Dilute Source CO_2 Capture:

Management of Atmospheric Coal-Produced Legacy Emissions

2018 NETL CO_2 Capture Technology Project Review Meeting

Pittsburgh, PA, 08/15/2018

FE0026861

Carbon Engineering

Management, Partners and Shareholders

Investors

CE has received and been awarded ~$30 million in funding from private investors and government partners.

Current largest investors are Bill Gates & Murray Edwards.

Key Management

Steve Oldham – CEO, B. Sc.

- 20+ years executive experience in commercializing major technology projects
- Executive positions in general management, business and strategy at MDA, one of Canada's largest technology companies

Susan Koch – CFO, CPA, CA

- Energy technology development finance veteran
- Previously CFO at General Fusion, Vaperma, and Cellex Power, where she helped raise $130M from global investors

David St. Angelo – CTO, M.Sc.

- 25 years in technology leadership spanning photovoltaics, batteries, carbon capture and biofuels
- Previous positions include SVP at Joule Unlimited, VP Skyonic Corporation and VP Valence Technology

David Keith – Founder, Acting Chief Scientist

- 25 years working at the interface of climate science, technology, and public policy Professor at Harvard University
- Listed as one of TIME magazine's Heroes of the Environment 2009

Government Partners

Carbon Engineering

Project Overview

Funding, Participants, and Performance Dates

Total Project Budget: $1.875 M USD

Federal Cost Share: 80% ($1.5 M USD)

Non-Federal Cost Share: 20% ($375 k USD)

Project Participants: Carbon Engineering Ltd.

Project Performance Periods:

BP1: 2016-09-19 to 2017-09-18
BP2: 2017-09-19 to 2019-03-31

Project Overview

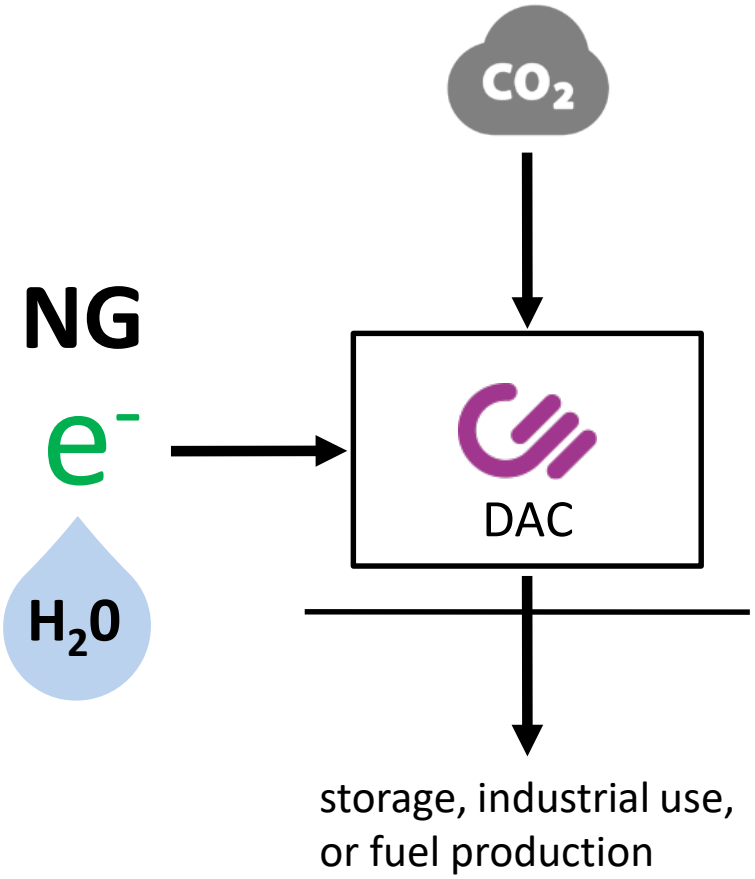
Overall Project Objectives

Cultivate a dilute source CO_2 DAC technology that can be applied to re-capture legacy coal-based emissions directly from the atmosphere.

Develop a better understanding of DAC performance through lab and pilot study, and codifying these results in TEA format.

