NuDACCS – Nuclear Direct Air Capture with Carbon Storage

DE-FE0032160

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Battelle Memorial Institute

U.S. Department of Energy

National Energy Technology Laboratory
Carbon Management Research Project Review Meeting
August 5 – August 9, 2024

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Agenda

- Overview
- Technology Background
- FEED
- Business Case Analysis
- Lifecycle Analysis
- Workforce Readiness
- Environmental Justice
- Key Findings

Project Overview

Period of Performance:

October 2022 – September 2024

Project Funding:

Federal Share: $2,499,178

Non-Federal Share: $864,446

Total: $3,363,624

Project Team Members:

- BATTELLE
- Aircapture
- Southern Company
- The University of Alabama
- Sargent & Lundy
- Carbonvert

Project Goal:

The project will define system costs, performance, socio-economic impacts, and business-case options for leveraging available thermal energy from the nuclear plant to separate CO_2 from ambient air for off-site geologic storage.

Project

Purpose: Conduct a Front-End Engineering and Design (FEED) and associated supplemental studies to determine the technical, economic, and socio-economic viability of utilizing nuclear heat/power source for deploying a direct air capture (DAC) installation capturing a minimum **5,000 net tpa**

Task List

- Task 1.0 PM
- Task 2.0 FEED
  - DAC
  - Balance of Plant (BOP)
- Task 3.0 Project Economics and Business Case
- Task 4.0 Lifecycle Analysis and EH&S
- Task 5.0 Socio-Economic Impact
  - Environmental Justice
  - Economic Revitalization and Jobs Outcomes Analysis
  - Workforce readiness

Deliverables

Task/ subtask	Deliverable Title	Planned completion (month after award)	Verification method	Delivered?
1.6	Project Kickoff Meeting	3	Meeting Notes	Y
1.1	Updated PMPlan Complete	1	PMP submitted to DOE	Y
1.4	Updated DMPlan Complete	1	DMP submitted to DOE	Y
2.2.1	Process Design and Initial HAZOP Complete	9	Memo to DOE	Y
2.2	FEED Study Complete	17	Memo to DOE	Y
3.2	Cost Estimate BCA Complete	17	Memo to DOE	Y
4.1, 4.2	LCA and EH&S Risk Complete	17	Memo to DOE	Y
1.3	Workforce Readiness Plan Report Complete	12 initial, 17 final	Memo to DOE	Y
5.1, 5.2	Environmental Justice and Economic Revitalization Analyses	10 mid-project, 17 final	Briefing to DOE and project Stakeholders	Y
1.7	Final Report	18	Memo to DOE and project Stakeholders	(Target August)
1.2	TMP Complete	3 initial, 17 final	Memo to DOE	Y

