OUTLINE

• Introduction
• What is the BASTOR Project?
• SLR’s Current Assignment
• Activities to date
• Current findings
• Way forward
Overview:

SLR has approximately 1,000 staff in offices in Europe, North America, Australasia and Africa. We provide global advice and support on a wide range of strategic and site specific environmental issues to a diverse and growing base of business, regulatory and governmental clients. Turnover in 2012 was c.100 million euros.
OIL AND GAS SERVICES

- Prospectivity evaluation
- Exploration planning
- Operations geology
- Data room and portfolio evaluation
- Evaluation of farm-in and farm-out opportunities
- Procurement and contract negotiation
- Management of exploration programmes
- Administration of exploration research projects
- Promotion and dissemination of research results
- CPR reports for AIM listings
- Oil spill contingency planning
- Environmental monitoring
- Planning and management of oily waste arisings
SLR AND CCS

- Active CCS practice based in Dublin
- Draw on technical expertise from SLR around the world
- Active in CCS since mid 1990’s
- Focus on transport and storage, and wider implications of CCS
- Projects around the world
  - Currently working in Baltic Sea, offshore Nova Scotia and South Africa
EXAMPLES OF PAST CCS PROJECTS

• Assessment of the All Island Potential for Geological Storage of Carbon Dioxide in Ireland (EPA and GSNI).
• Carbon Capture Ready components of proposed new coal fired power station (RWE)
• Preparation of FP7 Application for EU Funding of Multi National Research Project on CCS Storage Site Characterisation
• Potential for Carbon Dioxide Sequestration in the Clare Basin (ESB)
• The Re-Use of Offshore Oil and Gas Pipelines (DTI)
• Report on Infrastructure, Availability and Costs for CO₂ Transportation and Storage Offshore – Southern North Sea (DTI)
EXAMPLES OF CCS REPORTS
THE BASTOR BALTIC SEA CO2 PROGRAMME

• Bastor Programme: collaboration between

  – Finland
    • VTT
    • Finnish Industrial Partners
  – Sweden
    • Elforsk
    • Swedish Industrial Partners
    • Global CCS Institute
  – Others?
BASTOR
BALTIC SEA STORAGE OF CO2

• Study on CO₂ storage potential in Baltic Sea region
• Study based on analysis of previously measured available data
• Focus is on the southern part of the Baltic Sea region
• The first phase started by the Finnish CCSP research programme
• Current phase continued by the Swedish CCS Project consortium
SOURCES OF CO2

Legend
- Cement and lime production
- Iron and steel production
- Non-ferrous metal production
- Offshore oil and gas activities
- Oil and gas refineries
- Other
- Power and heat production
- Production of chemicals
- Pulp and paper production
- Waste treatment or incineration

global environmental solutions
SOUTHERN PART OF BALTIC SEA

Source: Erslstöm, SGU, (OPAB)
DEFINITION OF THE STUDY AREA

Identification of saline aquifers for CO2 storage

Geological cross section west-east

 Depths of base of the Baltic Basin
MAIN TASKS

- Data compilation
- GIS map creation
- Basin screening
- Calculation of theoretical storage potential
- Build static model
- Final closure structure selection and modelling
- Dynamic modelling of selected structures
- Injection test methodology
- Final report
DATA COMPILATION TO DATE

• Data sources
  – Published literature
  – OPAB/Svenska
  – Latvian Environment, Geology and Meteorology Centre (general data)

• Data includes
  – Onshore and offshore structure maps (almost all)
  – Cambrian reservoir isopach maps (Sweden, Lithuania, Poland, Kaliningrad)
  – Well data (Sweden, Latvia, some Lithuania)
  – Reservoir and seal formation properties (Sweden, some Lithuania and Poland)
  – Reservoir conditions/production data (Sweden, some Lithuania)
CAMBRIAN RESERVOIR & DALDERS MONOCLINE
### Basin Screening – Minimum Criteria

