CLEEN
Cluster for Energy and Environment

ccsp
Carbon Capture and Storage Program

Assessing the sustainability of CCS technologies in Finland – Highlighting future potential, uncertainties and challenges for technology implementation

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Aim of the paper

- **To discuss the potential sustainability impacts** related to implementation of **CCS technologies in Finland**
- Highlight critical aspects related to **future potential, uncertainties and challenges** for sustainable CCS implementation

Outcome/contribution

academic

industrial

- **Sketch "framework"** for defining and assessing the **sustainability of CCS** - challenges & development needs
- **Indicate prerequisites** for sustainable and acceptable **CCS implementation** – potential, barriers & areas of action

Approach – Work in progress

- **Multidisciplinary sustainability assessment**
  - Environmental aspects
  - Economic aspects
  - Risks (Environment, Health & Safety)
  - Regulatory aspects
  - Acceptability

- plant vs. local energy system

- local vs. global

- Finland vs. other countries

- **Empiric part → Industry driven**
  - Case studies of different CCS-concepts
  - Acceptability of CCS (interviews & media analysis)
  - Expert workshop discussing future of CCS in Finland
- **Literature**
  - Scientific literature, technical reports, company reports, expert opinions, R& D outcome, legislation

CCS = Different technological concepts!

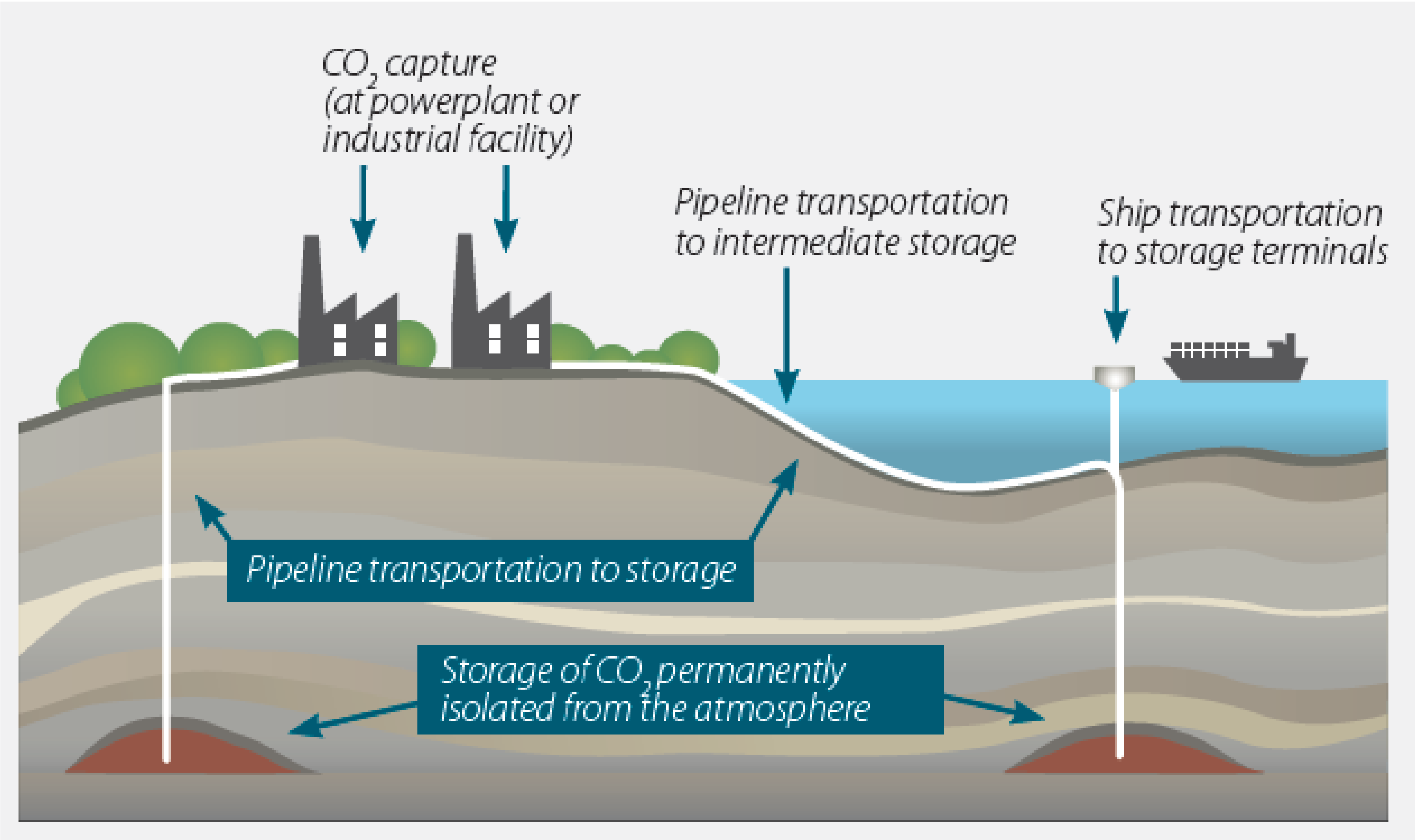
CCS – Carbon capture and storage

Capture

- **Separation of carbon dioxide (CO_2) from industry and energy-related sources**, such as fossil-fuel combustion plants, refineries and iron and steel plants, **before the CO_2 is released into the atmosphere**

Storage

- Annually, millions of tons of CO_2 would need to be **stored safely in isolation from the atmosphere → permanently or for thousands of years**
- Most **potential and operational storage sites** (close to Finland) are situated **in the North Sea** (Teir et al., 2011)
  - Storage potential under the Baltic Sea is under investigation (Nieminen et al., 2011)


CO_2 capture
(at powerplant or
industrial facility)
Pipeline transportation
to intermediate storage
Ship transportation
to storage terminals
Pipeline transportation to storage
Storage of CO_2 permanently
isolated from the atmosphere

Environmental aspects

