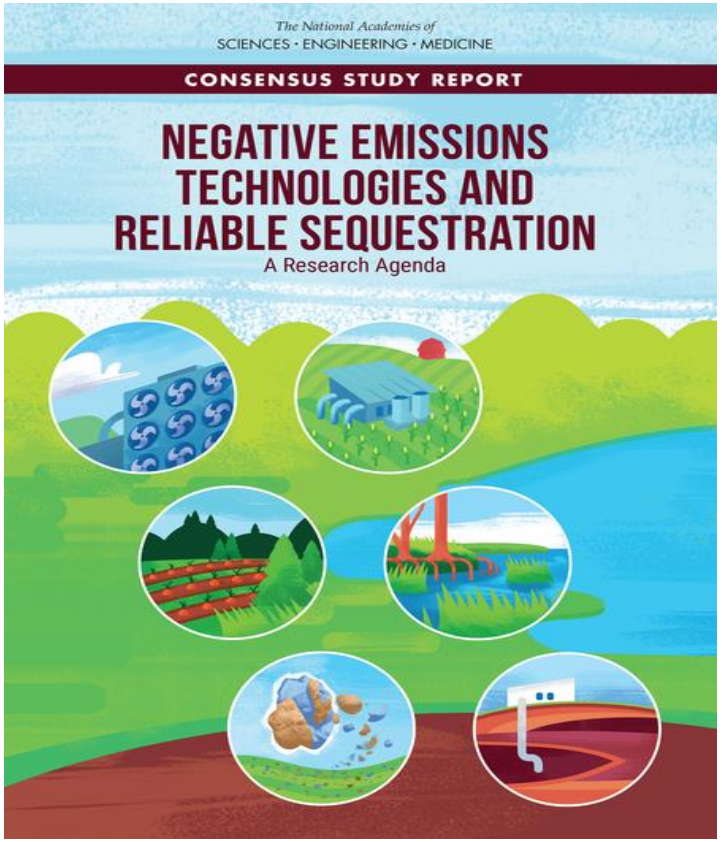
The National Academies of
SCIENCES • ENGINEERING • MEDICINE

