

CARBON REMOVAL WTF?

INTRODUCTION TO THE SCIENCE

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SCI + ENG + TECH

POLITICS + PoLICY

BUSINESS

CAPITAL

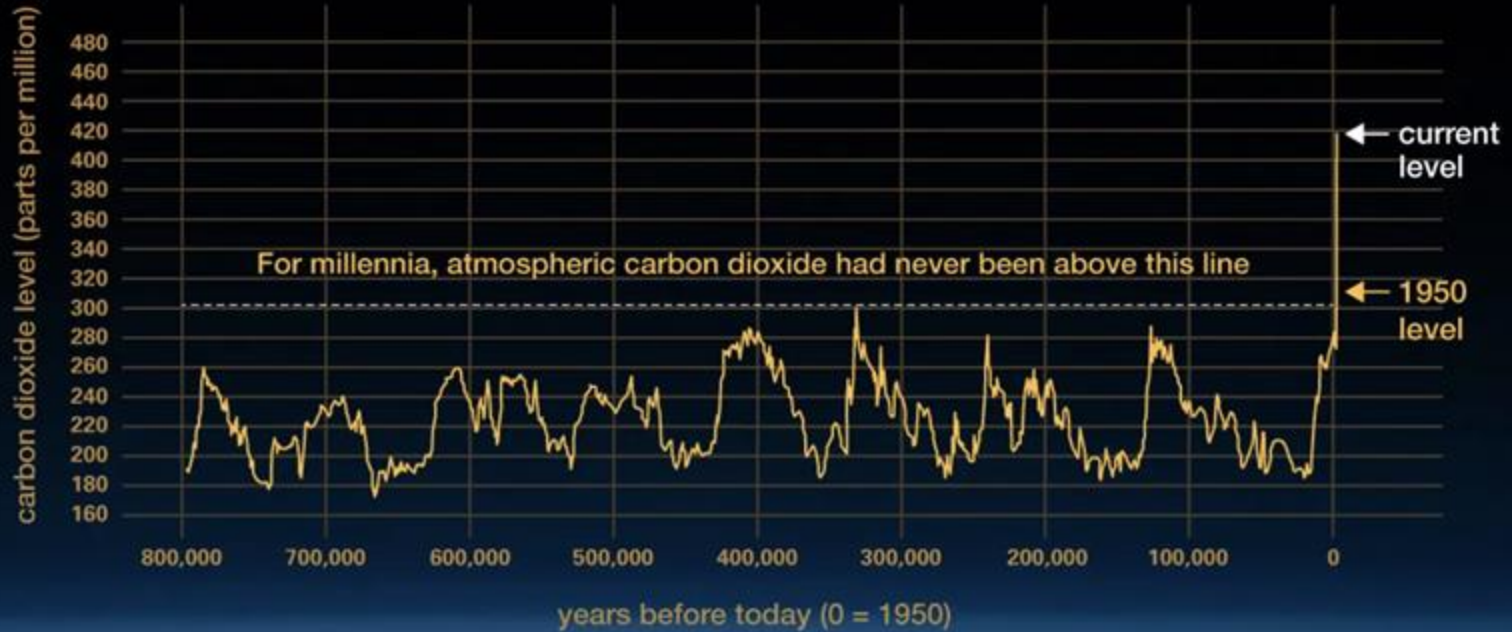
COMMUNITY

MEDIA



NEW

[CO₂] went from ~0.03% to ~0.04%...that's a huge problem (!)