- **CO_2 emissions are significantly reduced** with CCS, but process efficiency decreases, and **more fuels or electricity and other resources are needed**
  - Increasing need for fuels and chemicals increases formation of air emissions (Schreiber et al. 2012; Zapp et al. 2012), however, **emissions of some substances to air may** potentially **even decrease** with different combustion, capture & purification methods due to CCS
- **Geological storage** is currently the only utilized option for permanent CO_2 storage
  - Potential **storage sites are outside Finland**
  - Utilization of CO_2 and mineral carbonation are potential options
- **Ethical considerations** are central
  - Is CCS necessary, or will it further slow down the changes in our energy system?

Economic aspects

- CCS would require **significant investments** in capture technologies, transport and storage
- Other challenges are the **low efficiency** of capture technologies (*energy penalty*) and **transportation costs**
  - Using excess heat for district heating could improve efficiency
- At present, the **price of CO_2 emission allowance in EU ETS is far too low** to make CCS feasible
  - The break-even point for the price of emission allowances would be around ~ 50 – 100 €/t CO_2 (literature, case studies) (case dependent!) → Current price is close to 5 €
- From the energy system perspective, **CCS is a large scale option** which fits well on the existing infrastructure
  - While there are other low carbon options for energy production, **energy/carbon intensive industry could benefit from CCS**

Risks (Environment, Health & Safety)

- Main concerns relate to the very large quantities of CO_2 which need to be handled, transported and stored
  - Other potential aspects relate to use of **solvents (amines)**
- The **release of large amount of CO_2** has a **potential to cause major accident** for humans & the environment
  - Humans are very sensitive to changes in CO_2 concentrations in the air (can even be lethal)
  - Elevated CO_2 concentrations in ambient air will enhance plant growth and photosynthesis, but high CO_2 levels in the soil cause negative effects (e.g. vegetation die-off)
- **Safe storage would need to be secured,** while most of the risks along the CCS chain can be managed with careful planning, R& D, education and **risk management** practices
  - **CO_2 is commonly handled in industrial processes**

