STORAGE POTENTIAL OF POLAND (THE BALTIC BASIN)

Adam Wójcicki & Jolanta Pacześna, PGI-NRI

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CO2 storage projects – Poland and Europe

- 1995-.. Borzęcin gas field (acidic gas – 60% CO2; INiG, POGC)
- 2004-2008 Kaniów coal beds (RECOPOL& MoVeCBM; CMI)
- Bełchatów demo CCS project (EEPR funding; PGI-NRI involvement; cancelled)
- Pilot project on injection into Jurassic aquifer (same as for Bełchatów demo site) – research permit granted in 2011
- Kędzierzyn demo CCS project cancelled (to be relocated?)
- LOTOS EOR? (ECO2 project)
- New power blocks – CCS ready to be proven
- Regional studies
**Estimations of CO2 storage capacity (PL)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Storage potential, Mt</th>
</tr>
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<tbody>
<tr>
<td><strong>CASTOR</strong></td>
<td></td>
</tr>
<tr>
<td>EU GeoCapacity</td>
<td>3 752</td>
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<tr>
<td>CO2 Atlas of Poland</td>
<td>3 522</td>
</tr>
<tr>
<td>Cr1, J1, T formations (upper limits)</td>
<td>8 299</td>
</tr>
<tr>
<td>Hydrocarbon fields (31 structures)</td>
<td>764</td>
</tr>
<tr>
<td>Coal seams (selected CBM fields at depth of 1-2 km)</td>
<td>414</td>
</tr>
<tr>
<td>Coal seams within Polish SCB at depth of 1-2 km</td>
<td>1 254</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td><strong>5-9.5 Gt</strong></td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td><strong>~92 Gt</strong></td>
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</tbody>
</table>

- Saline (Mezozoic) aquifers are of biggest potential and sufficient to store emissions of big plants,
- Hydrocarbon fields (mostly gas) are of small capacity,
- Coal seams (methane recovery) are of local importance (SCB), the technology is not mature yet.

*Emission of industrial installations ~ 200 Mt/yr*
The Programme

„Assessment of formations and structures for safe CO2 geological storage including monitoring plans“;

Ordered by Ministry of Environment (=the permitting authority of Directive on geological storage of CO2).

Conducted by 6 national institutions (PGI-NRI – leader, AGH-UST, CMI, MEERI, O&GI, PBG).

Timeframe: 10.2008-09.2012; ~80 persons involved;

Goals:

Supporting Polish demo projects,

Providing the permitting authority with information necessary for implementing CO2 storage,

Cooperation with other stakeholders, R&D organizations.
It covers entire territory of Poland and the Baltic economic zone, but is focused on:

- regional studies for 8 areas with saline aquifers,
- hydrocarbon fields and coal beds in general,
- case studies for saline aquifer structures (4),
- case studies for hydrocarbon fields (2) and coal beds (1).

reinterpretation of archive data, laboratory analyzes
Site screening/selection criteria (based on CO2STORE guidelines)

- **Seal thickness**: minimum 50 m, the seal integrity is essential
- **Aquifer depth**: from 800 m to 2500+ m
- **Aquifer net thickness**: minimum 20-30 m (~a single layer)
- **Porosity of the reservoir**: minimum 10%, preferably 20%
- **Permeability of the reservoir**: minimum 50-100 mD
- **Salinity**: minimum 30 g/l, in case of relic, isolated fluids it might be lower
- **Capillary entry pressure** – is the caprock good enough, impermeable?
- **Information necessary to evaluate the structure against criteria mentioned above**
The regional studies

The following geological formations are perspective for the regional study areas of saline aquifers:

- I (central) – Jurassic (J1, J2 sandstones), T;
- II (S) – Lower Miocene;
- III (central-NE) – Jurassic (J1, J2 sandstones), Cr1,T;
- IV (SE) – Carpathian front foredeep (J to Cm basement);
- V (E) – Carboniferous (C3 sandstones), Cm;
- VI (W) – Permian (P1), T, J;
- VII (NW) – Jurassic (J1 sandstones), T3, T1 – a small part offshore;
- VIII (N, incl. offshore area – E part of Polish Baltic economic zone) – Cm2.
The outcome of the programme