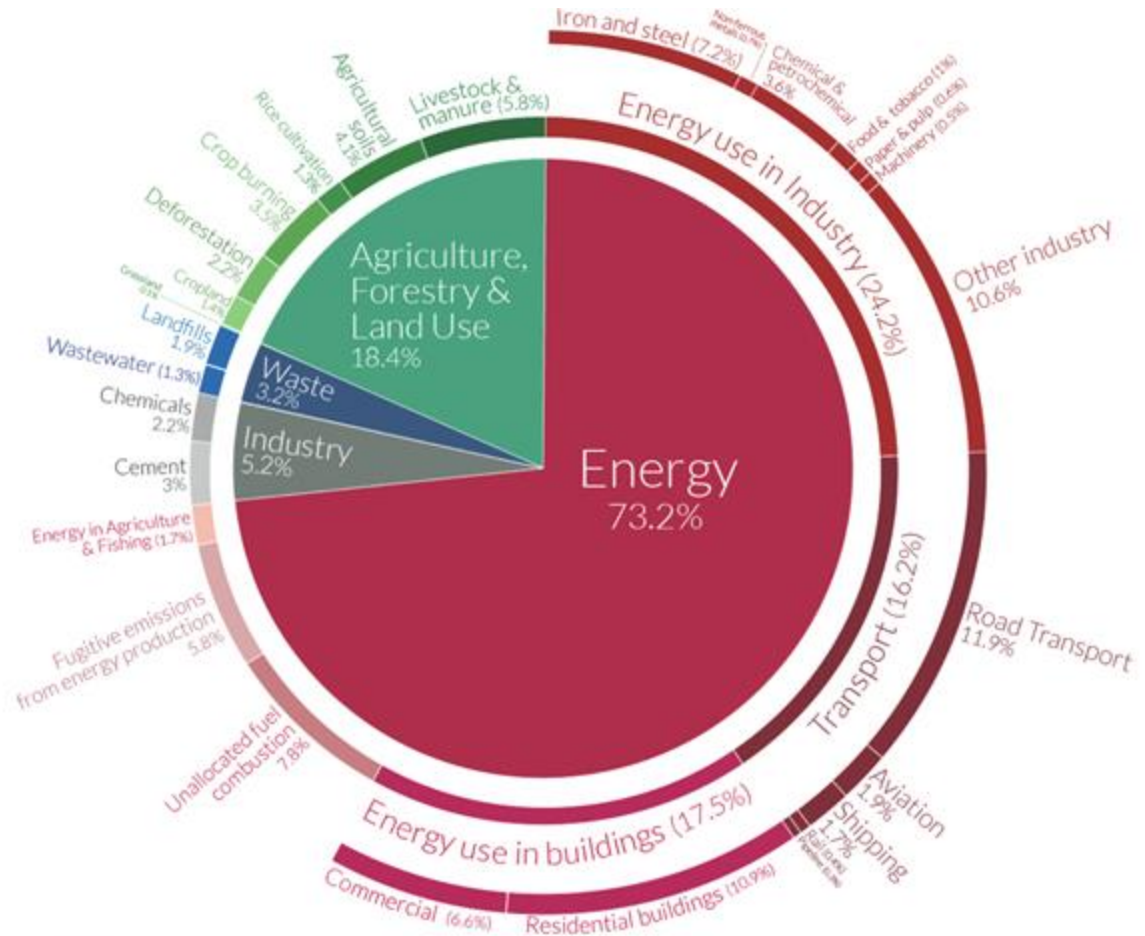


Everyone you have ever known or even heard of lives here



WHERE DO ALL THE CARBON EMISSIONS COME FROM?

