BIPARTISAN POLICY CENTER

Breakdown of National Academies Research Agenda for Carbon Dioxide Removal by Stage of Research

NET	Stage of Research	Specific Research Needs	Annual Funding Needs	Cumulative Funding Needs (in millions of $)	Potential Federal Agencies & Research Partners
Coastal Blue Carbon[i]	Basic Research	Fate of carbon[ii] and selection of plants in coastal ecosystems.	$6M/yr for 5-10 yrs	$30 - 60	NSF, DOE, EPA, NASA, NOAA, USFS/USDA and the U.S. Army Corps of Engineers
	Development	Map/monitor coastal wetlands and establish a national coastal wetland data center.	$4M/yr for 20 yrs	$80	
	Demonstration/ Deployment	Establish and operate a network of research sites for experimental work. Demonstration projects and field experiment network.	$40M/yr for 20 yrs $10M/yr for 20 yrs	$1,000	
	Deployment	Research on incentives and barriers.	$5M/yr for 10 yrs	$50	
	Total			**$1,160 - 1,190**	
Terrestrial					
Agricultural Soils	Basic Research	Develop new crop varieties. Research on soil decomposition at depth. Biochar studies.	$40-50M/yr for 20 yrs $3-4M/yr for 5 yrs $3M/yr for 5-10 yrs	$830 - 1,050	USDA, NSF, DOE, and land-grant universities
	Development, Measurement, and Monitoring	Monitoring system on existing USDA National Resource Inventory locations. Data platform to quantify agricultural soil carbon removal.	$5M/yr ongoing $5M/yr for 5 yrs	$100 - 125	
	Demonstration	Experimental network improving soil processes, 10-15 sites at $600K/yr each.	$6-9M/yr for >=12 yrs	$72 - 108	
	Deployment	Scale-up of agricultural sequestering activities.	$2M/yr for 3 yrs	$6	
	Total Agricultural (cumulative)			$1,008 - 1,289	

Afforestation/ Reforestation/ Forest Management	Basic Research	Landfill design to minimize wood decomposition; and assessment of emissions balance, cost, and land requirements for consuming wood products.	$2.4M/yr for 3 yrs	$7.2	USFS has main responsibility in partnership with USDA, NSF, and EPA
	Development, Measurement, and Monitoring	Monitor forest carbon stock enhancement projects.	$5M/yr for >=3 yrs	$15	
	Demonstration	Forest demonstration projects.	$4.5M/yr for 3 yrs	$13.5	
	Deployment	Research on incentives and reducing the use of biomass for fuel.	$2M/yr for 3 yrs	$6	
	Total Forest (cumulative)			$41.7	
	Total			**$1,049.7 - 1,330.7**	
Bioenergy with Carbon Capture and Storage (BECCS)	Crosscutting Activities*	Life cycle analysis and integrated assessment modeling to understand land constraints	$3.7-14M/yr for 10 yrs	$37 - 140	USDA, DOE, NSF, EPA, and the national laboratories.
	Biomass-to-Power with Carbon Capture	Biomass Supply & Logistics	$53-122.6M/yr for 5 yrs	$493.7 - 1,180.3	
		High Efficiency Biomass Power	$39-93.5M/yr for 10 yrs		
	Biomass-to-Fuel with Biochar	Biochar[iii] permanence in soil and impact on crop productivity, and conversion pathways profitable for fuel production.	$39.4-102.5M/yr for 10 yrs	$384 - 995	
	Biomass-to-Fuel with Carbon Capture	Carbon negative pathways, 7-10 projects per year at $0.2-1 million/project.	$4.2-6M/yr for 10 yrs	$42 - 60	
	Total			**$956.7 - 2,375.3**	
Direct Air Capture (DAC)	Basic and Applied Research	Design and test materials and component designs with many $1 million efforts. Establish evaluation for performance.	$20-30M/yr for 10 yrs $3-5M/yr for 10 yrs	$230 - 350	DOE's Office of Fossil Energy and NETL, with cooperation from researchers and industry
	Development	Scale up materials and components for pilot scale.	$13-25M/yr for 10 yrs	$130 - 250	
	Demonstration	Establish a National DAC Test Center. Build and test $20 million/project pilots.	$30-60M/yr for 10 yrs	$300 - 600	
	Deployment	Scale to >10,000 tons CO2/year removed at $100 million/project.	$115-120M/yr for 10 yrs	$1,150 - 1,200	
	Total			**$1,810 - 2,400**	
Carbon Mineralization	Basic Research	Kinetics of carbon capture by minerals.	$5.5M/yr for 10 yrs		
		Rock mechanics, numerical modeling, and field studies	$17M/yr for 10 yrs		
		Mapping of reactive mineral deposits (scoping for pilots).	$7.5M/yr for 5 yrs		

		Develop a resource database for carbon mineralization.	$2M/yr for 5 yrs	$452.5	DOE Basic Energy Sciences and Office of Fossil Energy, NSF, USGS, and universities
		Reactive mineral additions to soils.**	$3M/yr for 10 yrs		
		Environmental impacts of mineral additions to ecosystems.	$10M/yr for 10 yrs		
		Socioenvironmental impacts of expanded extraction industry.	$5M/yr for 10 yrs		
	Pilot Studies	Medium-scale injection of CO2 in peridotite rock.	$10M/yr for 10 yrs	$245	
		Medium-scale injection of CO2 in a basalt formation.	$10M/yr for 10 yrs		
		Surficial (ex situ[iv]) carbon removal pilot studies.	$3.5M/yr for 10 yrs		
		Mine tailings and industrial wastes.	$1M/yr for 10 yrs		
	Total			**$697.5**	
Secure Geologic Storage	Basic Research and Development	Reduce risks of induced seismicity.	$50M/yr for 10 yrs	$850	DOE, NSF, EPA, USGS, and BLM
		Improve secondary trapping prediction and methods.	$25M/yr for 10 yrs		
		Improve simulation models for performance prediction.	$10M/yr for 10 yrs		
	Development/ Demonstration	Improve site characterization and selection.	$45M/yr for 10 yrs	$1,450	
		Improve and lower cost for monitoring and verification.	$50M/yr for 10 yrs		
		Co-optimize CO2 with enhanced oil recovery and sequestration.	$50M/yr for 10 yrs		
	Deployment	Assess and manage risk of CO2 leakage.	$20M/yr for 10 yrs	$210	
		Research on best practices and public engagement.	$1M/yr for 10 yrs		
	Total			**$2,510**	
	Grand Total			**$8,183.9 - 10,503.5**	

* "Crosscutting Activities" listed under BECCS are the biggest expense for, and is shared with, the Afforestation/Reforestation/Forest Management budget.
** "Reactive mineral additions" listed under Carbon Mineralization is a shared priority with the Agricultural Soils budget.

[i] Coastal Blue Carbon refers to processes that increase the amount of carbon stored in living plants or sediments in coastal wetland ecosystems.
[ii] Refers to the production and burial of carbon in coastal wetland ecosystems.
[iii] Biochar refers to plant and animal material turned into charcoal that can store carbon.
[iv] Ex situ carbon mineralization involves transporting solid reactants to a site of CO2 capture and reacting them with fluid or gas rich in CO2 to form carbonate minerals able to store CO2.