Business from technology

Carbon capture – Potentials and barriers in the Nordic countries

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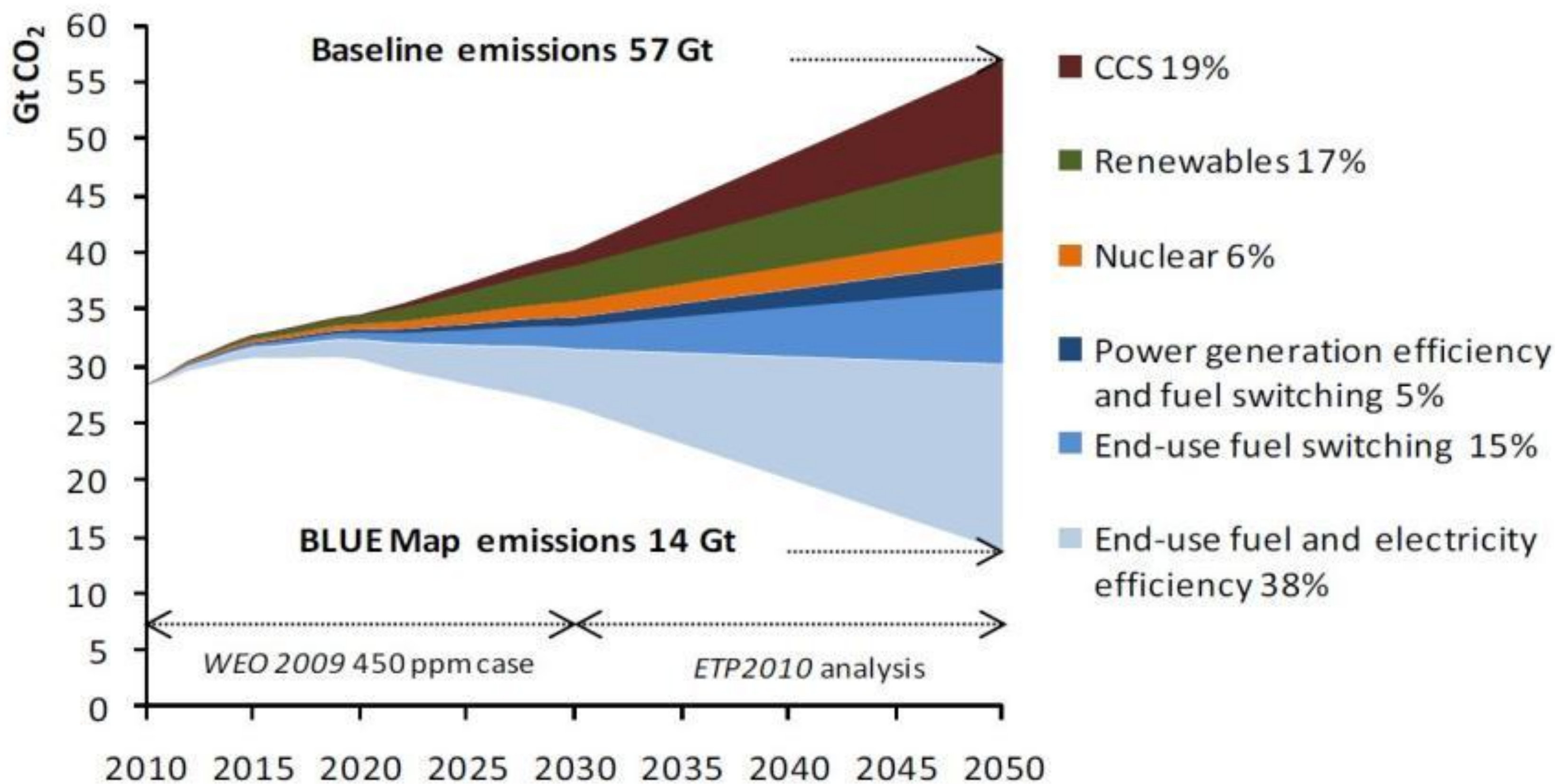
Outline

- Background
- Carbon capture technologies
- CO_2 capture potential in Nordic countries
- CCS barriers in general
- Challenges and barriers to CO_2 capture in main Nordic industry sectors
- CCS in Finland
- Meri-Pori
- The way forward

Why do we need to capture CO_2?



