

# Roadmap for implementation of Bio-CCS in the Nordic countries

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# VTT Technical research centre of Finland

The largest multitechnological applied research organisation in Northern Europe



Personnel 2.935 (1.1.2010) ■ Turnover 276 M€ (budget for 2010)

## Customer sectors

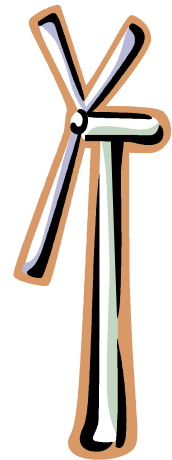
- Biotechnology, pharmaceutical and food industries
- Electronics
- Energy
- ICT
- Real estate and construction
- Machines and vehicles
- Services and logistics
- Forest industry
- Process industry and environment

## Focus areas of research

- Applied materials
- Bio- and chemical processes
- Energy
- Information and communication technologies
- Industrial systems management
- Microtechnologies and electronics
- Services and the built environment
- Business research

## Climate change mitigation measures

- All available tools are necessary to meet the goals (blue map)
  - Energy saving
  - Renewable energy
    - CO<sub>2</sub> neutral fuels (biofuels including BTL, algae...)
    - Wind, Solar, geothermal, wave...
  - Combined heat and power (CHP)
  - Efficiency improvement
  - Carbon sinks
  - Nuclear
  - **Carbon capture and storage (CCS)**



## Sectors for carbon capture and storage

### ■ Energy

- Condensing power
- CHP
- Heat production
- Fuel production (oil refineries, BTL, SNG)

### ■ Industry

- Iron and steel industry
- Cement and lime industry
- Chemical industry
- Non-ferrous metal production
- Pulp and paper
- Others

## Sectors for carbon capture and storage

- Energy
  - Condensing power
  - **CHP**
  - **Heat production**
  - Fuel production (oil refineries, **BTL, SNG**)
- Industry
  - Iron and steel industry
  - Cement and lime industry
  - Chemical industry
  - Non-ferrous metal production
  - **Pulp and paper**
  - Others?

## What is BioCCS?

- CO<sub>2</sub> capture from energy production and industrial process streams utilising biomass as raw material
- Captured CO<sub>2</sub> is permanently stored in isolation from atmosphere
- Capture and storage of CO<sub>2</sub> from biogenic sources results in negative net emissions and functions as a carbon sink



## Largest CO<sub>2</sub> emitting facilities in Nordic countries

- Data for 2007
- Only facilities with emissions >0.1 Mt CO<sub>2</sub>/a included  
→ Covers 277 facilities
- Fossil, inorganic and biogenic\* CO<sub>2</sub> emissions mapped

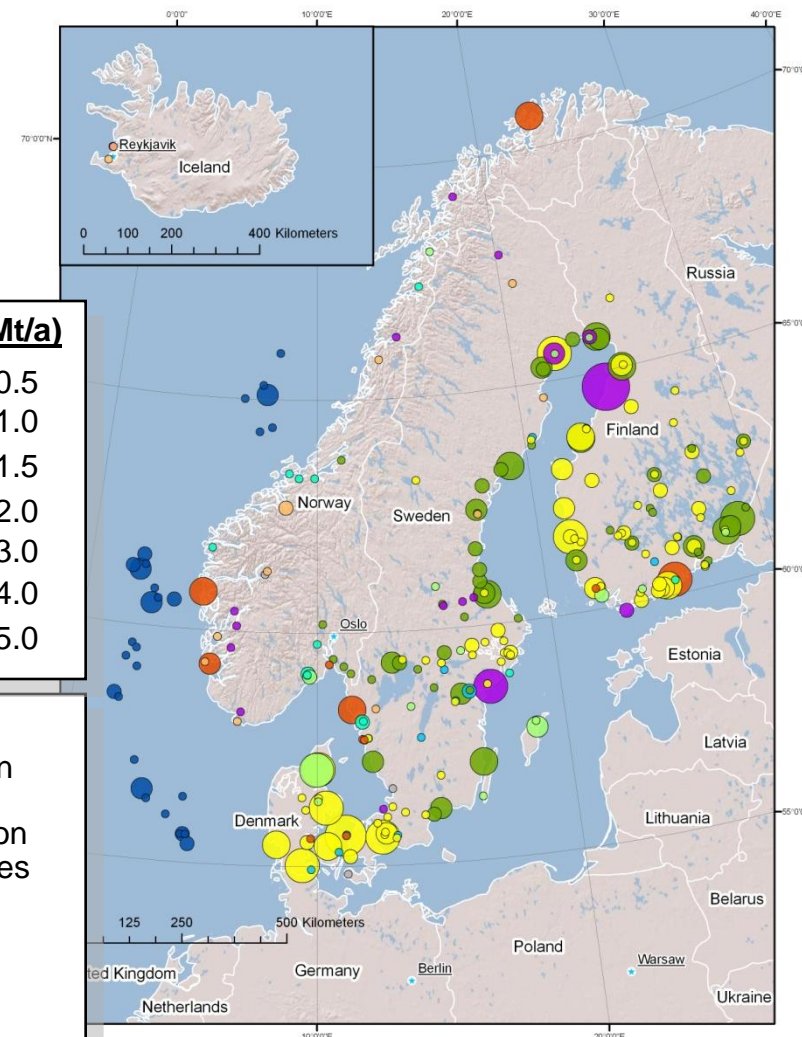
### CO<sub>2</sub> em.(Mt/a)

