CARBON UTILIZATION – A VITAL AND EFFECTIVE PATHWAY FOR DECARBONIZATION

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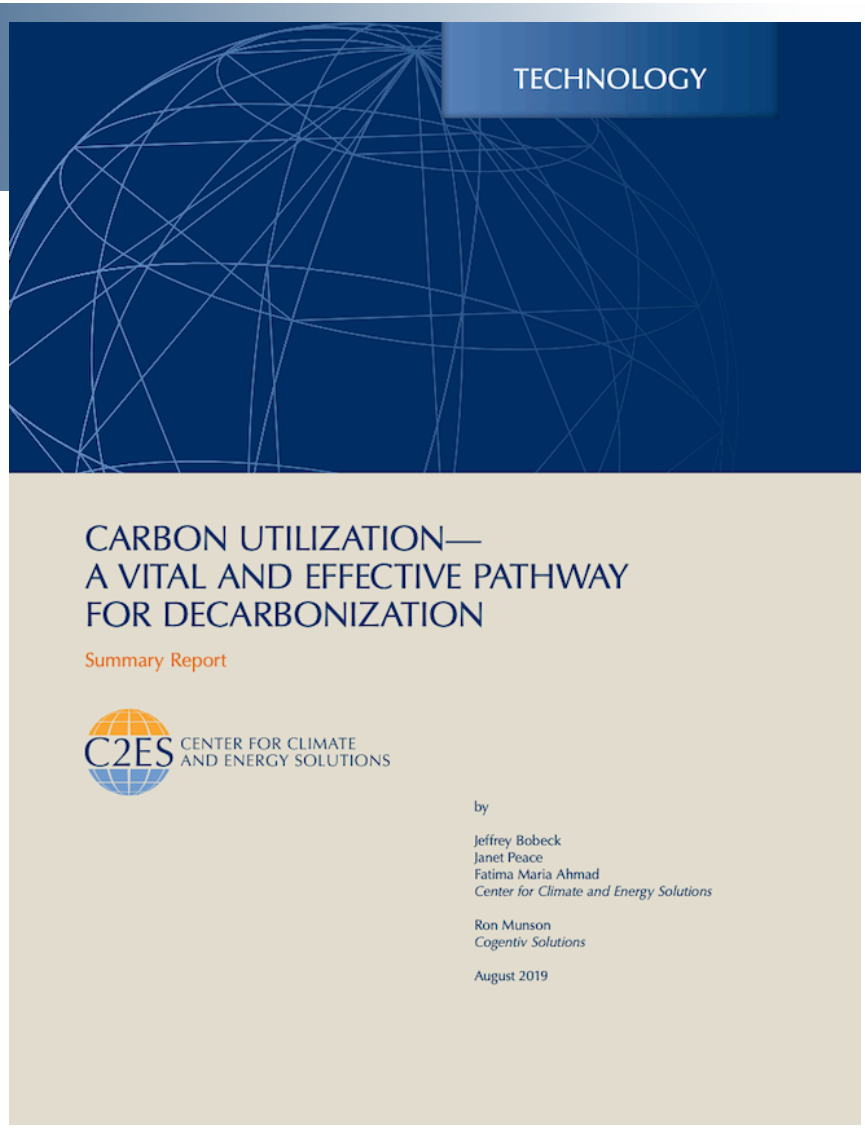
C2ES Report on Carbon Utilization

- Four high-level workshops of **Carbon Capture Coalition** participants
- Original research contributed by **Cogentiv Solutions**
- Build upon past work of the **National Academy of Sciences, Global CO_2 Initiative**
- More than 20 interviews with **carbon utilization developers** and experts
- Goal: **Identify policy options** that will support a path forward for carbon utilization



Carbon Utilization Sectors

Construction Materials

- Cement and concrete
- Asphalt
- Aggregate
- Timber/super hardwood

Fuel

- Synthetic (methanol, butanol, natural gas, syngas, etc.)
- Micro-algae fuel
- Macro-algae fuel

New materials

- Carbon fiber
- Carbon nanotubes and fullerenes
- Graphene

Industrial gas & fluids

- Enhanced oil recovery
- Enhanced coal bed methane recovery
- Enhanced water recovery
- Semiconductor fabrication
- Power cycles

Plastics

- Polyurethane foams
- Polycarbonate (glass replacement)
- Acrylonitrile butadiene styrene
- Many more

Agriculture & food

- Algae-based food or animal feed
- Microbial fertilizer
- Biochar, bio-pesticides, bio-cosmetics