- Regional studies being completed;
- Case studies (4 structures in saline aquifers, one oil, two gas fields, one CBM area).
- Estimated realistic/effective storage capacity for Poland is about 15 Gt (saline aquifers >92%, hydrocarbon fields 7%, coal beds <1%); about 94% onshore
The distribution of wells onshore and offshore is uneven, depending on exploration programmes of POGC (onshore) and Petrobaltic (offshore). Same refers to seismic – Petrobaltic lines are mainly of 1980 and 90s (Anolik et al., 2008), POGC onshore of various vintages.
There are a couple of hydrocarbon fields in Polish part of the Baltic Basin considered as CO2 storage sites. These are B3 and B8 in NE offshore area and Kamień Pomorski in west. Storage capacities of these fields are of 2-7 Mt. Other fields are smaller and/or not developed yet.
Map of the top of Cambrian/floor of Ordovician. The Cambrian aquifer is secondary to Jurassic onshore, but not so bad within 1,3-2 km depth range (in oil fields in eastern part average porosity is up to 10% and permeability 60-100 mD; some sandstone beds reach 20% porosity) but with compartments. Realistic storage capacity ~ **0.9 Gt** (sweep efficiency 2%).
Lithology of the Middle Cambrian aquifer

Map of facies and paleothickness of the Cambrian aquifer. Yellow and olive denote prevalence of sandstones, in brown areas shales and mudstones prevail. Onshore and NW offshore part of the area VIII are ruled out.
Map of present thickness of the Cambrian aquifer.
Reservoir properties of the Cambrian aquifer

Map of effective porosity of the Cambrian aquifer.
Reservoir properties of the Cambrian aquifer

Maps of permeability and effective porosity of the Cambrian aquifer after laboratory measurements.
Reservoir properties of the Cambrian aquifer

Maps of porosity of the Cambrian aquifer after laboratory measurements of gas & oil and gas filtration space (AGH – archive report).
The regional seal – Upper Cambrian (of insufficient thickness)
The regional seal – Caradoc (of sufficient thickness)
The regional seal – Llandovery (of sufficient thickness)
The regional seal – Wenlock (of sufficient thickness)
There is a great interest in exploration for unconventional hydrocarbons in Poland (even offshore). However, recent reports of PGI and USGS rather point out no real conflict with CO2 storage. The red polygon denotes perspective area of Cambrian aquifer offshore.
Conclusions

Studies of the National Programme and other projects can provide the following conclusions on Polish part of Baltic basin:

- In area VII (NW Poland) structures in Jurassic and Triassic aquifers make up about 3 Gt capacity. Offshore part of VII is small and excluded because of NATURA2000.

- In area VIII Cambrian aquifer is perspective, both offshore and onshore. Offshore area has in average a relatively poor reservoir properties (though there are hydrocarbon fields) and capacity 0.9 Gt, onshore part south of Russian border has far better properties but the area is smaller, so its capacity is similar, of at least 0.8 Gt.
Conclusions

Studies of the National Programme and other projects can provide the following additional conclusions on the selected area of Polish economic zone of Baltic:

- Offshore data (wells, seismic) are of LOTOS-Petrobaltic but those older than 1989/90 are state owned – in both cases approval of respective owners is needed to use data in new projects.

- Caprock includes Upper Ordovician claystones of sufficient thickness (~50 m) and a far thicker Silurian complex (minimum 150 m) but O3/S1 formations are perspective for unconventional hydrocarbon resources.
The new project (for Ministry of Environment)

„A detailed assessment of areas perspective for CO2 storage on the area of Polish economic zone of Baltic Sea”(2014-2016)

The Workpackages of the project:
- Data acquisition, database construction;
- Static (structural-parametric) models of the storage complex (including analyzes of rock samples);
- Dynamic simulations for the storage sites;
- Risk identification and risk management plans;
- Monitoring programme for the storage sites;
- A prefeasibility study for the storage sites;
- Coordination, information strategies, dissemination of results.
Thank you for your attention:

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