FEED Study of Carbon Capture Inc DAC and CarbonCure Utilization Technologies Using United States Steel's Gary Works Plant Waste Heat

(DE-FE0032154)

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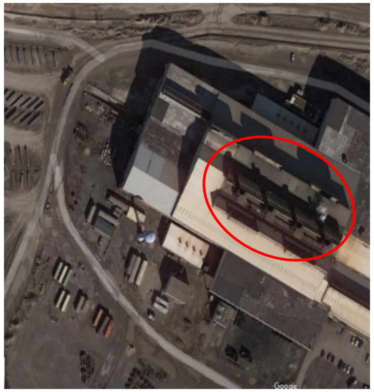
DOE/NETL 2022 Carbon Management Project Review Meeting (August 15-19, 2022)

Pittsburgh Pa.

Direct Air Capture + Utilization = DACU

Waste heat from Steel plant and utilize captured CO_2 for cement

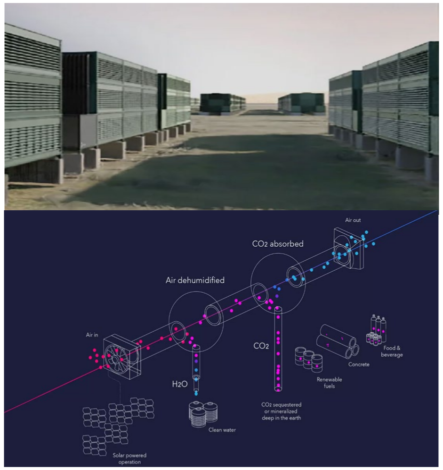
USS



US Steel Gary Works Facility Host Site Aerial View

Waste Heat

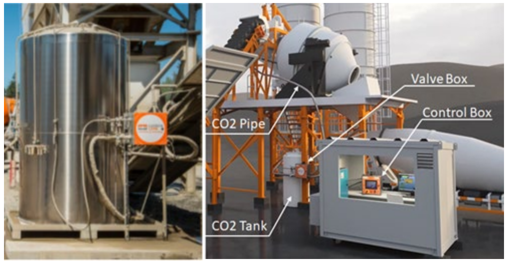
Carbon Capture



Captured CO_2

CARBONCURE
SIMPLY BETTER CONCRETE

CarbonCure's CO_2 Dosing Tank and Utilization System



CO_2 incorporated into concrete

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OVERVIEW

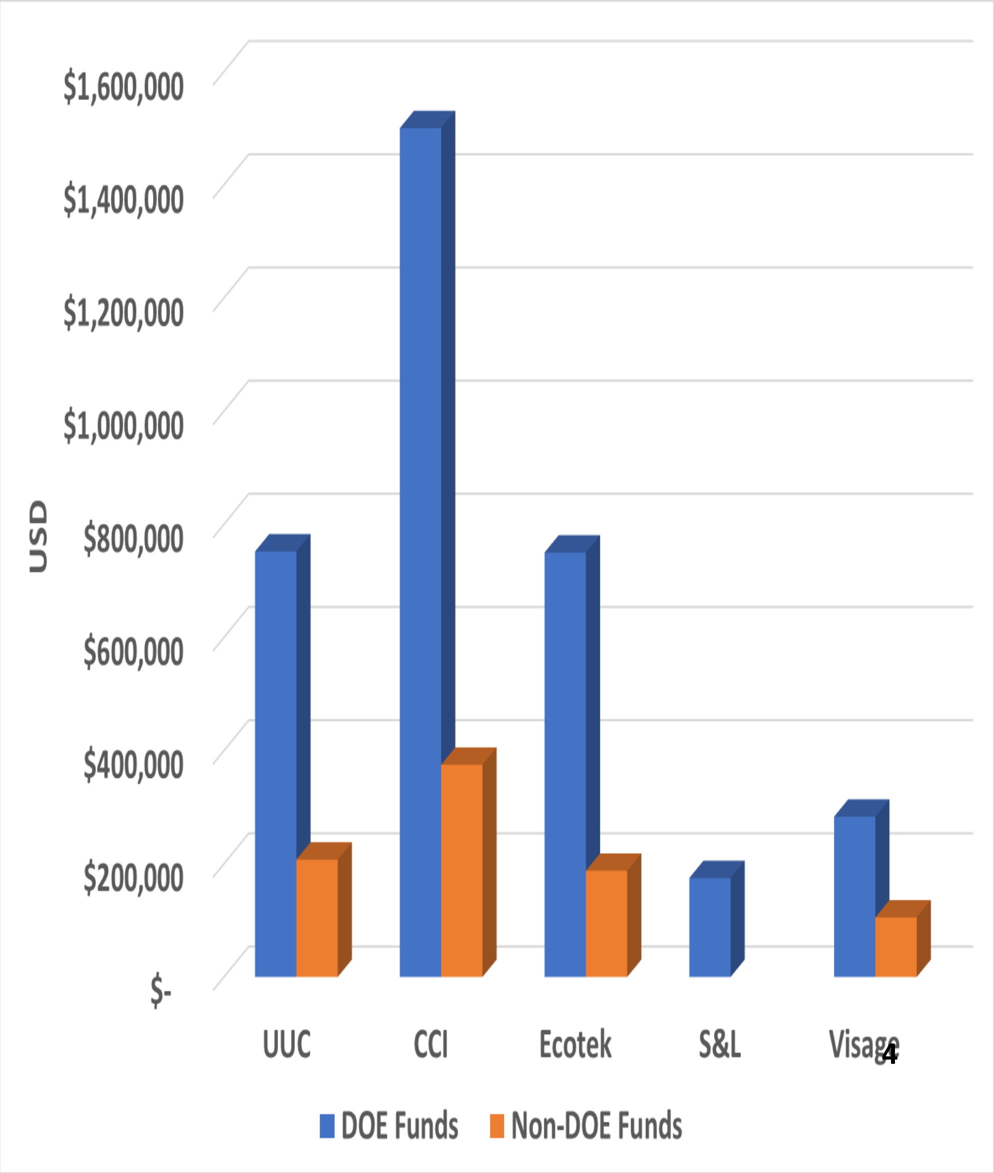
DOE: $3,459,554

Cost Share: $874,868

Work Period: 18 months

OBJECTIVES

- Perform a FEED study for DACU (DAC + Utilization)
- Remove a minimum of 5,000 tonnes/yr net CO_2 (captured) from air (Note: additional CO_2 avoided)
- Convert, sequester and utilize captured CO_2
- Utilize waste heat from a domestic steel plant located in Gary, Indiana
- Demonstrate full CO_2 value chain
- Illustrates how full CO_2 value chain impacts job creation, regional economic development, and environmental justice



