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**ccsp**

Carbon Capture and Storage Program

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# Finnish Carbon Capture and Storage R&D Program (CCSP)

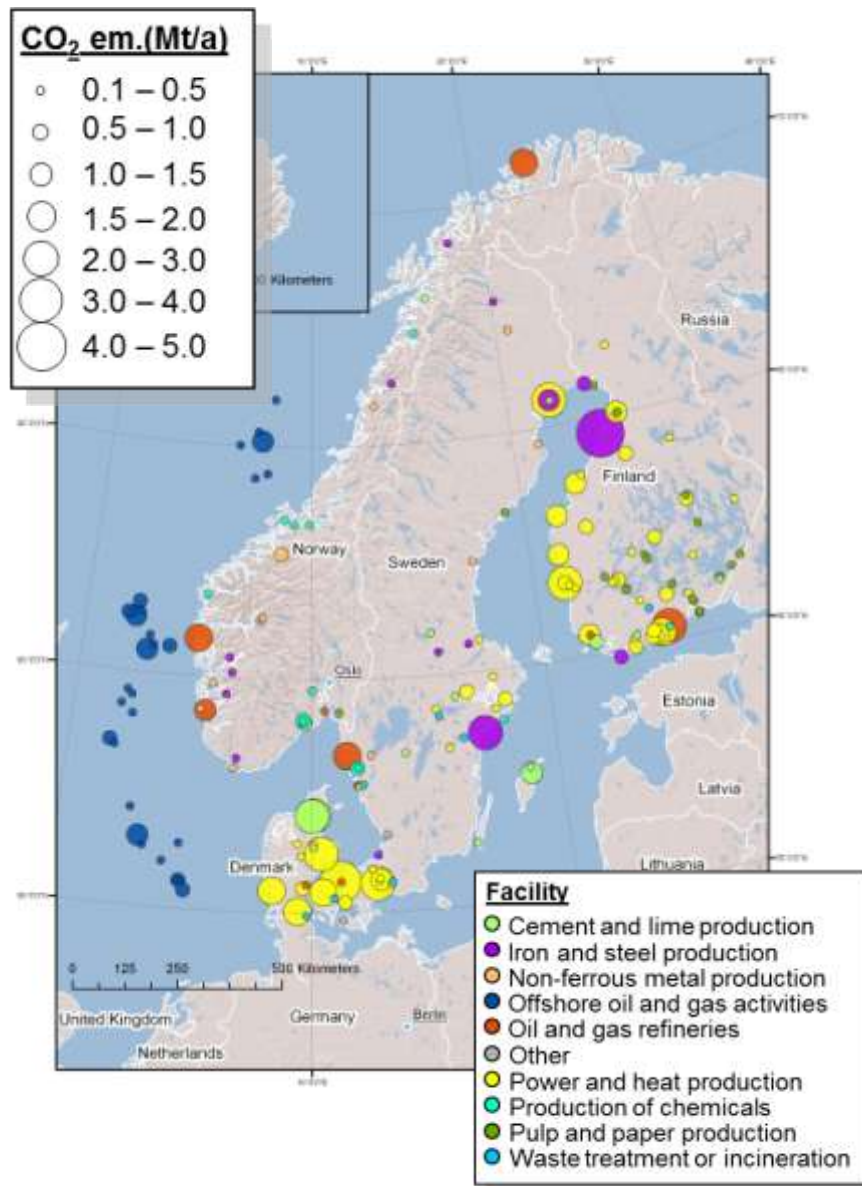
Sebastian Teir

# Contents

- Prospects for CCS in Finland
- What is being done in CCSP
- Results so far

# CCS in Finland?

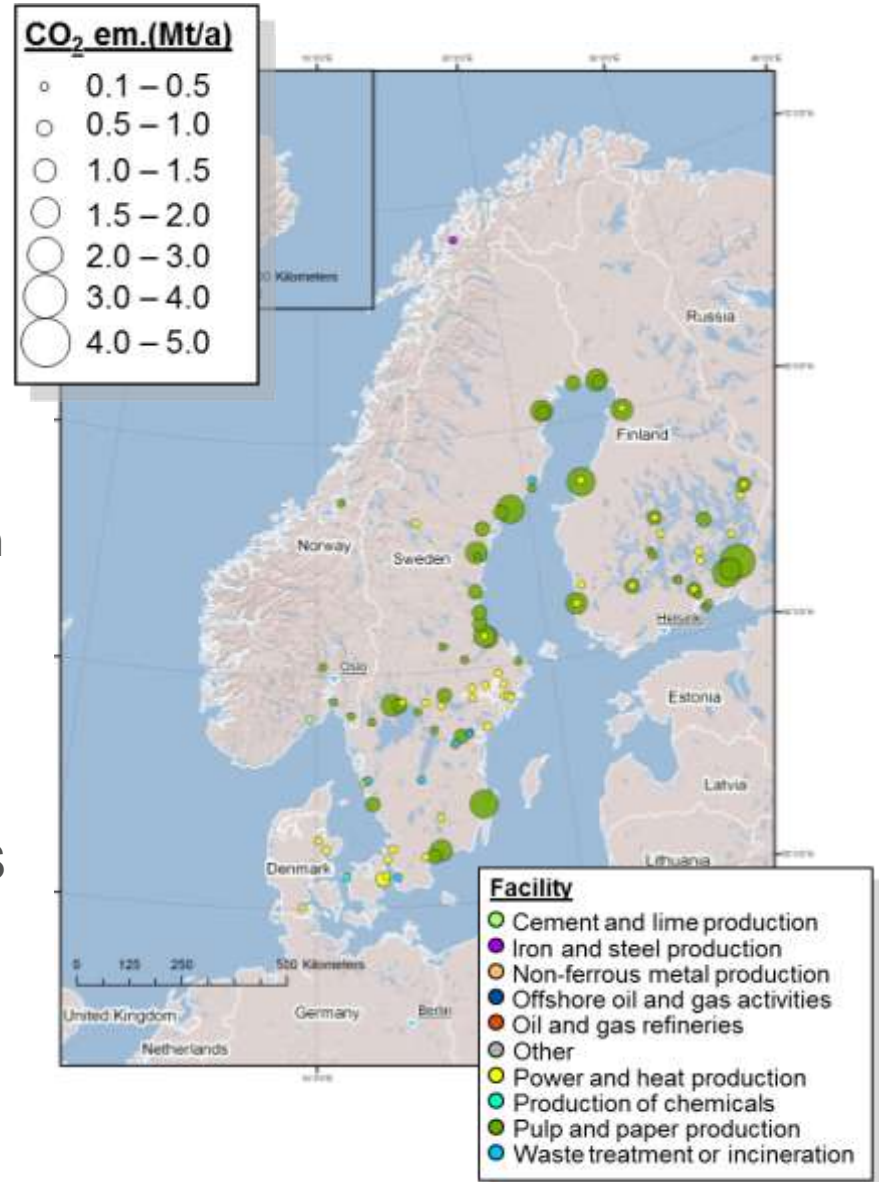
- Potential for ~18 Mt/a reduction by CCS ([Low carbon Finland 2050](#))
  - Total CO<sub>2</sub> emissions ~60 Mt/a, GHG ~70 Mt/a
- Most emission sources on the coast line, distances large → favors ship transport
- North Sea and Barents Sea closest verified storage sites
- CCS would cost 40-120 €/t CO<sub>2</sub> avoided



[VTT 2010]

# Bio-CCS in Finland?

- Bio-CCS only large-scale technology that can remove CO<sub>2</sub> from the atmosphere
- Liquid biofuels (BTL) production a near-term “low-hanging fruit”
  - near-pure CO<sub>2</sub> streams will be available
  - unit size 0.3-1.0 Mt/a
- Significant potential for bio-CCS in Finland and Sweden
- Currently no incentive for bio-CCS
- Biomass resources restricted



