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Deep Decarbonization Activities at the National Academies: A Focus on the 2018 Negative Emissions Technologies Report & Current Deep Decarbonization Initiative

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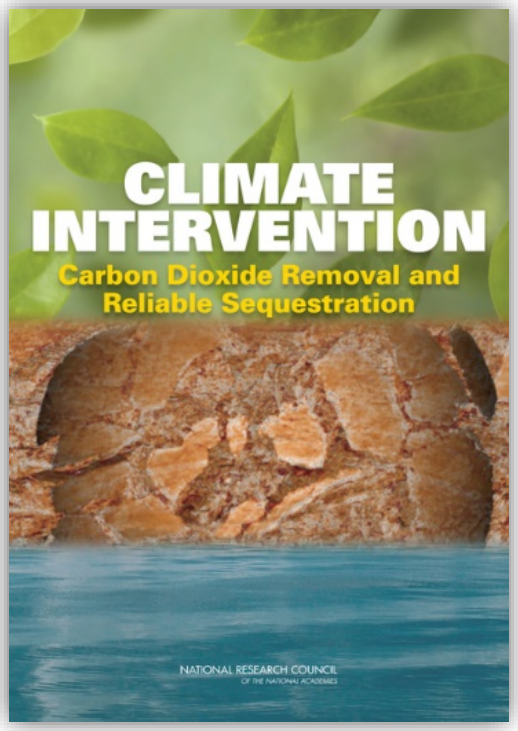
Deep Decarbonization Involves

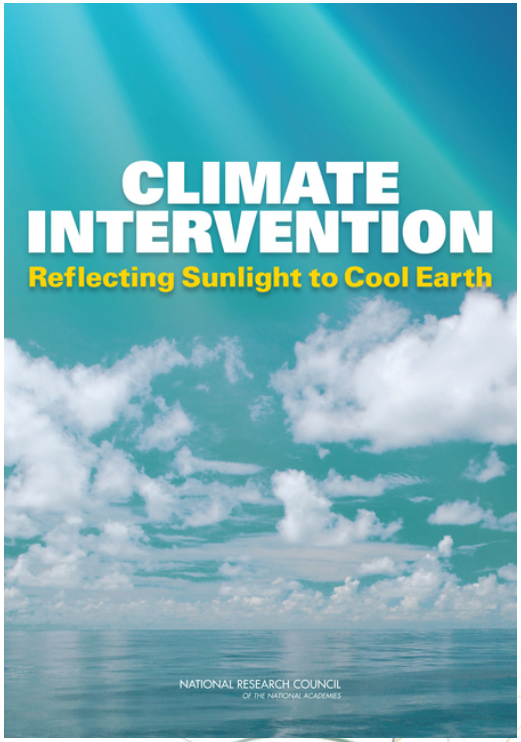
Carbon Emissions Mitigation Technologies reduce or eliminate carbon dioxide emissions from fossil fuel use, cement production and land use change.

Negative Emissions Technologies (NETs) remove carbon dioxide from atmosphere and store it on or underneath Earth's surface. The 2018 report considers only storage in terrestrial or coastal ecosystems or in geologic reservoirs. Disposal in oceans is not considered.

Study Motivation: Climate Interventions study

2015 National Academies geoengineering report identified need for a for **detailed** research and development agenda on carbon dioxide removal to assess benefits, risks, and sustainable scale potential; and increase commercial viability