Technology Background

DAC: Direct Air Capture of CO_2



Strategic and Transformative Technology:

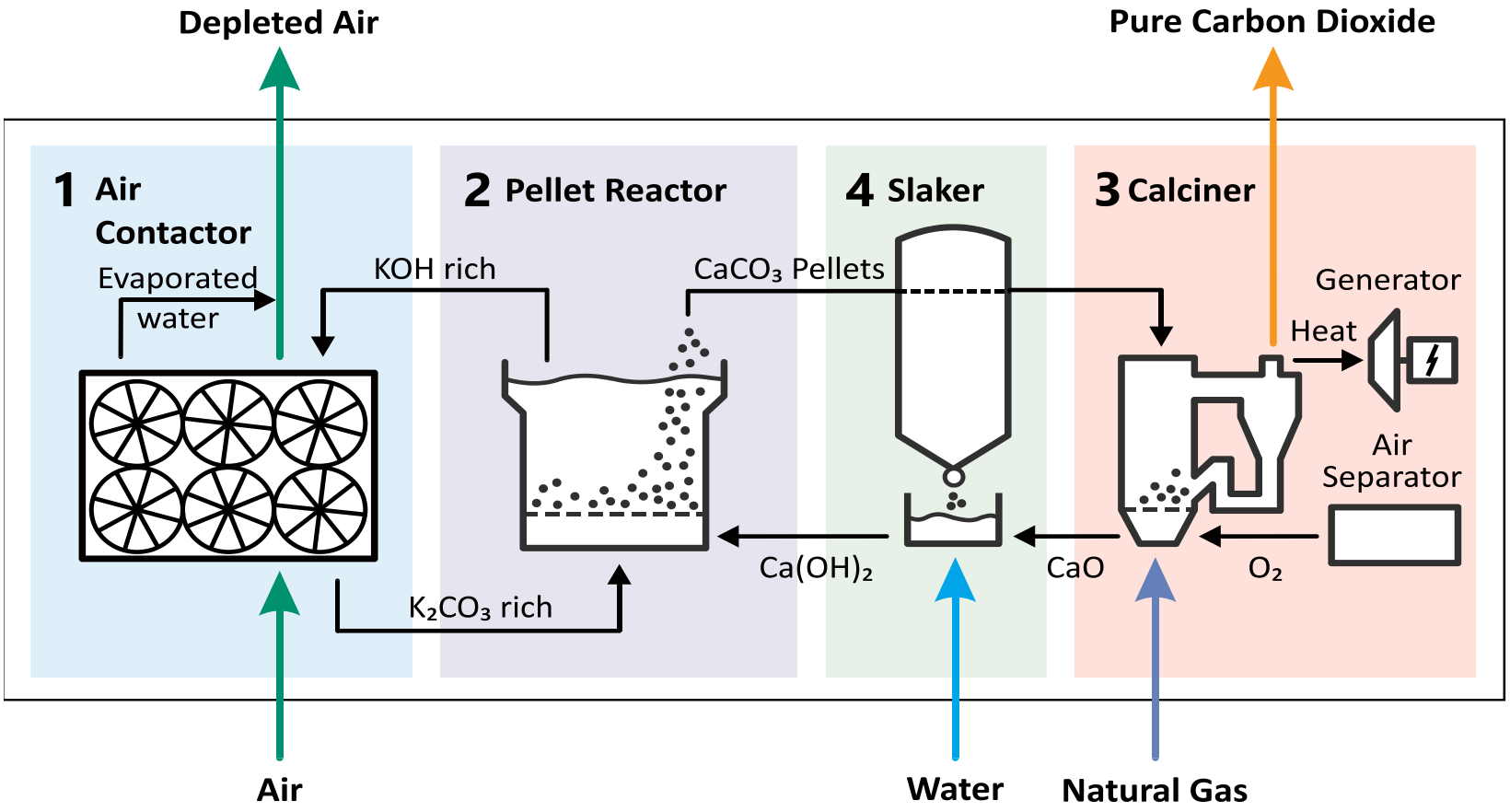
- Negative Emission Technology
- Can locate anywhere
- Manages emissions from any source
- Highly scaleable

Complimentary to CCS:

- Higher thermodynamic barrier
- Larger air volume to be processed

Technology Background

CE's DAC Process



Technology Background

Pilot Plant in Squamish, British Columbia

- Broke ground in 2015
- 1 t/day CO_2 capture capacity
- ~10,000 total hours operated
- Patented technology
- End-to-end demonstration

