



Doubling the climate benefit by combining biomass with CCS

**Carbon Capture and Storage Program final
results seminar**

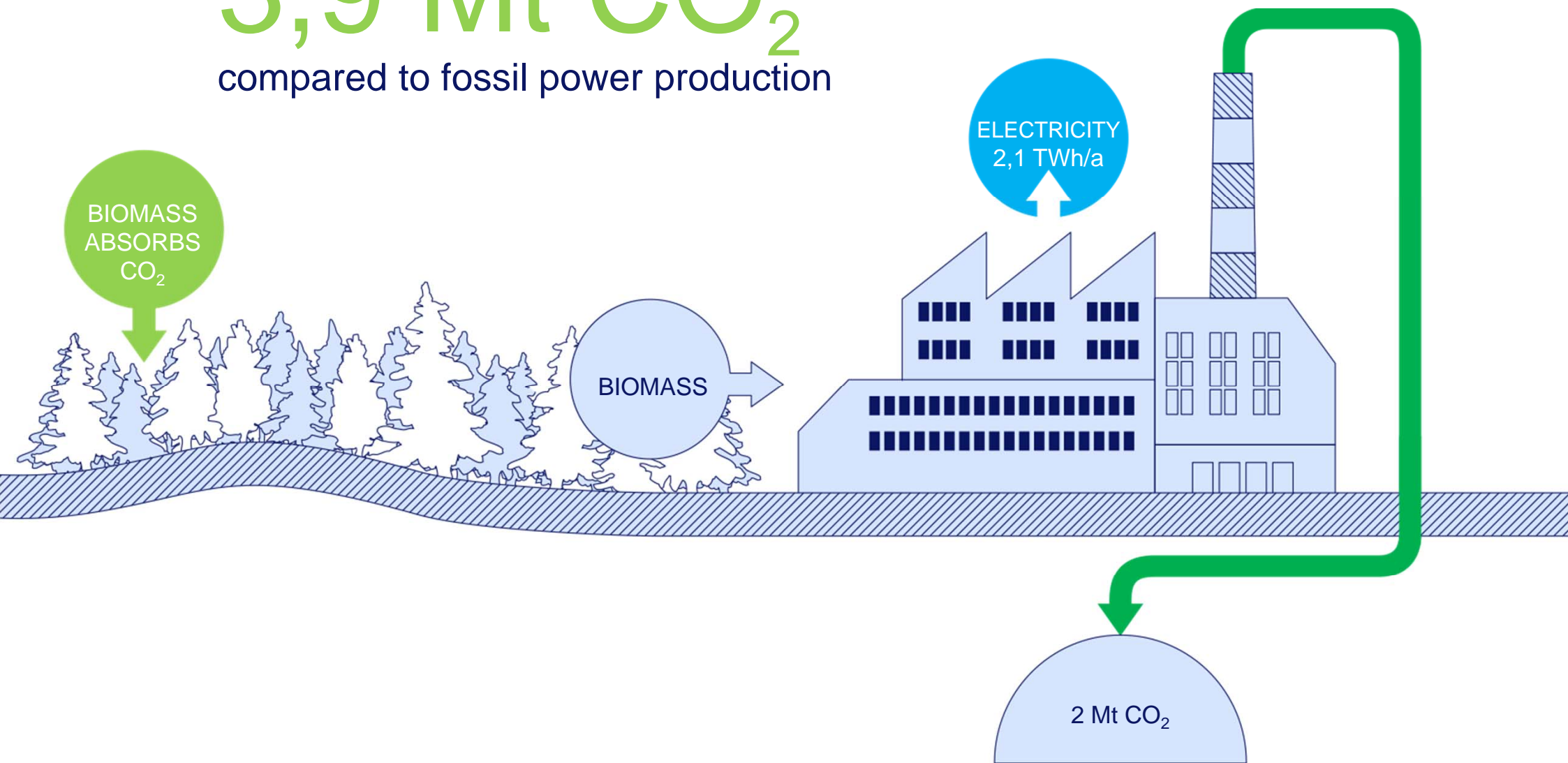
Antti Arasto

13.10.2016

Bio-CCS is a systemic issue more than technical

The beauty of Bio-CCS and negative emissions is the ability to offset emissions over sectors and time

