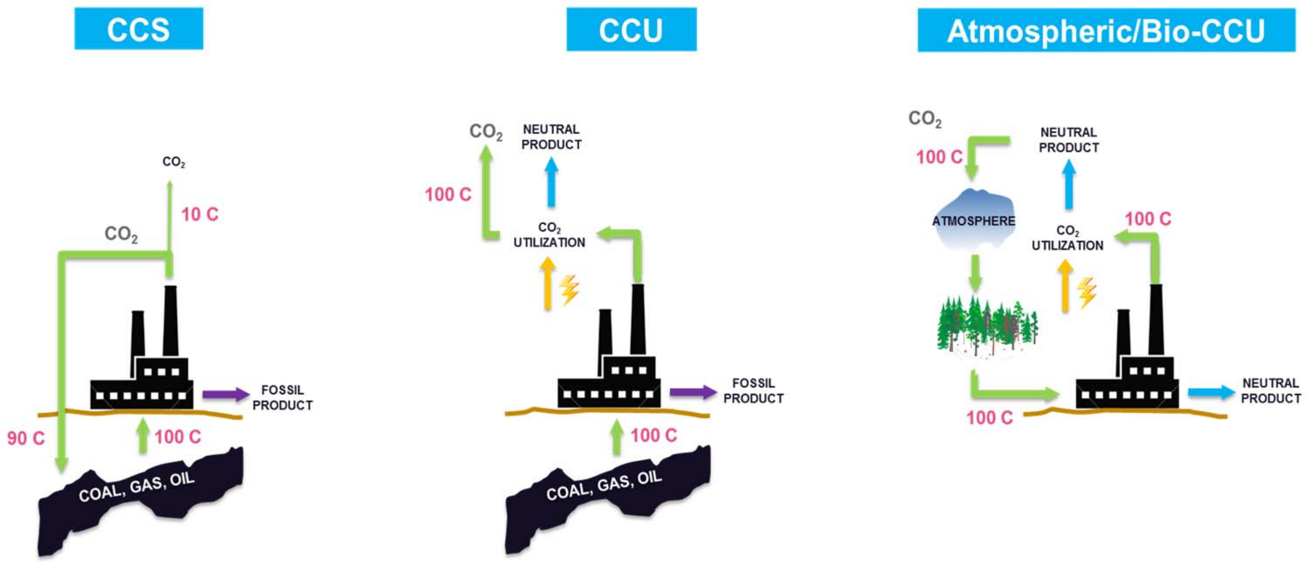
Ovatko CCU ja hiilen uusiotalous osa ratkaisua?

Hiilitieto ry:n talviseminaari

22.3.2018

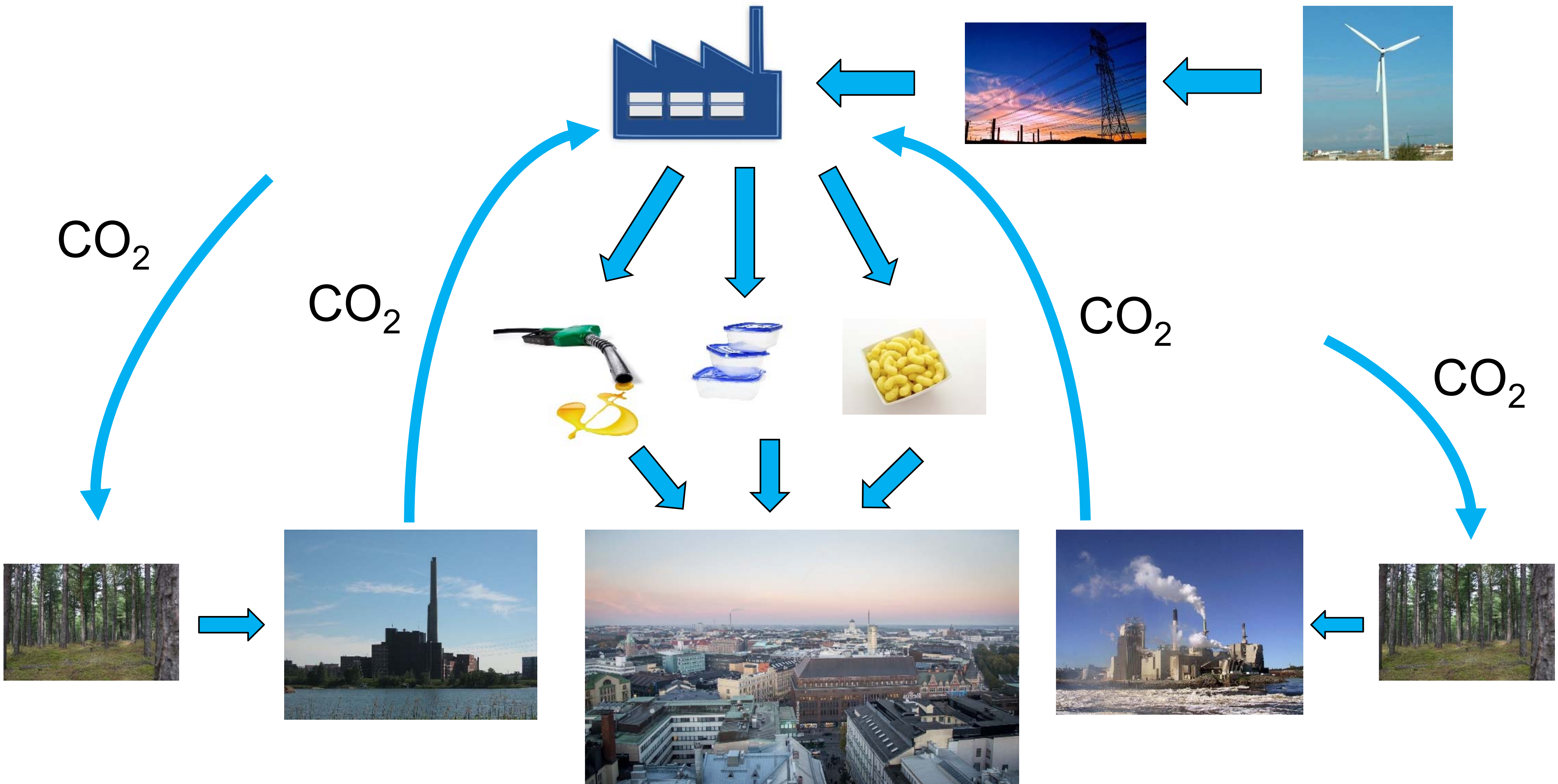
Tutkimusprofessori Juha Lehtonen

CCU vs. CCS



- In CCS CO_2 is captured before release to the atmosphere and permanently stored in underground geological formations
  - CCS in connection with utilization of biomass or direct CO_2 air capture can offer negative emissions
- In CCU, the captured CO_2 is utilized as a source of carbon for the production of energy carriers, chemicals or materials
  - At its best, CCU can be carbon neutral

Carbon Reuse Economy



VTT Carbon Reuse Economy

VTT Mobile Fischer-Tropsch synthesis unit

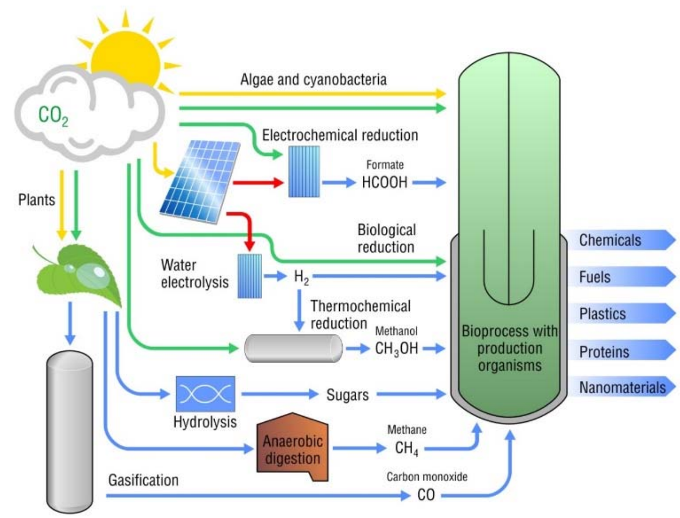
CO_2 utilization by catalytic and chemical routes

Microbial conversion of C1 compounds

Sustainable chemicals, fuels and materials without fossil resources

VTT competence

- Biotechnical upgrading
- Catalytic upgrading
- Thermochemical processes
- Energy systems
- Modelling
- Piloting facilities

