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Integration of CCS with Gas Turbines

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NORCE

Content

- Scope
- Motivations for CC(U)S
- Capture, Utilization, Transport & Storage
- Key barriers
- Discussion

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Scope of this presentation

To provide an overview of the CCS system & technologies

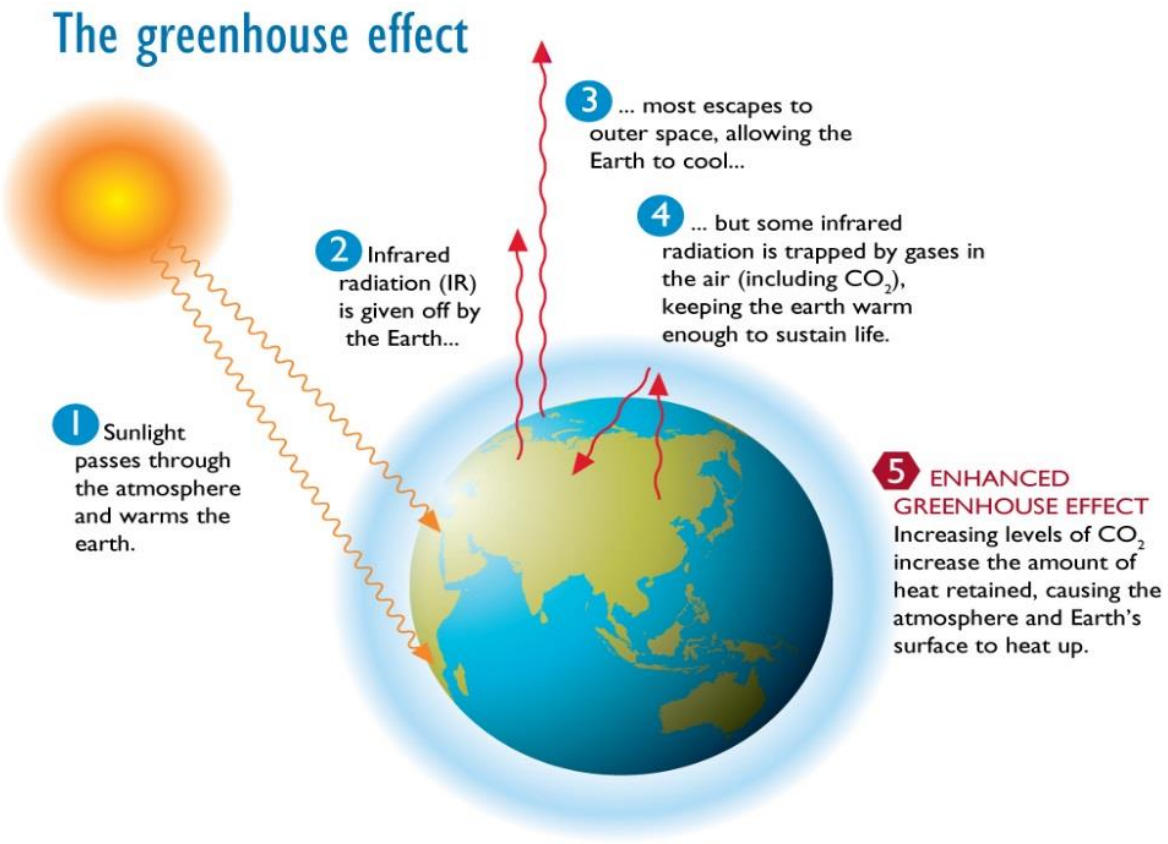
To provide the basis for the discussion in the 2nd day of the workshop

How to supply energy in the transition time?

Kyoto Protocol in 1997

Several years of efforts

Paris Agreement in 2015



Source: Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)

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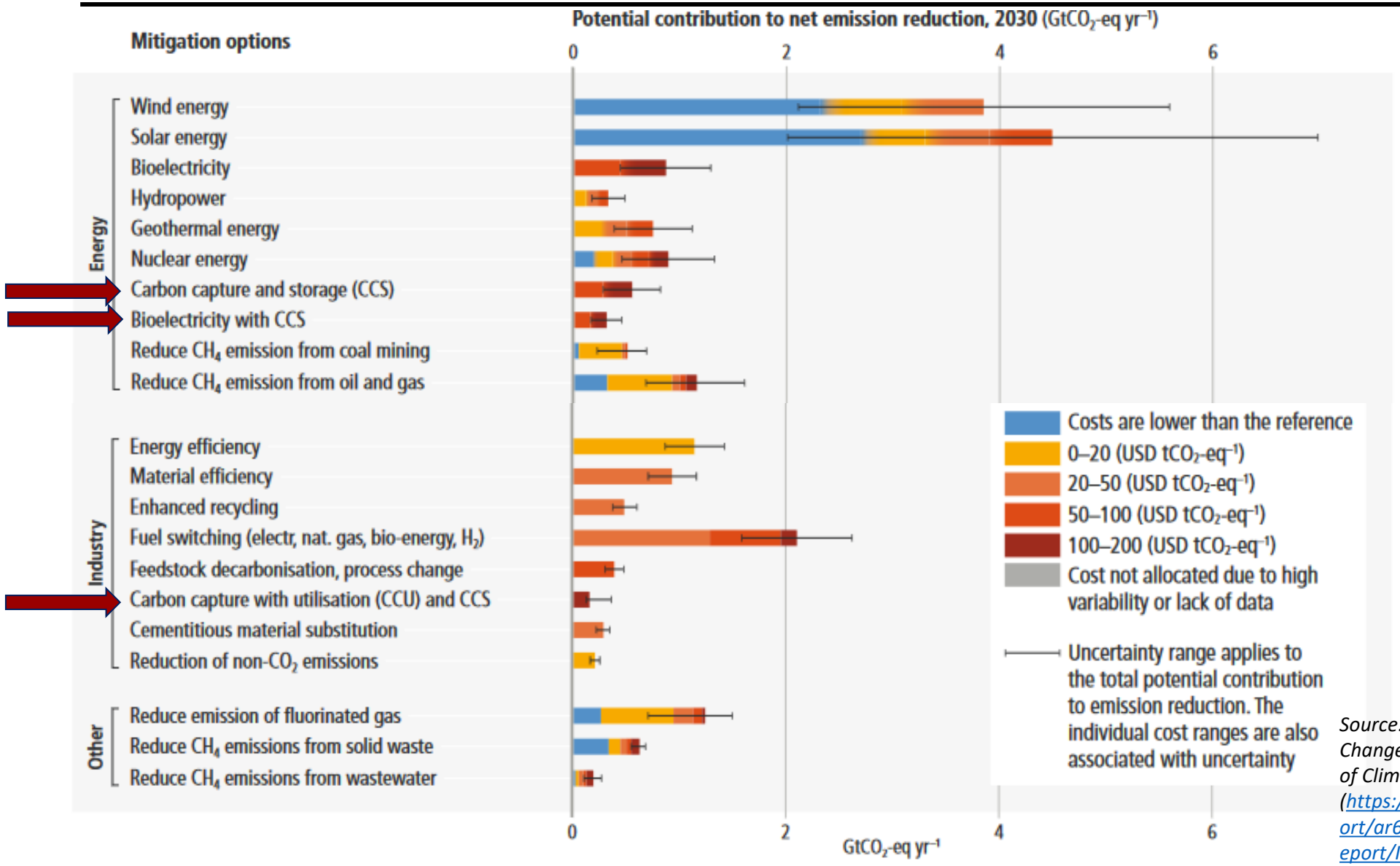
CCS importance in GHG mitigation scenarios



CCUS technologies are recognized as one of the ten priority actions in the SET-Plan

Source: IPCC Climate Change 2022: Mitigation of Climate Change (https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf)