A REDUCTION OF 3,9 Mt CO₂ compared to fossil power production



Magnitude of issues at hand

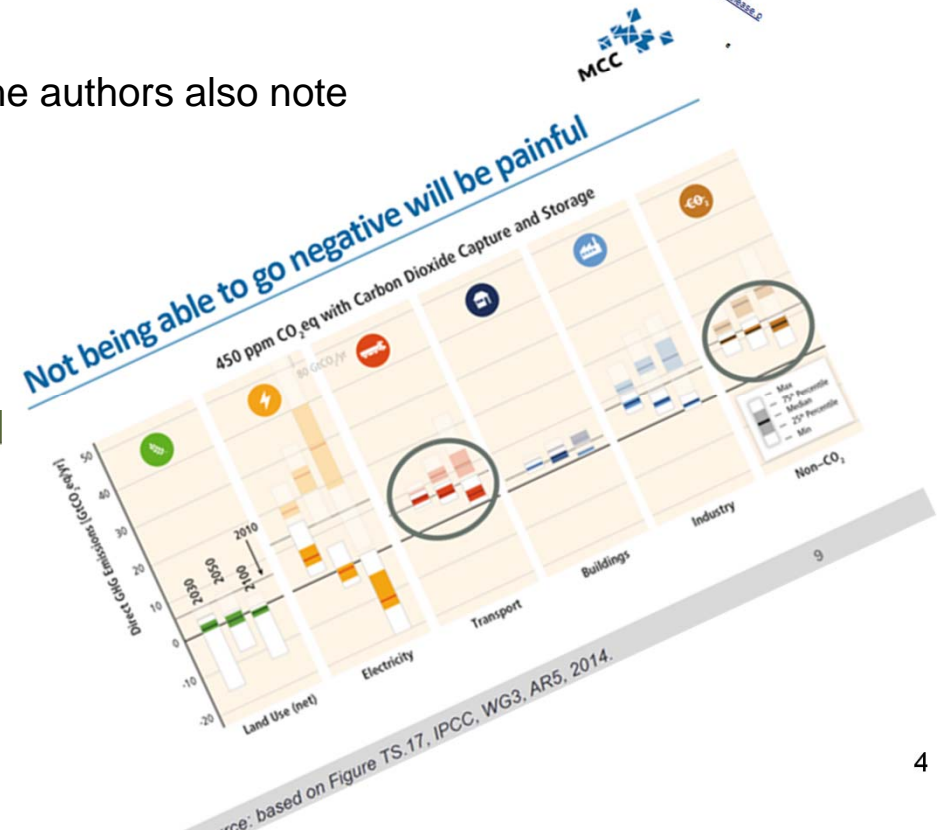
- IPCC Working Group III reports that these **negative emissions technologies** (also called CDR—Carbon Dioxide Removing—technologies”) could enable removal of **10 Gt** a year from the atmosphere by **2050**, and perhaps 40 Gt a year by the end of century. To have a >50% chance of limiting warming below 2 °C, most recent scenarios from integrated assessment models (IAMs) require large-scale deployment of negative emissions technologies (NETs). These are technologies that result in the net removal of greenhouse gases from the atmosphere [Smith et al. 2015]
- UNEP Emissions Gap Report finds potential in BioCCS: The authors also note that “BioCCS technology would be a necessity in later-action scenarios and in 1.5 degree Celsius scenarios due to the need for steeper and deeper GHG emission cuts after 2020/2030.”
http://www.unep.org/publications/ebooks/emissionsgapreport2013/portals/50188/emissionsgapreport_pressrelease.pdf

European Climate Policy Roadmap 2050 → 85% GHG reduction cannot be met without CCS and complimentary Bio-CCS

Urgency in the IPCC Fifth Assessment Report calls for solutions that can remove CO₂ from the atmosphere