# Carbon Capture and Storage Program (CCSP)

- Target: technological readiness for pilots and demonstrations by the end of the program
- 17 industrial partners, 9 research partners, 1.1.2011 – 31.12.2015
  - Volume: ~3 M€/a
- Key focus areas:
  - Carbon capture and storage (CCS) in CHP systems
  - CCS related to multi-fuel and Bio-CCS
  - Monitoring technologies
  - Acceptability of CCS
- Long-term breakthroughs
  - Chemical looping combustion (CLC)
  - Mineral carbonation
- Close collaboration with Swedish CCS Project (Bastor2)

## Finnish international network activities related to CCS coordinated in CCSP

- IEA GHG ExCo
- IEA CCS
- Zero Emission Platform (ZEP)
- EERA CCS
- NordiCCS
- EASAC
- CO2GeoNet, CGS Europe
- Gas union
- EU MUSTANG

## Main partners of CCSP

### Companies:

1. Andritz Oy
2. Fortum Oyj
3. Fortum Power & Heat Oy
4. Foster Wheeler Energia Oy
5. Gasum Oy
6. Helsingin Energia
7. Neste Jacobs Oy
8. Neste Oil Oyj
9. Nordkalk Oyj
10. Oulun Energia
11. Outotec Oyj
12. Ramboll Finland Oy
13. Ruukki Metals Oy
14. Stora Enso Oyj
15. Tapojärvi Oy
16. Vibrometric Oy
17. ÅF-Consult Oy