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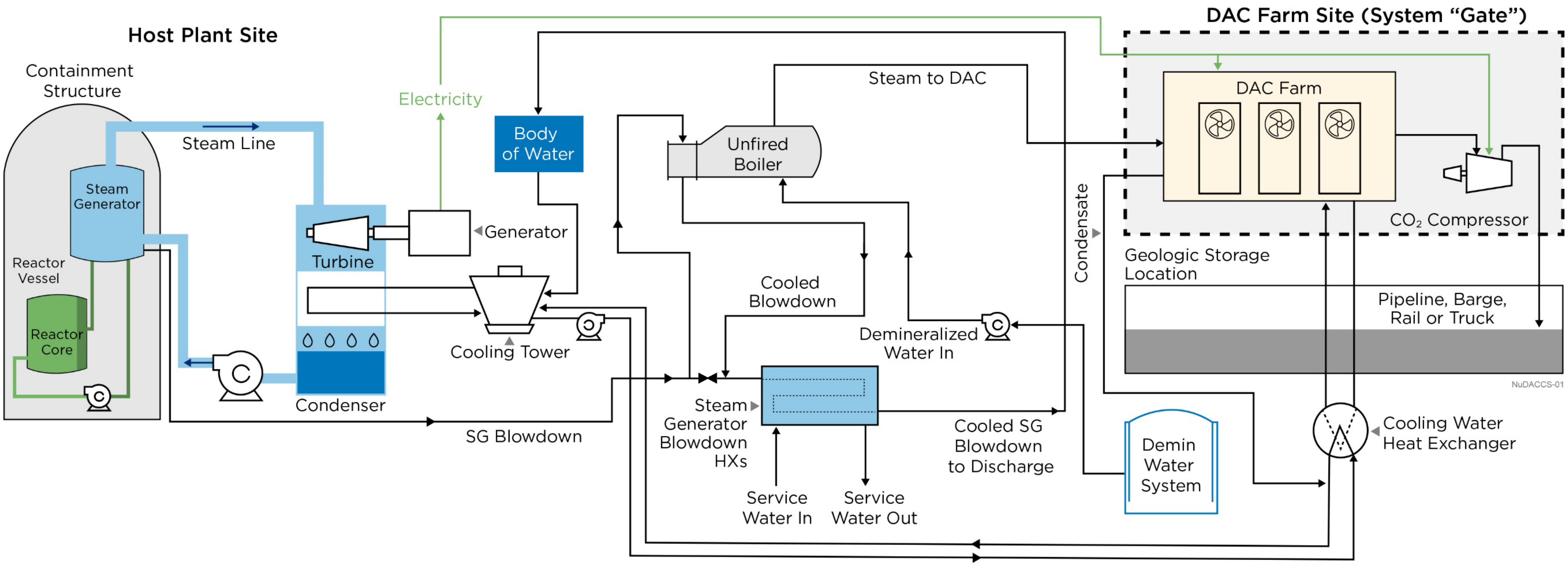
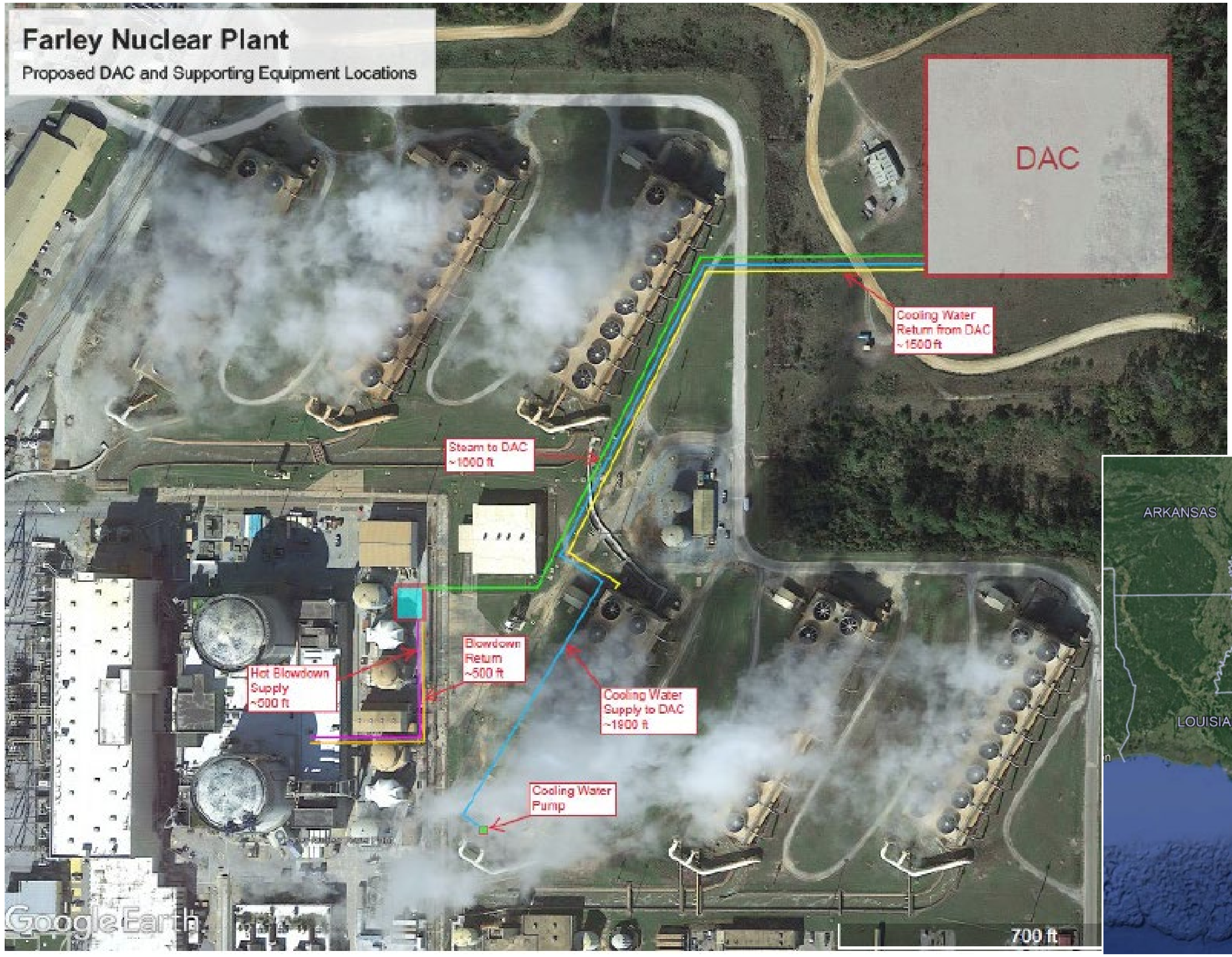
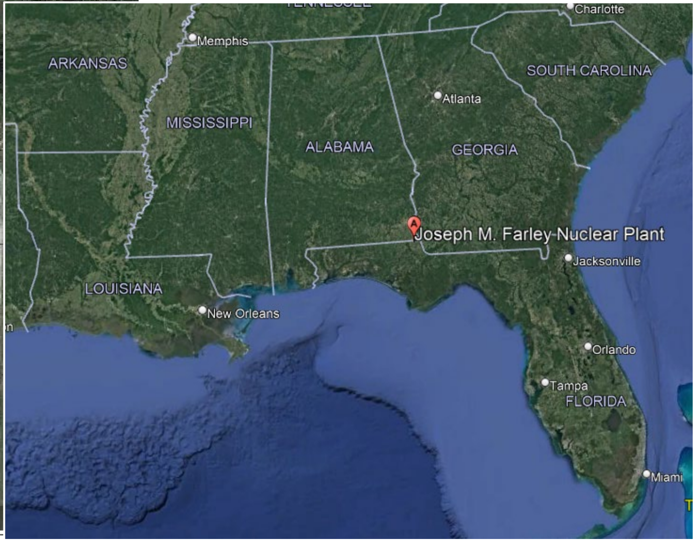
Overall Concept



Project Location





- Preliminary tie-ins and equipment locations determined
- Site visit refined the initial design

