Mission
▪ Ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while
▪ Developing technologies to manage carbon across the full life cycle, and
▪ Enabling environmental sustainability for all Americans.

Vision
▪ To be the nation’s premier energy technology laboratory, delivering integrated solutions to enable transformation to a sustainable energy future.
Strategic Vision and Programmatic Update

Mission
• Demonstrate and ultimately deploy carbon management technologies through multiple carbon conversion approaches
• Mitigate externalities of fossil fuel use in a just and sustainable way, with the goal of achieving 50% reduction in U.S. GHG pollution by 2030 and a carbon-neutral economy by 2050.

Goals
• Support R&D that can convert CO₂ into products
  • Conversion must be environmentally and economically attractive
• Support scaling (demonstration) of technology where appropriate

Drivers
• United States 2022 CO₂ energy related emissions ≈ 5.0 gigatonnes
  • Total global equivalent ≈ 36.8 gigatonnes

Challenges
• Scale of CO₂ emissions relative to demand
• Qualifying economic viability and environmental impact requires significant resources
• Availability and carbon footprint of energy inputs (e.g. electricity, hydrogen, etc...)
• “It’s tough to make predictions, especially about the future"
Program Structure and Budget

Carbon Conversion Program R&D Areas

- Biological Uptake
  - Algae & Bioproducts
- Catalytic Pathway
  - Fuels & Chemicals
- Mineralization
  - Inorganic Materials

Annual Funding (in Millions)

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Carbon Conversion Program Within NETL

R&D through Research and Innovation Center
- Majority focus on conversion into chemicals
- Activity in catalyst design, microwave reformation, reactive capture, and more

Life cycle Analysis through Energy Systems Analysis Team
- Vital to determining economic viability and environmental impact
- Active in Global CO₂ initiative
- Challenges
  - Working to harmonize LCA methodology with other groups
  - Requires collaboration across multiple offices, departments, and external entities

Techno-economic analysis through Energy Process Analysis Team
- All successful technologies must add value
- Sensitivity analysis dependent upon many unknowns
- Not as straightforward to qualify as technical viability
Carbon Conversion Through NETL via BIL

BIL represents ~$310MM investment over five years
One aspect is “Utilization Procurement Grants,” aka UPGrants

https://netl.doe.gov/upgrants

DE-FOA-0002829

Demonstration Grants
50% cost share

To Eligible Entities
States, local gov, public utility/agency

Procure and use commercial or industrial products
Derived from anthropogenic carbon oxides
Less GHG emissions than incumbent
Vendor must pass critical review
Extramural research outside of NETL

Various funding mechanisms employed
- Field Work Proposals with other national laboratories
- Funding Opportunity Announcements
  - Majority of funding is competitively awarded
- Grant Programs
  - SBIR and STTR for small businesses and institutions of higher education
  - Other mechanisms including TCF, ACT, EPSCoR

Robust project portfolio
- Thirty-five active projects within the portfolio and growing quickly
  - Mineralization, catalytic pathway, and biological uptake
Carbon Conversion via Biological Uptake

A range of products are possible

- Animal feeds
- Nutraceuticals
- Dyes/colorants
- Polymers
- Soil amendments
- Fuels
  - Specific to the mission of DOE EERE’s BETO (BioEnergy Technologies Office)

Advantages and challenges

- Uses well understood processes (10,000+ years of human agricultural experience)
- Mostly enabled with catalog engineering (uses COTS equipment)
- Biological processes well suited to creating many complex carbon molecules
- Large areas required to achieve gigatonne scale
  - Kinetically slower than higher temp/pressure processes
Carbon Conversion via Biological Uptake

Pictures courtesy of University of Illinois Urbana-Champaign

Picture courtesy of Global Algae Innovations

Picture courtesy of University of Maryland Center for Environmental Science
Carbon Conversion via Catalytic Pathway

A wide range of products are possible
- Fuels
- Polymers
- Solid carbons
- Alcohols
- C2-C4 products (ethane, propane, butane, etc...)
- Methanol and Methane

Advantages and challenges
- Pathways to gigatonne scale exist
- Almost any molecule can be synthesized
  - Including those currently derived from fossil fuels
- Value of products must outweigh cost of energy inputs
- Breakthroughs may require significant funding (e.g. electrochemistry and catalysts)
Carbon Conversion via Catalytic Pathway

Picture courtesy of SkyNano

Picture courtesy of University of Louisville
Carbon Conversion via Mineralization

A limited range of products are possible
- Cured concrete blocks (CMUs)
- Synthetic aggregates
- Suboxides
- Other building materials

Advantages and challenges
- Can be energetically downhill
- Can apply at gigatonne scale
- Mostly enabled with catalog engineering (uses COTS equipment)
- Can address other waste streams (e.g. produced water or mine tailings)
- Products often have a low specific value (i.e. $/tonne requires large scale)
Carbon Conversion via Mineralization

Pictures courtesy of UCLA

Picture courtesy of University of Wisconsin Madison
Necessity of TEA/LCA for an Uncertain Future

Tomorrow will look a lot like today
- Mix of fossil, renewable, and nuclear resources
  - Abundant waste heat integration opportunities
  - Industrial electricity prices of $60 - $80 / MWh

Inexpensive and abundant hydrogen
- $1/kg Hydrogen
  - Thermochemical conversion of CO₂ into chemicals and plastics
  - Industry widely decarbonized (e.g. steel, cement, fertilizer)

Techno-cornucopian worldview
- Inexpensive electricity at $20 - $30 / MWh
- Widescale electrification
- Favorable for electrochemical approaches

Other unknowns
- Carbon prices/credits, DAC costs, energy breakthroughs, R&D costs, etc…
Carbon Conversion Program Tools

https://netl.doe.gov/carbon-management/carbon-conversion

https://www.netl.doe.gov/LCA/CO2U
Carbon Conversion Contacts and Resources

Joseph Stoffa
NETL Technology Manager
Joseph.Stoffa@netl.doe.gov

Emily Connor
DOE HQ BIL Program Manager
Emily.Connor@hq.doe.gov

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