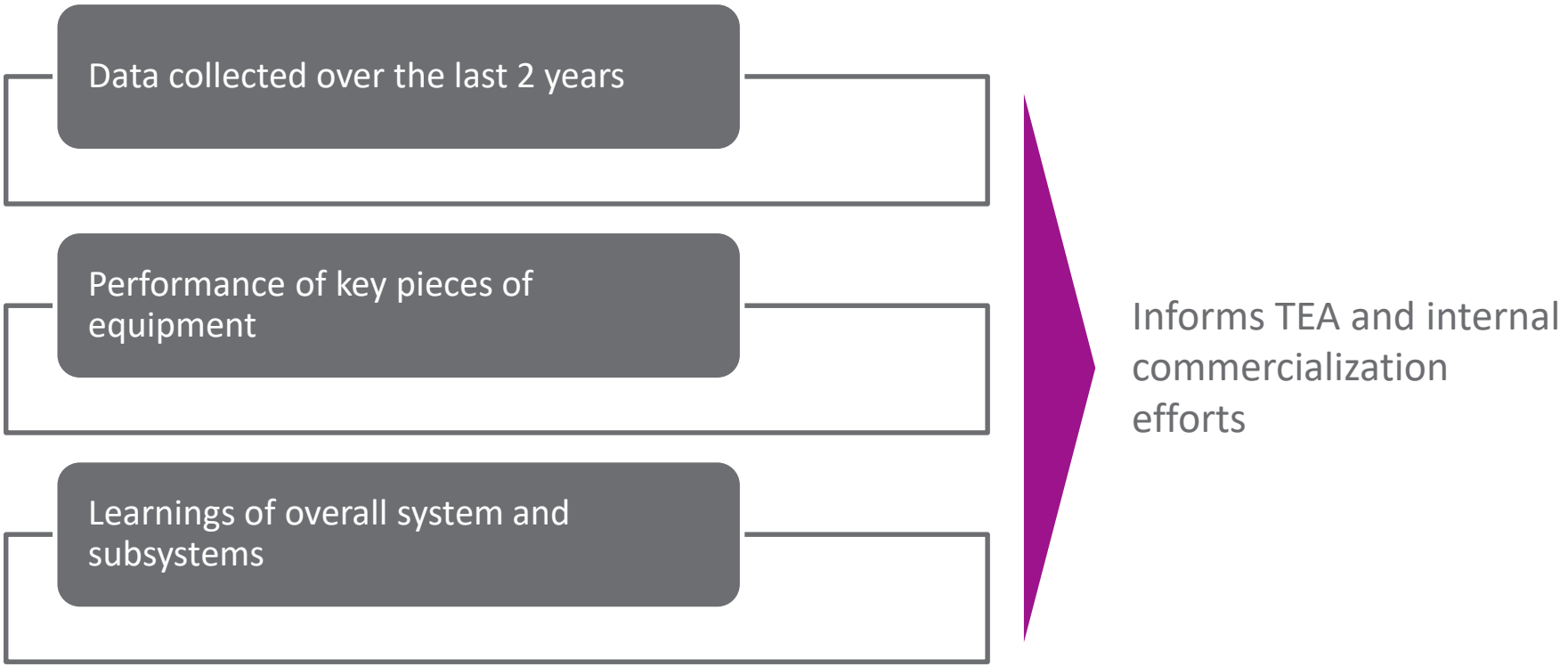
Project Scope

Work Plan and Milestones

Task 1	Task 2	Task 3	Task 4	Task 5
Project Management and Planning	**Pilot Operation, Sensitivity Analysis, and Component Optimization**	**Testing, Performance Analysis, and Technology Optimization**	**Engineering Input for Scale-up and Technology Cost Projections**	**Technology Cost Projections and Technical Assessment of Applicability to Coal Stream**
• DMP Completed • Year 1 Annual Report and Updated Project Management Plan • Project Final Report	• Synthesis Data Showing >3000 hours Pilot Operation • Research results from lab and technology integration ready for input to prototype development	• Identification of Feasible Alternative Technologies and Path Forward • Pilot Operations – Completion of Long-term Effects Research	• Updated Process Flow Diagram and Vendor Request for Quote	• Major Equipment Specification and Component Cost Model • Engineering Assessment, Full Plant Cost Model