... mostly from energy use



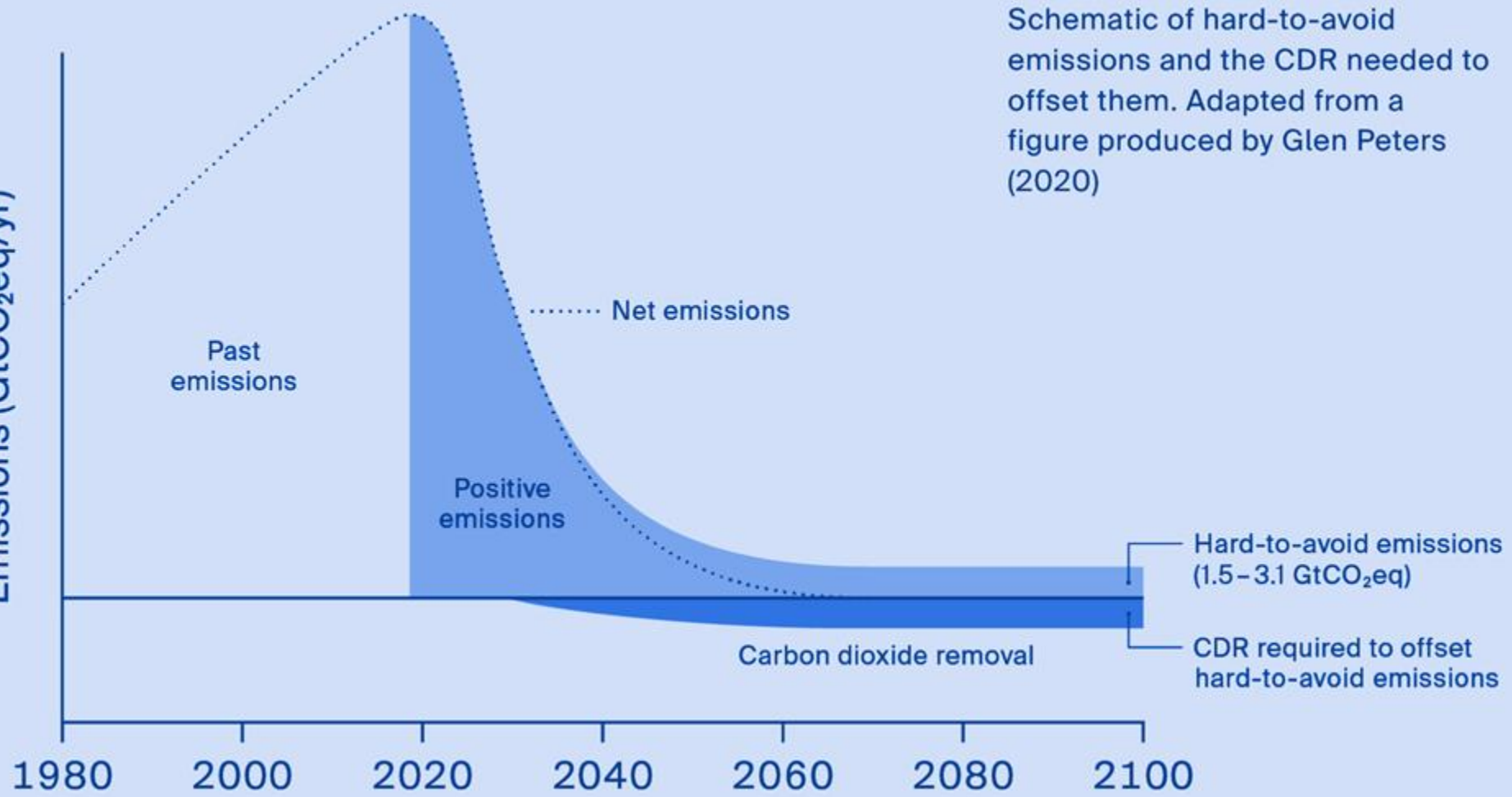
CAPTURE CO₂ from the air or ocean

- + PROCESS / CLEAN UP as needed
- + SEQUESTER (in rock, or in useful stuff)

= CARBON DIOXIDE REMOVAL (CDR)

Schematic of hard-to-avoid emissions and the CDR needed to offset them. Adapted from a figure produced by Glen Peters (2020)

Emissions (GtCO₂eq/yr)