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Background on Technologies and Partners

CarbonCapture™

Fast facts

CarbonCapture Inc. makes modular direct air capture machines that filter CO_2 out of the atmosphere.

- Based in Los Angeles, CA
- Raised $43m in venture capital
- Staff of 38, growing quickly
- First field deployments in mid-2023
- Focus on developing CO_2 storage and utilization projects in North America
- DAC-only, no point source or EOR
- Technology platform accelerates innovation via open systems approach to sorbents

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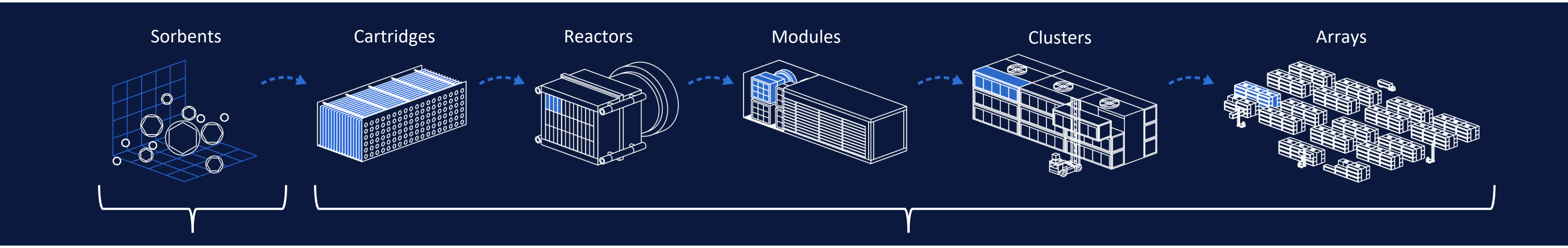
CarbonCapture™

DAC technology platform

Our product strategy is based on **a deeply modular, open systems architecture**. We've created a DAC technology platform that works with multiple families of solid sorbents and allows for rapid deployments, minimizes obsolescence, enables incremental upgrades, and speeds up development cycles.



Open systems enable:

- Rapid deployment of new sorbents
- Programmable operating processes

Deep modularity enables:

- Plug & play sorbent cartridges
- Size-of-site flexibility and distributed deployments
- Rapid deployment of new hardware innovations
- Mixed environments: multiple sorbent and hardware generations

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CarbonCapture™

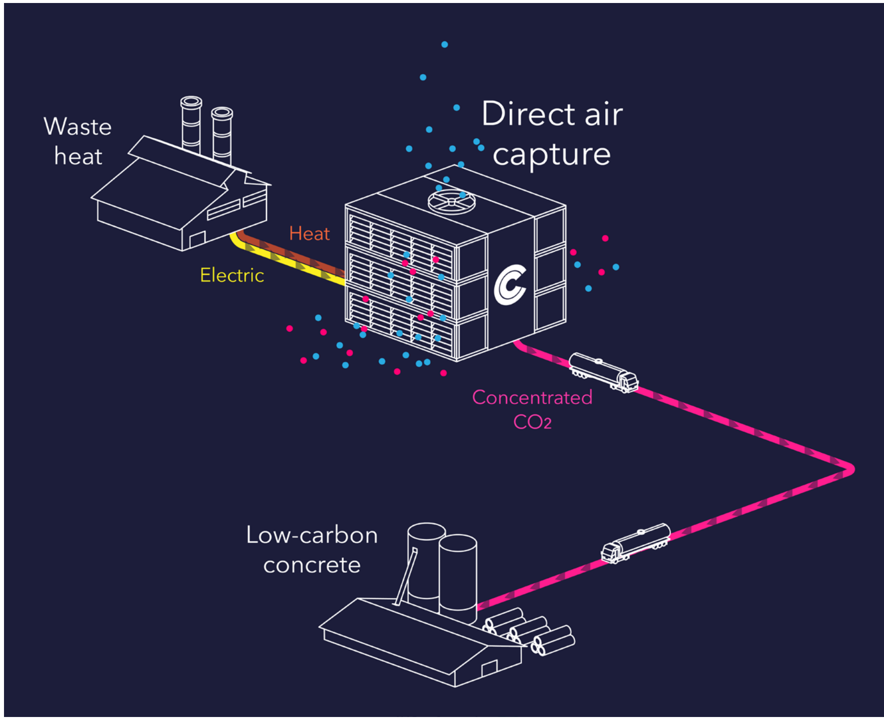
Technology platform

Core system: modular temperature vacuum swing adsorption system capable of accepting multiple types of solid sorbents

Go-to-market sorbent: switchable hydrophilic or hydrophobic structure sorbent

Advantages:

- Low cost: capture costs are expected to be $73 to 115/t CO_2 by 2030
- Modular and compact: each module in the shape and size of standard shipping container, can be mass manufactured off site, and can capture over 500 tons of CO_2 /yr.
- Scalable: modules can be deployed in small quantities (for industrial locations like cement plants) or in very large arrays (for megaton scale carbon removal farms)
- Low temperature: with a relatively low desorption heat of 100°-300° C (212-572 °F), multiple renewable energy sources are applicable (e.g., geothermal, solar, nuclear, and industrial waste heat)



