

# Deployment of CCS in Nordic industries – case studies

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Jan Mayen

Reykjavik

Island

Norge

Oslo

Sverige

Stockholm

Finland

Helsinki

Tallinn

Estla

Riga

København

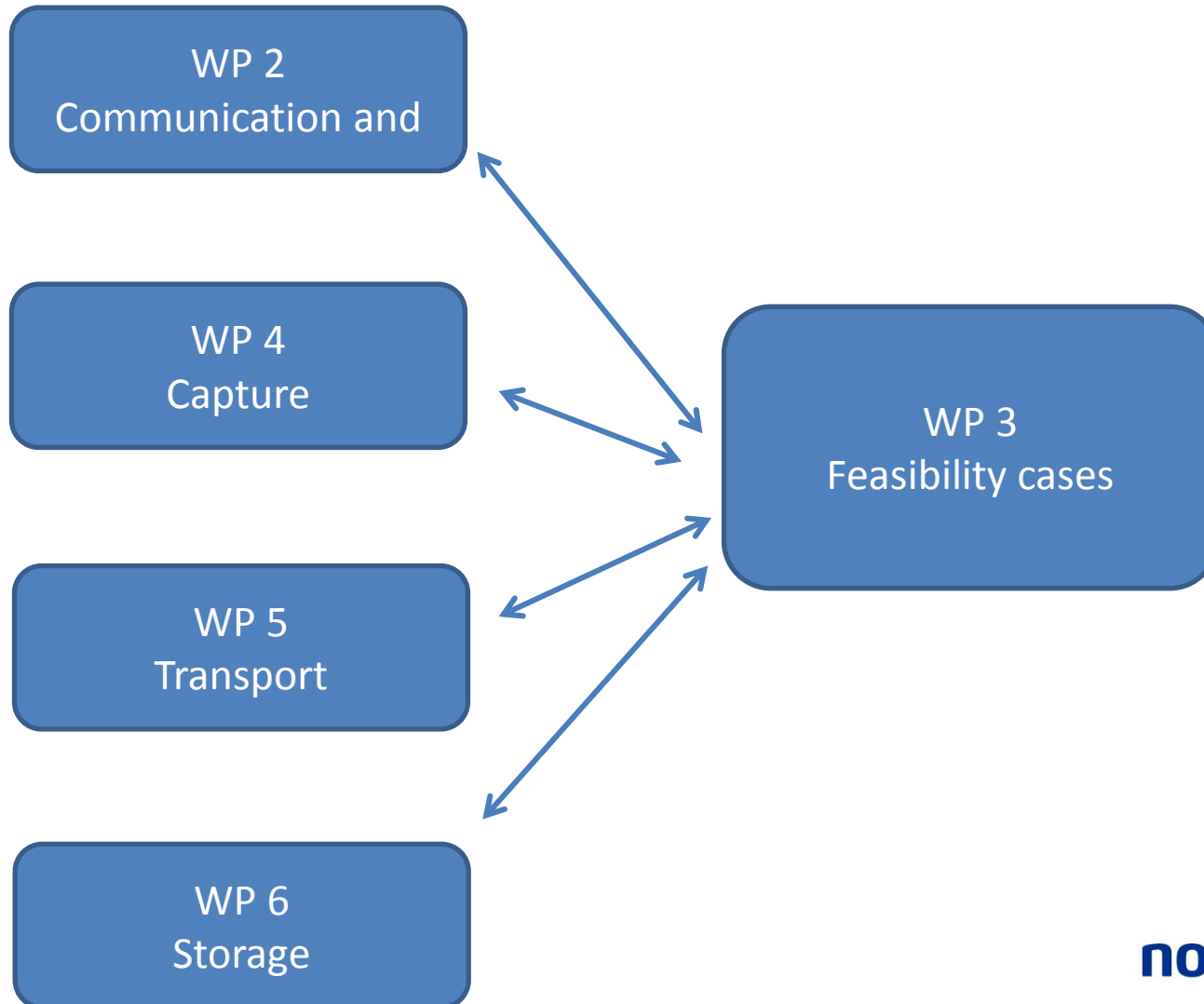
# Nordic region

- Each of the 5 countries are unique: size, industry, geology, politics....
- Norway has CO<sub>2</sub> storage capacity
- Finland and Sweden have large CO<sub>2</sub> sources, biogenic and industrial in origin
- Denmark has a limited onshore storage potential, and large CO<sub>2</sub> emissions from power production
- Iceland is fairly isolated with a unique CO<sub>2</sub> storage solution

# NORDICCS PROJECT

- The NORDICCS project has outlined the technologies most attractive for CO<sub>2</sub> capture, transport and storage
- Identify potential CCS cases in the region.
- The 6 cases cover a wide range in CO<sub>2</sub> volume, industry sectors, distance between sources, number of sources and distance to storage.