- 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

### 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

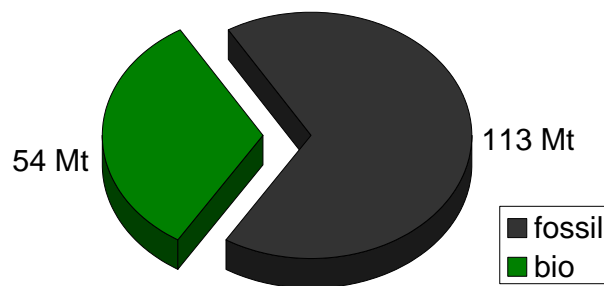
### Fossil, inorganic and biogenic CO<sub>2</sub> emissions



\* from biomass combustion

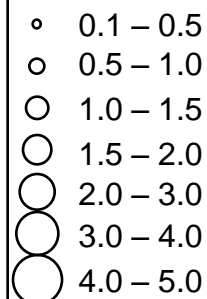
## Largest biogenic CO<sub>2</sub> emitting facilities in Nordic countries

- Data for 2007
- Only facilities with emissions >0.1 Mt CO<sub>2</sub>/a included
  - → 18 facilities emitting over 1Mt / CO<sub>2</sub>/a



Total emissions from facilities emitting >0.1 Mt CO<sub>2</sub> in the Nordic countries in 2007

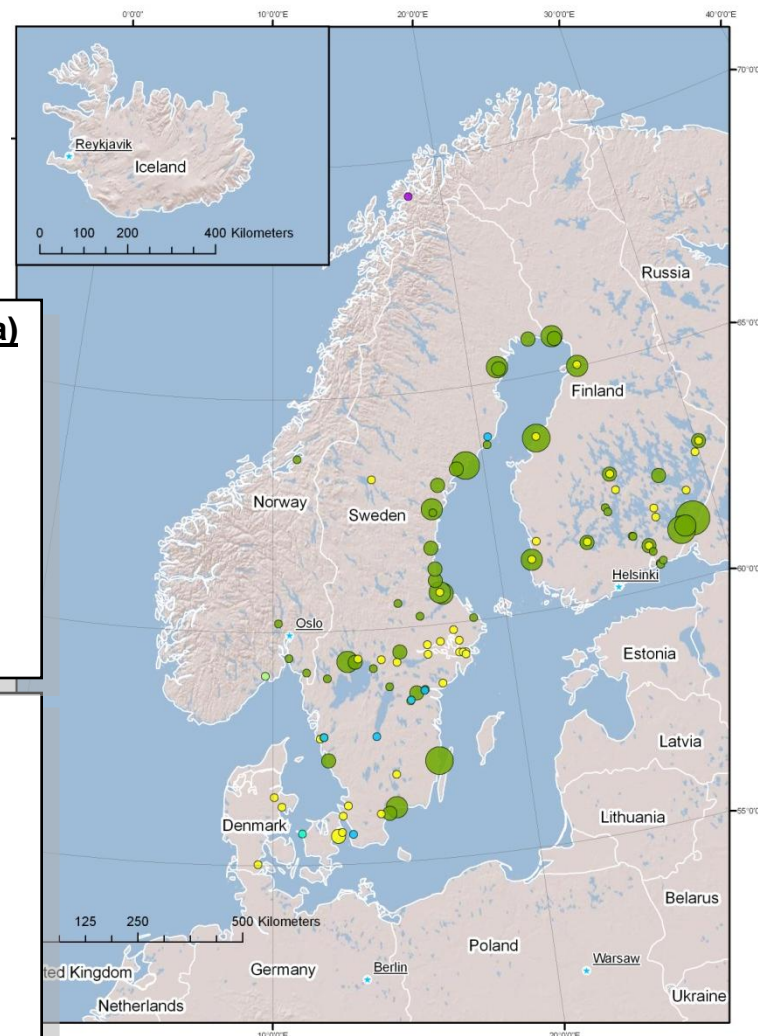
### CO<sub>2</sub> em.(Mt/a)



