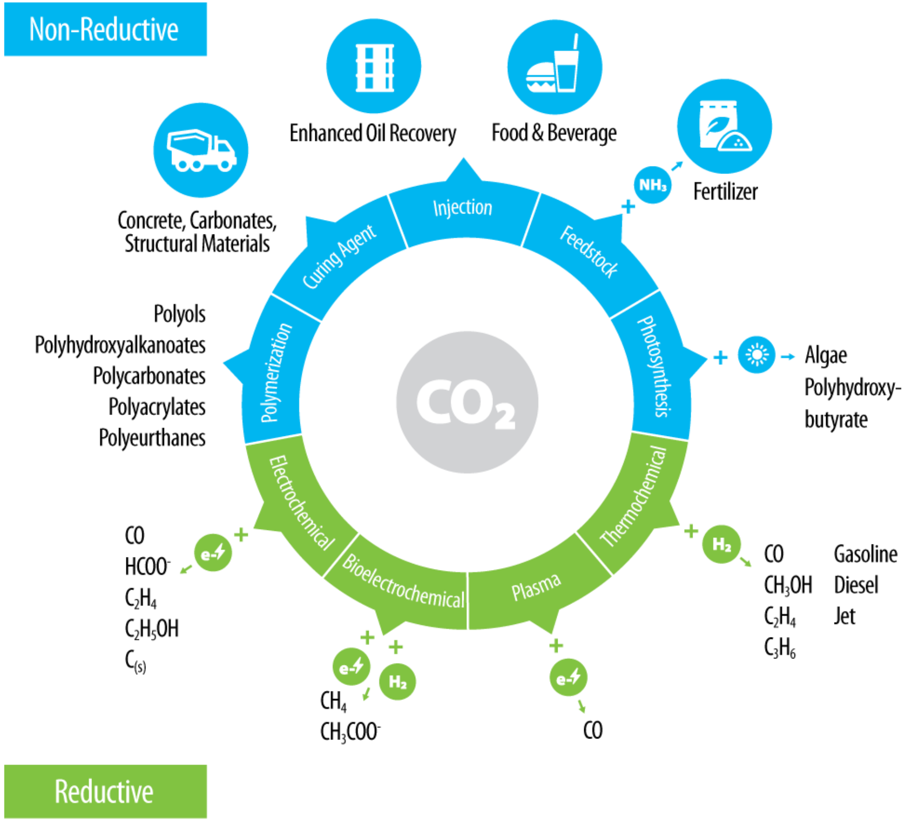
CO_2 Utilization

USEA CCUS 101: Capture to Containment
October 8th, 2025

Photo by Agata Bogucka, NREL 91683

CO_2 Utilization Options



CO_2 can be utilized directly (non-reductive utilization) or undergo chemical transformation (reductive utilization) as precursor to other products

Multiple technologies exist to take CO_2 to products with varying advantages and disadvantages

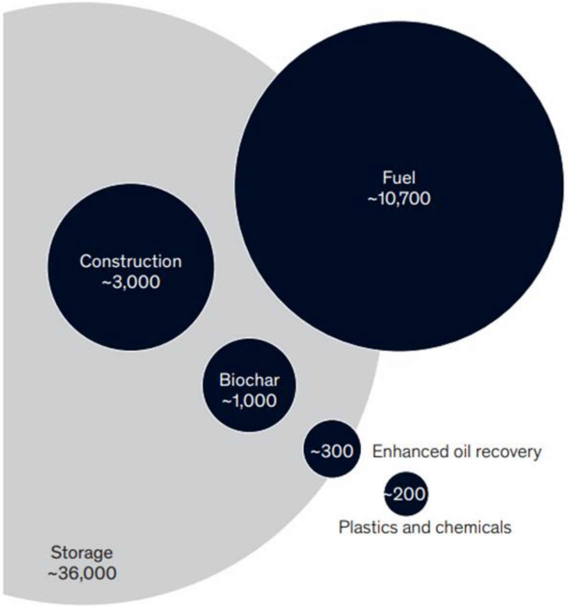
R. Grim, et al., *Energy Environ. Sci.*, 2020, **13**, 472-494.

