



Negative CO₂

Negative CO₂ Emissions with Chemical-
Looping Combustion of Biomass

Nordicenergy.org/flagship/negative-co2/

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Legend**Storage areas**

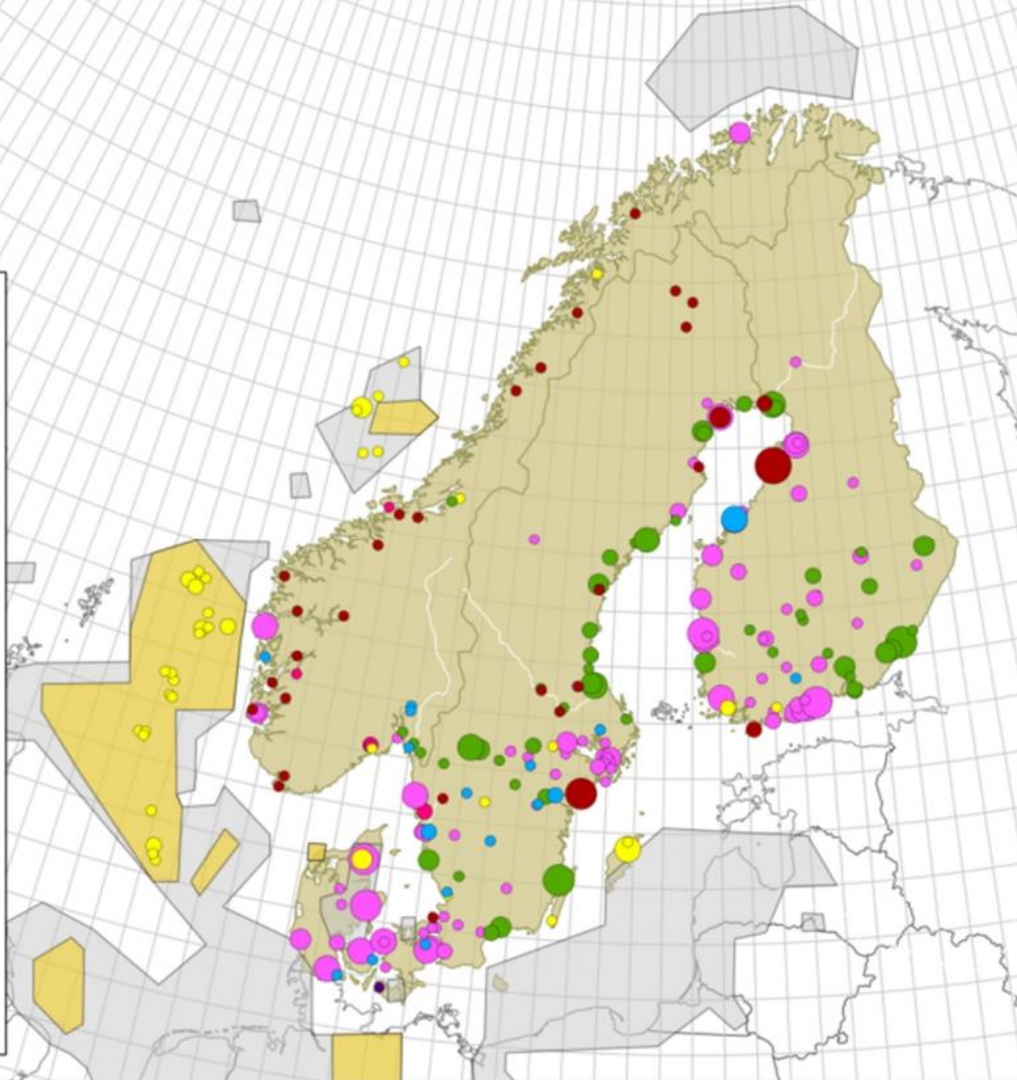
- Potential geological formations
- Highly potential geological formations

Type of facility

- Food and beverage sector
- Chemical industry
- Energy industries and energy sector
- Mineral Industry
- Other activities
- Paper and wood processing
- Production and processing of metals
- Waste and waste water management

Annual CO₂ emissions

- 100-500 kt
- 500-1000 kt
- 1000-1500 kt
- 1500-2000 kt
- 2000-3000 kt
- 3000-4000 kt
- >4000 kt



