



A Chart Industries Company

Project DE-FE0032148

Cryogenic Carbon Capture From Cement Production

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Overview



- Project Introduction
- CCC Technology Overview
- Previous CCC Demonstrations
- Progress and System Design

Project Introduction

Project Overview – Cryogenic Carbon Capture From Cement Production



30 TPD CCC Pilot

Design based off field-tested 1 TPD unit

Location at Sugar Creek Cement Plant near Kansas City, Missouri

Skid-based design that can be built mostly off-site with limited integration

Project Start: Feb. 1, 2022

Project End: Originally April 30, 2025

No-Cost Time Extensions for Phase I and
Additional time requested for Phase II

Partnership with National Energy Technology Laboratory (NETL)

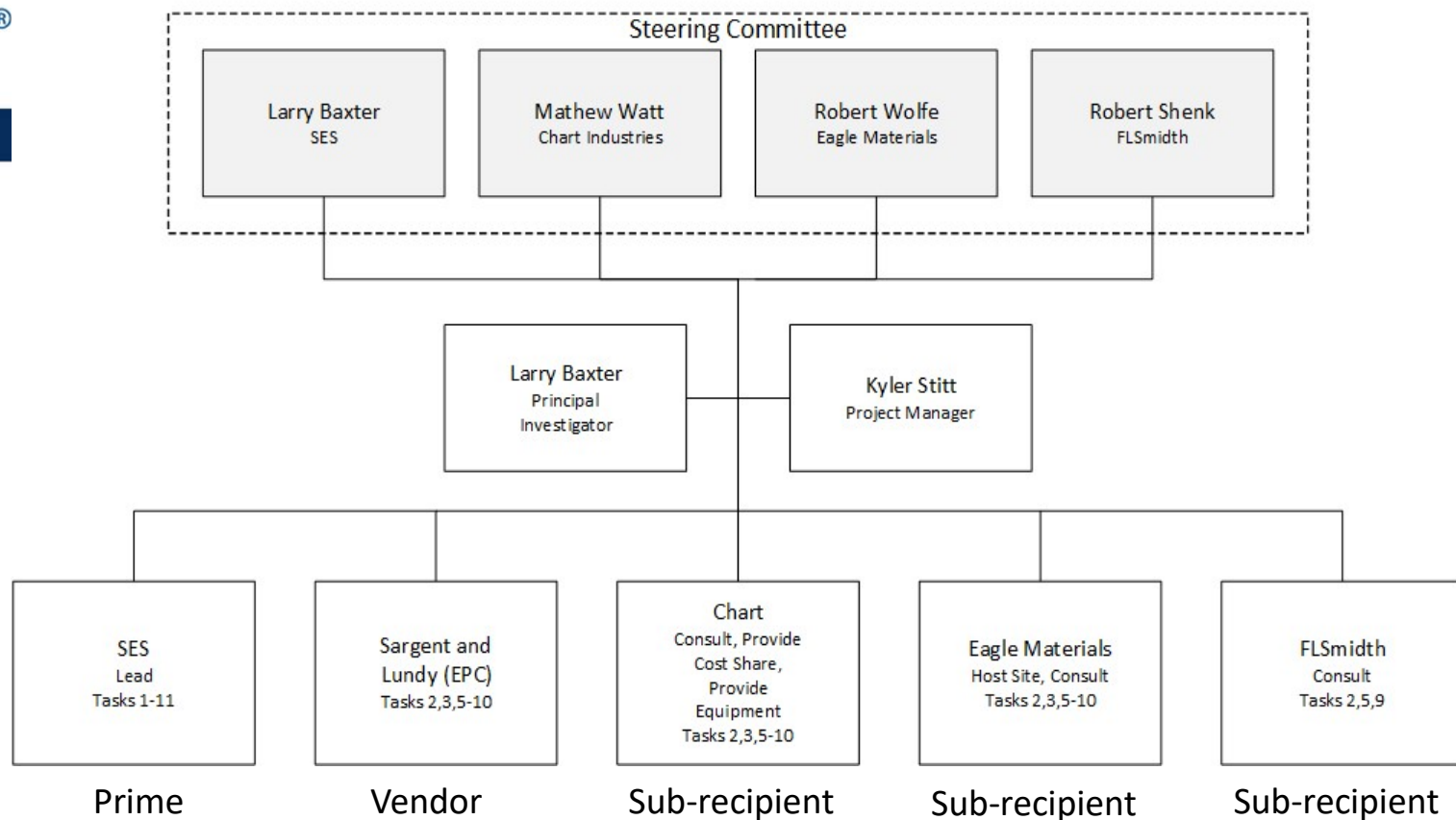


Project Team



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Project Team



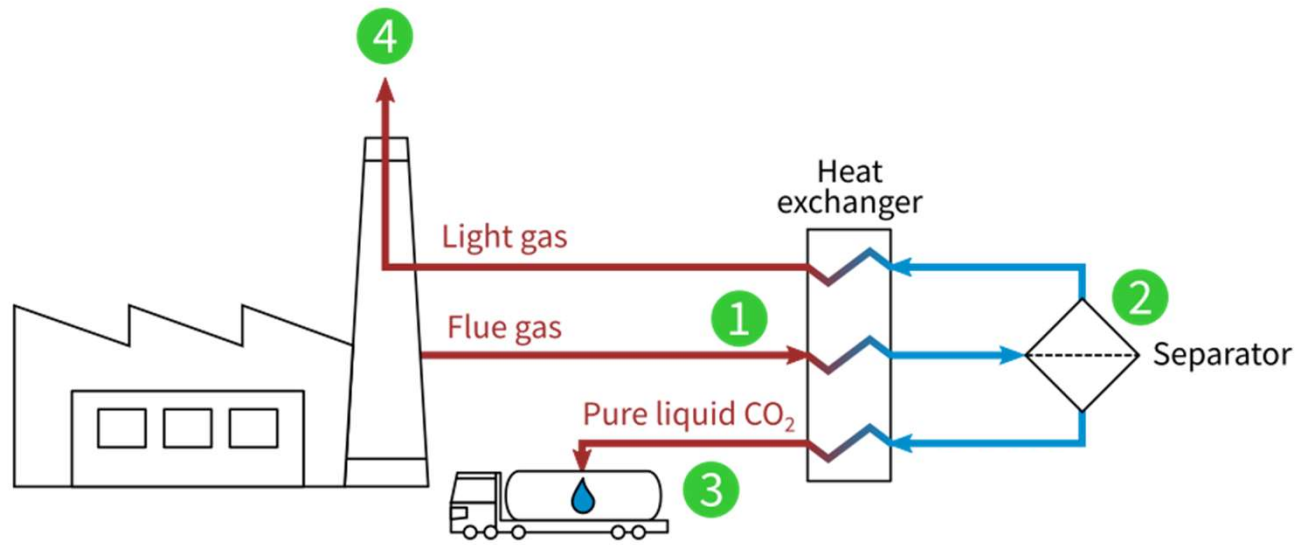
Success Criteria



Decision Point	Success Criteria
Completion of Phase 1	<ul style="list-style-type: none"> – The remaining cost of plant construction, operation, and decommissioning is less than or equal to the proposed remaining budget of Phases 2 and 3 as determined by the final plant design. – The lead-times provided by the vendors allow for sufficient time to complete construction and commissioning by the end of Phase II, as determined by the construction plan provided by the EPC.
Completion of Phase 2	<ul style="list-style-type: none"> – All operating and environmental approvals finalized. – Detailed construction plan implemented.
Completion of Phase 3	<p>Commissioning Subsystems all certified, including:</p> <ul style="list-style-type: none"> – The ability to cool the gas to at least -117° C – The multi-stream heat exchanger achieving 5°C minimum approach temperature <p>Startup, shutdown, emergency, and standard operating procedures finalized.</p> <p>Testing</p> <ul style="list-style-type: none"> – Complete continuous testing for a minimum of 2 months – Capture during the testing at 1.22 mol% CO₂ in outlet stream (i.e., 95% capture with 19.8 mol% CO₂ on a dry basis) and 95% CO₂ purity at 30 tonnes/day CO₂. <p>Decommissioning</p> <ul style="list-style-type: none"> – Complete decommissioning of plant per the decommissioning plan <p>TEA</p> <ul style="list-style-type: none"> – Full-scale TEA showing energy of CO₂ captured less than 0.83 MJ_e/kg CO₂

CCC Process Overview

Conceptually Simple Process



- 1 Flue gas is cooled
- 2 CO₂ is separated from the light gases
- 3 CO₂ is melted and prepared for transport
- 4 Light gases are reheated and released to atmosphere

