



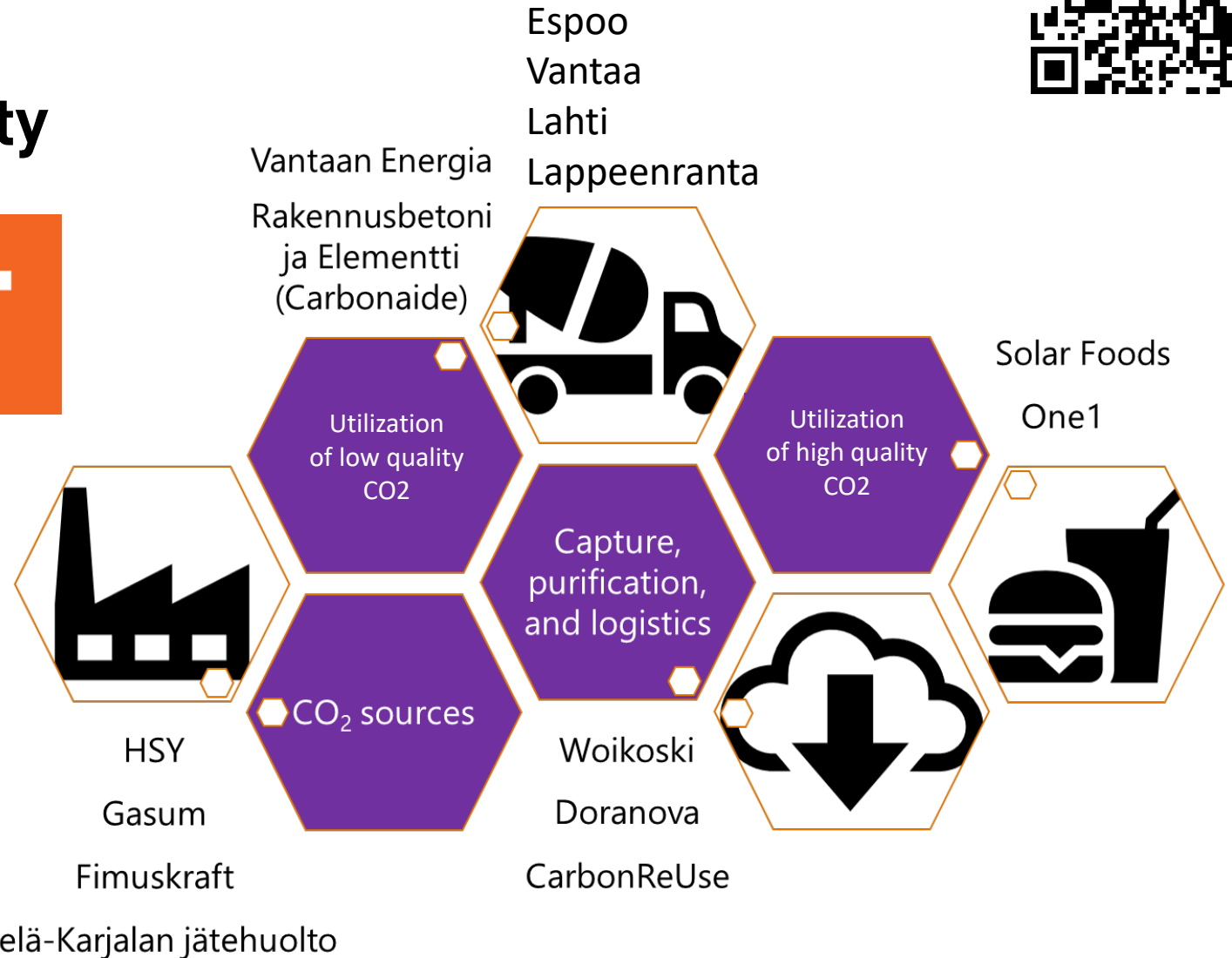
An Industrial Ecosystem for BioCO₂

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Content

- Biogenic CO₂-Value Chain
 - Sources
 - Capturing
 - Logistics
 - Applications
- Regional Synergies (example)
- Discussion and Conclusions

Biogenic CO₂ -Value Chain

- (1) Requires **partners** for every step
- (2) Not only **sustainable**, but also **profitable**

