The Nordic CCS Roadmap

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Key Message:
Nordic Collaboration will allow us to meet our joint goal of 20 Mt CO₂ captured and stored by 2050!

- Economy of scale
- Natural Gas Sweetening
- EOR
- Industrial CCS

→ Sustainable use of hydrocarbon resources!
Status of Nordic CCS

• Nordic energy supply has extensive amount of renewable hydro and nuclear power. Nordic electricity generation therefore has relatively low CO₂ emissions:
  • Emissions: Nordic Region: 100 g CO₂ per kWh; Global average: 550 g/kWh; EU average: 430 g/kWh

• Joint Goal of Carbon Neutrality by 2050
  • CO₂ emissions from: transport (30%), offshore oil & gas (29%), industry (25%)
  • CCS important for: industry, natural gas, gas-fired power plants
  • CCS assumed to be a major share of reductions from industry, starting 2040
  • CCS on power plants in combination with offshore EOR by 2027
  • 18 Mt of CO₂ removed by Bio -CCS by 2050
  • Emission from: bio-refineries, steel mills, cement, pulp & paper
  • Industry: aluminium plants 40% of total CO₂
Nordic Climate Targets Cannot be Met without CCS

Includes CCS in Denmark, Finland, Norway and Sweden.
Source: International Energy Agency (2013), Nordic Energy Technology Perspectives, OECD/IEA, Paris

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<th>Country</th>
<th>CCS for CO2 removal</th>
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**Tonni:**
- Industrial production increases
- Using current technology

**Inno:**
- Rapid technology development
- More urbanization
Nordic CCS today!

Prediction of CO$_2$ safely injected and stored
Opportunity in Nordic synergies – Significant Economies of Scale
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- Vast storage capacity off coasts of Norway and Denmark
- Large emission sources in Sweden & Finland
- Joint CCS projects could allow scale up
- Reductions in cost due to economies of scale
- Joint transport network - cost saving
Nordic synergies – Accelerating 'Carbon Negative' solutions

- Great biomass energy sources in Sweden and Finland
- Potential for BECCS projects that can go carbon negative!

**CO₂ emissions from stationary point sources with emissions > 100,000 tonnes (2009)**
EOR is the driver for successful CCS Projects in the USA

Challenge:

- CCS projects are expensive

US/Canadian Solution: EOR

- CCS has been profitable in the USA for 30 years through the use of CO$_2$ for Enhanced Oil Recovery (EOR)
- CO$_2$ is an excellent agent to enhance oil recovery
- All 5 active CCS projects in the USA are EOR projects
  - 3 in natural gas processing, 1 fertilizer, 1 hydrogen production
- 6 EOR projects in the planning in the US and Canada
Enhanced Oil Recovery (EOR) can kick-start Nordic CCS Projects

Opportunities

• Vast storage/EOR capacity off coasts of Norway and Denmark
• New oil and gas infrastructure development ongoing that could accommodate EOR
• EOR can create a market for CO₂ that can kick-start CCS in land-based Industry!
  • Cement, Steel, Pulp and paper, Fertilizer plants

Challenges

• Previous Attempts in Denmark and Norway to start CO₂ EOR failed partially due to lack of large enough volumes of CO₂ (2-5 M tonnes per year required)
• Steady supply of CO₂ needed
"Sweetening" the deal for CCS - Case Study

• **Gas Sweetening** to remove CO$_2$ in Norway's natural gas before export to Europe

• New oil and gas fields at Utsira/Barents Sea/Northern Norway have CO$_2$ levels >2.5%

• **Steady CO$_2$ supply** which is necessary to start an EOR project

• **Location** onshore close to ‘source & sink’

• **Economies of scale** significant for volumes of CO$_2$ captured of up to 2-3 Mt/year
Case: Skagerak industry cluster

Capture sites:
- Esso refinery, Norway
- Norcem cement plant, Norway
- Preemraff refinery, Sweden
- Borealis chemical plant, Sweden
- Portland cement, Denmark
- Nordjyllandsverket, Denmark

Transport: via ship

Hub:
- Kårstø, Norway
- Hirtshals, Denmark
  - Location chosen closest to first capture site

Storage: Utsira, Norway or Gassum, Skagerak
Cost of different NORDICCS Case Scenarios
- \textit{N}^{th} \text{ of a kind (NOAK)} Capture Technology
How do we Realize Deployment?

• Utilization of CO₂ for EOR storage projects to enhance oil recovery from oil and gas production
  • Increases lifetime and recovery of oil fields – a goal in itself.
  • Creates a market for CO₂ -> Lower cost industrial CCS projects
• "Economy of Scale" from Nordic collaboration results in lower cost CCS projects
  • Joint hubs and storage results in savings in:
    • infrastructure investments & operational expense, risk management
• Changes to the European Carbon Market are necessary for industrial CCS
  • Bio emissions should count
  • Incentives/legislation needed
    • CCS Certificates for producers
    • Feed in Tariffs, Emission Performance Standards, Strengthening ETS
• Risk Distribution Necessary
  • Government support for the first implementations to reduce risk
    (CAPEX & OPEX)
Prediction of CO₂
safely injected
and stored

10 mill t/year

Sleipner

Snøhvit


Scenario 1
As is

Sleipner - Photo: Harald Pettersen - Statoil
Melkøya - Photo: HELGE HANSEN - Statoil
Photo: Store Norske Spitsbergen Kulkompani AS
Norcem Brevik - Norway - Photo: Norcem
Østrand pulp mill
Prediction of CO$_2$ safely injected and stored
Prediction of CO₂ safely injected and stored
Plans for the Update

• Since the Oct 2013 issuance of the Nordic CCS Roadmap 7 detailed CCS case studies have been performed in the NORDICCS project
• Results from the Case studies including technology assessments and cost data will be included in Version 2 of the Roadmap to be issued in Oct 2015:
  – Natural Gas Sweetening project, generic location, Norway
  – Reykjavik Energy plant, Hellesheidi, Iceland
  – Norcem, Brevik, Norway
  – Generic steel plant northern shore of the Gulf of Bothnia, Finland
  – SCA Östrand pulp mill, Sweden
  – Amagerværket, Copenhagen, Denmark
  – Preem Petroleum, Lysekil, Sweden
• Section on framework conditions will be updated to include recent developments & policy changes, 2030 Goals of last week etc.
• A partner workshop will be held in early 2015 for input to roadmap
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Roadmap can be found here: http://epapir.fagtrykk.no/Web/sintef/nordiccs/