Project Scope

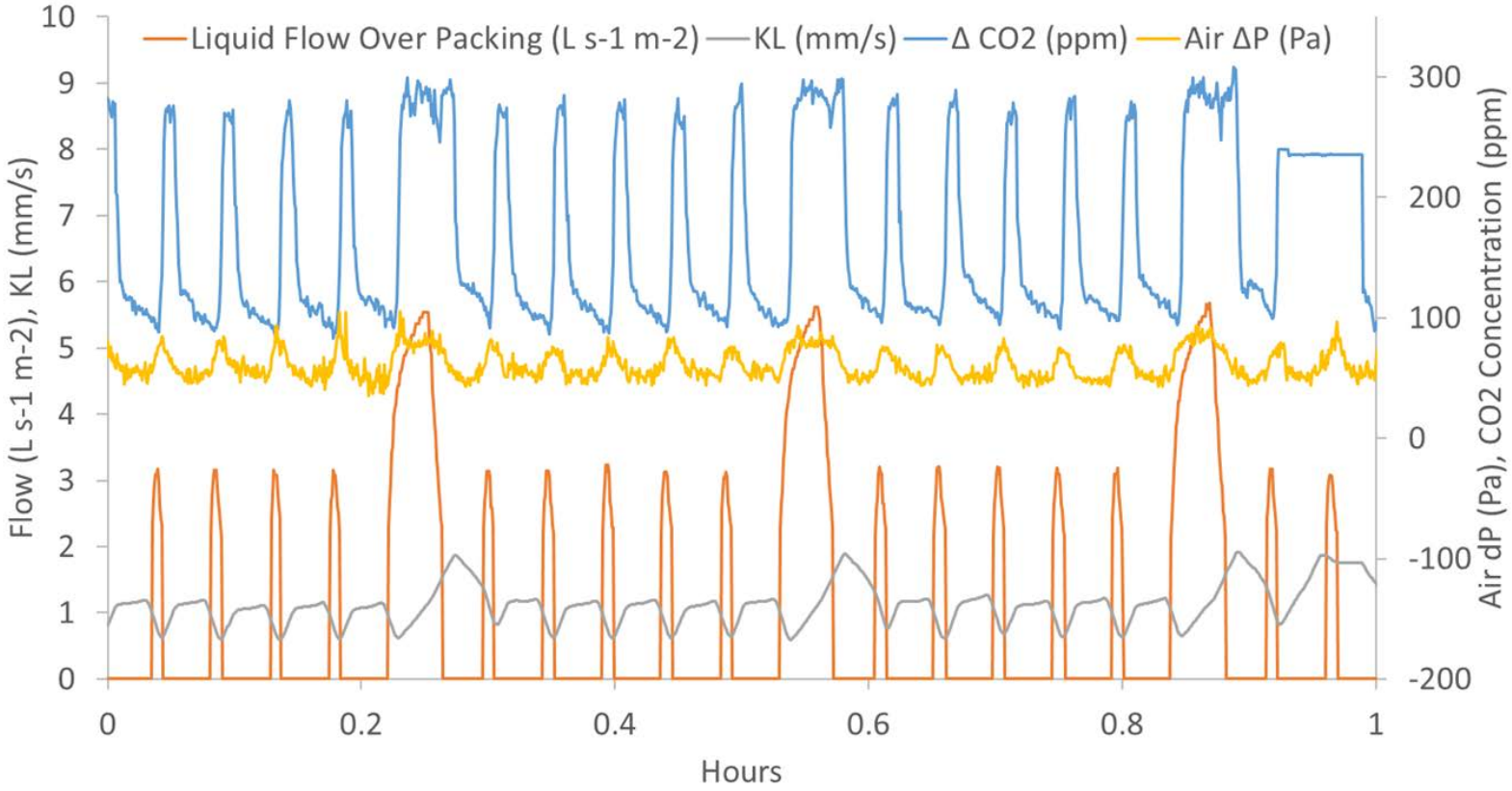
Progress and Current Status



Progress and Current Status

Air Contactor Performance Data – Mass Transfer, Pressure Drop