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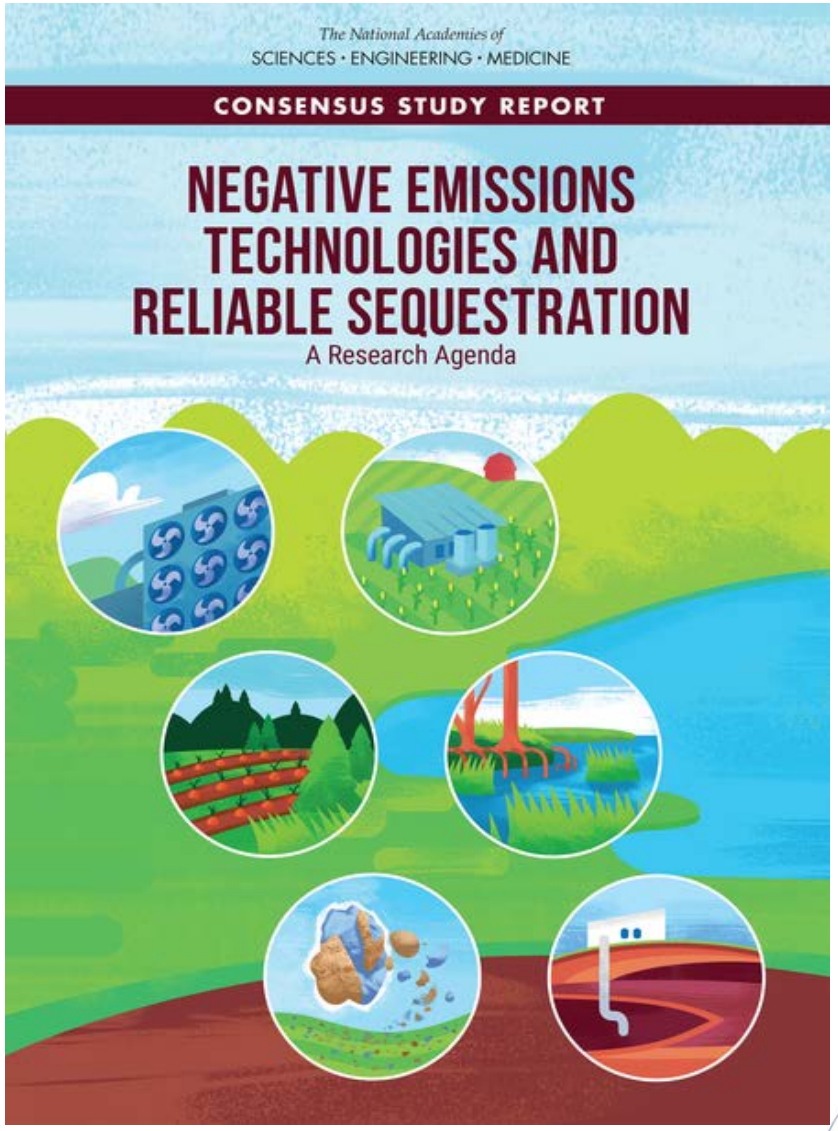
Statement of Task

- Assess the benefits, risks, and sustainable scale potential for NETs in terrestrial and coastal environments
- Define components & tasks of a R&D program and specific tasks required to answer these questions
- Estimate the costs and potential impacts of such R&D
- Recommend ways to implement such a research and development program



Negative Emissions Technologies

Coastal blue carbon

Direct air capture

Terrestrial carbon removal and sequestration

Carbon mineralization

Bioenergy with carbon capture and sequestration (BECCS)