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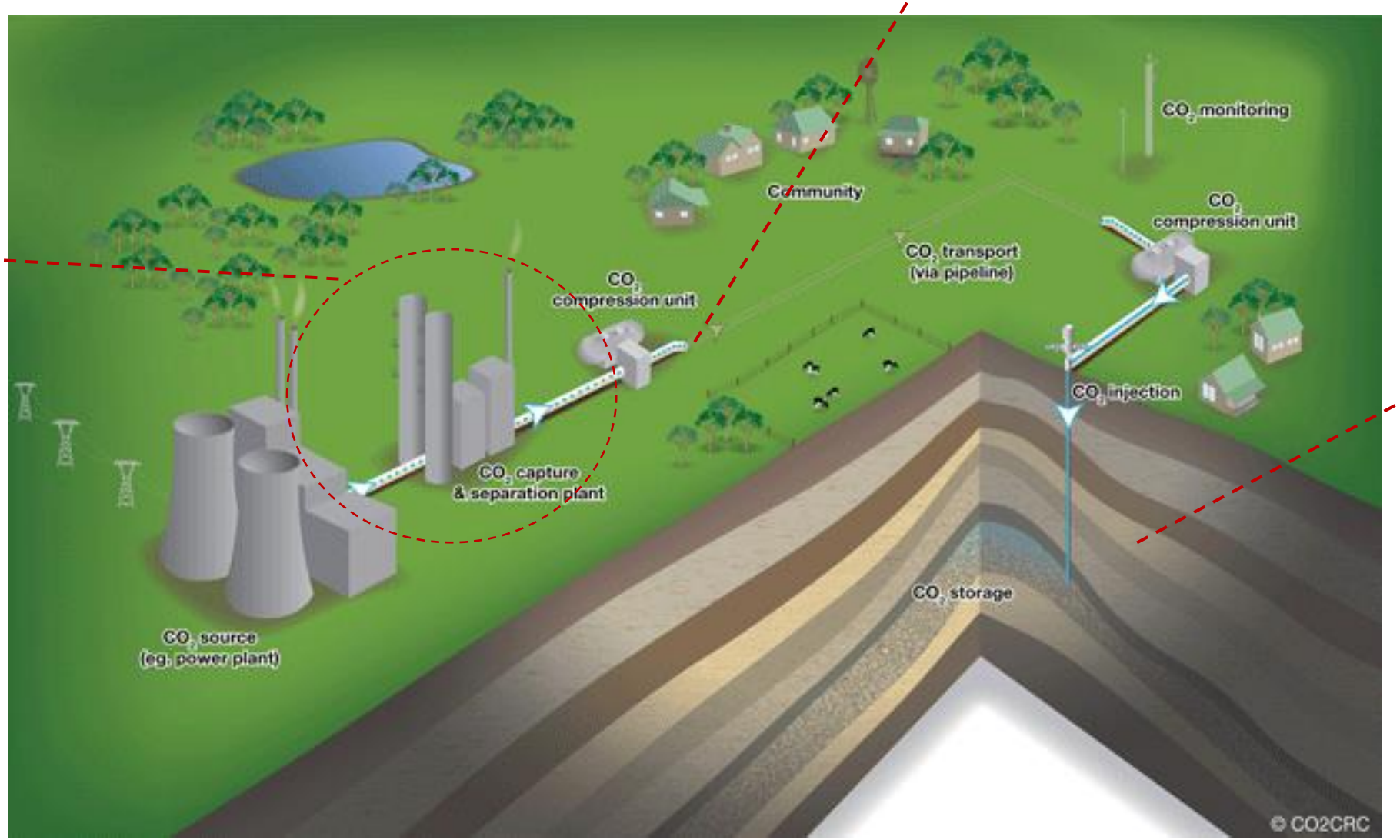
What is CCS?

Transport

Capture

Storage



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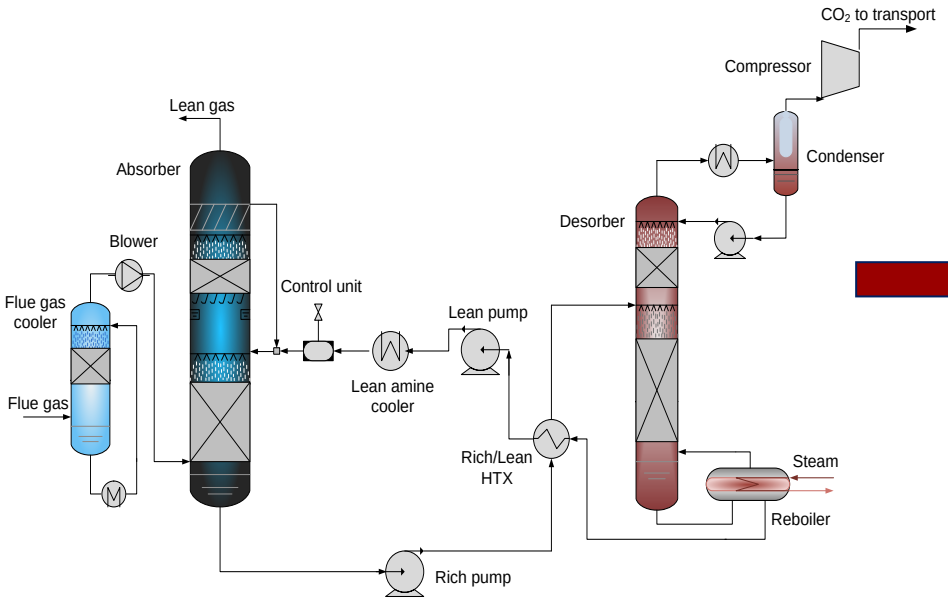
CCS – A chain of processes/technologies that enable

1. Capture of CO_2 from large points sources

Power plants, steel, cement, refineries, gas processing, etc.

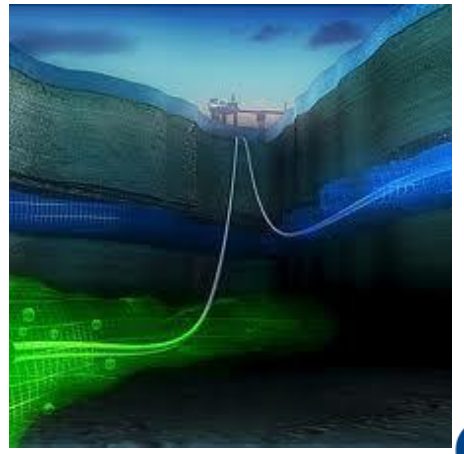


2. Transport

Trucks, ships, pipelines

3. Storage of CO_2 in geological formations

Depleted oil and gas fields, saline aquifers, etc.



