Carbon Utilization Program

NATIONAL ENERGY TECHNOLOGY LABORATORY

Joseph Stoffa, PhD
Technology Manager

Mission, Goals, Drivers, Challenges

Mission

- Minimize the climate and environmental impacts of fossil energy
- Advance carbon management through multiple approaches
  - Includes conversion of CO_2 into products

Goals

- Economically transform CO_2 into products, in an environmentally conscious manner

Drivers

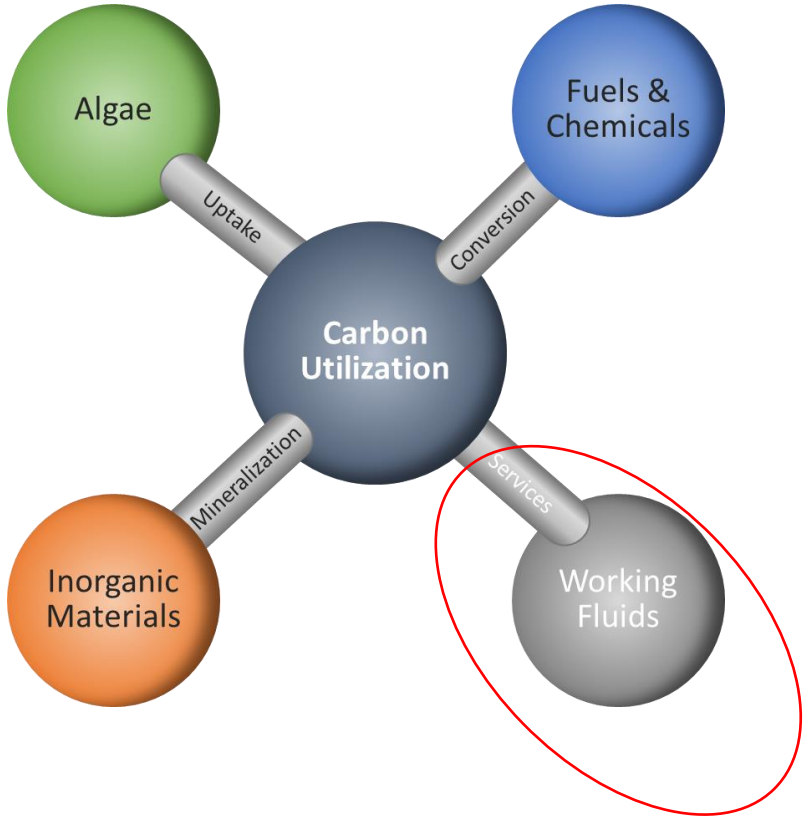
- United States 2019 CO_2 energy related emissions ≈ 5.1 gigatons
  - Total global equivalent ≈ 33.1 gigatonnes