Geologic sequestration

Committee Members

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- **Mahdi Al-Kaisi**, Iowa State University
- **Mark Barteau (NAE)**, Texas A&M University
- **Erica Belmont**, University of Wyoming
- **Sally Benson**, Stanford University
- **Richard Birdsey**, Woods Hole Research Center
- **Dane Boysen**, Modular Chemical Inc.
- **Riley Duren**, Jet Propulsion Laboratory
- **Charles Hopkinson**, University of Georgia
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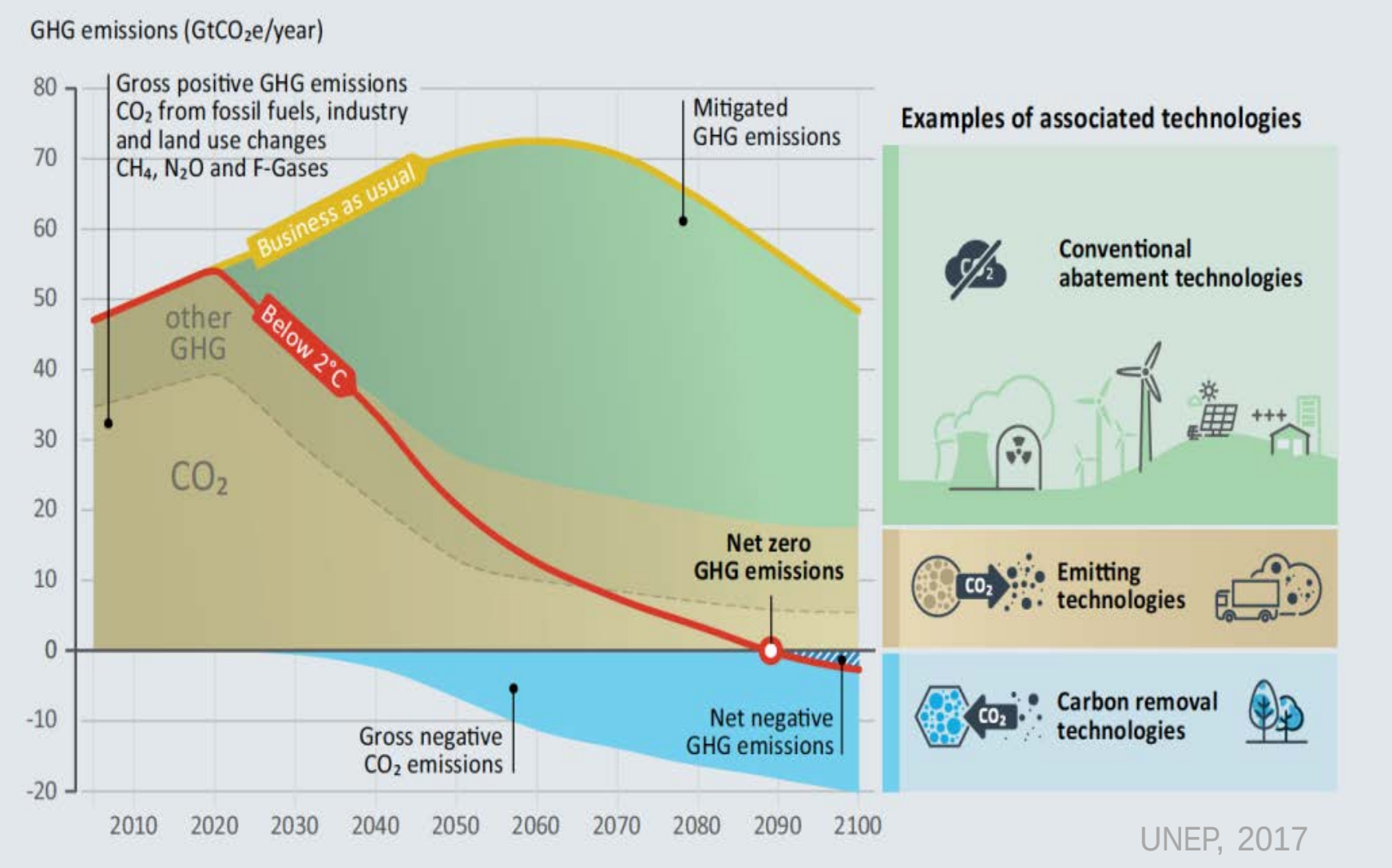
Rationale for NETs



UNEP, 2017

FINDING: NETs are best viewed as a component of mitigation portfolio, rather than a way to decrease atmospheric concentrations of CO_2 only after anthropogenic emissions have been eliminated

Mitigation Portfolio

- Energy efficiency
- Low or zero-carbon fuel sources and end use technologies
- NETs

For example…. Commercial Aviation

Option 1: Develop Cellulosic Biofuels	Could be expensive and requires land to grow feedstock
Option 2: Capture and store 10 kg of atmospheric CO_2 with a NET for each gallon of fossil fuel consumed	If this cost \$50/tCO_2 then the offset would cost an additional \$0.50/gallon

Coastal Blue Carbon

- Practices that increase amount of carbon stored in living plants or sediments in tidal marshlands, seagrass beds, and other tidal or salt-water wetlands
- Limiting factors:
  - Available land given coastal development and land use
  - Understanding of future rates with sea level rise and coastal management

Research Agenda Highlights

Coastal Blue Carbon

Core of Research Plan:

- Establish and operate network of research sites ($40M/y for 20 years)
  - Would straddle edaphic gradients and include both natural systems and those undergoing coastal engineering projects
  - Common set of measurements across network
  - How best to add CO2 removal and storage to coastal engineering projects at the lowest cost

Other Elements of Research Plan:

- Basic research ($6M/y for 5-10 years)
- Map and monitor coastal wetlands ($2M/y for 20 years)
- Data center ($2M/y for 20 years)
- Social science research ($5M/y for 10 years)
  - cost-effective adaptive management
  - response of coastal land owners/managers to incentives
  - policies to manage responsibility for carbon lost to inundation/erosion

Primary Limiting Factors:

- Available land given coastal development and land use
- Understanding of future rates with sea level rise and coastal management

Potential federal sponsors

- NSF
- DOE
- EPA
- NASA
- U.S. Army Corps of Engineers
- NOAA

Coastal Blue Carbon Research Plan and Budget for NETs (see Table 8-3)

NET	Research Title	Cost $/y	Duration Years	Summary	Potential Sponsors of Research	Barrier(s) Addressed or Frontier
Coastal	Basic research to understand and use coastal ecosystems as a NET	6 M	5-10	5 projects at $2M/y for 10 years to address fate of organic carbon produced and buried in soils/sediments of coastal ecosystems; 5 projects at $2M/y for 10 years to address change in area coastal blue carbon ecosystems in response to change in major climate change or sea level rise and management drivers, 5 projects at $2M/y for 5 years to address selection of materials and coastal plants/phenotypes producing high organic carbon density materials with slow decay rates buried in coastal sediments carbon.	• NSF • USACE • DOE • Industry	• Scientific/ Technical Knowledge • Permanence

TABLE 2.4. Costs and components of a coastal blue carbon research agenda

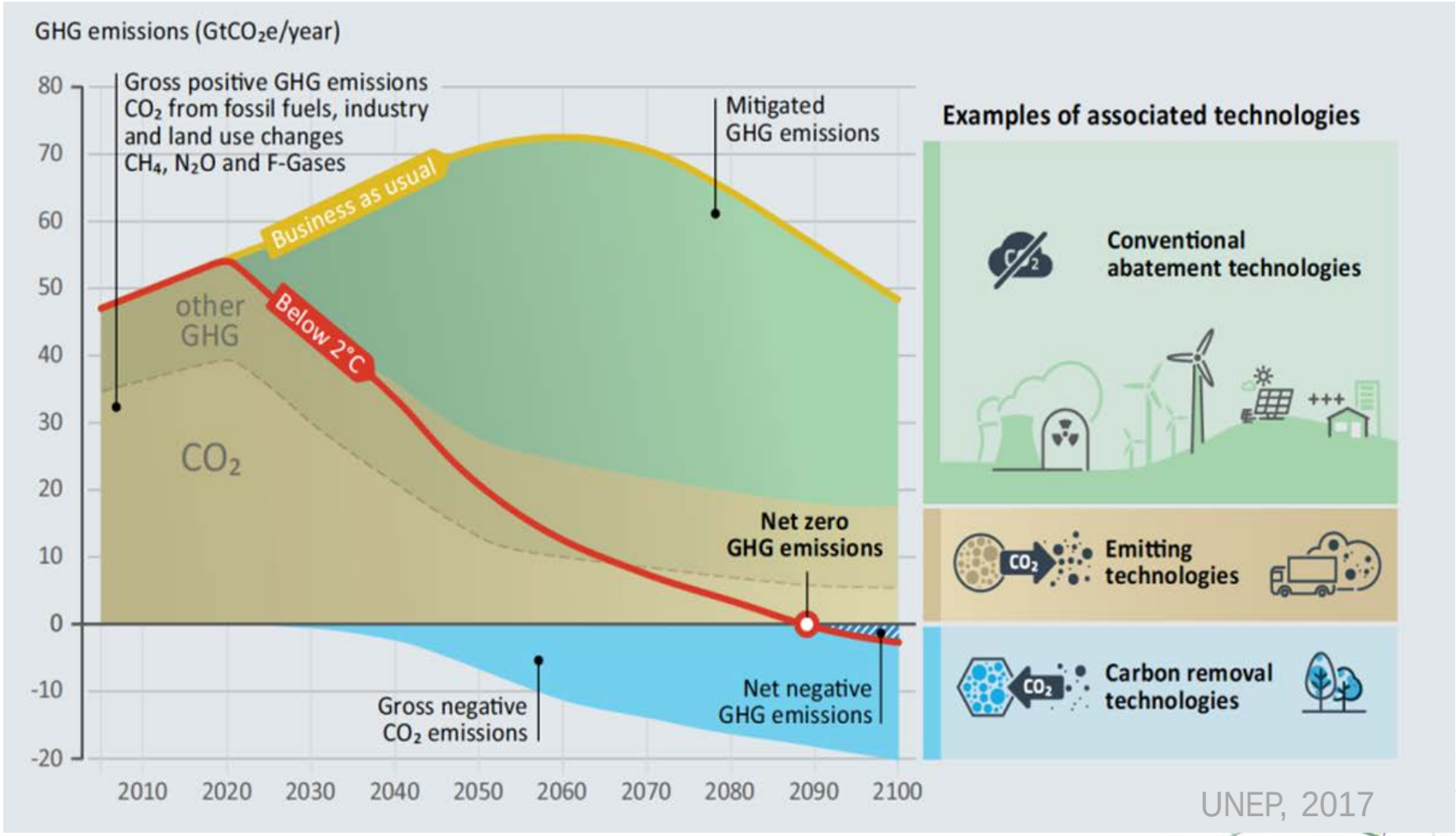
	Recommended Research	Estimated Research Budget	Time Frame (yr)	Justification
Basic Research	Basic research in understanding and using coastal ecosystems as a NET	6M	5-10	5 projects at $2M/y for 10 years to address fate of organic carbon produced and buried in soils/sediments of coastal ecosystems; 5 projects at $2M/y for 10 years to address change in area coastal blue carbon ecosystems in response to change in major climate change or sea level rise and management drivers, 5 projects at $2M/y for 5 years to address selection of materials and coastal plants/phenotypes producing high organic carbon density materials with slow decay rates buried in coastal sediments carbon.
Development	Mapping current and future (i.e. after sea level rise) coastal wetlands.	2M	20	Former NASA CMS projects (wetland: $1.5M/yr; seagrass $500K/yr)
	National Coastal Wetland Data Center, including data on all restoration and carbon removal projects.	2M	20	Scale of NSF Sustainability Research Networks