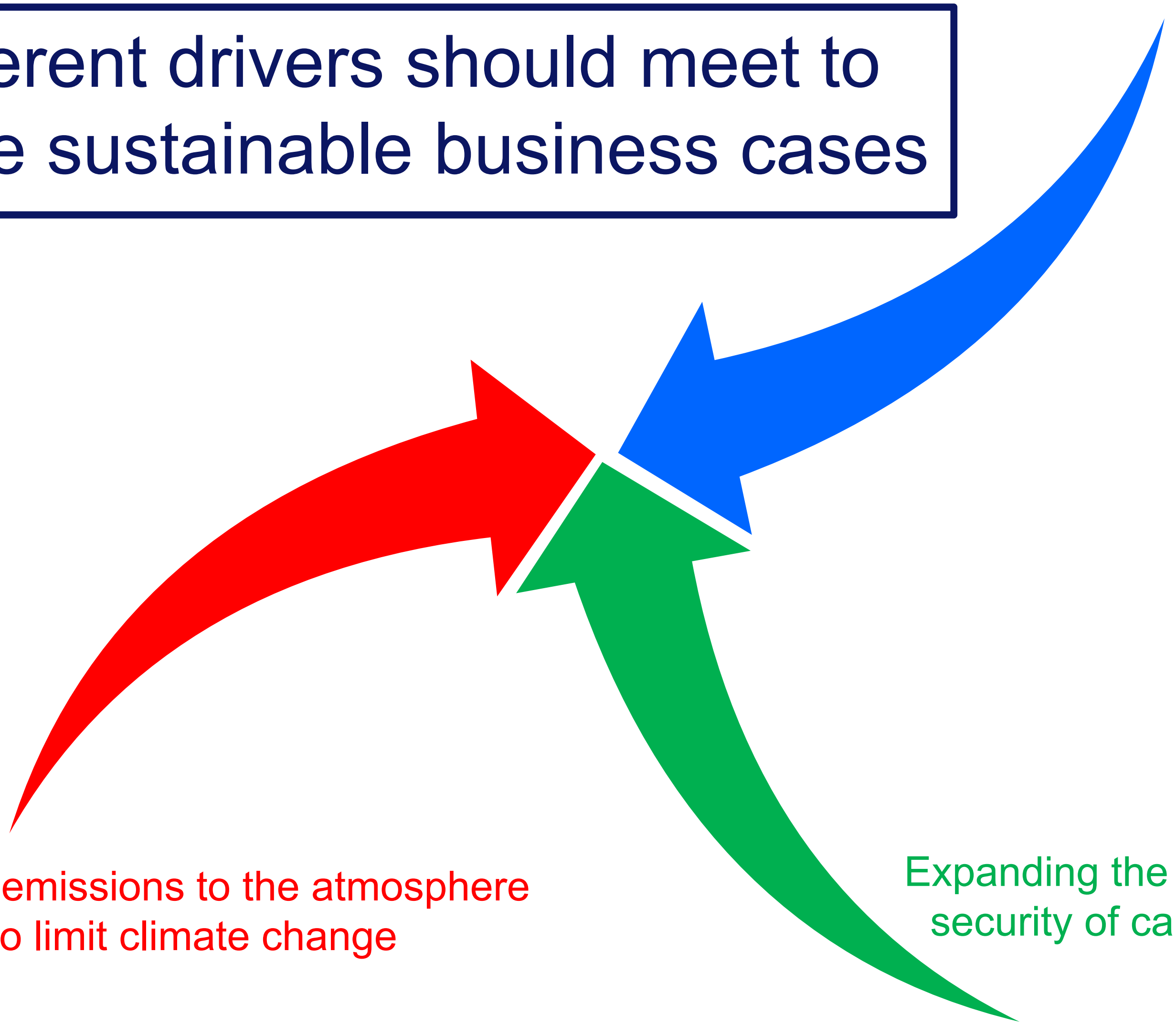


VTT biotechnical C1 utilization routes

VTT view on CCU

Different drivers should meet to create sustainable business cases

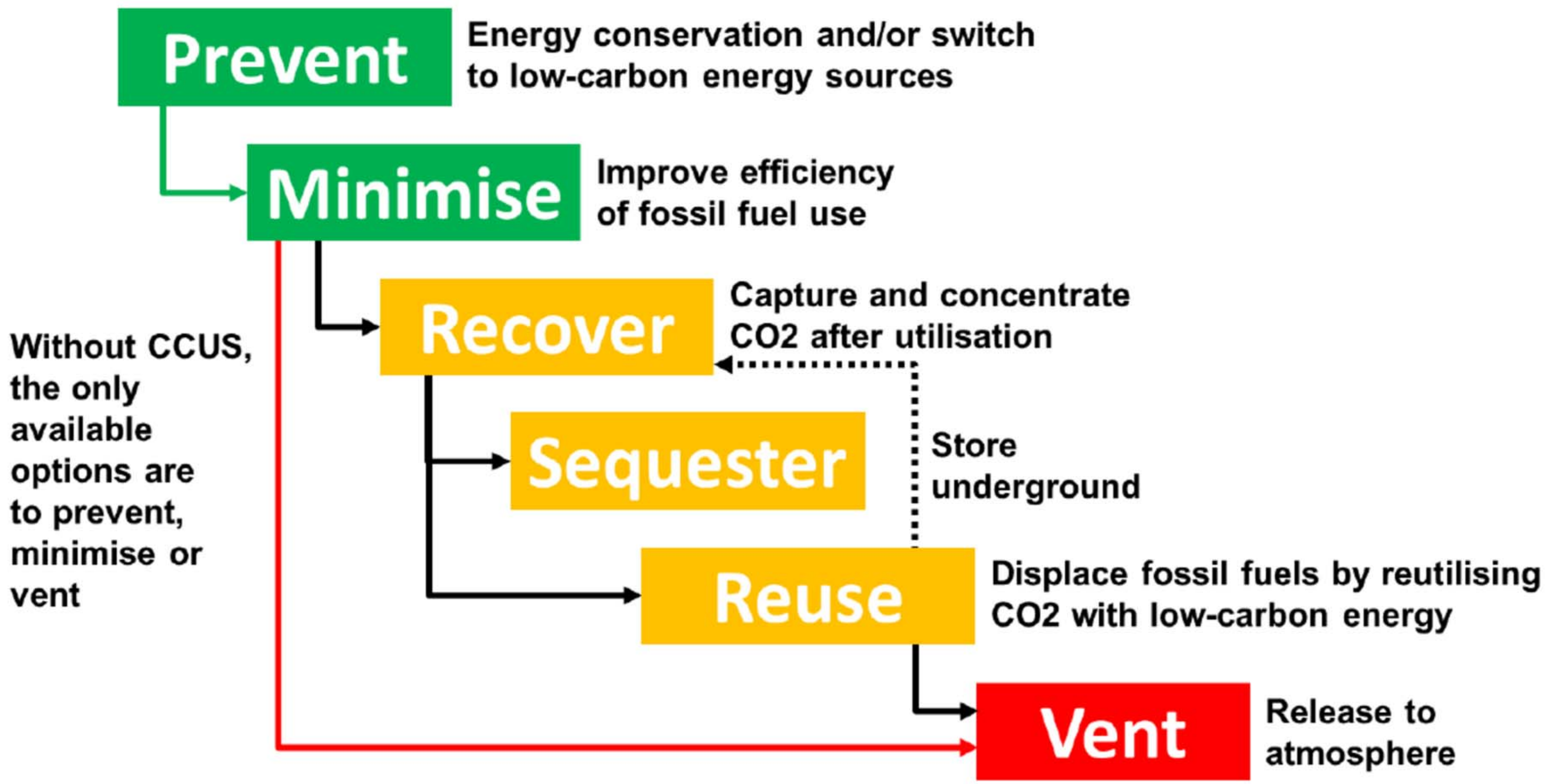
The potential for new business



Decreasing CO_2 emissions to the atmosphere in order to limit climate change

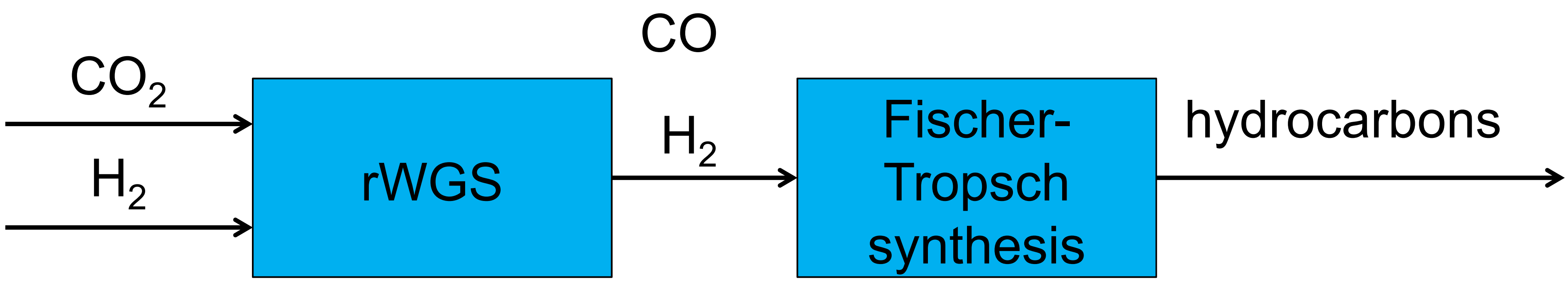
Expanding the resource basis and energy security of carbon dependent industries

CCUS hierarchy



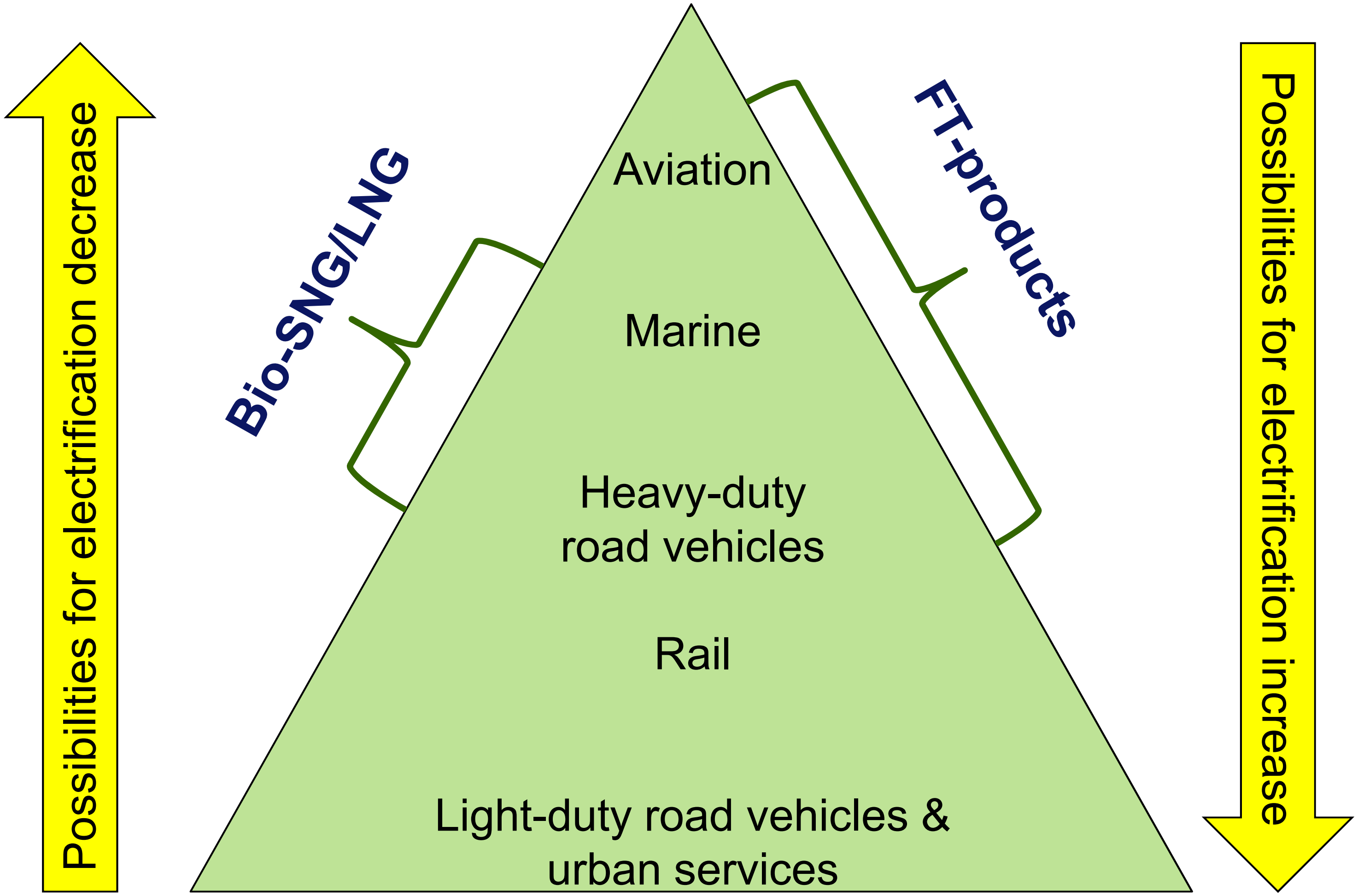
Hannula, I. and Reiner, D.M. (2017) The race to solve the sustainable transport problem via carbon-neutral synthetic fuels and battery electric vehicles. Energy Policy Research Group EPRG, University of Cambridge. EPRG Working Paper 1721. Cambridge Working Paper in Economics 1758.

