS RESOURCES ESTIMATIONS

#### DISTRIBUTION OF SHALE PLAYS IN EUROPE

<table>
<thead>
<tr>
<th>Country</th>
<th>Shale Gas Resources</th>
<th>Natural Gas Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BCM</td>
<td>TCF</td>
</tr>
<tr>
<td>Poland</td>
<td>5295.84</td>
<td>187</td>
</tr>
<tr>
<td>France</td>
<td>5097.6</td>
<td>180</td>
</tr>
<tr>
<td>Norway</td>
<td>2350.56</td>
<td>83</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1189.44</td>
<td>42</td>
</tr>
<tr>
<td>Sweden</td>
<td>1161.12</td>
<td>41</td>
</tr>
<tr>
<td>Denmark</td>
<td>651.36</td>
<td>23</td>
</tr>
<tr>
<td>U.K.</td>
<td>566.4</td>
<td>20</td>
</tr>
<tr>
<td>Netherlands</td>
<td>481.44</td>
<td>17</td>
</tr>
<tr>
<td>Turkey</td>
<td>424.8</td>
<td>15</td>
</tr>
<tr>
<td>Germany</td>
<td>226.56</td>
<td>8</td>
</tr>
<tr>
<td>Lithuania</td>
<td>113.28</td>
<td>4</td>
</tr>
<tr>
<td>Ro+Hu+Bg</td>
<td>538.08</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: US Energy Information Administration, April 2011  
Bcm=10⁹m³, Tcf=10¹²ft³

According to preliminary estimates, the Europe total shale gas in place resources could be 17500 BCM. If these can be proven and produced, it could dramatically change Europe's energy balance, reducing the continent's dependence on gas imports.
POLISH SHALE GAS RESOURCES ESTIMATES

<table>
<thead>
<tr>
<th>Shale Gas Basins</th>
<th>Risked Gas In-Place</th>
<th>Recoverable Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bcm</td>
<td>Tcf</td>
</tr>
<tr>
<td>Baltic Basin</td>
<td>14556</td>
<td>514</td>
</tr>
<tr>
<td>Lublin Basin</td>
<td>6287</td>
<td>222</td>
</tr>
<tr>
<td>Podlasie depression</td>
<td>1586</td>
<td>56</td>
</tr>
</tbody>
</table>

Source: US Energy Information Administration, April 2011
Bcm=10^9m³, Tcf=10^{12}ft³
Up to date 22 companies (including 3 Polish companies: PGNiG SA (POGC), Orlen Upstream and Lotos) have been awarded 111 concessions for exploration of unconventional resources. Another submitted applications wait for awarding decision in the Polish Ministry of Environment.
Polish national company PGNiG SA (POGC) has been awarded 15 concessions covering an area of 12 766.10 km². PGNiG SA (POGC) concessions are located within important Paloezoic sedimentary basins, starting from the Baltic Syneclise in the northern Poland, through Podlasie Basin in the central part, ending in the Lublin Basin in the south. Lower Paleozoic shales of Silurian and Ordovician age are considered as the most prospective for unconventional hydrocarbons and are the main target for “shale gas” and “shale oil” exploration.
SHALE GAS/OIL – WHAT KIND OF ROCKS ARE WE LOOKING FOR?

Characteristics of perspective horizon for shale gas/oil exploration:

- Laterally continuous
- Not significantly disturbed by tectonic activity (natural fracture presence might be favourable in terms of hydraulic fracturing)
- Thickness higher than 30m
- High organic matter content (more than 2% TOC)
- Thermal maturity in gas/oil window
- Brittle enough to be fractured (contains more than 40% of sillica and has proper geomechanical properties)
- Contains hydrocarbons!!!
Accessible geological, geophysical and geochemical data suggest that Ordovician and Silurian shales are rich enough in organic matter and thermally matured enough to be worth an inputted interest. According to available data, PGNiG SA (POGC) concessions are located within the area of different, but generally high, exploration potential what creates hope for the future success.
PGNIG SA – EXECUTED AND PLANNED EXPLORATION ACTIVITIES FOR SHALE GAS/OIL IN 2013

