VTT TECHNICAL RESEARCH CENTRE OF FINLAND LTD

Doubling the climate benefit by combining biomass with CCS

Carbon Capture and Storage Program final results seminar

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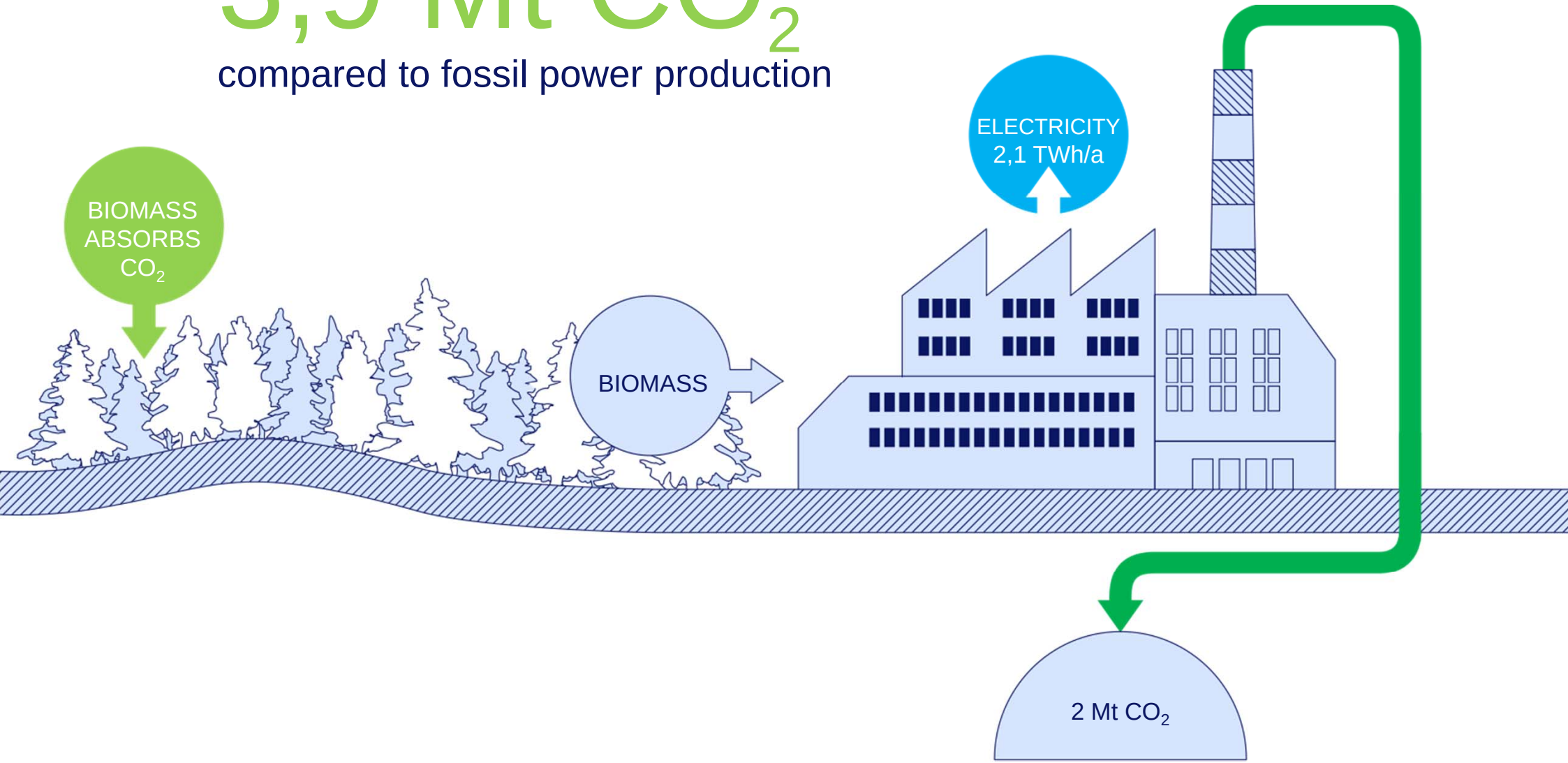
Bio-CCS is a systemic issue more than technical