BUT WHY? FOUR REASONS TO REMOVE CARBON

CLEAN UP Eliminate yesterday's emissions

BALANCE Net-zero requires some CDR (e.g. 10 Gt/yr by 2050)

RISK Reduce risk of “overshooting” 2°C

***JUSTICE** A pathway for restoration and fairness



CAN IT SCALE?



CAN IT LAST?



DOES IT WORK?



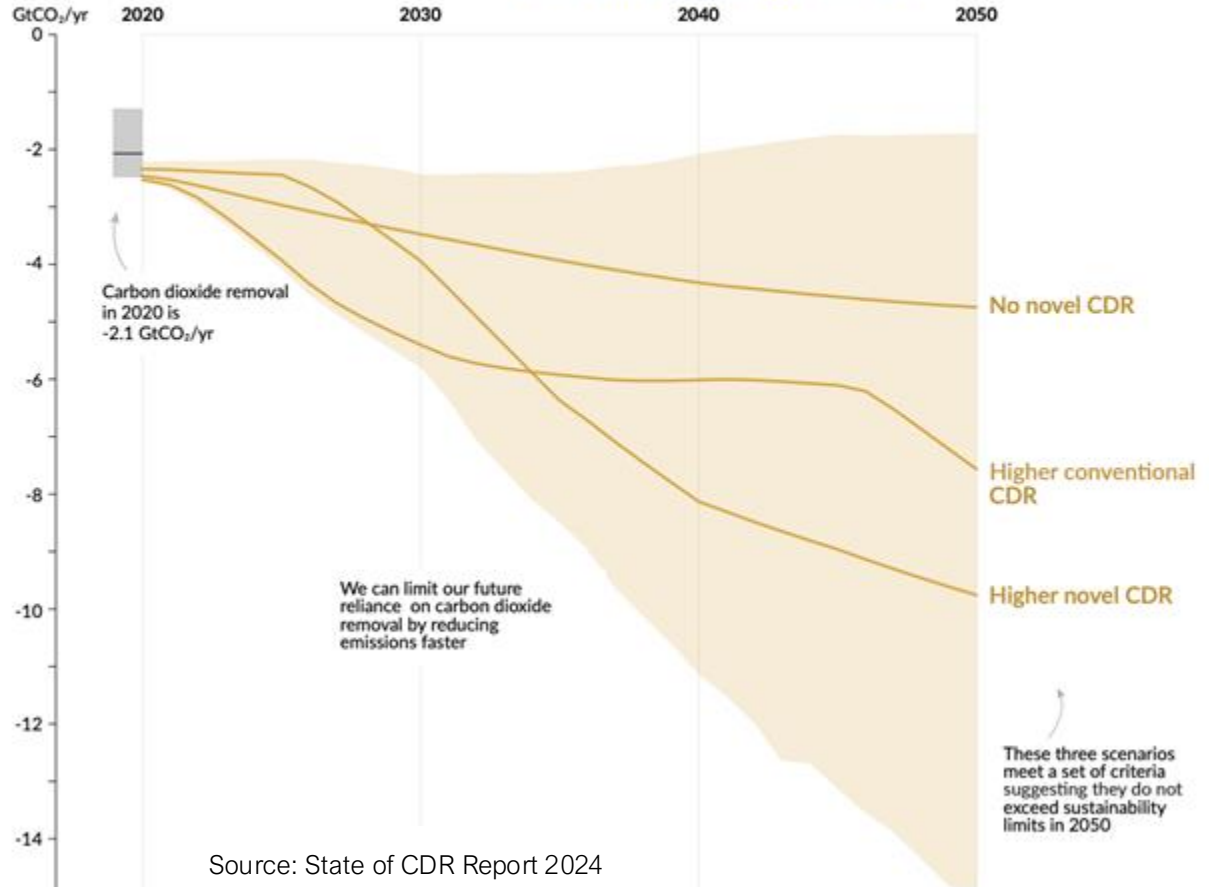
DOES IT WORK WELL?