Direct air capture using industrial waste heat, with CO_2 storage in concrete

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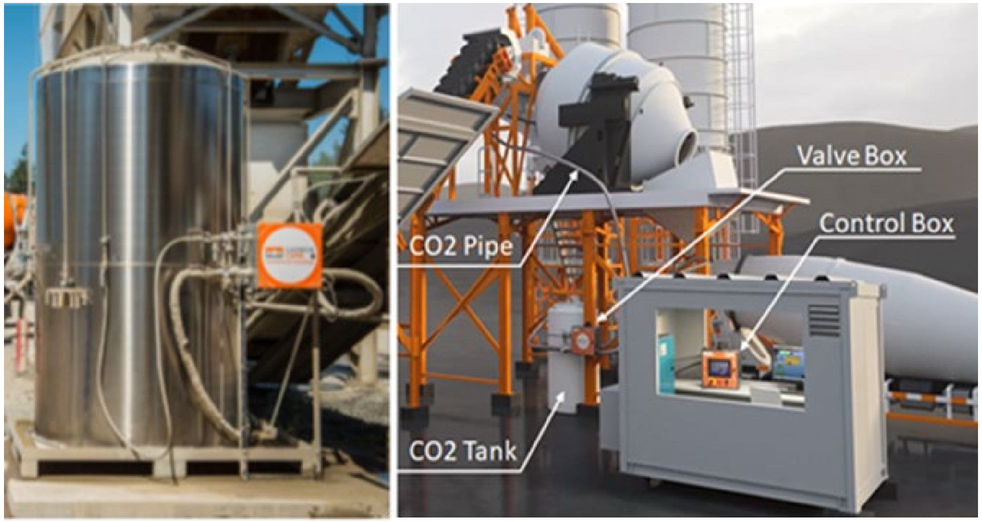
CarbonCure Technology: Commercialized CO_2 Utilization Technology for Concrete



CarbonCure's retrofitted equipment into concrete plants

RESULTS

- Permanent Sequestration
- Less cement needed
- Avoids 25# CO_2 / cy of concrete
- Can still add any admixture normally
- Does not affect set time or workability
- Has neutral affect on natural (long term) carbonization
- Does not cause reduced pH and corrosion

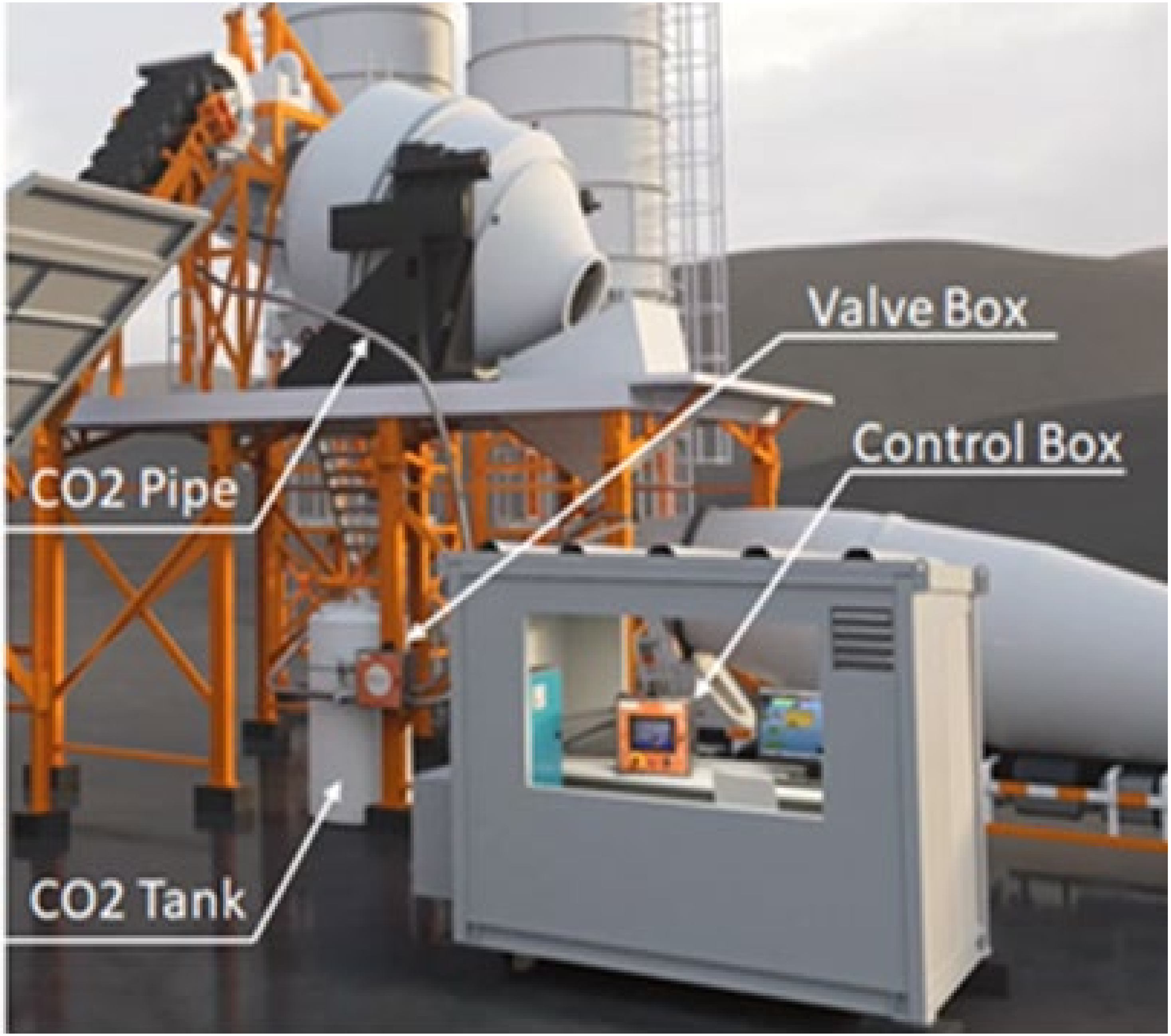
- The CarbonCure Valve Box is connected to the onsite CO_2 storage tank, and automatically injects a precise dosage of liquid CO_2 (300 psi/-50° C (-58 °F) into the concrete during mixing.

