CO$_2$ storage atlas for Sweden - a contribution to the Nordic Competence Centre for CCS, NORDICCS

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NORDICCS concept:

Assumptions and premises (1) → Nordic CCS platform → Nordic CCS roadmap → Framework conditions → Economy → Strategies for CCS realisation

Feasibility studies on CCS industry cases:
- CO₂ capture
  - Energy analyses (5)
  - CCS integrated (6) in industry
- CO₂ transport (4)
  - Cost-effective CO₂ transport
- CO₂ storage (2)
  - The Nordic CO₂ storage atlas
  - Guidelines for site storage
  - Site storage modelling

R&D recommendations

Communication (3) and dissemination:
- Public awareness and acceptance
- Dissemination and networking

Spreading excellence

Partners:

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Summary

The Swedish part of the CO₂ storage atlas is based on a screening process by analysing existing deep wells and seismic data regarding deep saline aquifers and cap rocks in SW Scania and SE Baltic Sea.

Sweden presents eight potential deep saline aquifer storage units and one single storage trap. Very preliminary estimations indicate a potential Swedish CO₂ storage capacity of 3400 Mt or more.

The poster was presented at 31st Nordic Geological Winter Meeting, 8-10 January, Lund University, Sweden.

Keywords  CO₂ storage mapping, Storage Capacity, webGIS, Storage atlas, Scania, Baltic Sea.

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About NORDICCS

Nordic CCS Competence Centre, NORDICCS, is a networking platform for increased CCS deployment in the Nordic countries. NORDICCS has 10 research partners and six industry partners, is led by SINTEF Energy Research, and is supported by Nordic Innovation through the Top-level Research Initiative.

The views presented in this report solely represent those of the authors and do not necessarily reflect those of other members in the NORDICCS consortia, NORDEN, The Top Level Research Initiative or Nordic Innovation.

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During the last 10-20 years Nordic countries have been involved in several international CO\textsubscript{2} storage mapping projects. Swedish contributions have traditionally been limited. However, in 2011 all five Nordic countries joined forces in a CCS competence centre – NORDICCS, and one of the major tasks of the centre is the creation of a united Nordic CO\textsubscript{2} storage atlas which will be publicly available in 2015 as a web-based Geographical Information System (GIS).

The Swedish part of the CO\textsubscript{2} storage atlas is based on a screening process by analysing existing deep wells and seismic data regarding deep saline aquifers and cap rocks in SW Scania and SE Baltic Sea. Parameters included are lithology, volume, net/gross, porosity, permeability, injectivity, reservoir type, salinity, CO\textsubscript{2} density at reservoir conditions, efficiency factor, cap rocks. The parameter values are used to estimate and model the CO\textsubscript{2} storage capacity. Furthermore, injection simulations of CO\textsubscript{2} in selected Nordic storage sites will narrow the uncertainty in storage capacity assessment. The compiled information is transferred into a GIS environment and integrated into the Nordic CO\textsubscript{2} storage geodatabase which is the basis for the webGIS.

In autumn 2013 the first part of the Nordic CO\textsubscript{2} storage atlas was completed. Sweden presents eight potential deep saline aquifer storage units and one single storage trap. Very preliminary estimations indicate a potential Swedish CO\textsubscript{2} storage capacity of 3400 Mt or more. However, future modelling and Swedish legislation prohibiting onshore storage will affect this number.

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Nordic CCS cooperation

In 2011 the five Nordic countries joined forces in order to enhance awareness of the unique opportunities for geological storage of CO₂ in the Nordic region. This was funded by the Nordic countries research programme – the Nordic Top-Lever Research Initiative together with partners from the industry. The result was the Nordic Competence Centre for CCS – NORDICCS.

The project will operate over a five year period and has the overall objective to boost the deployment of CCS in the Nordic countries by creating a durable network of excellence integrating R&D capacities and relevant industry and to demonstrate how CCS can contribute to the Nordic portfolio of climate change mitigation options.

Potential storage sites in Sweden

Screening of available data on deep well logs and seismic has shown two areas in southern Sweden with potential for geological storage of CO₂ – the south-east Baltic Sea and south-west Scania. A total of eight storage units and one trap have been identified. Examples of important parameters are depth, lithology, volume, porosity, permeability and cap rocks.