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

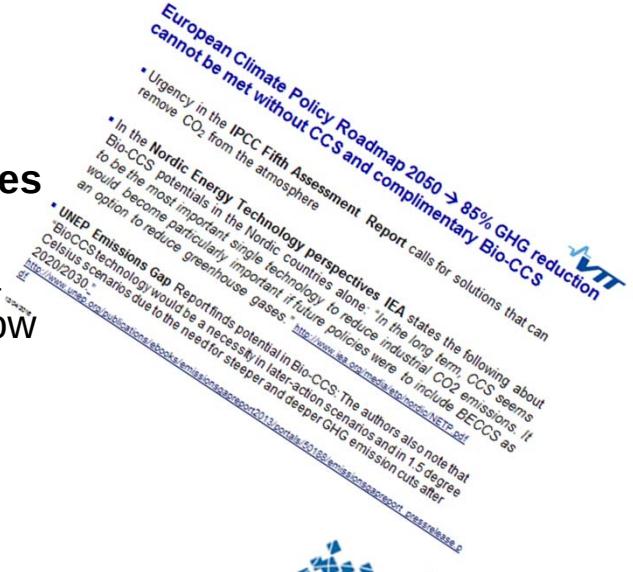
A REDUCTION OF 3,9 Mt CO_2

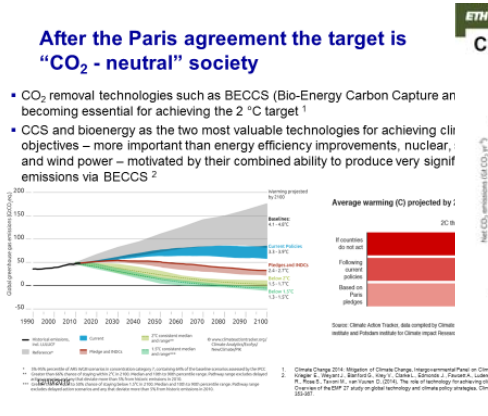
compared to fossil power production

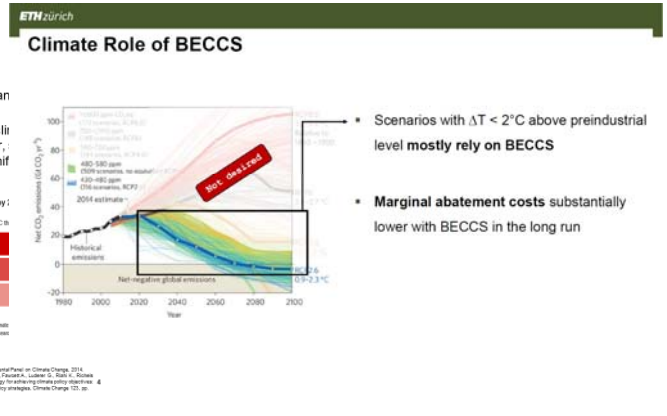


Magnitude of issues at hand

- 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







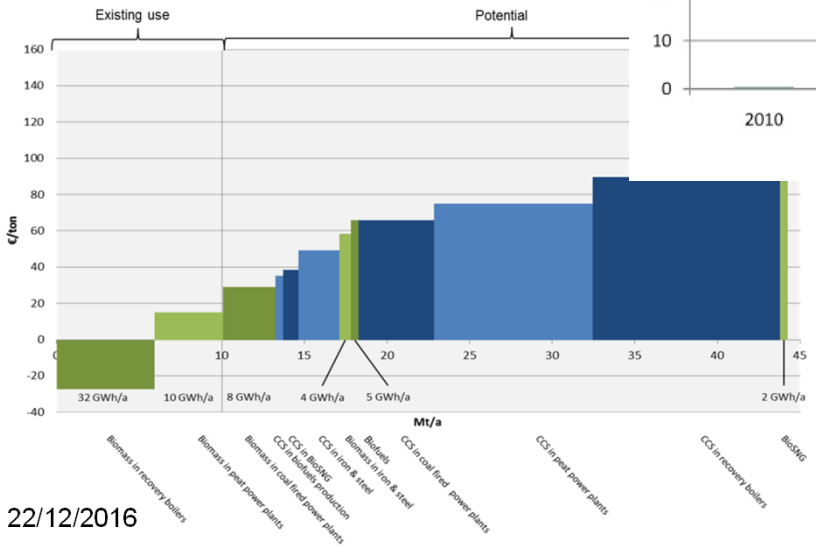
Bio-CCS(U)S is tightly connected to market driven future use of biomass – low hanging fruits related to (near)future applications