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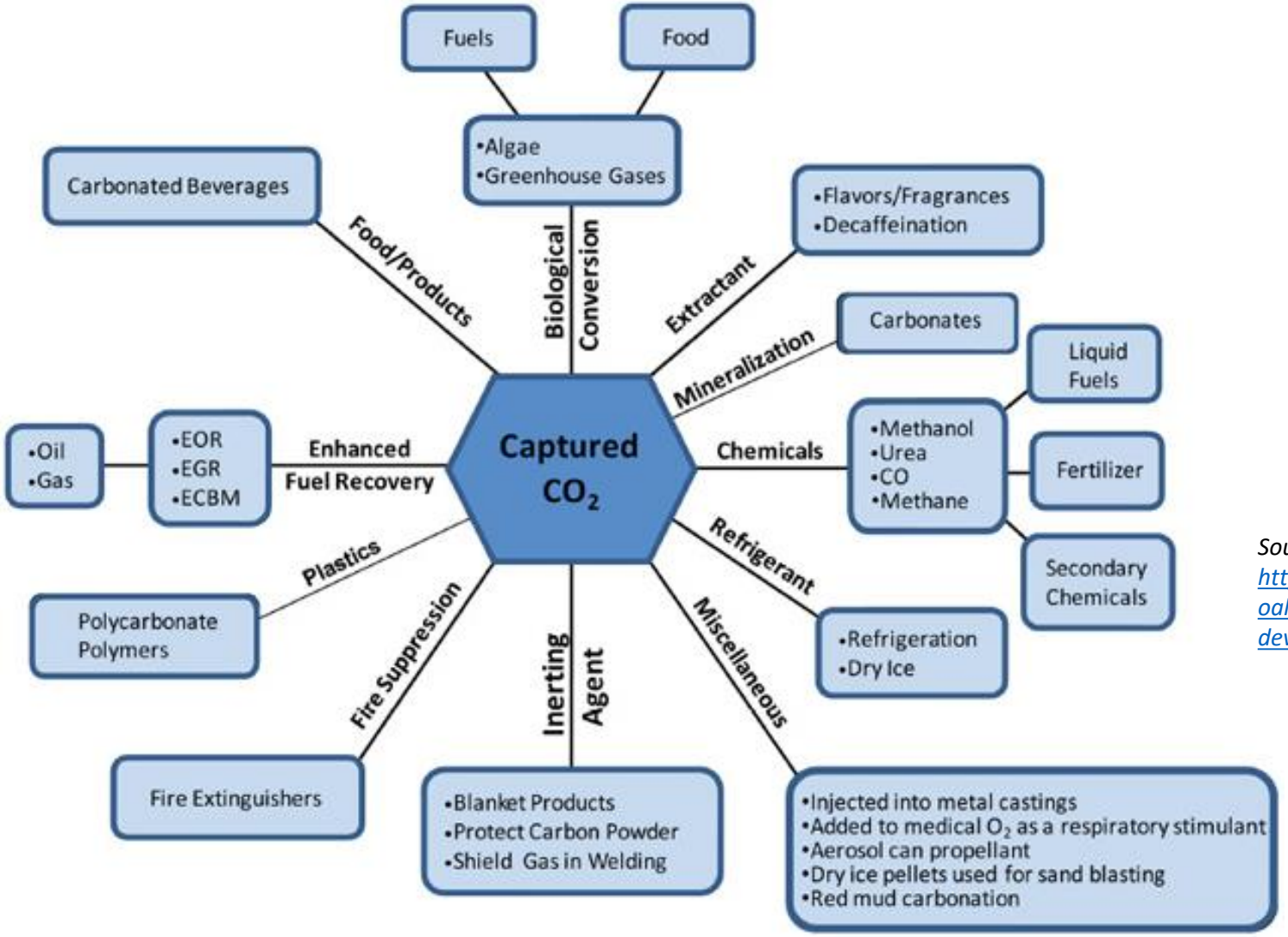
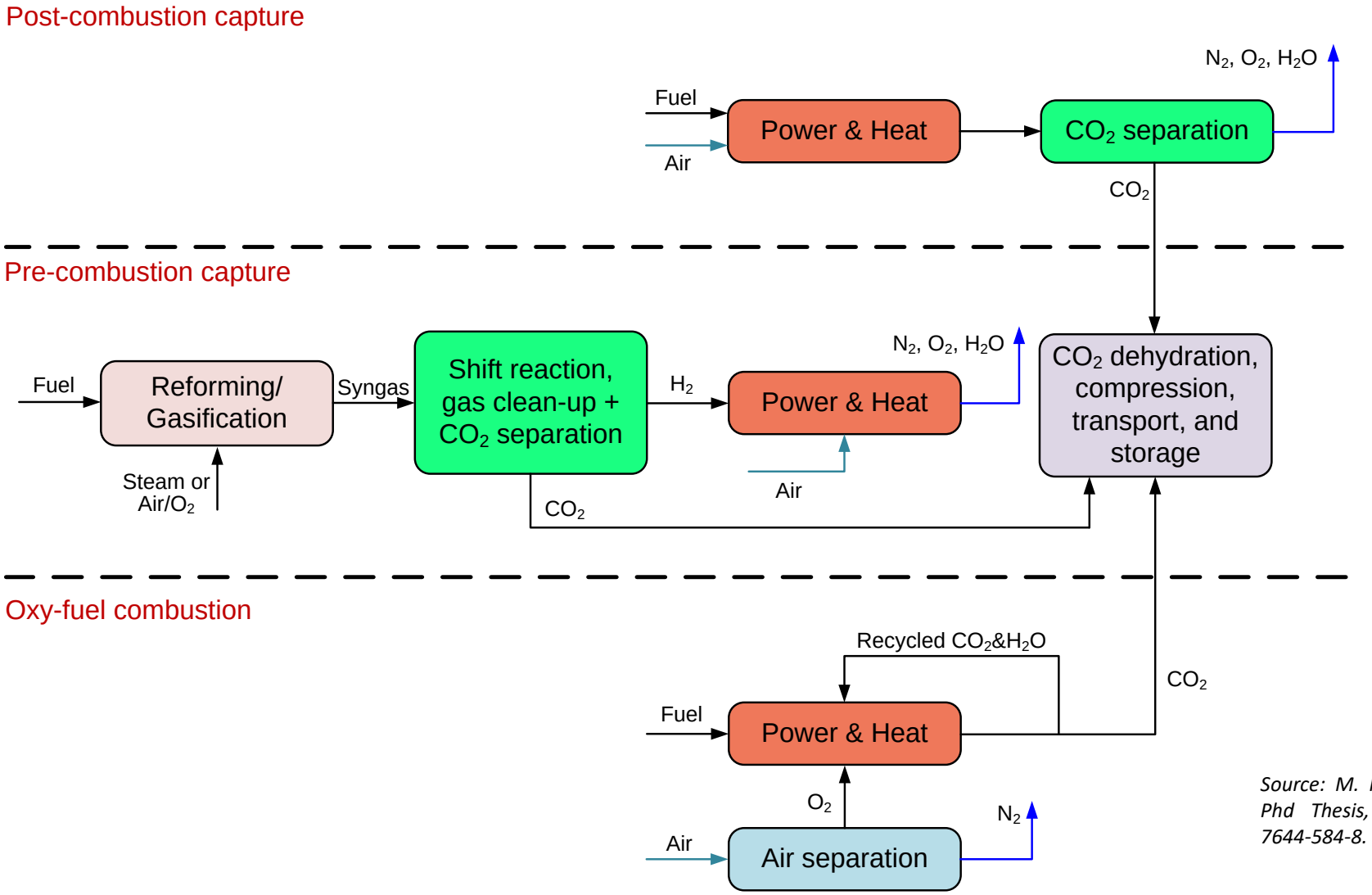
Utilization in CCUS

The current and potential uses of CO_2



Source: https://www.netl.doe.gov/research/coal/carbon-storage/research-and-development/co2-utilization

Capture techniques – Heat & power sector



Source: M. Mansouri, 2014, Phd Thesis, ISBN: 978-82-7644-584-8.