### Research organizations and universities:

18. Aalto University
19. Finnish Environment Institute (SYKE)
20. Geological Survey of Finland (GTK)
21. Lappeenranta University of Technology (LUT)
22. Tampere University of Technology (TUT)
23. University of Oulu (UO)
24. University of Tampere (UTA)
25. VTT Technical Research Centre of Finland
26. Åbo Akademi University

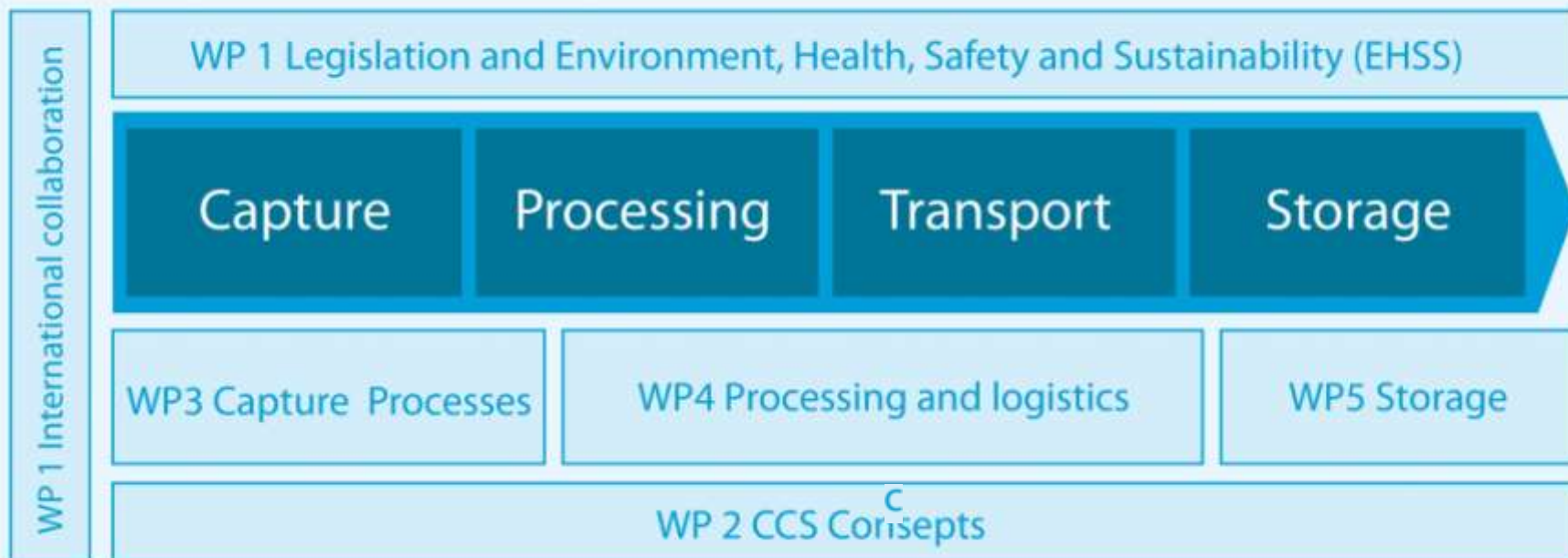
The Program is principally open for new incomers during its whole duration

## Finnish industrial expertise in CCS

- Oxy-fuel combustion in CFB boilers and looping technologies (Foster Wheeler)
  - CIUDEN 30 MWth oxy-CFB pilot started up in 2012
  - Aiming for demonstration in 2015 (Compostilla, Spain)
  - Provided reactors for CaL-looping pilot in Spain
- Monitoring and verification of emissions from CO<sub>2</sub> capture (Ramboll)
- Monitor technology for geological CO<sub>2</sub> storage (Vibrometric)
- Experience from planning a large-scale CCS demonstration project (Fortum)