**CO₂
point
sources
and
storage
areas**
(in Nordic
countries at
2010)



Negative CO₂

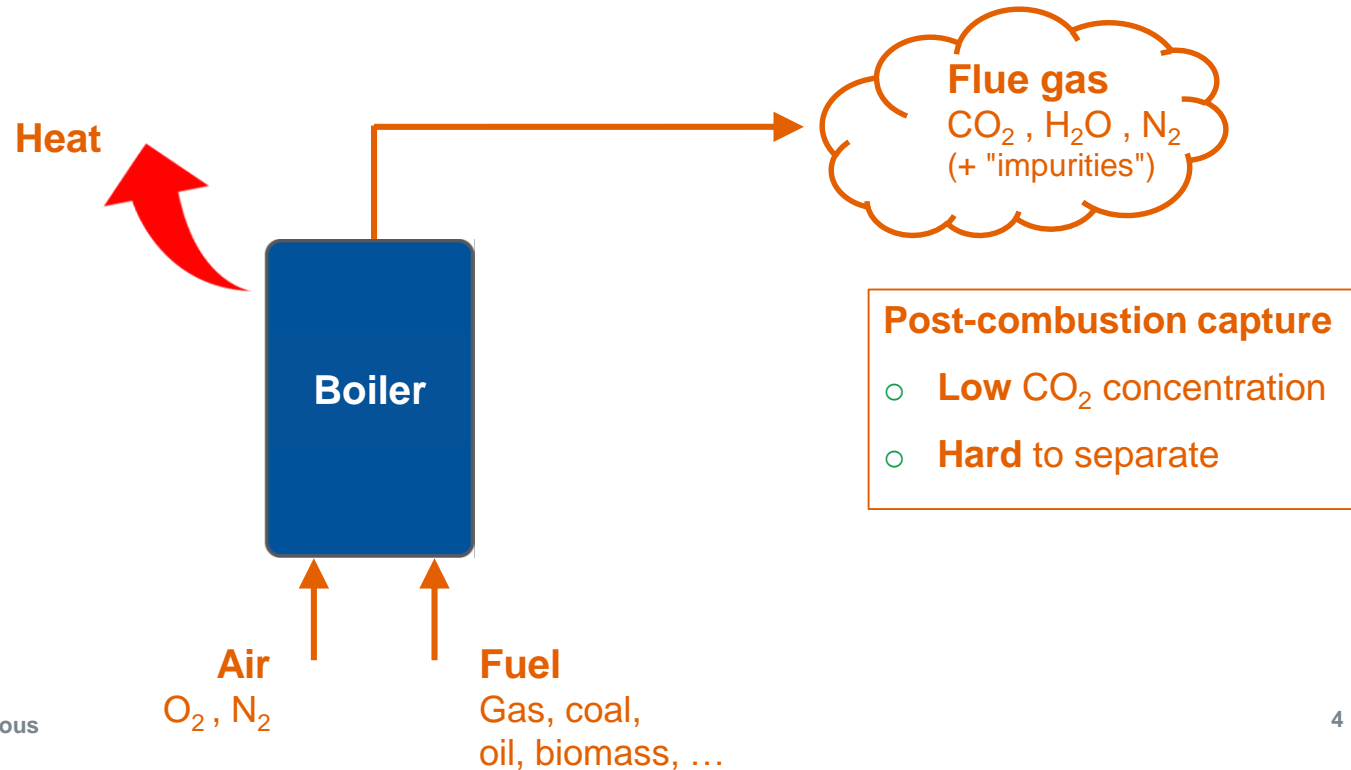
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VTT

