Emerging Technologies to Address Climate Change:

Focus on Negative Emission Technologies - Land, Ocean

Emerging Negative Emission Technologies to Address Climate Change

SDGs 13, 14, 15, 17

Proposal for Thematic Session 2

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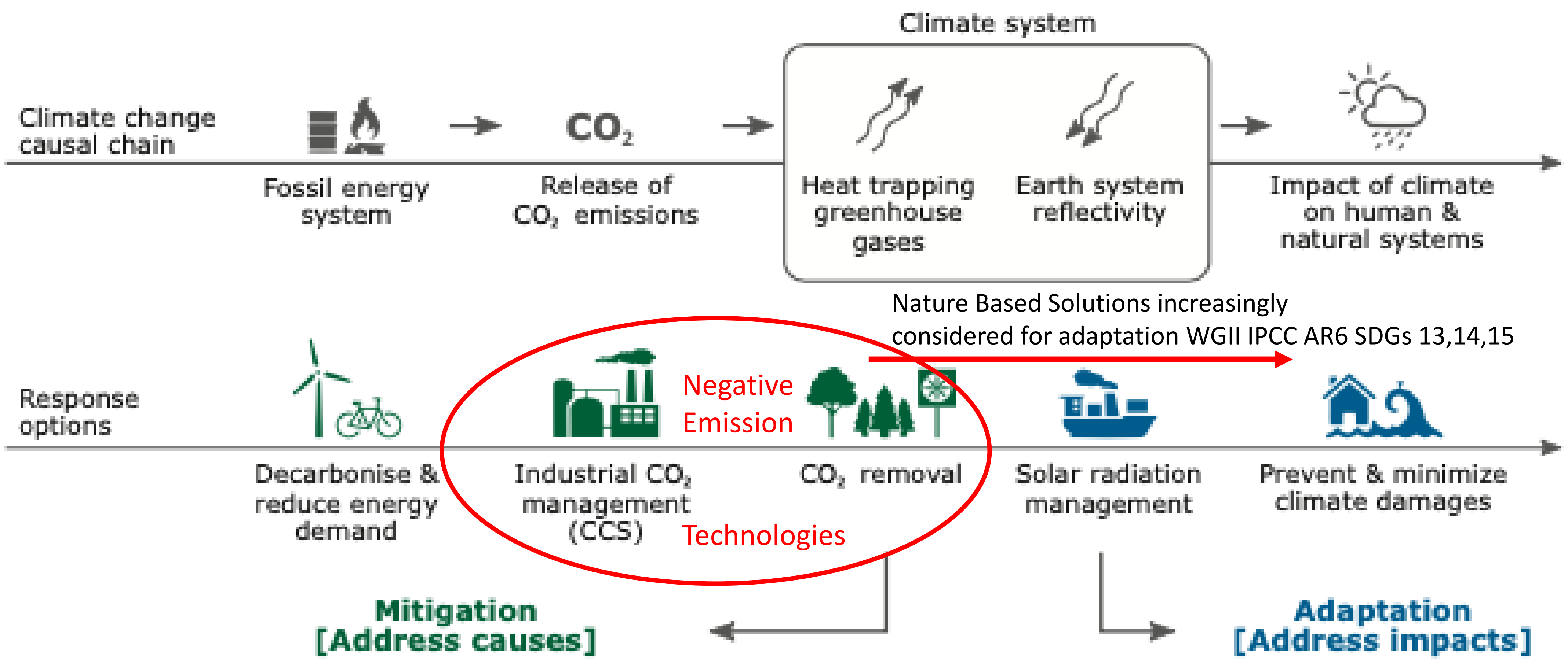
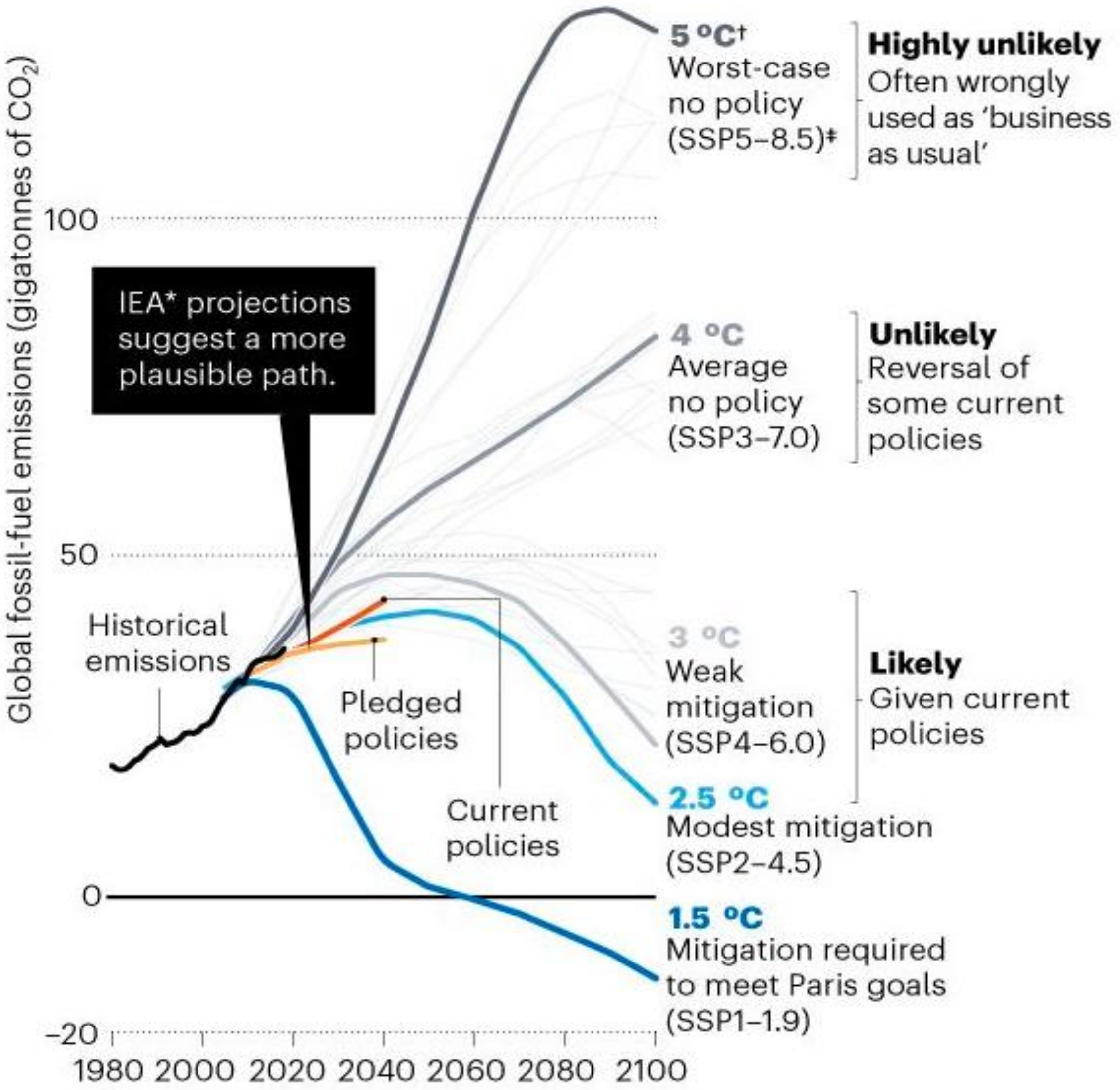