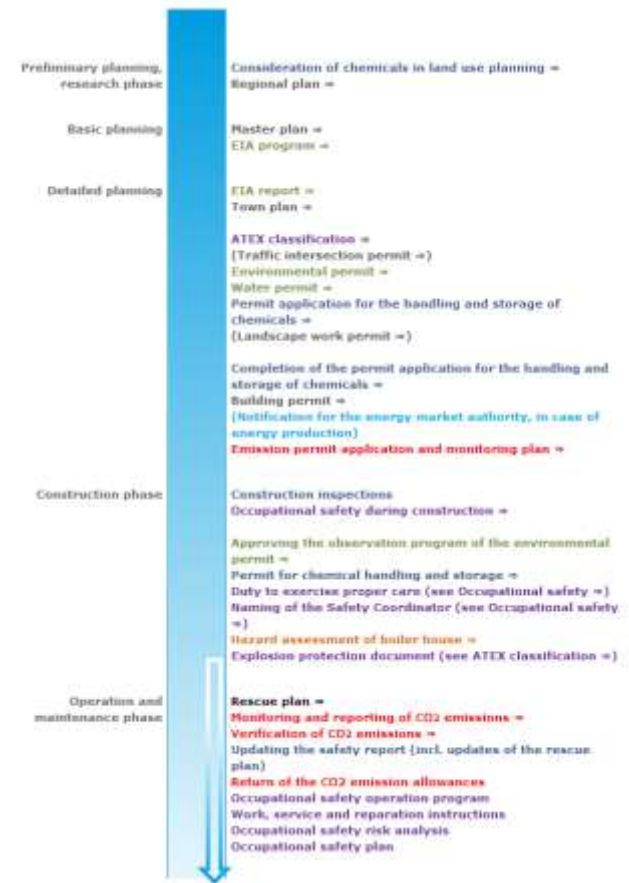


# Carbon Capture & Storage Program



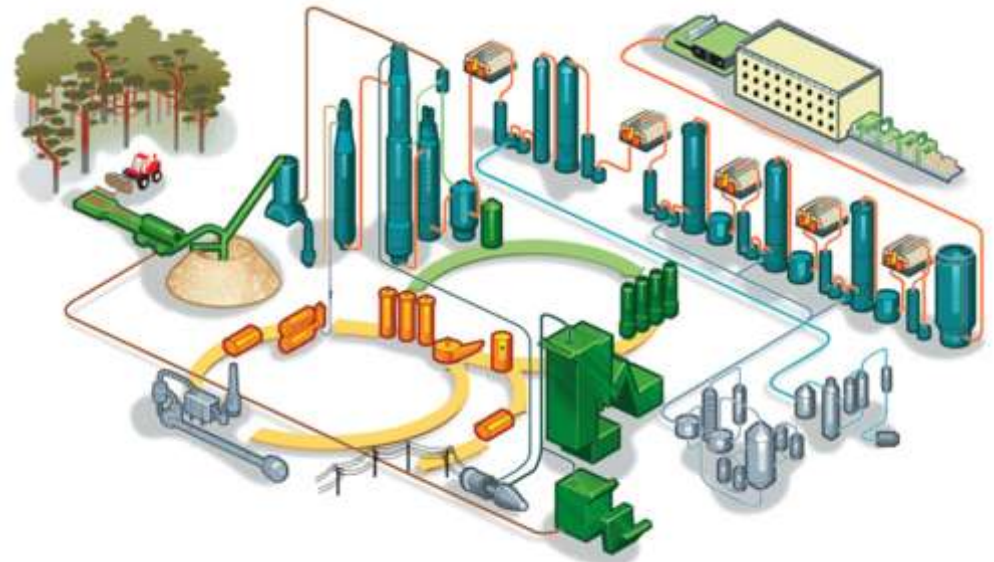
# Framework for CCS (WP1)

- Update on the legislative framework for CCS
- CCS project implementation roadmap ready
- Analysis of the acceptability of CCS in Finland
- Participation in international networks
  - E.g. EASAC report



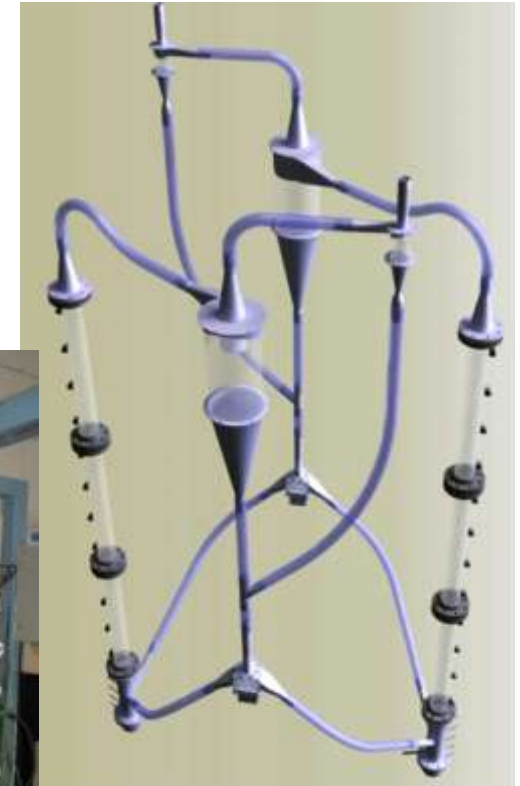
# CCS Concept Studies (WP2)