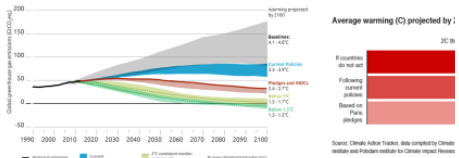
In the **Nordic Energy Technology perspectives** IEA states the following about Bio-CCS potentials in the Nordic countries alone: “In the long term, CCS seems to be the most important single technology to reduce industrial CO₂ emissions. It would become particularly important if future policies were to include BECCS as an option to reduce greenhouse gases.” http://www.iea.org/media/etp/etp_nordic.pdf

UNEP Emissions Gap Report finds potential in Bio-CCS: The authors also note that Bio-CCS technology would be a necessity in later-action scenarios and in 1.5 degree Celsius scenarios due to the need for steeper and deeper GHG emission cuts after 2020/2030.” http://www.unep.org/publications/ebooks/emissionsgapreport2013/portals/50188/emissionsgapreport_pressrelease.pdf

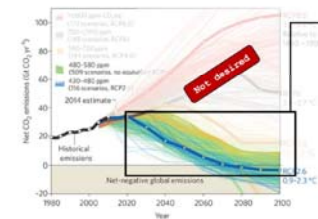


After the Paris agreement the target is “CO₂ - neutral” society

- CO₂ removal technologies such as BECCS (Bio-Energy Carbon Capture and Storage) becoming essential for achieving the 2 °C target¹
- CCS and bioenergy as the two most valuable technologies for achieving cli objectives – more important than energy efficiency improvements, nuclear, and wind power – motivated by their combined ability to produce very significant emissions via BECCS²



ETH zürich Climate Role of BECCS



- Scenarios with $\Delta T < 2^\circ\text{C}$ above preindustrial level mostly rely on BECCS
- Marginal abatement costs substantially lower with BECCS in the long run

1. In the scenario of 1.5°C global average temperature increase, BECCS is essential for achieving the target. BECCS is essential for achieving the target in all scenarios that are consistent with the 1.5°C target. BECCS is essential for achieving the target in all scenarios that are consistent with the 1.5°C target. BECCS is essential for achieving the target in all scenarios that are consistent with the 1.5°C target.

2. Climate Change 2014: Impacts, Adaptation, and Resilience Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 2014. Cambridge University Press.

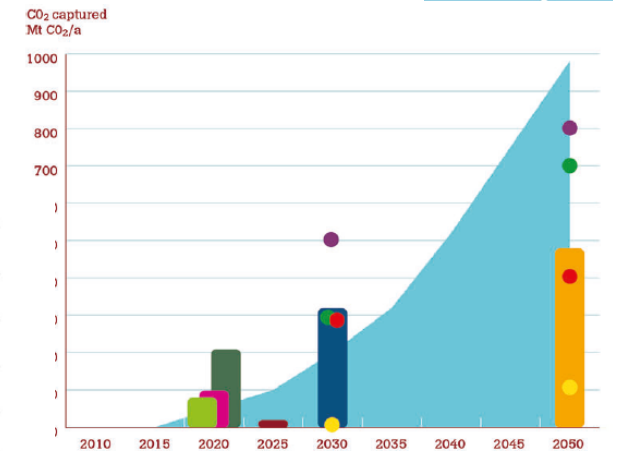
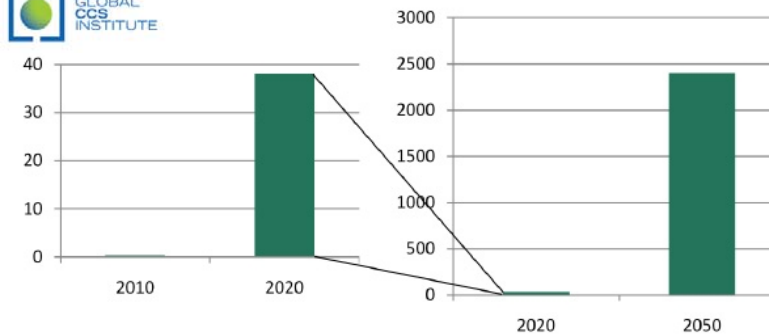
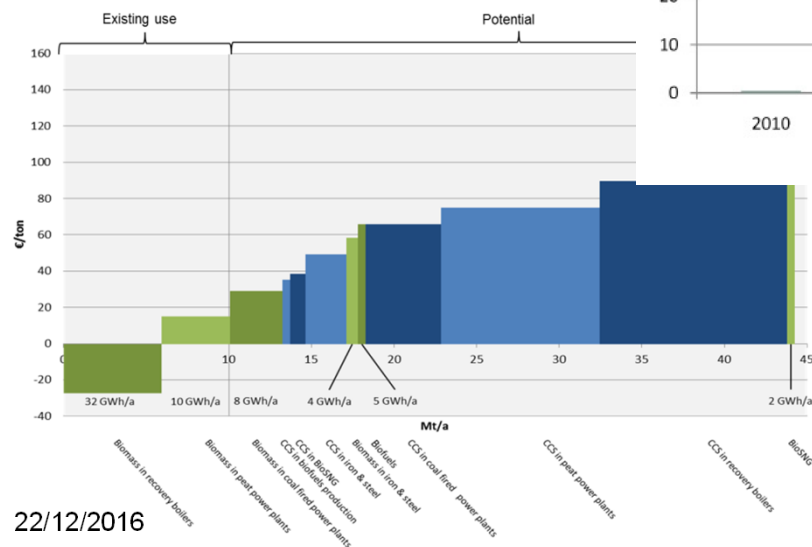
Bio-CCS(U)S is tightly connected to market driven future use of biomass – low hanging fruits related to (near)future applications