Figure 1. Human response options to the climate problem. Horizontal arrows in the top row show the causal chain of the climate change problem. Vertical arrows and bottom row define locus and modes of intervention for climate policy. Graph further developed from Keith (2000).

Jan C Minx *et al* 2018 *Environ. Res. Lett.* **13** 063001

Global Climate Goals



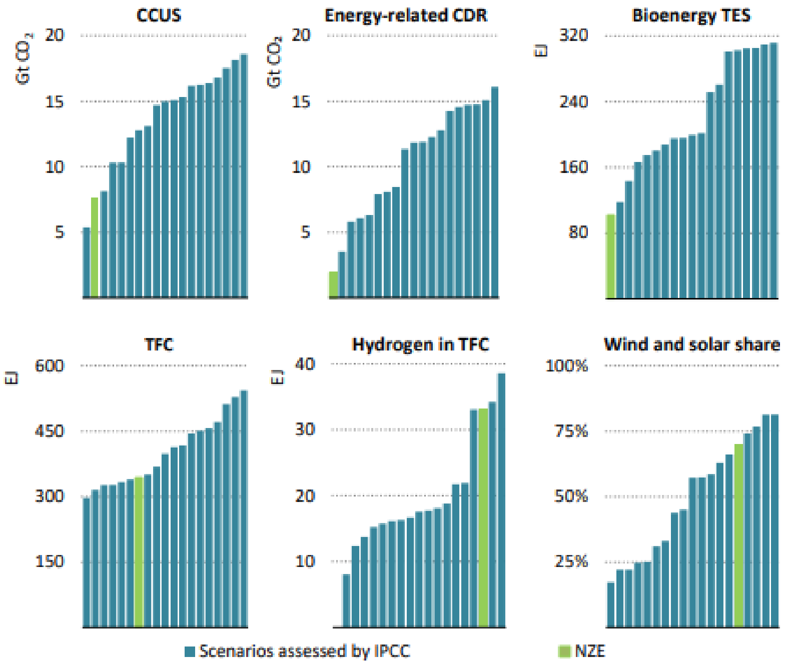
We are headed for this now

2015 Paris Goals require NET!!

Hausfather & Peters, Nature 577, 618 (2020)

Most Net Zero Carbon Scenarios even by 2050 Assume Negative Carbon Technologies

Figure 2.11 ▹ Comparison of selected indicators of the IPCC scenarios and the NZE in 2050



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The NZE has the lowest level of energy-related CDR and bioenergy of any scenario that achieves net-zero energy sector and industrial process CO_2 emissions in 2050

Notes: CCUS = carbon capture, utilisation and storage; CDR = carbon direct removal; TES = total energy supply; TFC = total final consumption. Energy-related CDR includes CO_2 captured through bioenergy with CCUS and direct air capture with CCUS and put into permanent storage. Wind and solar share are given as a percentage of total electricity generation. Only 17 of the 18 scenarios assessed by the IPCC report hydrogen use in TFC.

- **Use of CCUS.** The scenarios assessed by the IPCC have a median of around 15 Gt CO_2 captured using CCUS in 2050, more than double the level in the NZE.
- **Use of CDR.** CO_2 emissions captured and stored from BECCS and DACCS in the IPCC scenarios range from 3.5-16 Gt CO_2 in 2050, compared with 1.9 Gt CO_2 in the NZE.

Comparison of IEA and IPCC
Net Zero by 2050 Scenarios just for the energy sector–
all include CDR and CCUS

CDR – carbon direct removal
CCUS - carbon capture utilization and storage

https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

Negative Carbon Technologies put Carbon back into geological, ocean or land reservoirs