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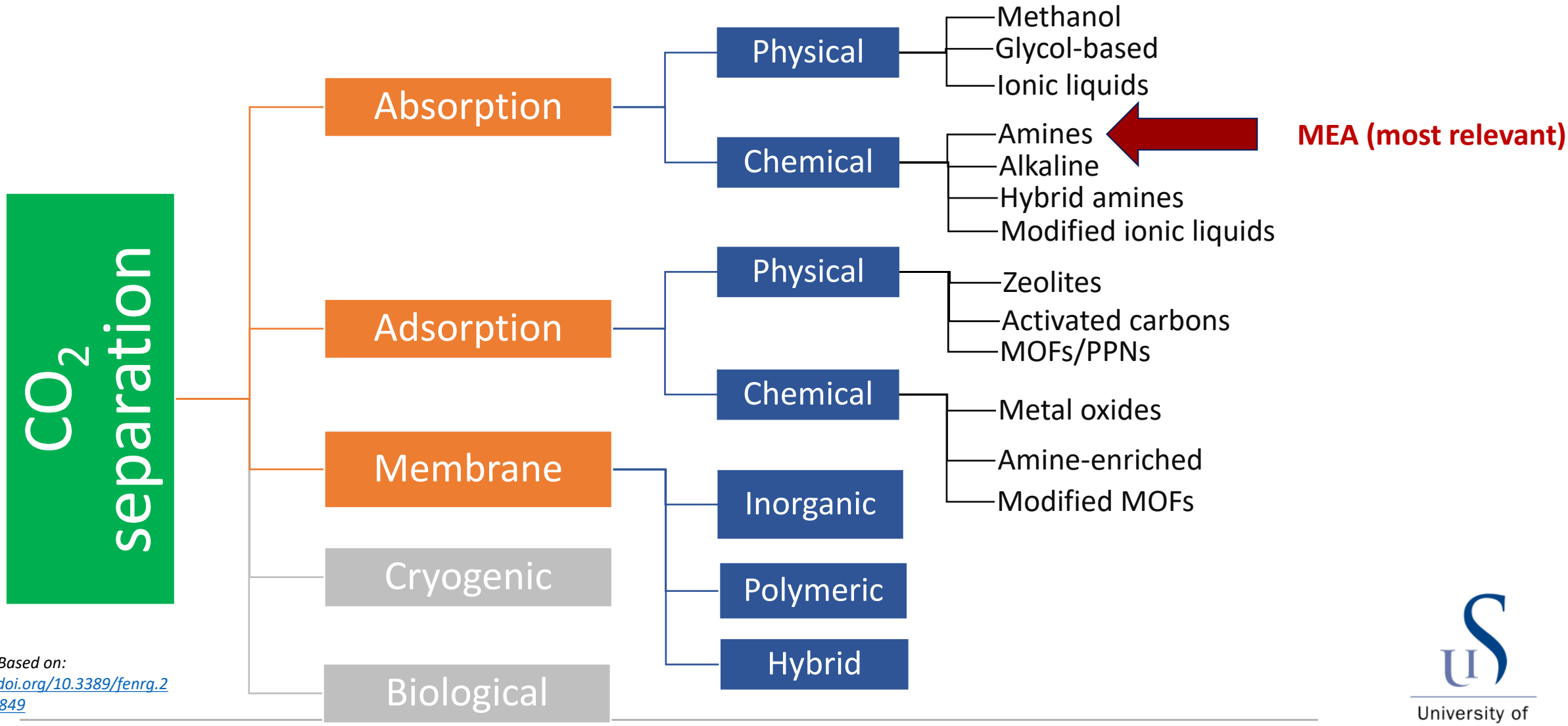
CO_2 separation technologies



Source: Based on: *https://doi.org/10.3389/fenrg.2020.560849*

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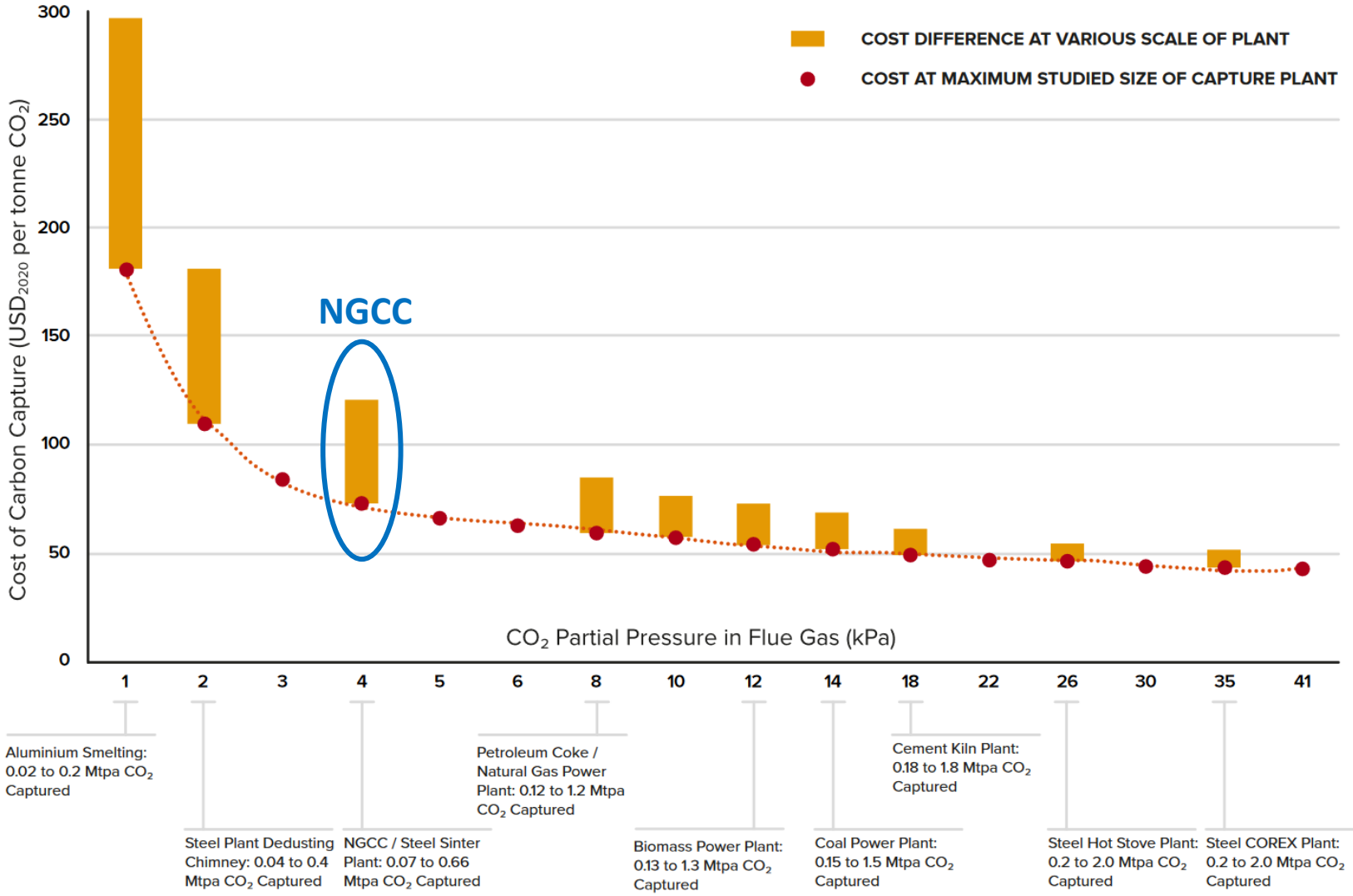
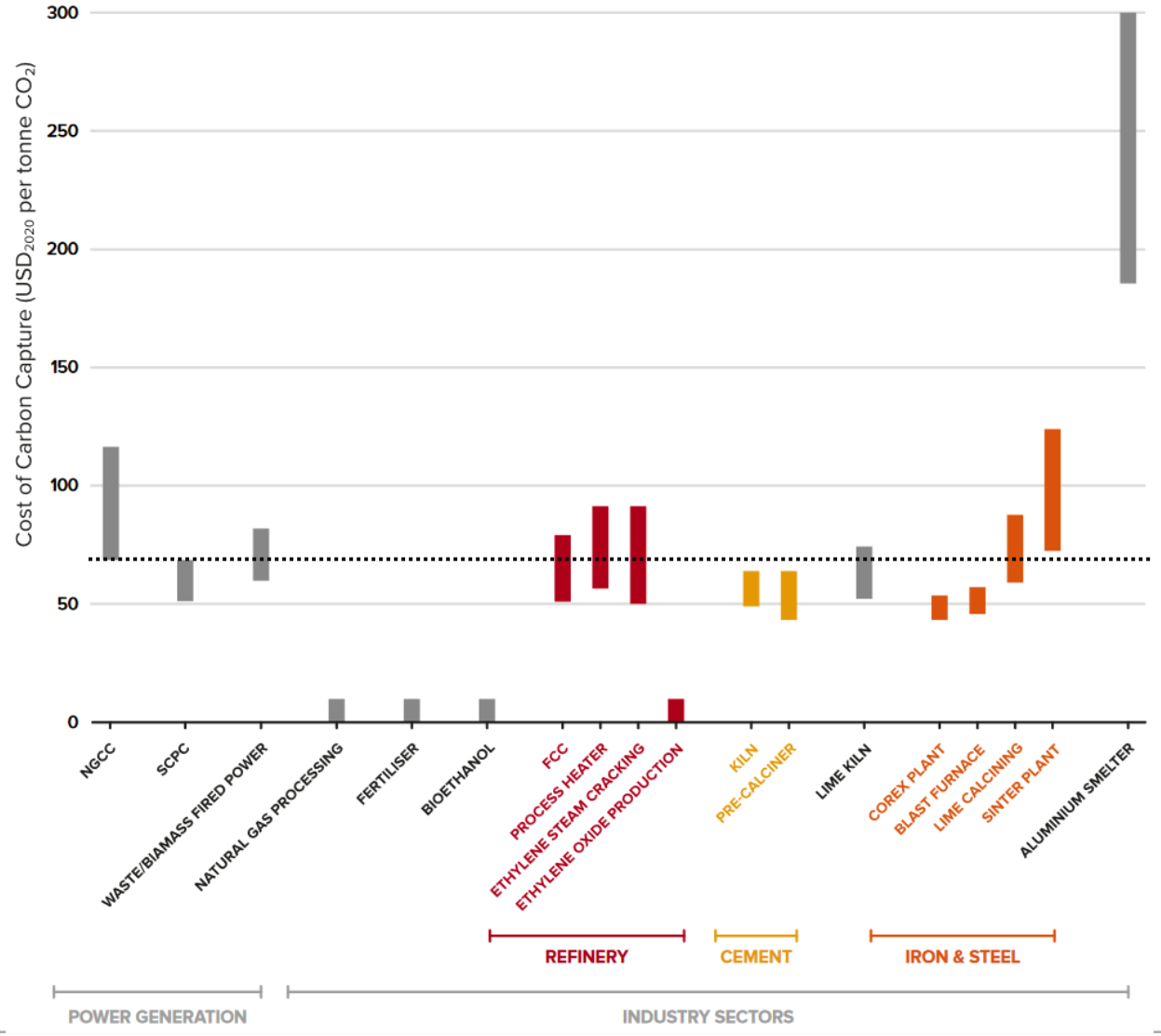
CO_2 capture cost – Sensitive to scale & application 1