Preliminary Simplified CCC PFD

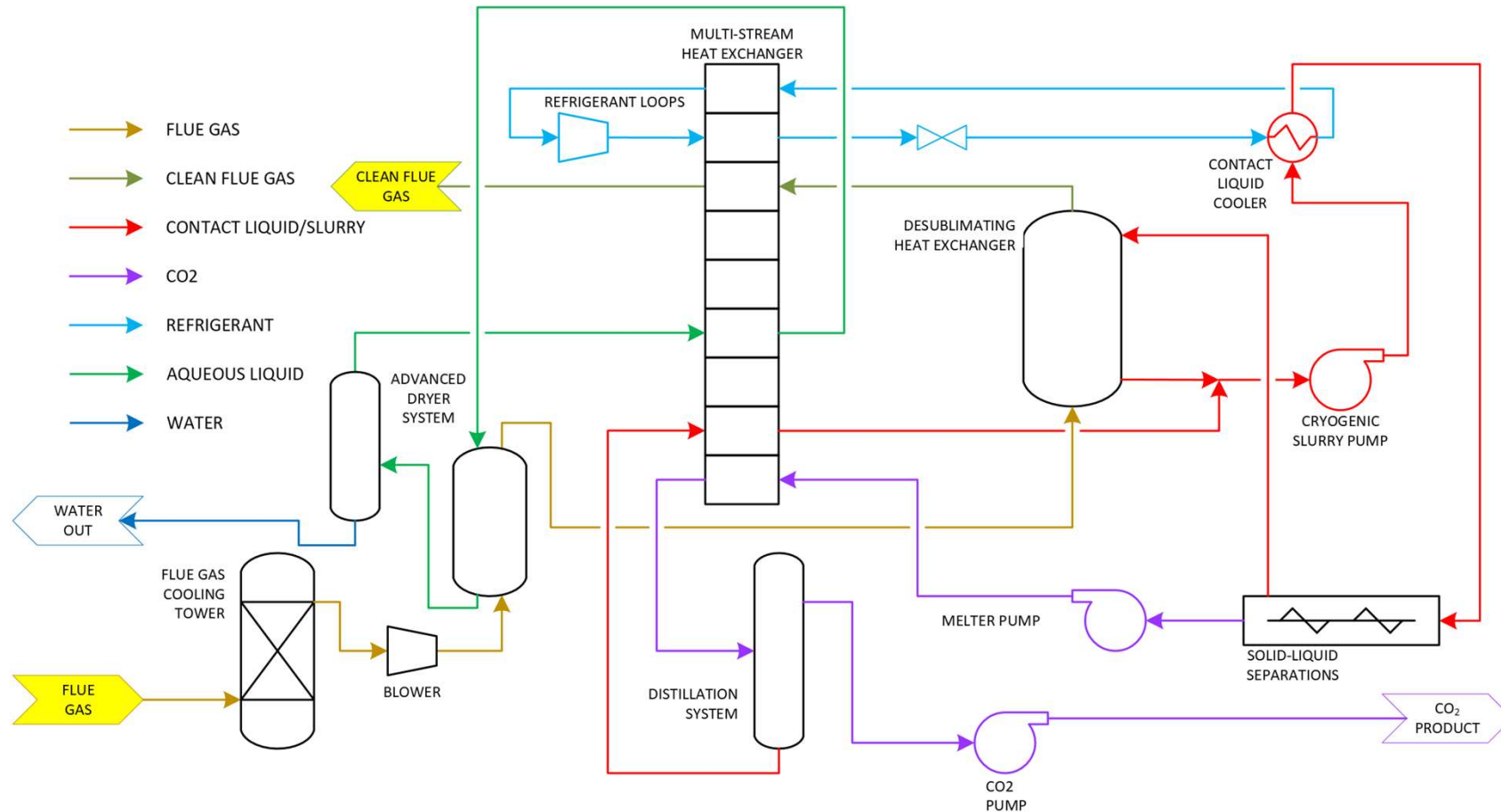


Chart and Howden Manufactured Equipment Make up Majority of Plant

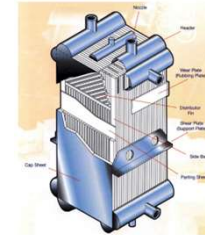
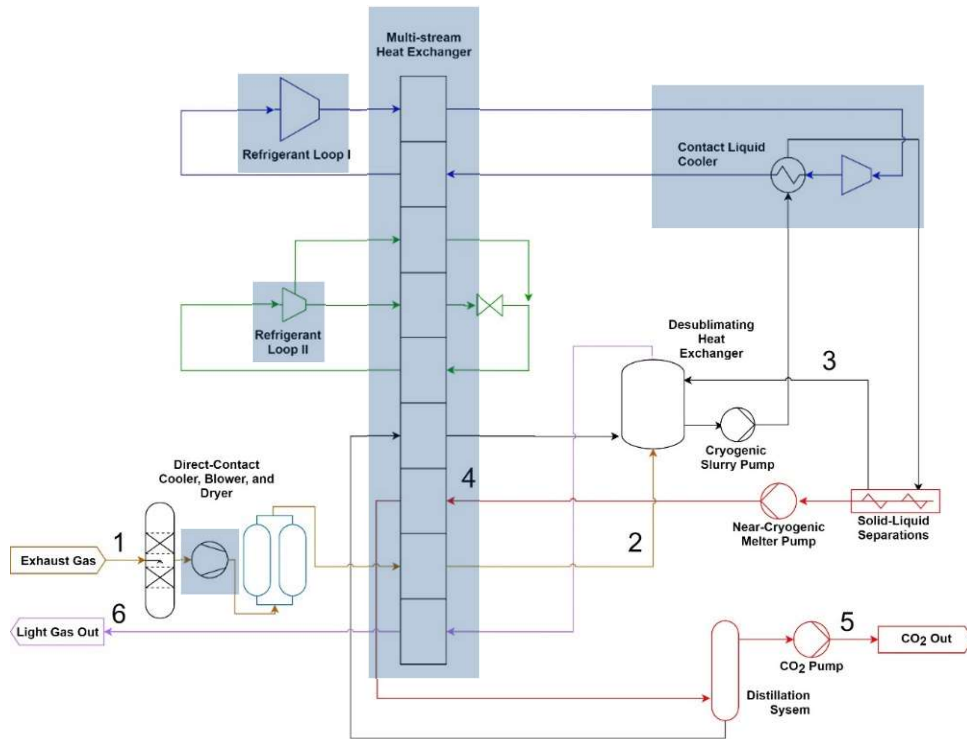


Chart Brazed Aluminum Heat Exchangers and Cold Boxes

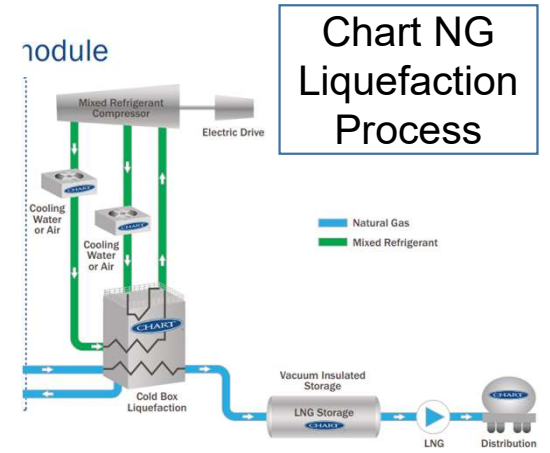


Chart NG Liquefaction Process



Howden Blowers and Compressors

Scaling – Similar to Existing Processes



Similar to 30 TPD
Plant Scale



CCC Benefits



Lowest energy and cost retrofit technology

Easiest retrofit carbon capture technology

Robust to pollutants and captures most criteria pollutants

Produces high-purity, liquid CO₂

Very high capture rates, up to negative emissions (99%+)