SDGs 13, 14,15,17

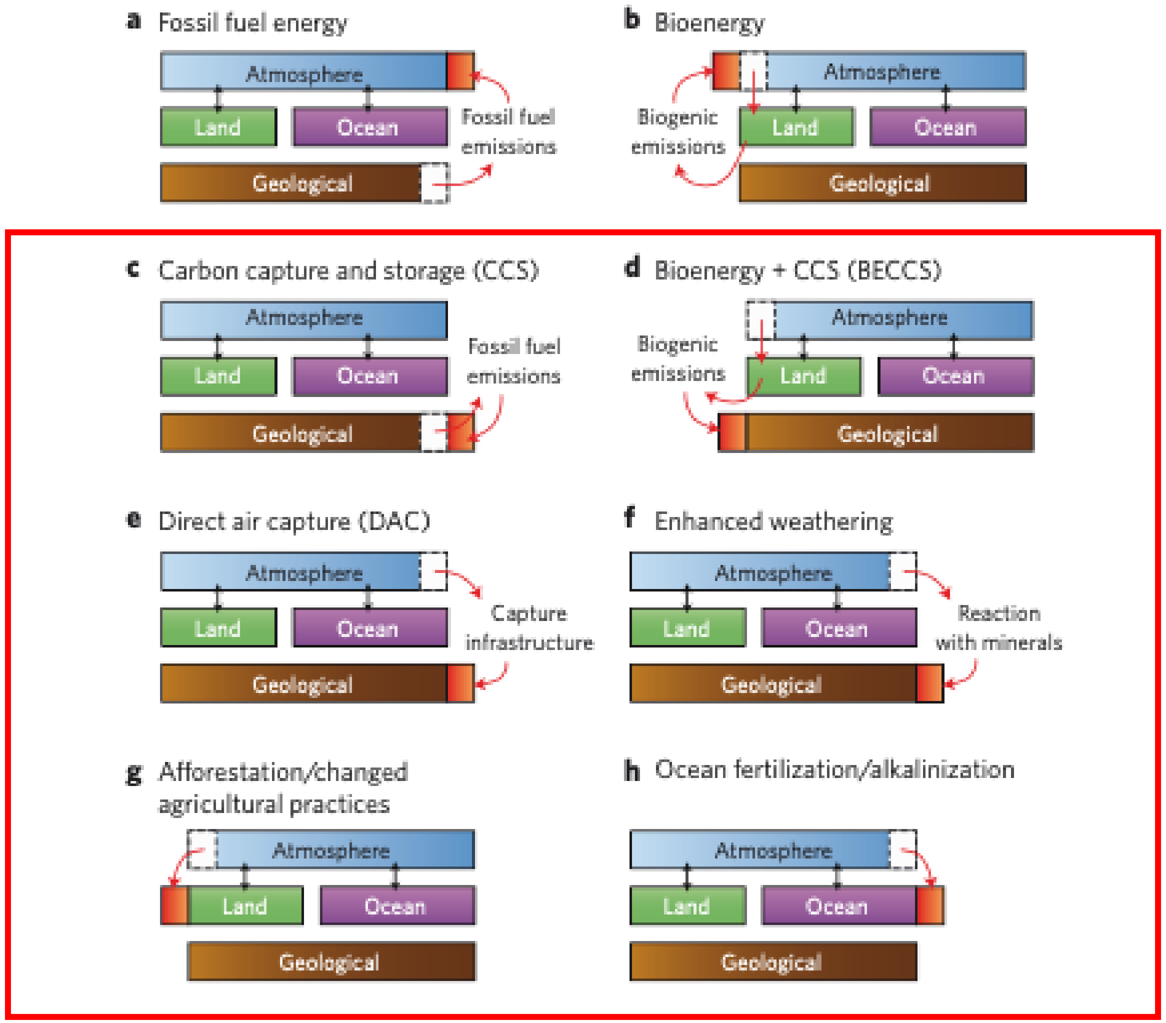


Figure 1 | Schematic representation of carbon flows among atmospheric, land, ocean and geological reservoirs. a, Climate change results from

Smith et al., Nature Climate Change DOI 10.1038 (2015)