COST AT SCALE?

Carbon dioxide removal is a feature of all 1.5°C scenarios that meet the Paris temperature goal, in addition to reducing emissions

Carbon dioxide removal (GtCO₂/yr), in 2020 and in three Paris-consistent 1.5°C scenarios



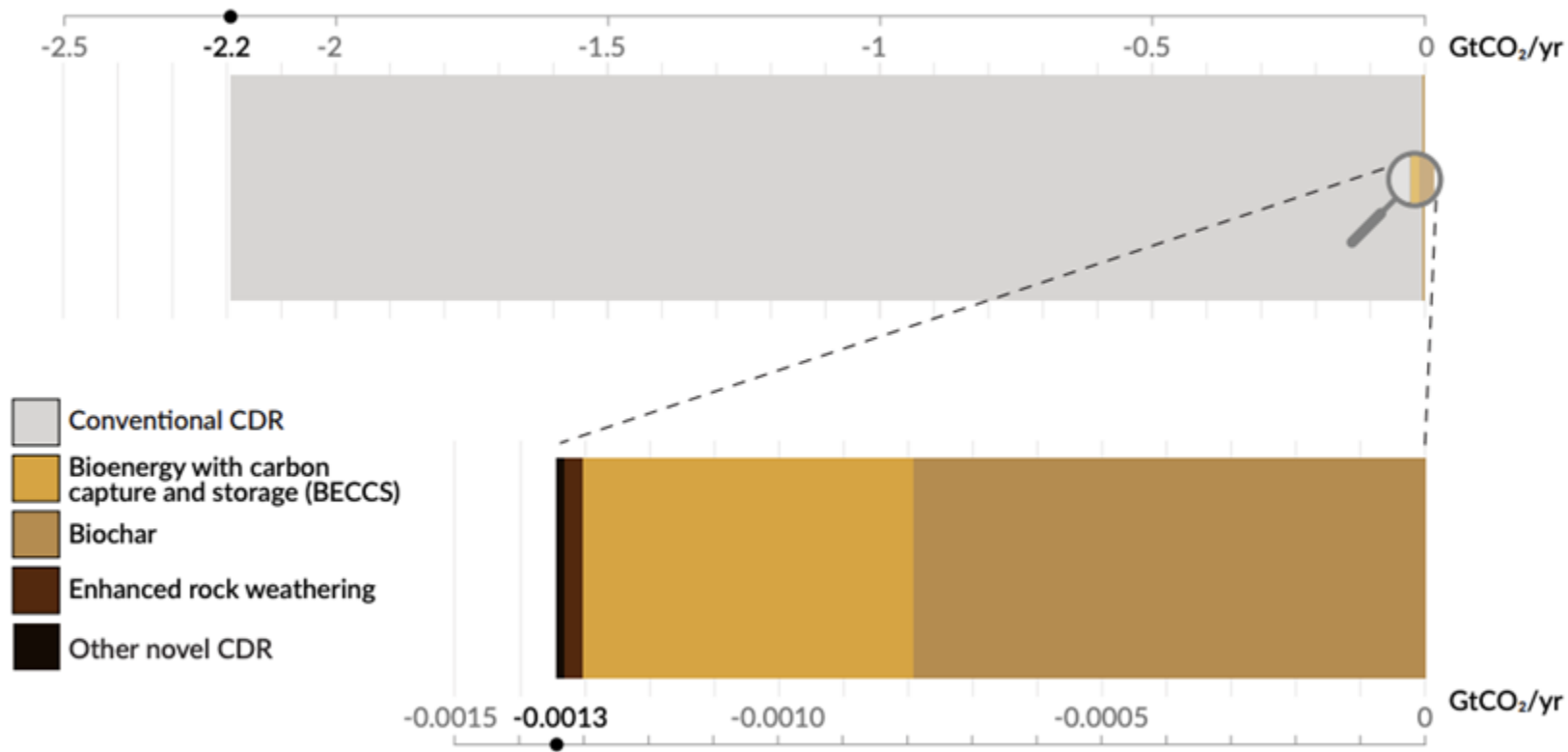
Source: State of CDR Report 2024

HOW MUCH CDR
DO WE NEED?

... WAY more than
we have today.

Only a tiny fraction of all carbon dioxide removal results from **novel methods**

Total amount of carbon dioxide removal, split into **conventional** and **novel** methods (GtCO₂/yr)



Amount of carbon dioxide removal (CDR) is the sum of conventional CDR (2013-2022) and novel CDR (2023)

Source: State of CDR Report 2024



UNITED NATIONS TIMELINE

MOOD



2007	IPCC AR4 CCS	CDR IS NOT A RELEVANT THING
2015	IPCC AR5 CDR methods have biogeochemical and technological limitations to their potential on the global scale. There is insufficient knowledge to quantify how much CO2 emissions could be partially offset by CDR on a century timescale. CDR methods may carry side effects and long-term consequences on a global scale. (footnote 18, p23)	MAYBE, BUT PROBABLY NOT
2018	IPCC SR15 All modeled scenarios limiting warming to 1.5C with no or limited overshoot rely on CDR (e.g. Summary for policymakers, p14)	ALRIGHT FINE! SOME IS REQUIRED
2019+	Trillion Trees. Let's plant trees! No. But. Yes. And. etc.	WHY DO YOU HATE TREES?
2022	IPCC AR6 Need additional 1.2 Gt/yr of CDR by 2030 (summary report)	MORE, SOONER THAN WE THOUGHT
2023	Paris Agreement Article 6.4 Supervisory Body "Engineering-based approaches are technologically and economically unproven...do not contribute to sustainable development...not suitable for implementation in developing countries...do not contribute to reducing mitigation costs...do not serve any of the objectives ...Article 6.4..."	YES, BUT ONLY MY FAVORITE FLAVOR OF CDR



NO, IT'S A MYTH

NETFLIX

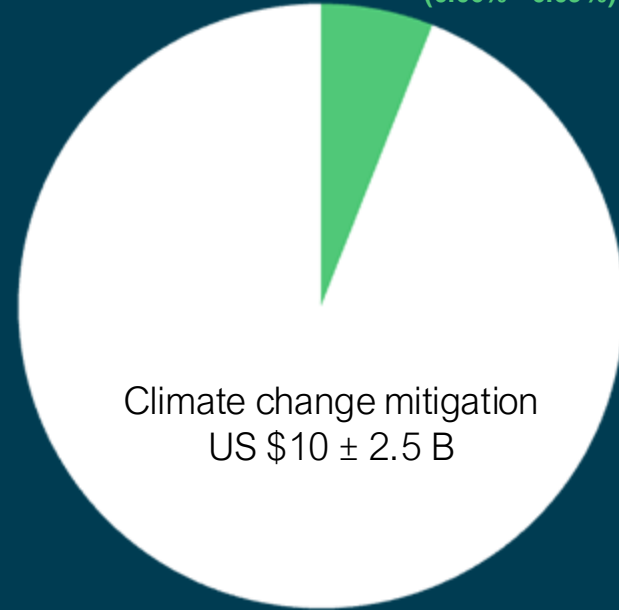
CDR	JUST CCS IN DISGUISE
ENGINEERED	NATURE BASED
CDR GETS	TOO MUCH MONEY & PRESS
ONLY AFTER	DEEP DECARBONIZATION
OFFSETS	DELAY REAL ACTION
SHINY PLAYTHING	TECH BROS
UNPROVEN	EXPENSIVE