Market Size and Value of CO_2 Utilization Products

Market Size

Technical potential of CCUS in 2030, metric megatons of CO_2 per year[1]

■ Carbon capture and use ■ Carbon capture and storage



Selected examples

Fuel
Synfuel and macro- or microalgae fuel

Enhanced oil recovery (EOR)
Conventional or unconventional CO_2 EOR and CO_2 EOR in residual oil zones

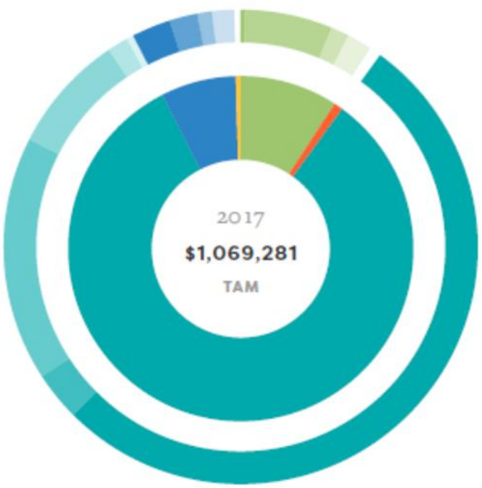
Construction materials
Cement and aggregates

Plastics and chemicals
Polyethylene, polypropylene, carbon fiber, and methanol

Biochar
A charcoal derived from burning organic agriculture- and forestry -waste products