New ocean technologies are being proposed

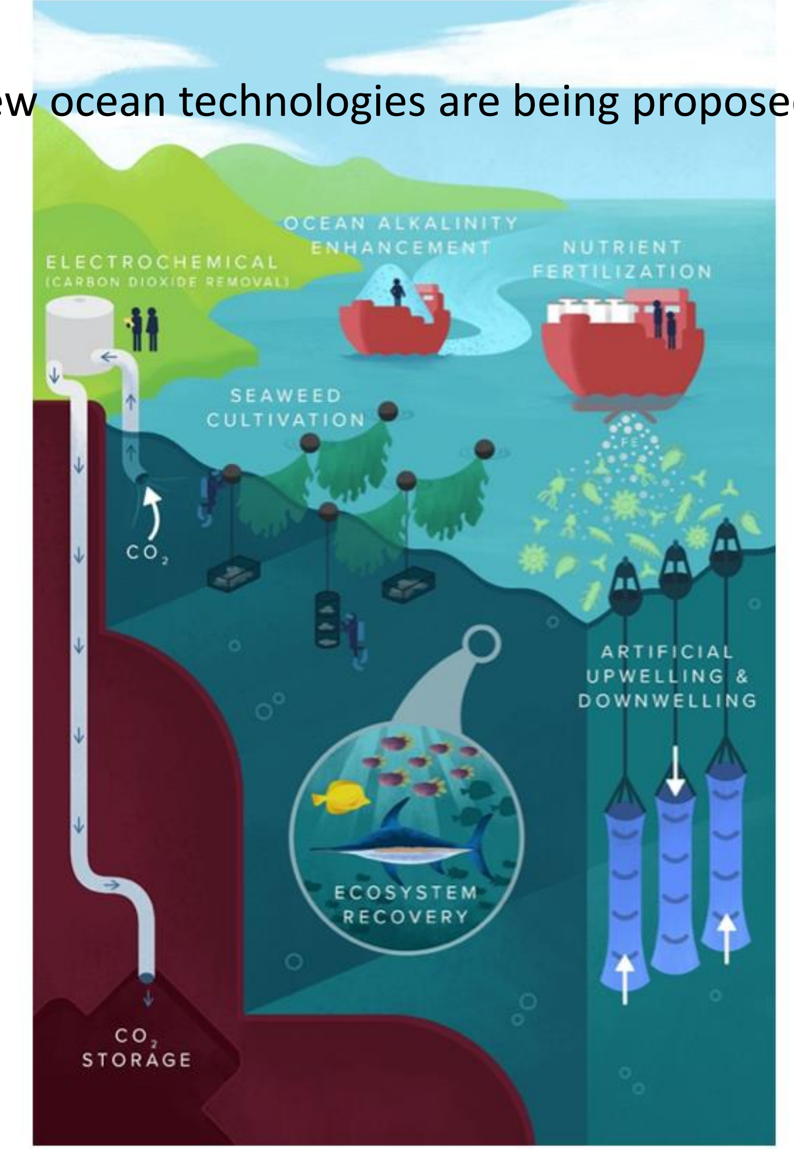


FIGURE S.1 Ocean-based CDR approaches explored in this report.

https://www.nationalacademies.org/our-work/a-research-strategy-for-ocean-carbon-dioxide-removal-and-sequestration 2021

We do not know enough about benefits and trade-offs of Negative Carbon Technologies

- Knowledge: The knowledge base is inadequate, based in many cases only on laboratory-scale experiments, conceptual theory and/or numerical models and needs to be expanded to better understand risks and benefits to responsibly scale up any of the ocean-based CDR approaches.
- Governance: Social and regulatory acceptability is likely to be a barrier to many ocean CDR approaches, particularly ones requiring industrial infrastructure. There will be both project-specific and approach- specific social, political, and regulatory discussions, as well as contestation around the role of CDR broadly. Field-scale trials are likely to be a site of wider societal debate around decarbonization and climate response strategies.
- Unknown environmental and social impacts: All ocean-based CDR approaches will modify the marine environment in some way, with both intended and unintended impacts. However, the knowledge base is weak on the unintended impacts and the consequences of both intended and unintended CDR impacts on marine ecosystems and coastal human communities.
- Monitoring and verification: Monitoring and verification activities are essential to quantify the efficacy and the durability of carbon storage of ocean-based CDR approaches and to identify environmental and social impacts. Potential synergies may exist with other ocean and environmental or climate observing systems. Substantial challenges remain, however, particularly for observing impacts on marine organisms and the resulting implications for marine ecosystems as well as documenting regional- to global-scale impacts on ocean carbon storage.
- Cost: Accurate estimation of the cost of a CO_2 removal approach at low technological readiness is challenging, and costs presented come with considerable uncertainty. It is typical for early-stage assessments to underestimate costs, and for that reason some recommend the inclusion of capital cost contingencies over 100 percent (effectively doubling the calculated capital cost). Cost discovery will be an important feature of a research strategy that aims to investigate approaches through increasing technology readiness.