0.1% CLUB: PHILANTHROPY, GLOBAL (2021)

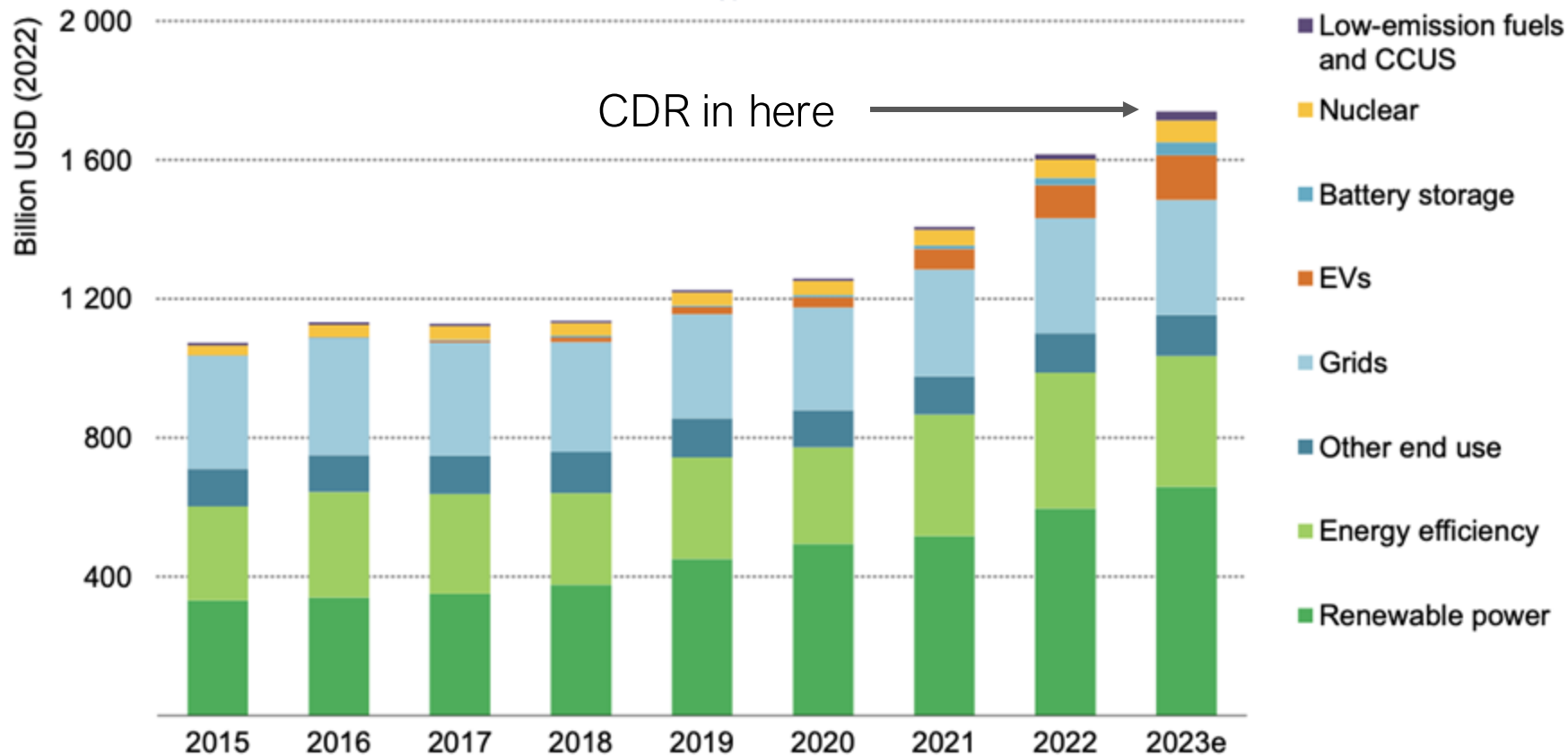
Climate change mitigation
US \$10 ± 2.5 B (0.9% - 1.5%)



Carbon dioxide removal
US \$0.60 ± 0.15 B (6%)
(0.06% - 0.09%)