Challenges

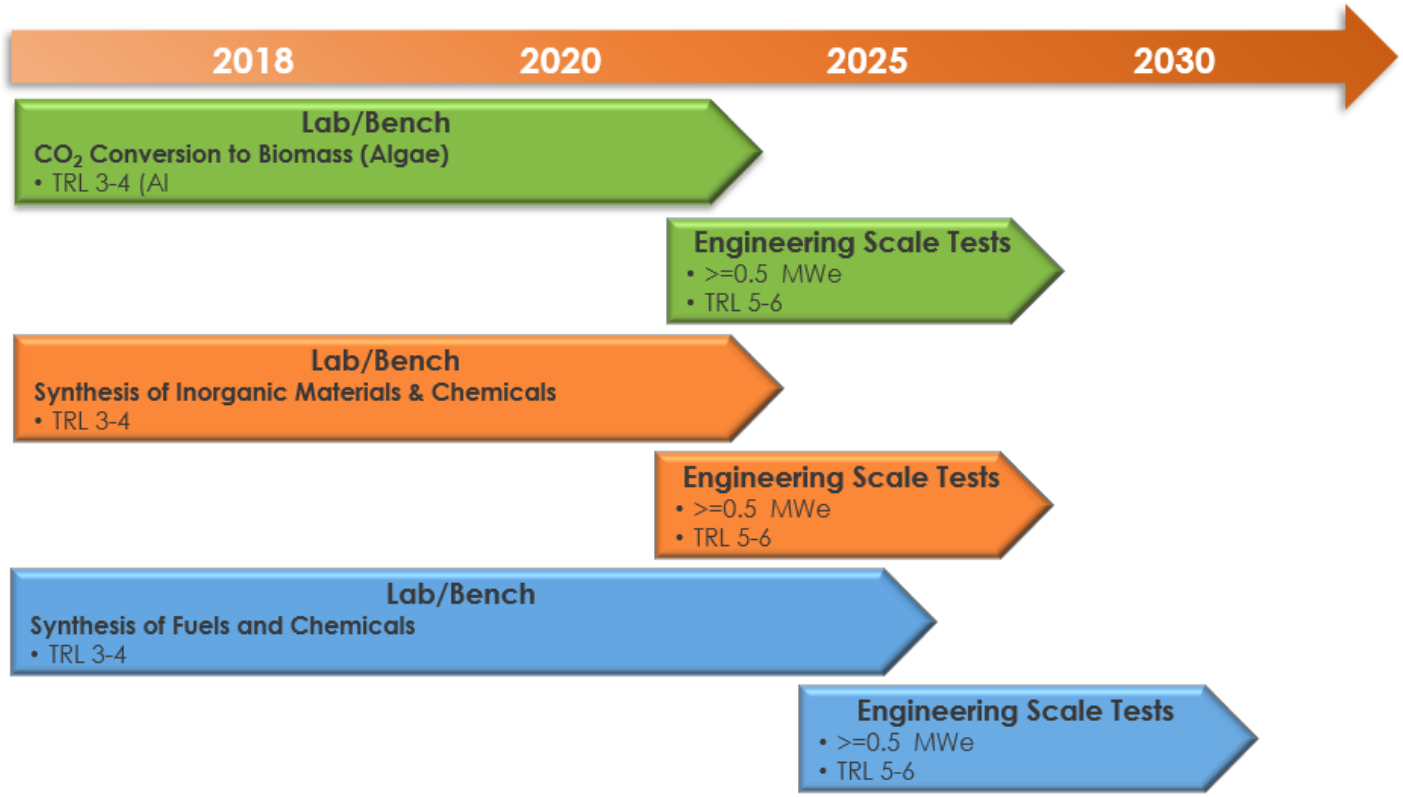
- Scale of CO_2 emissions relative to CO_2 consumption
- Qualifying economic viability and environmental impact requires significant resources
  - Technical viability is relatively easy to qualify
- Electricity prices rarely negative/free
- It's tough to make predictions, especially about the future

Carbon Utilization Program Structure

Carbon Utilization Program R&D Areas



Focus of other programs



Carbon Utilization Program within NETL

R&D through NETL's Research and Innovation Center

- Majority focus on conversion into chemicals
- Activity in catalyst design, microwave reformation, reactive capture, and more
- Presentation on Tuesday