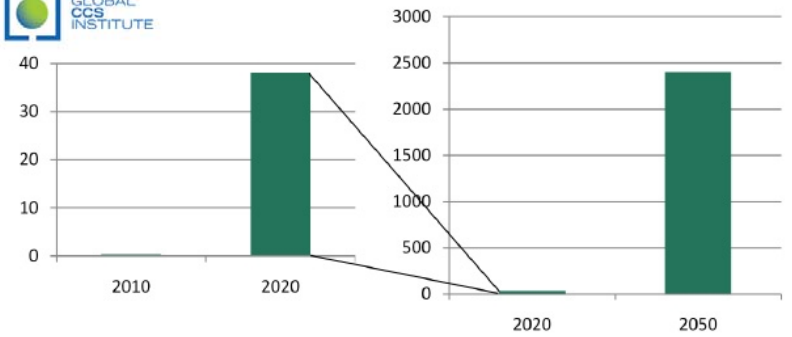
Bio-CCS technology	Technical potential in net negative GHG emissions (Gt CO_2-equivalent)			
	Global[1]		OECD Europe[2]	
Electricity generation with CCS	**2030**	**2050**	**2030**	**2050**
Co-firing in coal-fired power plant (post-, pre-, oxy-fuel combustion)	-4.3	-9.9	-0.3	-0.7
Dedicated combustion 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.

