twelve

Reactive Carbon Capture Workshop

January 18, 2024

quick intro

- PhD, Electrochemical Engineering
  - Experimental and computational studies of CO_2 electrocatalysis for multi-carbon products in GDE systems
- Finalists in the Carbon XPrize competition in 2020
  - CO_2-to-ethylene electrolyzer pilot plant in Calgary connected to CO_2 capture unit at an NG power plant
- Scientific Partnership Development
  - Led grant writing and stakeholder engagement to successfully raise $3.9M for the Midwest Nuclear Direct Air Capture (MINDAC) Hub
- Technical Program Manager, Strategy
  - Techno-Economic Analysis (TEA)
  - Lifecycle Assessment (LCA)
  - Using the above analyses to inform company strategy

Josh Wicks, PhD

transforming global CO_2 emissions

into a trillion-dollar opportunity









we have transformed CO_2 into products for flagship customers

E-Jet®: world's first jet fuel made from CO_2 electrolysis

U.S. AIR FORCE

Alaska AIRLINES

Microsoft

world's first CO2Made® ingredients for Tide

P&G

world's first CO2Made® auto parts

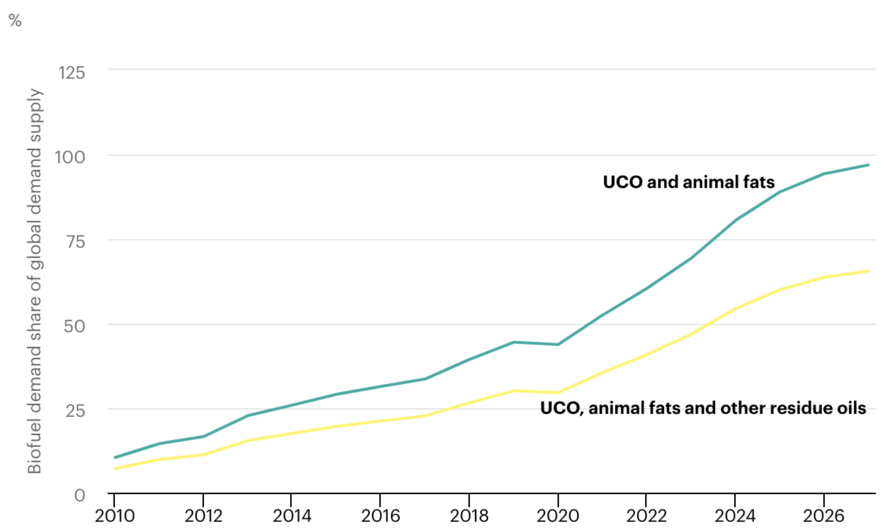
Mercedes-Benz

world's first CO2Made® sunglass lenses

PANGAIA LAB × twelve

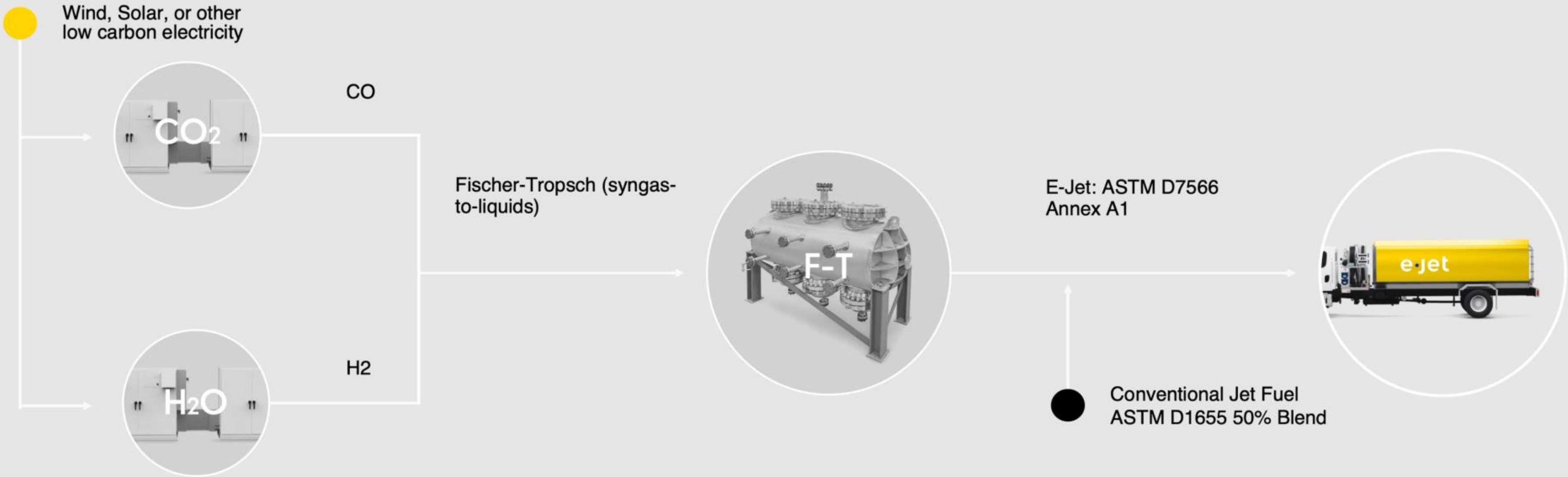
why power-to-liquids sustainable aviation fuel (SAF)?