Sources

- Biogas Plants
- Flue Gases
- Food Industry
- Air

Capturing

- Pre-Combustion
- Post-Combustion
- DAC

Purification

- (Dehydration)
- Amine
- PSA
- C + Membrane
- Liquefaction

Logistics

- Trucks
- Trains
- Ships
- Pipes

Applications

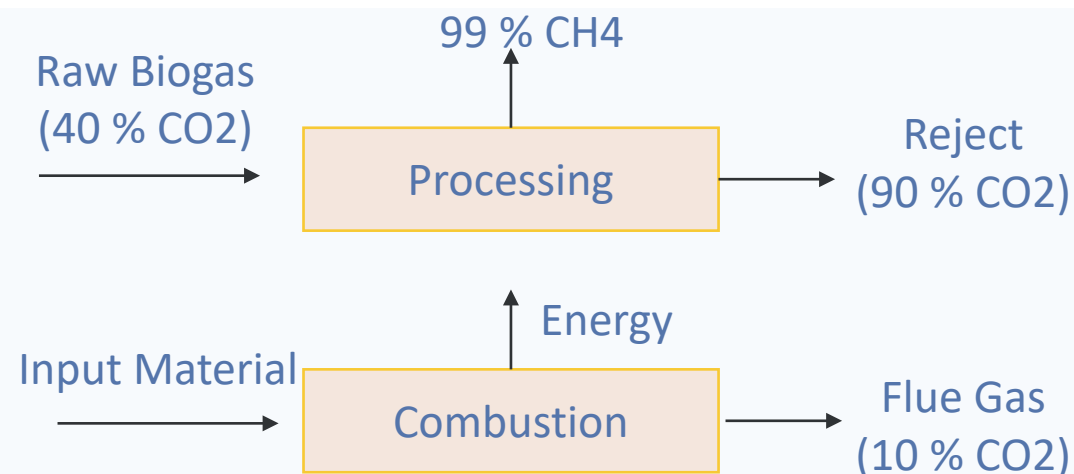
- Food grade
- Synthetic fuels
- Green houses
- Algae
- Mineralization

Sources

- ***Know your reject***
 - *CO₂ vol.-%*
 - *CO₂ volumes [kt/a]*
 - *Impurities*
- We measured 10 different industrial gas flows
 - *Biogas plants and flue gases*
 - *PSA, membranes, scrubbing etc.*
 - *Different input materials (bio, industrial etc.)*
- Impurity identification mainly by GC and FTIR
 - *Journal article under construction*

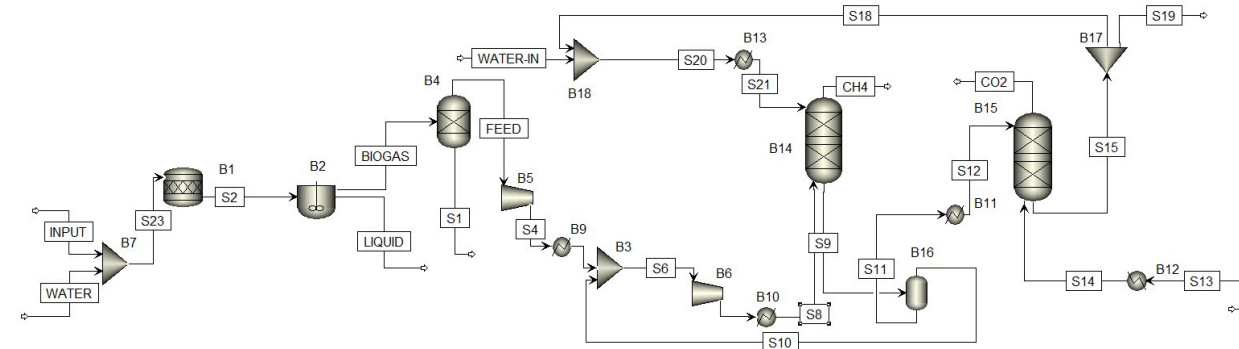


<https://www.biotalous.fi/hiilidioksidissa-kuplii-mahdollisuuksia/>



Capturing and Purification

- **99,9 % CO₂-concentration is NOT always required**
- To reach the standards, a lot of steps may be required (increasing the costs)
 - 660 €/tonne (>> 100 € / tonne)*
 - *Techno-economic analysis of integrated carbon capture and utilisation compared with carbon capture and utilisation with syngas production (2023)*
- **Difficult to find equipment providers**
- Aspen Plus® simulations to optimize the steps
 - *Journal article under construction*



Aspen Plus model example (LUT)

Some technology providers

- [Shell, Carbon Dioxide Purification Catalyst](#)
- [Lummus, Gas Conditioning & Treating / CO₂ Removal / Recovery](#)
- [Ratermann, CO₂ Purification System](#)
- [NORIT, CO₂ purification by activated carbon](#)
- [ReiCat, CATOX \(catalytic oxidation\)](#)
- [Bright, CO₂ purification and liquefaction](#)

Logistics

- Important questions:

(1) Pipe or bottle?

(2) Liquefaction or compression?