Hydrocarbon fuels from carbon dioxide



rWGS = reverse Water-Gas Shift reaction

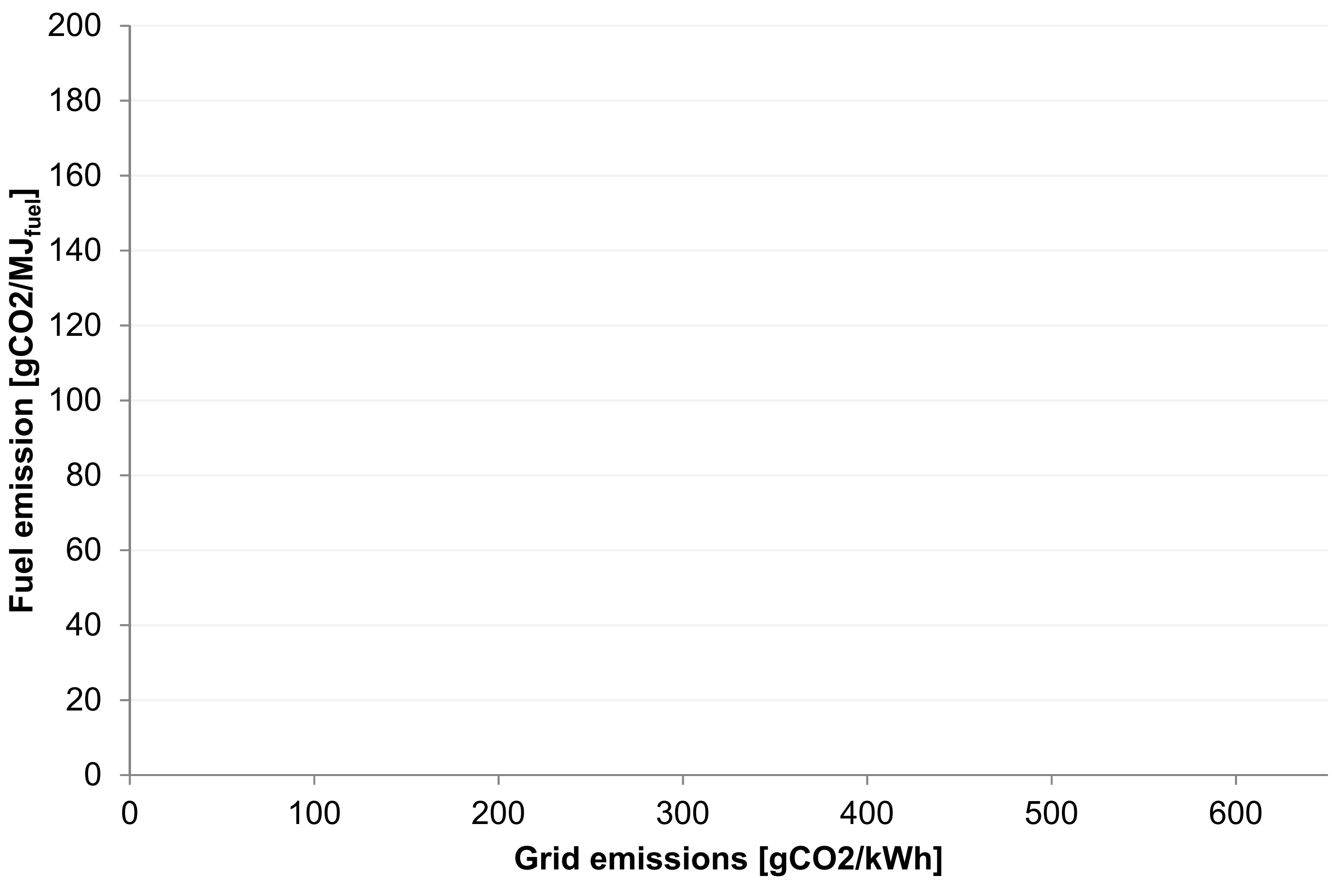
Hierarchy of propulsion options



Ministry of Transport and Communications

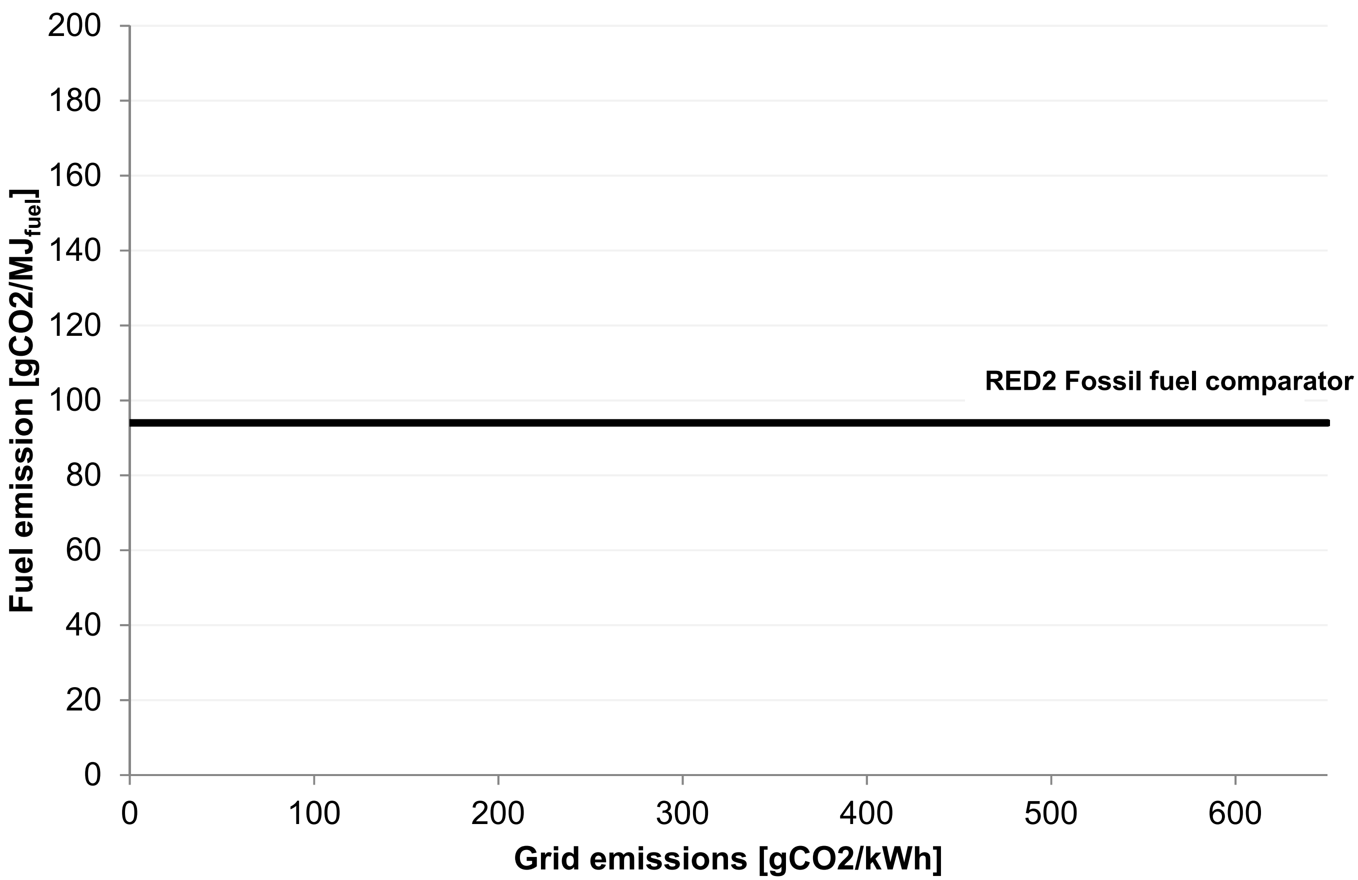
Source: Nils-Olof Nylund, IMECHE Future Fuels 2016.