Wejherowo License
Executed:
Lubocino-1 well
Lubocino-2H well
Opalino-2 well
Lubocino 3D seismic survey
Planned:
Opalino-3,-4 wells
Kochanowo-1 well
Czestkowo-1 well
Tepcz-1 well
Opalino 3D seismic survey

Kartuzy Szemud and Stara Kiszewa Licenses
Executed:
Somonino-Przywidz 2D seismic survey
Wysin-1 well – currently drilled
Planned:
Borcz-1 well
Miłowo-1 well
Kartuzy Szemud-1 well
Mirowo-1well

Bartoszyce and Górowo Iławieckie Licenses
Analysis of available geological and geophysical data is now being performed.
After the results is known, new exploration program will be created for these two licenses

172, 173, 192, 193 Licenses
New 2D seismic data has been recently acquired and is now being interpreted.
New wells will be planned after interpretation results.
Drilling is planned for 2014

Warka- Ursynów and Kock-Tarkawica Licenses
Executed:
Czernic-Ryki 2D seismic survey
Planned:
Wojcieszków-1 well

Pionki Kazimierz and Ryki- Żyrzyn Licenses
Analysis of available geological and geophysical data is now being performed.
After the results is known, the decision about well location and drilling will be made

Tomaszów Lubelski and Wisniów-Tarnoszyn Licenses
Executed:
Lubycza Królewska-1 well
Korczmin 2D seismic survey
Planned:
Fracking in Lubycza Królewska well
Kościaszyn-1 well
The first vertical exploration well, Lubocino-1, was drilled at the beginning of 2011. The well ended up in Cambrian deposits and drilled 1843.5 m of Silurian and 63 m of Ordovician strata. 800 m of core was recovered, which was further analyzed to examine geochemical, petrophysical and geomechanical properties of the rocks. Wide spectrum of wireline logging was also applied. The results of combination of both, laboratory and geophysical analysis, turned out to be very promising and confirmed the presence of unconventional gas within the Ordovician and Silurian strata.
LUBOCINO-1 WELL RESULTS – GEOCHEMICAL INTERPRETATION

Geochemistry interval 2200 - 2972 m

- Presence of organic matter content (TOC > 0.5%) from laboratory analyses indicate good and very good source rock potential in prospective interval (2550 – 2972m).
- Total gas from MudLog during shows increased value in the most prospective interval 2550 – 2972 m.
- Temperature $T_{\text{max}}$ shows sufficient thermal maturity of organic matter within Lower Silurian and Ordovician deposits.
- Hydrogen index values are also satisfactory and are placed at the transition zone of oil and wet gas window.
Reservoir properties
interval
2200 - 2972m

• Laboratory analyses of permeability indicate its good properties especially in the 2550 – 2972 m interval where they reach up to 50mD. Its significant scattering suggest rock matrix permeability as well as fracturability and presence of fractures.

• Total porosity values measured by porosimeter and magnetic resonance analyses correspond well with total porosity interpreted from wireline logs.

• Effective porosity values measured by NMR analyses do not correlate sufficiently with effective porosity interpreted from wireline logs.
Lubocino-2H horizontal well was spudded on 28.08.2012 at the same well pad location as vertical Lubocino-1. The horizontal section was drilled at the 2925m TVD. The total measured depth of the well was 3980m (MD). The horizontal section, 932m in length, was drilled in the Upper Ordovician horizon in the 200° azimuth.
Lubocino-2H well was drilled in Upper Ordovician horizon (Caradocian Sasin Formation) in the interval containing high amount of sillica. Geomechanical analysis of the core samples and geophysical measurements indicated these rocks to be brittle. What is more geochemical analysis showed high content of organic matter, proper thermal maturity and hydrocarbon saturation.

7 stages of hydraulic fracturing was planned but due to technical problems 6 were executed.