Postcombustion capture (absorption process)

POTENTIALS

- Closest to commercial scale - several commercial actors
- CO_2 source/industry irrelevant
- Retrofit – suitable and easy
- New generation solvents require less energy – more efficient utilization of lower level heat (improved regeneration)
- Several small scale pilots existing – next: Demonstration

CHALLENGES

- Significant CAPEX investment (CO_2 conc.)
- Large drop in plant efficiency (power plant 10 – 15 %-units) – increase in electricity production costs
- Require large amount of chemicals (cost + environmental/health effects)
- Treatment of waste streams
- Equipment corrosion
- Lay-out restrictions in existing plants
- Still at development stage for use in other than (petro)chemical industry
  - Dust levels
  - Amine inhibitors (SOx, NOx, HM)
  - Degradation products (nitrous amines)

Precombustion (decarbonisation) capture

POTENTIALS

- Pressurized CO_2 capture mature
- Higher CO_2 content (15 – 60 vol-%)
- Physical solvents (20 – 40 bar)
- Less expensive capture technology (stripping of CO_2 from pressurized processes)
- Lowest drop in plant efficiency compared to other capture technologies
- Worldwide development mainly focused on IGCC and NGCC
- Potential for development

CHALLENGES

- Mainly for IGCC, NGCC, natural gas reforming and production of H_2
- Combustion of H_2 in gas turbine still in development phase
- CAPEX in line with competing technologies
- Issues related to IGCC technology
  - Technological barriers
  - Complicated IGCC process – not mature – expensive
  - Only few IGCC plants operating
  - IGCC not yet commercially successful

CO-shift: $CO + H_2O \rightarrow H_2 + CO_2$

CO/CO_2
SO_x
Energy
Ash

Source: Vattenfall

Oxyfuel (O_2/CO_2 recycle) combustion capture

Steam turbine

Electricity

CO_2

POTENTIALS

- High CO_2 concentration
- Moderate energy penalty
- Development potential: Large energy requirements for production of O_2 (e.g. membranes)

CHALLENGES

- Primarily applicable only to new power plants
- Technical challenges
  - Operational conditions
  - Overall availability even without CCS
  - Impurity levels
- Requires ASU and handling of O_2
  - Safety
  - CAPEX
  - High energy demand