GHG balances for CCU-fuels



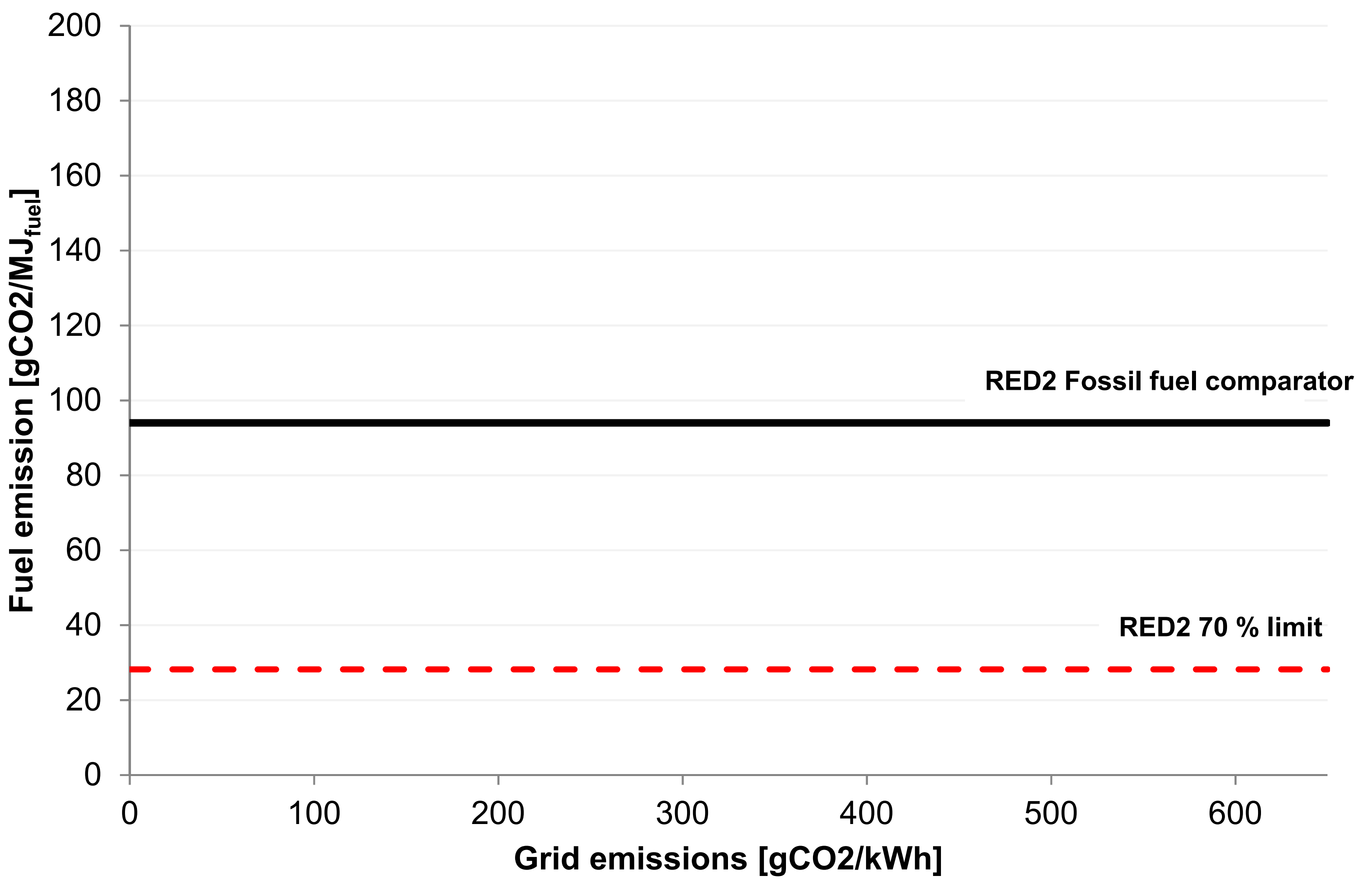
Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

GHG balances for CCU-fuels



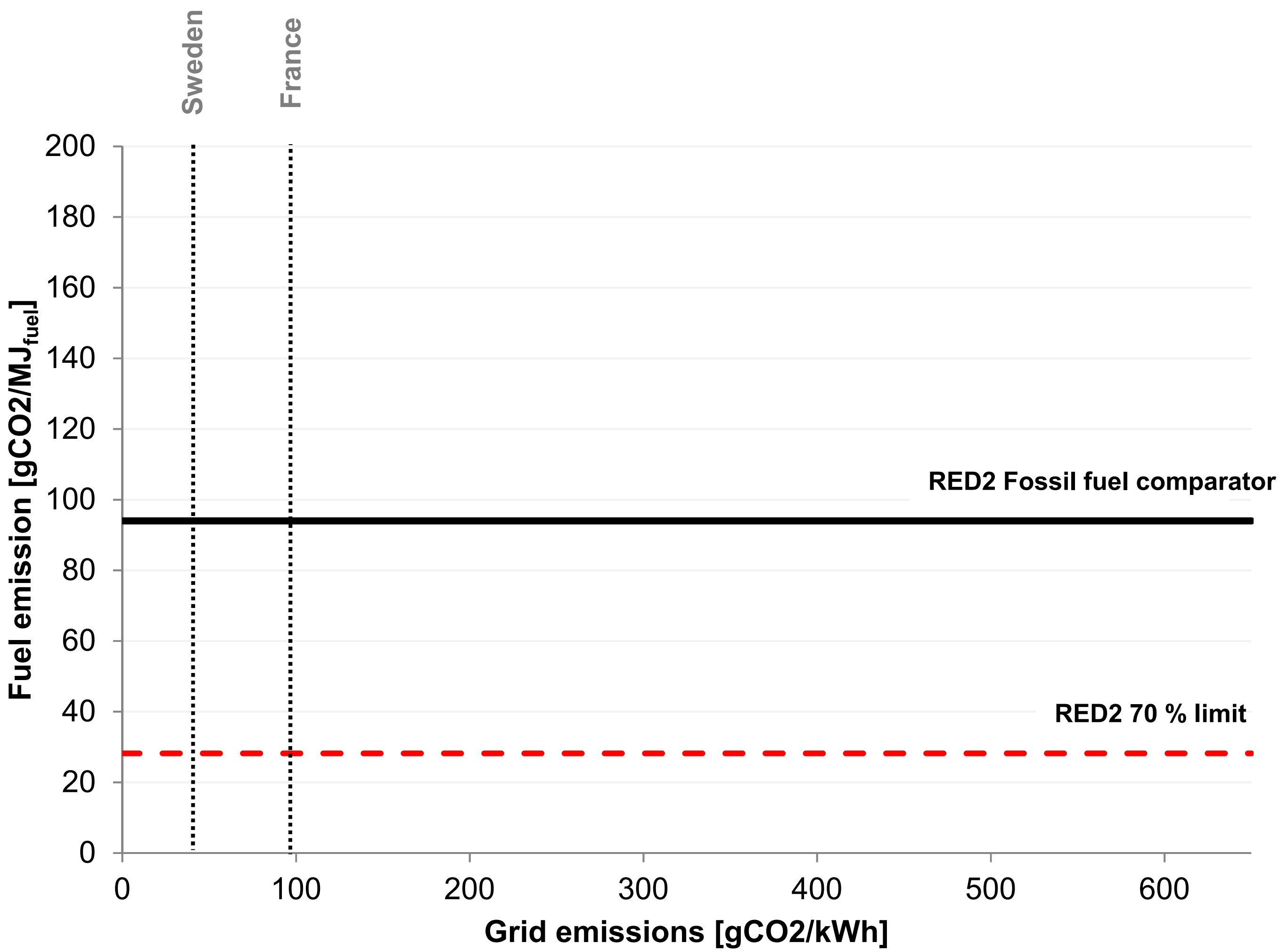
Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

GHG balances for CCU-fuels



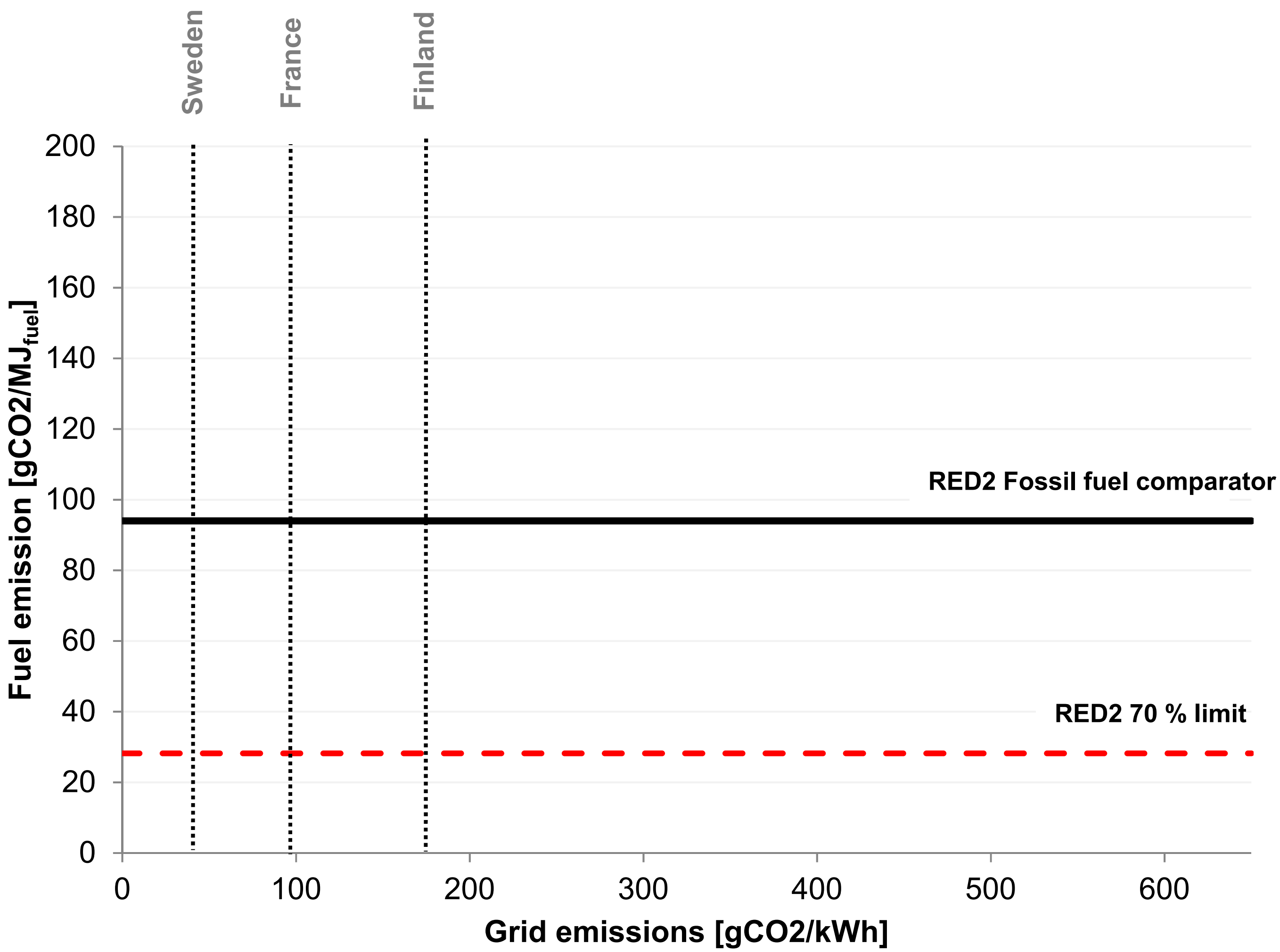
Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