<table>
<thead>
<tr>
<th>Suitability Criterion</th>
<th>Suitability threshold</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Depth</td>
<td>&gt;800 m</td>
<td>0.07</td>
</tr>
<tr>
<td>2 Size at surface</td>
<td>&gt;2500 km&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.06</td>
</tr>
<tr>
<td>3 Seismicity</td>
<td>&lt;High (i.e., not in subduction zones)</td>
<td>0.06</td>
</tr>
<tr>
<td>4 Reservoir/Seal</td>
<td>At least one major extensive and competent seal</td>
<td>0.08</td>
</tr>
<tr>
<td>5 Faulting and/or fracturing</td>
<td>Low to moderate</td>
<td>0.07</td>
</tr>
<tr>
<td>6 Pressure regime</td>
<td>Not overpressured</td>
<td>0.05</td>
</tr>
<tr>
<td>7 Regulatory status</td>
<td>Accessible</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>0.42</strong></td>
</tr>
</tbody>
</table>
### Basin Screening – Secondary Qualifiers

<table>
<thead>
<tr>
<th>Suitability Criterion</th>
<th>Suitability Threshold</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>&gt;800 m</td>
<td>0.07</td>
</tr>
<tr>
<td>Size at surface</td>
<td>&gt;2500 km²</td>
<td>0.06</td>
</tr>
<tr>
<td>Seismicity</td>
<td>High (i.e., not in subduction zones)</td>
<td>0.06</td>
</tr>
<tr>
<td>Reservoir/Seal</td>
<td>At least one major extensive and competent seal</td>
<td>0.08</td>
</tr>
<tr>
<td>Faulting and/or fracking</td>
<td>Low to moderate</td>
<td>0.07</td>
</tr>
<tr>
<td>Pressure regime</td>
<td>Not overpressured</td>
<td>0.05</td>
</tr>
<tr>
<td>Regulatory status</td>
<td>Accessible</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>0.42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential Criterion</th>
<th>Poor Potential</th>
<th>Good Potential</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ sources</td>
<td>At &gt;500 km distance</td>
<td>At &lt;500 km distance</td>
<td>0.08</td>
</tr>
<tr>
<td>Physical accessibility</td>
<td>Difficult</td>
<td>Good</td>
<td>0.03</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>None or poor</td>
<td>Developed</td>
<td>0.05</td>
</tr>
<tr>
<td>Hydrogeology Flow systems</td>
<td>Shallow, short</td>
<td>Deep and/or long</td>
<td>0.08</td>
</tr>
<tr>
<td>Geothermal regime¹</td>
<td>Warm</td>
<td>Cold</td>
<td>0.10</td>
</tr>
<tr>
<td>Hydrocarbon potential and industry maturity</td>
<td>None, poor</td>
<td>Large, mature</td>
<td>0.08</td>
</tr>
<tr>
<td>Coal</td>
<td>Too shallow or too deep</td>
<td>Between 400 and 1000 m depth</td>
<td>0.04</td>
</tr>
<tr>
<td>Coal value²</td>
<td>Economic</td>
<td>Uneconomic</td>
<td>0.04</td>
</tr>
<tr>
<td>Climate</td>
<td>Arctic and sub-arctic</td>
<td>Temperate</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>0.58</td>
</tr>
</tbody>
</table>
### RANKING OF BALTIC SEA SUB BASINS FOR CO2 STORAGE

<table>
<thead>
<tr>
<th>Rank</th>
<th>Basin</th>
<th>Characteristics</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Slupsk Border Zone</td>
<td>Proven reservoir/seal pair, moderate size structures, offshore, large saline aquifer, limited faulting, good accessibility, &lt;500kms to strategic CO2 sources</td>
<td>0.76</td>
</tr>
<tr>
<td>2</td>
<td>Gdansk-Kura Depression</td>
<td>Existing oil and gas production infrastructure, moderate sized structures, offshore, fair accessibility, &gt;500kms to some strategic CO2 sources</td>
<td>0.75</td>
</tr>
<tr>
<td>3</td>
<td>Liepaja Saldus Ridge</td>
<td>Proven reservoir/seal pair, moderate size structures, offshore, fair accessibility, &lt;500kms to strategic CO2 sources</td>
<td>0.75</td>
</tr>
<tr>
<td>4</td>
<td>Latvian Estonian Lithuanian Border Zone</td>
<td>Proven reservoir/seal pairs, small structures, potential saline aquifer, only small area sufficiently deep for CO2 storage, accessible, 250kms to strategic CO2 sources</td>
<td>0.71</td>
</tr>
</tbody>
</table>