2925m (horizontal section depth)
3D SEISMIC DATA IN PLANNING THE HORIZONTAL WELLS- LUBOCINO 3D SEISMIC SURVAY

Using different seismic attributes (relating on acoustic parameters of rocks and principles of acoustic waves propagation) it is possible to define the areas of the best geological and geomechanical properties of rocks. It is highly recquired in the planning of well location and stimulation processes.
Opalino-2 well is the exploration well designed to recognize the Lower Paleozoic potential for unconventional exploration and the saturation within Middle Cambrian deposits.

The well was drilled at the end of 2012 to the TD of 3050m. Around 300m of core was taken which is now subjected to the detailed laboratory analysis. Preliminary analysis results suggest better parameters of Lower Paleozoic rocks for unconventional oil/gas exploration than in the nearby Lubocino-1 well. Opalino-2 well was logged with all necessary tools to get the reservoir characteristics as accurate as possible.

Middle Cambrian horizon was tested and the inflow of gas (85% CH4) was recorded.
WYSIN-1 WELL

Wysin-1 well is the first exploration well designed to recognize the Lower Paleozoic potential for unconventional exploration on Stara Kiszewa License.

The well was spudded at the end of March 2013.

Wysin-1 well is a vertical well and is going to be drilled to the total depth of 3990m TVD. Drilling will be finished in Middle Cambrian deposits.

Around 370m of core is going to be taken that will be subjected to the detailed laboratory analysis. The well will be logged with all necessary tools to get the reservoir characteristics as accurate as possible.
Lubycza Królewska-1 well, on Tomaszów Lubelski concession, was spudded on Mar. 26th 2012. The total depth of the well was at 3530m. The well was going to drill 1300 m of Silurian and 250 m of Ordovician deposits while in fact it recognized 2055m of Silurian and 268m of Ordovician. The high changes between planned and actual stratigraphy were the result of the tectonic zone presence. Many technical problems with well drilling were encountered. Nearly 800m of core was recovered and is now being subjected to the detailed laboratory analysis. The well was logged with all necessary tools to get the reservoir characteristics as accurate as possible.
WHAT IS THE RISK ASSOCIATED WITH EXPLORATION OF UNCONVENTIONAL GAS RESOURCES IN POLAND?

The risks associated with exploration of unconventional gas deposits in Poland include:

- **unrecognized geology** – most of the archive wells come from 1970s and 1980s, what results in the absence of the most required data for shale prospectivity analysis (geochemical data indicating organic matter content and maturity, kerogen type etc.). Old geophysical measurements don’t give the possibility of reliable reservoir parameters estimation,
- **urbanization of the area** – population density in Poland is quite high (122 persons/km²). What is more, the perspective zones for “shale gas” exploration are located within areas used for agriculture activities,
- **restrictive regulations on environmental protection** – the concession owner has to take into consideration local Polish and European Union legal regulations,
- **large number of environmentally protected areas and objects** – numerous concession areas are covered by National Parkas, Nature Preservation Areas as well as Natura 2000 zones. Exploration works are highly limited within these. Exploration should be provided according to Spatial Development Plan created by local authorities,
- **negative opinions from local authorities, especially from attractive touristic areas,**
- **access to proper water resources** – drilling and fracturing one horizontal well requires 8000-20 000 m³ of water,
- **very high capital cost (cost and number of wells, large production facilities),**
- **cost of proper technologies,**
SUMMARY AND CONCLUSIONS

- Poland has the potentially largest resources of shale gas in Europe.

- The development of the unconventional gas/oil in Europe is still in the preliminary stage.

- Exploration of unconventional gas/oil will not be easy but one should remember that such gas accumulations create opportunities for both Europe and for companies starting the exploration.

- The existing evaluations of the shale gas potential in Poland are promising.

- Further evaluation is ongoing and each month brings new data. The understanding of Palaeozoic formations increases with each drilled well.

- It is very possible that Poland could have gas on a scale large enough not only to cover its demand, but probably to export gas or to replace coal-power generation as well.
THANK YOU FOR YOUR ATTENTION