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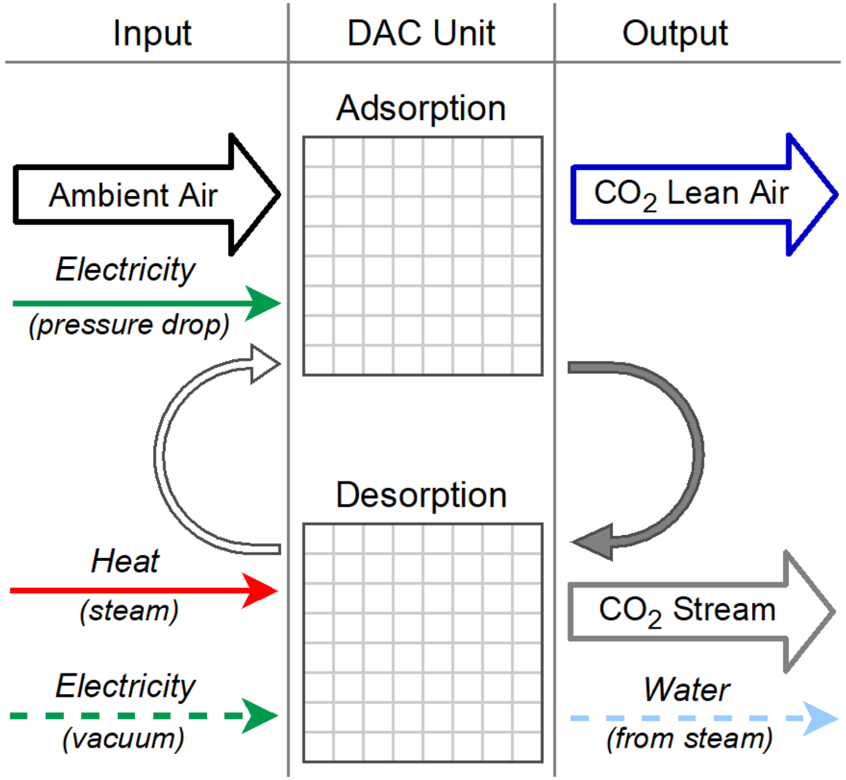
Technology Background

Step 1 (Capture): CO_2 is collected by moving air or mixtures of air and CO_2 rich gases across a proprietary contactor which adsorbs CO_2.

Step 2 (Regeneration): The contactor is moved into a regeneration box where low-temperature steam flows across the contactor, removing CO_2 from the contactor, and the CO_2 is collected.



Goal: Use commercially available contactors and sorbents in an efficient system design to decrease the cost of DAC.

Polymeric Amine Sorbent

Monolithic Contactor

- Low pressure drop
- Low thermal mass
- High geometric surface area
- Compatible with various construction methods

Adsorption

- 900 seconds / monolith in ambient air

Desorption

- Saturated Steam in less than 90 seconds

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Aircapture Scale-Up/Testing

TRL 7+ achieved for DAC technology by Q4 2024

SN1: NCCC, Wilsonville, AL
March 2023 to July 2024
5 Campaigns, +140 days of operations,
>92% uptime (DE-FE0031961)

SN3: Aircapture Berkeley, CA April 2024
>50% CAPEX Reduction
>20% OPEX Reduction

Project Hajar, 8 SN3 DACs + Supporting Skids June 2024
Proving out DAC Grove concept first designed in
DE-FE0032160 & DE-FE0032157

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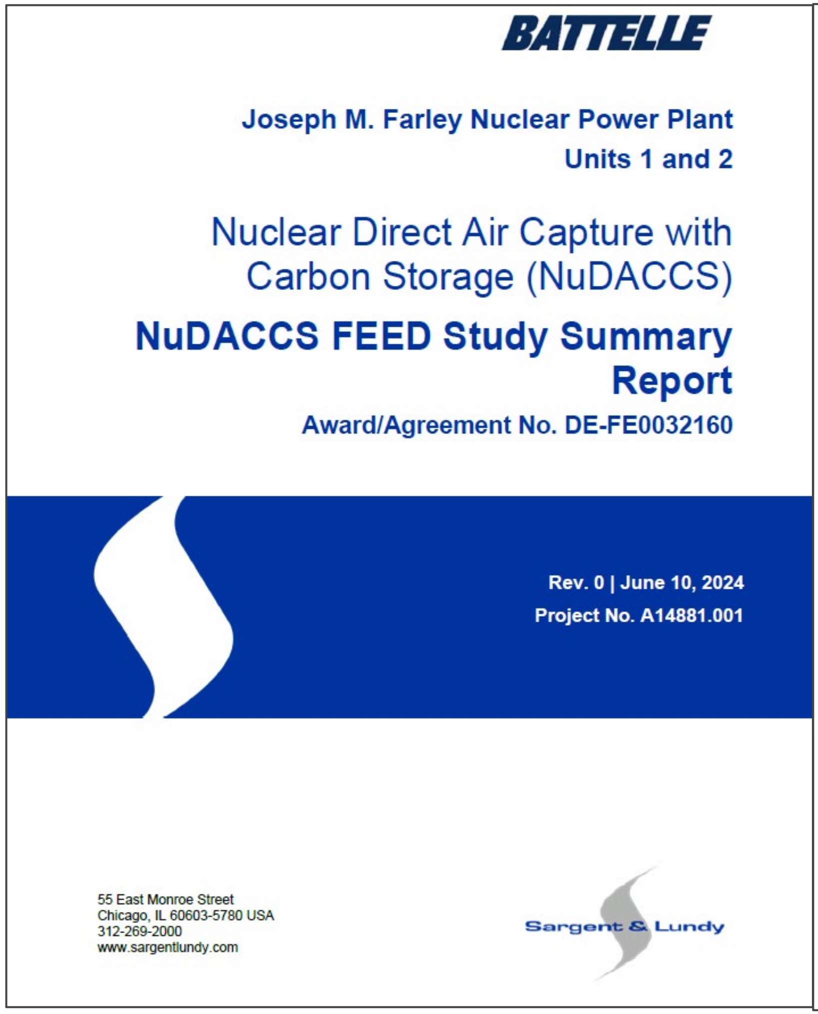
FEED Study

- FEED study was completed
- Including process, BOP, constructability review, HAZOP, and other analyses
- Cost estimate created using Air Capture and S&L inputs
- Submitted on June 28th, 2024 currently under review by DOE