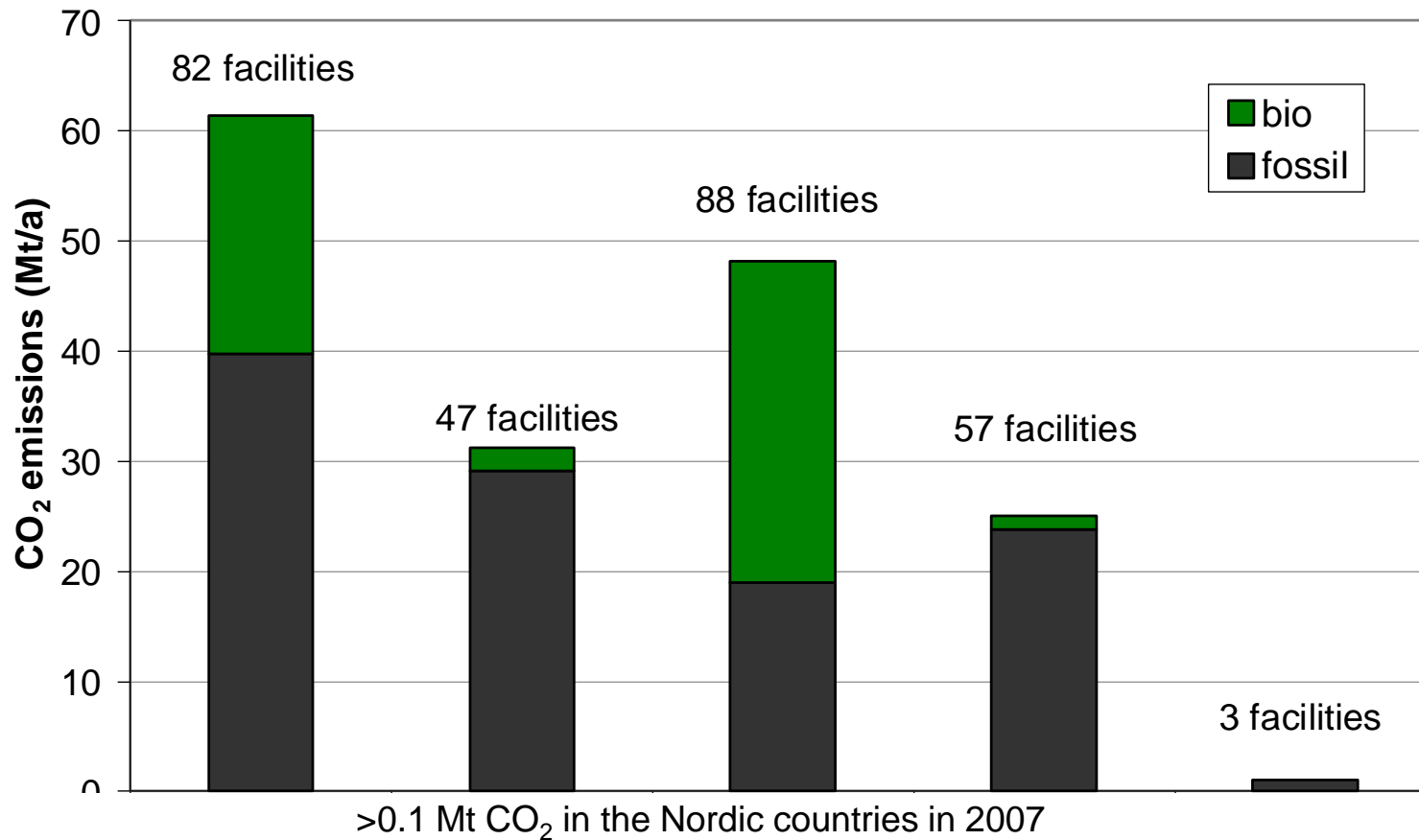
### Facility

- 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
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- Pulp and paper production
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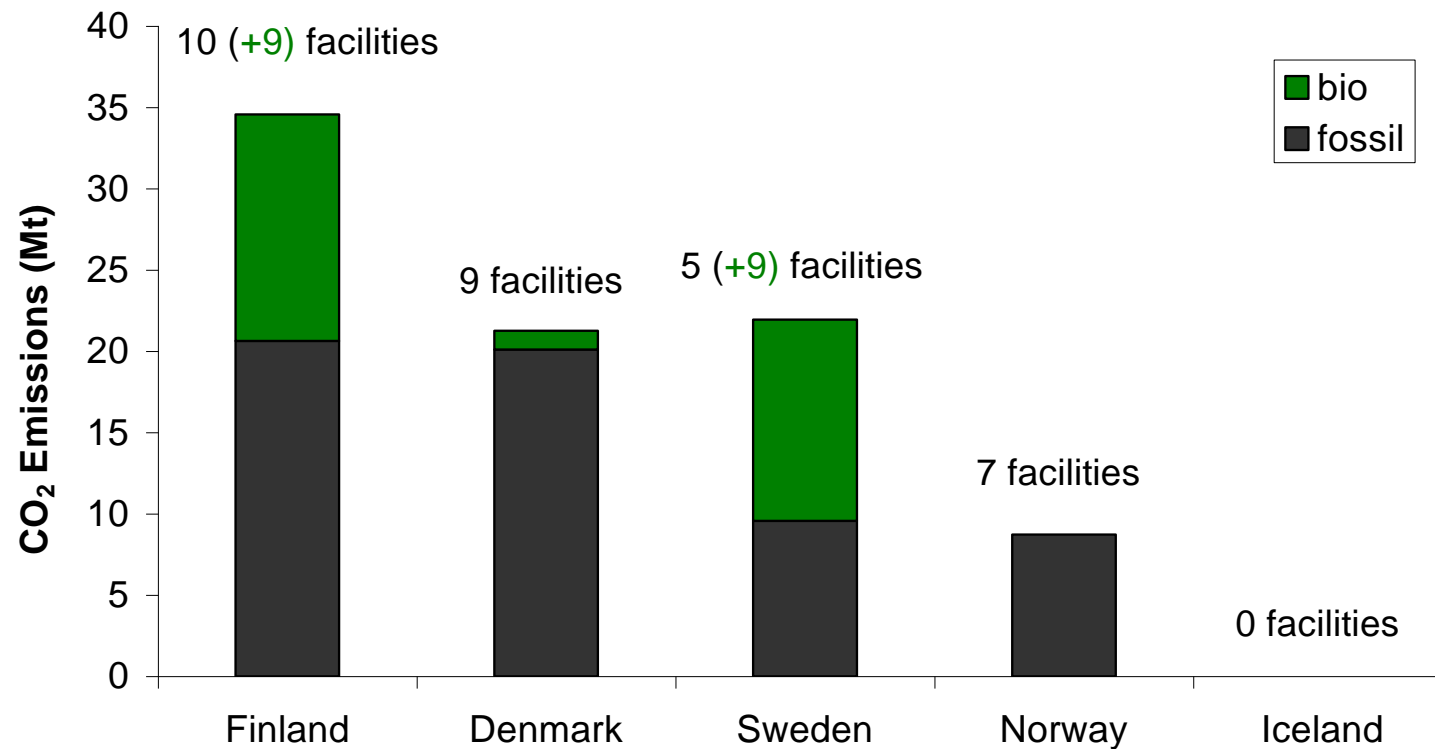
### Biogenic CO<sub>2</sub> emissions