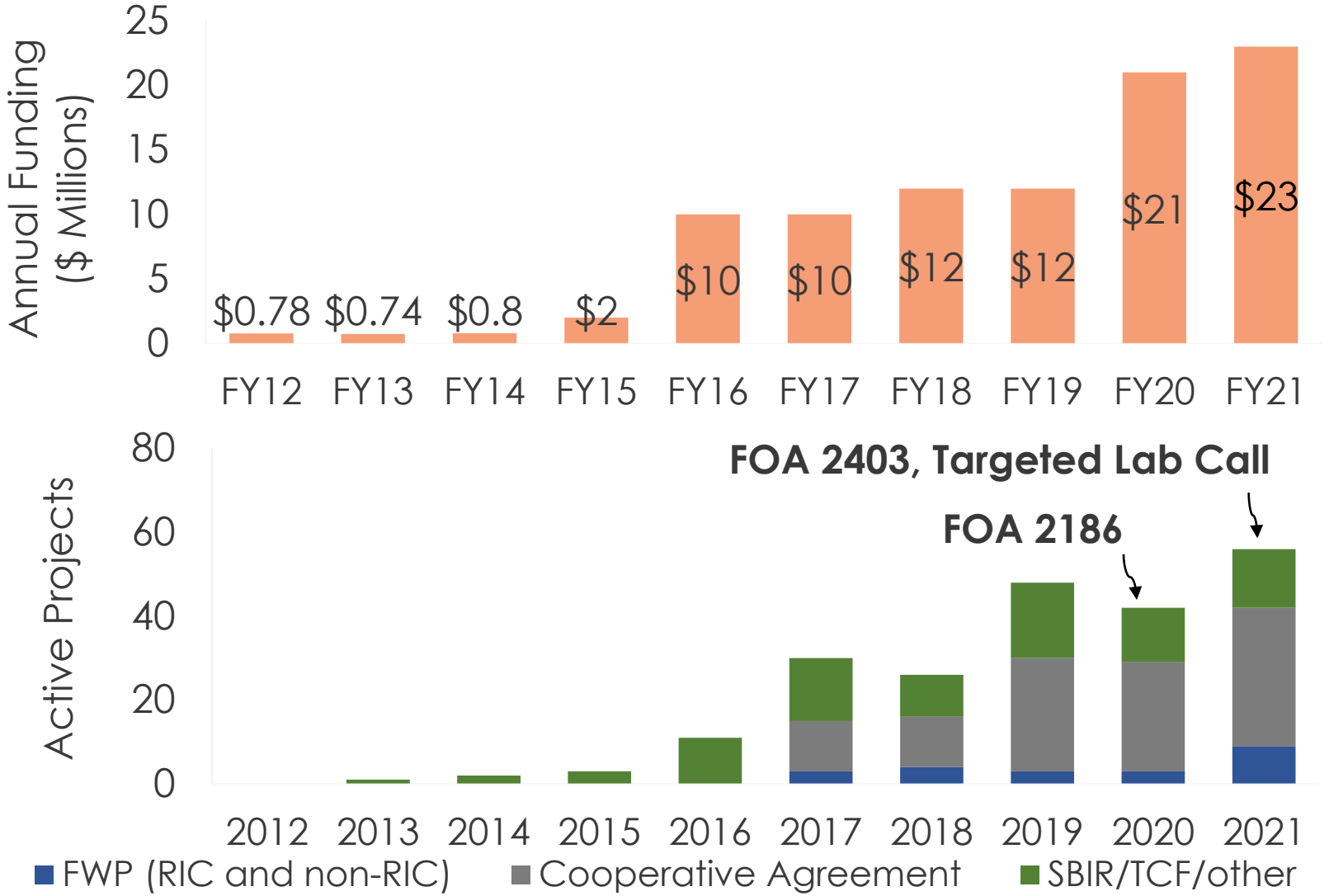
LifeCycle Analysis through NETL's Energy Systems Analysis Team

- Vital to determining economic viability and environmental impact
- Active in Global CO_2 initiative
- Presentation later today

TechnoEconomic Analysis through NETL's Energy Process Analysis Team

- All successful technologies must add value
- Sensitivity analysis dependent upon many unknowns