GHG balances for CCU-fuels



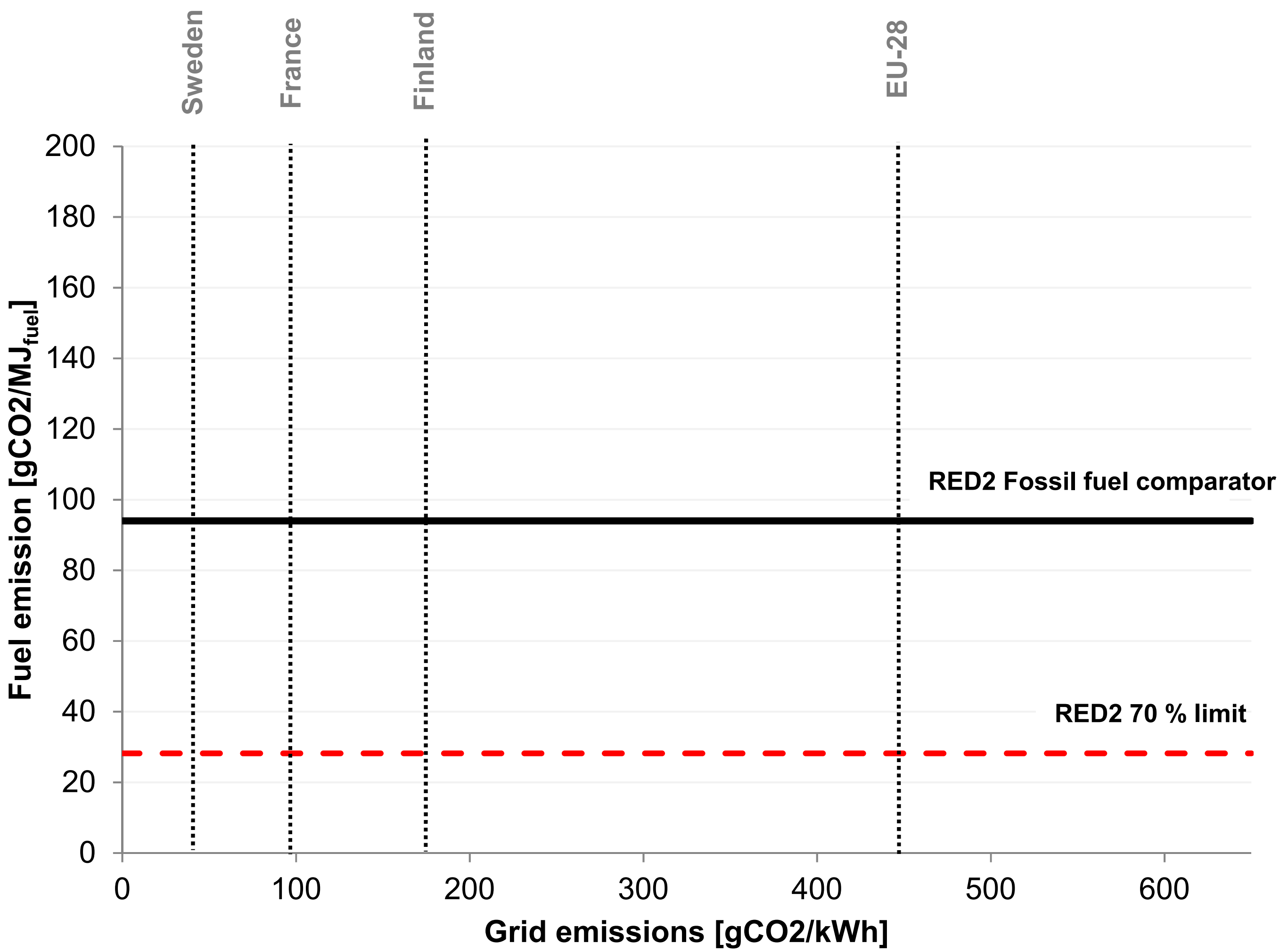
Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

GHG balances for CCU-fuels



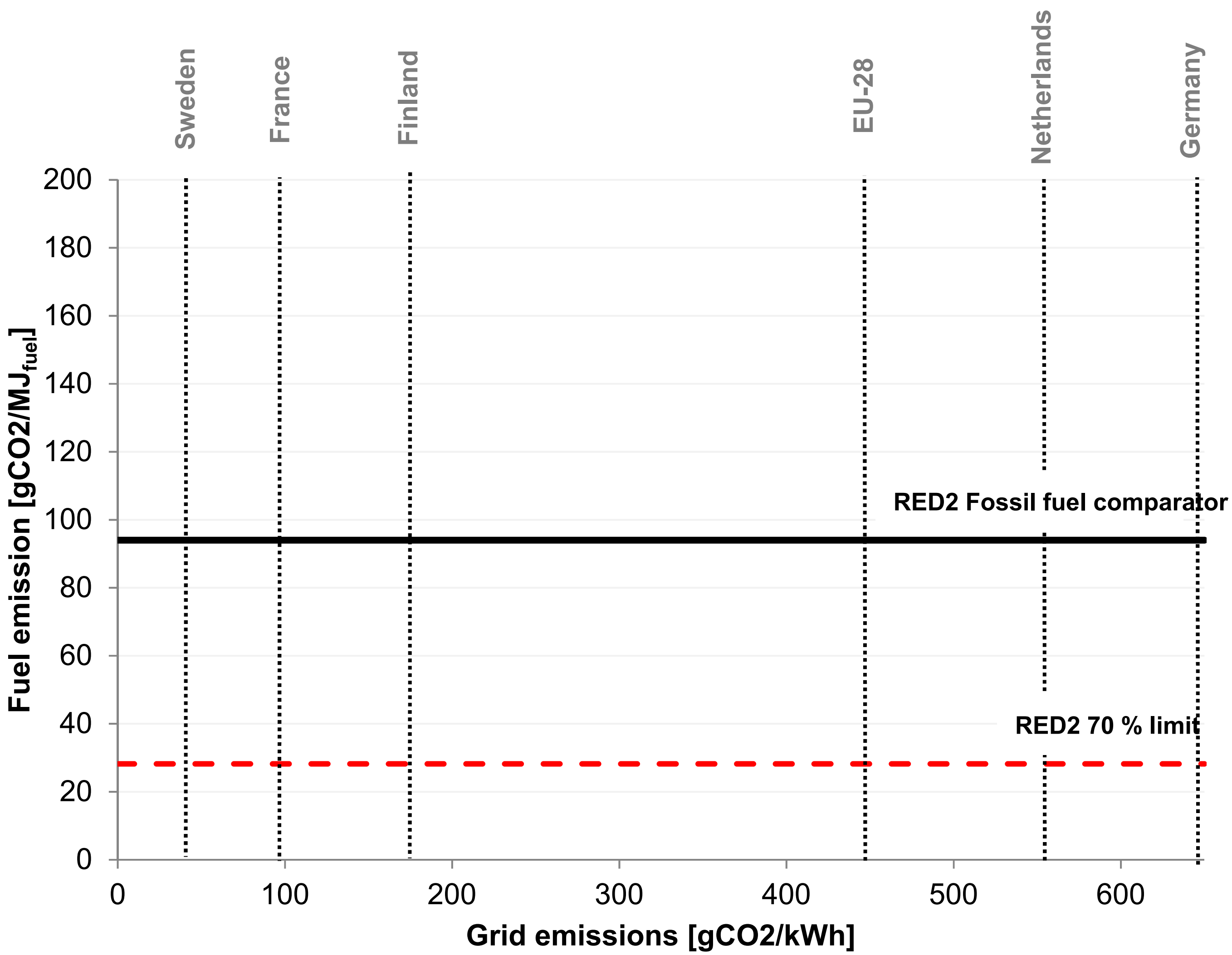
Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

GHG balances for CCU-fuels



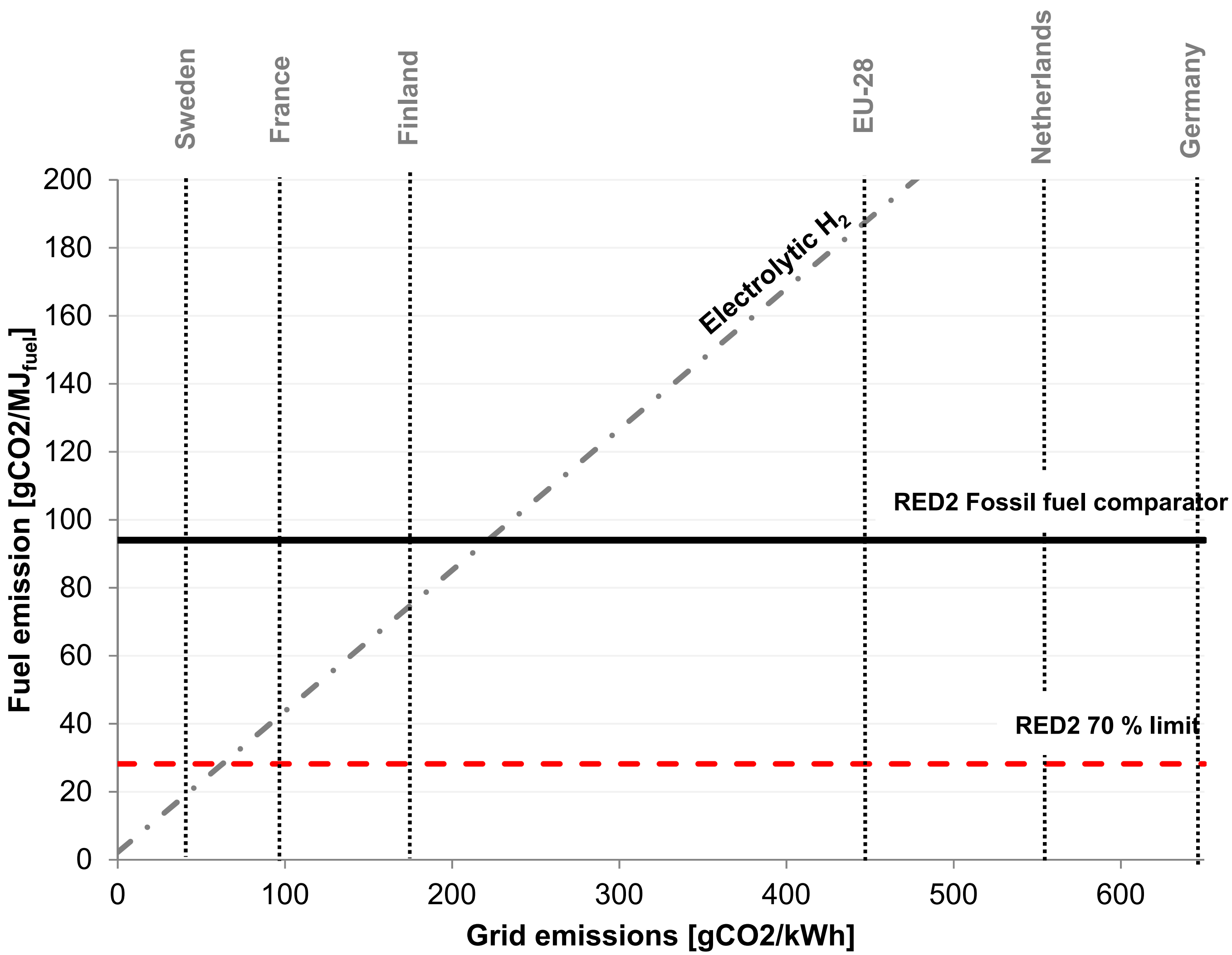
Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