Integrated grid-scale energy storage

Independent Validation

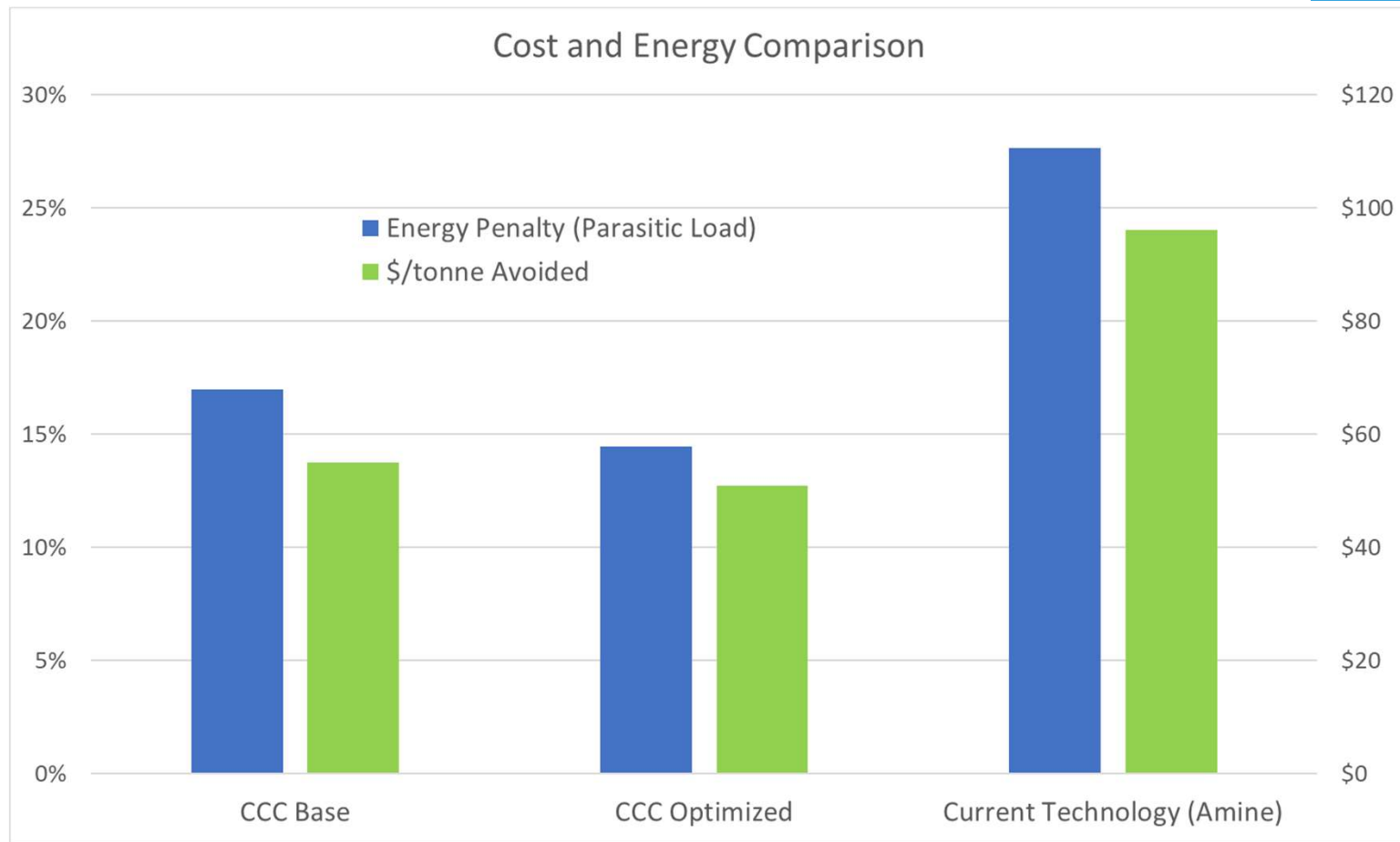


“Of all these [carbon capture] processes, I regard the CCC process to have the greatest potential”

-Howard Herzog, MIT Energy Initiative



Cost and Energy Savings



Based on Rev 2a Baseline NETL Study with Updated Costs. Additional value and revenues could be gained from CO₂ sales and energy storage.