- The CarbonCure Control Box syncs with the plant's batching software.

- The CO_2 becomes dry ice, then melts into batch. It combines with the Calcium in the cement to create Nano Calcium Carbonate, which is stronger than Calcium and uniformly distributed in batch.

- Mineralization reactions that take place at the batching plant improve the compressive strength of the concrete, which then enables the reduction of cement content in mix designs while maintaining strength requirements.

- There is sufficient Calcium Hydroxide in batch to react and maintain pH during process.


Valve Box
Control Box
CO2 Pipe
CO2 Tank

Ozinga Utilization Sites

CO_2 utilized at Ozinga host site through the deployment of CarbonCure process

Ozinga Plant Locations

★ **US Steel DAC Site Location**

- Ozinga: has redi-mix facilities throughout the US and in particular in the region
- Closest Ozinga facility is only ~ 4 miles away from US Steel facility (DAC Host Site)
- Ozinga utilizes the CarbonCure process at their facilities. They currently use industrial grade CO_2
- There is a major business driver to use captured CO_2 in the CarbonCure process at the Ozinga sites
- Target of 5,000 tCO2/yr results in dispensing the captured CO_2 to ~ 200 Ozinga sites (based on current volume of CO2 used per site)
- This number of sites is feasible in the region

DAC Host Site: US Steel Site

Possible location of the DAC system at US Steel facility

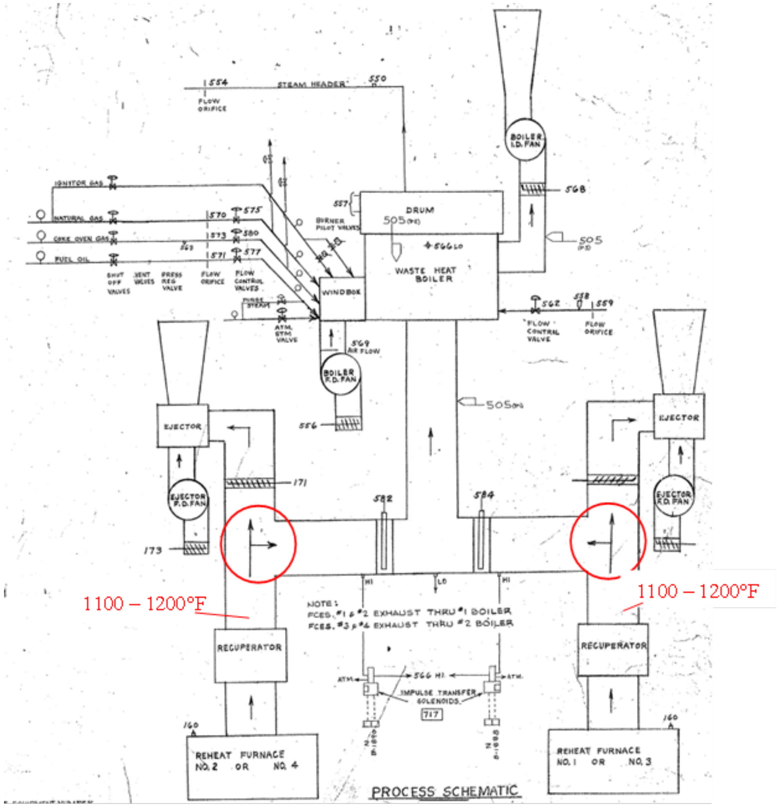
Potential Sources of Power

- Renewable energy to run the DAC unit can be obtained from Adjacent White County's: Rosewater Wind (102 MW), Brickyard Solar, Indiana Crossroads Solar plant through NIPSCO power's existing transmission line.
- If needed, the US Steel plant can also supply any necessary power for the DAC system