## Total emissions from facilities

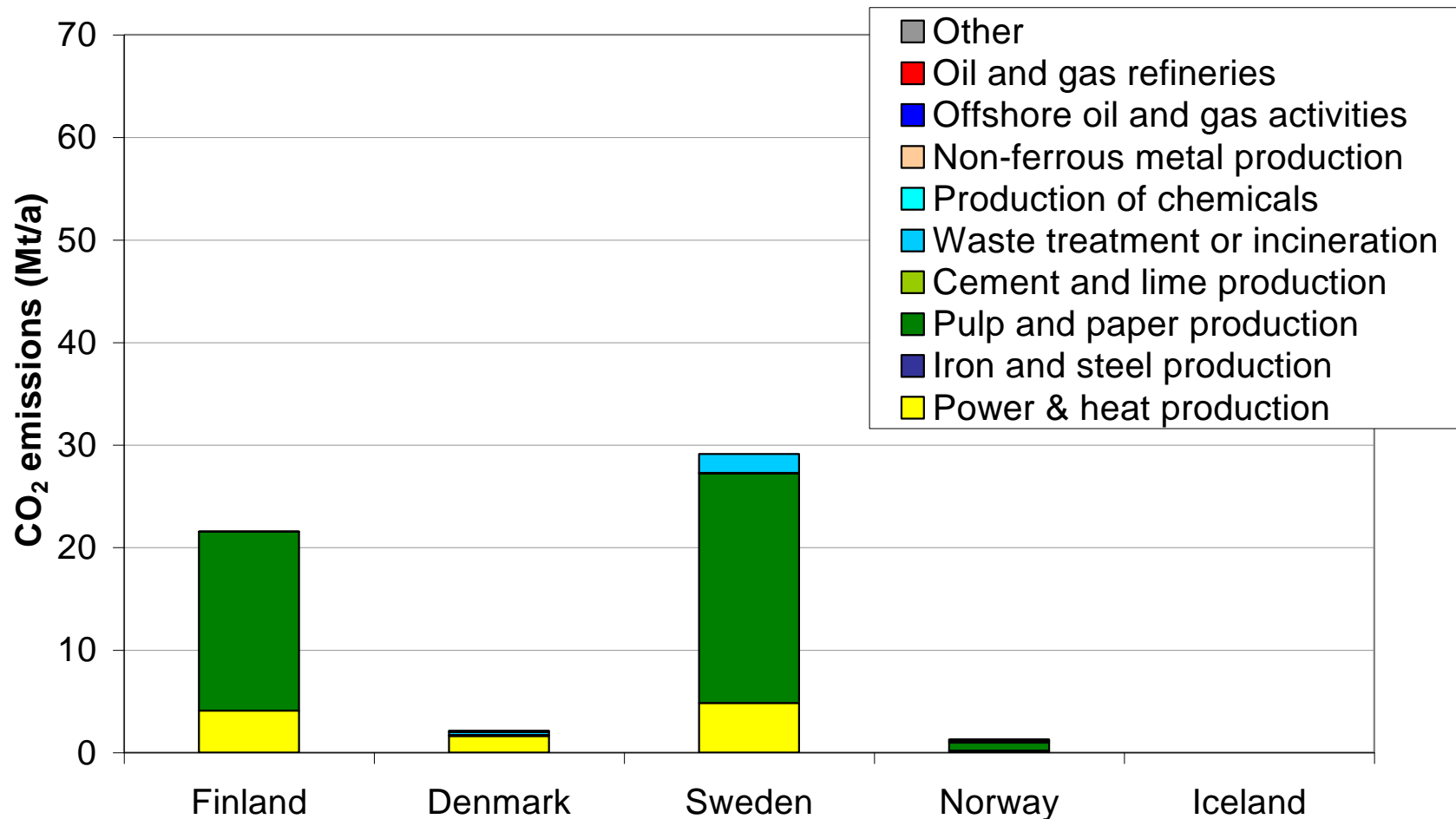


## Total emissions from facilities over 1.0 Mt CO<sub>2</sub>/a



Nordic countries in 2007

## Biogenic CO<sub>2</sub> emissions in the Nordic countries



Facilities emitting >0.1 Mt CO<sub>2</sub>/a in 2007

## Target sectors for application of BioCCS

- Largest potential in pulp and paper industry
- BTL processes enable recovery of CO<sub>2</sub> as side product in the scale of ~0,5-1Mt/a
- Heat production requires application of CCS to small scale
- Co-firing of biomass with coal provides opportunities for BioCCS with "conventional" applications
  - Co-firing of peat and biomass
- Capacities in CHP are moderate, but largest facilities are situated inland

⇒ Most potential in CHP and Pulp & Paper

## Pulp and paper industry

- Majority of emissions biogenic
- Largest potential in recovery boilers
  - Technically very challenging
    - Primary purpose: chemical recovery  
=> need for high availability
    - Challenging conditions
- Lime kiln
  - Small potential compared to other sources
- Bark boiler
  - Relatively small scale