Bio-CCS technology	Technical potential in net negative GHG emissions (Gt CO ₂ -equivalent)			
	Global ¹		OECD Europe ²	
	2030	2050	2030	2050
Electricity generation with CCS				
Co-firing in coal-fired power plant (post-, pre-, oxy-fuel combustion)	-4.3	-9.9	-0.3	-0.7
Dedicated combustion and gasification of biomass (post-, pre-, oxy-fuel)	-5.7	-10.4	-0.5	-0.8
Biofuels production with CCS				
Bio-ethanol (lignocellulosic biomass)	-0.5	-1.1	-0.04	-0.1
Synthetic biofuels via thermochemical processes	-3.3	-5.8	-0.3	-0.4

¹ The global supply of biomass feedstock is assumed to be equal for all selected Bio-CCS technologies: 2030 and 2050, respectively.
² The potential supply of biomass feedstock from OECD Europe is assumed to be equal for all selected 5.8 and 9.6 EJ/yr in 2030 and 2050, respectively.



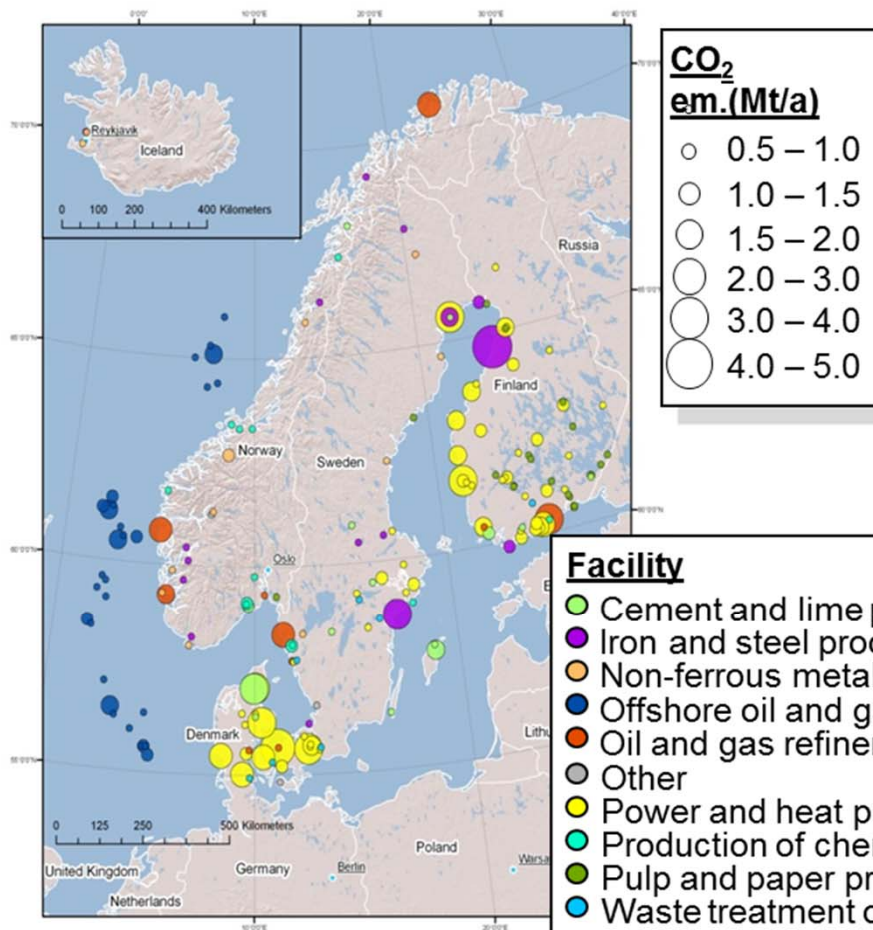
Ecofys 2012



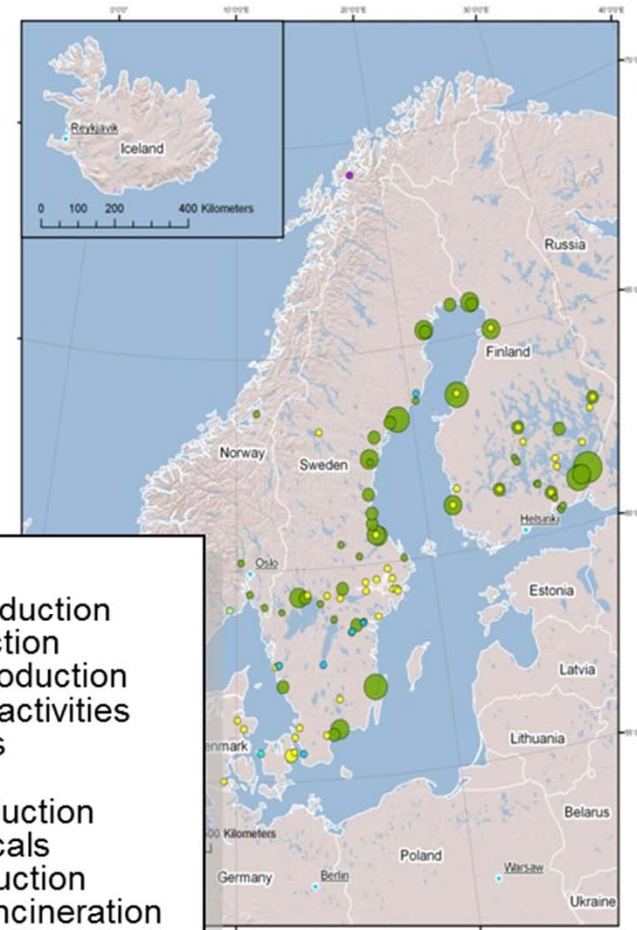
- Total CO₂ captured in Europe (IEA CCS Technology Roadmap 2009)
- CO₂ captured from co-firing installations, potential in existing boilers (Chalmers boiler database)
- CO₂ captured from all bioelectricity production (NREAPs, Directive 2009/28/EC)
- Maximum CO₂ capture potential from biofuels in road transportation in Europe (NREAPs, Directive 2009/28/EC)
- Maximum CO₂ capture potential from biofuels in aviation in Europe (European Commission, 4th EBTP Stakeholder Meeting, 40% in 2050)
- Maximum CO₂ capture potential from biofuels in road transportation in Europe (EBTP Strategic Research Agenda 2010 Update, 25% in 2030)
- CO₂ captured from pulp and paper in Europe, 38 large and medium-sized units, existing production, no increase projected (Pöyry database)
- Post-combustion co-firing, IGCC co-firing and oxyfuel co-firing (IEA GHG 2011)
- Dedicated combustion and gasification (IEA GHG 2011)
- Lignocellulosic bioethanol (IEA GHG 2011)
- FT biodiesel (IEA GHG 2011)

Biomass utilisation in Nordic is mainly forest biomass dominated by pulp and paper industry, Combined Heat and Power production in CFB boilers and future biorefineries