Annual clean energy investment, 2015-2023e



THANK YOU

EXTRA / APPENDIX

CDR ANALOGUES & TRUST

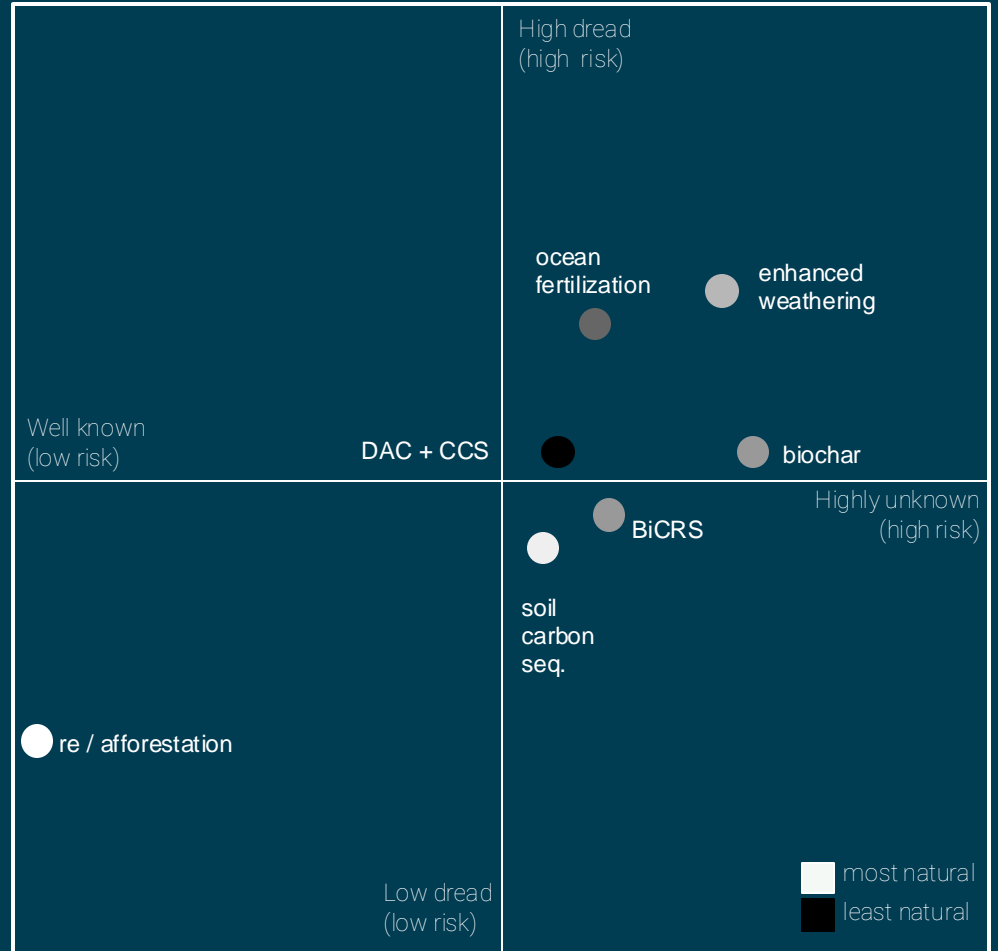
CDR PATHWAY	FEATURES <i>(ops., financing, human factors)</i>	ANALOGUE / TRUST
DAC + storage	Air handling, steel, construction, FEED studies, infrastructure; closed system	Onshore wind, drilling, pipelines
Afforestation	Seedlings / nurseries, labor intensive, remote sites, long maturation time; open system	Forest management, timber, conservation
Soil carbon	Soil handling, tilling / mixing, microbiome, community-based; open system	Food, agriculture
Bio. carbon + storage (BiCRS)	Bio-material handling, logistics, steel & concrete construction, FEED studies, infrastructure; closed + open systems	Pulp and paper, drilling, pipelines
Enhanced rock weathering (ERW)	Logistics; open + closed systems	Mine tailings, remediation, agriculture
Ocean fertilization	Logistics, open system (??)	Russ George experiment of 2012. Aquaculture?
CO2 removal from seawater (DOC)	Water handling, steel & concrete construction, FEED studies; closed + open	Municipal water treatment, desalination