TABLE 2.4. Costs and components of a coastal blue carbon research agenda (continued)

	Recommended Research	Estimated Research Budget	Time Frame (yr)	Justification
Demonstration/Deployment	Carbon-rich NET demonstration projects & field experiment network	10M	20	Carbon-rich NET demonstration projects & field experiment network (15 sites funded at $670K/site/yr)
	Integrated network of coastal sites for scientific and experimental work on carbon removal and storage.	40M	20	15 engineered sites at a cost of $1M/yr per site (approximate funding for an LTER); 20 augmented managed & engineered sites at a cost of $500K/yr; 8 new managed sites at $500K/yr (wetland transgression – 0-2ft and seagrass); 5 U.S. scale synthesis activities (wetland: 3; seagrass: 2) at a cost of $200k/yr per activity
Deployment	Coastal blue carbon project deployment (social science, economic & policy research on incentives and barriers)	5M	10	Policies, incentives & barriers will change as coastal risk increases

How much NETs required:

- 10 Gt/yr global & 1 GT/yr US (2050)
- 20 Gt/yr global & 2 Gt/yr US (2100)



UNEP, 2017

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.**

OVERARCHING FINDING FROM NET REPORT

- **Existing options cannot provide amount of negative emissions needed to meet demand/need without unprecedented levels of adoption or changes in land use that could affect food availability and biodiversity**

- **Safe and economical direct air capture or carbon mineralization would have essentially unlimited capacity to remove carbon**

- **Blue carbon has capacity that is less than the other options, but potentially very low incremental cost given large co-benefits**

Overarching Recommendation: The nation should launch a substantial research initiative to advance negative emissions technologies:

- improve coastal blue carbon, afforestation/reforestation, changes in forest management, uptake and storage by agricultural soils, and BECCS to increase capacity and to reduce negative impacts and costs
- 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
- advance NET-enabling research on biofuels and carbon sequestration that should be undertaken anyway as part of an emissions mitigation research portfolio

Motivations for a Cross Academies Deep Decarbonization Initiative

- **Deep decarbonization of the U.S. economy will occur via the decisions of millions of actors across all sectors & will happen over generations not years.**