- First assessment on the processes and costs of CCS connected to CHP systems
- Assessment of industrial CCS concepts (steel, oil refinery, pulp and paper)
- Utilisation of CO<sub>2</sub>
- Bio-CCS roadmap



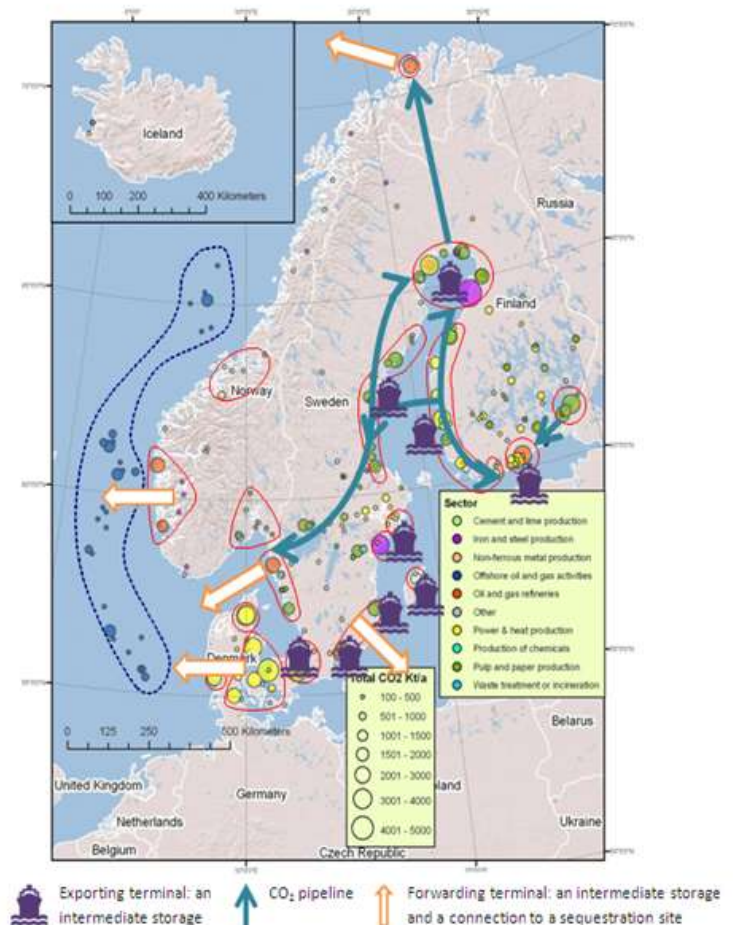
# Technologies for capture of CO<sub>2</sub> (WP3 )

- Chemical looping combustion (CLC)
  - Test facility for CLC hydrodynamics built and in operation
- Better understanding of heat stable salt formations in capture processes
- Better understanding of oxy-combustion in CFB through modeling



## Monitoring methods and logistics (WP4)

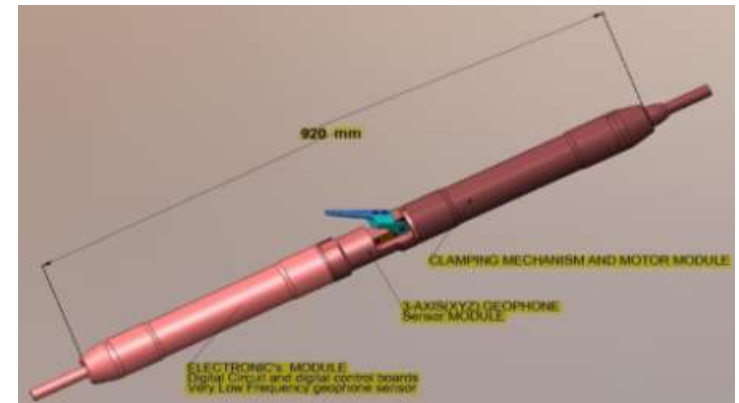
- Monitoring methods for amine emissions from CO<sub>2</sub> capture being developed
- A first draft of the long-term (year 2050) CO<sub>2</sub> capture infrastructure around Baltic Sea region
- Possibility for intermediate storage of CO<sub>2</sub> in underground caverns undergoing assessment