GHG balances for CCU-fuels



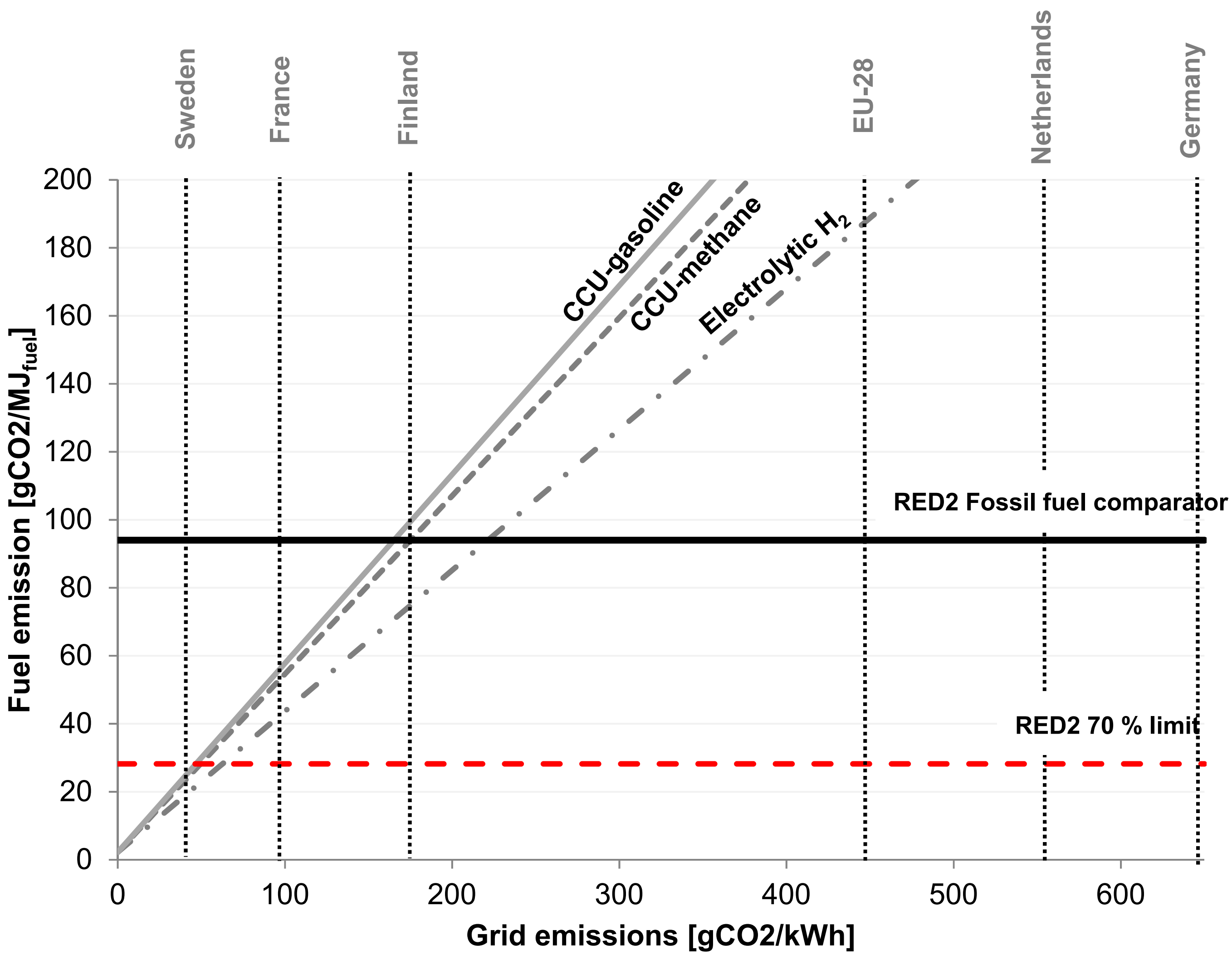
Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

GHG balances for CCU-fuels



Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

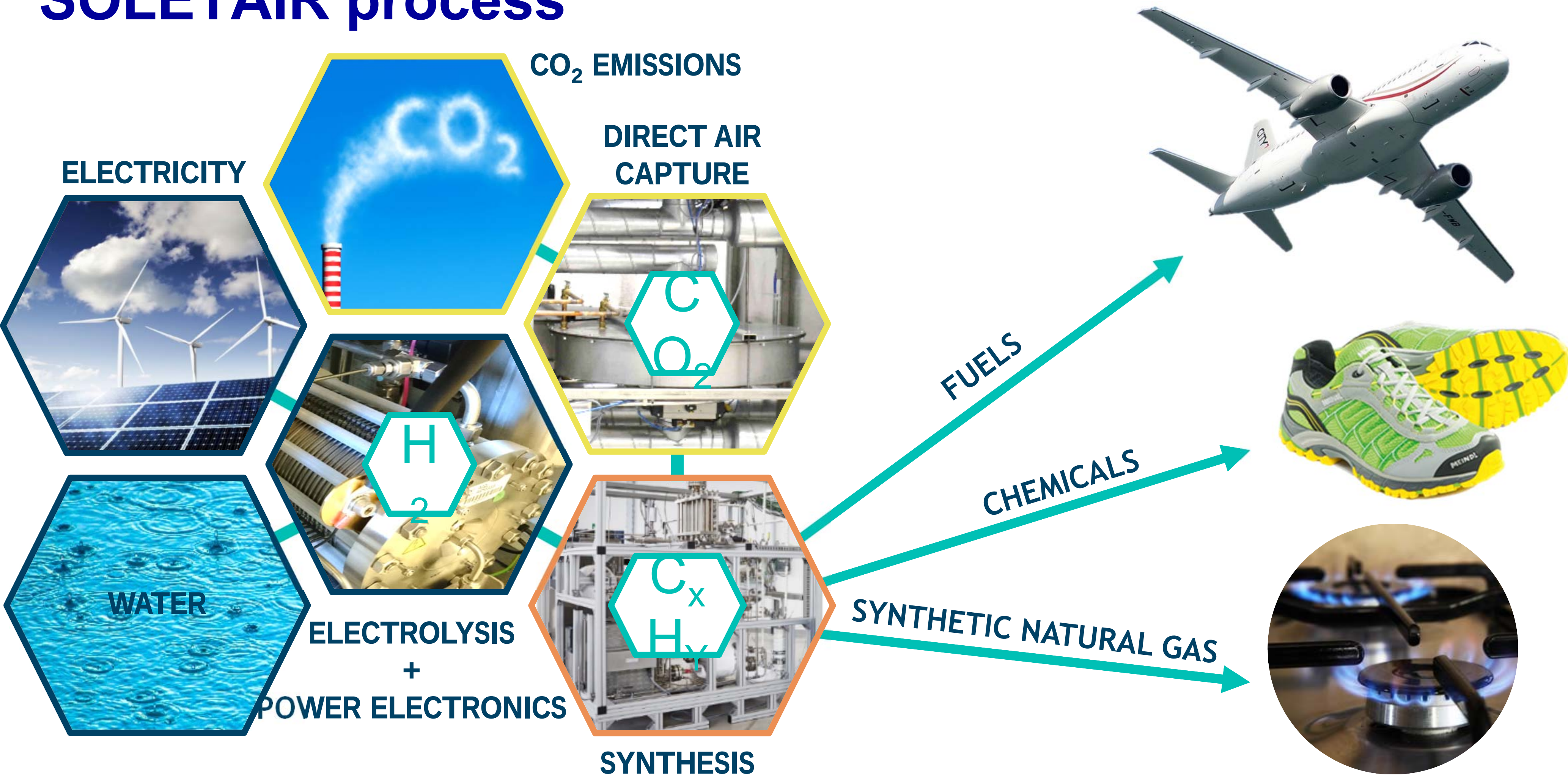
GHG balances for CCU-fuels



Source: Koponen, Hannula, *GHG emission balances and prospects of hydrogen enhanced synthetic biofuels from solid biomass in the European context*, Applied Energy, Volume 200, 15 August 2017, Pages 106-118, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2017.05.014.

Soletair, polttoaineita ilmasta ja vedestä

SOLETAIR process



Main objectives

- To **integrate** all individual components together.
- To learn how the concept can be realized in a feasible way.
- To learn what kind of business possibilities lie in the PtX concept.