# Nordiccs case studies



# CCS cases

## Cluster

### Main source case

Detailed CO<sub>2</sub> capture assessment, technical and economical

### Surrounding sources

No assessment of CO<sub>2</sub> capture, estimate of CO<sub>2</sub> amount relevant for transport

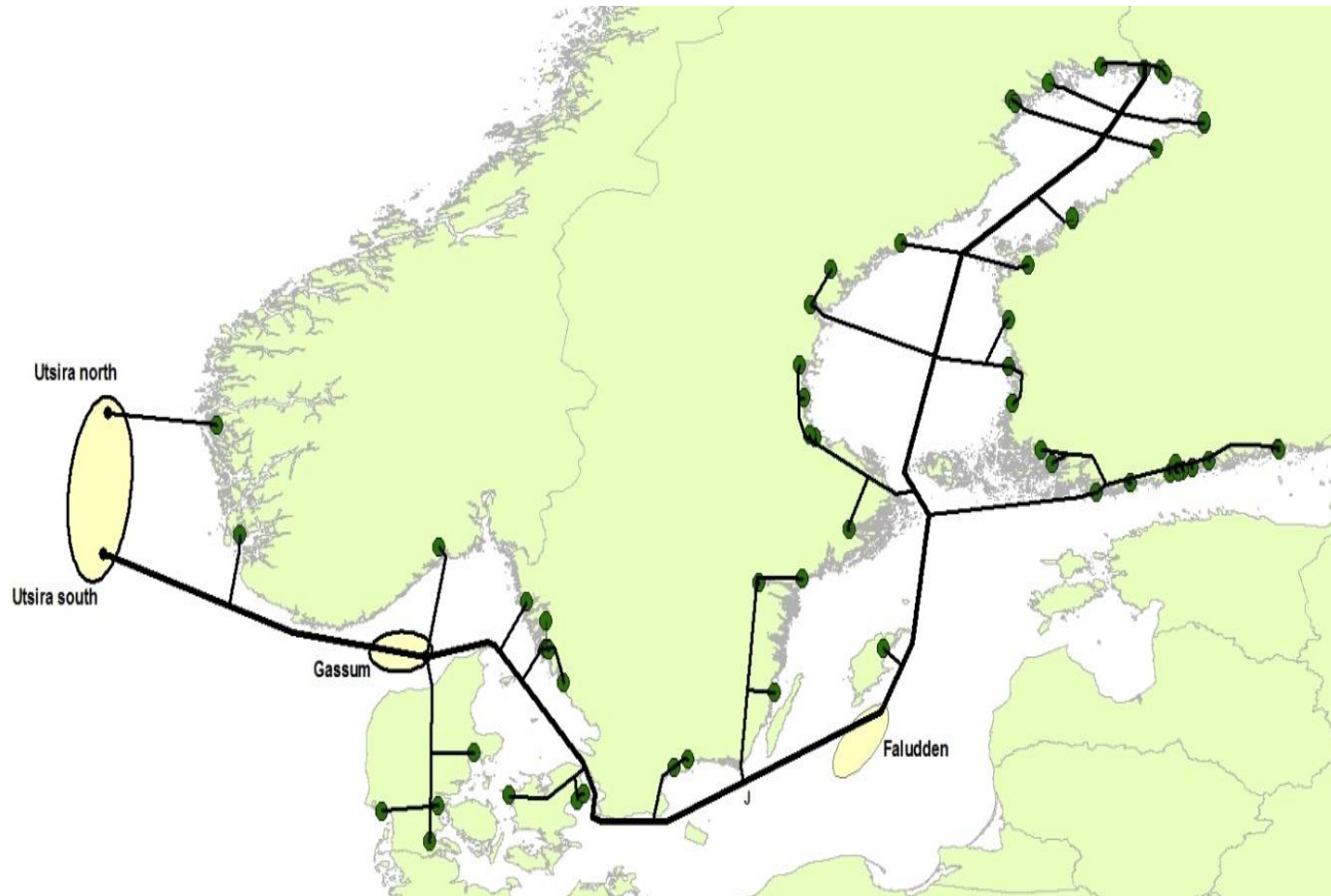
## Transport

Technical and economic assessment of transportation methods and routes for the cluster