Storage
Saline aquifers and depleted oil and gas reservoirs

Market Value

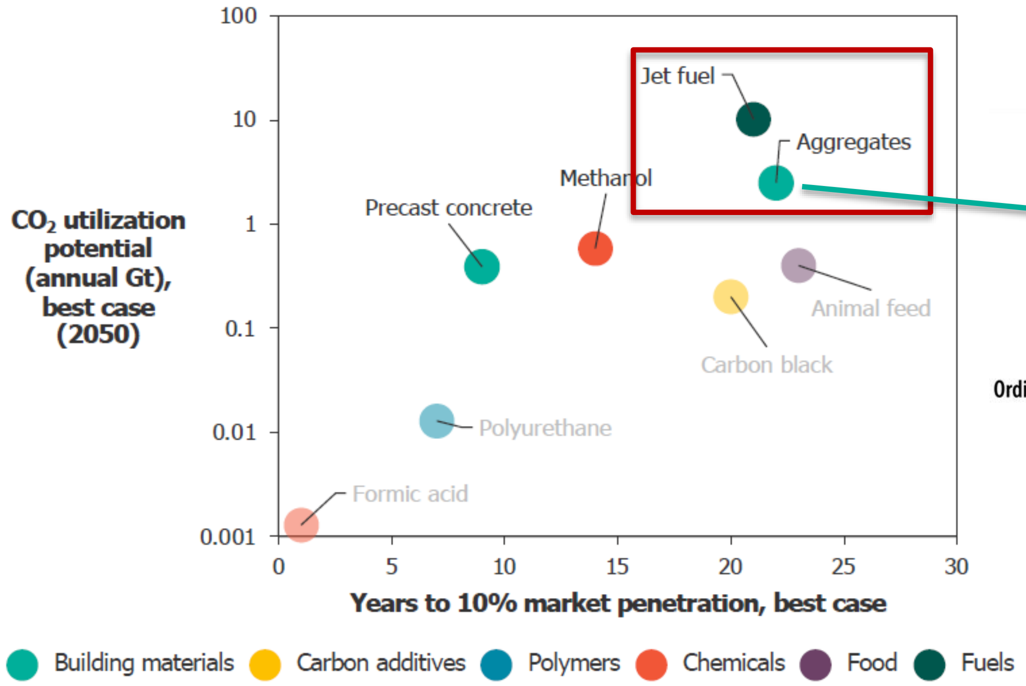


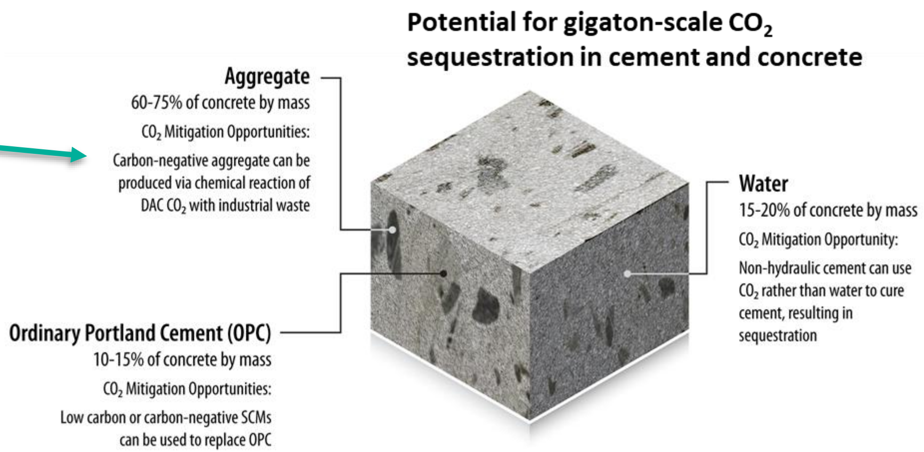
PRODUCT	$ IN MILLIONS
BUILDING MATERIALS	$101,130
Cements	$1,240
Concretes	$65,000
Asphalts	$12,190
Aggregates	$22,700
WOOD-BASED PANELS	$12,508
FUELS	$882,149
Gasoline	$543,400
Jet Fuel	$38,760
Diesel	$186,660
Natural Gas	$83,705
Ethanol	$23,550
Biodiesel	$6,074
PLASTICS	$71,694
High density polyethylene	$25,393
Linear Low density polyethylene	$20,502
Low density polyethylene	$11,522
Polypropylene	$14,276
CHEMICALS	$1,800
AGRICULTURE AND AQUACULTURE	N/A
CONSUMER GOODS	N/A
TOTAL	$1,069,281

Biniek et al., McKinsey Quarterly, June 2020

Jacobson and Lucas, Carbon180, 2018

Utilizing CO_2 could be a $1 Trillion Industry…in due time

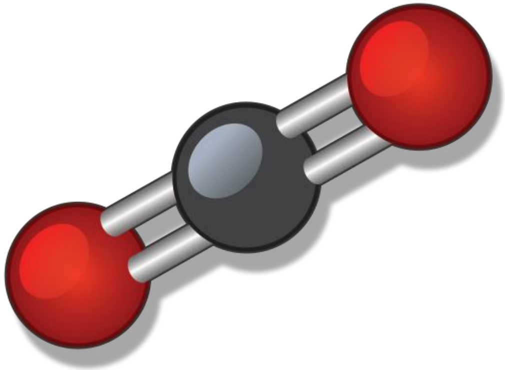




Implementing CO_2 Capture and Utilization at Scale and Speed, Global CO_2 Initiative, 2022