Cost is very high at low CO_2 partial pressure and reduces significantly at higher partial pressures



Source: GCCSI, https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Technology-Readiness-and-Costs-for-CCS-2021-1.pdf

CO_2 capture cost – Sensitive to scale & application 2



Source: GCCSI, https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Technology-Readiness-and-Costs-for-CCS-2021-1.pdf

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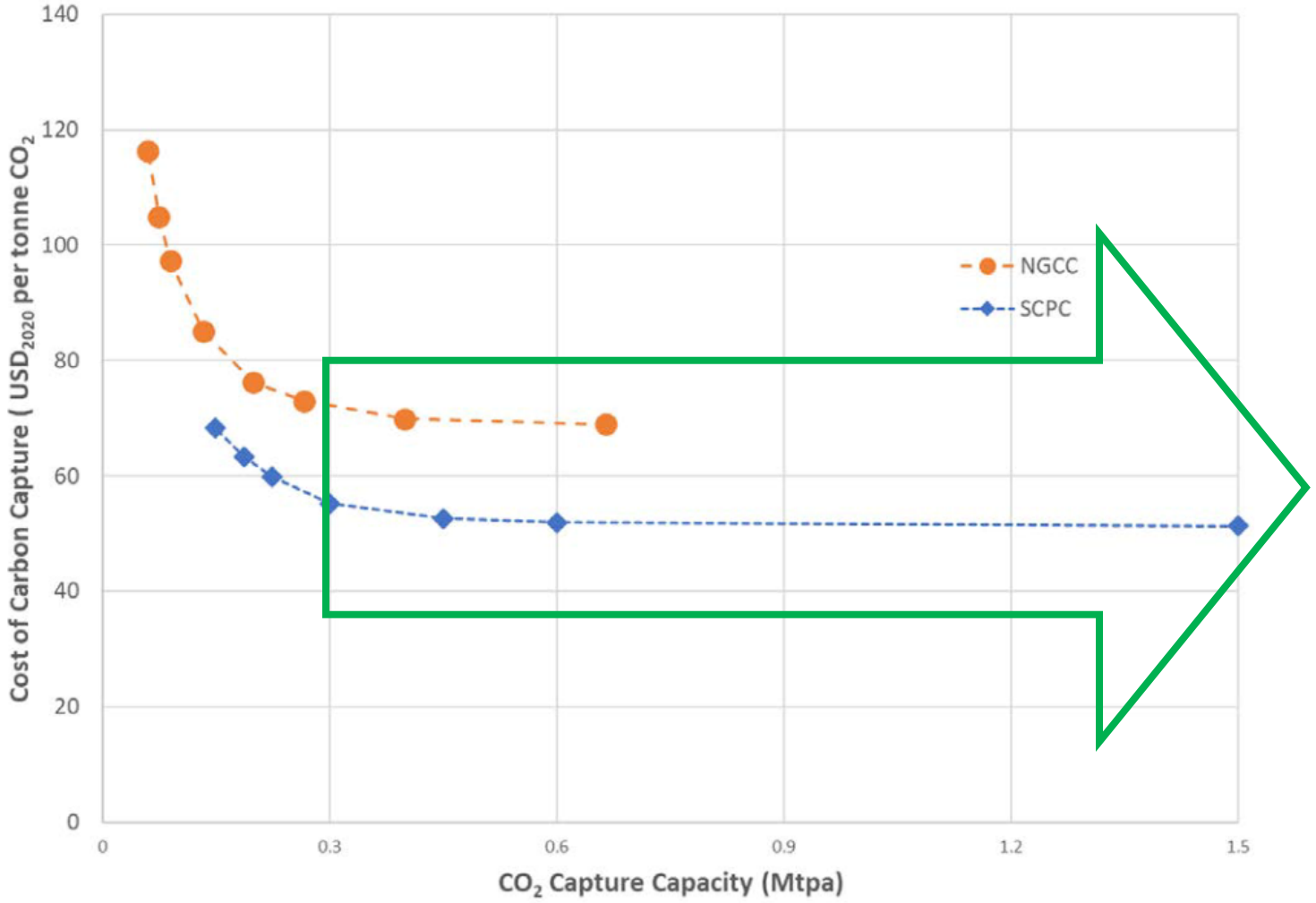
CO_2 capture cost – Sensitive to capacity of capture unit



Source: GCCSI, https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Technology-Readiness-and-Costs-for-CCS-2021-1.pdf