Chemicals

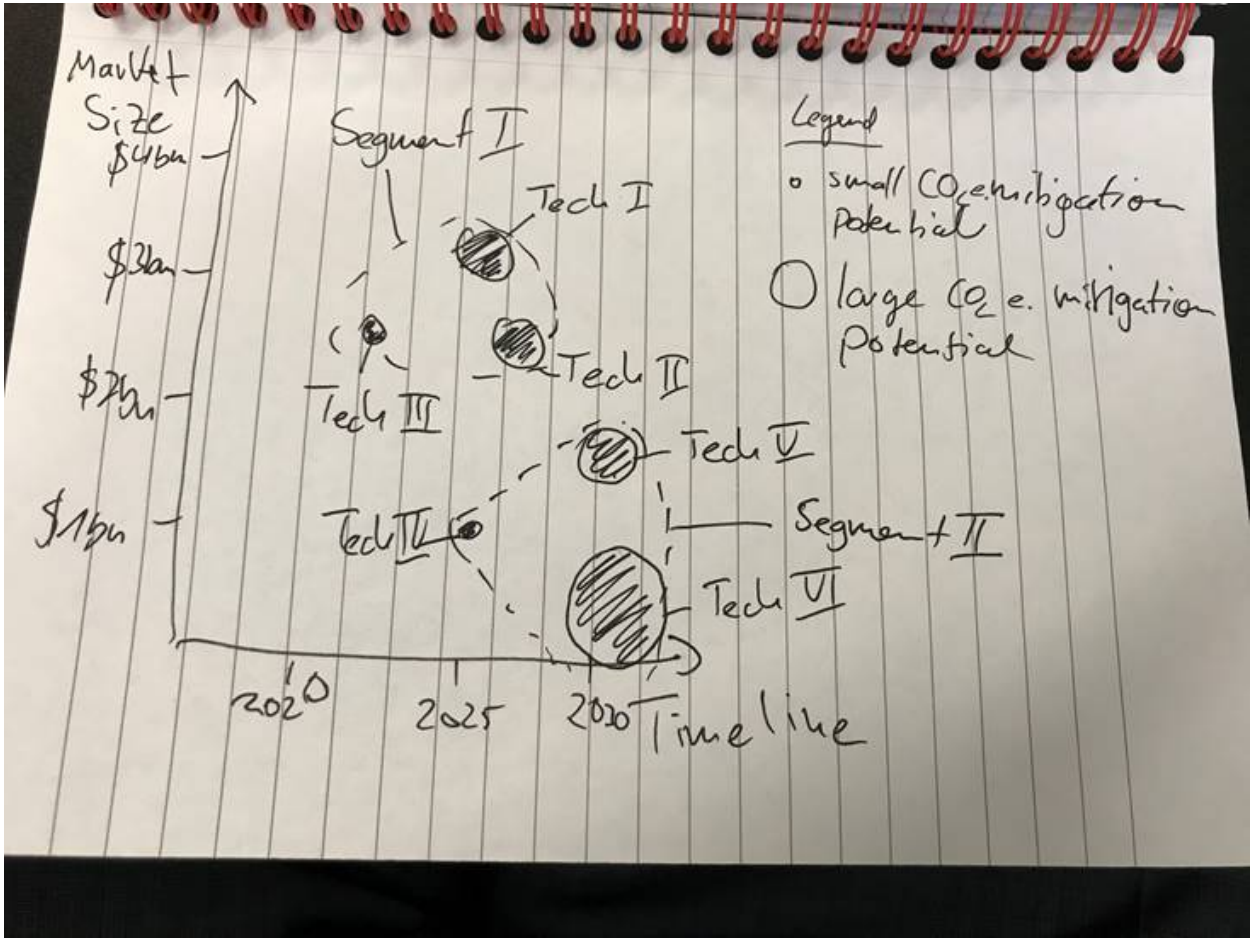
- Preservatives (formic acid)
- Medicinal
- Antifreeze (ethylene glycol)
- Carbon black
- Many more