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Joseph M. Farley Nuclear Power Plant
Units 1 and 2

Nuclear Direct Air Capture with Carbon Storage (NuDACCS)

NuDACCS FEED Study Summary Report

Award/Agreement No. DE-FE0032160

Rev. 0 | June 10, 2024
Project No. A14881.001

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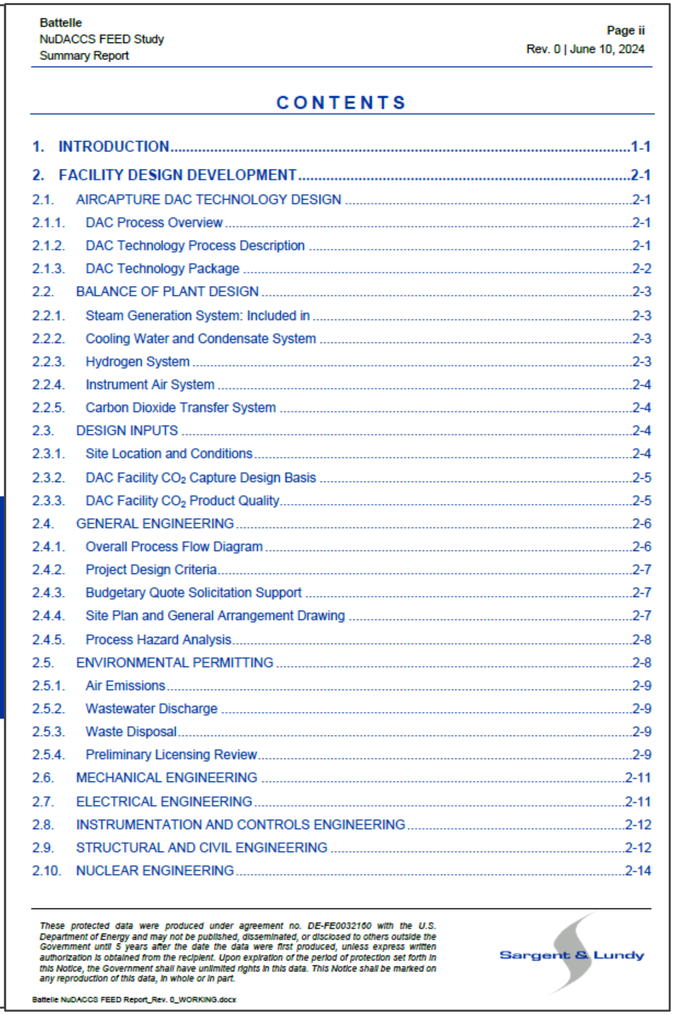

Battelle
NuDACCS FEED Study
Summary Report

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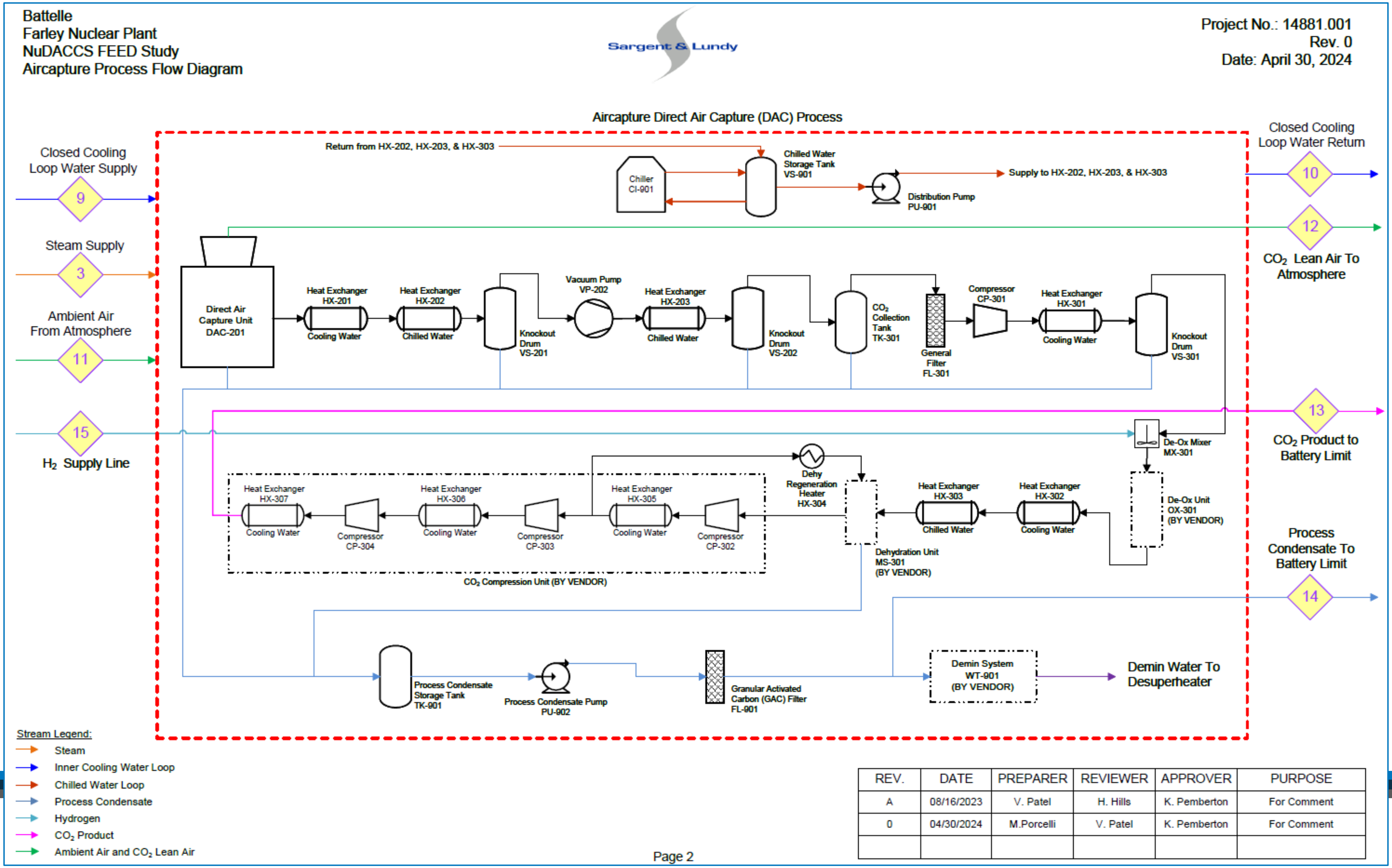
Sargent & Lundy