## Storage of CO<sub>2</sub> (WP5)

- Geological storage
  - A first geological storage capacity estimate of the Baltic Sea region
  - Monitor technology for geological CO<sub>2</sub> storage being developed
- CO<sub>2</sub> fixation as solid carbonates
  - Pilot plant for carbonate production from steel slags under construction

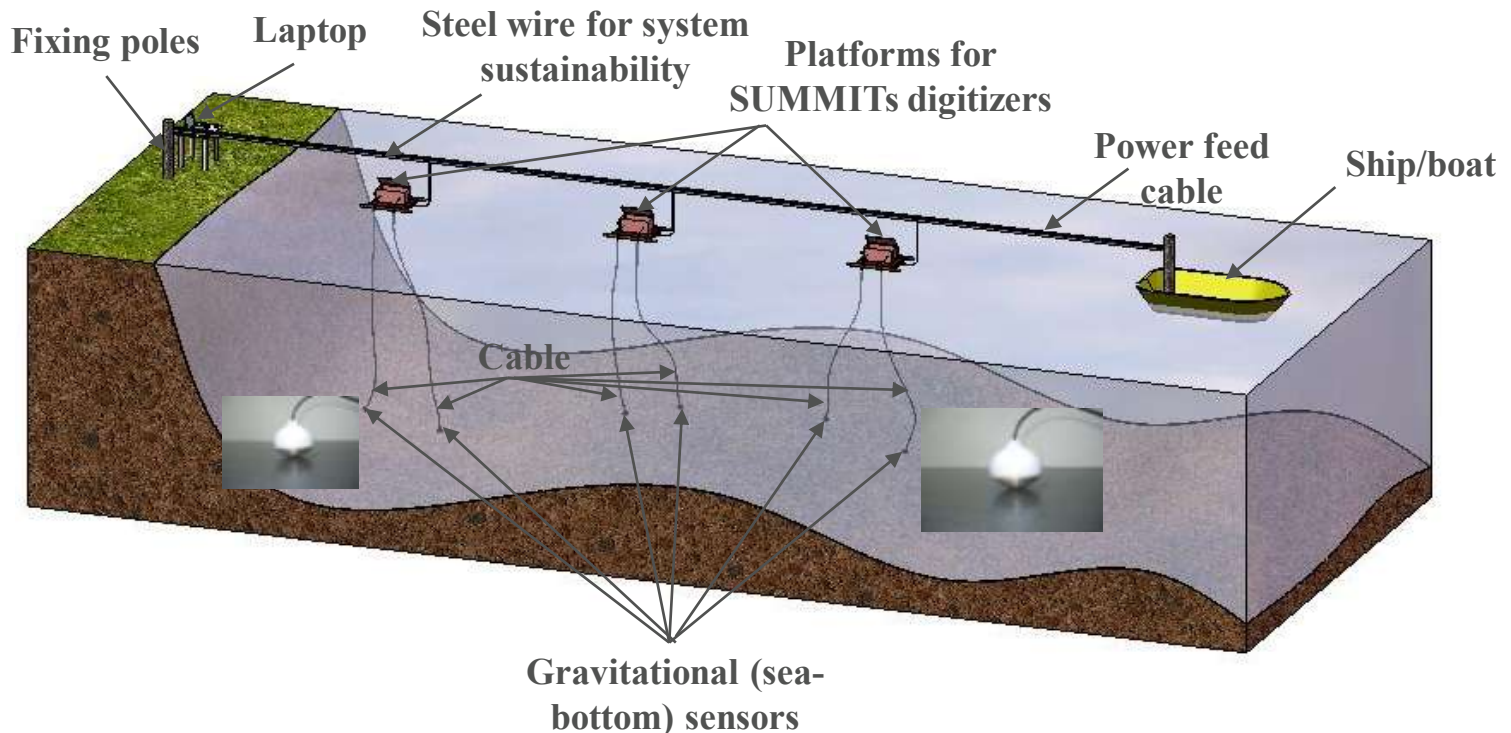


## Potential for geol. storage of CO<sub>2</sub> in the Baltic Sea

- A collaboration with the Swedish CCS project (BASTOR)
- A first estimate on the geological storage potential of CO<sub>2</sub> in the Baltic Sea has been made
- Report now available:  
<http://www.vtt.fi/inf/pdf/technology/2013/T101.pdf>
- Work continues in the Swedish CCS project to improve the reliability of the capacity estimates

