# Carbon Utilization Program



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# Carbon Utilization Technology Areas

#### NATIONAL ERG TECHNOLOGY ABORATORY

Industrial

Waste Heat

Solar-Heating Or Photo-driven

Wind-Electric

Methane

**Mineralization of** 

Catalyst

Methanol

#### **Carbon Utilization Program R&D Areas**







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### Goals and Objectives

**Carbon Utilization Program** 



### Fossil Energy 2018-2022 Strategic Vision

FE Strategic Goal

• Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources

### Objective

• Develop technologies to maximize the value from fossil energy resources, including their production and use

### Sub-Objective

• Utilize CO<sub>2</sub> or coal to produce valuable products, including chemicals, fuels, or high-value material



# Challenges of Carbon Utilization

- Thermodynamic stability of CO<sub>2</sub>
- Electricity prices are rarely negative/free
- Rigorous, transparent and standard Life Cycle Analysis (LCA)
- Contaminants, impurities, and variations in captured CO<sub>2</sub> or flue gas











### Sources of Anthropogenic CO<sub>2</sub>

#### CO<sub>2</sub> Sources for Carbon Utilization





Industrial Facilities (e.g. cement kilns ~22% CO<sub>2</sub>)







ATIONAL

HNOLOGY



# Mineralization into Inorganic Materials



#### **Program Focus Area**

- R&D Activities and Challenges:
  - Controlling and accelerating carbonate reactions
  - Optimizing process design
  - Characterizing and accepting new material formulations
  - Scaling improving CO<sub>2</sub> uptake





# Carbon Uptake Using Algae

#### **Program Focus Area**

- R&D Activities
  - Improving CO<sub>2</sub> capture, transportation, uptake and conversion into high valued bioproducts.
  - Developing novel reactor and raceway designs, dewatering methods and genomics

### • Challenges

- Efficiently capturing, transporting, and releasing of CO<sub>2</sub>into algal media
- Developing energy efficient dewatering techniques
- Discovering/developing algal strains that grow well in the presence of  $SO_x$  and  $NO_x$
- Improving utilization and biomass productivity





# Carbon Utilization Program Budget



U.S. DEPARTMENT OF

Carbon Utilization (\$M)		
FY 18 Enacted	FY 19 Enacted	FY 20 Enacted
\$12	\$12	\$21

Office of Fossil Energy 2018-2022 Strategic Vision:

"Utilize CO<sub>2</sub> or coal to produce valuable products, including chemicals, fuels, or highvalue materials"



# Carbon Utilization Projects







https://netl.doe.gov/coal/carbon-utilization

**Conversion into Fuels and Chemicals** CO<sub>2</sub> Uptake (Algae) **Mineralization into Inorganic Materials** 

### **Active Projects**



# NETL-RIC: Carbon Utilization R&D



#### Primary Research Areas:

- Catalytic conversion of CO<sub>2</sub> into industrially relevant chemicals
- Electro-microbial CO<sub>2</sub> transformation for fine chemicals production
- Utilization of CO<sub>2</sub> streams for production of structural materials
- Lifecycle and market assessment studies

### Key Successes:

- Reducing precious metal content in catalysts while maintaining performance
- Development of Biological Electro-Synthesis Technologies (BEST)
- Improving cement properties with CO<sub>2</sub>

Gold-Copper Nanocatalysts



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Retained performance ~50% reduction in gold



Microwave-Assisted Thermal CO<sub>2</sub> Conversion

- Mixed metal oxides absorb microwaves generating heat
- Opening opportunities for CO<sub>2</sub> utilization pathways that traditionally require high temperatures



https://www.netl.doe.gov/sites/default/files/netl-file/D-Kauffman-NETL-Catalytic-Conversion-of-CO2.pdf https://netl.doe.gov/sites/default/files/2019-03/USE-REUSE-25-Catalytic-Conversion-of-CO2-20190114.pdf Carbon Utilization Technology Development Schedule







FOA 2186: Novel Concepts for the Utilization of Carbon Dioxide from Utility and Industrial Sources

#### Areas of Interests: Issued February 2020

#### AOI 1 – Synthesis of Value-Added Organic Products

Proof of concept and validation in laboratory environment

#### AOI 2 – Production of Inorganic Materials: Solid carbon products

Field scale testing and development

### AOI 3 – Integrated CO<sub>2</sub> Capture with Algae

Bench-scale development and testing Address CO<sub>2</sub> capture, conditioning, transport and transfer to the algae medium

#### AOI 4 – Production of Inorganic Materials: Maximizing Uptake in Concrete and Cement

Field scale testing and development

#### Federal Funding(\$ Million)

- AOI 1: Fuels & Chemicals \$2.0
  AOI 2: Solid Carbon
  AOI 3: Algae \$6.0
- AOI 4: Mineralization

AOI 1

AOI 2

AOI 3

AOI 4

2







\$7.0

\$2.0

# Carbon Utilization Accomplishments

NATIONAL ENERGY TECHNOLOGY LABORATORY

Reducing the cost of captured carbon and putting it to work for America

CO<sub>2</sub> UTILIZATION BOOSTED BY MICROWAVE-ASSISTED CATALYST Efficient and economical microwave-assisted catalysts provide groundbreaking solutions to carbon utilization challenges

NOVEL CATALYSTS ENHANCE CONVERSION OF CO<sub>2</sub> INTO HIGH-VALUE CHEMICALS

Innovative catalysts convert waste CO<sub>2</sub> into higher-value, industrially relevant chemicals and materials and eliminates expensive precious metals





EMISSIONS REDUCTION PATH FOR COAL INDUSTRY IN CARBON-NEGATIVE CONCRETE REINFORCEMENT Utilizing CO<sub>2</sub> and industrial byproducts to create CO<sub>2</sub>negative upcycled concrete that performs as well, or better, than traditional construction materials



# Program Summary



#### **Program Goals**

- Utilize waste carbon streams to produce valuable products
- Reduce emissions (LCA)

### Program Pathways

- Conversion to chemicals and fuels
- Mineralization into inorganic materials
- Uptake using Algae

### Near-term/Mid-term Objectives

- Increase catalyst yield, selectivity, and conversion
- Increase CO2 uptake and conversion in mineralization products
- Improve CO2 uptake and conversion utilizing algae technologies

### Program Accomplishments

• Improved products, catalysts, designs and processes



## Carbon Utilization Contacts and Resources





# NETL Website

https://netl.doe.gov/coal/carbon-utilization

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