Battelle NuDACCS FEED Report_Rev. 0_WORKING.docx

BOP/Plant Farley Interfaces



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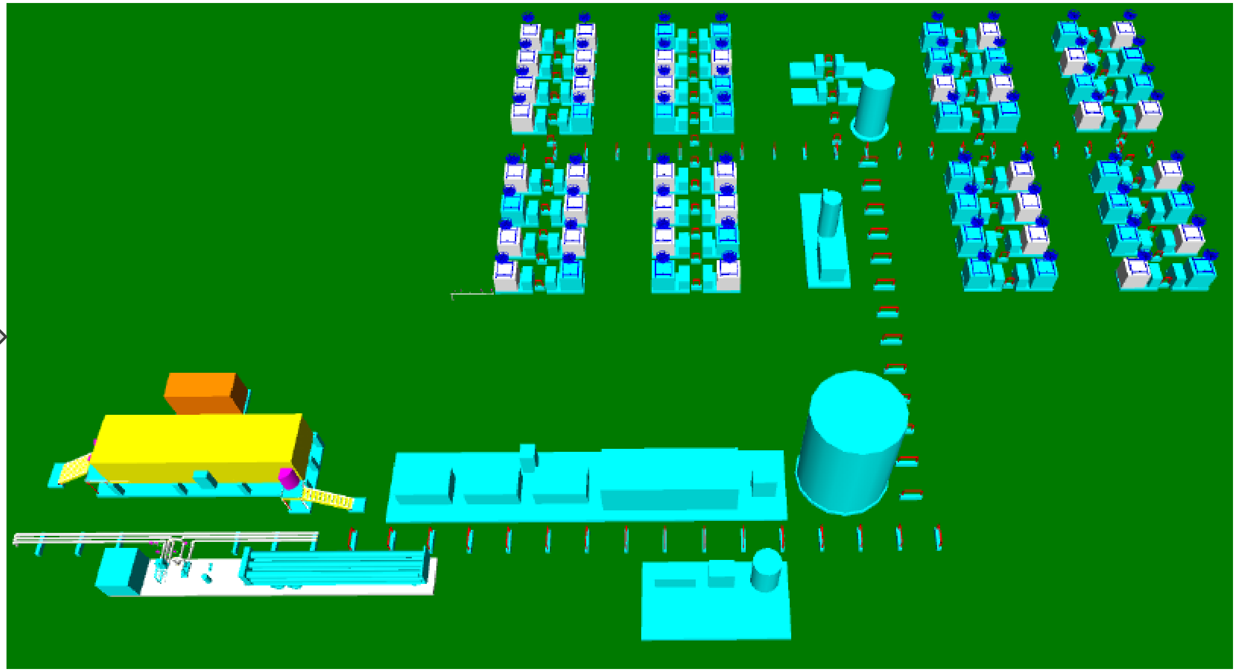
Aircapture Concept DAC Layout CFD – Initial Conditions

- Translated GA to 3D model – Focused on DAC island, utilities, transport, and conditioning/compression infrastructure