Previous Demonstrations

1 Ton/day Demo



Storage
and Utility
Skid

Pre-Treatment
and Electrical
Skid

Cryogenic Carbon
Capture Skid

Pre-Treatment and Electrical Skid

Cryogenic Carbon Capture Skid



Capture at Cement Plant

Small Pilot Operated by SES

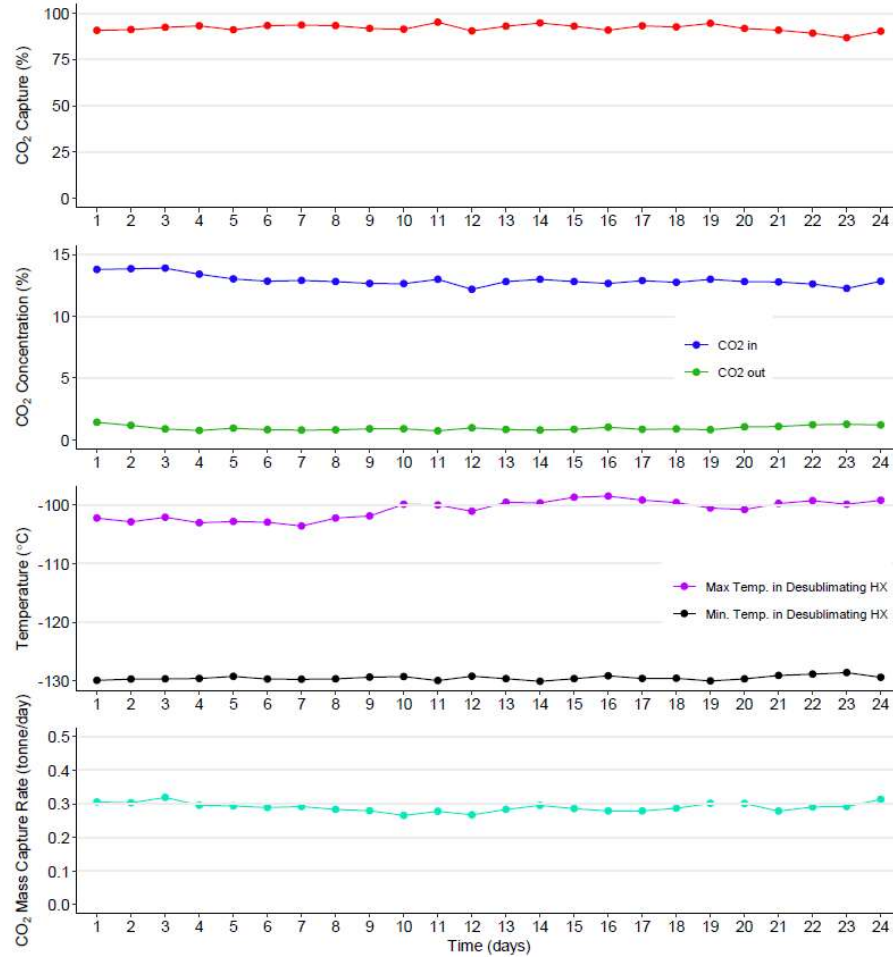


Use in Concrete

CarbonCure Utilization Partner