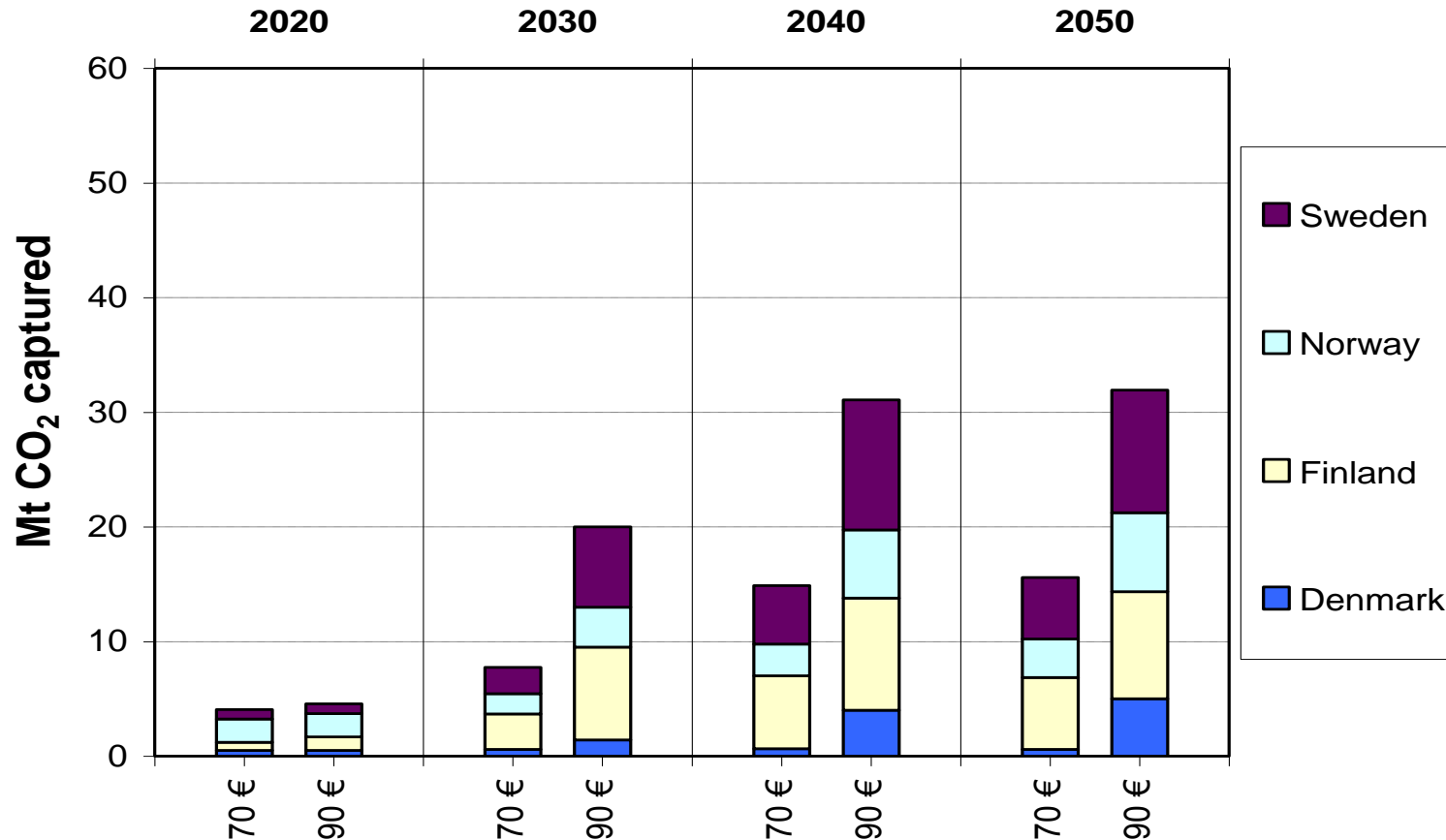


## Combined Heat and Power, CHP

- Possibilities for efficiency gains with CHP connection
- Typical inland locations
- Baseload behaviour, steady load and high availability
- Bio CHP installations are characterised by smaller scale compared to fossil units