GLOBAL CCS INSTITUTE

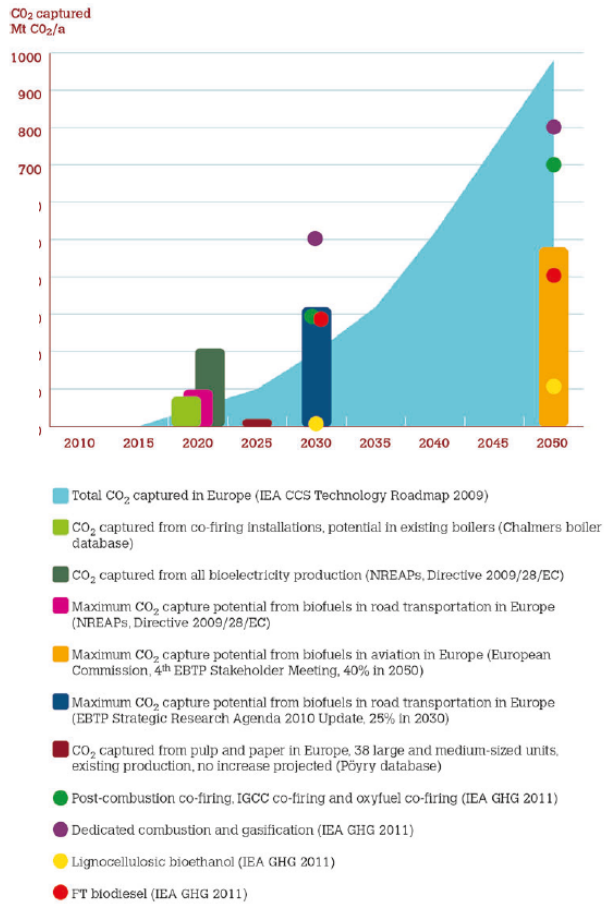
Ecofys 2012





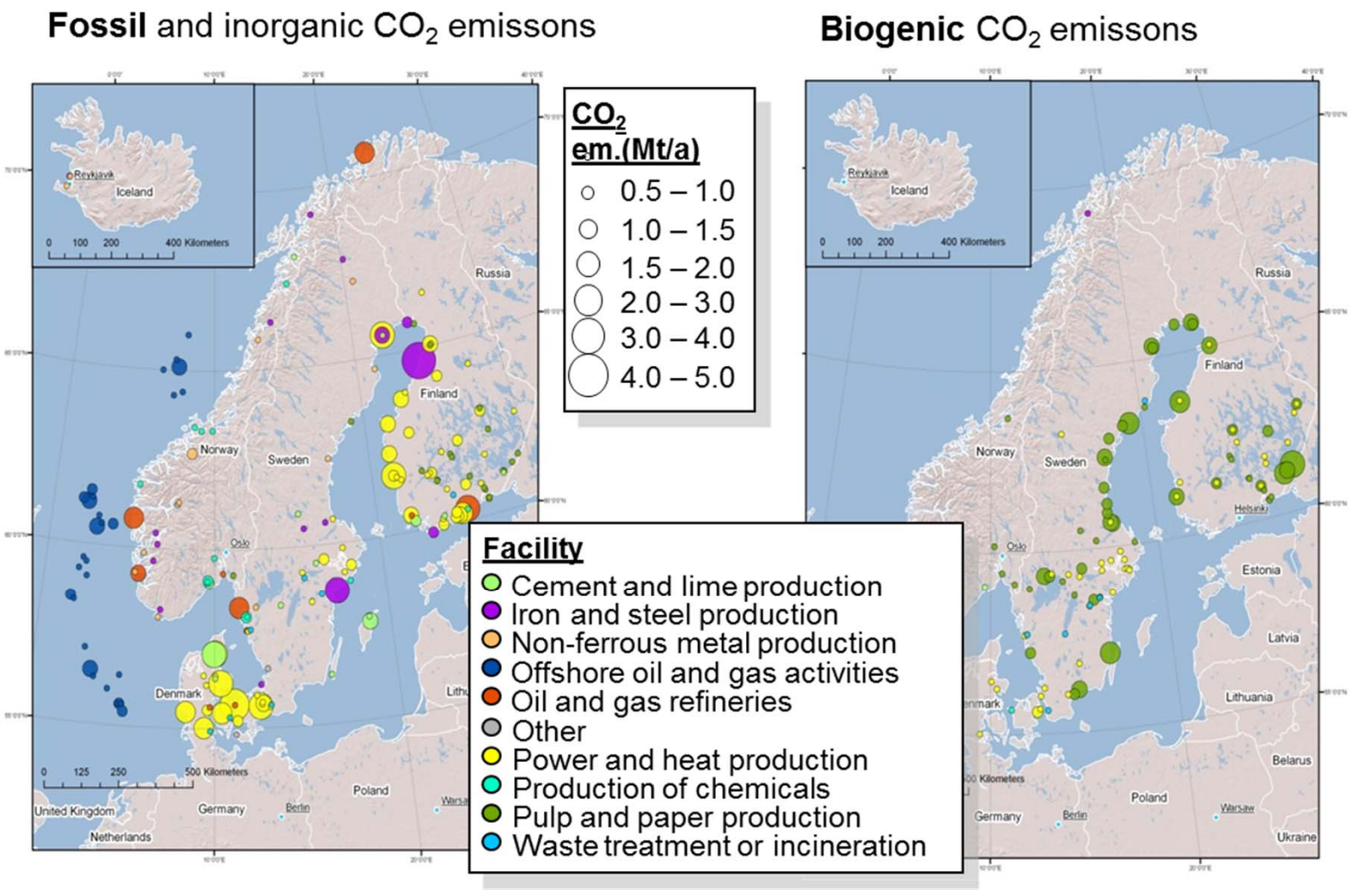
European Biofuels TECHNOLOGY PLATFORM
Accelerating deployment of advanced biofuels in Europe