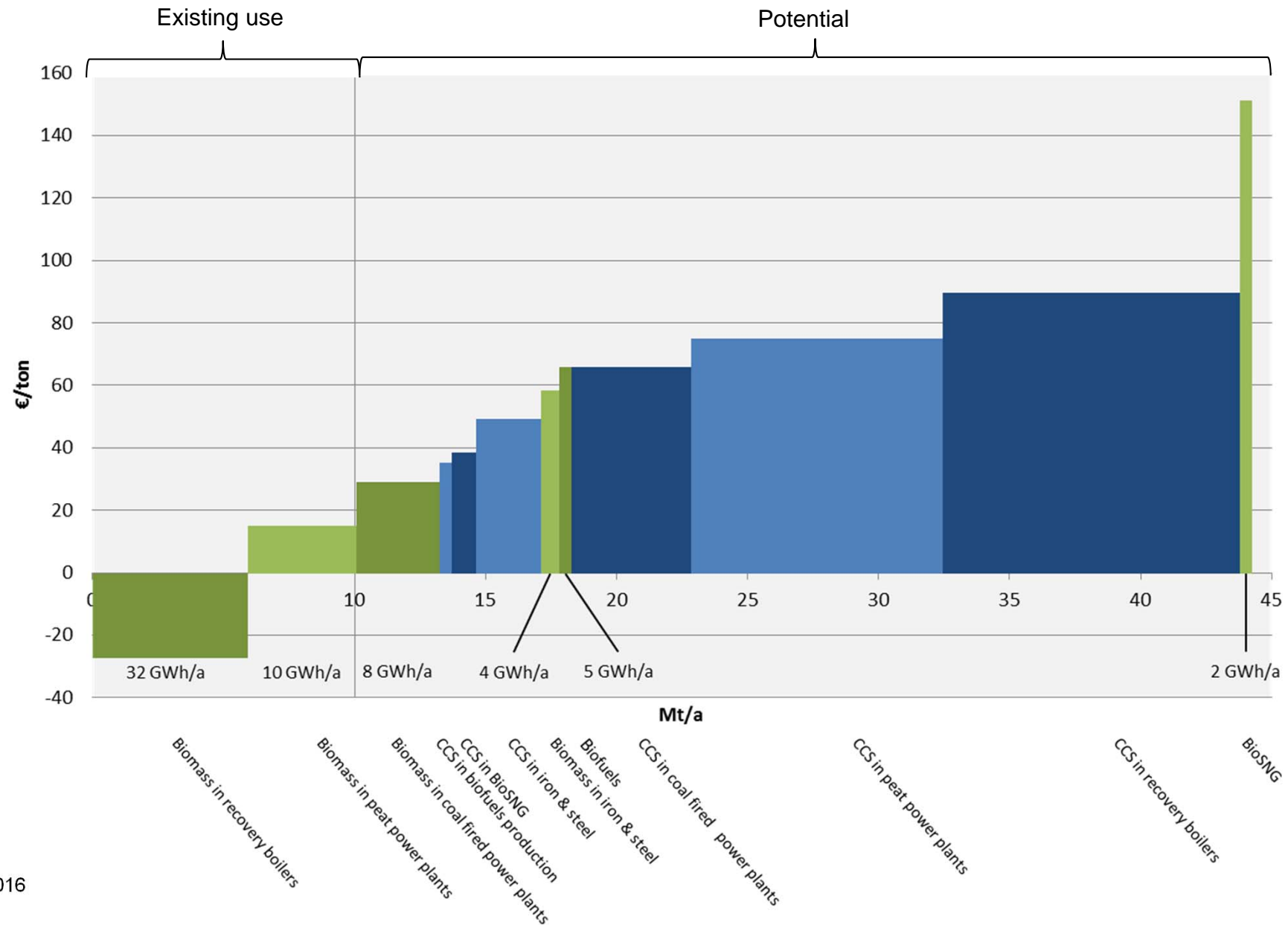
Fossil and inorganic CO₂ emissions



Biogenic CO₂ emissions

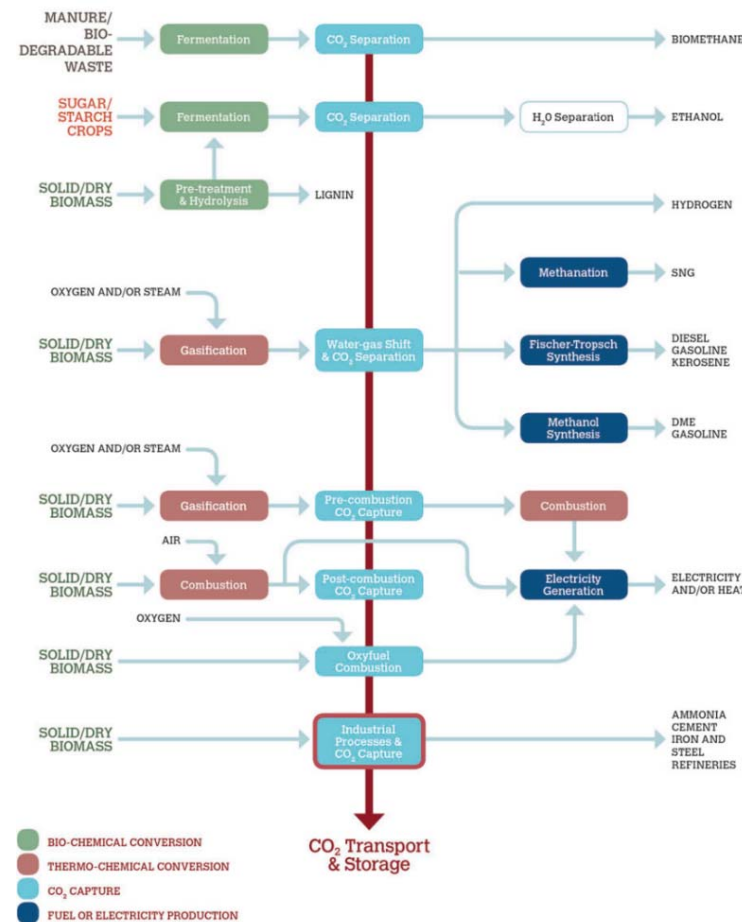