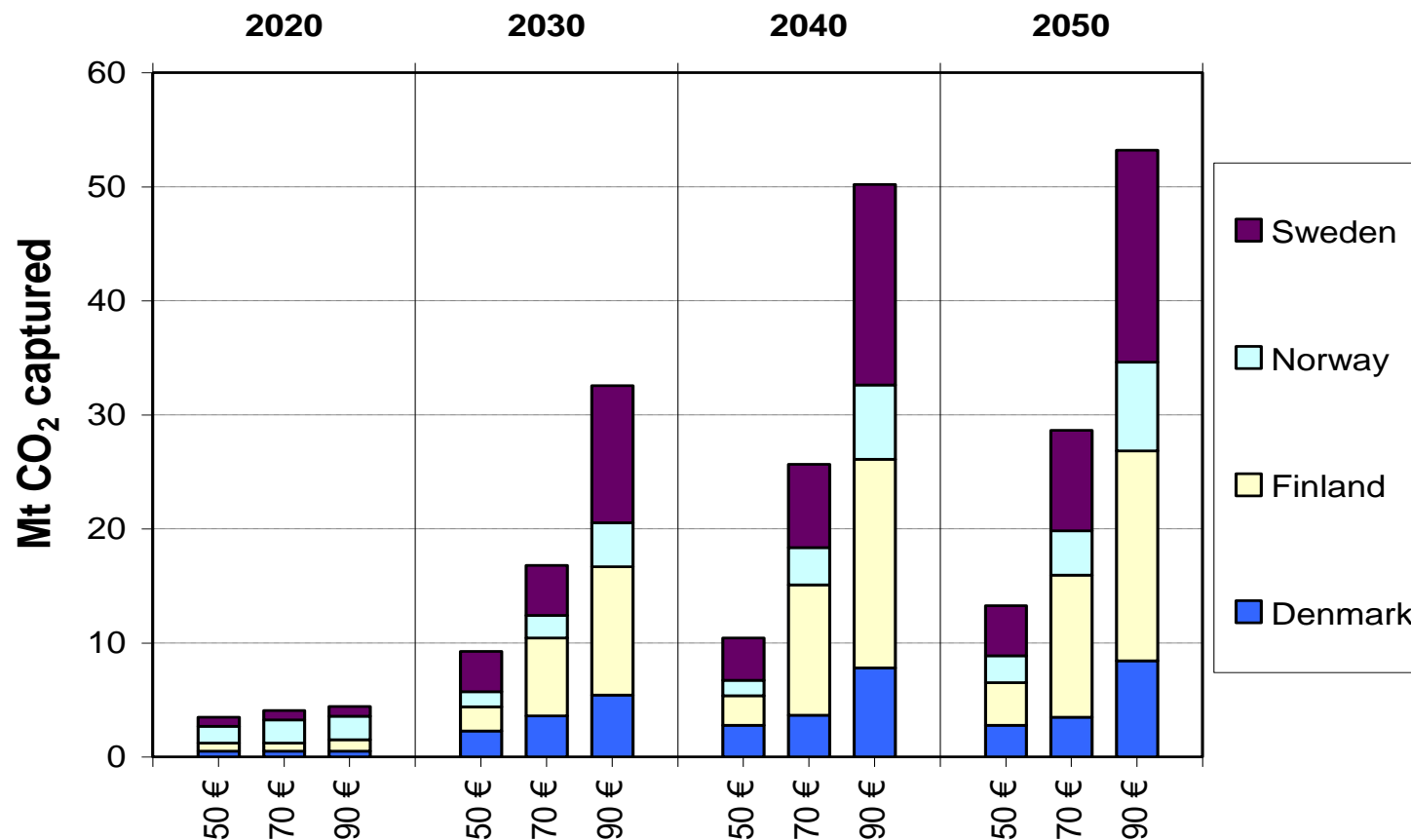


## Scenarios for captured CO<sub>2</sub> in Nordic countries



Scenario results from Times energy system modelling: CO<sub>2</sub> captured in the each Nordic country with the option for BioCCS excluded. Exogenous allowance prices are set in the model to increase gradually from 20 €/tonne in 2010 to 30, 50, 70 or 90 €/t CO<sub>2</sub> in 2040.