- ISO/TR 27921:

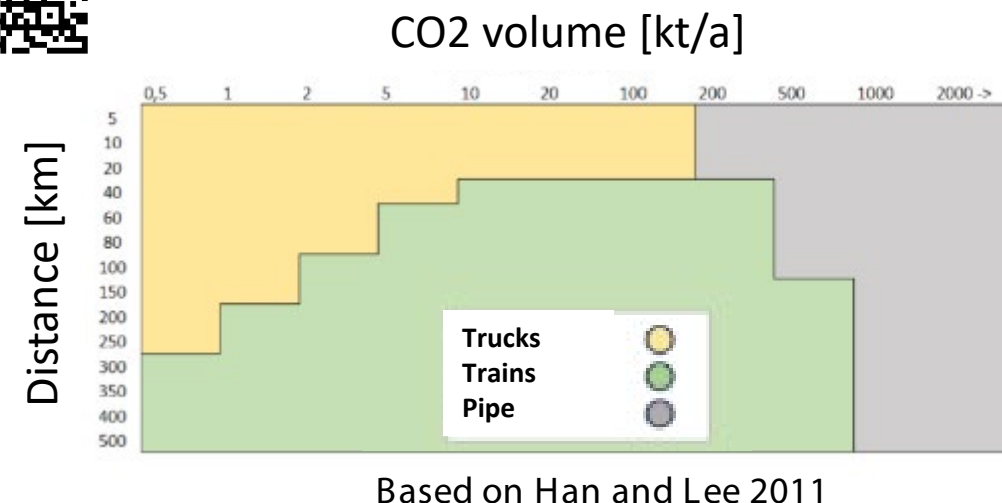
- *Carbon dioxide capture, transportation, and geological storage – Cross Cutting Issues – CO2 stream composition*

- In lit. research about monitoring

- *Performing quality assurance of carbon dioxide for carbon capture and storage*



<https://www.labopen.fi/lab-pro/kustannustehokkailla-co2-logistiikkaratkaisuilla-kohti-hiilineutraaliutta/>



Liquefaction or compression

	Liquefaction	Compression
Investment	~ 5 M€	~ 1 M€
Density [norm.]	10	1
Purification benefit	Yes	No



<https://www.labopen.fi/lab-rdi-journal/paastovahennyksia-jalisaarvoa-tuotteille-hiilidioksidin-hyotykaytolla/>

Applications

- **CCU is more than synthetic fuels**
- **Low-CO2 standards missing**
 - EIGA70 (Food grade)
 - ISBT (Brewery)
 - European Pharmacopoeia
- **Consider the following**
 - *Purity grade*
 - *TRL level*
 - *Uptake and other ingredients*
 - *Environmental aspects*
 - *Locality*

CO2-Applications (TRL 9)		Example companies
Food industry	Drinks (carbonic acid)	Hartwall
	Decaffeination	Kahvikaveri
	Protein	Solar Foods
	Dry ice blasting	Woikoski
Building materials	Concrete curing	Carbonaide
	Filling substrates	Carbon8
Chemicals	Refrigerants	Woikoski
	Salicylic acid	
	Urea	Yara
Plastics	Polycarbonate	Asahi Kasei
	Polypropylene carbonate (PPC)	Norner
	Polycarbonate polyol	Covestro*
Fuels	Methanol	George Olah (CRI)
	Methane	Q Power
Other	Green houses	Many
	Supercritical solvent	Nanoform
	Water pH-adjustment	Linde

Regional Synergies

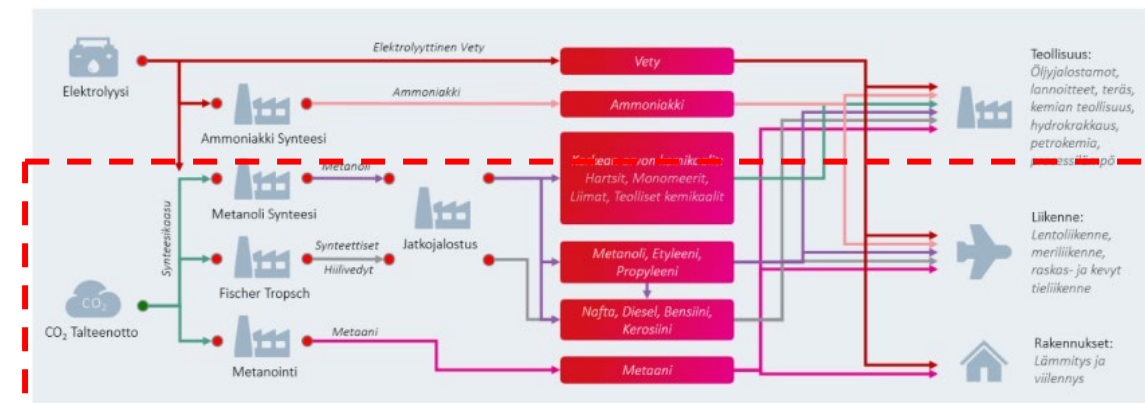
- Benchmarking areas containing both sources and usage
- Example from Lahti (Kujala)
- Benefits
 - Short distances
 - Potential for value chains



Discussion and Conclusions

- In Finland, ***lack of storages*** and ***huge bioCO2-point sources*** provoke establishing CCU-value chains
- **Time for action is now:** *lack of legislation* and *technology providers* are clear preventing forces to overcome
- **Money talks:** CO2 price trends, supply and demand contracts, investments, Emission Trade System (ETS)...
- **Regionality:** integrated solutions and CO2 clusters living together with H2 clusters?

Energian siirtoverkot vetytalouden
ja puhtaan energiajärjestelmän
mahdollistajina (11/2023)



Thank You!

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