Carbon Utilization's Potential Contribution to Decarbonization

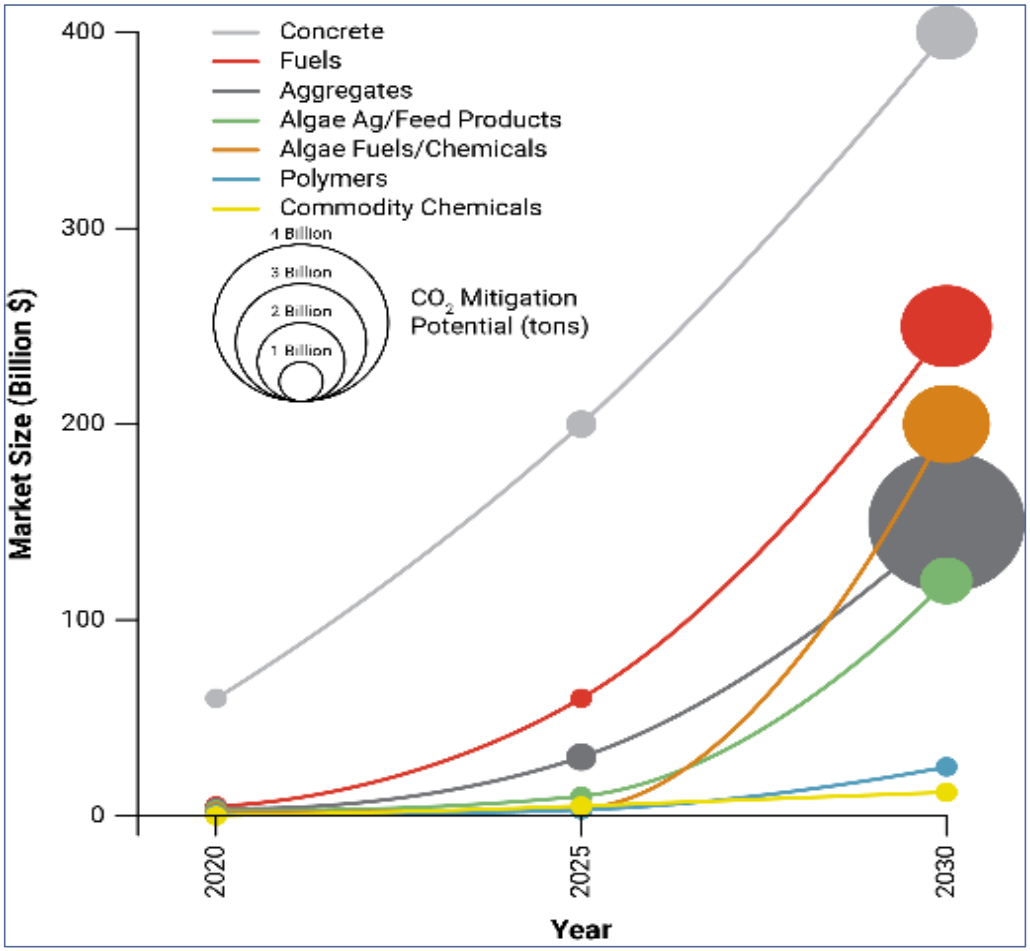
Accelerating development and deployment of CO_2 utilization would provide critical pathways for decarbonization. Those include:

1. ***Decarbonization of certain industrial sectors.*** While many sources of carbon emissions can be solved through traditional carbon capture, certain industrial sectors are harder to decarbonize.
2. ***Decarbonization in locations where more options are needed.*** Development of carbon capture in some geographic locations may be constrained by social issues or land use restrictions.
3. ***Increased development for broader carbon capture technologies.*** Inclusion of CCU technology development within federal DOE R&D will help drive carbon capture innovation generally, where CCU developments may have technology transfer potential beyond their original scope.

An Idea . . . .


Market Size
$4bn
$3bn
$2bn
$1bn
Segment I
Tech I
Tech II
Tech III
Tech IV
Tech V
Tech VI
Segment II
Legend
small CO2e. mitigation Potential
large CO2e. mitigation Potential
2020
2025
2030
Timeline

2030 Market Size Projection and CO_2 Mitigation Potential



Policy Imperatives for Accelerating CCU by 2030

Immediate Actions (2019)

- **Publish IRS guidance** for implementation of 45Q
- Pass the **USE IT Act**
- Reauthorize, reform and increase funding for **DOE's Fossil R&D program**
- Include **CO_2 pipelines** in national infrastructure legislation

Mid-term Actions (2019-2022)

- Lower the **45Q eligibility threshold** and extend the 2024 "commence construction" deadline
- **Increase federal R&D spending** to a level to meet research needs of the 2018 NAS Report
- Permit the funding of **more and larger pilot projects** ($5 million-10 million range), ensure follow-through to commercialization
- Create **low-carbon procurement** preferences
- **Update codes and standards** to permit or specify low-carbon products