DAC Host Site: US Steel Site

Planned source of heat at US Steel facility host site

Planned Source of Heat

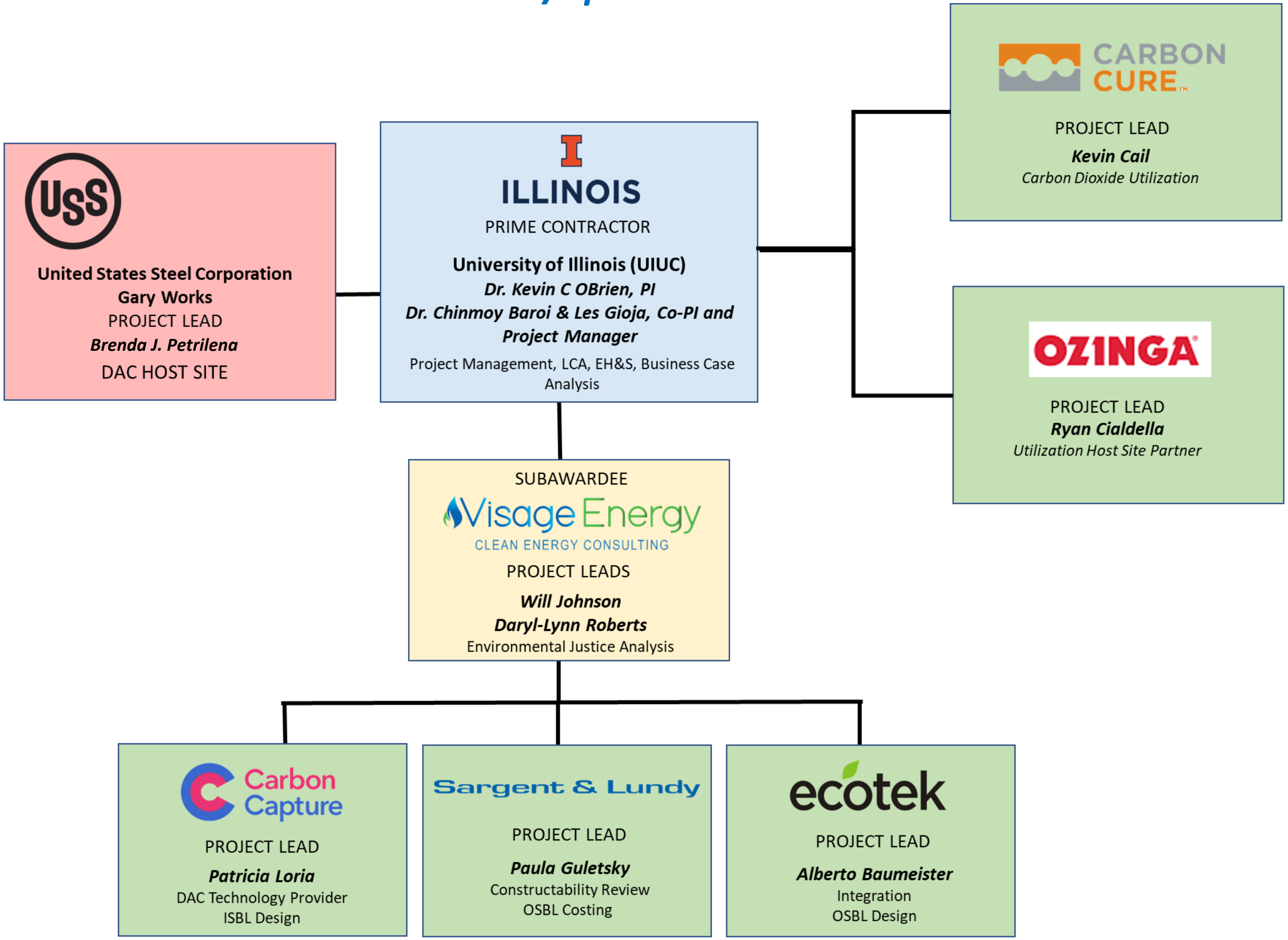


Waste heat source (*sufficient heat for CCI's system*) for the DAC system

Project Management

Management Structure

Designed to enable transition to build/operate



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PRIME CONTRACTOR
University of Illinois (UIUC)
Dr. Kevin C OBrien, PI
Dr. Chinmoy Baroi & Les Gioja, Co-PI and Project Manager
Project Management, LCA, EH&S, Business Case Analysis

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DAC HOST SITE

CARBON CURE
PROJECT LEAD
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Carbon Dioxide Utilization

OZINGA
PROJECT LEAD
Ryan Cialdella
Utilization Host Site Partner

SUBAWARDEE
Visage Energy
CLEAN ENERGY CONSULTING
PROJECT LEADS
Will Johnson
Daryl-Lynn Roberts
Environmental Justice Analysis

Carbon Capture
PROJECT LEAD
Patricia Loria
DAC Technology Provider
ISBL Design

Sargent & Lundy
PROJECT LEAD
Paula Guletsky
Constructability Review
OSBL Costing

ecotek
PROJECT LEAD
Alberto Baumeister
Integration
OSBL Design

Milestones

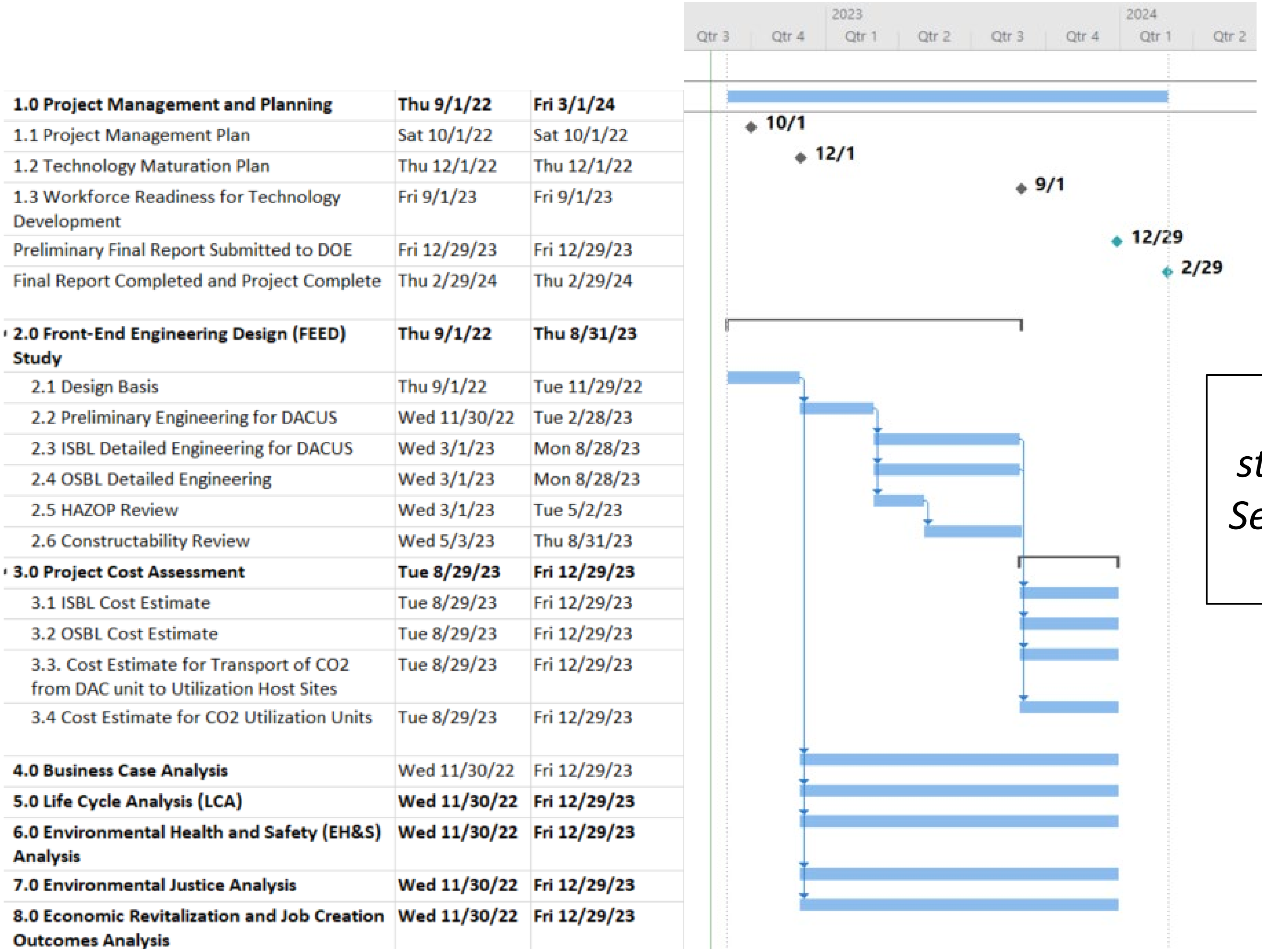
Dates to be adjusted when DOE contract received