Brutal Reality of CO_2 Conversion to Fuel

High Oxygen Content

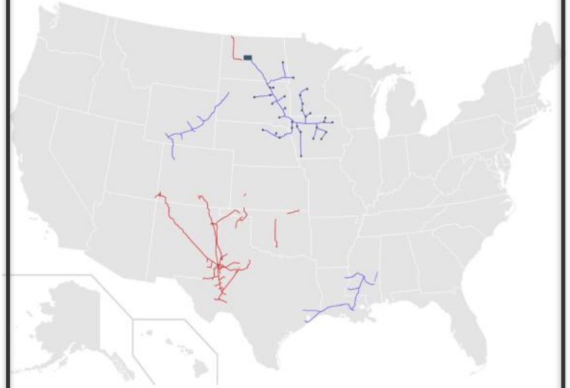


And neither free nor pure

Requires Lots of Energy

Limited Pipeline Infrastructure

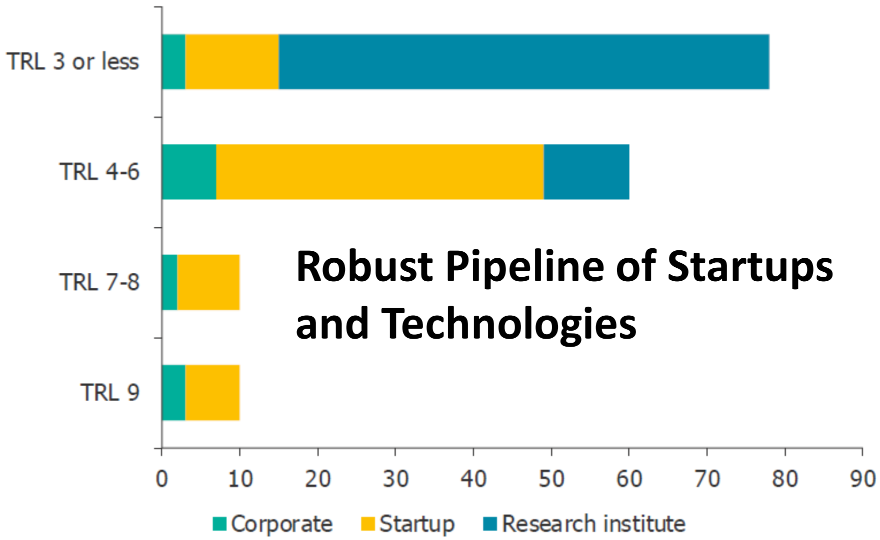
American Carbon Alliance



Considerations for CO_2 Utilization

Adding CO_2 utilization to an ethanol biorefinery has the potential to increase ethanol production by up to 45%

Z. Huang, et al, *Applied Energy* 280 (2020) 115964



Robust Pipeline of Startups and Technologies

Global CO_2 Initiative, *Implementing CO_2 Capture and Utilization at Scale and Speed*, May 2022

Opportunities and Advantages:

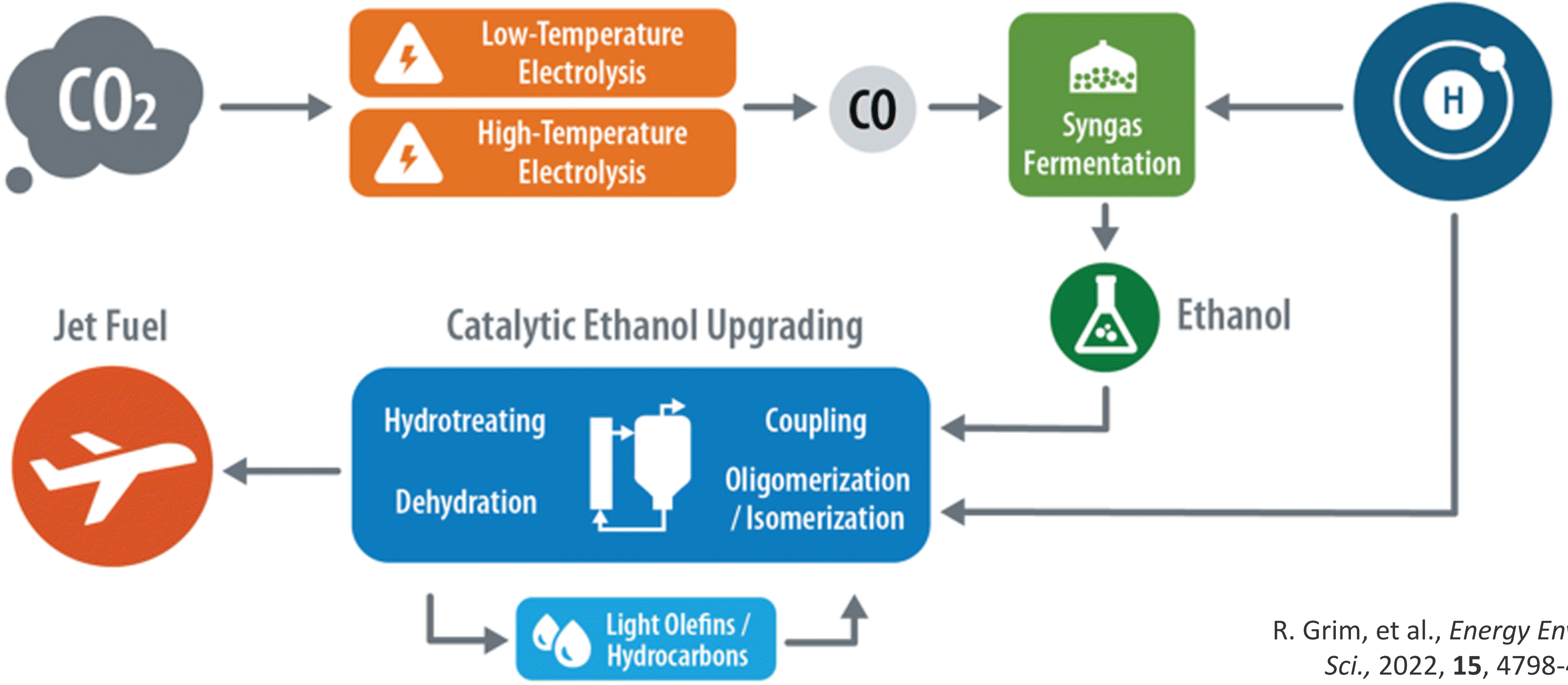
- Domestic feedstock for expanded production of fuels, chemicals, and materials
- Robust pipeline of technologies
- Supports our carbon-based economy

Challenges:

- Limited integration, diverse unit ops, and scale-up
- Energy supply and energy intensity
- Cost and market demand
- Scale and rate of CO_2 feed streams relative to CO_2 conversion needs