## Storage

Technical and economic assessment of storage

# Complex calculations



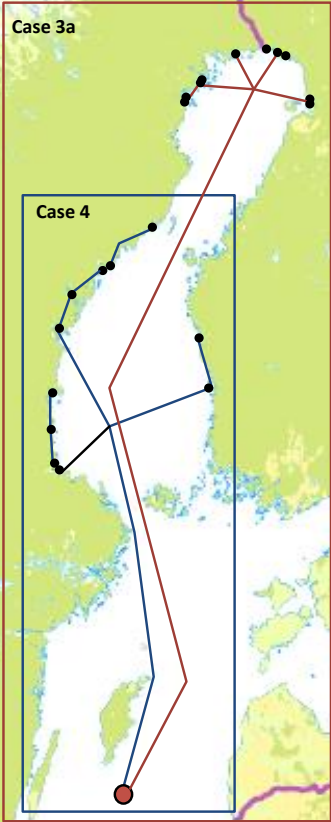
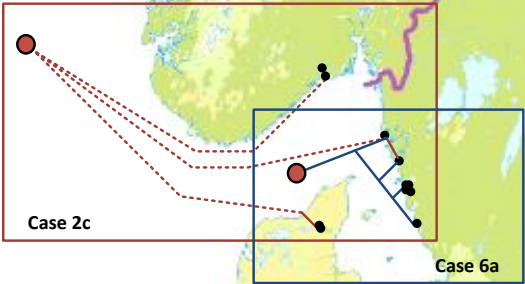
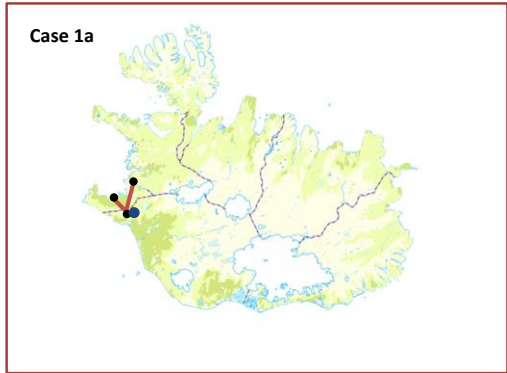
# Criteria for CCS case/cluster development

- Involve all five Nordic countries
- Major Nordic emitters of CO<sub>2</sub>-sources: Steel, power, cement, bio, refineries
- CCS relevance and location
- Technical, legal and economical perspectives
- Cross border networks