# Geophone array for coastal region sites

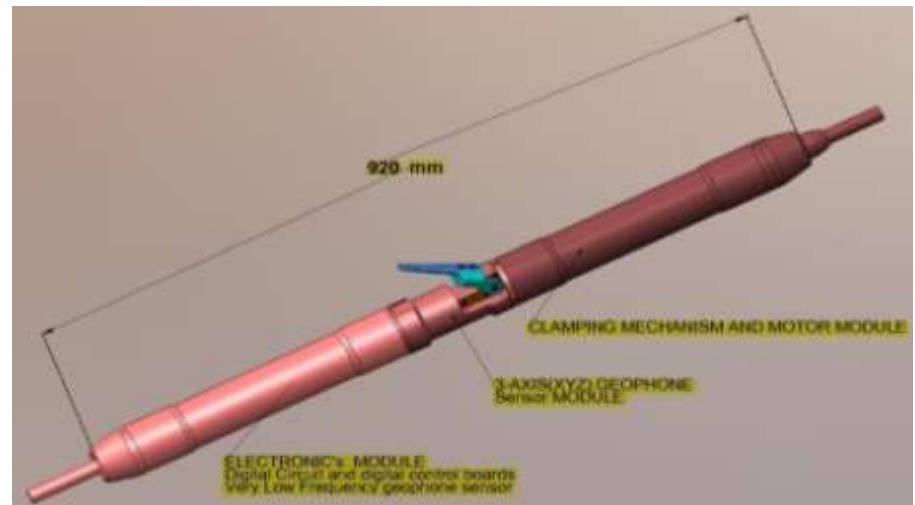
- The ability of performing seismic measurements on shallow sea bottom is likely to become a necessity for storage sites located in coastal regions.
- An array of 48 1-channel sea-bottom sensors was constructed beginning of 2012 and successfully tested in a 30 m deep lake in Canada in 2013.





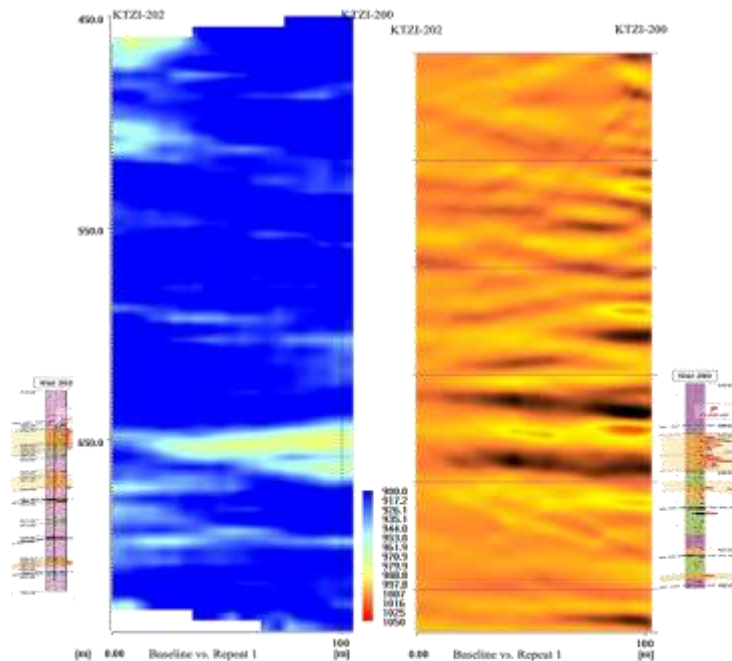
# Receiver chain for borehole seismic surveys

- A receiver tool for borehole seismic surveys at CO<sub>2</sub> storage sites has been developed for measurements at depths of 1.6 to 2 km
- In-situ evaluations were done at the Heletz injection site (Israel), as a part of the EU funded MUSTANG project
  - Test records are currently being evaluated