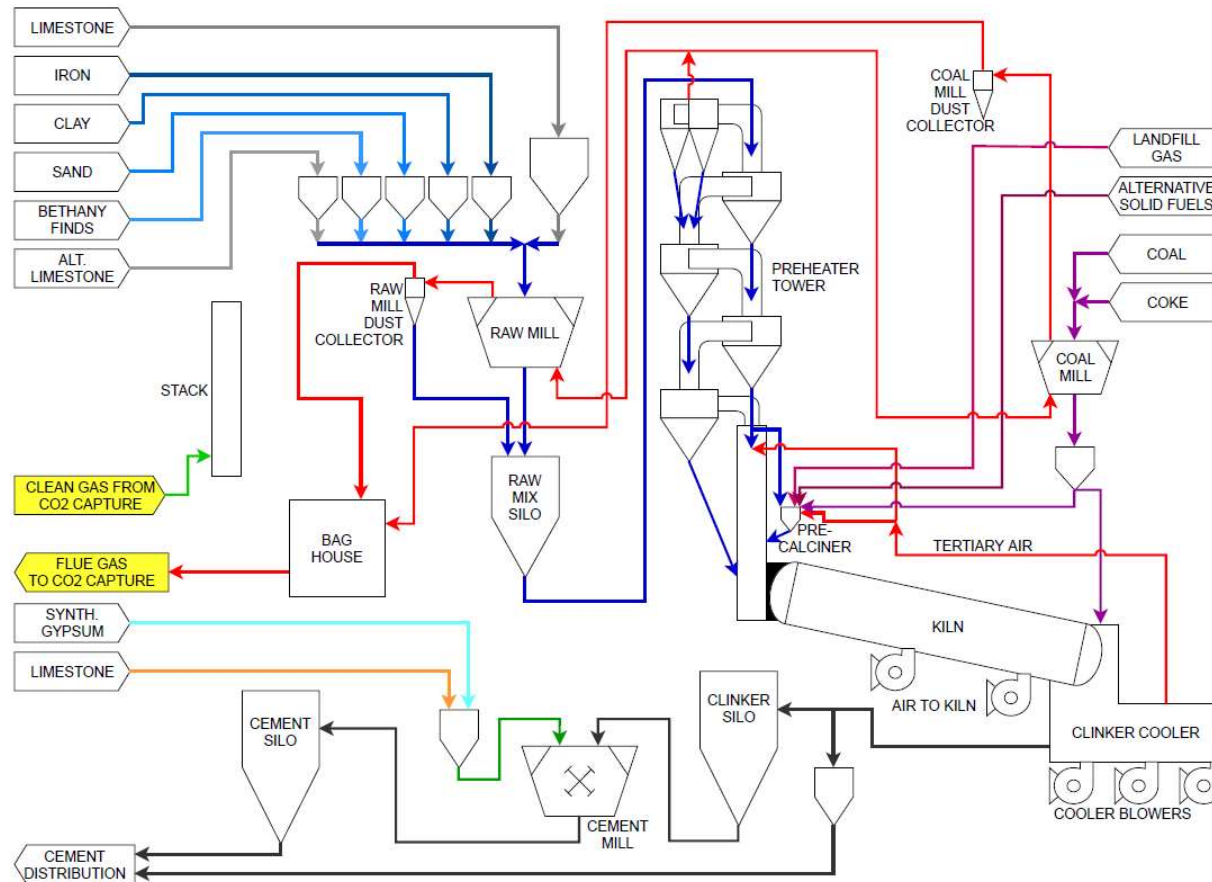


Continuous Testing



Skid-Based CCC System Design at Sugar Creek

PFD of Sugar Creek Cement Plant



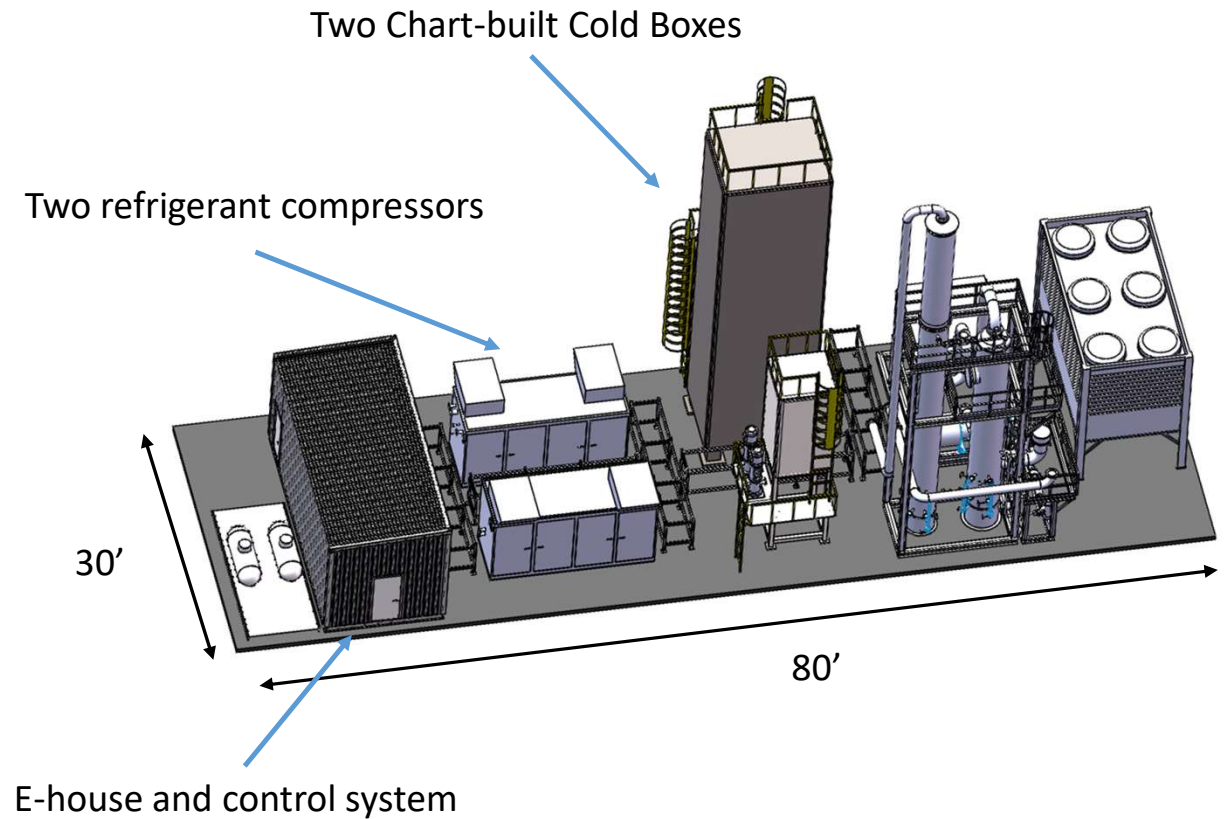
Overhead View



Plot Plan Isometric



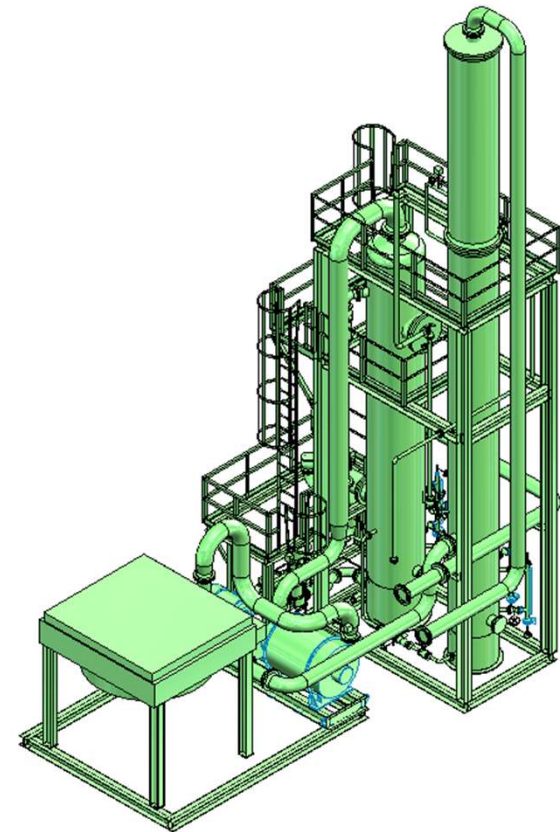
- Skid-based design
- Limited integration with host site
- On-site integration by Sargent & Lundy