Air separation

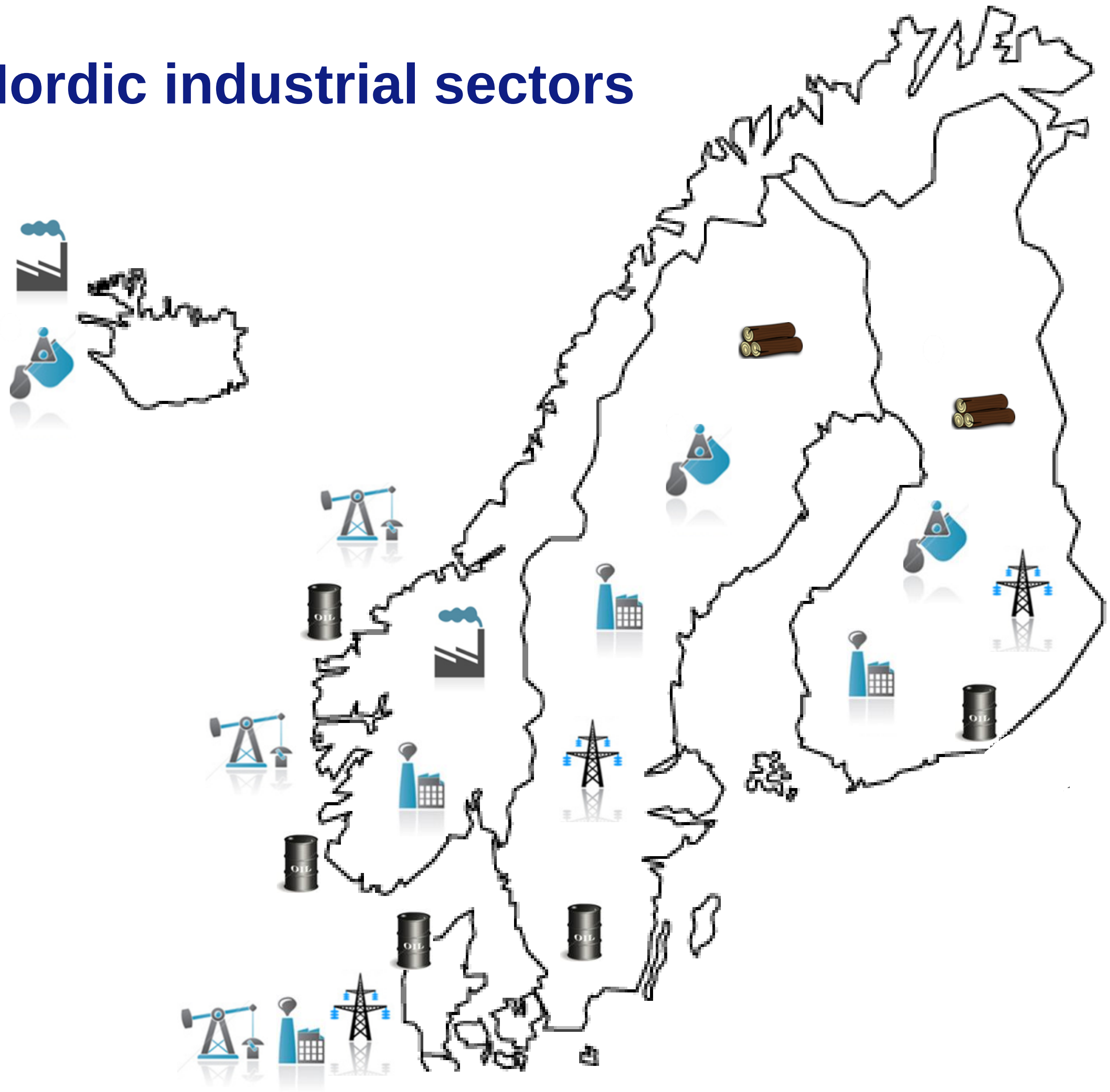
Bottom ash

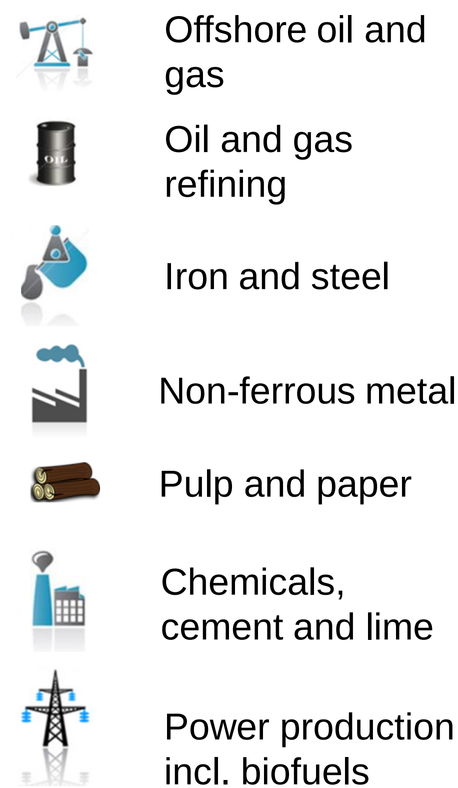
Energy

Ash

Source: Vattenfall

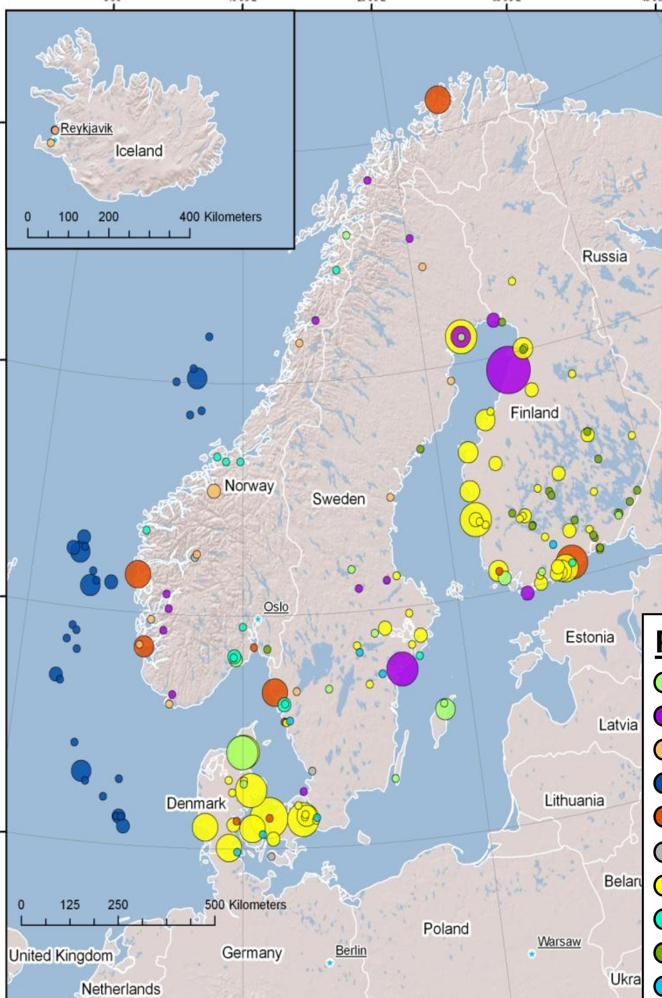
Nordic industrial sectors





Nordic CO_2 emissions > 0,1 Mt/a (2007)

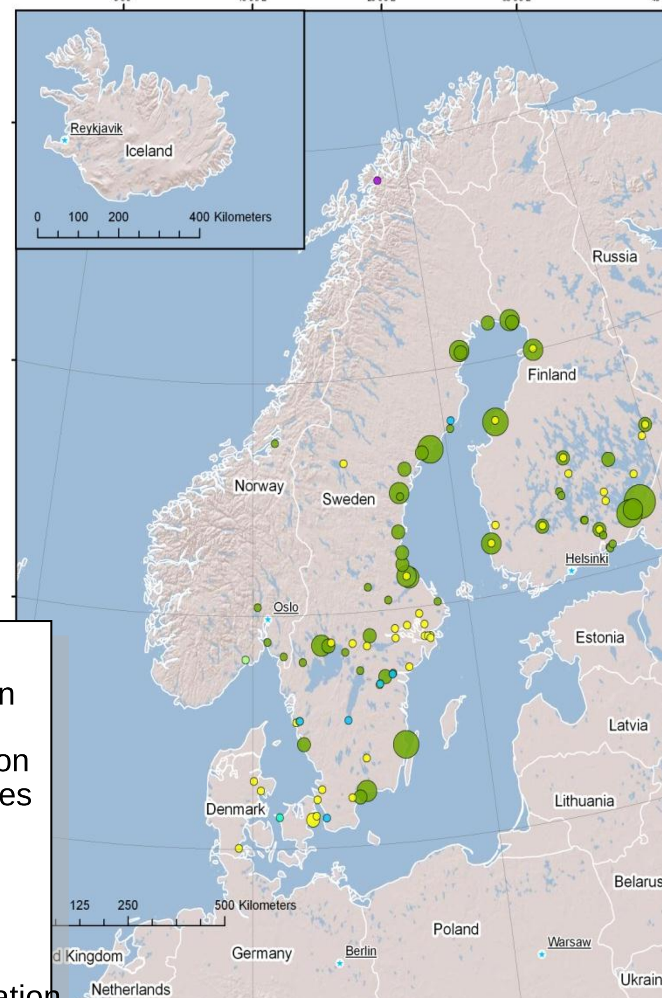
Fossil and inorganic CO_2 emissons



CO_2 (Mt/a)

- 0.1 – 0.5
- 0.5 – 1.0
- 1.0 – 1.5
- 1.5 – 2.0
- 2.0 – 3.0
- 3.0 – 4.0
- 4.0 – 5.0

Biogenic CO_2 emissons



Facility

- 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

Barriers to CCS in general

ECONOMIC

POLICIES AND REGULATIONS

PUBLIC PERCEPTION

SCALE-UP

- Capture technology in power plant still at development stage
- Vattenfall largest pilot in Germany: Schwarze Pumpe (30 MWth) oxy-fuel