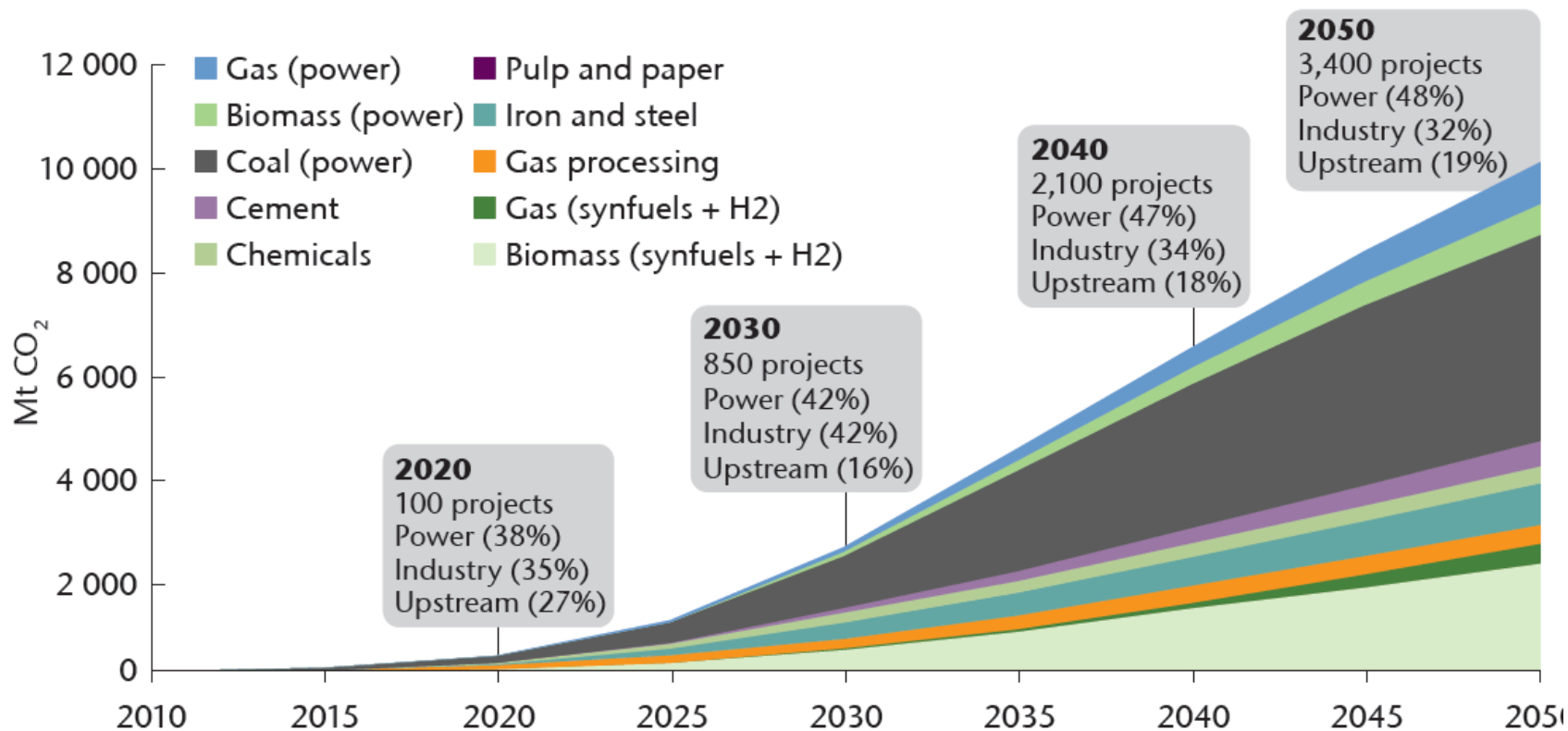
## Scenarios for captured CO<sub>2</sub> in Nordic countries with BioCCS



Scenario results from Times energy system modelling: CO<sub>2</sub> captured in the each Nordic country with the option for BioCCS included. Exogenous allowance prices are set in the model to increase gradually from 20 €/tonne in 2010 to 30, 50, 70 or 90 €/t CO<sub>2</sub> in 2040.