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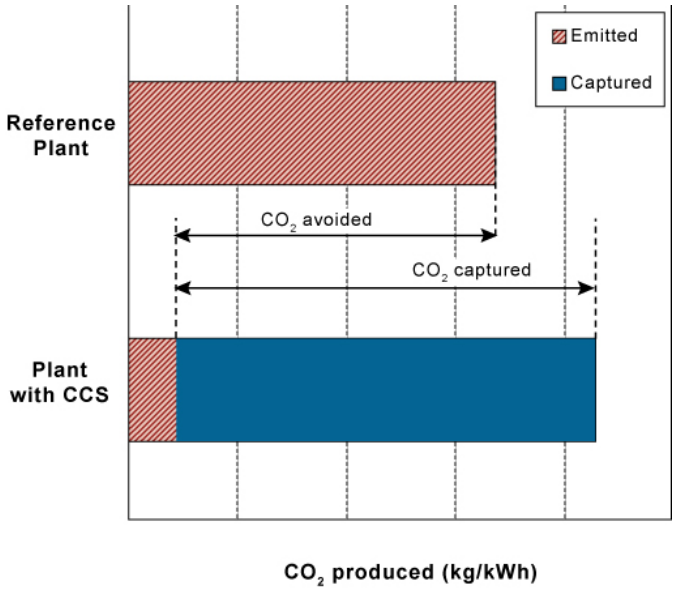
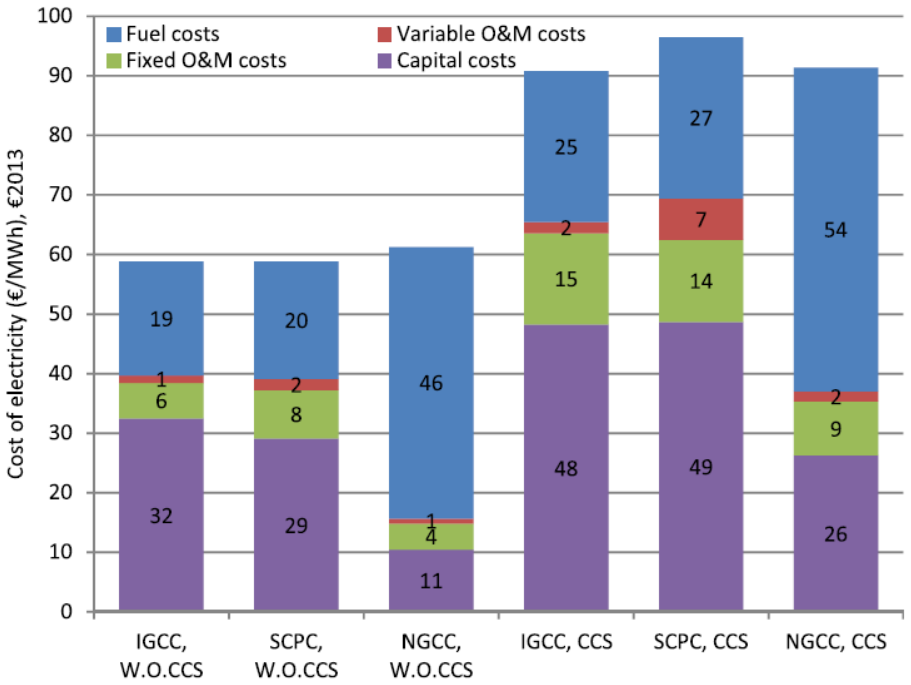
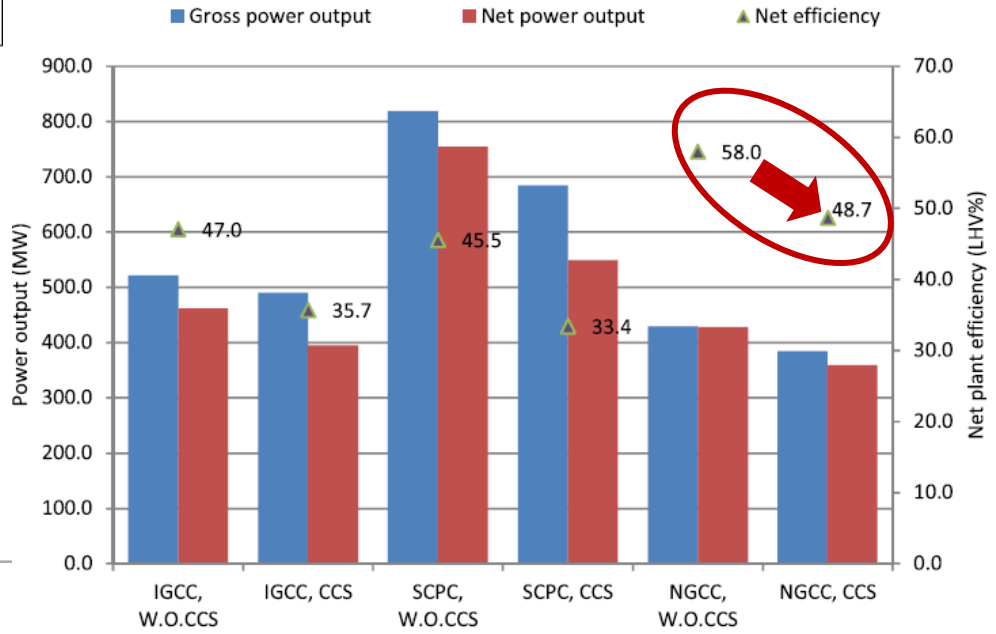
Consequences on the performance

Source: IPCC Special Report on CCS







Source: http://dx.doi.org/10.1016/j.ijhydene.2014.08.020

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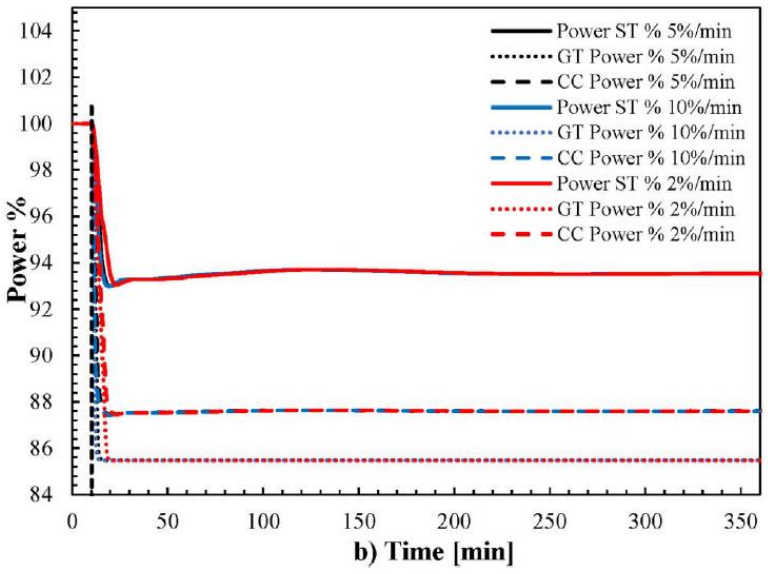
Post-combustion capture dynamics

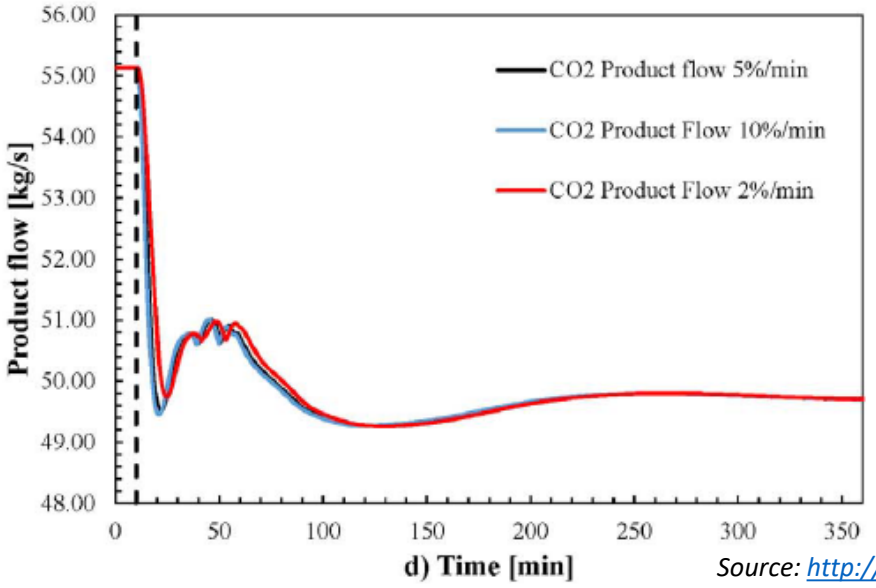
Source: PhD Thesis of Nina Enaasen Flø, NTNU, https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/301562

	Residence time [min]	Volumetric flow solvent [m^3/min]	Hold-up [m^3]
Absorber sump	5	32.9	164.6
Buffer tank	16	68.8	1100.5
Reboiler	5		353.2
Desorber sump	5	70.7	353.3
Desorber sump and reboiler	10	70.7	706.6
Cross heat exchanger and piping	26	66.8	1736.7
Reboiler steam side	1	5.9	5.9