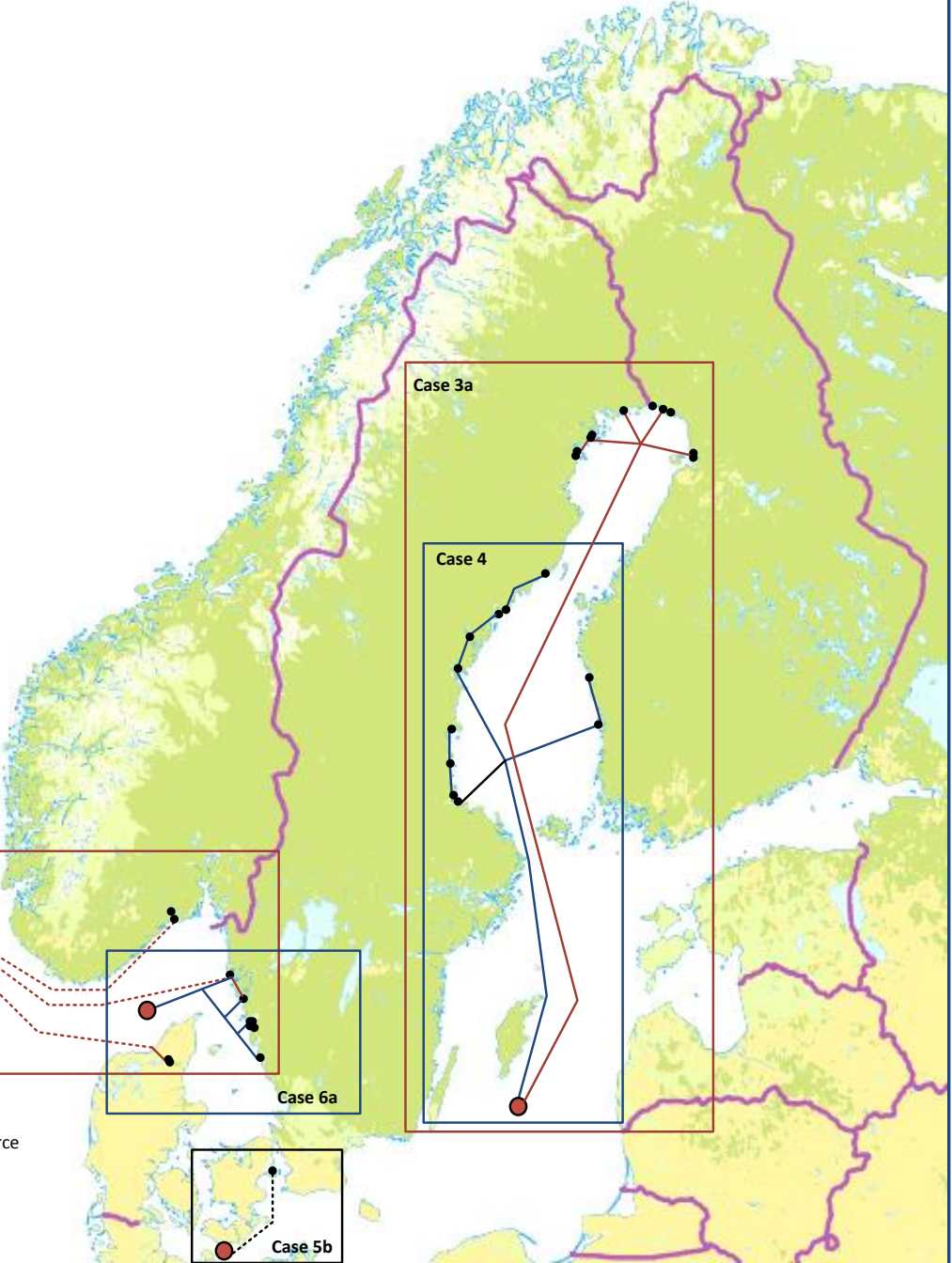


# Main sources and sinks





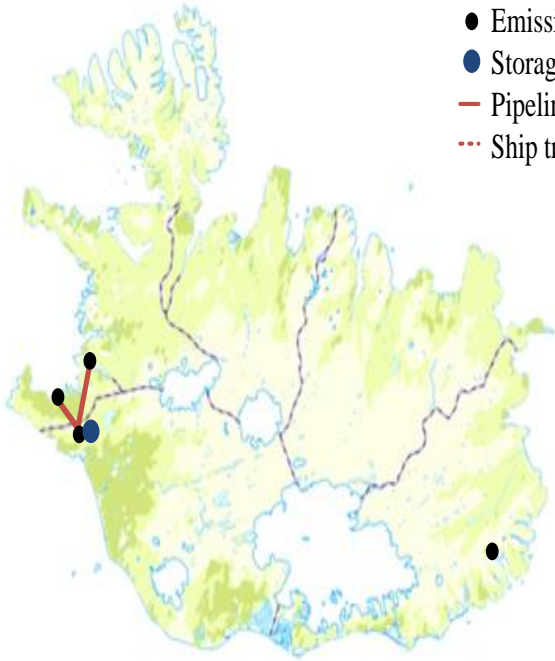
- Emission source
- Storage site
- Pipeline
- Ship route