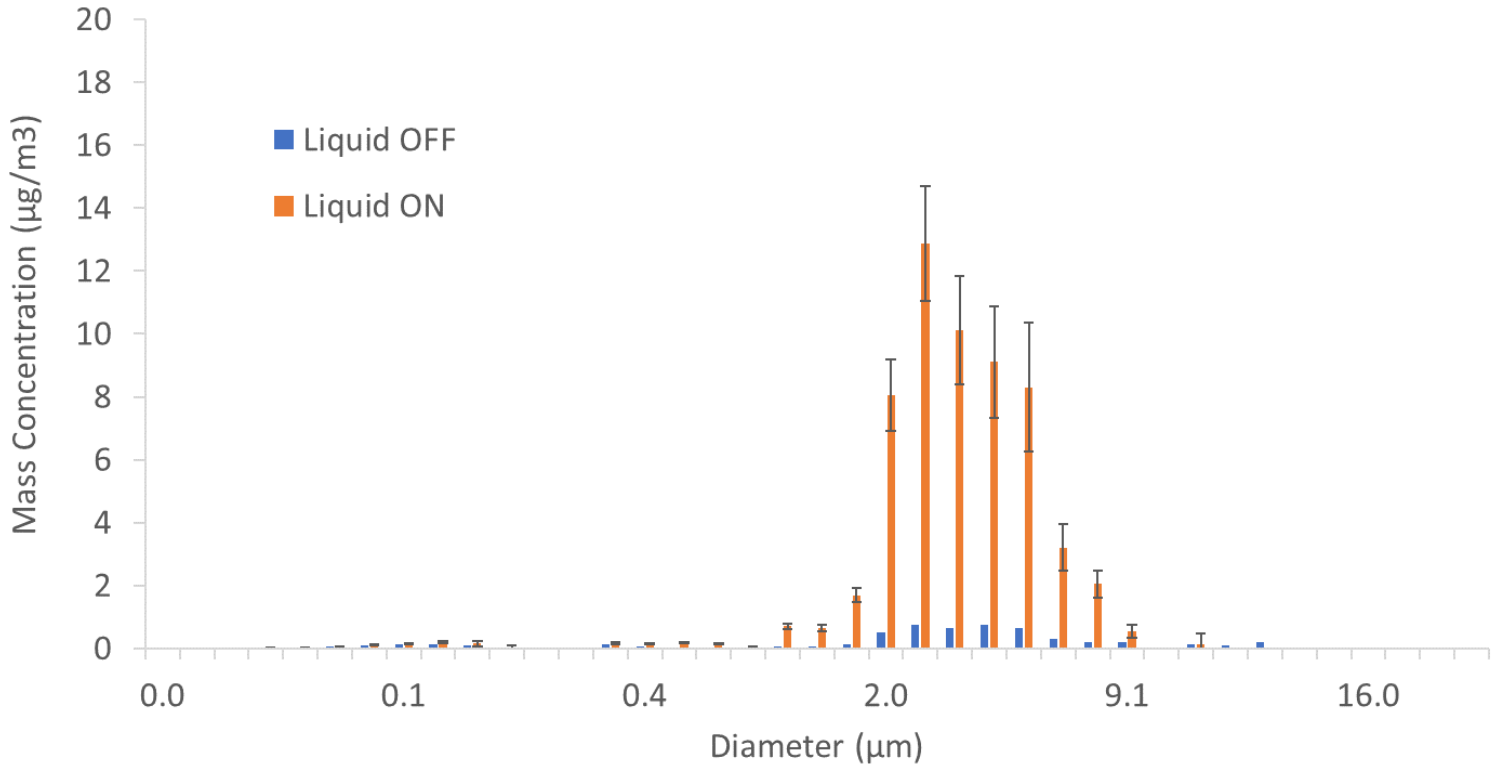
Time series pilot contactor operation data showing patented fluid flow cycles.
Average air flow velocity of 1.17 m/s at 18 C ambient temperature.