Producing Synthetic Aviation Fuel from CO_2

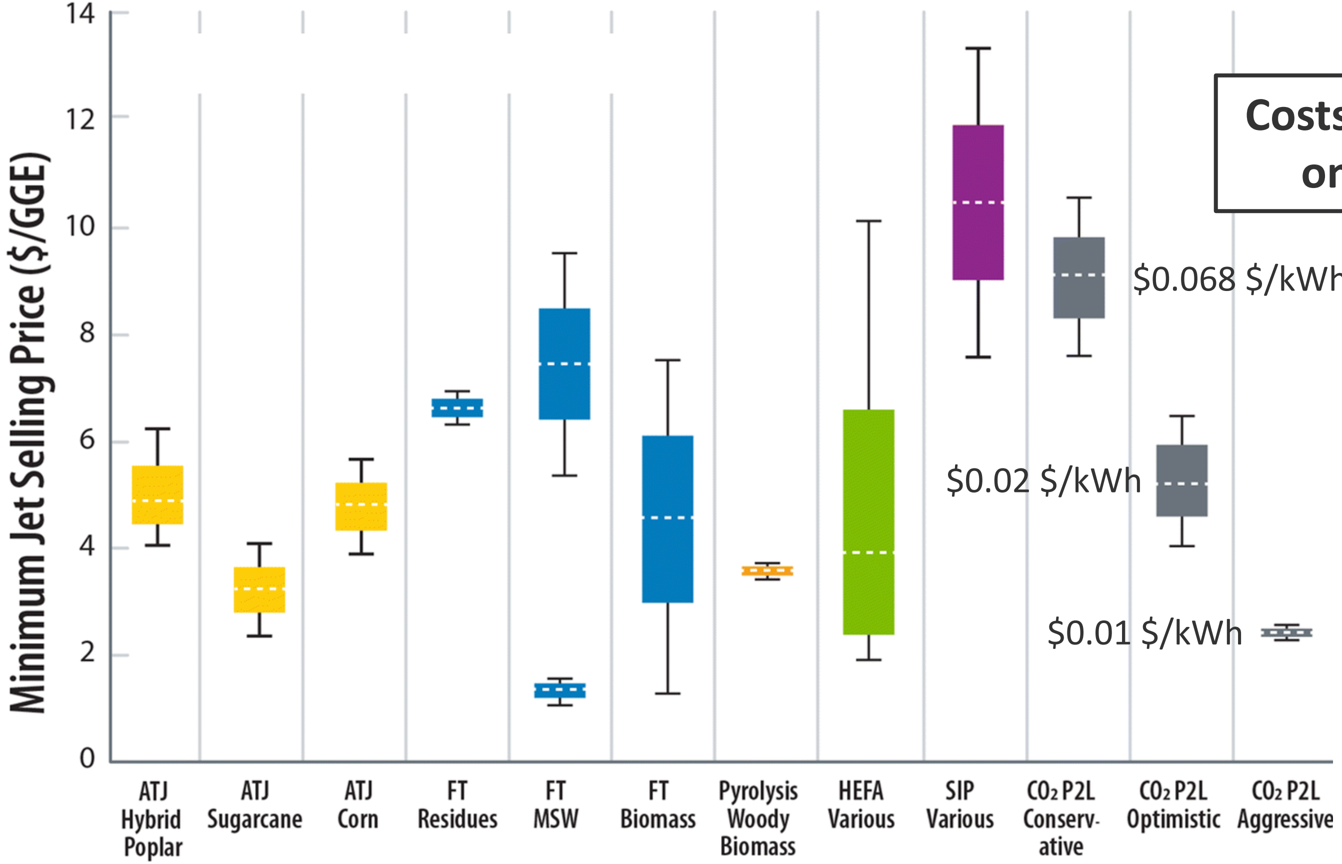
Example Process for Producing Jet Fuel from CO_2



R. Grim, et al., *Energy Environ. Sci.*, 2022, **15**, 4798-4812.

**NOTE: This is *one* possible pathway to reach synthetic aviation fuel from CO_2 and is not necessarily indicative of the most optimized or “best” design. All results are reflective to this pathway only.

