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Carbon Dioxide Removal

Analysis of CDR technologies and their role in meeting the Paris Climate Goals

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Agenda

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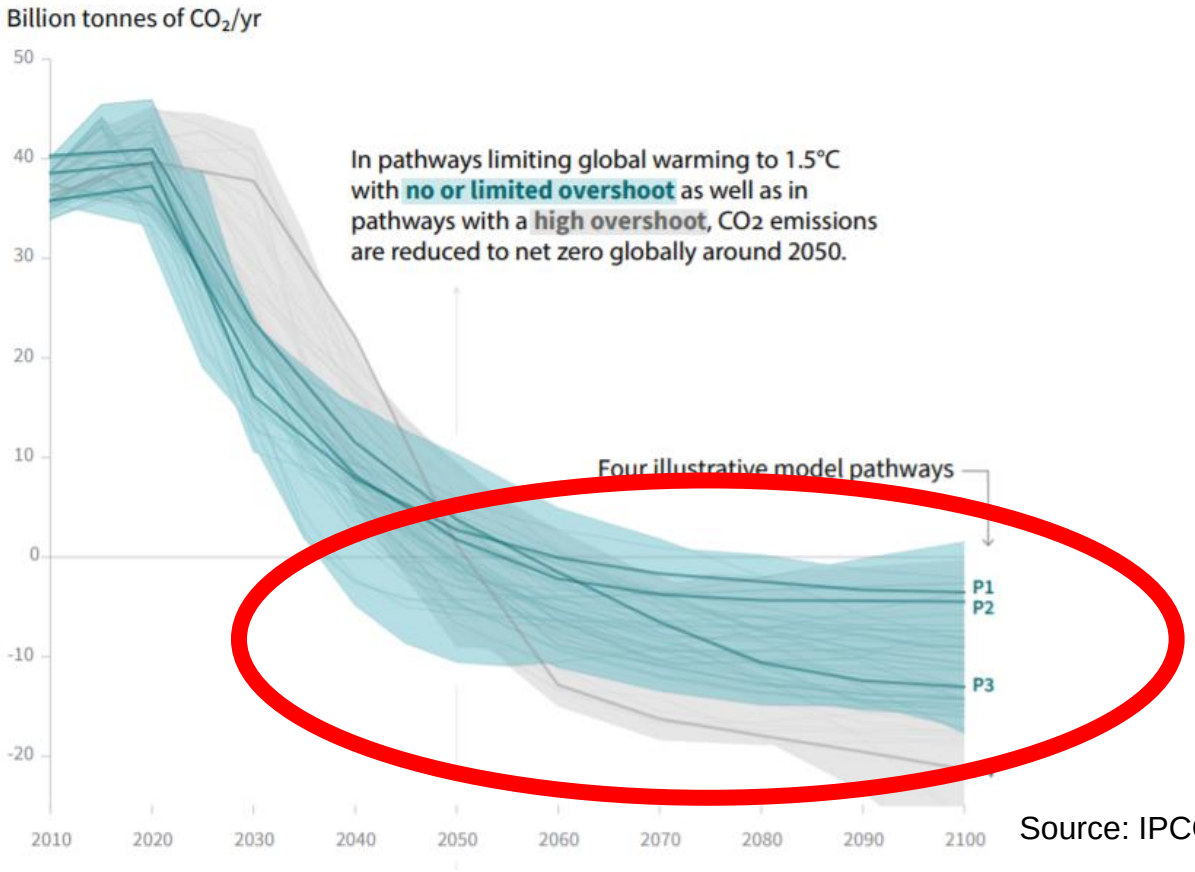
1) Motivation



Source: IPCC 2018b, p. 15

Yet „technologies for CDR are mostly in their infancy despite their importance to ambitious climate change mitigation pathways" (IPCC 2018a, 70)

2) CDR technologies and measures

CCTS based CDR	Other CDR
BECCTS	Afforestation / Reforestation
DACTS	Enhanced Weathering
	Ocean Fertilization

2.1) Carbon Capture, Transport and Storage (CCTS)

- **Capturing CO2 from point sources, transporting, and storing it (permanently) underground**
- **Technology deployed since the 70s for EOR**
- **CO2 capturing technology applied in industrial processes and gas processing plants**
- Worldwide two power plants equipped with “Carbon Capture” equipment currently operating: Petra Nova (USA), Boundary Dam Power Station (BDPS) Block 3 (Canada)
  - Captured CO2 used for enhanced oil recovery
  - at BDPS small-scale permanent storage pilot project with excess CO_2 not used for EOR

- **But:**
  - Large number of projects canceled before completion (see next slide)
  - Public funding schemes cut down (e.g. USA, Norway, …)