# Iceland

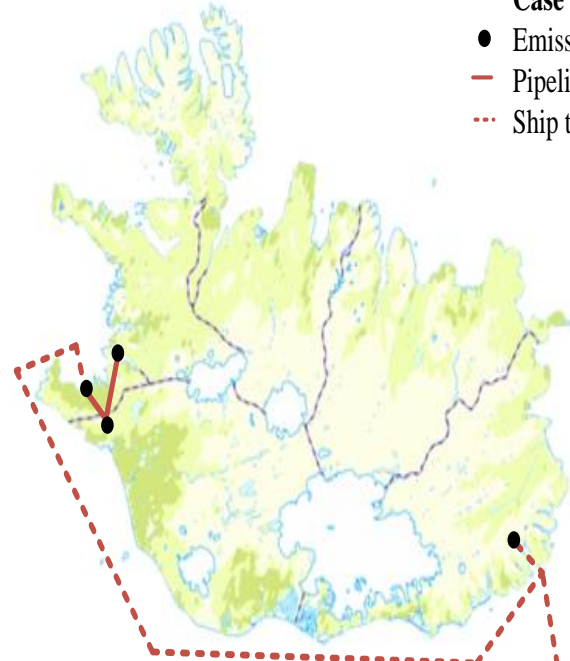
## Case 1a

- Emission source
- Storage site
- Pipeline transport
- ⋯ Ship transport



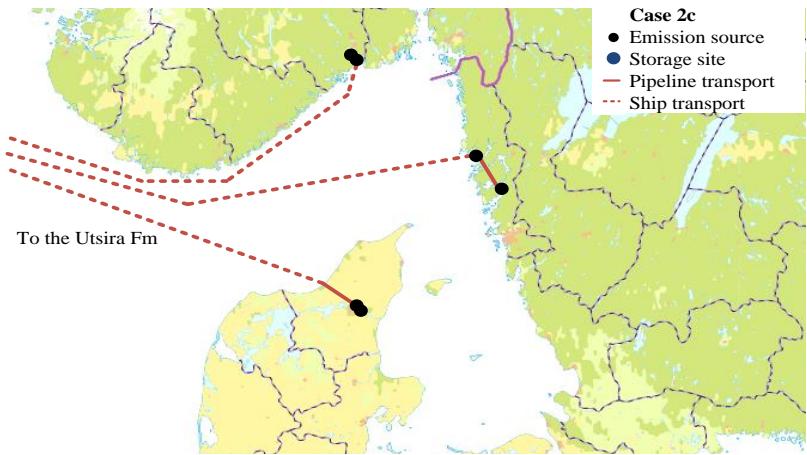