Zep Zero emissions platform

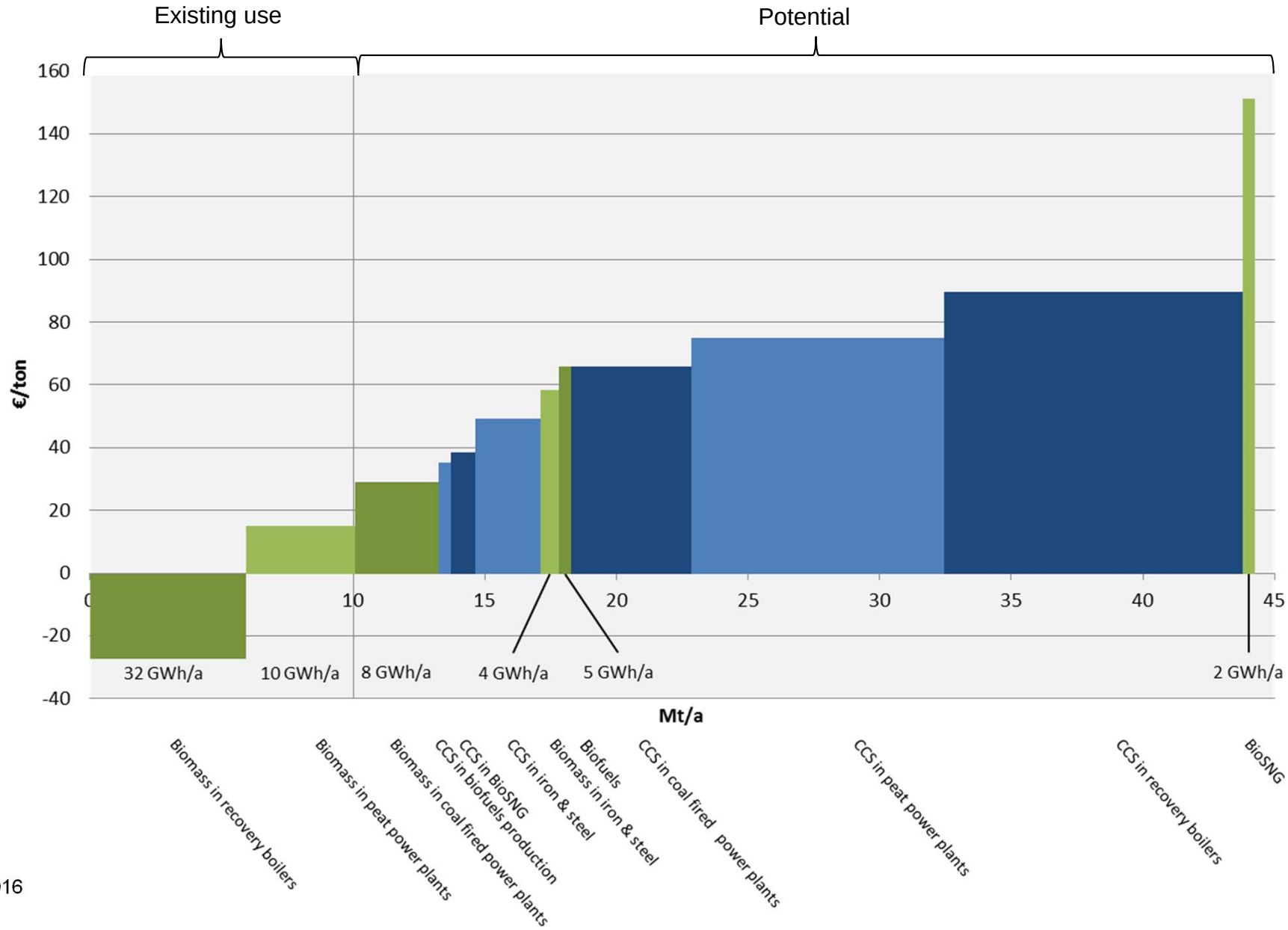


Biomass utilisation in Nordic is mainly forest biomass

dominated by pulp and paper industry, Combined Heat and Power production in CFB boilers and future biorefineries