Regulatory aspects

- CCS value chain will fall under the **national legislations of more countries than Finland alone**
  - Depends of the transport route & storage site
- Specific issues are mentioned in the **CCS directive**, but in principle, CCS is treated as any other industrial activity, requiring EIA, environmental permit, etc.
- From the **Finnish point of view**, biggest regulatory **challenges & uncertainties** are
  - **Ship transport of CO_2 is not covered by the EU-ETS → Potential emission reductions could not be credited**
  - **London Convention on the prevention of marine pollution** by dumping of wastes and other matter is waiting for ratifications allowing cross-border CO_2 ship transport
  - **CCS with biomass combustion** is not recognized by EU ETS

Acceptability

- General knowledge related to CCS in Finland is rather poor (Eurobarometer 2011)
- Based on empiric data, **CCS is not a burning issue in Finland** (Kojo & Nurmi 2012; Innola & Kojo 2013)
- **Stakeholder concerns reflect topical issues in CCS related R& D**, but since there are no actual plans to implement CCS in Finland
  - **Interest remains rather low**
  - CCS is not considered as a viable option in near future
- Majority of the news items related to CCS in **print media** were **either neutral or moderately positive**, while only a small amount were considered critical

  → **Potential for engaging stakeholders in framing CCS policies → Need to increase awareness**

Discussion (1/3)

Weak vs. strong interpretation of sustainability

- **Weak sustainability** = man made capital may compensate for loss of natural capital
- **Strong sustainability** = natural capital has to be protected and restored, and can't be compensated by anything else

Potential interpretation

- CCS enables cutting greenhouse gas emissions and mitigating climate change in a situation where global energy demand is growing, many people lack access to energy, and changes in energy production systems are slow
- **However…**

Discussion (2/3)

- **However…**
  - **Fossil resources depletion** continues
  - **Problem solving is postponed** to future generations?
  - Implications for environmental, economic and social development?
  - Global vs. local impacts?
  - Time-scale of the assessment
  - Value-based judgment
- According to strong interpretation, the **idea of CCS** technologies as such **is not sustainable**
- According to weak interpretation, there are **situations in which CCS could be a sustainable solution**
  - Differences between CCS concepts can be significant

Discussion (3/3)

- Challenges related to CO_2 storage and lack of domestic storage potential could potentially be partly tackled with **effective utilization of captured CO_2**
  - Utilization potential of CO_2 is under research, but at the moment the **potential is rather small**, compared to potentially captured amounts of CO_2 (Aresta 2007)
  - Another challenge relates to timescale – in most utilization options, **captured carbon would be released** after a rather short time span
- Impact on **national economics, employment and balance of trade?**
  - Additional income from negative emissions (biomass)?
  - Carbon neutral utilisation of peat?

Preliminary conclusions (1/2)

- Many of the **impacts of CCS** technologies are **case specific**
  - Application of CCS can be a **trade-off between different dimensions of sustainability**
- Technological development is linked with all aspects of sustainability
  - **Improving process efficiency** would likely improve environmental and economic performance and acceptability
  - **Safe and permanent storage** with enough capacity would need to be secured
- **From industrial point of view**, the economic feasibility of CCS should be improved
  - **Technological challenge** = energy penalty of CCS
  - **Political/institutional challenge** = stability of climate & energy policy, CO_2 prices & GHG emission reduction targets

Preliminary conclusions (2/2)

- **Concrete CCS implementation plans** might be required to test the applicability of the CCS related legislation and **to motivate changes**
  - Regulatory questions related to **cross-border ship transport** of CO_2 and **bio-CCS** would need to be solved
  - Current situation involves **high uncertainty** from industrial point of view, potentially **preventing any implementation plans**
- At the moment, **attitudes towards CCS are rather neutral** in Finland, due to lack of actual implementation plans, and potentially also because of lack of domestic storage potential
- For active **public engagement** and participation, **awareness related to CCS** should be actively promoted
  - **General public, regulators, authorities, media**

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Thank you!

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