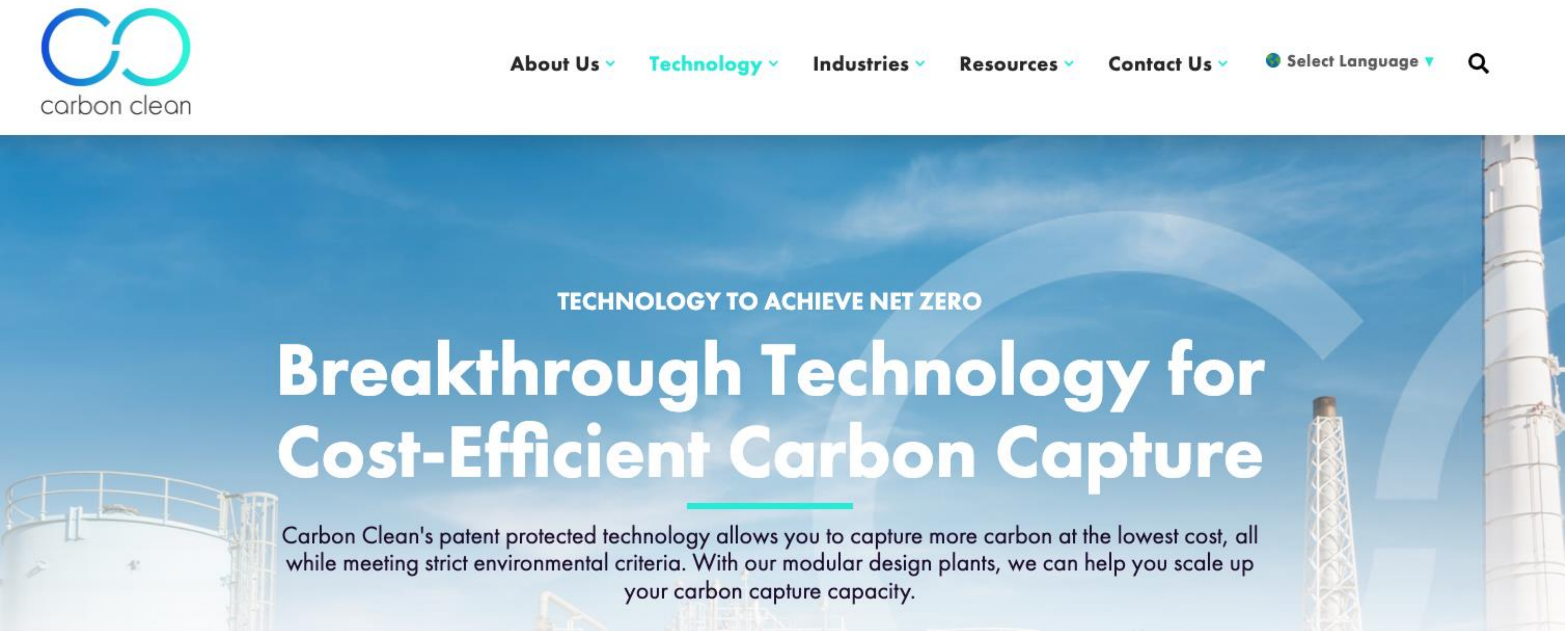
https://www.nationalacademies.org/our-work/a-research-strategy-for-ocean-carbon-dioxide-removal-and-sequestration 2021

Also IPCC AR6 WGII 2022 provides assessments of latest demonstrations of terrestrial NET