- **It is essential that the transition is supported by organizations that provide scientifically-sound advice, can engage all sectors of the economy, and have the longevity to operate throughout a generational transition.**

- **The National Academies is an authoritative, independent, and long-lived advisor to the national that can engage across all sectors of the issue**

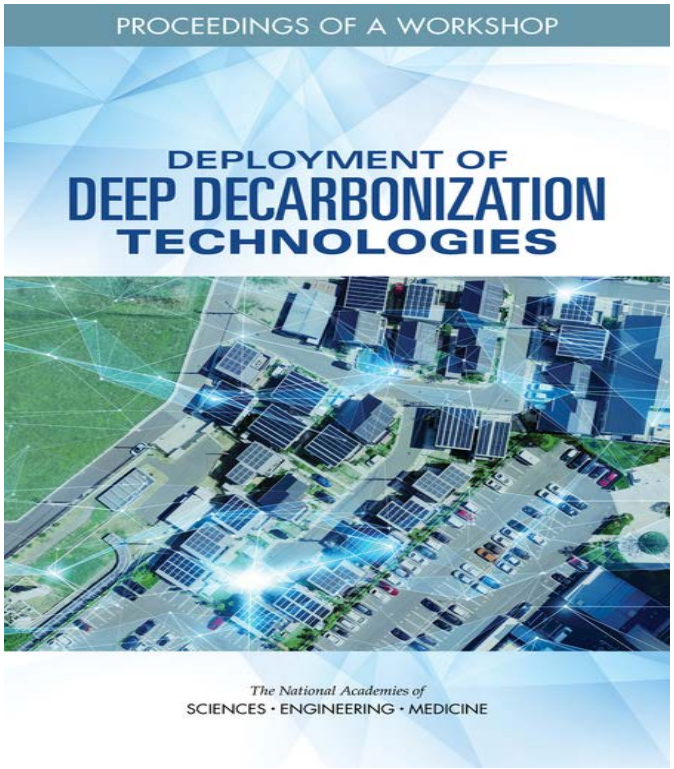
Structure of Cross Academies Deep Decarbonization Initiative

- **Workshop - framing workshop considering technology scale-up and deployment for U.S. decarbonization pathways**

- **Consensus Study - what is the status of decarbonization technologies, economics, policy, and human behaviors; what are challenges/opportunities posed by scaling up decarbonization technologies; where will we be in 10 years; what are near-term, low risk research investments and policy improvements?**

- **Roundtable/Action Collaborative - further explore specific topics through workshops, consensus studies or other activities and develop a broad portfolio of products to engage policy makers, industry, NGOs, and public stakeholders to take action on challenges and opportunities associated with a low GHG emissions future**

Workshop on Deployment & Scale-Up of Decarbonization Technologies – July 23-24, 2019



- Focused on selected technological sectors (LDVs, electricity, heavy industry, and value chain for food production)
- Also included sessions on negative emissions technologies, societal transformation, and policy
- Participation and attendance by many BEES members
- Helped define focus and task for consensus study

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Consensus Study "Technology, Policy, and Social Barriers and Opportunities in Decarbonization of the US"

- Develop a report summarizing the status of technologies, policies, and societal factors needed for decarbonization and assess research and policy needs
- Make recommendations for research and policy in the near to mid-term (5-20 years) that are required to put the United States on a deep decarbonization pathway
- Planned study products will include interim and final reports as well as webcasts of meetings, social media content, and committee webinars
- Interim report to be released in early 2021 to provide "… an assessment of no regrets policies, strategies, and research directions that provide benefits across a spectrum of low carbon futures."
- Both reports will serve as roadmaps for future long-term Academies efforts in decarbonization

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Current Status & Future Activities

- **Non-federal study with funding provided by the Academies Presidents' Fund, Sloan, Heising-Simons, ClearPath, Quadrivium, Incite Labs, Gates Ventures**

- **First meeting March 10-11 one of last**
- **In person meetings held**

- **Staffing – includes time for staff across all Academies divisions**

- **Interrelated climate initiatives are a major focus of Academies Presidents, program staff, and the Academies Office of Development**

- **Follow-ons to current deep decarbonization activities**

Thank you

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