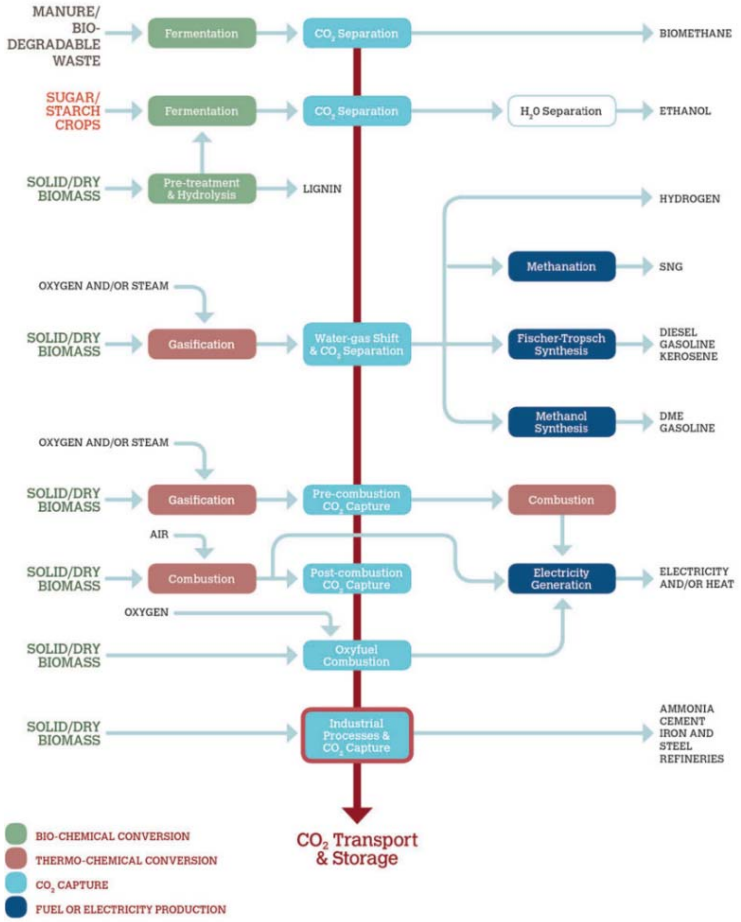


Techno-political Bio-CCS potential in Finland 2025



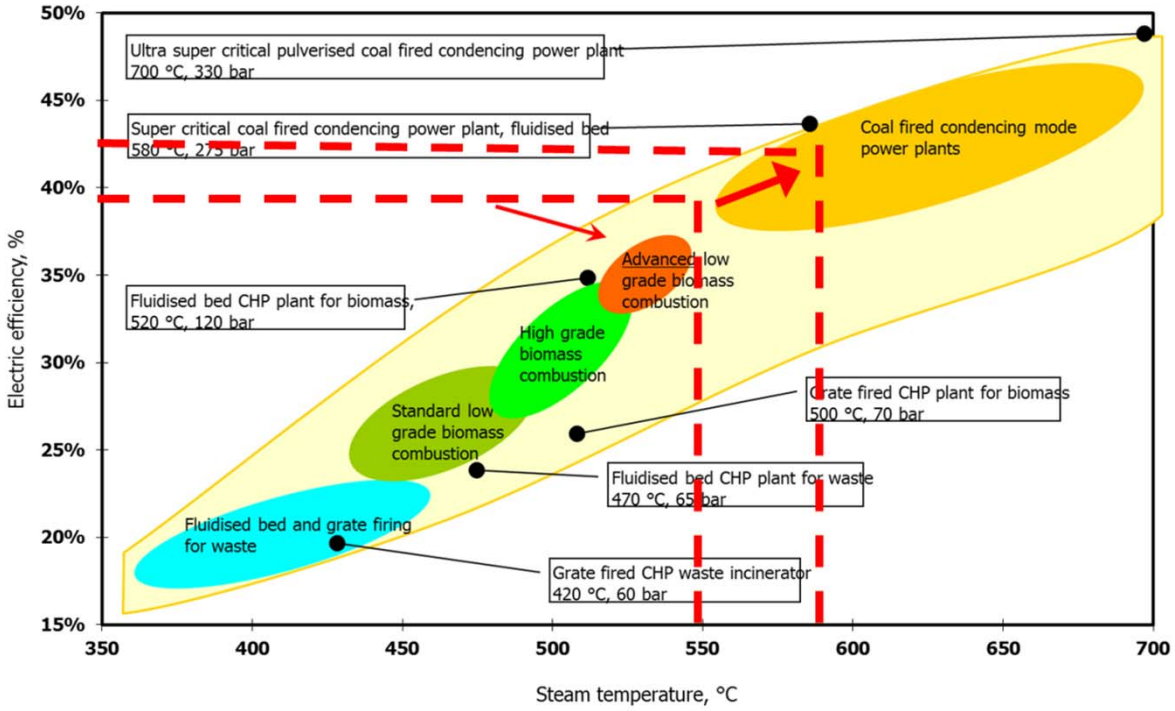
Future of Bio-CCS in industrial sectors in Finland

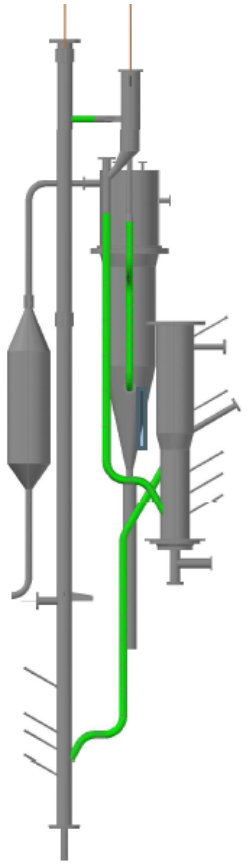
- Industrial and industrial energy use of biomass
  - Pulp and paper industry
  - Liquid biofuels production
- Power sector
  - Co-firing of biomass
  - CHP production
- Heat
  - Residential heating
  - District heat production