Acc. to a simulation study by Montañés et al. (100-85% load change):

1. The capture addition to the NGCC plant should not impose any problem for stable power plant operation under scheduled load changes
2. Inefficient transient operation of the PCC unit can be expected in the long timescales
3. The control parameter is also affecting the transient performance of both GT and PCC sides





Source: http://dx.doi.org/10.1016/j.ijggc.2017.05.011

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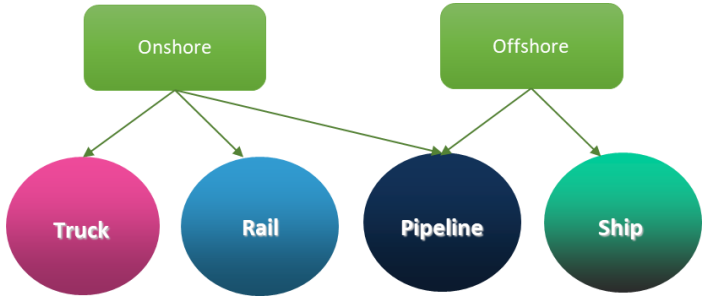
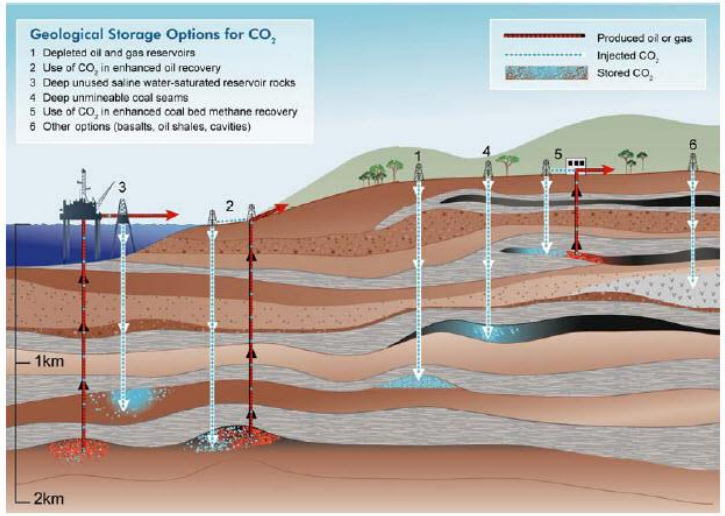
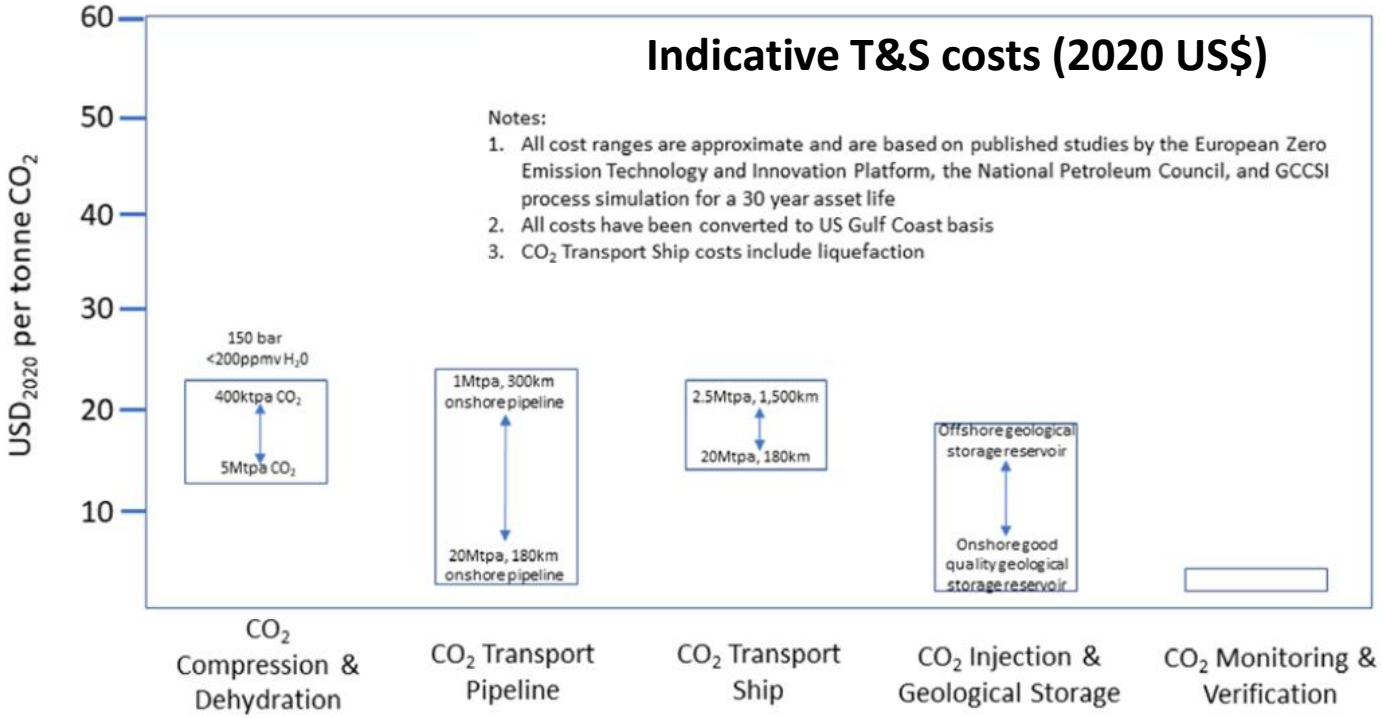
Transport & Storage

Transport





Different geological storage (*Source: IPCC & CO2CRC*)



Source: GCCSI, Technology Readiness and costs for CCS, 2021.

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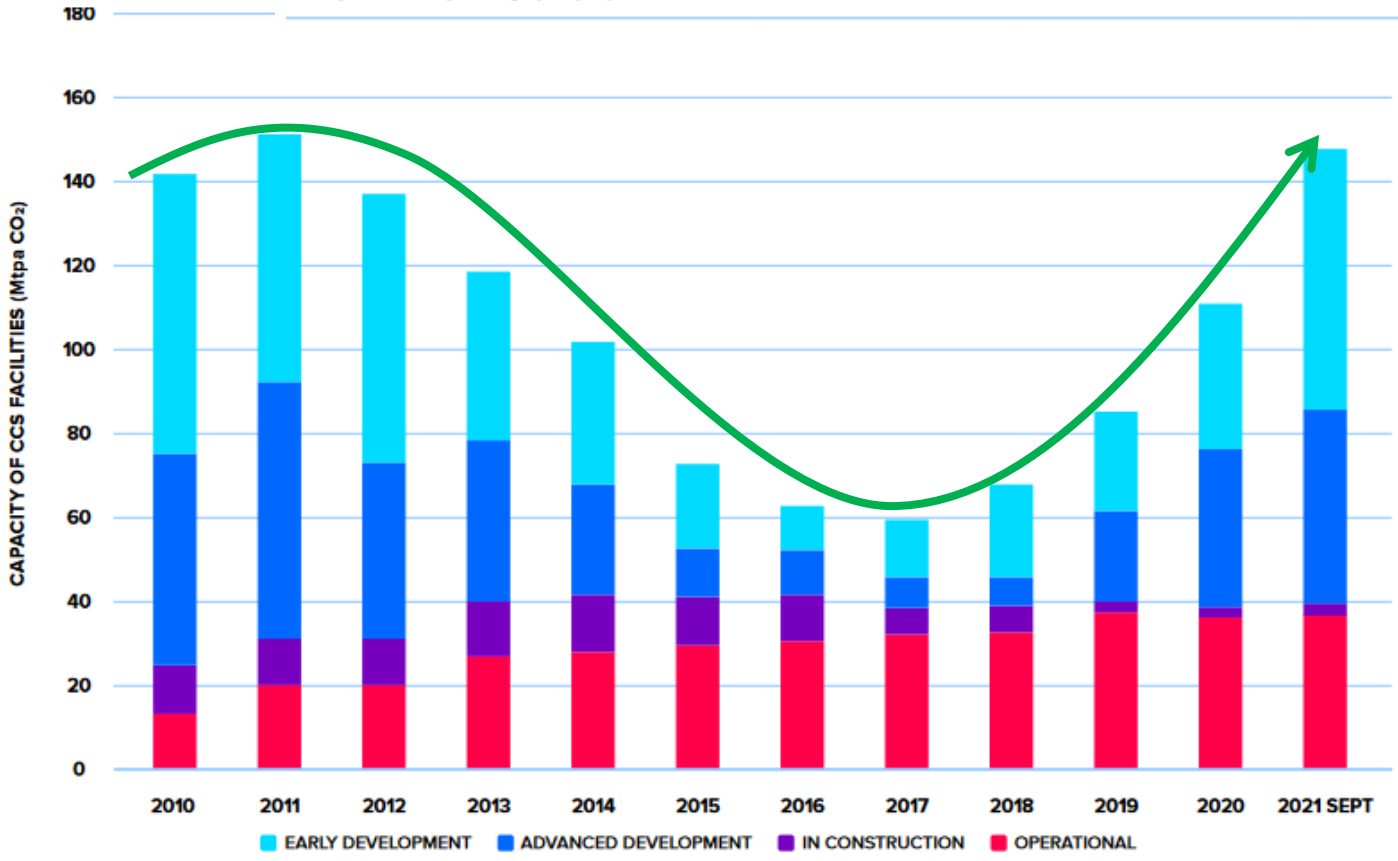
CCS projects status

