

Market and Climate Opportunities for CO₂ Utilization

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NSF Workshop on Advanced Manufacturing for Industrial Decarbonization
August 3&4, 2023, Arlington, VA



CCU products are needed for the energy and industry sectors

- Necessary for net-zero CO₂ emissions
- Offer carbon capture AND useful and valuable goods
- Complement other carbon management options



Distinct differences in CCU products

- **Carbon sources** for CCU
 - fossil based industrial processes
 - non-fossil processes
 - direct air capture
 - direct ocean capture
- **Track 1 CCU products:** removal/storage of carbon for > 100 years
- **Track 2 CCU products:** decompose to CO₂ in < 100 years
- Origin, magnitude, **and** destiny of the carbon determine climate impact

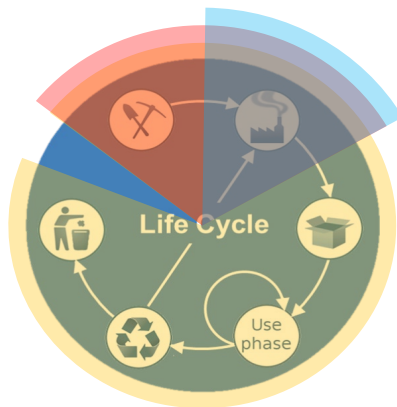
Carbon Capture and Storage	Track 1	Carbon Capture and Utilization
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CO₂ source and sink combinations are important

CO ₂ Source		Process Type		Product Type						
		Enhanced Oil Recovery	Geological Sequestration	Track 1		Track 1/2		Track 2		
				Construction Materials	Specialty Materials	Chemicals	Agriculture	Fuels	Food	Working Fluids
Fossil Fuels	Coal	Continues dependence on fossil resources	Net point source reduction of emissions	Profitable Storage - continued dependence on fossil CO ₂		Modest net impact on emissions - can reduce demand but most fossil carbon is released		Modest net impact on emissions - can reduce demand but all fossil carbon is released		
	Oil									
	Natural Gas									
Fossil Carbon	Limestone									
Bio-captured	Biomass	Replaces fossil CO ₂ - supports continued fossil fuel use	Permanent storage - no economic return	Sweet Spot - negative emissions - economic return		Potential for permanent storage >100 years		Circular Economy		
Ambient	Air									
	Water									

Rigorous and transparent assessments are essential







- to ensure climate benefits
- to identify economic viability
- to factor in additional aspects, including societal considerations and alternatives to CCU products



** Funded by US
Department of Energy*

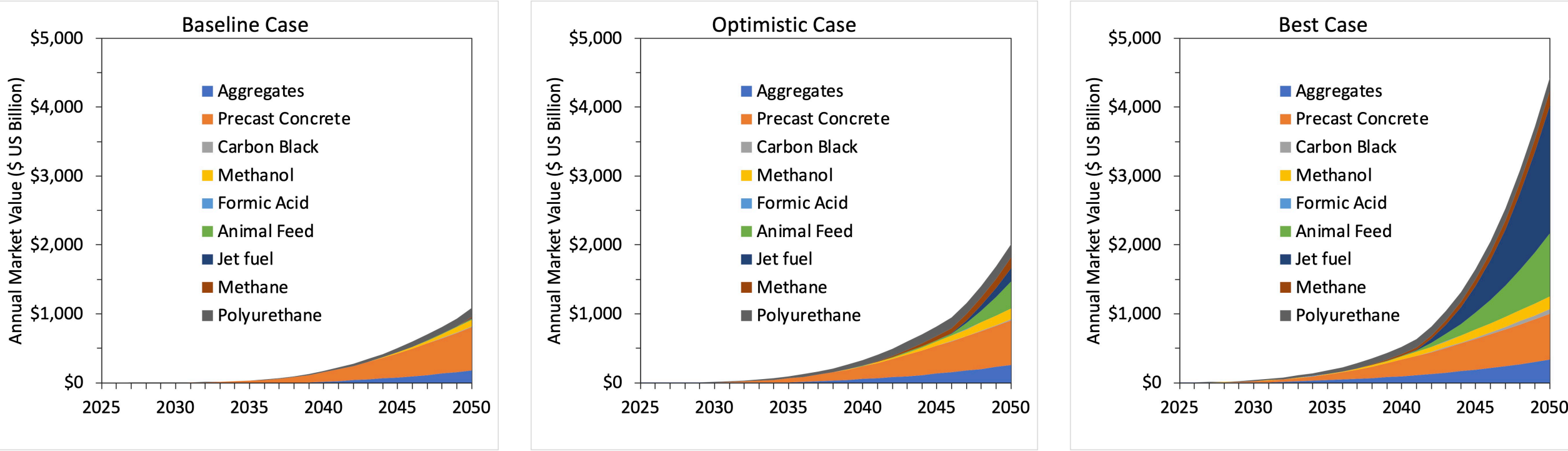
<https://www.globalco2initiative.org/evaluation/>
<https://assessccus.globalco2initiative.org/>

Climate and economic significance

Annual potential in 2050:		Utilization of 2 to 27 gigatonnes of CO ₂ Market opportunity of \$1,100 to \$4,400 billions		
		Annual market opportunity (\$ billions)	Annual CO ₂ consumption (gigatonnes)	
Track 1	 Construction materials Precast concrete, aggregates	800 - 1,000	1.0 - 9.5	CO ₂ is a new ingredient
Track 2	 Fuels Jet fuel, methane	21 - 2,060	0.28 - 10.80	
Track 2	 Chemicals Formic acid, methanol	100 - 180	0.26 - 0.58	CO ₂ replaces fossil carbon
Track 1 or 2	 Pure carbon materials Carbon black	14 - 66	0.04 - 0.20	
Track 1 or 2	 Polymers Polyurethane	130 - 190	0.002 - 0.013	
Track 2	 Food Animal feed	18 - 920	0.005 - 0.400	CO ₂ is a new ingredient

Compare this to expected remaining emissions, e.g. IEA 2020 (CCUS In Clean Energy Transitions)

Opportunities are big but sensitive to actions taken!



2 – 27 gigatonnes of CO₂/year

Magnitudes and time scales for CCUS action

Now (**finite** need)



Legacy emissions

Now & perpetually



Inevitable emissions

Implications on the long-term need for CCUS

CO₂ capture and removal (CCS, CDR)

- Now and long enough to bring CO₂ in water and air to an acceptable level
- Draw down is strongly aided by natural solutions, which should **not** be used to generate carbon offsets



CO₂ capture and conversion to utilize the carbon in lieu of fossil carbon (CCU, CDU)

- Implemented now to build capacity and create cost competitiveness
- Perpetually needed to provide carbon-based products
- Needed together with bio-mass based and recycled carbon products, that cannot cover market needs alone
- Balance the carbon budget (Track 1 materials!)