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 CO_2 cost levels – Bio-CLC





World's first Bio-CLC testing at pilot scale

Dr. Sebastian Teir

Negative CO_2 emissions by bio-CLC

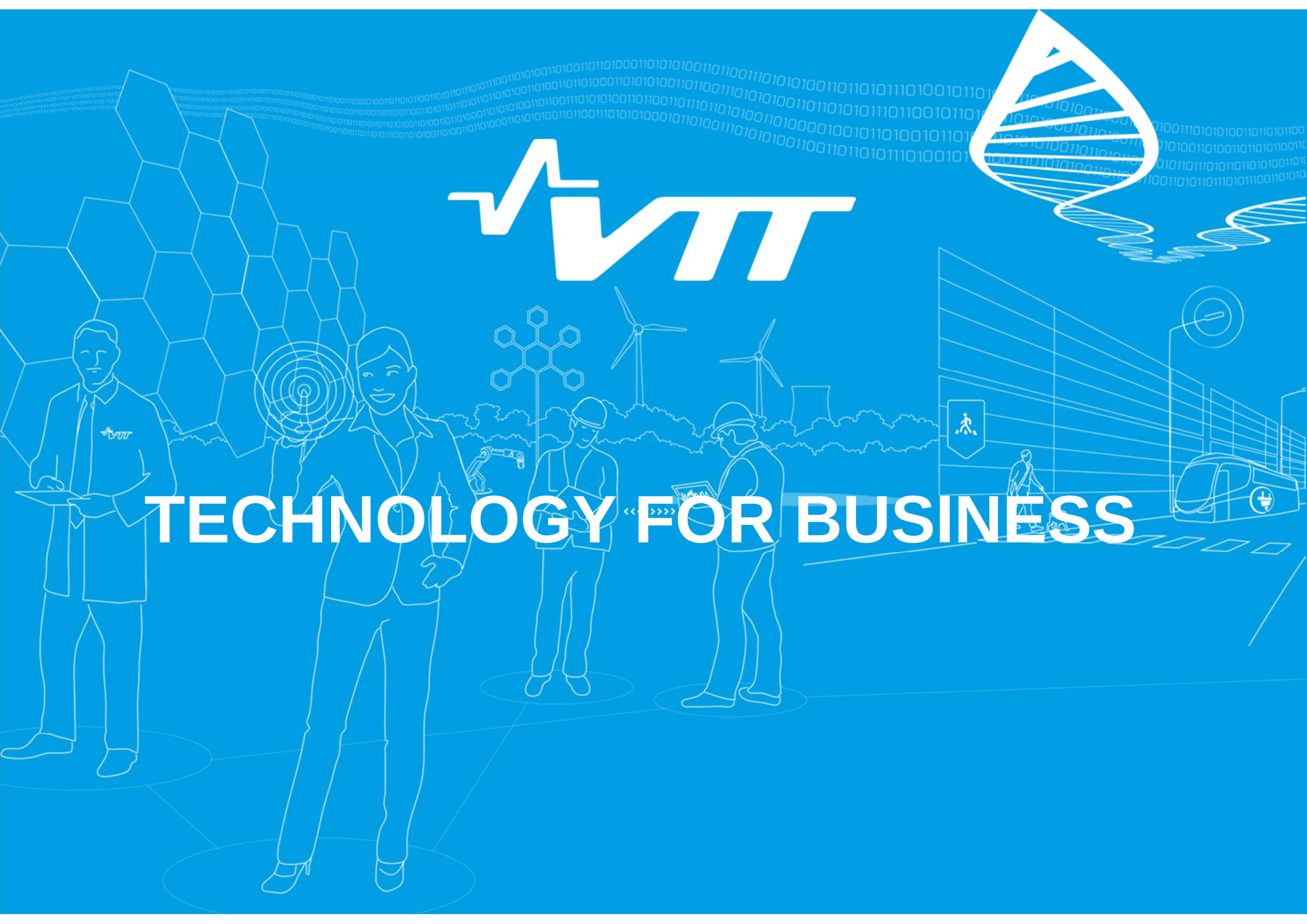
VTT Technical Research Centre of Finland Ltd

TECHNOLOGY FOR BUSINESS

- Chemical looping combustion (CLC) a promising technology for bio-CCS
  - Lowest energy requirements of known CO_2 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 CO_2 should be considered as storing fossil CO_2 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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