Progress and Current Status

Air Contactor Performance Data – Drift

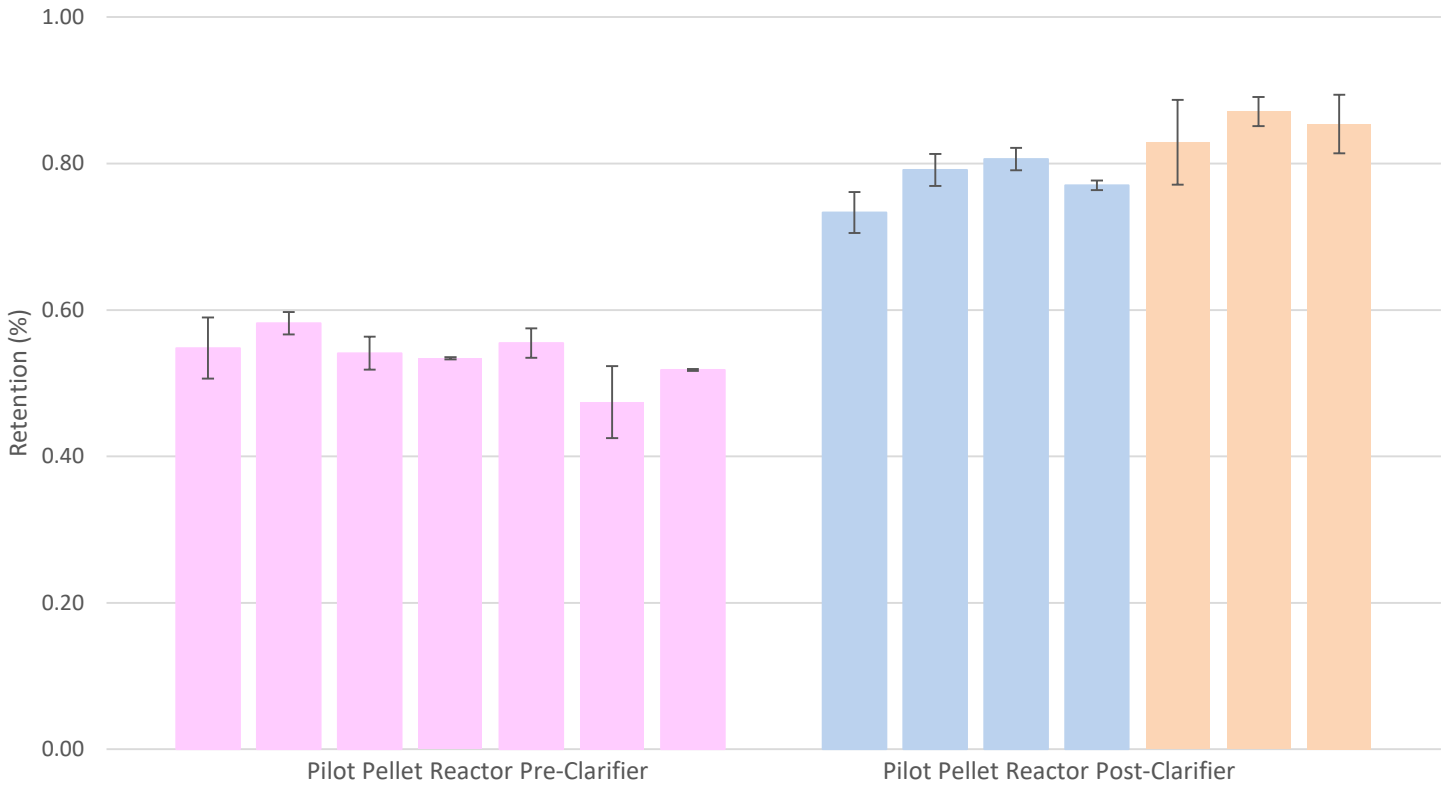
Particle size distribution measured at contactor outflow showing contrast between drift with liquid flow on and off.



Progress and Current Status

Pellet Reactor

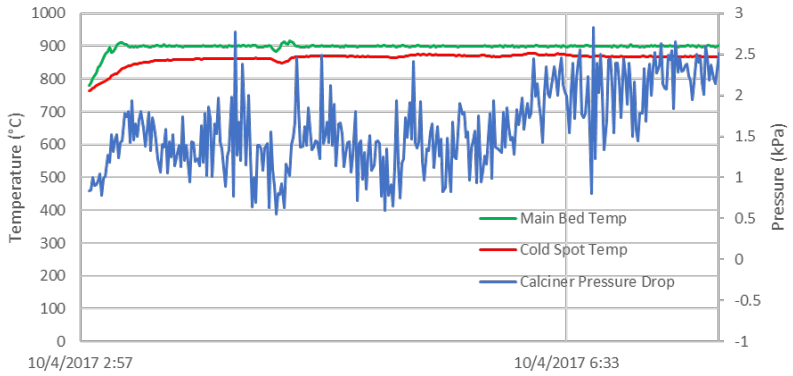
Optimization efforts led to increased retention in pilot pellet reactor system of at least 20% above baseline