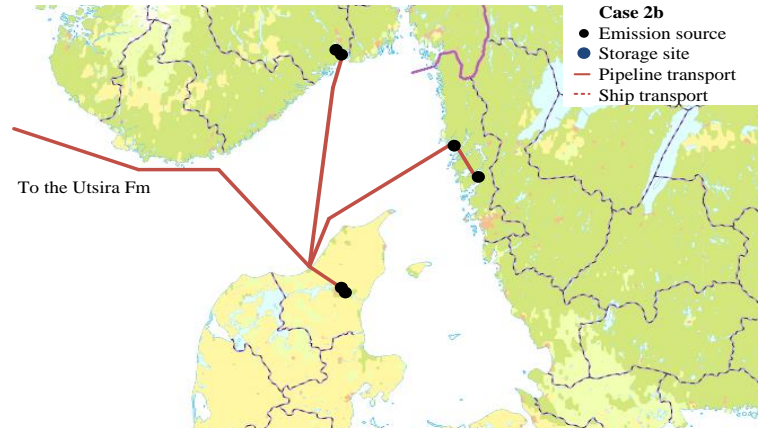
## Case 1b

- Emission source
- Pipeline transport
- ⋯ Ship transport



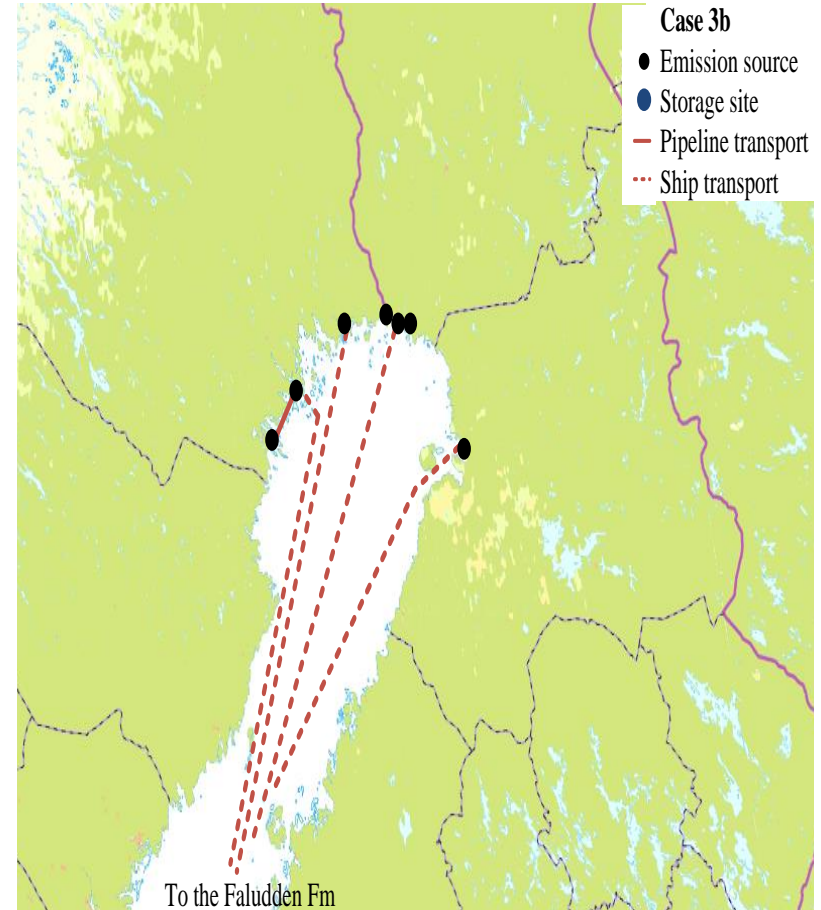
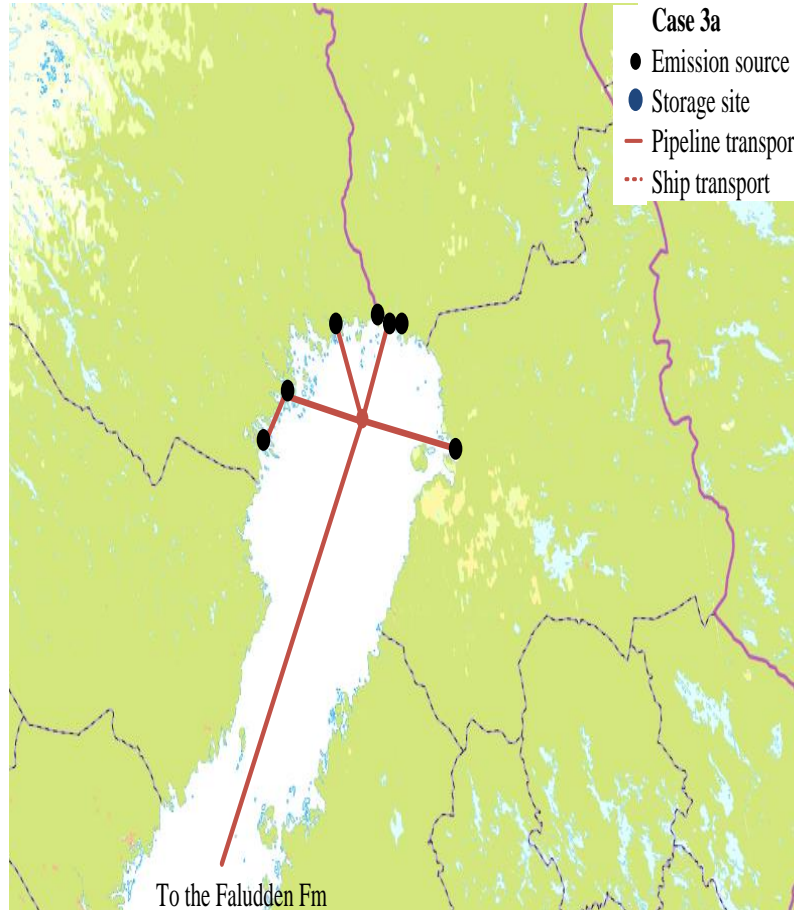
To the Utsira Fm