The challenge of scale-up

Stabilizing at 450 ppmv

Cumulative Global Carbon Stored Between 2010-2050:

~ 100,000 $MtCO_2$

(CCS: 18% from global electricity production)

[IEA 2008, ACT-scenario]

Stabilizing at 550 ppmv

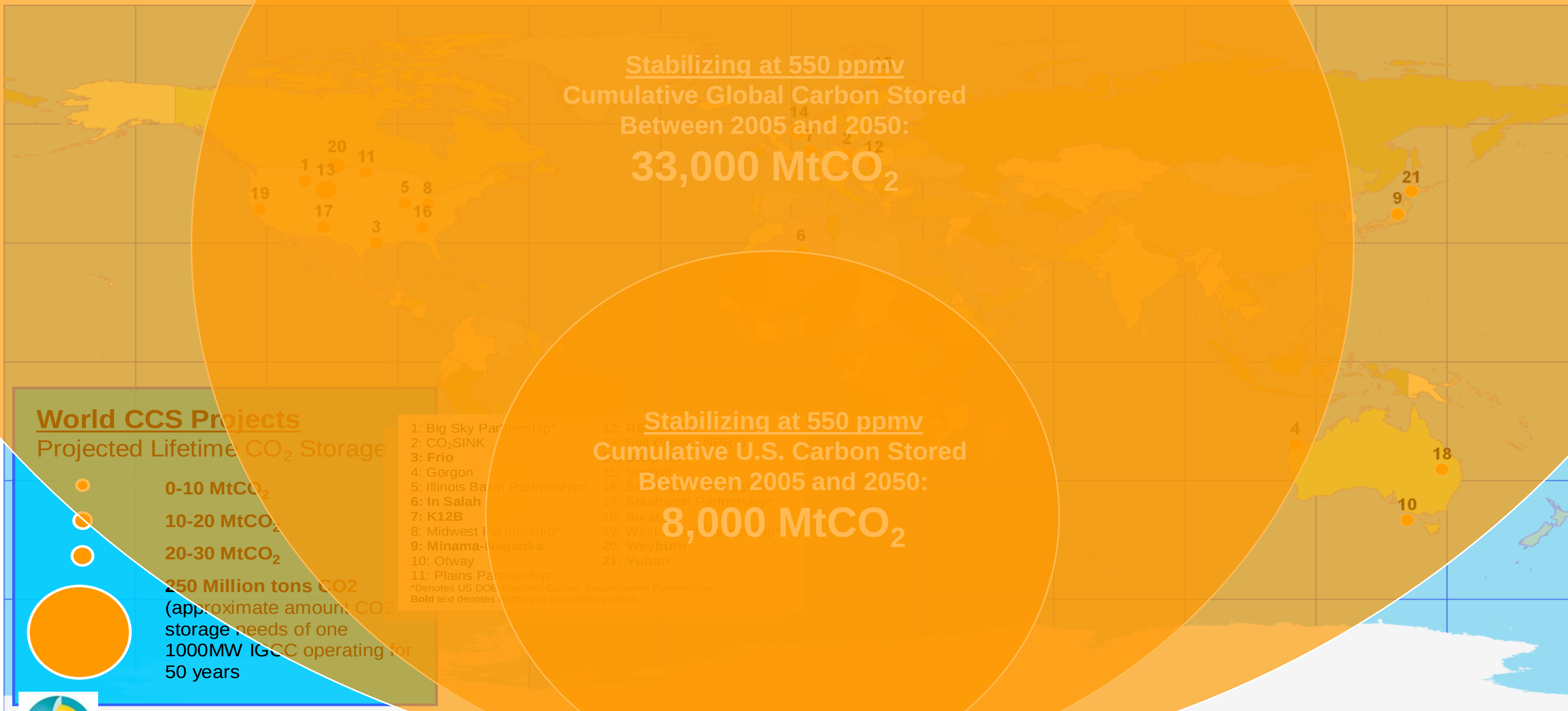
Cumulative Global Carbon Stored Between 2005 and 2050:

33,000 $MtCO_2$

Stabilizing at 550 ppmv

Cumulative U.S. Carbon Stored Between 2005 and 2050:

8,000 $MtCO_2$



[Joint Global Change Research Institute
Pacific Northwest National Laboratory Battelle, IEA 2008]

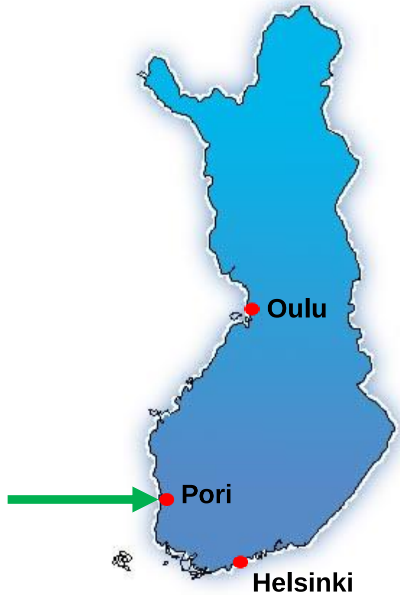
Deployment of carbon capture in different industrial sectors

Industry	Technologies	Potentials	Barriers	Deployment	Cost
Power production	Post-combustion Pre-combustion Oxy-fuel combustion Advanced	Large sector and large point sources Most focus/development Carbon intensity of power production	Efficiency drop Low CO_2 concentration EU ETS allowance price	Mostly developed Scale-up to commercial	Base case
Iron and steel	Post-combustion Oxygen Blast Furnace (OBF)	Current processes are dependent on coal Large point source emission	Carbon leakage CO_2 neutral steel plant is not possible within feasible frames	NER 300 – OBF Demonstration: European steel producers, France Pilot plant Sweden	Potentially lower
Cement and lime	Post-combustion Oxy-fuel combustion Calcium Looping Cycle	Local end-product market High CO_2 concentration	No carbon leakage – local markets Flue gas contaminants No power production	Little research No project experience	Potentially lower
Pulp and paper	Post-combustion Pre-combustion	28% of Nordic CO_2 emissions Potentially high CO_2 concentration Carbon sink	Carbon leakage Biogenic CO_2 Small point source emissions Limited potential in Europe	No industrial initiatives	Higher cost
Oil and gas	Post-combustion Pre-combustion	Large emissions Close to storage Technology knowledge EOR Waste heat available	(Carbon leakage) – refineries? Location/space limitations	Existing	Potentially lower (drying and compression only)

CCS activities in Finland

- CCS Finland (2008 – 2011)
- 2008 – 2010 : FINNCAP Meri-Pori CCS demonstration project
- 2011 – 2015 : National Carbon Capture and Storage Program CCSP
- Largest CO_2 production plant: Neste Oil Refinery
  - Aga Linde produces 400 000 t/a CO_2 for commercial use - PSA capture from steam reformer
- Development of power plant concept with CCS
- Industry-driven development of oxy-fuel combustion for fluidized bed boilers
- Development of mineral carbonization processes
- No underground storage possibilities in Finnish ground
  - Baltic Sea, North Sea or Barents sea
- No plans for large-scale projects in near future

FINNCAP Meri-Pori



- Joint demonstration project Fortum and Teollisuuden Voima (TVO)
- 565 MW coal-fired condensing power plant
- 1,25 Mt/a CO_2 (50% of flue gases with 90% capture) – 1,5% of Finnish CO_2 emissions in 2007
- 500 M€ project - EU NER 300
- Financial
  - Investment would not be feasible
  - NER 300 application not submitted
- Strategic
  - Change of strategy – CCS no longer core business
  - No large-scale focus on CCS in the future

The way forward

- Technology development – energy penalty (more efficient use of lower level heat)
- Risk management
  - Development in site selection methods
  - Development in measuring, monitoring and verification of stored CO_2
- Succeeding in CCS technology demonstrations 2010 – 2020
- Increased competitive power of CCS technology compared to other emission reducing methods
- Long-term political decisions
- International commitment → consumers pay
- Ensuring storage stability and safety
- Public acceptance and awareness

Courtesy of Statoil, 2010

Thank you for your attention

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