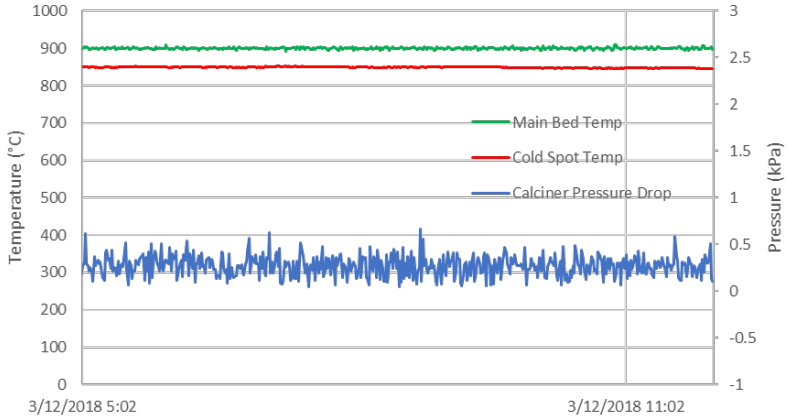


Progress and Current Status

Calciner

Processed 15,000 kg of $CaCO_3$ in DAC pilot in a closed loop

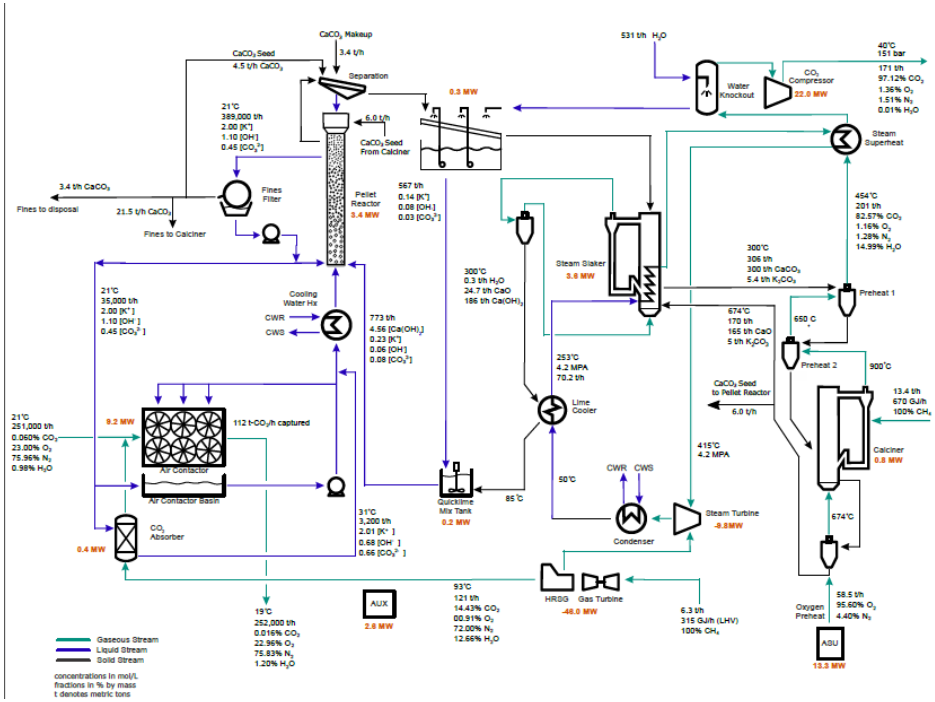




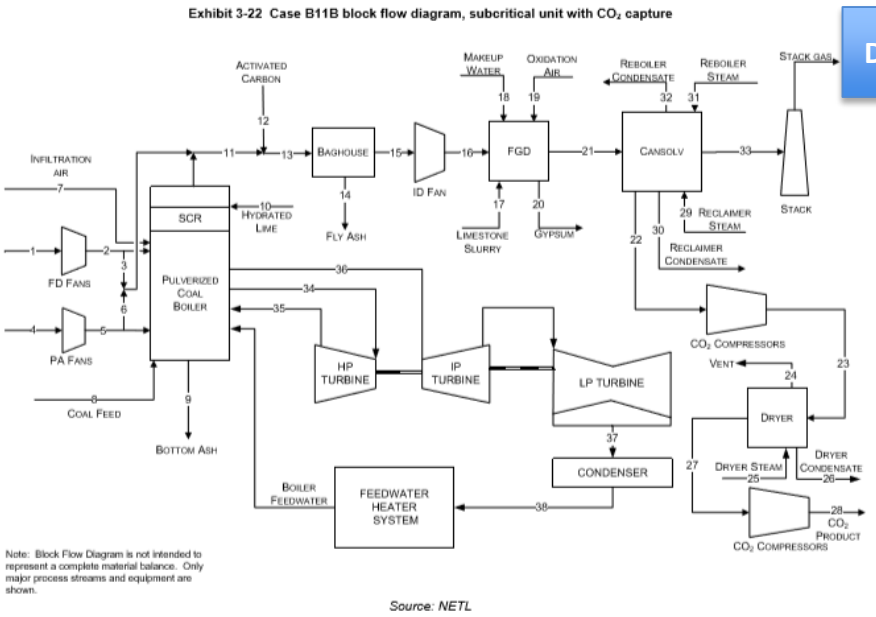
Progress and Current Status

Techno-Economic Analysis

Baseline: Dilute Source Atmospheric CO_2 – DAC Plant