The target KPI's of the project are

- Energy efficiency from power to gas 60 %
- Total nominal investment cost of the PtG unit < 1,2 €/We or < 2 €/W SNG

SOLETAIR pilot in LUT campus

All units are inside containers > Fully transferable

Operated in the showcase mode May – September, 2017

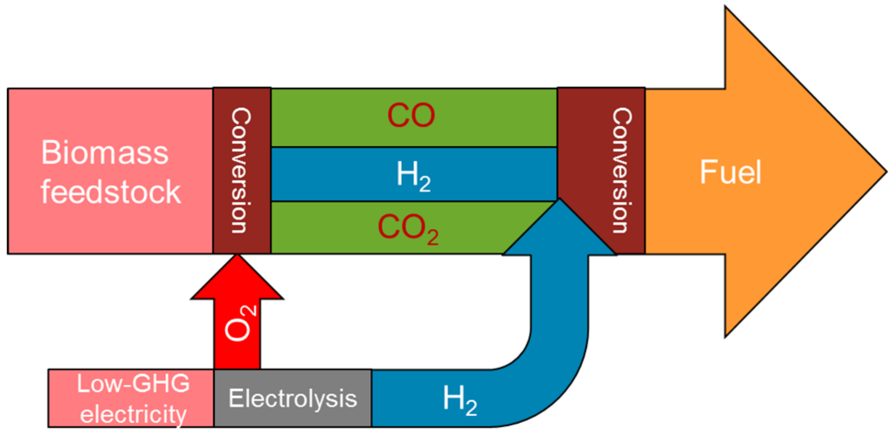
DAC

ELECTROLYSIS

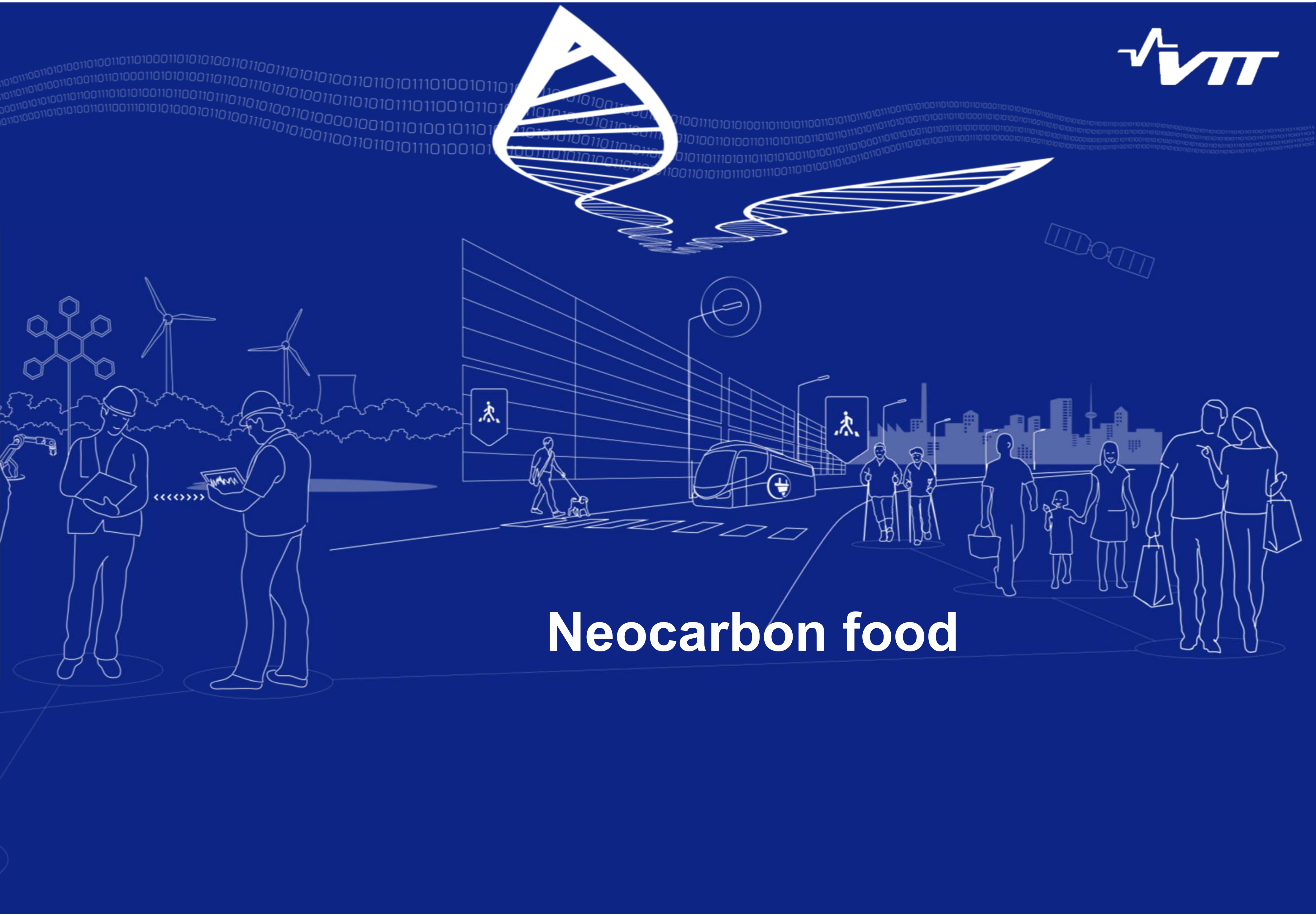
SYNTHESIS

Synteettisiä polttoaineita vetybuustauksella

Hydrogen enhanced synthetic biofuels - More than twofold increase in biofuel output



- CC(U)S can have a role in processes relying on thermochemical conversion in future, such as industrial heat production, chemicals recovery, BTL and BTX
- If all sustainably available wastes and residues in the EU were collected and converted only to biofuels, using maximal hydrogen enhancement, the daily production would amount to 1.8 - 2.8 million oil equivalent barrels displacing up to 41 - 63 per cent of the EU's road transport fuel demand in 2030.
- Economically attractive over non-enhanced designs when the average cost of low-GHG hydrogen falls below 2.2-2.8 €/kg, depending on the process configuration



Neocarbon food


Why Neo-Carbon Food

1. One fifth of human caused greenhouse gas emissions is connected to food production.
2. World population 7.5 → 9 billion by 2050.
3. Climate change and draughts reduce food yields. Global over fishing: peak annual catch in 1996.

Minimal requirements for protein production

Electricity

CO_2

Water

Minerals

Microorganisms

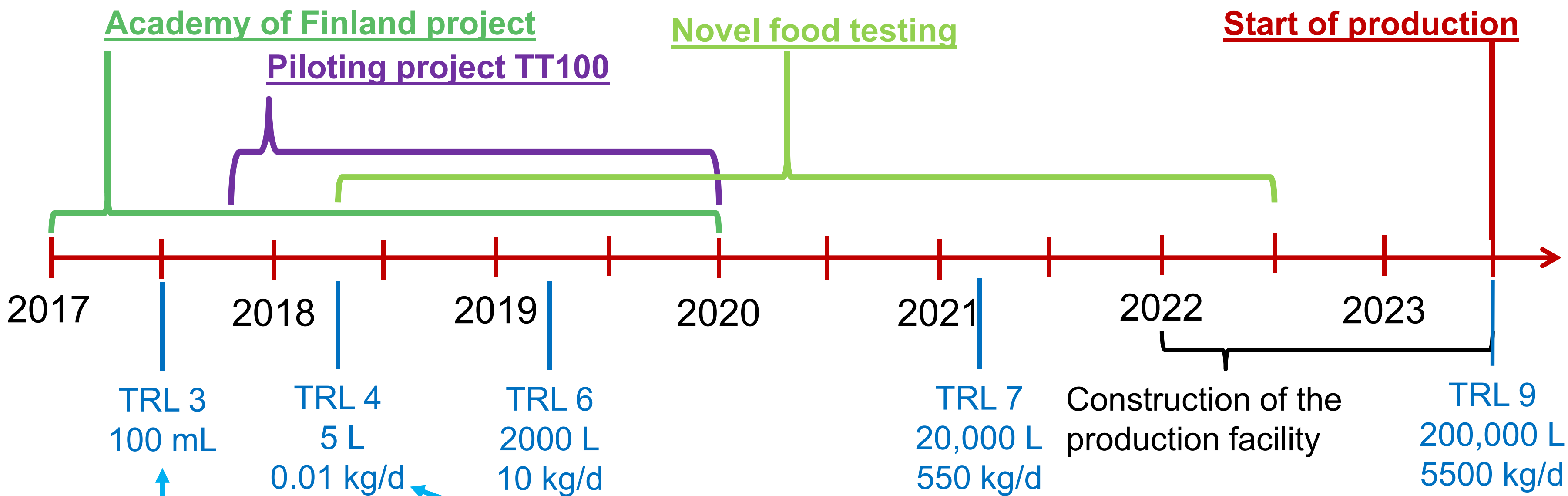
Food & Feed

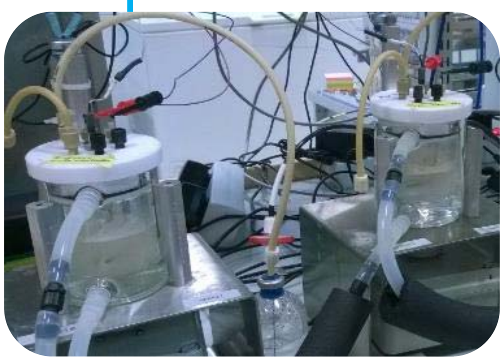
Protein produced with microorganisms is called single-cell protein; SCP.

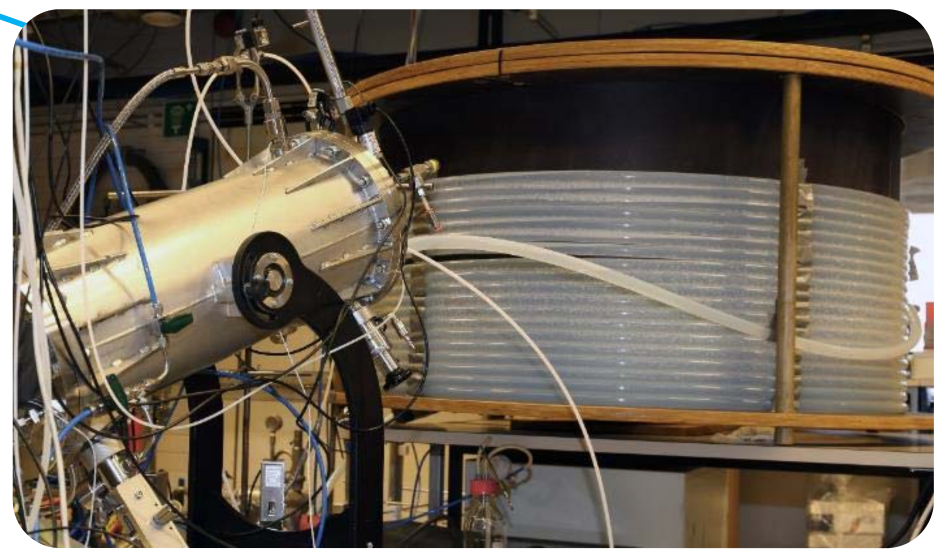
”Algae” Spirulina and *Chlorella* are produced using direct sunlight.