Budget Period	Task or Subtask Number	Milestone Title & Description	Planned Completion Date	Actual Completion Date	Verification Method
1	1.1	Updated Project Management Plan	10/1/2022		Project Management Plan file
1	1.2	Technology Maturation Plan (TMP)	12/1/2022		Project Management Plan file
1	1.3	Workforce Readiness Plan	9/1/2023		Project Management Plan file
1	2.1	Project Design Basis Completed	11/29/2022		Topical Report File
1	2.5	HAZOP Completed	5/2/2023		Topical Report File
1	2.6	Constructability Review Complete	8/31/2023		Topical Report File
1	3.0	Project Cost Assessment	12/29/2023		Topical Report File
1	4.0	Business Case Analysis Completed	12/29/2023		Topical Report File
1	5.0	Life Cycle Analysis (LCA)	12/29/2023		Topical Report File
1	6.0	Environmental Health and Safety (EH&S) Analysis	12/29/2023		Topical Report File
1	7.0	Environmental Justice Analysis	12/29/2023		Topical Report File
1	8.0	Economic Revitalization and Job Creation Outcomes Analysis	12/29/2023		Topical Report File

Assumed start date of September 1, 2022

Gantt Chart

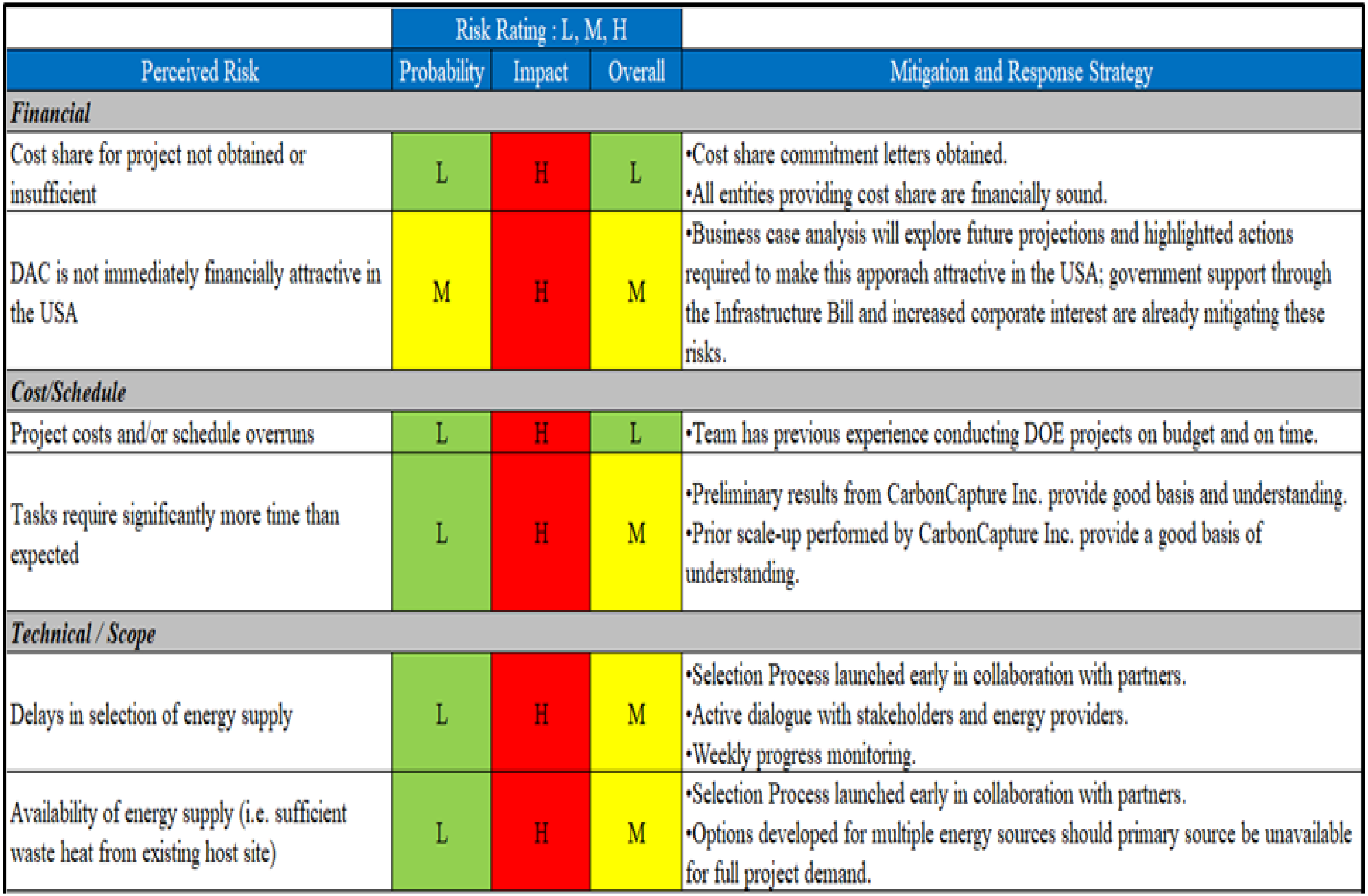
Dates to be adjusted when DOE contract received