# Skagerrak

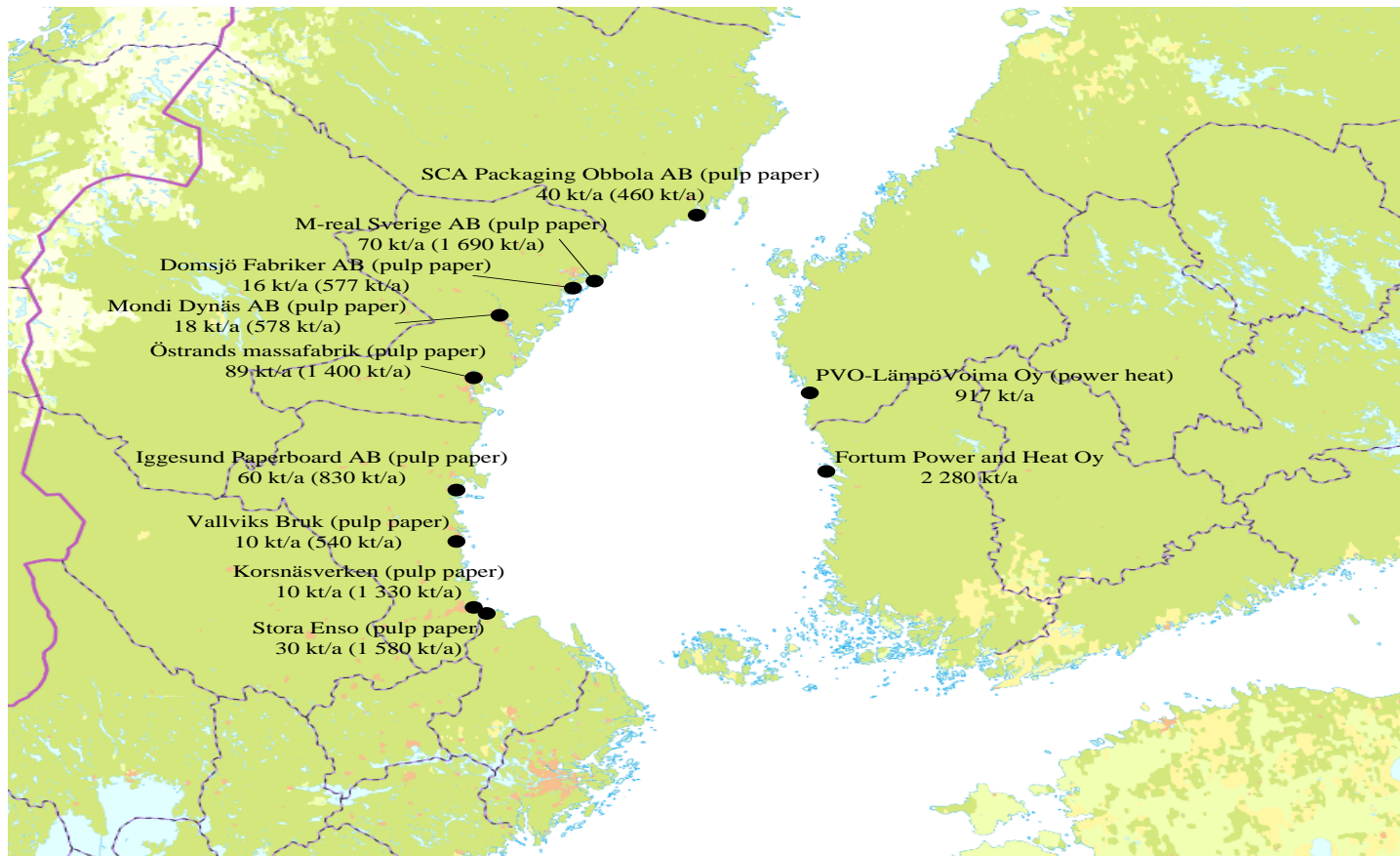




# Bay of Bothnia



# North east coast of Sweden

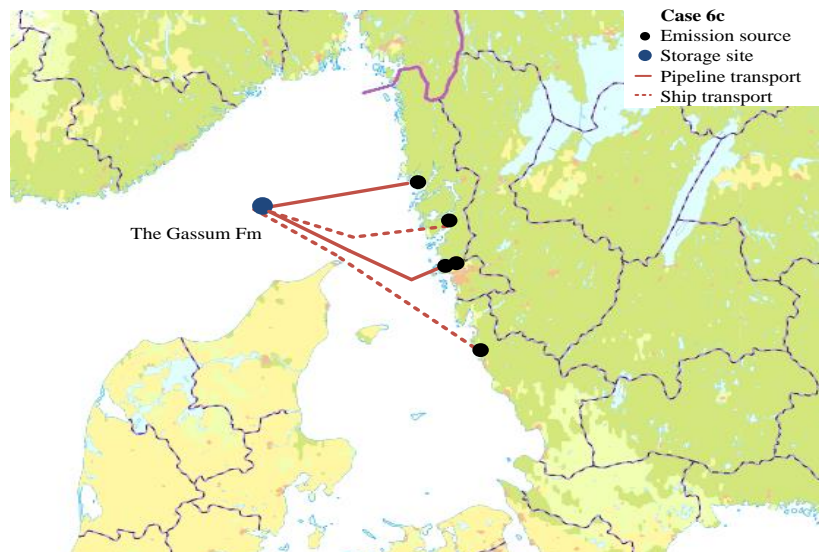
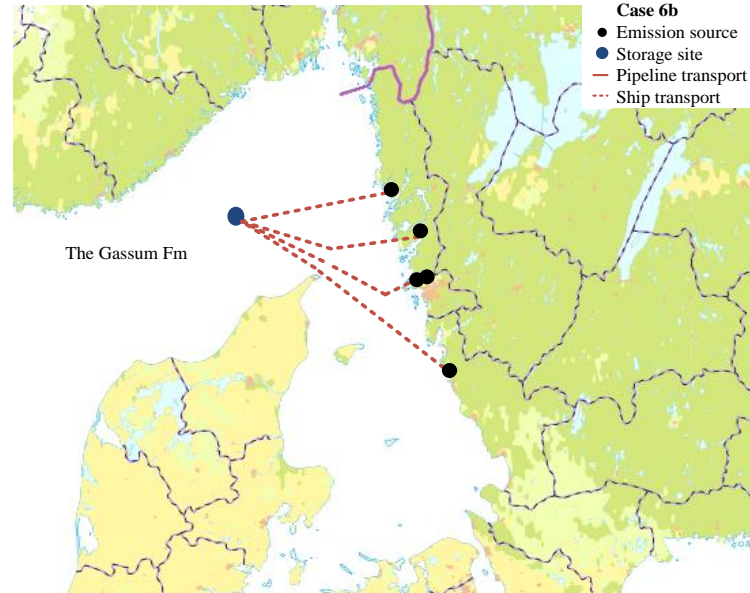
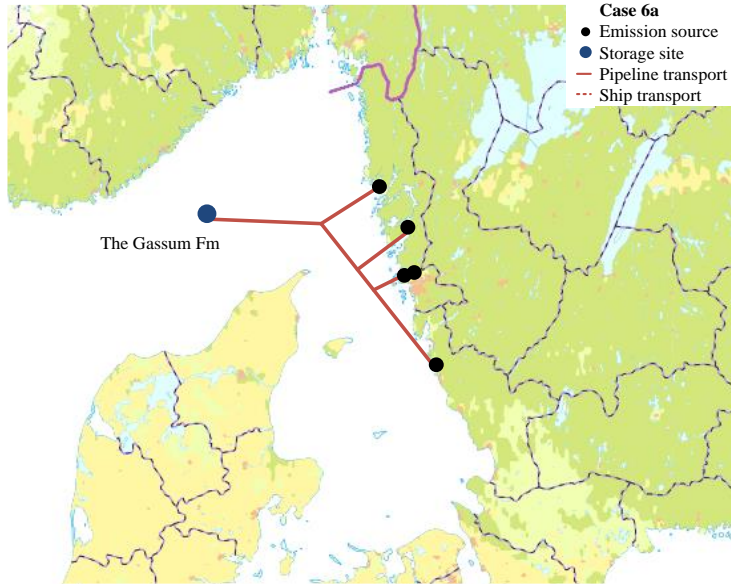