CDR

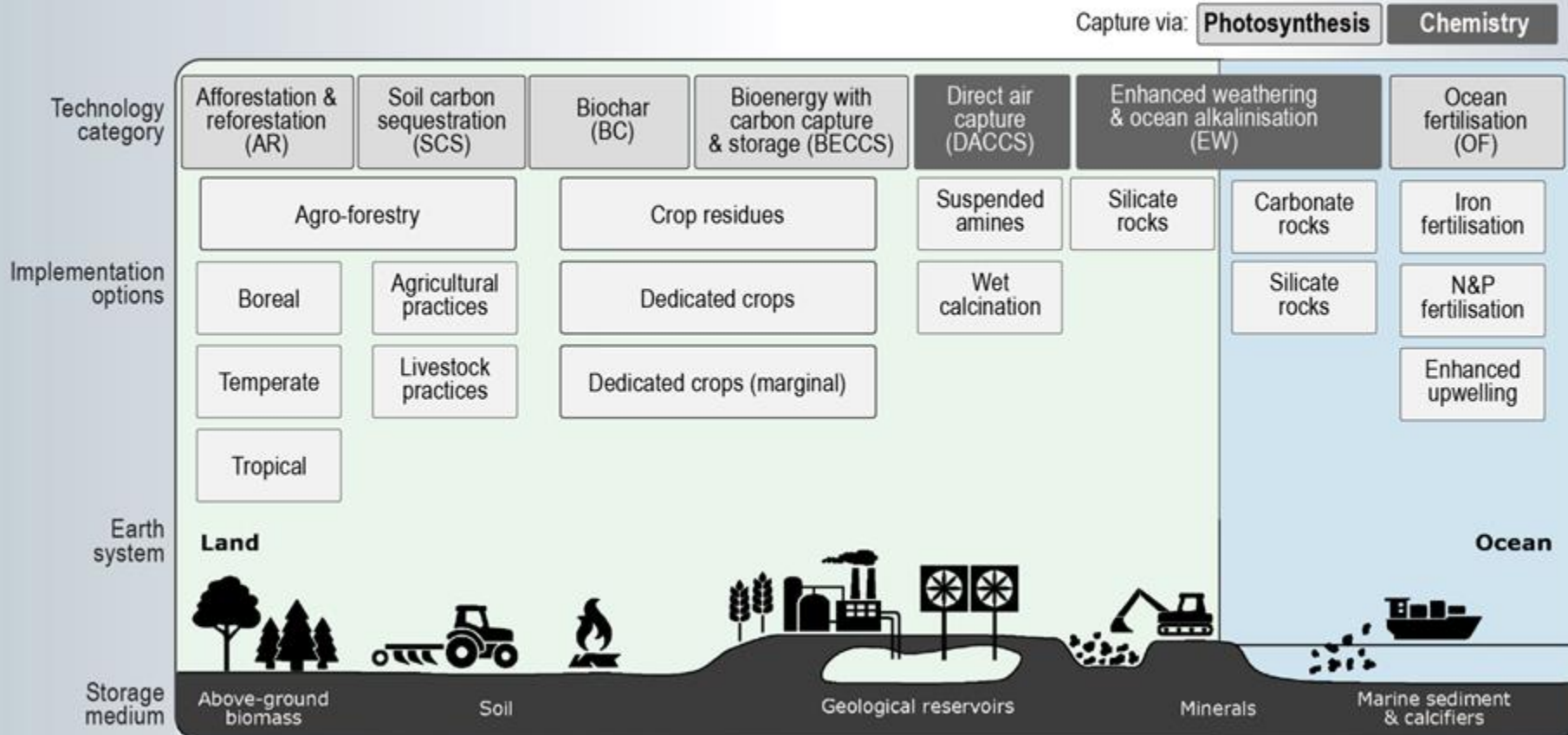
PERCEPTIONS

Public perception can inform policy, capital, and business, and the climate community, not just social acceptance

Reproduced from Behavioural frameworks to understand public perceptions of and risk response to carbon dioxide removal, T.R.Schrum et al., *Interface Focus* 10, 20200002 (2020). N = 113 Amazon MTurk participants.



Options for Negative Emissions: Plants or Chemistry



9 minutes

Dr. Marcius Extavour–

Title: CDR & the science surrounding it

Brief: Define CDR, introduce key scientific concepts relating to CDR, IPCC Modeling, Climate Budgets

Slide outline

1. Title
2. Intro to me personally
3. What is all this fuss about? 280 ppm vs 420 ppm. The CO₂ concentration is too damn high
4. How did we get here? Graph - it's us, specifically use of fossil fuels
5. WHY CDR?
 - a. We're now past the point of JUST reducing; we also will need to clean up some past emissions
 - b. We may also not be able to, or NOT WANT TO bring our emissions to zero, it's possible that CDR may be cheaper solution
 - c. The 80%, 90%...
6. Defining CDR
7. CDR vs emissions reductions
8. How much do we need? 10 Gt/yr by 2050...More on that later
9. Needed CDR vs existing CDR - we're closer to being at 0 than we are
10. Time matters - Durability. What is it, why it's important, how different methods may vary in permanence. Introduce the concept and why it matters
11. Knowledge gaps - list of questions
12. CDR in context: it's getting a lot of buzz, but is still a tiny part of the actual energy and spending. BUT GROWING VERY FAST
13. END: hot take: list of CDR "myths" (truth-isms)