Carbon Utilization Program Budget and Project History

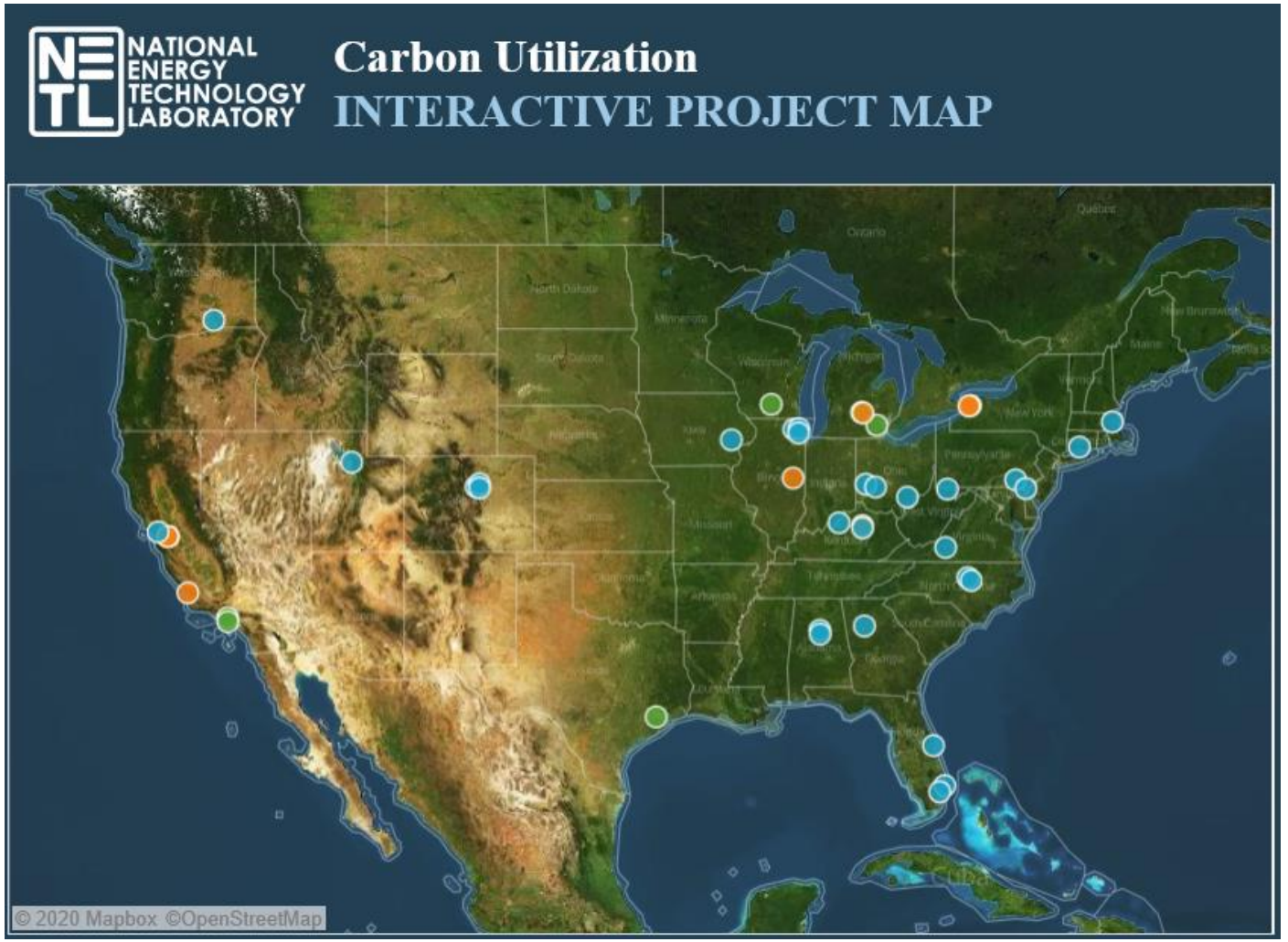


Carbon Utilization ($M)		
FY 20 Enacted	FY 21 Enacted	FY 22 Requested
$21	$23	$38

Office of Fossil Energy 2018-2022 Strategic Vision:

Utilize CO_2 to produce valuable products, including chemicals, fuels, or high-value materials

Carbon Utilization Projects



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

Accomplishments Since Last Year

Program supported XPRIZE winning R&D of UCLA Carbon Built

- One of two winners out of forty-seven submissions from seven countries
- "This outstanding project represents another example of how the U.S. Department of Energy's (DOE) Office of Fossil Energy and NETL collaborate with and support outstanding university researchers to advance carbon management solutions and reduce CO_2 emissions," said NETL Director Brian Anderson, Ph.D.