	OPERATIONAL	IN CONSTRUCTION	ADVANCED DEVELOPMENT	EARLY DEVELOPMENT	OPERATION SUSPENDED	TOTAL
Number of facilities	27	4	58	44	2	135
Capture capacity (Mtpa)	36.6	3.1	46.7	60.9	2.1	149.3



In Europe (acc. to GCCSI):

- 35 projects under development (as of Sep. 2021)
- Mostly around the North Sea region, but also in other locations

Source: GCCSI, Global Status of CCS 2021

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CCS projects in Europe

Source: IOGP, https://iogpeurope.org/wp-content/uploads/2022/01/Map-of-EU-CCS-Projects-January-2022.pdf

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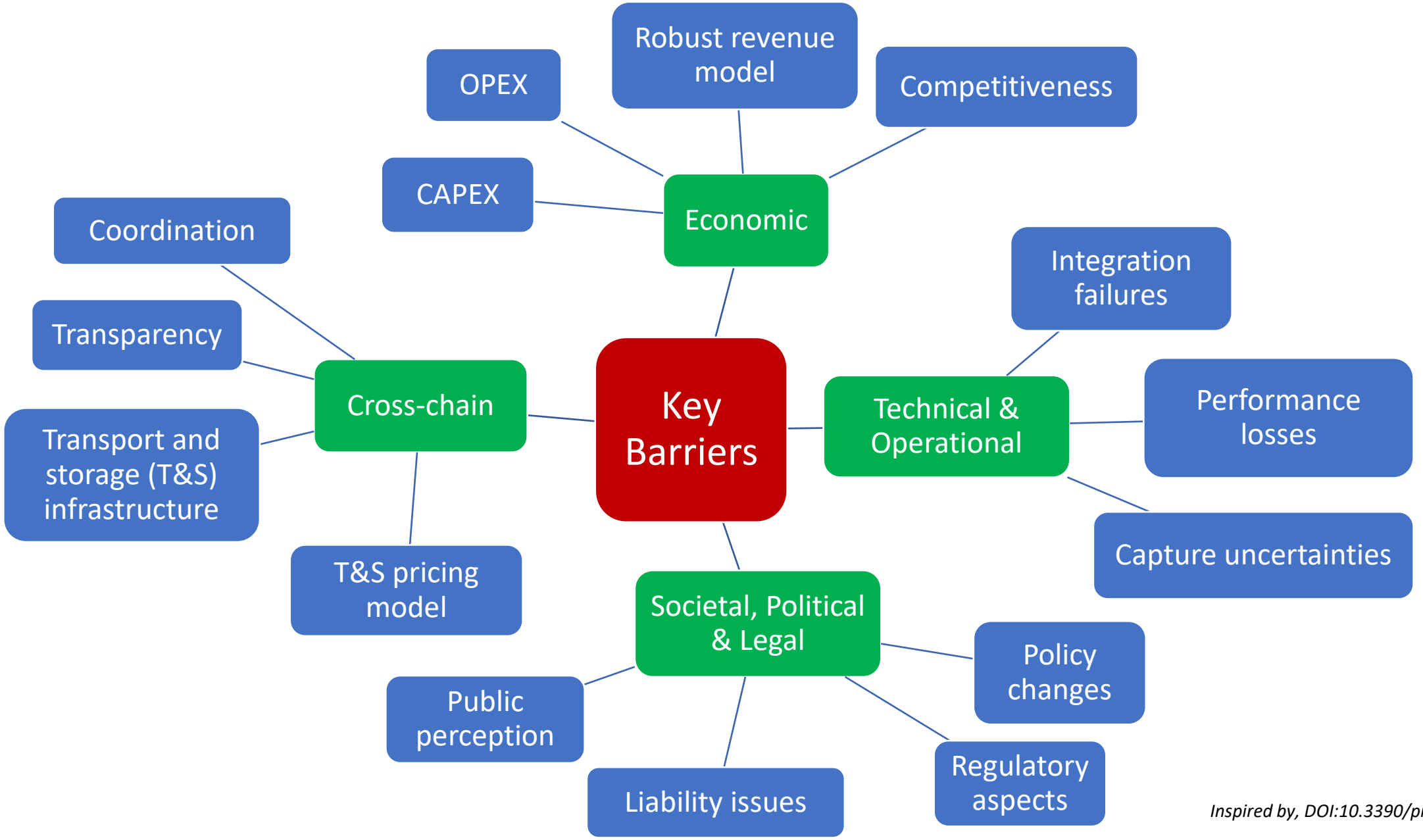
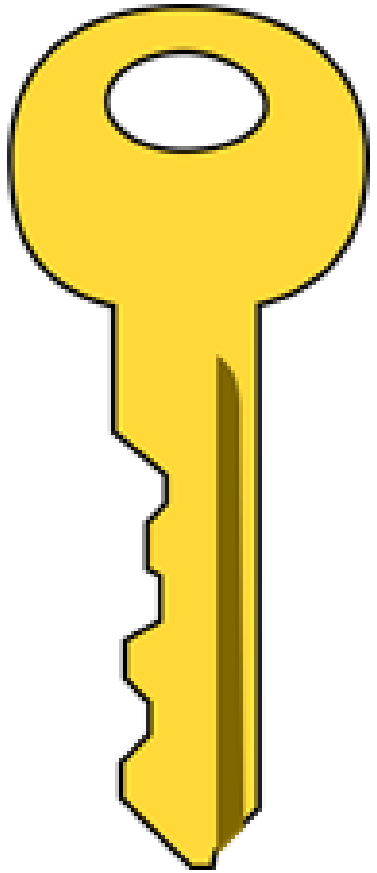


Inspired by, DOI:10.3390/pr8050576

Key takeaways & discussion points



There are several challenges when considering CC(U)S as a mitigation option more specifically for the GT users

Costs, performance losses, CO_2 partial pressure, immaturity of technologies etc.

Does it make sense to invest in such a cost intensive integration:

When operated only a couple of hundreds of hours annually?

What about other users than the utility sector?

Short-term implementation targeted or a long-term vision?

Thank you!