- Four main sub basins identified and ranked in order of suitability for CO2 storage
- The border zones have potential storage capacity in saline aquifers
- Existing oil and gas fields have limited storage capacity except as local sites for specific projects (e.g. Lotos refinery in Gdansk to B3 Field offshore Poland)
REGIONAL MAP OF SEDIMENTARY BASINS WITH CO₂ STORAGE POTENTIAL
METHODOLOGY FOR CALCULATION OF STORAGE POTENTIAL

• Digitise closures at Cambrian level from maps and reports
• Source field & reservoir data from various reports
• Apply EU GeoCapacity CO$_2$ storage capacity formula to obtain
  – Regional estimates based on bulk volume of aquifers
  – Regional estimates based on trap volumes
  – Capacity estimation in hydrocarbon fields (Schuppers et al 2003)
  – Capacity estimation in hydrocarbon fields (Bachu 2007)
### BALTIC SEA SUMMARY STORAGE POTENTIAL

<table>
<thead>
<tr>
<th></th>
<th>Estimated CO₂ Storage Capacity (10⁶ tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Baltic Sea Field Total</td>
<td>852.28</td>
</tr>
<tr>
<td>Dalders Structure</td>
<td>127.91</td>
</tr>
<tr>
<td>Dalders Monocline</td>
<td>1923.55</td>
</tr>
<tr>
<td>Regional Cambrian Below 900m</td>
<td>16221.56</td>
</tr>
</tbody>
</table>

**Health warnings**

- Limited well data for Dalders area – calculations for structures are based on static reservoir model volumes, LGMC Cambrian structure data and the E6-1 well data.
- Dalders Monocline uncertainty – thickness was assumed to increase from the south west (about 30m) to the north east (about 110m) based on the reservoir thickness observed in the P6 and B-9 wells.

Regional Estimates for CO₂ storage potential in saline aquifer in the Cambrian below 900m are comparable to Sliaupa, S. 2009.
**Estimated CO2 Storage Capacity (10^6 tonnes)**

<table>
<thead>
<tr>
<th></th>
<th>Latvia</th>
<th>Lithuania</th>
<th>Poland</th>
<th>Kaliningrad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocarbon - General Storage Potential</td>
<td>28.87</td>
<td>3.28</td>
<td>15.10</td>
<td>167.10</td>
</tr>
<tr>
<td>Hydrocarbon - Field Storage Potential</td>
<td>1.86</td>
<td>2.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saline Aquifer - Field Storage Potential</td>
<td>633.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>633.46</td>
<td>30.72</td>
<td>5.90</td>
<td>167.10</td>
</tr>
</tbody>
</table>

**Health warnings**

- OOIP and EUR values used for hydrocarbon fields based on the LO&G report data are likely to be overestimated (demonstrated by Svenska data for 3 onshore Lithuanian fields).

- 40 new structures indentified in Poland (for a total surface of 1,046 km^2) in addition to the 7 structures from BASTOR1, but no reservoir or field data are available for these structures. Hence, the total theoretical storage capacity for Poland still remains low.

- Additional 145 structures have been identified in Kaliningrad from published literature. The combined surface area including these new structures is 708 km^2 vs 419 km^2 previously in BASTOR1 with more reliable structure outlines. Storage capacity estimations are still mostly based on EUR from the LO&G report with only an additional 15.1Mt from 12 additional structures (the largest of which is D6-1 field) for which more recent published EUR data is available.

- Latvia storage capacity data is based on individual structure outlines and estimated based on well data form E6-1, E7-1 and P6 wells.
TECHNO ECONOMIC RESOURCE PYRAMID (CSLF 2007)

Increasing Certainty of Storage Potential

- Theoretical Capacity
- Effective Capacity
- Practical Capacity
- Matched Capacity

Increasing cost of storage
THE JURISDICTIONAL CHALLENGE

global environmental solutions
NEXT STEPS – BASTOR 2

- Obtain additional data from selected Kaliningrad fields to increase regional theoretical storage capacity (in discussion with VNIGRI)
- Obtain additional data from selected Polish offshore fields to increase storage capacity and obtain reservoir data (in discussion with PGI)
- Refine static reservoir models and choose target structures
- Build dynamic models on chosen target area based on the static reservoir models and production field data
- Assess sealing cap rock potential
- Develop an injection test methodology to include MMV programme
- Compile final report
CCS IS SEEN AS AN ESSENTIAL TOOL TO COMBATING GLOBAL WARMING

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