Supporting R&D in new and existing areas

- Reactive Capture and Conversion (RCC)
- Biological uptake via algae
- Potential for ACT awards (Accelerating CCUS Technology)
- SBIR Program

Collaboration with multiple stakeholders

- Necessary due to the scale and breadth of the challenge
- Interest in carbon utilization has increased drastically within the last two years
  - Congressional Research Services, June 16 2021, Funding for Carbon Capture and Carbon Removal at DOE

Reactive Capture and Conversion (RCC)

Newer area of focus within the program

- Published RFI seeking input on RCC in 2019
- RCC is distinct from other capture technologies
- CO_2 becomes incorporated into the final product and is neither regenerated, transported for further use, nor stored as pure CO_2
- Avoids energy intensive regeneration
  - Adsorption towers are also a relatively expensive component

Targeted lab call

- Focus on conversion or mineralization

Five new national nab projects

- LLNL – Direct Air Reactive Capture and Conversion for Utility-Scale Energy Storage
- NETL – Integrating CO_2-Selective Polymer Layers and Electrocatalytic Conversion
- NREL – A Pressure-Swing Process for Reactive CO_2 Capture and Conversion to Methanol through Precise Control of Co-Located Active Sites in Dual Functional Materials
- ORNL – Porous Catalytic Polymers for Simultaneous CO_2 Capture and Conversion to Value-added Chemicals
- PNNL Integrated Capture and Conversion of CO_2 into Materials: Pathways for Producing CO_2-Negative Building Composites

Additional Support for R&D on Biological Uptake

DE-FOA-0002403 – ENGINEERING-SCALE TESTING AND VALIDATION OF ALGAE-BASED TECHNOLOGIES AND BIOPRODUCTS

- Four selections at ~$2MM DOE share each
- Support for R&D to develop and test technologies that can utilize carbon dioxide from power systems or other industrial sources for bio-mediated uptake by algal systems to create valuable products and services.
- Scale of ~1000 liters

Four new projects selected

- Global Algae Innovations – Carbon Capture and Utilization for Protein and Fatty Acids
- Helios-NRG — Engineering-Scale Validation of Novel Algae CO_2 Capture and Bioproducts Technology
- Texas A&M AgriLife Research — Algae-based Carbon Capture and Utilization (CACCU) to Transform Economics and Environmental Impacts
- University of Illinois — Improving the Cost-Effectiveness of Algal CO_2 Utilization by Synergistic Integration with Power Plant and Wastewater Treatment Operations

Additional Progress on CO_2 Conversion

Largest project count within our portfolio

- The large majority of our ~60 active projects
- Focusing mostly on high volume with some support of R&D into high-value

Several conversion technologies under consideration

- Thermochemical, electrochemical, membrane, molten salt, plasma, microwave
  - Optimal route heavily dependent on CO_2 source, raw material costs, and geography

A range of liquid, gas, and solid products

- Formic acid, polymers, ethylene, aromatics, acetic acid, methanol, dimethyl carbonate, propane, propylene, carbon monoxide, nanotubes, graphene, etc…
  - Ensure that we minimize duplication across DOE offices
  - Fundamental tradeoff between high-volume and high-value

Conclusions

Mission and Goals

- Advance carbon management through multiple approaches
  - Economically transform CO_2 into products, in an environmentally conscious manner

Challenges

- Requires collaboration across multiple offices, departments, and external entities
- Accurate evaluation of technical, environmental, and economic viability
  - Technical viability is relatively easy to qualify
- Scale of CO_2 emissions relative to CO_2 consumption
  - United States 2019 CO_2 energy related emissions ≈ 5.1 gigatons
  - Total global equivalent ≈ 33.1 gigatonnes

Recent Accomplishments

- Expansion into new research areas
- Continued support of algae, conversion, and mineralization

Carbon Utilization Contacts and Resources

Amishi Kumar

FECM Program Manager

Amishi.Kumar@hq.doe.gov

Joseph Stoffa

NETL Technology Manager

Joseph.Stoffa@netl.doe.gov

CARBON UTILIZATION

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