1.0 Project Management and Planning	**Thu 9/1/22**	**Fri 3/1/24**
1.1 Project Management Plan	Sat 10/1/22	Sat 10/1/22
1.2 Technology Maturation Plan	Thu 12/1/22	Thu 12/1/22
1.3 Workforce Readiness for Technology Development	Fri 9/1/23	Fri 9/1/23
Preliminary Final Report Submitted to DOE	Fri 12/29/23	Fri 12/29/23
Final Report Completed and Project Complete	Thu 2/29/24	Thu 2/29/24
2.0 Front-End Engineering Design (FEED) Study	**Thu 9/1/22**	**Thu 8/31/23**
2.1 Design Basis	Thu 9/1/22	Tue 11/29/22
2.2 Preliminary Engineering for DACUS	Wed 11/30/22	Tue 2/28/23
2.3 ISBL Detailed Engineering for DACUS	Wed 3/1/23	Mon 8/28/23
2.4 OSBL Detailed Engineering	Wed 3/1/23	Mon 8/28/23
2.5 HAZOP Review	Wed 3/1/23	Tue 5/2/23
2.6 Constructability Review	Wed 5/3/23	Thu 8/31/23
3.0 Project Cost Assessment	**Tue 8/29/23**	**Fri 12/29/23**
3.1 ISBL Cost Estimate	Tue 8/29/23	Fri 12/29/23
3.2 OSBL Cost Estimate	Tue 8/29/23	Fri 12/29/23
3.3. Cost Estimate for Transport of CO2 from DAC unit to Utilization Host Sites	Tue 8/29/23	Fri 12/29/23
3.4 Cost Estimate for CO2 Utilization Units	Tue 8/29/23	Fri 12/29/23
4.0 Business Case Analysis	Wed 11/30/22	Fri 12/29/23
5.0 Life Cycle Analysis (LCA)	**Wed 11/30/22**	**Fri 12/29/23**
6.0 Environmental Health and Safety (EH&S) Analysis	**Wed 11/30/22**	**Fri 12/29/23**
7.0 Environmental Justice Analysis	**Wed 11/30/22**	**Fri 12/29/23**
8.0 Economic Revitalization and Job Creation Outcomes Analysis	**Wed 11/30/22**	**Fri 12/29/23**