Mycoprotein Quorn is produced from sugar using a *Fusarium* fungus. Produced in closed bioreactors.

Indicative development roadmap







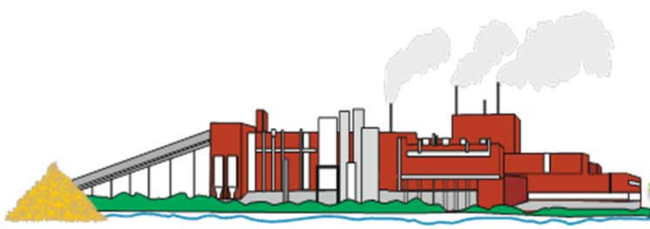
CCUS ja metsäteollisuus

There is a constant progress in the forest industries to increase positive GHG effect

- Carbon efficiency of processes is increasing
  - More efficient use of side-streams like lignin
  - Modern pulp mill is carbon neutral and over self-sufficient in energy
- Expanding product lifecycle, e.g. pulp into structural products
- Production of fuels and chemicals to replace fossil-based products in co-operation with other industries
- Technological development towards novel fractionation technologies to replace current pulping processes in the future

- Reforestation (increases carbon stocks in forests and secures future raw material supply)

Steps to negative emissions in forest industry



PHASE I – Base case
$1.3\ t\ CO_2/t$ pulp

Average pulp mill

PHASE II – Fossil free mill
$0.5\ t\ CO_2/t$ pulp

- Replacing fossil energy with renewable energy
- Electricity-based transportation
- More efficient chemicals use

PHASE III – Maximum material yield
$-0.4\ t\ CO_2/t$ pulp

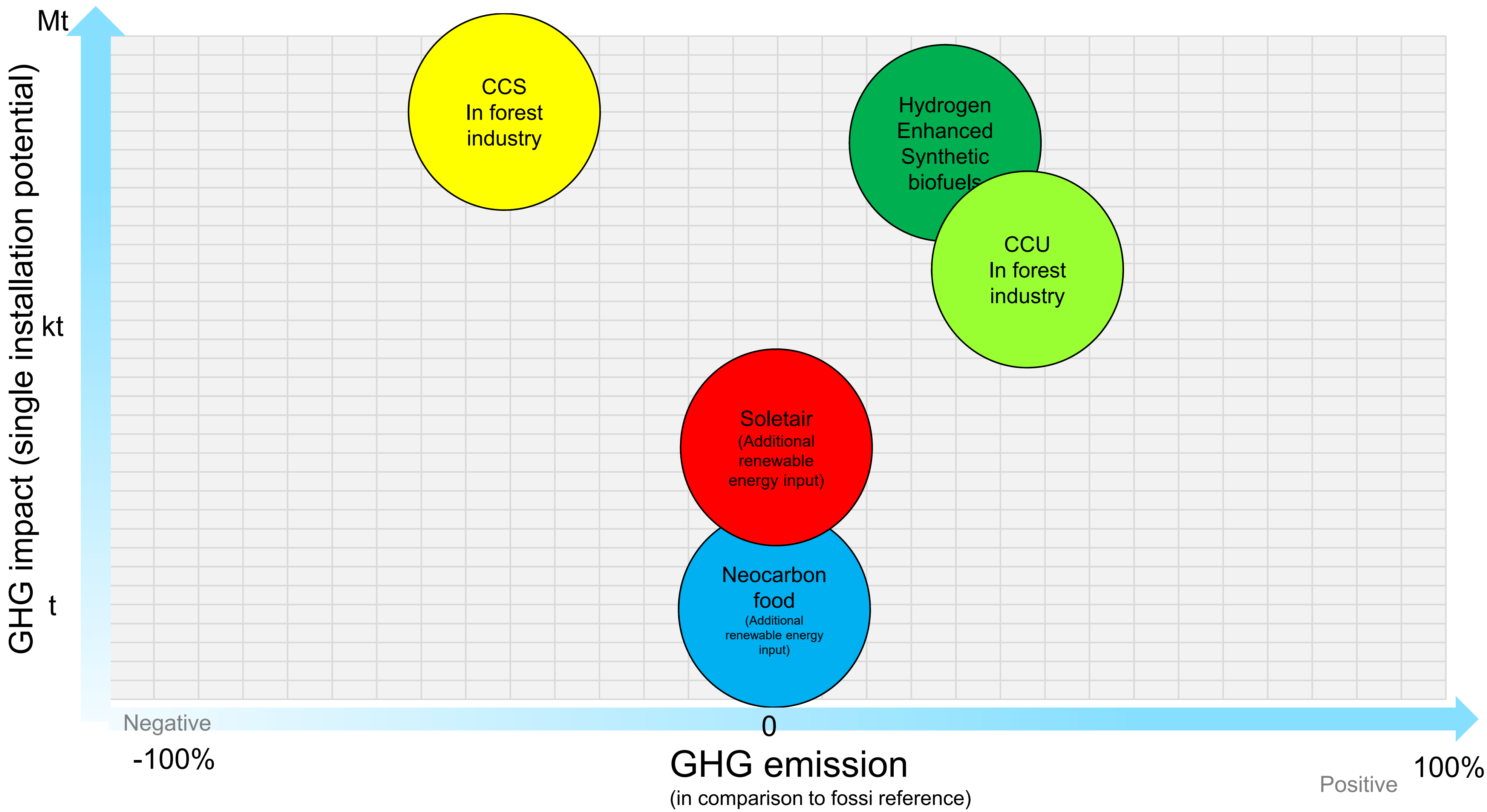
- Intensify use of raw material (increase carbon yield)
- Replacing materials (e.g. plastics)

PHASE IV – Bio-CCS
$-0.5\ t\ CO_2/t$ pulp

- Carbon capture and storage of remaining CO_2 emissions

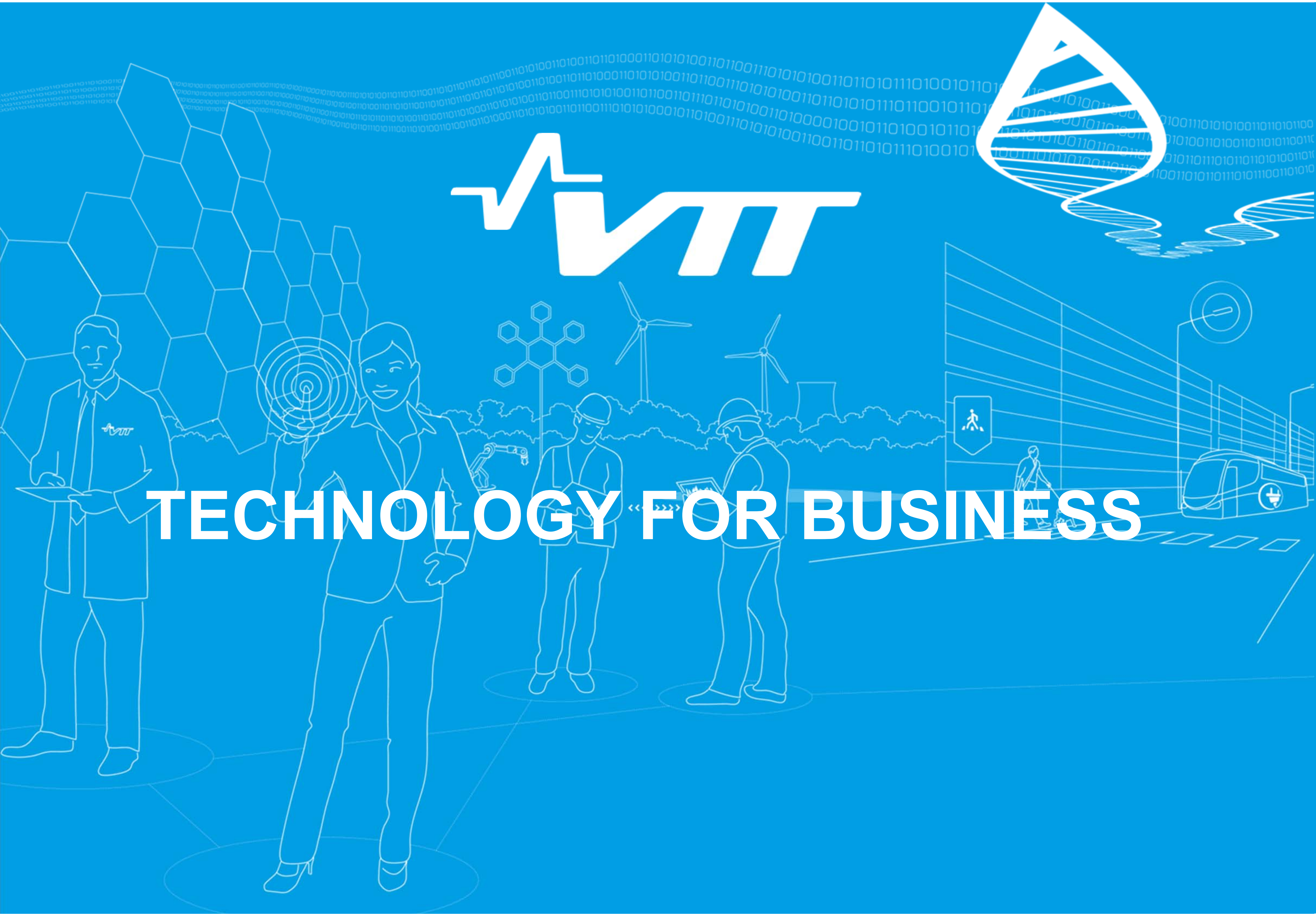
Summary

GHG impact of presented cases



Conclusions

- Different drivers of CCUS have to meet in order to create sustainable business
- Impact mechanisms of CCS and CCU on climate change mitigation are different
- By bio-CC(U)S, negative emissions can be reached
- There is a constant progress in the forest industry to become carbon neutral
- Business cases with near zero or even negative emissions can be established already now


TECHNOLOGY FOR BUSINESS