# Copenhagen





# Lysekil





Case	Description	Capture cost (€/t) (inclu. Location factor)	Transport cost (€/t)	Preliminar Storage cost (€/t)
Case 1: Iceland	Relatively small CO <sub>2</sub> emission sources, approx. 900 kt CO <sub>2</sub> /year from 4 sources. Aluminium sources with low CO <sub>2</sub> concentration	42 – 140 €/t CO <sub>2</sub> (53-172€/t CO <sub>2</sub> )	Onshore pipeline 9 €/t CO <sub>2</sub>	Onshore storage in nearby basaltic rocks*, 13 €/t CO <sub>2</sub> (*water and gas injection from CarbFix)
Case 2: Skagerrak	6 emission sources around the Skagerrak Basin (Norway, Sweden and Denmark), approx. 6 800 kt CO <sub>2</sub> /year.	54 – 69 €/t CO <sub>2</sub> (59-86€/t CO <sub>2</sub> )	Ship transport for storage in Gassum Fm 15 €/t CO <sub>2</sub> .	Gassum Fm 14 €/tonn
Case 3: Bay of Bothnia	14 000 kt CO <sub>2</sub> /year from 11 sources located both in Sweden and Finland.	58 – 68 €/t CO <sub>2</sub> (80-91€/t CO <sub>2</sub> )	Ship to Faludden , 18 €/t CO <sub>2</sub> .	Faludden Fm 16 €/tonn
Case 4: Sweden and Finland	11 emission sources around the Sea of Bothnia, approx. 10 400 kt/year CO <sub>2</sub>	59– 66 €/t CO <sub>2</sub> (70-105€/t CO <sub>2</sub> )	Pipeline to the Faludden , 13 €/t CO <sub>2</sub> .	Faludden Fm 16 €/tonn
Case 5: Copenhagen	A single emission source, approx. 1 500 kt CO <sub>2</sub> /year.	65 €/t CO <sub>2</sub> (68 €/t CO <sub>2</sub> )	Ship transport to the Havnsø , 5 €/t CO <sub>2</sub> .	Havnsø formation 20 €/tonn
Case 6: Lysekil	Approx. 4 600 kt CO <sub>2</sub> /year from 6 Swedish sources	58 – 101 €/t CO <sub>2</sub> (68-140€/t CO <sub>2</sub> )	Combination ship/Pipeline to Gassum , 12 €/t CO <sub>2</sub> .	Gassum formation 14 €/tonn

# Overall conclusion

- The six CCS cases cover a wide range in CO<sub>2</sub> volume, industry sectors, distance between sources, number of sources and distance to storage.
- Capture cost is the dominating cost element. The cost of capture is mostly dependent on the CO<sub>2</sub> volume.
- The adjustment of the generic cost with the location factor gives a more realistic cost estimate for the specific CO<sub>2</sub> emission sources.

# Overall conclusion

- The transport costs depend on the CO<sub>2</sub> volumes and the transport distance, and generally lie in the region of 12-20 EUR per ton.
- Ship- pipeline- combinations.
  - The operational cost is higher for ship, but the sunk cost in pipelines is considerable and reduces the flexibility of the transport network.
- The large CO<sub>2</sub> volumes in the Bay of Bothnia pose a challenge due to the lack of storage sites in the region.
- Storage costs have been proven hard to obtain, and a complicating factor is that the cost is very site specific. Reliable cost estimates for storage can only come from increased knowledge of the specific storage reservoir.

NEXT STEP.....

**DRILLING AND DEMOS!!!!**

# Next step

We need more information about Gassum and Faludden= drilling!!!!

We need demo projects!!  
Capture-transport-storage

# Summary

The Nordic region is a well suited region for CCS

Industry sources- transport experience- storage opportunities -

What are we waiting for????

# For more information

<http://www.sintef.no/projectweb/nordiccs/>



# NORDICCS partners