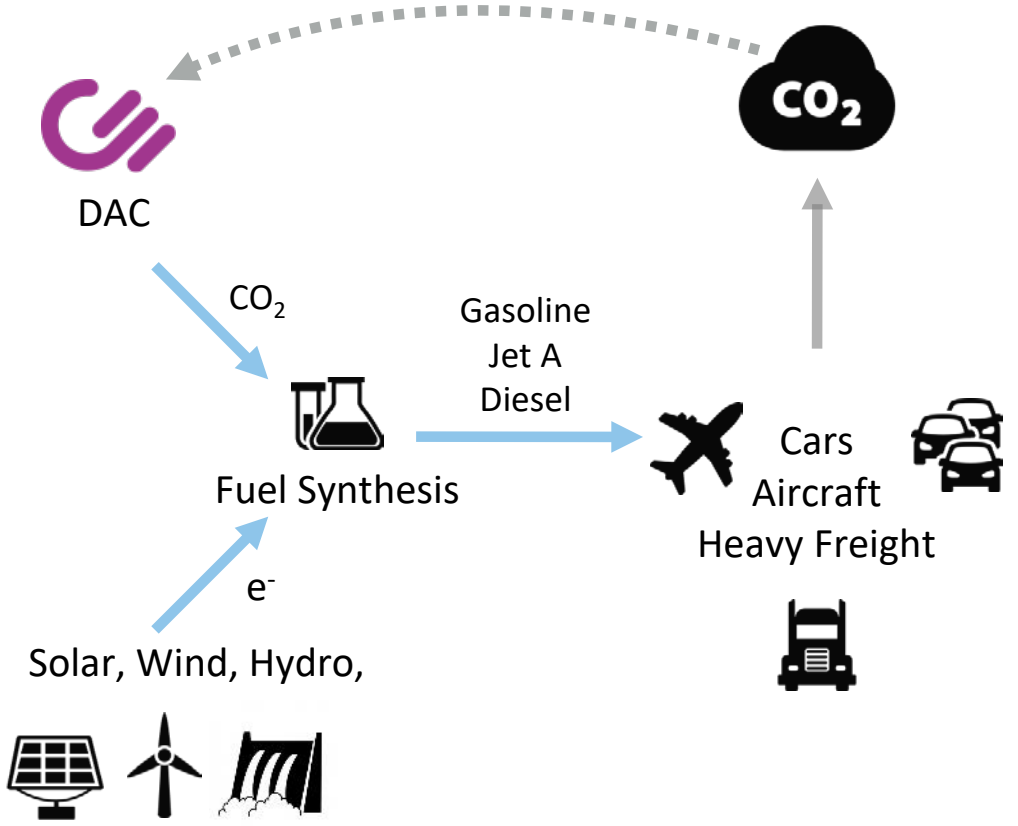
Case 1: Dilute Source CCS exhaust – Polishing Unit



Future Work

AIR TO FUELS™ Technology

Enables progressive de-carbonization of transport by gradual fuel switching



Future Work

First Commercial AIR TO FUELS™ Facility

Acknowledgements

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