Foundations are Funding Research and Development of Negative Carbon Technologies

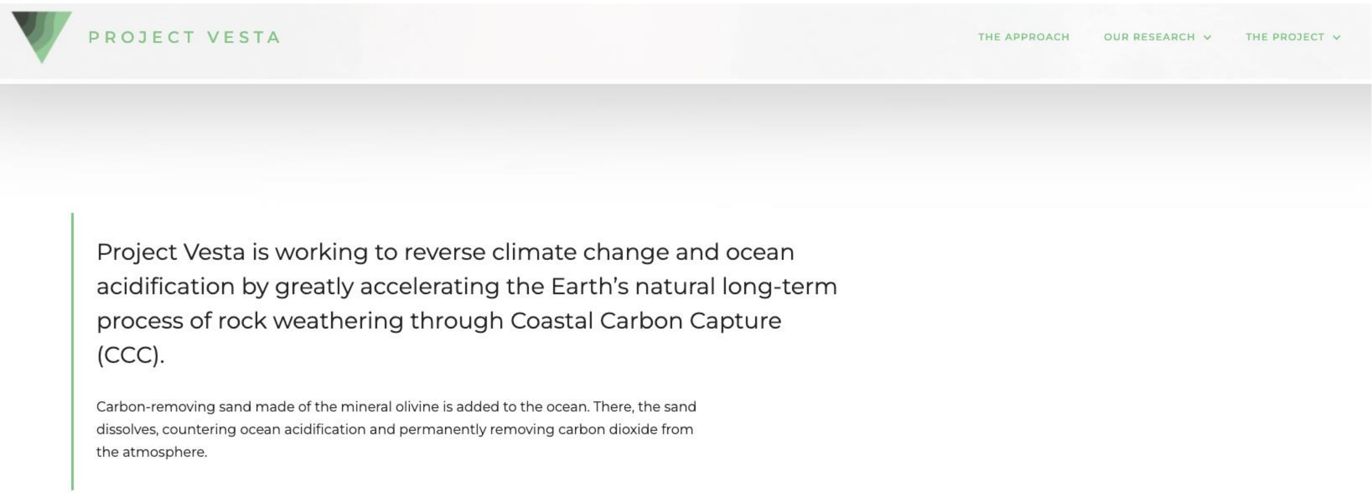
https://www.climateworks.org/programs/carbon-dioxide-removal/

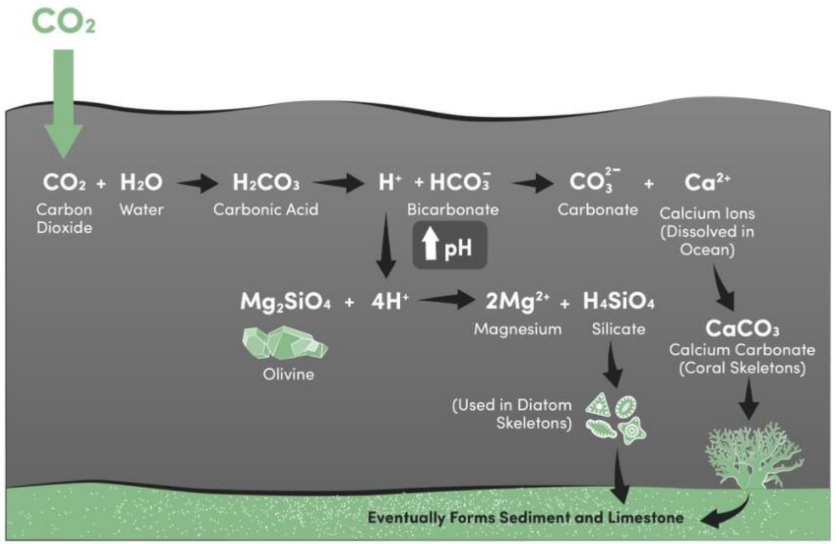
Company Formed in 2009 to Research and Deploy higher tech CCUS Negative Carbon Technologies
Technology is now in 44 locations worldwide US, Europe, India, Indonesia