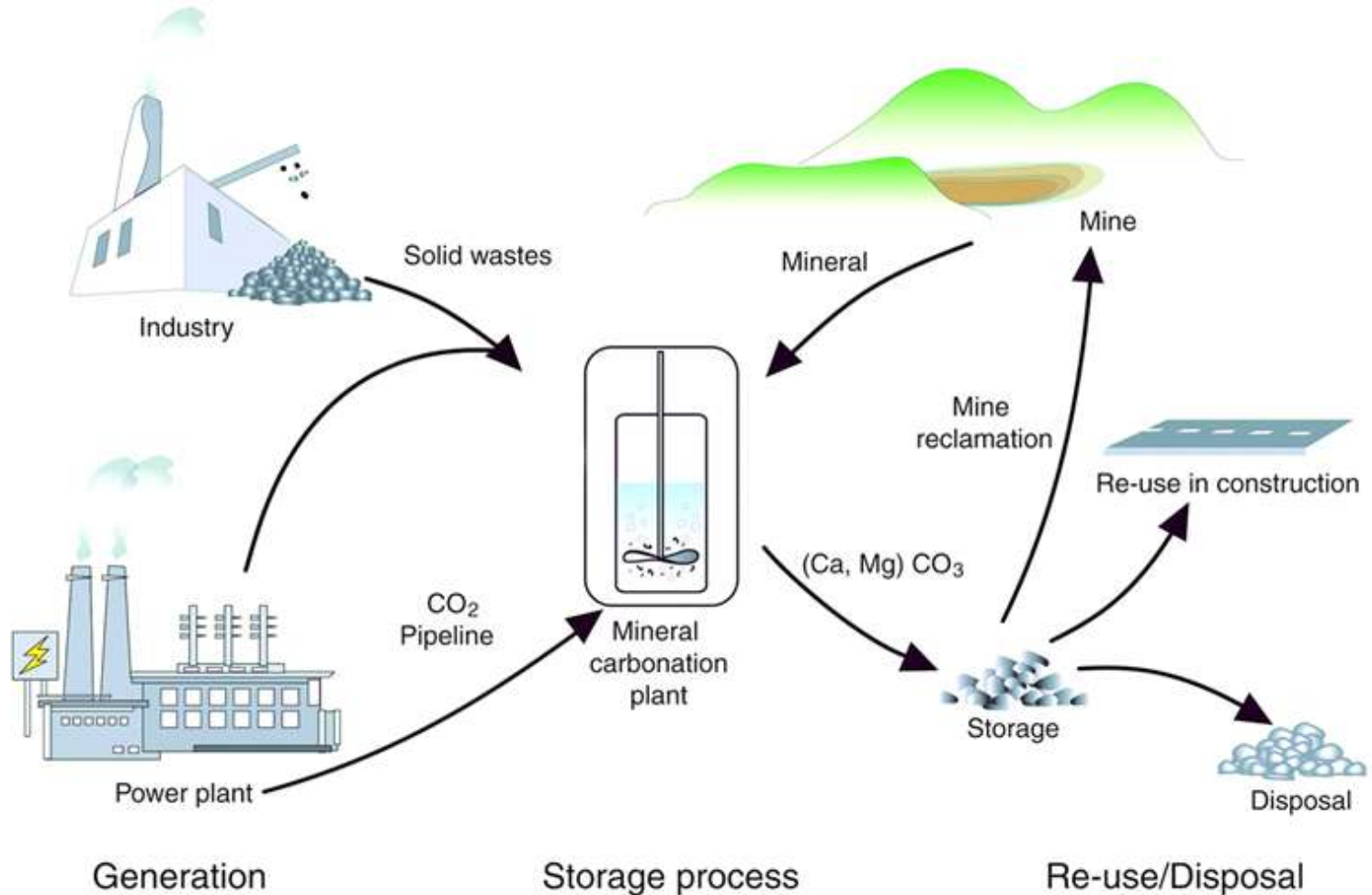


# Reprocessing of Ketzin data

- Reprocessing of the Vertical Seismic Profiling (VSP) / Moving Source Profiling (MSP) and crosshole data collected at Ketzin in 2007-2011
  - Using specialized imaging techniques, e.g. Image-Point migration



# Concept of *ex-situ* mineral carbonation



[Figure: IPCC, 2005]

## Upcoming in CCSP

- Selection of key concepts during 2013 → focus
- **Joint seminar & workshop with NordiCCS in 21-22 October 2013 (Espoo)**
  - Seminar part 21 October open for everyone
  - All NordiCCS participants please book the date!

## References

- [VTT\(2012\) - Low carbon Finland 2050](#)
- [VTT\(2010\) - Potential for carbon capture and storage \(CCS\) in the Nordic region](#)
- [EASAC\(2013\) – Carbon capture and storage in Europe](#)
- [CCSP – Carbon Capture and Storage Program](#)

**CLEEN**

Cluster for Energy and Environment



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**ccsp**

Carbon Capture and Storage Program

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Thank you for your attention!

## The story so far...

- Methods have been successfully developed for detecting solvent emissions
  - Even lower detection limits than those of other laboratories in the field – accredited for nitrosamines in 2013
- Participation in report on Bio-CCS (ZEP & BTP)
- Concept evaluations on CCS with combined heat and power, heavy industry, and bio-CCS
- CFD furnace models on oxy-fuel combustion (CFB boilers)
- Experiment rig (cold model) for CLC development
- Evaluation of CO<sub>2</sub> capture processes for steel industry
- Roadmap for CCS projects from an environmental and legal perspectives
- A first laboratory pilot plant for storing CO<sub>2</sub> as carbonate is being built
- A first assessment on public acceptance of CCS in Finland