Negative CO₂ project

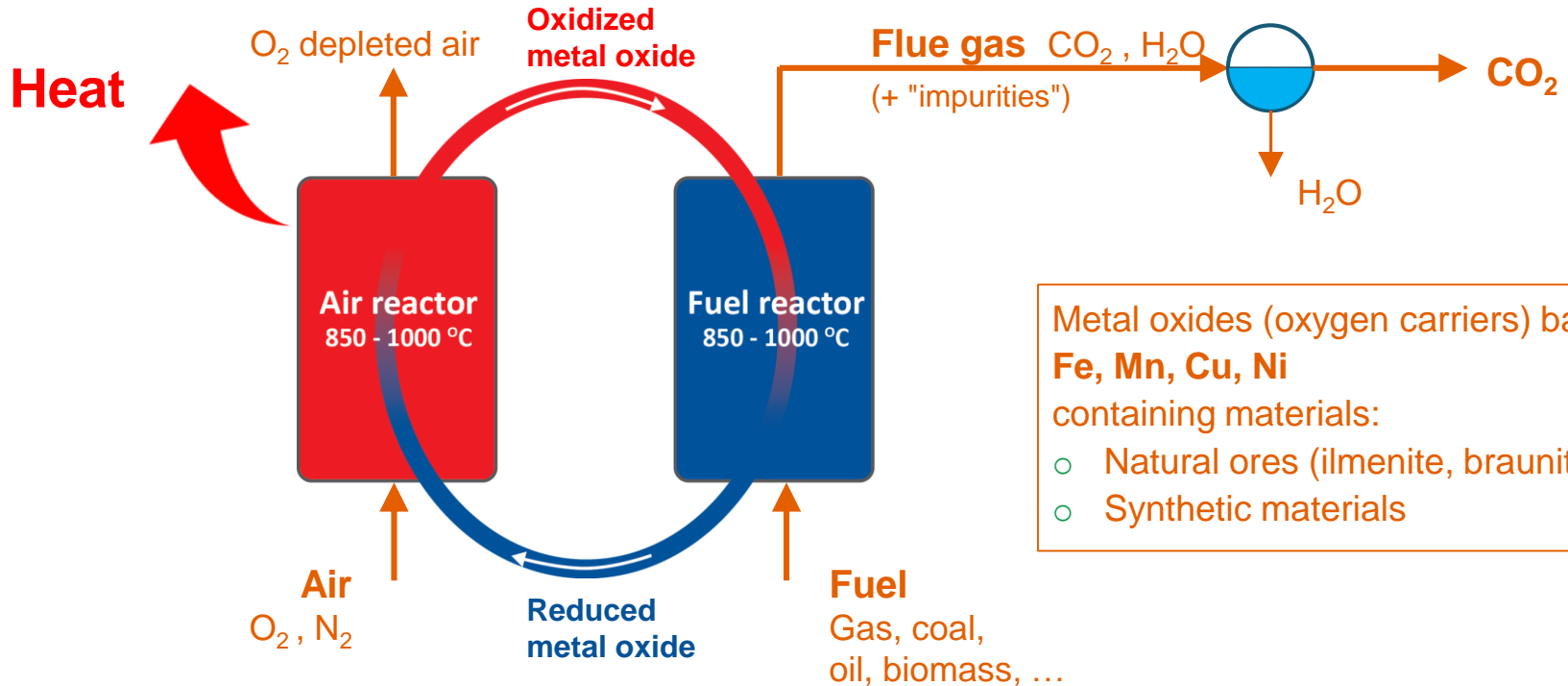
- Develops bio-CLC technology for cheaper bioenergy CCS
 - CLC = Chemical Looping Combustion

Combustion for heat and power



Chemical Looping Combustion - CLC

See also <https://www.nordicenergy.org/article/how-does-chemical-looping-combustion-work/>



Metal oxides (oxygen carriers) based on **Fe, Mn, Cu, Ni**

containing materials:

- Natural ores (ilmenite, braunite)
- Synthetic materials



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Negative CO₂ project

- Develops bio-CLC technology for cheaper bioenergy CCS
- Operates bio-CLC pilot units in Sweden, Finland, and Norway
- Is searching for medium-scale demonstration plant
- Models techno-economic studies of bio-CLC in energy systems

See also <https://www.nordicenergy.org/flagship/negative-co2/>





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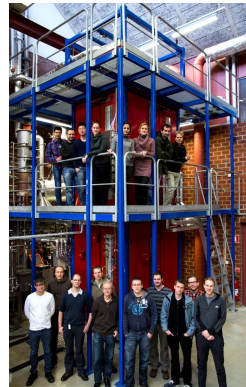
Yes, it works!



10 kW gas,
2003



10 kW solid,
2006



100 kW bio, 2011
Currently 3 pilot units



2.4 MW bio,
2015



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Ideal demonstration conditions?