Techno-political Bio-CCS potential in Finland 2025



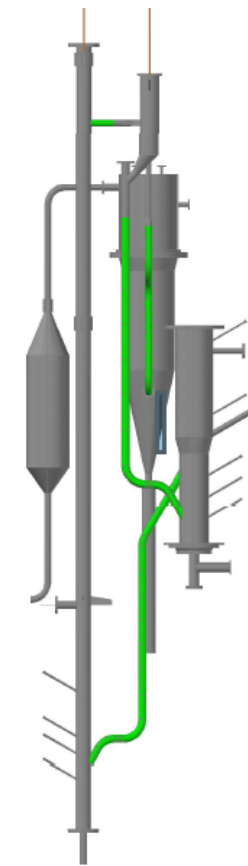
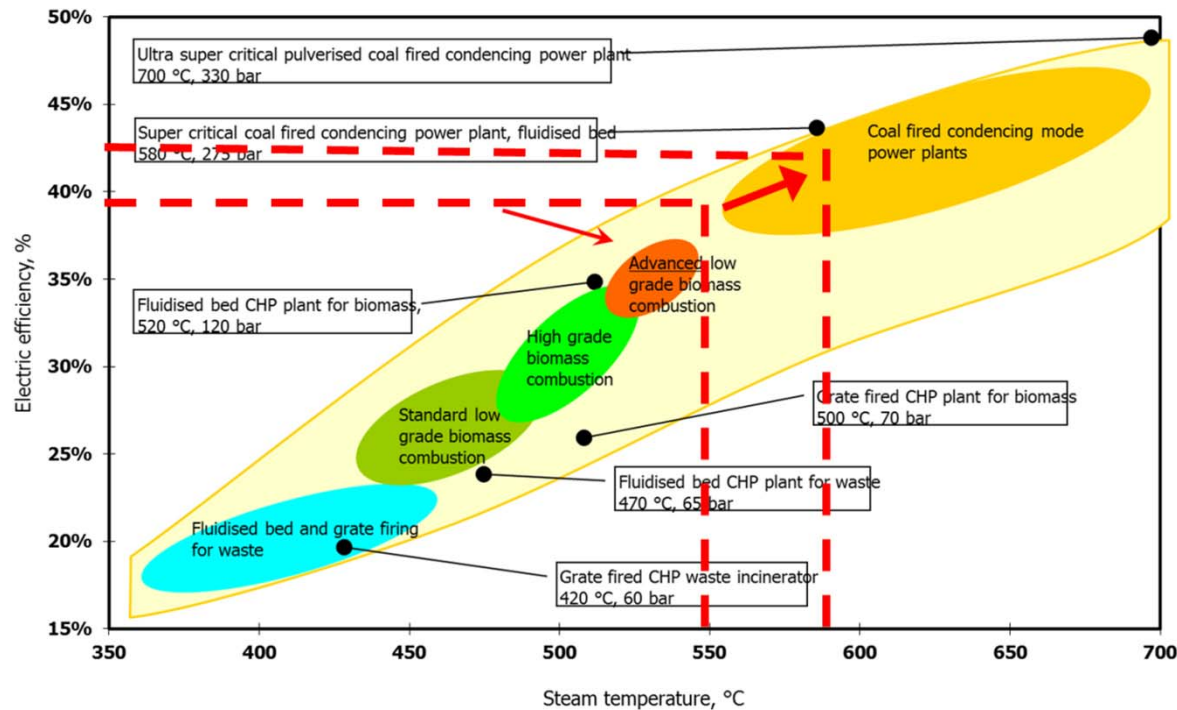
Future of Bio-CCS in industrial sectors in Finland