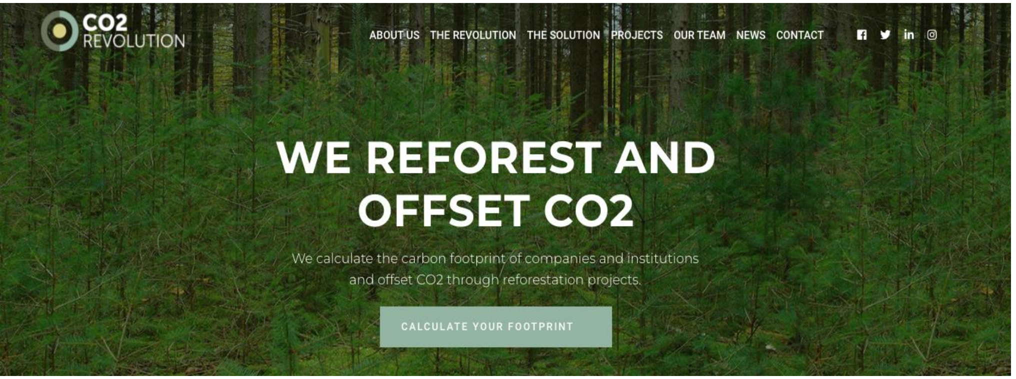
https://www.carbonclean.com/technology CCUS UK, offices India, Spain, US

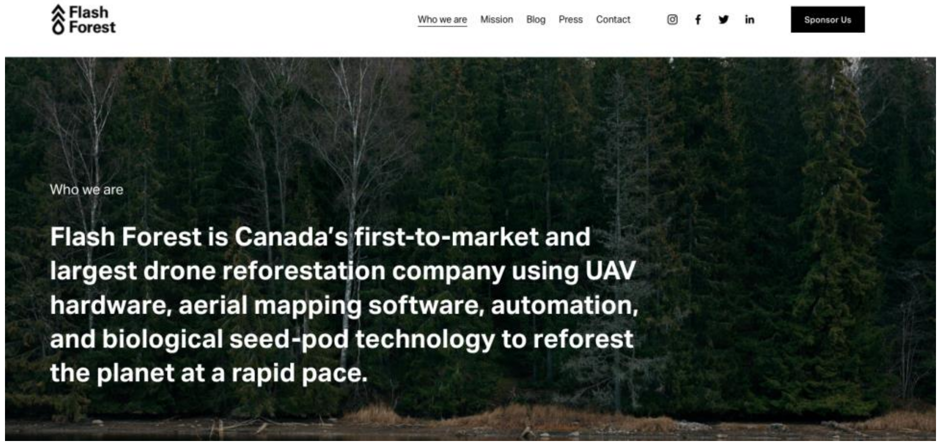
Companies are Forming to Research and Deploy 'New' Negative Carbon Technologies





https://www.vesta.earth/ US, France, Caribbean, India





https://co2revolution.es/ Spain

https://flashforest.ca/ Canada

Big Data, Drones, 'Smart' Seeds

Proposed Thematic Session 2: Emerging Negative Carbon Technologies to Address Climate Change

Potential Speakers (Need speaker suggestions from Asia, Global South)

- IEA, IIASA or IPCC AR6 speaker – why Negative Emissions Technologies are Important, how they are proposed to be used globally (in over 100 INDCs), North-South, potential issues
  - Keywan Riahi IIASA, AR6 WGIII, also 10-Member Group
- Authors of Authoritative Reviews of the technology behind Negative Emission Technologies – knowledge gaps, challenges
  - Jan Minx, Mercator Research Institute, Berlin, many reviews and assessments 2018, mostly terrestrial
  - Scott Downey, Chair of 2021 NAS report "A Research Strategy for Ocean-Based CO2 Removal and Sequestration"
- CEOs or CTOs of 'new' companies, Vesta, Grace Andrews; FlashForest CSO, Angelique Ahlstrom
- Senior Director funding CO2 Removal, ClimateWorks Foundation, Jan Mazurek (female)