- **Minimize the investment cost**
 - Use of existing fluidized bed units and other process components
- **Minimize the investment risk**
 - Multipurpose design. e.g. the bio-CLC unit can be utilized for energy production without CCS, if needed
- **Partial and/or stepwise demonstration**
 - The main target is to demonstrate the bio-CLC process,
 - other process parts, e.g. CO₂ capture and storage are similar to other CCS technologies
 - Capture and storage part can be installed later



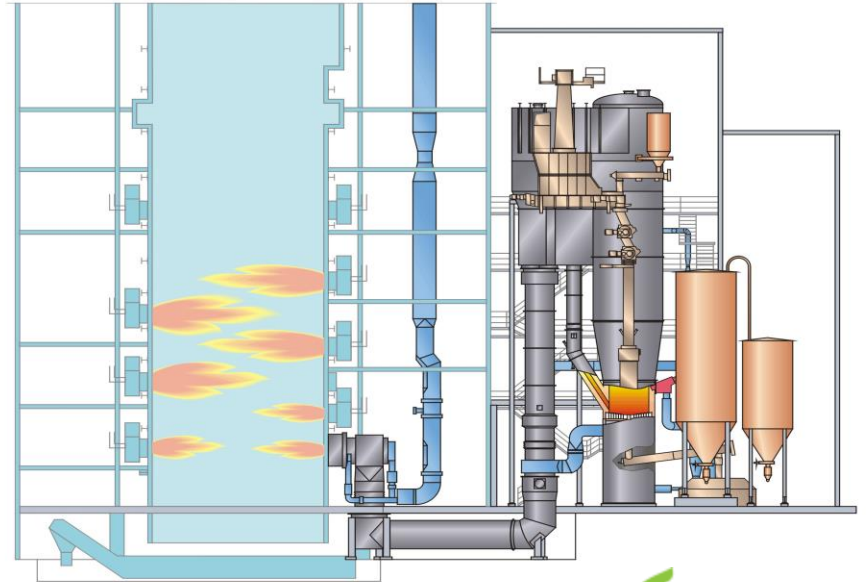
Funding possibilities and interested companies?

Lahti Energia bio-CLC demonstration plan

- In operation 1998-2019
- Nominal capacity 60 MW_{th}
- Fuels: previously SRF, demolition wood, wood waste (tested also tyres, dried sewage sludge, etc.); last years only clean wood
- CFB-gasifier planned to be bio-CLC fuel reactor
- Possibility to use also other existing infrastructure and fuel supply
- Heat generated to district heating

