Mapping the most prospective storage sites in the Nordic region

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Figure 1. All mapped CO_2 storage sites in the 5 Nordic countries.

Reservoir properties	Optimal - 3 point	Questionable – 2 point	Caution – 1 point	Remarks
Depth	>800m-2500m	600-800m	<600m	Case specific depending on temperature gradient in the area
Porosity	>20%	10-20%	<10%	
Permeability	>100 mD	10-100 mD or extrapolated from closest well drilled through the reservoir	<10 mD or no data	Indicate gas or fluid measurements
Heterogeneity	Low N/G>0.4 Existents of uniform high porosity layers with thickness above 5 meter	Moderate N/G 0.1-0.4 Alternating high/low porosity layers. Layer thickness below 5 meter	High N/G<0.1 Highly alternating thin high/low porosity layers or channel sands with low connectivity. Diagenesis	Since heterogeneity is hard to quantify it advisable to give a remark about interpreted depositional environment and if the area has known diagenesis
Pore pressure	Hydrostatic or lower		Overpressure	
Thickness (Net sand)	≥50m	15-50m	<15m	
Seal properties	Optimal	Questionable	Caution	
Thickness	>50m	20-50m	<20m	
Fault intensity	Low No mapped faults through reservoir or seal	Moderate Minor faults through reservoir or seal	High Large faults through reservoir and/or seal. Bounding faults	
Lateral extend	Continuous	Unsure about existence of a continuous seal Seal locally thinner than 20 meter	Not continuous	
Multiple seals	More than one	Only one	Unsure if a seal exists	
Lithology of the primary seal	Homogeneous clay, mud or evaporites	Chalk	High content of silt or sand	
Safety/risk	Optimal	Questionable	Caution	
Seismicity	Low	Moderate	High	Both frequency and magnitude. Subjective, give argument for this category if moderate or high is chosen.
Risk of contamination of groundwater	No	Unsure	Yes	
Maturity/data coverage	Optimal	Questionable	Caution	
Wells	Well though the actual trap or storage unit	Well(s) though equivalent geological formations	No well data	
Seismic survey	3D seismic	2D seismic younger than 1970	2D seismic lines older than 1970 or sparse data	

Figure 2. The Nordic characterisation and ranking scheme.

1. The Nordic CO_2 storage Atlas database

The database of the Nordic CO_2 storage Atlas contains 224 mapped storage sites (units and traps) within 26 storage formations and 248 hydrocarbon fields.

Norway: 42 units, 152 traps, 18 formations, 231 hydrocarbon fields

Denmark: 1 unit, 20 traps, 4 formations, 17 hydrocarbon fields

Sweden: 8 units, 1 trap, 4 formations

Iceland: Porous basalts areas

Finland: No storage options

Name	Ranking score	Storage Capacity in Mt	Country
Sognefjord Formation	45	11465	NO
Krossfjord Formation	45	3977	NO
Utsira Formation	44	21300	NO
Skade Formation	44	7560	NO
Heimdal Formation	44	5112	NO
Fensfjord Formation	44	4100	NO
Frigg Formation	44	1164	NO
Garn Formation	43	8003	NO
Gassum Aquifer (unit)	43	3700	DK
Havnsø (trap)	43	926	DK
Gassum (trap)	43	630	DK
Thisted (trap)	42	11039	DK
Hanstholm (trap)	42	2753	DK
Statfjord Formation	42	1850	NO
Johansen Formation	42	861	NO
Falluden (unit)	40	745	SE
Höganäs-Rya (unit)	39	543	SE
Arnager Greensand (unit)	39	521	SE
Total capacity		86249	

Figure 3. Ranking list of the 18 most prospective storage sites.

3. Ranking of the most prospective Nordic storage sites

Based on the ranking of all 224 mapped aquifer storage sites, the 18 most prospective sites were selected. If all ranking criteria are optimal the total score will be 45 (Figure 2). The 18 high ranked storage sites have a total storage potential of 86249 Mt.

The result shows that Norway has the most prospective sites in the Nordic region. This is partly an effect of the intensive hydrocarbon exploration in Norway, which has increased the geological knowledge level, making the Norwegian sites more mature for CO_2 storage. However, Norway has only ranked at formation level, no mapped traps were included.

None of the Danish or Swedish sites have the possibility to reach maximum ranking score, due to the lack of new high quality data as 3D seismic surveys and due to the data quality from old wells mainly drilled as part of exploration activity in the 1970'es.

2. Characterisations and ranking methodology

1. Evaluation of existing storage site characterisations and ranking methodologies
2. Development of a new Nordic ranking methodology
3. Ranking of storage sites according to the Nordic ranking scheme
4. Selection of prioritised sites Norway (10), Denmark (5) and Sweden (3)

The ranking criteria are primarily base on geological properties including geological risks and data quality. Economic and political criteria, such as distance to emission sources, on- or offshore location have been excluded since they are inherently variable and may change in the future.

Only aquifer storage sites have been evaluated and ranked, whereas prospective areas for injection in porous basalts and hydrocarbon fields are included, but not ranked, because the ranking criteria are different.

Figure 4. Map showing the 18 most prospective storage sites.

4. The 18 most prospective Nordic storage sites

The final result of the mapping, ranking and final selection of the most prospective Nordic CO_2 storage sites, based on NORDICCS (the Nordic competence Centre for CCS) characterisation and ranking of all mapped aquifer storage sites in the project.

The 224 mapped CO_2 storage sites and their associated data will be published in the Nordic CO_2 storage atlas. The atlas will be released as a webGIS in autumn 2015.

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