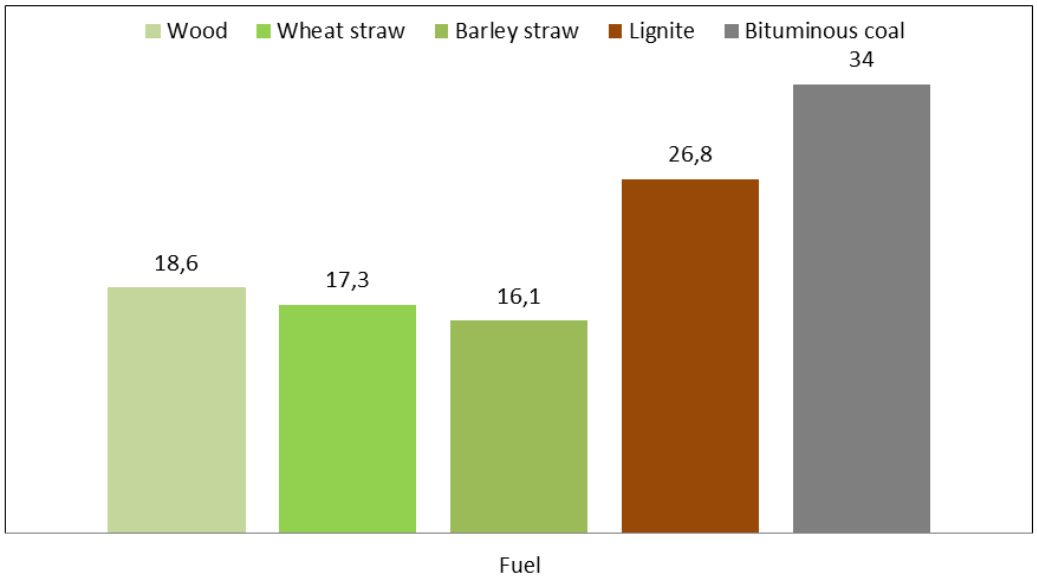
2.1) Carbon Capture, Transport and Storage (CCTS)

Project	Jänschwalde	Porto-Tolle	ROAD	Belchatow	Compostilla	Don Valley	Killingholm (C-GEN)	Longannet Project	Getica	ULCOS	Green Hydrogen
Country	DE	IT	NL	PL	ES	UK	UK	UK	RO	FR	NL
Technology	Oxyfuel	Post	Post	Post	Oxyfuel	Pre	Pre	Post	Post	Post	Pre
Storage	Aquifer	Aquifer	Oil-/ gasfield	Aquifer	Aquifer	EOR	Aquifer	EOR	Aquifer	Aquifer	EGR
Capacity [MW]	250	250	250	260	320	650	450	330	250	Steel	H_2
Plan in 2011	2015	2015	2015	2015	2015	2015	2015	2015	2015	2016	2016
Status in 2018	canceled 2011	canceled 2014	canceled 2017	canceled 2013	canceled 2013	canceled 2015	canceled 2015	canceled 2011	canceled 2014	canceled 2012	canceled 2012
	White Rose (UK Oxy)	Peel Energy	Peterhead	Teesside (Eston)	Eemshaven	Pegasus	Maritsa	Mongstad	Caledonia Clean Energy	Norway Full Chain CCS	
Country	UK	UK	UK	UK	NL	NL	BG	NO	UK	NO	
Technology	Oxyfuel	Post	Post	Various	Post	Oxyfuel	Post	Post	Post	Various	
Storage	Aquifer	Oil-/ gasfield	Oil-/ gasfield	Aquifer	EOR	Oil-/ gasfield	Aquifer	Aquifer	Aquifer/EOR	Aquifer	
Capacity [MW]	430	400	400	0.8 Mtpa	250	340	120	630	3 Mtpa	1.3 Mtpa	
Plan in 2011	2016	2016	2016	2016	2017	2017	2020	2020	-	-	
Status in 2018	canceled 2016	canceled 2012	canceled 2015	mid 2020s	canceled 2013	canceled 2013	canceled 2013	canceled 2013	2024	2022	

Sources: Adapted from (Oei, Kemfert, et al., 2014), including information from (GCCSI, 2014) and (GCCSI, 2017). Further sources about individual projects: Caledonia Clean Energy - http://www.globalccsinstitute.com/projects/caledonia-clean-energy-project, last accessed May 5, 2018; Norway Full Chain CCS - http://www.globalccsinstitute.com/projects/norway-full-chain-ccs-project, last accessed May 5, 2018; Don Valles & White Rose - https://euobserver.com/investigations/139257, last accessed May 5, 2018; ROAD - http://ieefa.org/ieefa-europe-carbon-capture-dream-dying/, last accessed May 5, 2018; Killingholm - http://sequestration.mit.edu/tools/projects/killingholme.html, last accessed May 5, 2018; Peterhead - https://www.shell.co.uk/about-us/latest-news-and-features/2015-news-and-features/peterhead-ccs-project-announcement.html, last accessed May 5, 2018.