 FOSTER WHEELER

CFB BIOMASS GASIFIER
40 - 70 MW_{th}

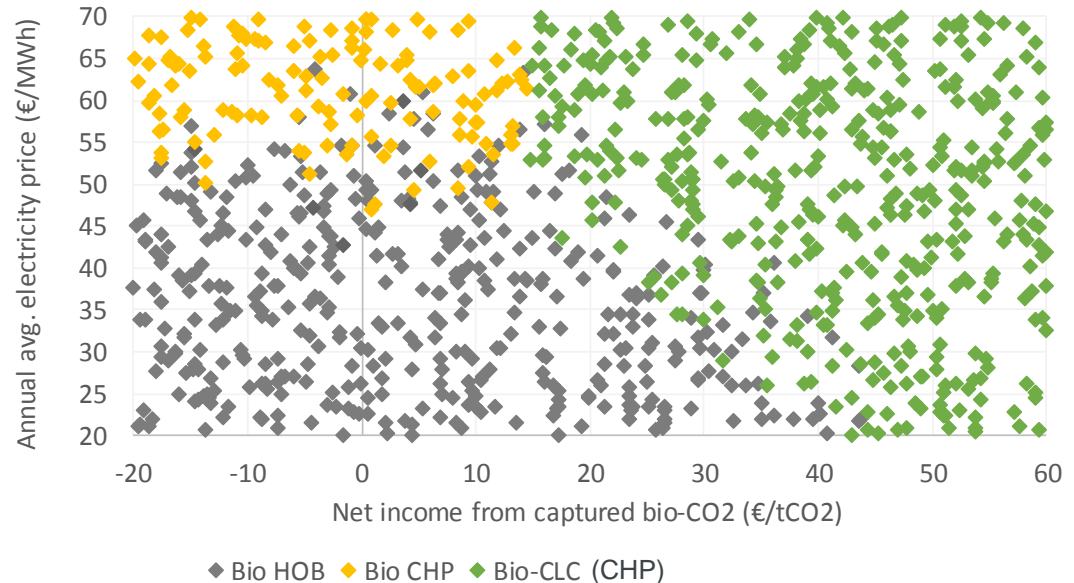


 LAHTI ENERGIA

Techno-economic analysis

Biomass CHP, heat only, or bio-CLC?

- Net-income from captured bio-CO₂ above 15€/tCO₂ could be enough for bio-CLC
- Electricity market price (current and expected) largely decides between CHP and heat only units
- Low electricity prices favor also large heat pumps



<https://www.sciencedirect.com/science/article/pii/S2213138818306520>

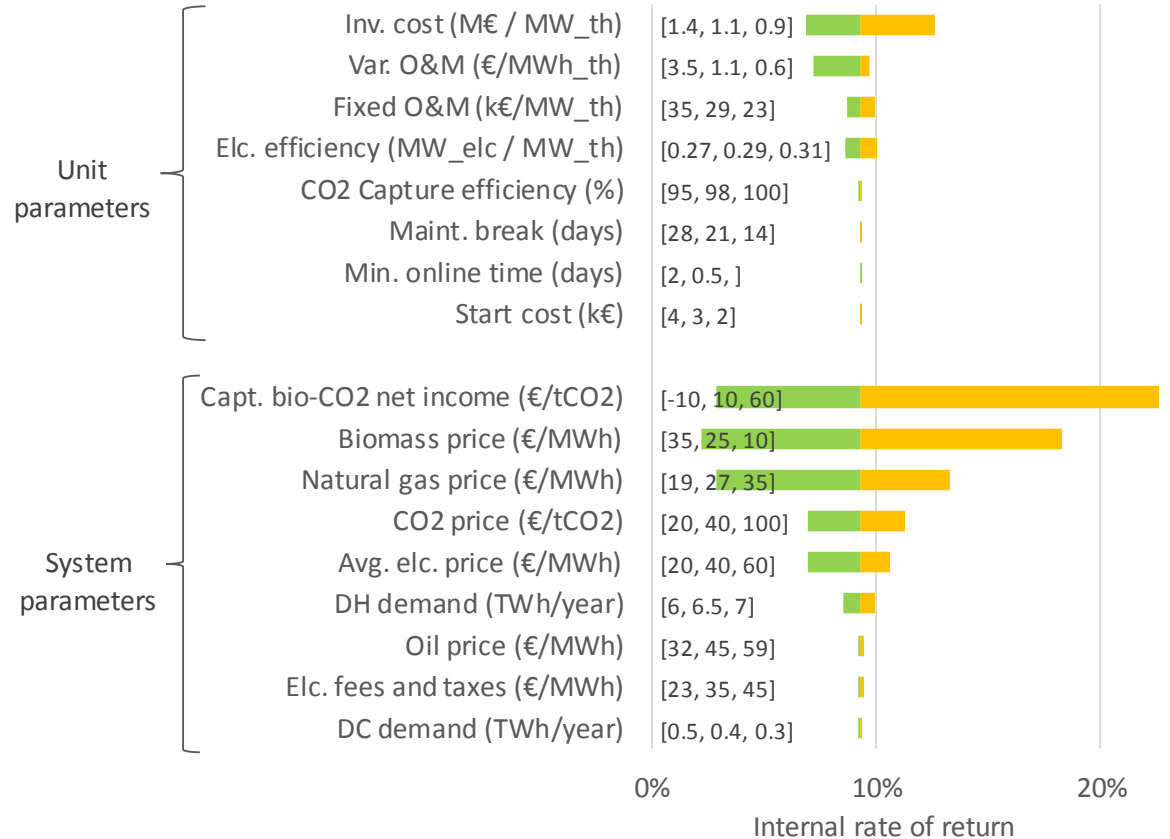


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What are the largest uncertainties?

- Case study modelled for the capital region of Finland.
- Local conditions will differ from a city to another





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