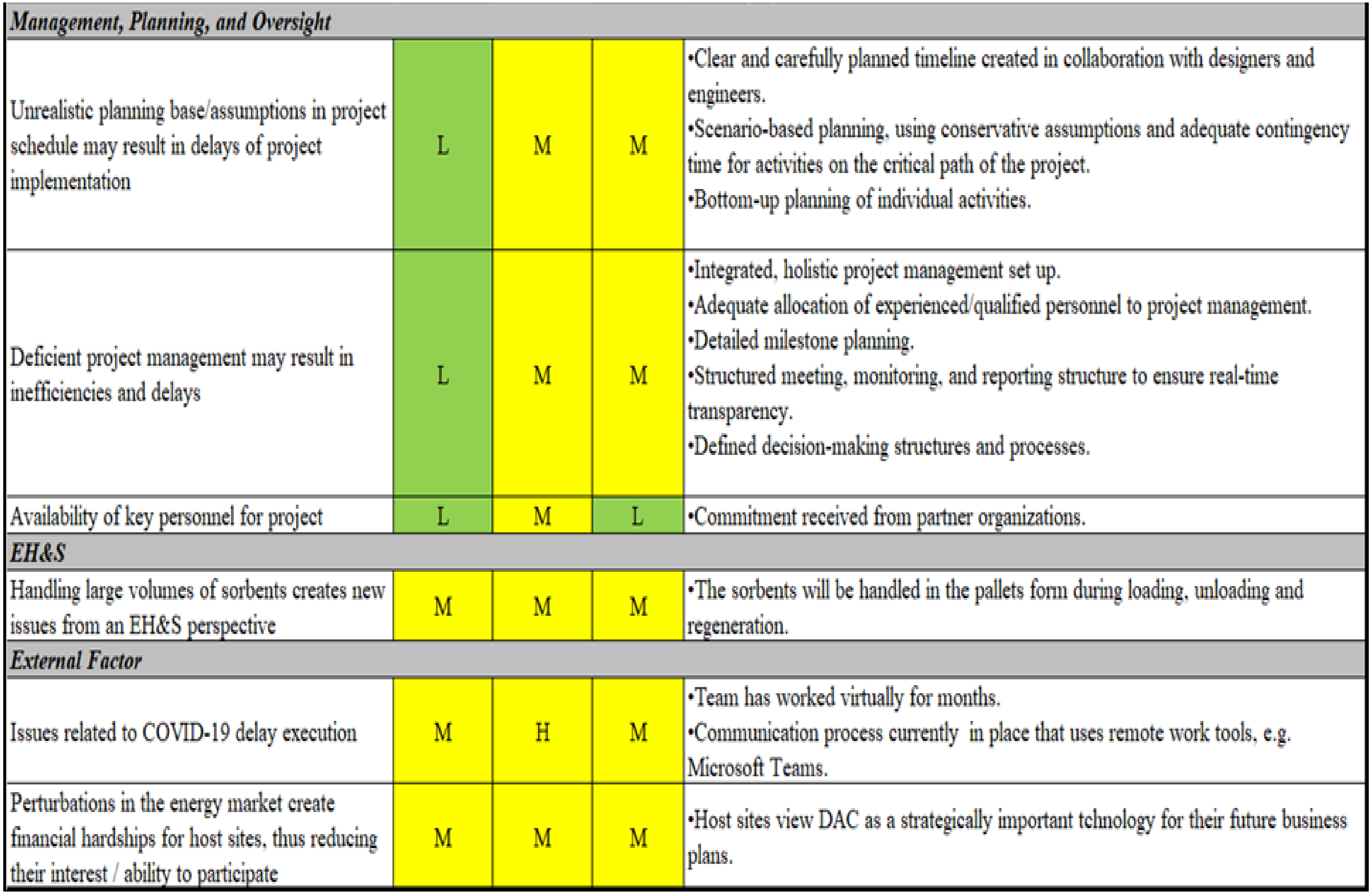
Assumed start date of September 1, 2022

Risk Management



	Risk Rating : L, M, H			
Perceived Risk	Probability	Impact	Overall	Mitigation and Response Strategy
Financial				
Cost share for project not obtained or insufficient	L	H	L	•Cost share commitment letters obtained. •All entities providing cost share are financially sound.
DAC is not immediately financially attractive in the USA	M	H	M	•Business case analysis will explore future projections and highlightted actions required to make this apporach attractive in the USA; government support through the Infrastructure Bill and increased corporate interest are already mitigating these risks.
Cost/Schedule				
Project costs and/or schedule overruns	L	H	L	•Team has previous experience conducting DOE projects on budget and on time.
Tasks require significantly more time than expected	L	H	M	•Preliminary results from CarbonCapture Inc. provide good basis and understanding. •Prior scale-up performed by CarbonCapture Inc. provide a good basis of understanding.
Technical / Scope				
Delays in selection of energy supply	L	H	M	•Selection Process launched early in collaboration with partners. •Active dialogue with stakeholders and energy providers. •Weekly progress monitoring.
Availability of energy supply (i.e. sufficient waste heat from existing host site)	L	H	M	•Selection Process launched early in collaboration with partners. •Options developed for multiple energy sources should primary source be unavailable for full project demand.

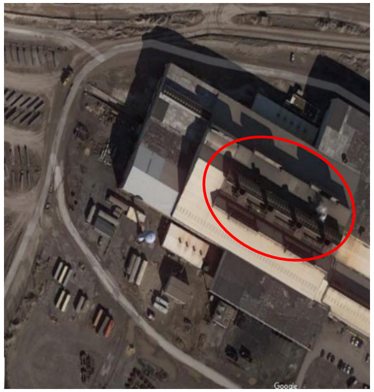
Risk Management



Management, Planning, and Oversight				
Unrealistic planning base/assumptions in project schedule may result in delays of project implementation	L	M	M	•Clear and carefully planned timeline created in collaboration with designers and engineers. •Scenario-based planning, using conservative assumptions and adequate contingency time for activities on the critical path of the project. •Bottom-up planning of individual activities.
Deficient project management may result in inefficiencies and delays	L	M	M	•Integrated, holistic project management set up. •Adequate allocation of experienced/qualified personnel to project management. •Detailed milestone planning. •Structured meeting, monitoring, and reporting structure to ensure real-time transparency. •Defined decision-making structures and processes.
Availability of key personnel for project	L	M	L	•Commitment received from partner organizations.
EH&S				
Handling large volumes of sorbents creates new issues from an EH&S perspective	M	M	M	•The sorbents will be handled in the pallets form during loading, unloading and regeneration.
External Factor				
Issues related to COVID-19 delay execution	M	H	M	•Team has worked virtually for months. •Communication process currently in place that uses remote work tools, e.g. Microsoft Teams.
Perturbations in the energy market create financial hardships for host sites, thus reducing their interest / ability to participate	M	M	M	•Host sites view DAC as a strategically important tchnology for their future business plans.

Direct Air Capture + Utilization = DACU

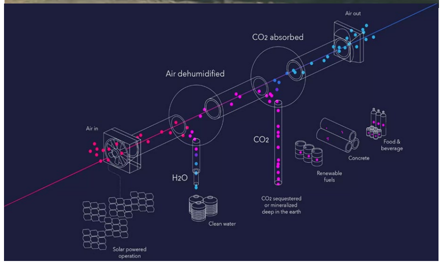
Waste heat from Steel plant and utilize captured CO_2 for cement



US Steel Gary Works Facility Host Site Aerial View

Waste Heat

Carbon Capture



Captured CO_2

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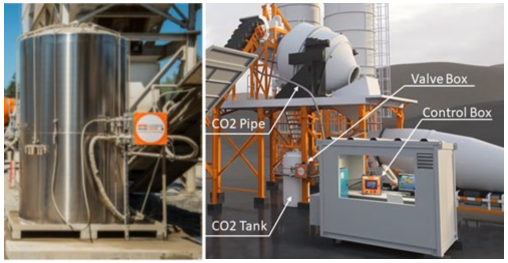
CarbonCure's CO_2 Dosing Tank and Utilization System



CO_2 incorporated into concrete

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Mariah Richardson, Elliott Roth	National Energy Technology Laboratory / US Department of Energy
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Ryan Cialdella	Ozinga
Alberto Baumeister	Ecotek
Paula Guletsky	Sargent & Lundy
Daryl-Lynn Roberts, Will Johnson	Visage Energy

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