Longer-Term Actions and Prospects

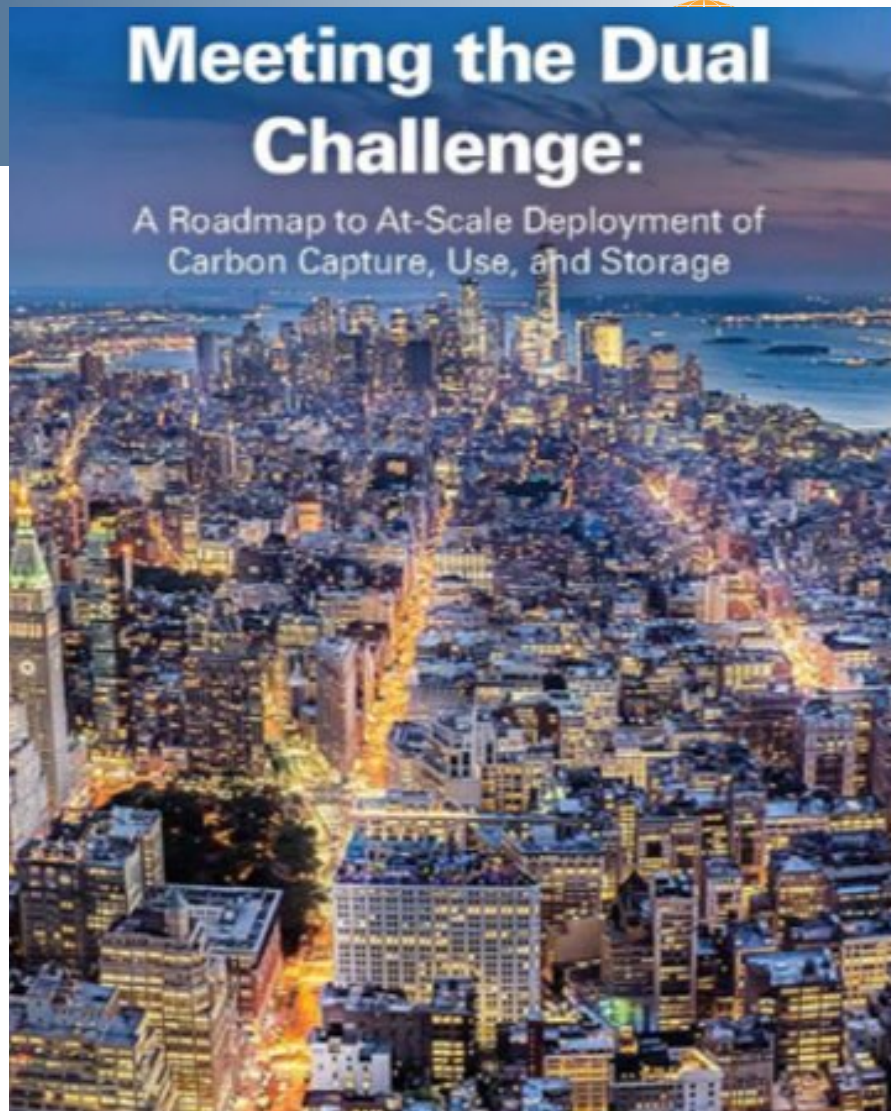
- **Targeted policies** alone cannot fully realize carbon utilization's potential.
- **Adoption of broad-based policies** and market preferences favoring decarbonization is imperative. (carbon pricing, performance standards)
- **Timing** is everything –
  - Carbon use markets need to reach a stage of **commercialization by 2030** if longer-term GHG impact is to be possible; and
  - **Near-term actions are required** if that 2030 goal is to be met.

National Petroleum Council CCUS Study

December 2019

- Requested by the U.S. Secretary of Energy
- "Define the potential pathways for integrating CCUS at scale into the energy and industrial marketplace."
- More than 300 contributors over two years

https://dualchallenge.npc.org/



NPC Study: Defining CCUS "Deployment at Scale"