Preliminary DAC Layout Concept

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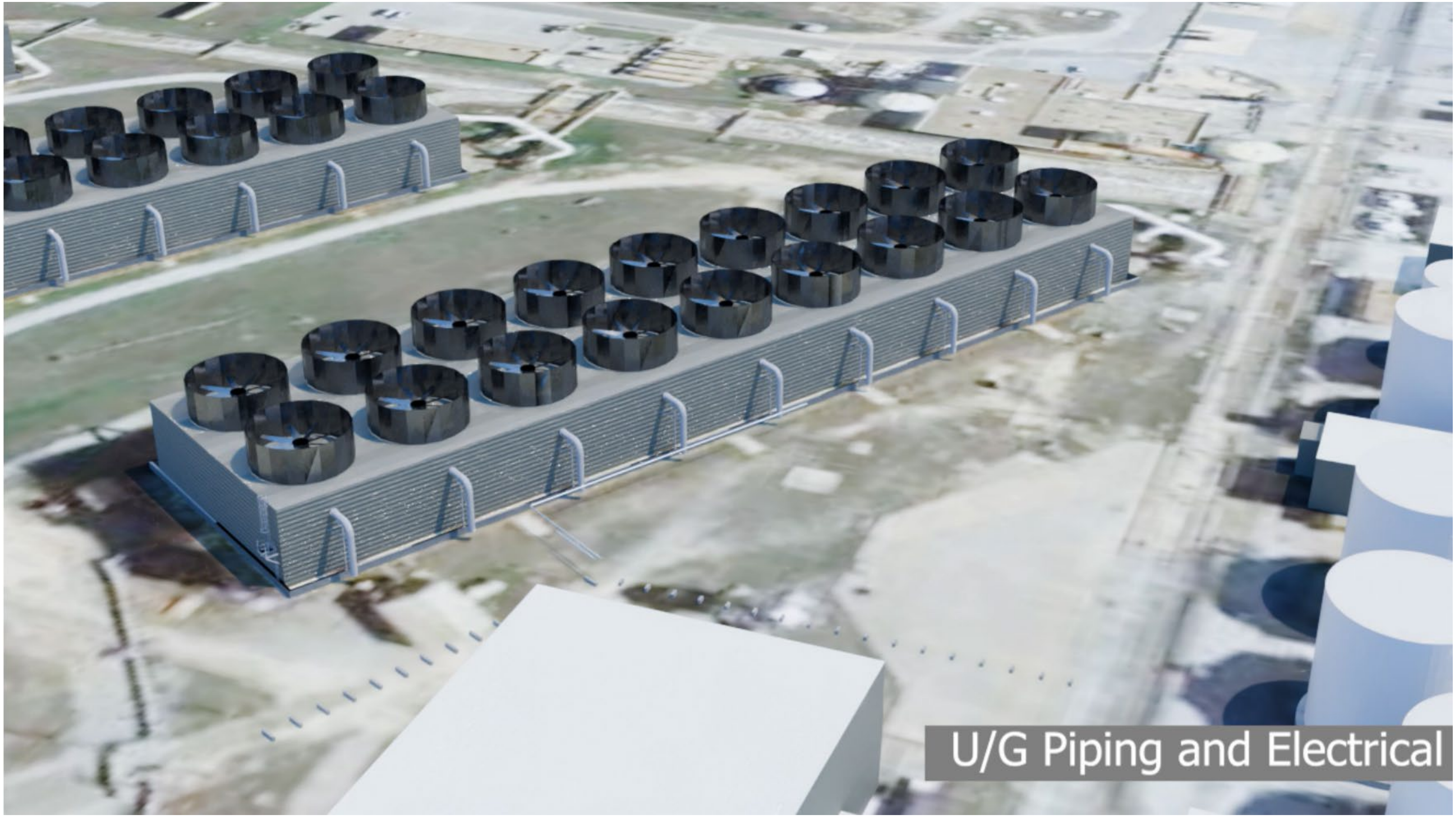
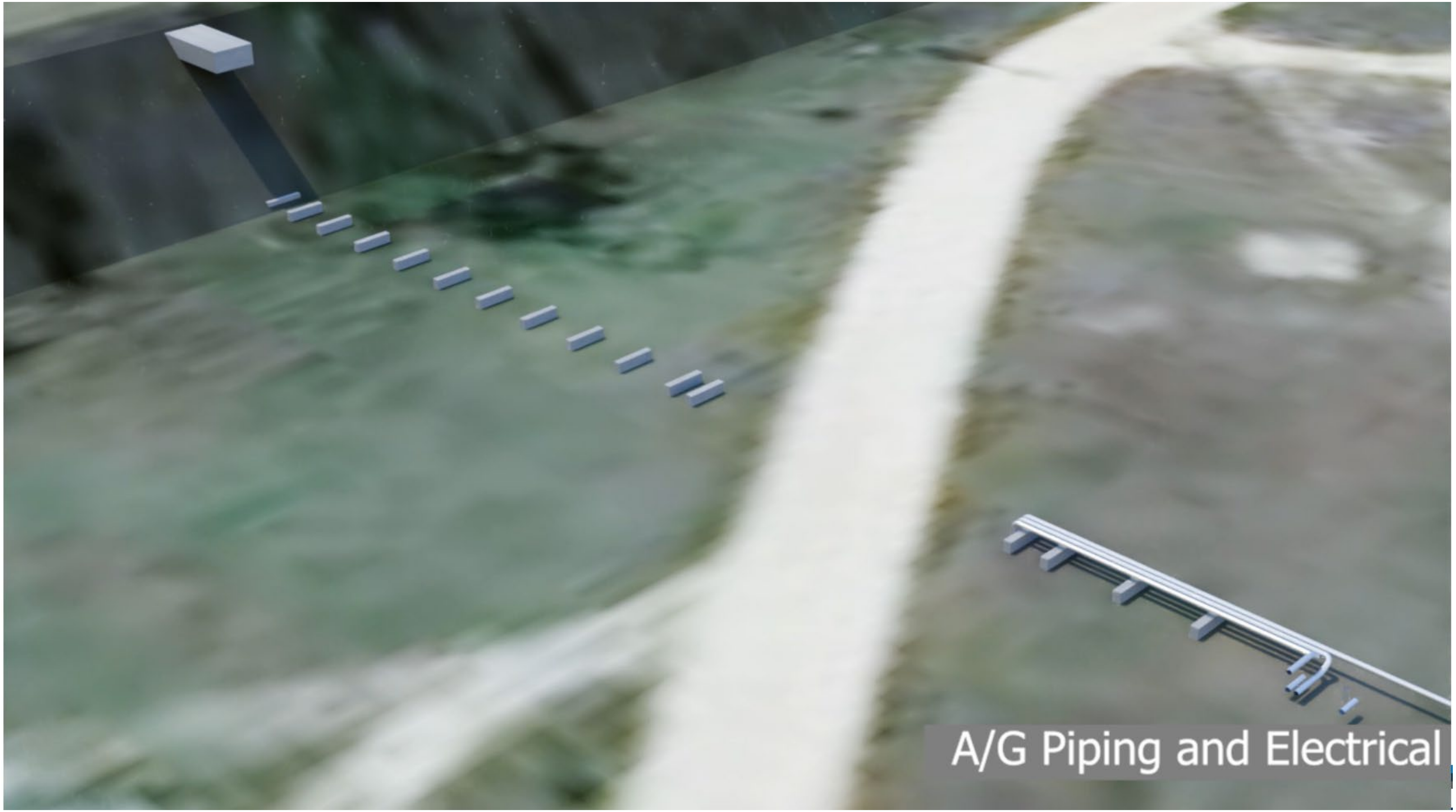
NUDACCS Feed Study