Negative Emissions Technologies

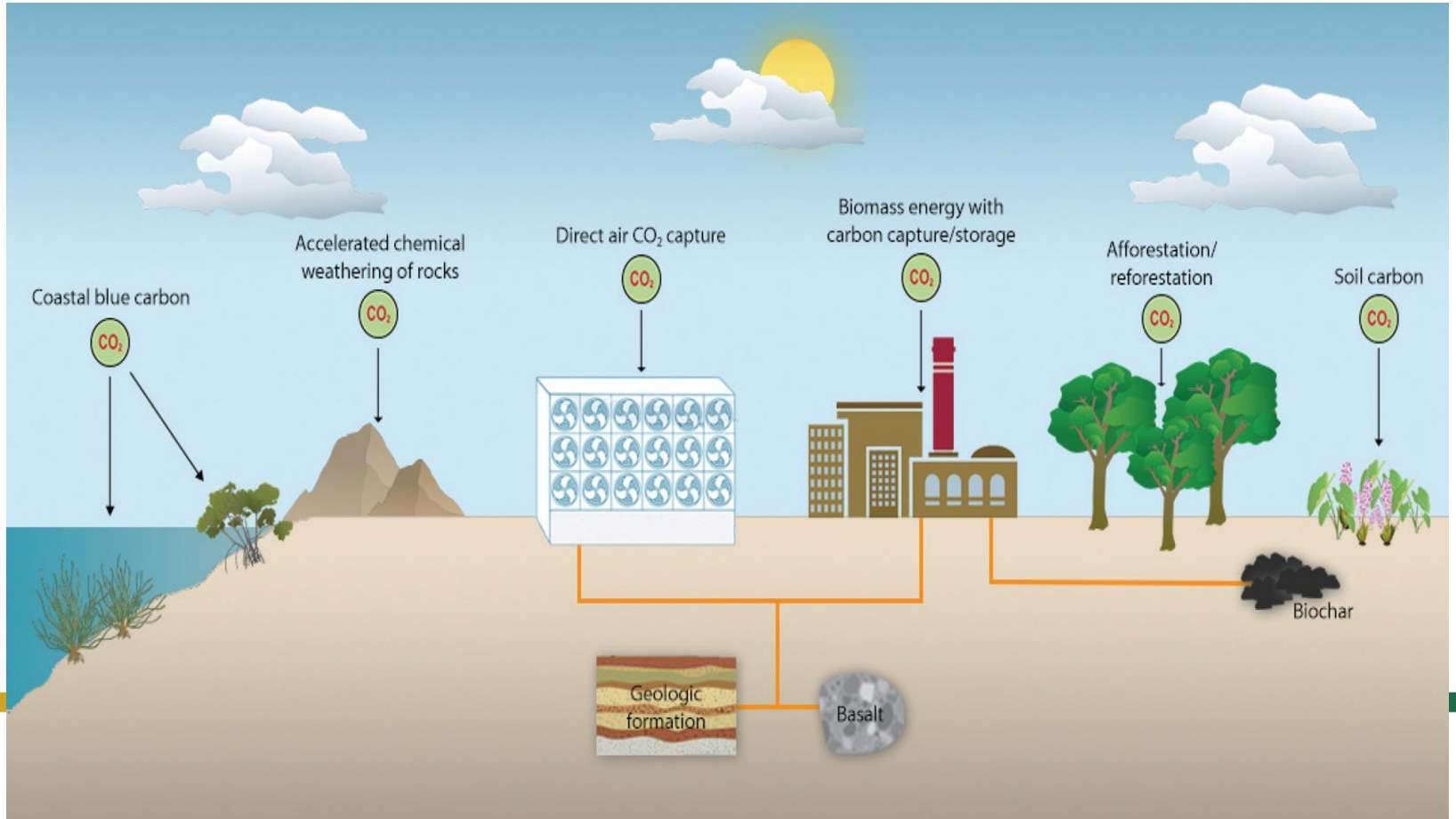
K John Holmes, National Academies
18 October 2019