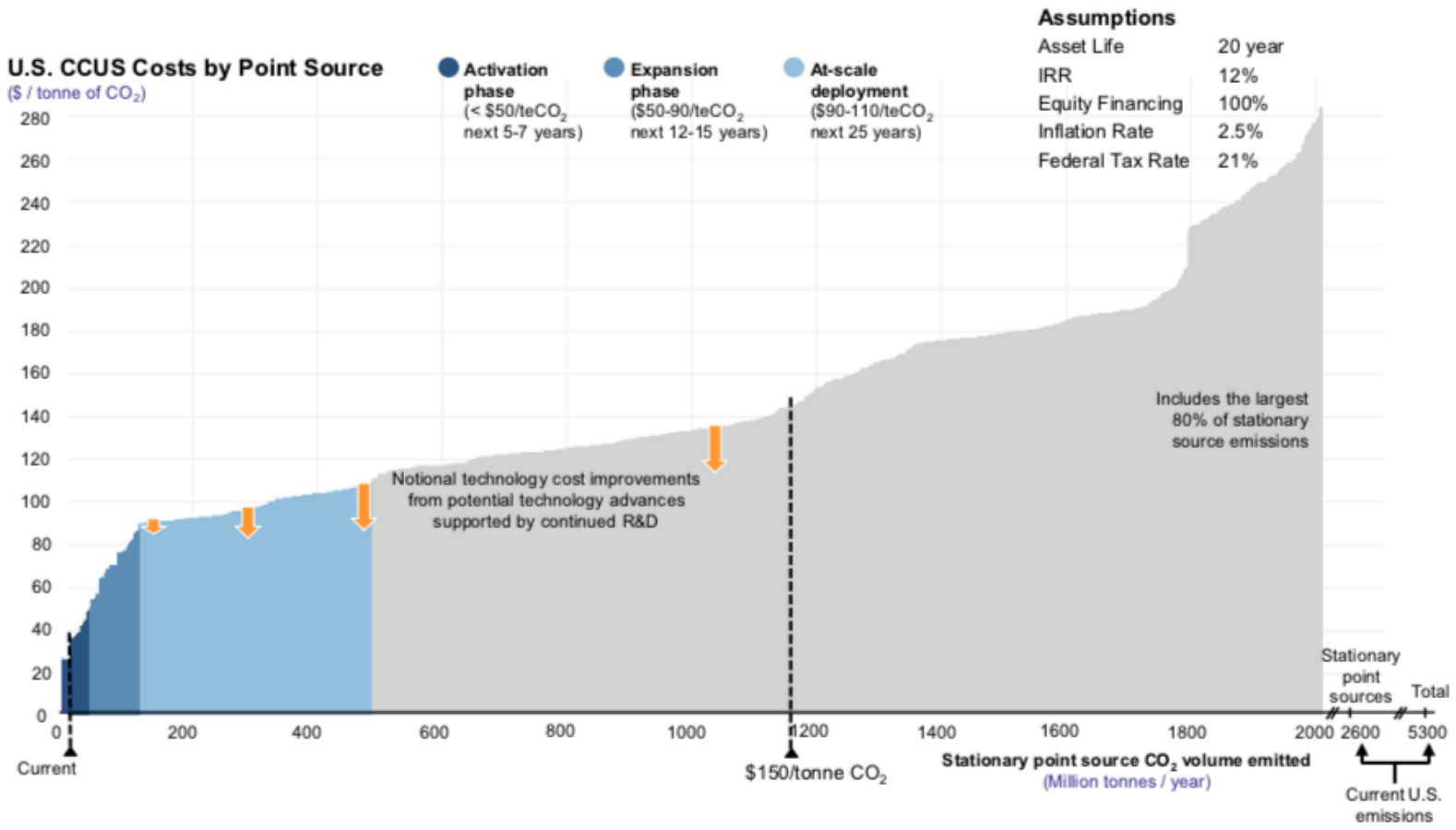
Will mean:

- Moving from 25 to **500 Million tonnes per annum** of CCUS capacity
- Infrastructure buildout equivalent of **13 million barrels per day** capacity
- Incremental investment of **$680 billion**
- Support for **236,000 U.S. jobs** and **GDP of $21 billion** annually

Will require:

- Improved **policies**, **incentives**, **regulations** and **legislation**
- Broad-based **innovation** and **technology** development
- Strong **collaboration** between **industry** and **government**
- Increased **understanding** and **confidence** in CCUS

NPC Study: Cost Assessment and Phases of Deployment



NPC Study: R&D Needs $15 Billion Over 10 Years

Technology	R&D (including pilot programs)	Demonstrations	Total	10-Year Total
Capture (including negative emissions technologies)	$500 million/year	$500 million/year	$1.0 billion/year (over 10 years)	$10 billion
Geologic Storage	$400 million/year		$400 million/year (over 10 years)	$4 billion
Nonconventional Storage (including EOR)	$50 million/year		$50 million/year (over 10 years)	$500 million
Use	$50million/year		$50 million/year (over 10 years)	$500 million
Total	**$1.0 billion/year**	**$500 million/year**	**$1.5 billion/year**	**$15 billion**

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