- PtL technologies use less land, less water, and have less lifecycle emissions than fossil jet fuel and most biomass-derived alternatives
- Waste and residue oils and fats that are feedstocks for HEFA are expected to face a supply crunch in 2027
- PtL fuels are necessary for long-term supply of SAF



IEA (2022)

transforming CO_2 into E-Jet®



1.

We use proprietary CO_2 electrolysis and H_2O electrolysis to produce syngas from captured CO_2 and water

2.

Syngas is used in commercial fuel production via Fischer-Tropsch process

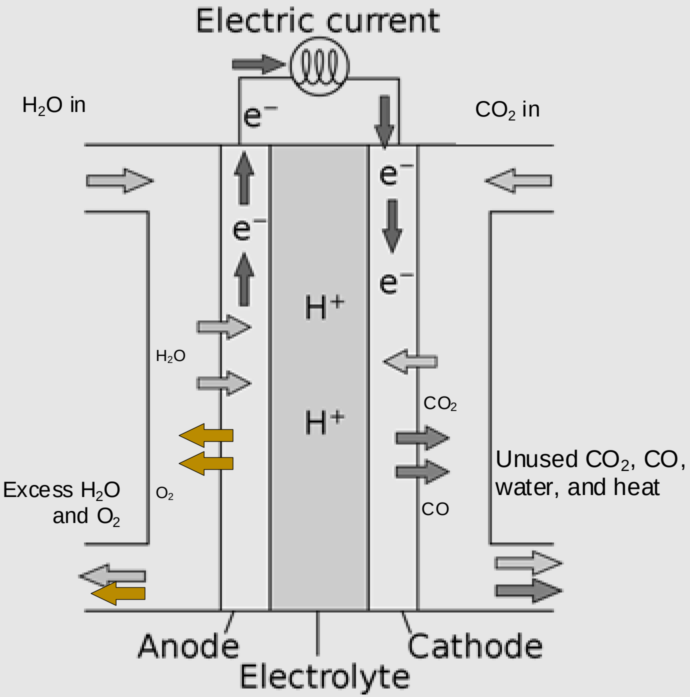
3.

The synthetic fuel (meeting ASTM D7566 Annex A1) is blended 50%/50% with conventional fuel (ASTM D1655)

4.

The blended fuel (meeting ASTM D1655) is then delivered to fueling infrastructure at target airports.

CO_2 electrolysis



THE METRICS THAT MATTER FOR COST-EFFECTIVE CO_2 ELECTROLYSIS

1. FARADAIC YIELD
The percent of the electrical current through the system that goes to producing the desired product.

2. VOLTAGE EFFICIENCY
The thermodynamic minimum voltage divided by the actual voltage.

3. CURRENT DENSITY
The amount of current per electrode area needed to convert CO_2 to CO and other hydrocarbons.

4. LIFETIME
How long the electrochemical reactor runs without a loss in energy efficiency or current density.

5. CO_2 UTILIZATION
How much of the input CO_2 to the reactor is converted to product in a single pass.

Improving technical performance metrics that dictate system OpEx and CapEx

commercialization (build – own – operate)