Trench Installation


Sleeper Installation


U/G Piping and Electrical


Unfired Boiler Installation


A/G Piping and Electrical


Foundations and DAC Equipment

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Business Case Analysis

- BCA
  - Project would need to take advantage of 45Q and voluntary credit market
  - Two factors drove economics:
    - Small DAC island size (driven by heat-source capacity) the DAC capacity nearly doubles by tying into both reactor units
    - Tie-ins in protected zone led to higher costs
  - Submitted to the DOE on July 16th, 2024

The University of Alabama
Nuclear Direct Air Capture with Carbon Sequestration
Business Case Analysis and
Review of Front-End Engineering Design Study

The University of Alabama

DIRECT AIR CAPTURE
COMBINED WITH DEDICATED LONG-TERM CARBON STORAGE,
COUPLED TO EXISTING LOW-CARBON ENERGY

1

Lifecycle Analysis

- LCA model is set up in openLCA following NETL guidelines and ISO 14040/14044 standards
- Net carbon removal efficiency of 92.6%
- Electricity production and H2 production (SMR) lead gray emissions
- Global warming potential roughly doubles if not utilizing waste heat from Plant Farley for Steam Generation
- This assumes power required for steam is generated from a Nuclear Source (NETL Database)

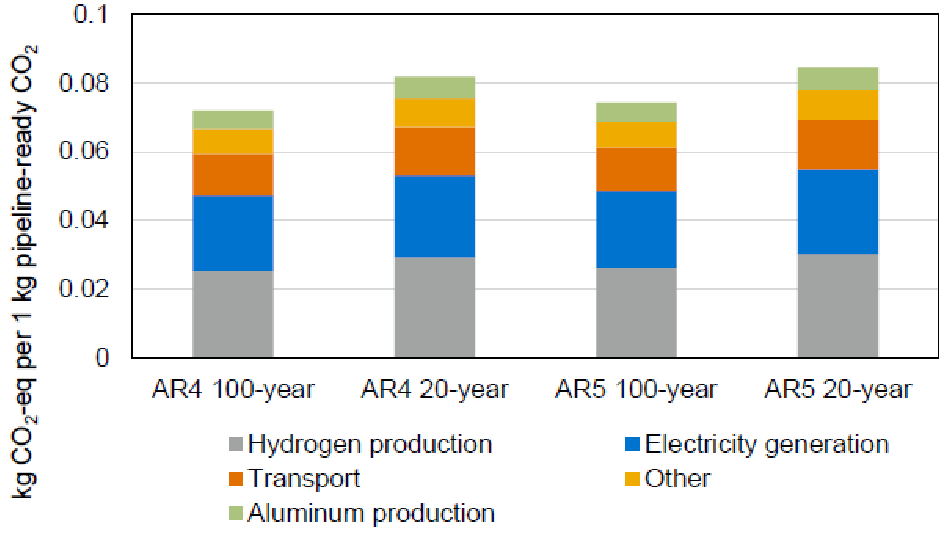


Figure 4. Contributions to GWP by process

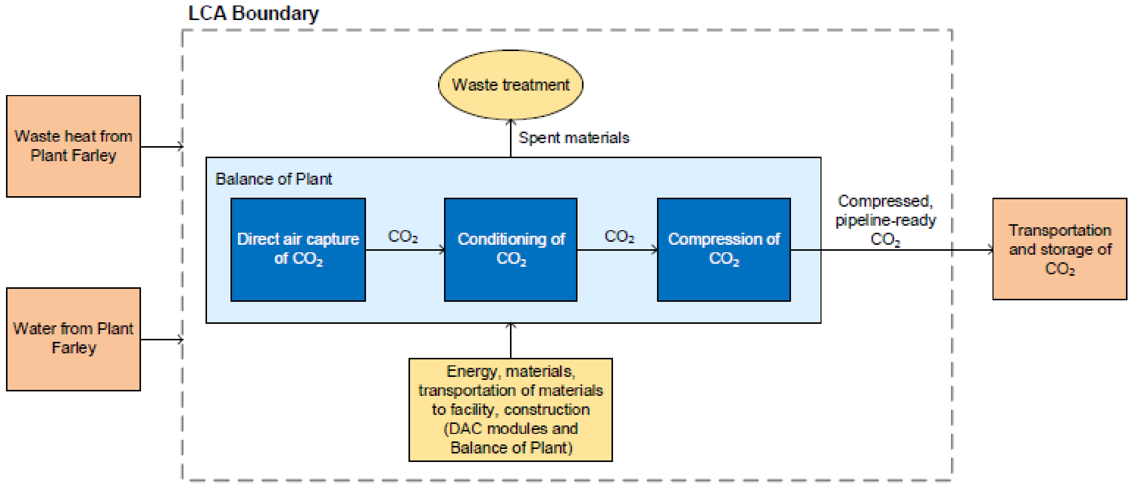
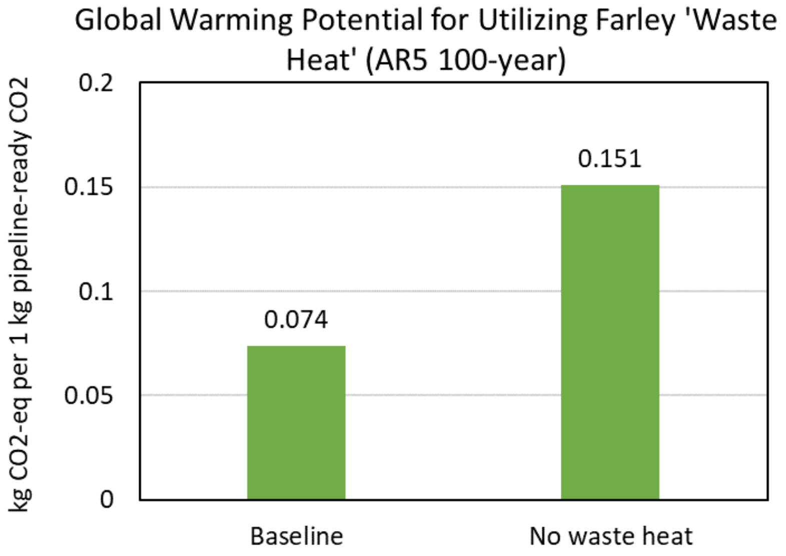