# Roadmap for application of BioCCS

## Global deployment of CCS 2010-50 by sector

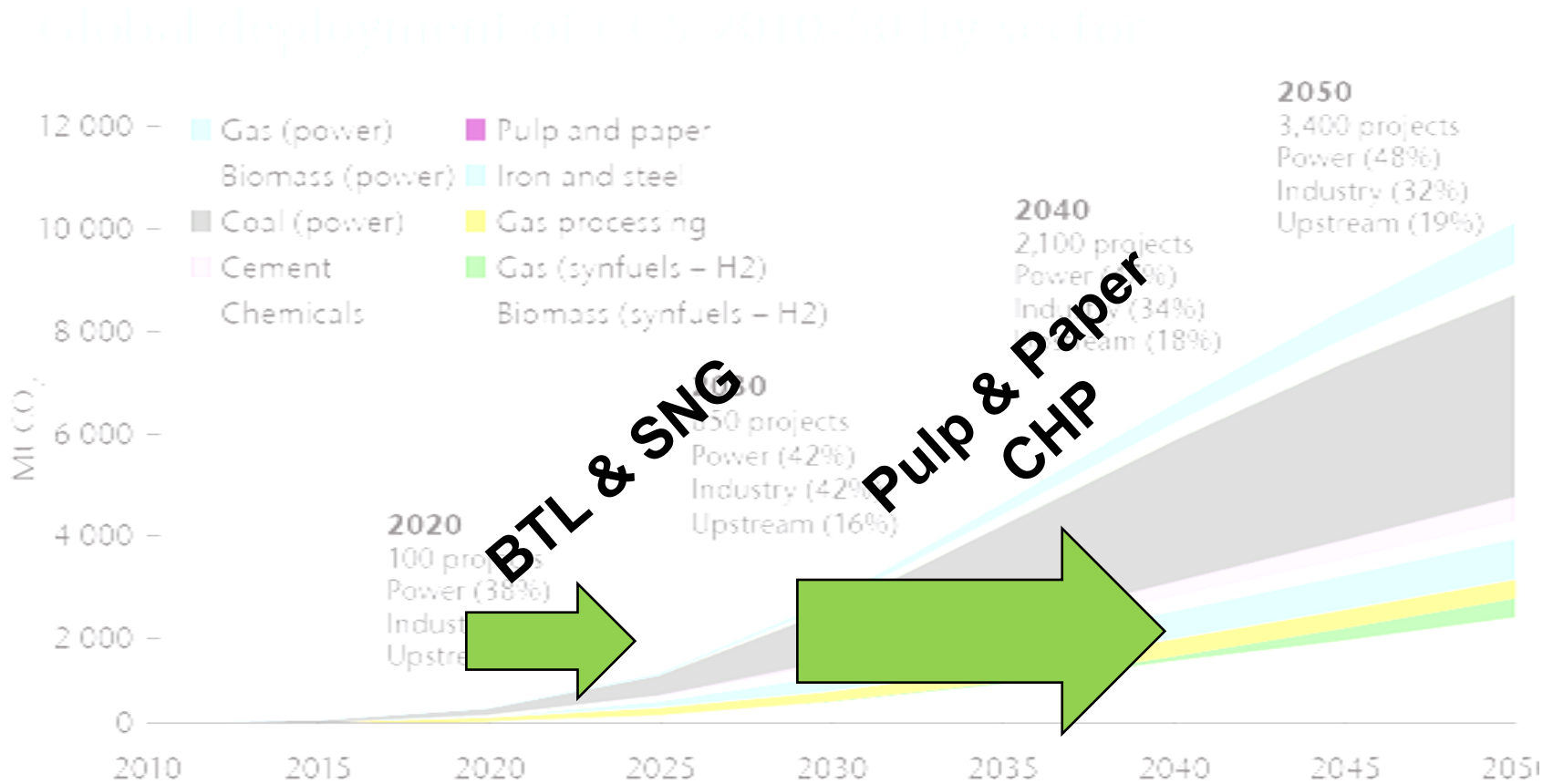


Technology Roadmap  
Carbon capture and storage  
OECD/IEA, 2009

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# Roadmap for application of BioCCS

Assuming global agreement, acceptability and subsidies for bio CCS



Technology Roadmap  
Carbon capture and storage  
OECD/IEA, 2009

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