Twelve E-Jet facility began construction in Moses Lake, WA in summer 2023

Signed offtake agreements with Alaska Airlines, Microsoft, and Shopify

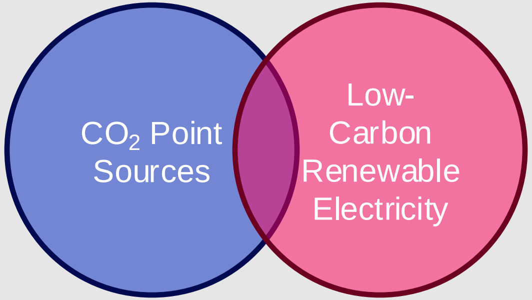
our investors and partners

Raised over $200M since we were founded in 2016, now > 250 people

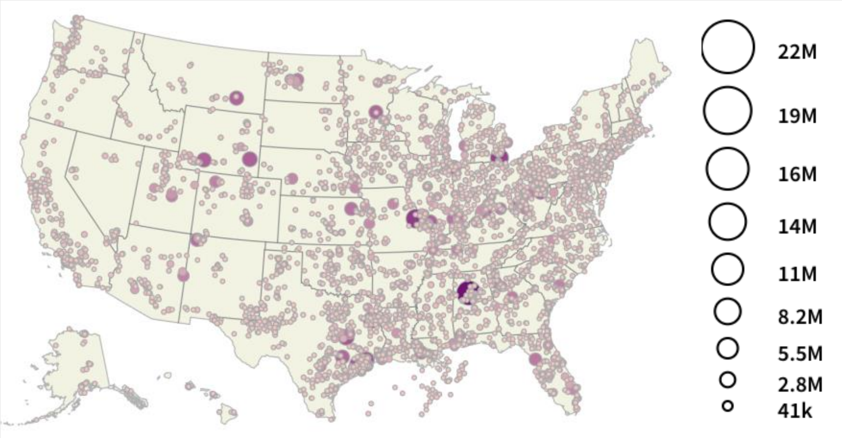
Opportunities and challenges for reactive capture (electrochemical)

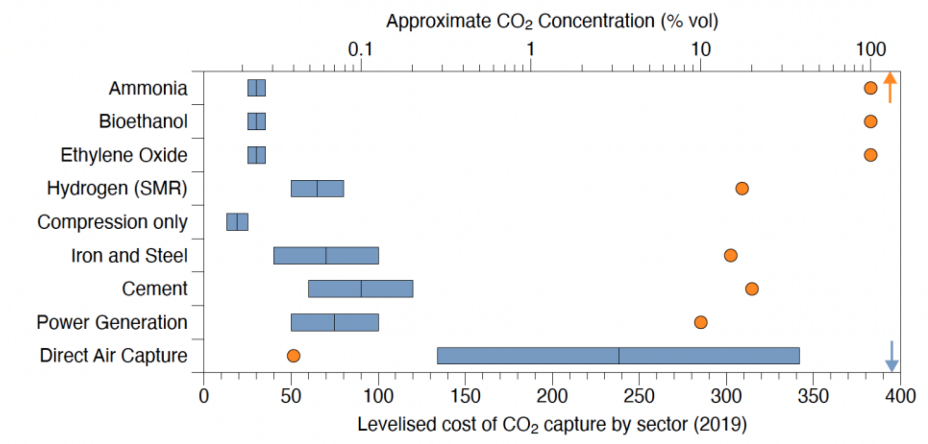
opportunity: geographic flexibility for reactive capture

- A suitable overlap of CO_2 point sources and areas with low-carbon renewable electricity does exist, but it is competitive.
- DAC reactive capture decouples these requirements, providing a major opportunity to deploy in areas not otherwise possible
- Clear alignment with GREENWELLS program and enables a future outlook where all the low-hanging-fruit point sources have been utilized



CO_2 Point Sources (tonnes CO_2e)





challenge: milestones along a roadmap

- The motivations and goals of reactive capture are clear
- However, there is an abundance of pathways, possible products, technologies, etc – but deployment of climatetech is time-bound
    - What are the intermediate milestones to get a given technology to deployment in this space (go/no-go decision points, technical milestones vs technical goals) ?
- Different answers for different technologies


twelve
questions?