Figure 2. LCA system boundaries



Workforce Readiness

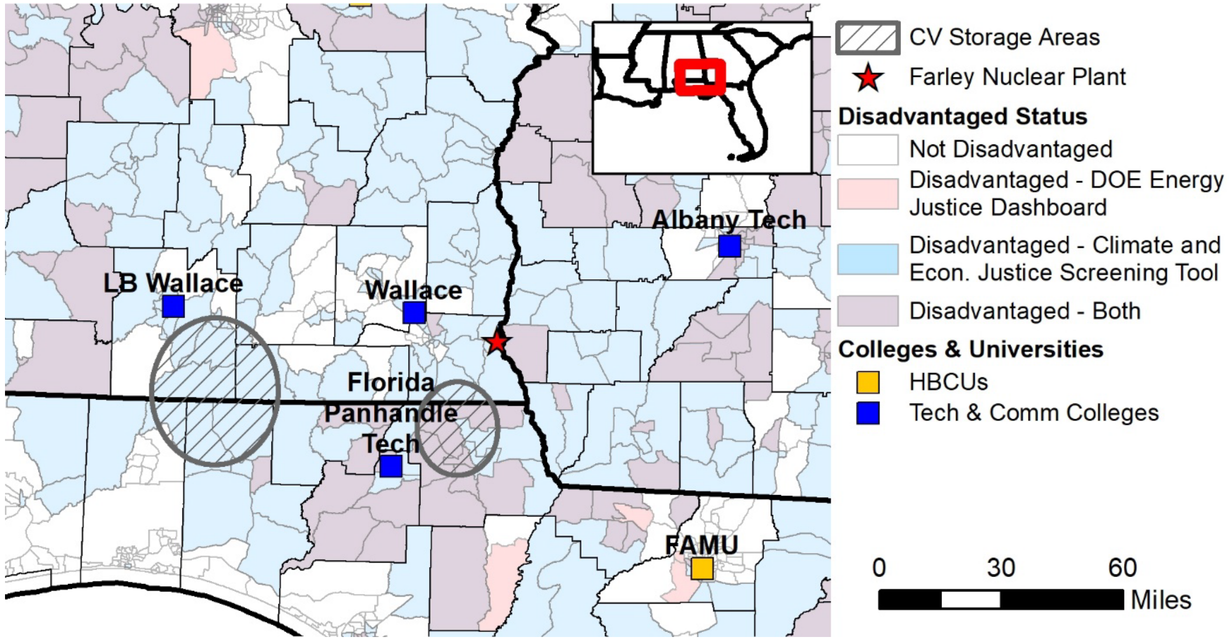
- Jobs created by the NuDACCS project will require short-term construction jobs and longer-term operations jobs.
- The team reached out to the nearby technical colleges, universities, and HBCUs. As part of this outreach each institution was asked about several topics.

Table 1. Formal Training requirements for jobs required to execute a DAC project.

Jobs	Union?	Experience	Education Needed	Training Institutions
Engineers	No	Entry Level to Senior Level	BS or higher	Universities, HBCUs
Welders and Joiners	Yes	Apprenticeship	Certification or 2-year degree	Tech & Community Colleges, Vocational Schools, Unions
Electricians	Yes	Apprenticeship	Certification or 2-year degree	Tech & Community Colleges, Vocational Schools, Unions
Cement Masons	Yes	Apprenticeship	Certification or 2-year degree	Tech & Community Colleges, Vocational Schools, Unions
Machinists	Yes	Apprenticeship	Certification or 2-year degree	Tech & Community Colleges, Vocational Schools, Unions
Fabricators	Yes	Apprenticeship	Certification or 2-year degree	Tech & Community Colleges, Vocational Schools, Unions
Construction laborers	Yes	Minimal	High School or equivalent	NA
Construction supervisors	Yes	On-the-job training	Certification or 2-year degree + OSHA training	Tech & Community Colleges, Vocational Schools, Unions
Manufacturing and Maintenance	Yes	Apprenticeship	Certification or 2-year degree	Tech & Community Colleges, Vocational Schools, Unions

Environmental Justice

- Overarching goal is to have benefits flow to disadvantaged communities and negative impacts avoided
- Disadvantaged communities have been identified using DOE and White House Council on Environmental Quality tools.
- Minority Serving Institutions (MSIs) and technical and community colleges can help train workers.
- Reports submitted to the DOE on July 12th, 2024



Key Findings

1. Optimizing available resources, such as heat sources, land, and cooling systems, is crucial for maximizing DAC capacity.
2. Developing infrastructure and equipment outside restricted site areas is important to minimize the impact on Farley operations and reduce project schedule risks.
3. Integrating with an operating nuclear power plant is complex but offers access to low-carbon power, heat, and cooling water.
4. Smaller installations can be supported by investments in common transport and injection infrastructure.
5. Such smaller installations may need to rely on barge, rail, or truck transport unless connected to a pipeline network.

Thank You!

- DOE NETL Project Manager – Zachary Roberts
- Aircapture
- Sargent and Lundy
- Southern Company
- University of Alabama
- Carbonvert

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It can be done

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