Source of Energy and CO_2 Impacts Cost of Jet Fuel Production

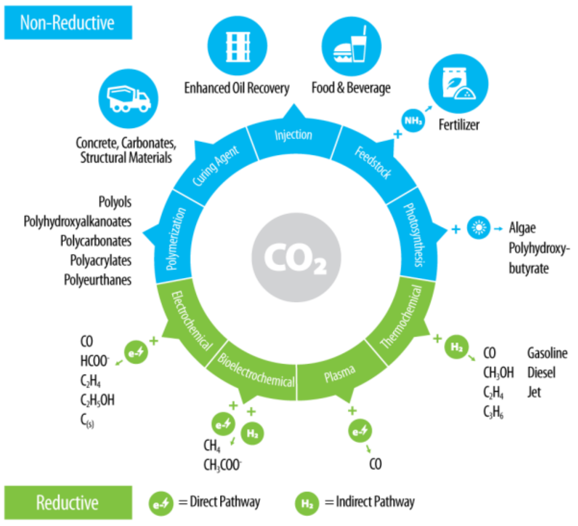


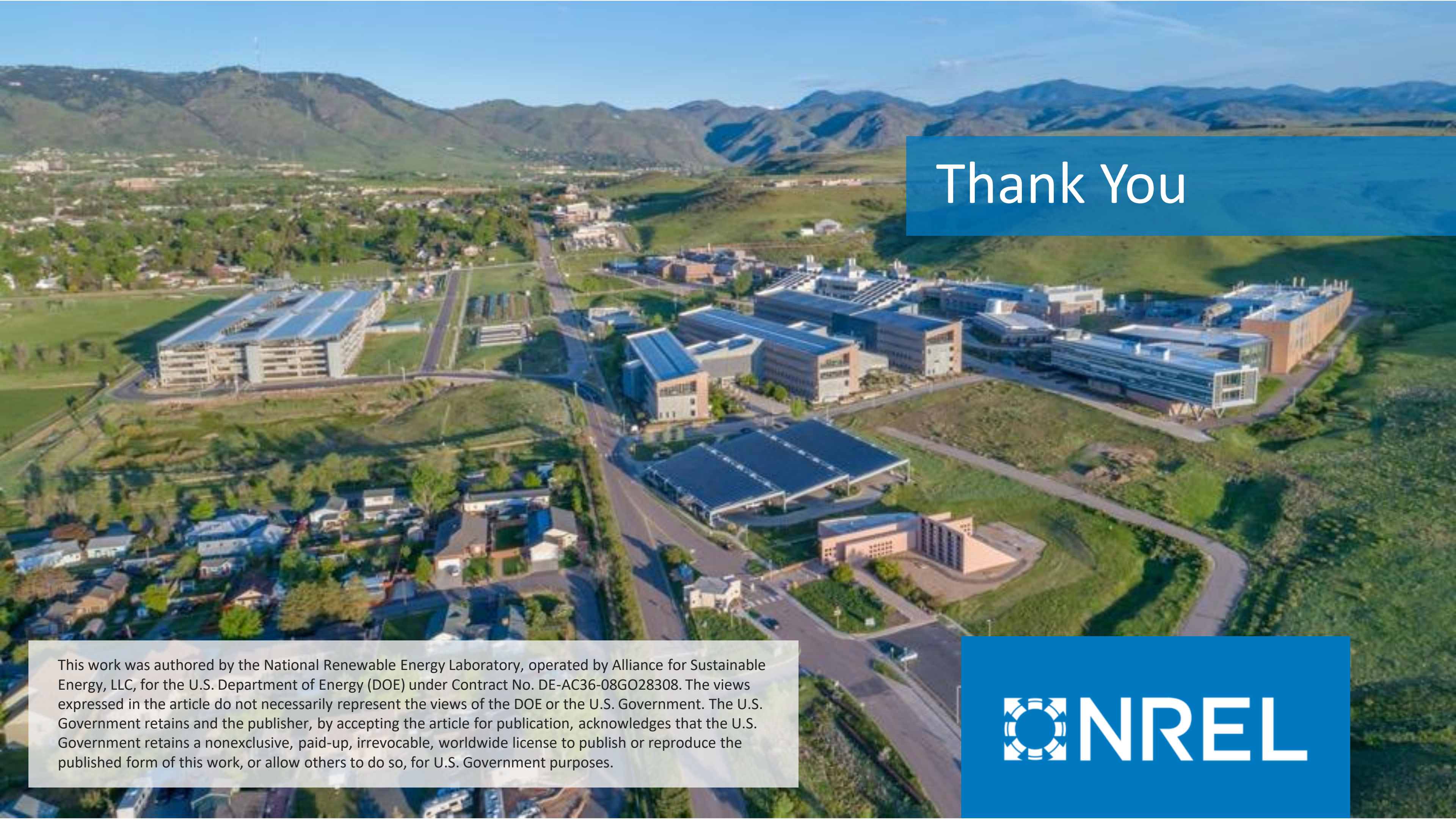
Costs depend heavily on energy price

R. Grim, et al., *Energy Environ. Sci.*, 2022, **15**, 4798-4812.

Takeaways

- **CO_2 can be utilized to produce a variety of products**
  - Primary utilization pathways today are fertilizer, enhanced oil recovery, and food and beverage
- **Potential market size for CO_2 utilization is $1 trillion, but is capital intensive and thus takes time to scale**
- **Source of energy and CO_2 has a significant impact on production costs for fuels and chemicals**
  - R&D needed to drive down cost curves





Thank You

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