2.2) Bioenergy with Carbon Capture, Transport and Storage (BECCTS)

- **Like CCTS, but usage of biomass instead of fossil fuels**
- **Unlike CCTS, potential to be truly a „negative emissions“ technology**
- **Problems: Lower LHV, competiton for land usage**
- **Drax Power Station (UK) only existing power plant equipped with BECCTS, but without storage capability**
- **Unproven whether BECCTS is truly emissions negative**



Source: own illustration based on McKendry (2002)

2.3) Direct Air Capture, Transport and Storage (DACTS)

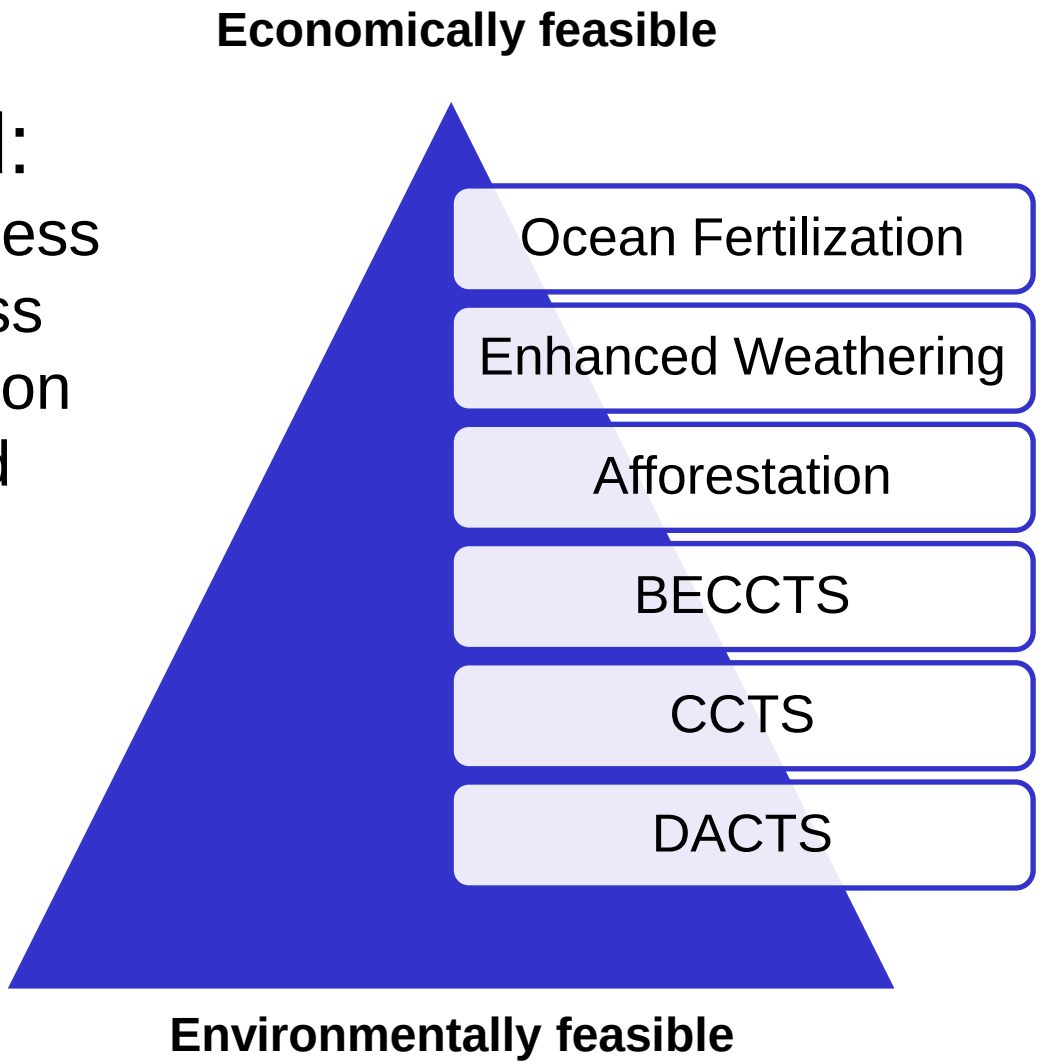
- **Versatile technology potentially applicable everywhere**
- **Inefficient and expensive due to low concentration of carbon dioxide in ambient air and high energy requirements**
- **Multiple facilities operated by Climeworks (Switzerland) and Carbon Engineering (Canada)**
- **Largest facility captures just approx. 900 tCO_2 per year with 600$ per tCO_2 captured[1]**
- **Very unlikely these problems can be solved in the near future or at all**

Climeworks. CNN – This power plant captures CO2 from the atmosphere. URL: http://www.climeworks.com/cnn-this-power-plant-captures-co2-from-the-atmosphere/

3) Conclusion

Challenges ahead:

- Technological readiness
- Economical readiness
- Large scale application
- Political strength and coordination
- Predicting and containment of side effects
- Competition against SDGs



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Thank you for your attention!

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