Front-end Treatment



- Key Unit Operations
 - Flue gas cooling
 - Initial flue gas drying
 - Blower to overcome pressure drop
 - Light gas heat recovery
- Manufactured to SES specifications by Koch Engineered Solutions



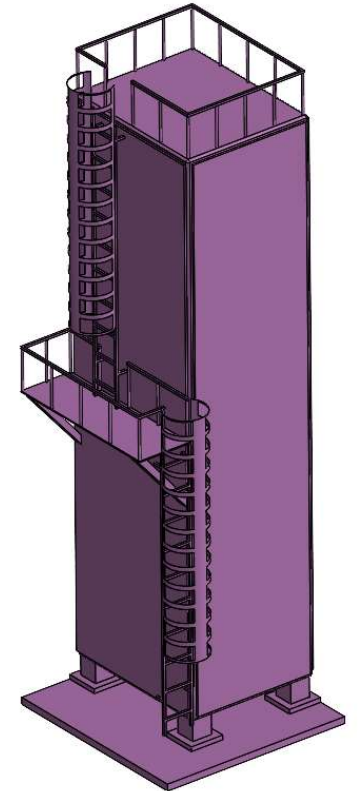
Primary Cold Box Design and Fabrication



- Chart Industries will perform detailed design and fabricate cold box and internals
- Key unit operations
 - BAHX recuperative HX
 - CO₂ purification
 - CO₂ liquid compression



Representative BAHX



CCC-Specific Equipment



- Detailed designed by SES
- Fabrication by Chart
- Key Unit Operations
 - CO₂ separation and purification
 - Contact liquid cleaning
 - Additional heat integration
 - Pumps and circulation

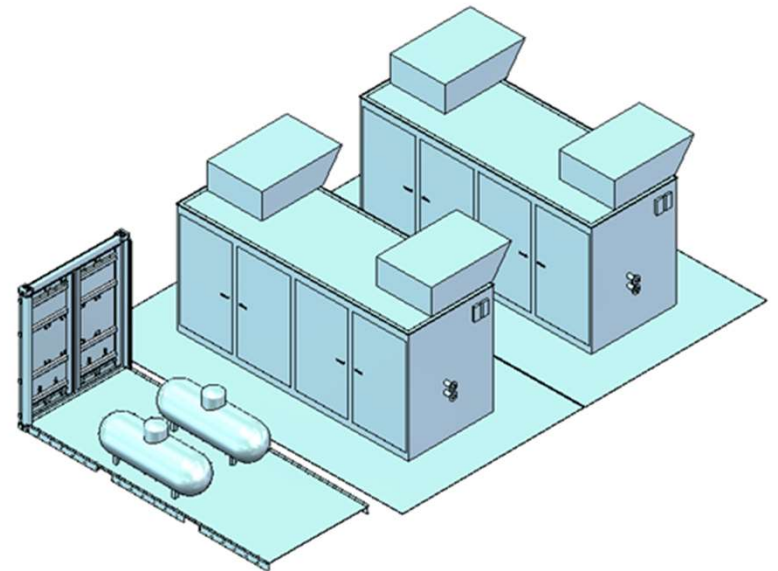


Representative Cold Box Internals

Refrigerant Compressors



- Howden Compressors (now a part of Chart Industries) will provide oil-injected screw compressors.
- Skid-mounted and easily integrated on site.
- Robust under various operating conditions.



Summary



- **CCC Benefits**

- Lowest energy and cost retrofit technology
- Easiest retrofit carbon capture technology
- Produces high-purity, liquid CO₂
- Very high capture rates, up to negative emissions (99%+)

- **Project Specifics**

- Nominally 30 TPD pilot on modern cement plant in Sugar Creek, Missouri
- Design based off extensively field and in-house tested 1 TPD capture unit
- Skid-based design that can be built mostly off-site with limited integration

Acknowledgments



- Thank you to the companies and organizations that are contributing to this project.