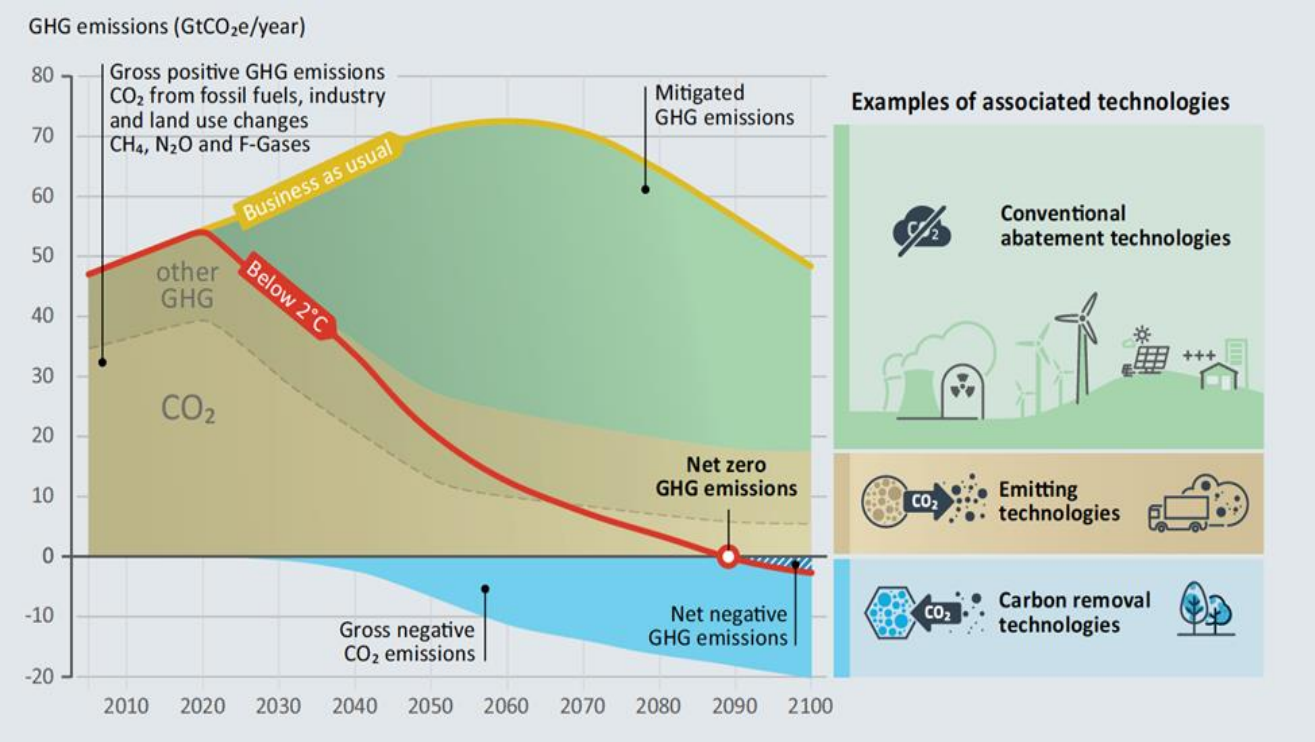
Study Committee Task Statement

- Identify the most urgent unanswered scientific and technical questions needed to assess the benefits, risks, and sustainable scale potential for NETs
- Define the essential components of a research and development program and specific tasks required to answer these questions
- Estimate the costs and potential impacts of such a research and development program to the extent possible in the timeframe of the study

Negative Emissions Technologies



The role of NETs in emissions mitigation



SOURCE: UNEP (Smith et al. 2017

~10 $GtCO_2$/y globally by midcentury

~20 $GtCO_2$/y globally by the century's end

How much can NETs contribute to emissions reductions ?

Negative Emissions Technology	Estimated Cost ($/tCO$_2$) L = 0-20 M =20-100 H = >100	Upper Bound* for Safe* Potential Rate of CO$_2$ Removal Possible Given Current Technology and Understanding and at ≤$100/tCO$_2$ (GtCO$_2$/y)	
		US	Global
Coastal blue carbon	L	0.02	0.13
Afforestation/ Reforestation	L	0.15	1
Forest management	L	0.1	1.5
Agricultural soils	L to M	0.25	3
BECCS	M	0.5	3.5-5.2
Direct air capture	H	0	0
Carbon mineralization	M to H	unknown	unknown
Total		1.02	9.13-10.83

* Upper bound assumes full adoption of agricultural soil conservation practices, forestry management practices, and waste biomass capture.

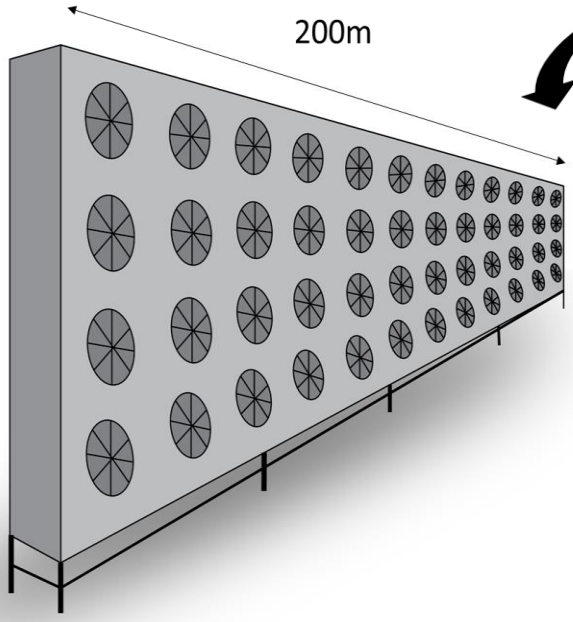
*Safe means without without large-scale land-use change that could adversely affect food availability and biodiversity.

How much can NETs contribute to emissions reductions?