CO₂ storage in the south–east Baltic Sea

In south-east Baltic Sea, three potential storage units and one trap have been identified. Early Cambrian storage units comprise two separate sandstones, the Viklau and När sandstones, both members of the File Haidar Formation. The two units consist of fine- to very fine-grained silt- and sandstones with shale and claystone interbeds, locally quartzitic. The units dip less than 1° east-south-east. A Middle Cambrian storage unit consists of the Faludden sandstone, a member of the Bohrglom Formation. The Faludden sandstone consists of a clear fine-grained, well sorted, calcite cemented quartz sandstone with local interbeds of shale and siltstone. The unit has a regional distribution and dips less than 1° east-south-east. The Faludden storage unit contains a structural trap, the Daler structure. The topmost cap rocks consist of c. 80 m Ordovician limestone followed by c. 500 m Silurian marlstone.

CO₂ storage in south-west Scania

In south-west Scania the deepest storage unit is the “Bunter sandstone” which is a member of the Hammar Formation including the Early Triassic Ljungsheden Sandstone. The “Bunter sandstone” is a medium-grained feldspar-rich sandstone interlayered with claystone. The next storage unit is the Höganas-Rya sequence, belonging to the Late Triassic Early Jurassic Höganäs Fm and the Early-Middle Jurassic Ryå Fm. This sequence consists of multilayered sandstone – claysandstone with shale and coal beds. The next storage unit is the Lower Cretaceous sands which belong to an unspecificed Early Cretaceous sequence. The Lower Cretaceous sands consist of quartz sandstone interlayered with siltstone and claystone. The topmost storage unit in south-west Scania is the Amager Greensand belonging to the Early-Late Cretaceous Amager Greensand Fm. The Amager Greensand is a fine- to medium-grained glauconitic quartz sandstone. All storage units dip gently (1°–2°) to the north-east. The topmost cap rocks consists of c. 1000 m Late Cretaceous–Danian clayey–chalky limestone.

Physical parameters and estimated capacity based on the U.S. DOE for formations

<table>
<thead>
<tr>
<th>Name</th>
<th>Depth (m)</th>
<th>Thickness (m)</th>
<th>Net/Gross</th>
<th>Porosity</th>
<th>Permeability</th>
<th>2% capacity Mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faludden</td>
<td>830</td>
<td>45</td>
<td>0.60</td>
<td>14</td>
<td>147</td>
<td>765</td>
</tr>
<tr>
<td>När</td>
<td>847</td>
<td>39</td>
<td>0.68</td>
<td>10</td>
<td>50</td>
<td>420</td>
</tr>
<tr>
<td>Viklau</td>
<td>865</td>
<td>57</td>
<td>0.68</td>
<td>8</td>
<td>30</td>
<td>553</td>
</tr>
<tr>
<td>Amager Greensand</td>
<td>946</td>
<td>39</td>
<td>0.68</td>
<td>26</td>
<td>400</td>
<td>523</td>
</tr>
<tr>
<td>L. Cret. sand A</td>
<td>965</td>
<td>29</td>
<td>0.65</td>
<td>25</td>
<td>200</td>
<td>350</td>
</tr>
<tr>
<td>L. Cret. sand B</td>
<td>975</td>
<td>28</td>
<td>0.65</td>
<td>25</td>
<td>200</td>
<td>350</td>
</tr>
<tr>
<td>Höganas-Rya</td>
<td>976</td>
<td>180</td>
<td>0.52</td>
<td>23</td>
<td>200</td>
<td>540</td>
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<tr>
<td>Bunter</td>
<td>1109</td>
<td>137</td>
<td>0.67</td>
<td>12</td>
<td>300</td>
<td>165</td>
</tr>
</tbody>
</table>

Future work

In the frame of the NORDICCS project, future work will include dynamic modelling and ranking of the storage sites regarding storage capacity – seal – faults – data coverage. This was followed by a thorough geological description for the best storage sites in each country in order to improve the understanding of each site’s complexity and specific characteristics. Finally, by the end of 2015, the NORDICCS storage atlas will be public available as a web-based GIS.

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