- Industrial and industrial energy use of biomass
 - Pulp and paper industry
 - Liquid biofuels production
- Power sector
 - Co-firing of biomass
 - CHP production
- Heat
 - Residential heating
 - District heat production



Technically Bio-CCS has no fundamental differences in comparison to fossil CCS besides accounting of negative emissions ZEP/EBTP 2012

Future of thermal power generation? Carbon removal from the atmosphere with as low as 36€/t CO₂ cost levels – Bio-CLC



World's first Bio-CLC testing at pilot scale

Dr. Sebastian Teir

Negative CO₂ emissions by bio-CLC

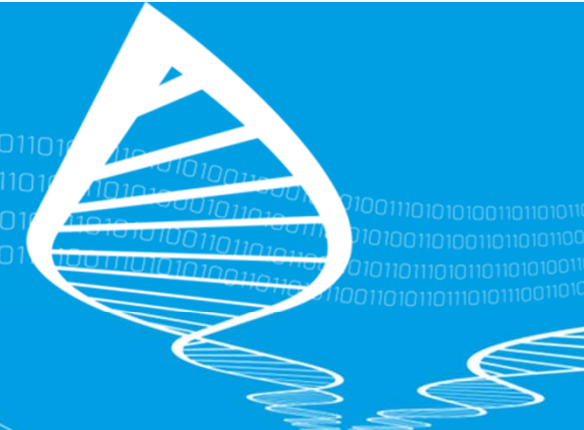
VTT Technical Research Centre of Finland Ltd



- Chemical looping combustion (CLC) a promising technology for bio-CCS
 - Lowest energy requirements of known CO₂ capture technologies
 - No high-temperature corrosion risk → improves efficiency for biomass combustion
- CLC at 20 kWth scale for biomass successfully tested at VTT Bioruukki

Conclusions

- Bio-CCS only industrial scale carbon negative technology that can be deployed today
 - Applying CCS and Bio-CCS appear almost necessary for achieving the climate policy targets and the least cost option for well below 2°C
- Bio-CC(U)S is primarily a systemic issue – potential and market drive
 - Bio-CCS can offset emissions across sectors and historical emissions
- In general, bio-CCS is not a solution to possible sustainability issues related to biomass. However it will have an impact on the greenhouse gas balance of biomass use
 - However, storing biogenic CO₂ should be considered as storing fossil CO₂ independent on the discussion regarding carbon neutrality of biomass
 - Bio-CCU prolong of use of carbon molecule (circular economy) and pave the way for technology deployment. Not generally resulting in direct large GHG emission savings, however it can be an enabler to a systemic change



TECHNOLOGY FOR BUSINESS