Finding: Existing options cannot provide amount of negative emissions needed (~10 GtCO2/y, global; 1-2 GtCO2/y, US) to help meet 2 degrees C goal without land use changes that could affect food availability & biodiversity

Recommendation: The nation should launch a substantial research initiative to advance negative emissions technologies as soon as practicable. One focus should be to make rapid progress on direct air capture and carbon mineralization technologies, which are underexplored but would have essentially unlimited capacity if high costs and many unknowns could be overcome

What does direct air capture look like at scale
10 of these to capture 1 $MtCO_2$ per year



Solvents rely on structured packing with solvent flow over the packing

Solid sorbents rely on a honey-comb structure with chemicals (amines) bound to structure

J. Wilcox, "Direct Air Capture", Workshop on Deep Decarbonization, National Academies 08/23/19

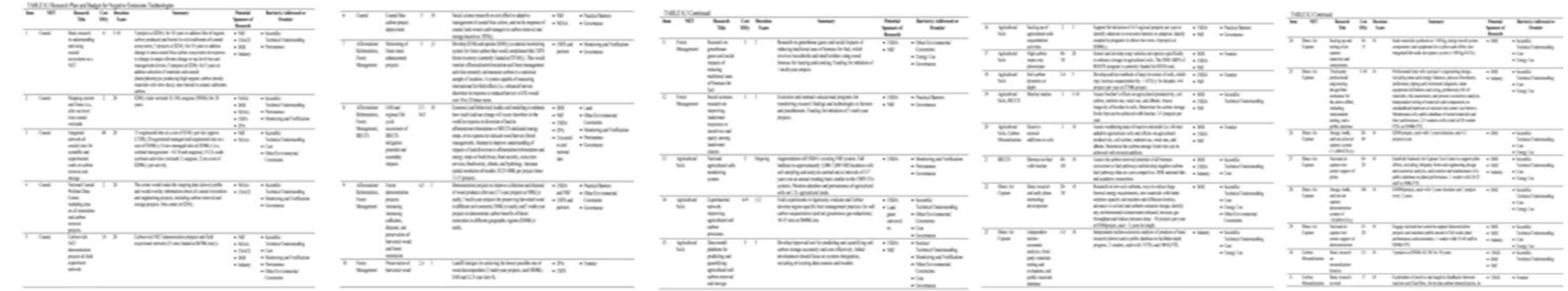
To Design a DAC Plant, you First Need to Design a Power Plant

- No matter which approach you choose, the heat required to recycle the material is **dominant** over the electricity required to drive the fans,
- To capture 1 $MtCO_2$/yr from air requires 300-500 MW of power!
- Choosing which energy resource to fuel the DAC plant will dictate the net CO_2 removed

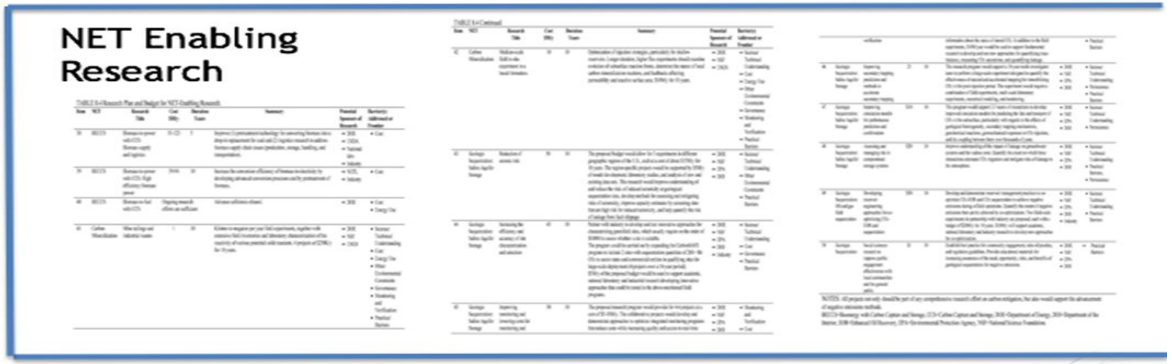
J. Wilcox, "Direct Air Capture", Workshop on Deep Decarbonization, National Academies 08/23/19

Current NET Activities

NET Research



NET Enabling Research



Academies report produced a detailed and granular research agenda for NETs.

Current NET Activities

- Much interest in NETs nowadays judging by the number of publications in peer-reviewed journals and popular press
- Research agenda developed by the Academies committee being used by many NGOs and DOE to help set priorities
- First federal incentives to do carbon dioxide removal provides $50/ton CO2 tax credit & California provides up to ~$200/ton CO2
- Other proposed legislation to incentivize carbon capture and use