Chevron natural gas carbon capture technology testing project

Cooperative Agreement No. DE-FE0031944
August 29, 2023

Scott McLemore, P.E.

Project overview

Award Period

- 10/01/2020 through 08/30/2024

Project Funding

- Total Funding: $22,189,674
- Federal Funding: $13,000,000.00
- Cost Share Funding: $9,189,674 (Cash Contribution by Chevron)

Project Participants

- Chevron U.S.A. Inc., Prime Contractor, host site and cost share provider
  - Principal Investigator: Scott McLemore
  - Project Manager: Stan Cross
- Technology Provider: Svante, Inc.
- ISBL Engineering, Procurement and Construction: Kiewit Engineering Group Inc (KEGI) and Kiewit Power Constructors (KPC)
- Program Administrator: Electricore, Inc.
- Plant Operation and Maintenance: Offshore Technology Services (OTS)

DOE-NETL Team

- Grants Officer: Lisa Kuzniar, Project Manager: Nicole Shamitko-Klingensmith, Contracting Specialist: Kelly Haught

Project objectives

The project will validate a transformational solid sorbent carbon capture technology at engineering scale under indicative natural gas flue gas conditions and continuous long-term operation at Chevron's Kern River oil field

- Successfully complete the design, construction, commissioning, and long-term testing of an engineering scale plant of approximately 25 tonnes per day (TPD) under steady-state conditions at varying flue gas carbon dioxide (CO_2) concentrations (~4–14%);
- Conduct a techno-economic analysis (TEA) on the VeloxoTherm™ technology as integrated into a nominal 550 MW (net) natural gas combined cycle (NGCC) power plant;
- Conduct a comprehensive gap analysis addressing the current stage of VeloxoTherm™ technology development for NGCC application; and
- Summarize the research, development, and demonstration requirements to close identified gaps to approach achievement of DOE's carbon capture performance goal of CO_2 capture with 95% CO_2 purity at a cost of $30/tonne of CO_2 captured by 2030.

Kern River carbon capture plant

San Joaquin Valley, CA USA

Natural gas-based flue gas testing

Understand and measure capture plant performance on boiler, NGCC and SMR feed flue gas

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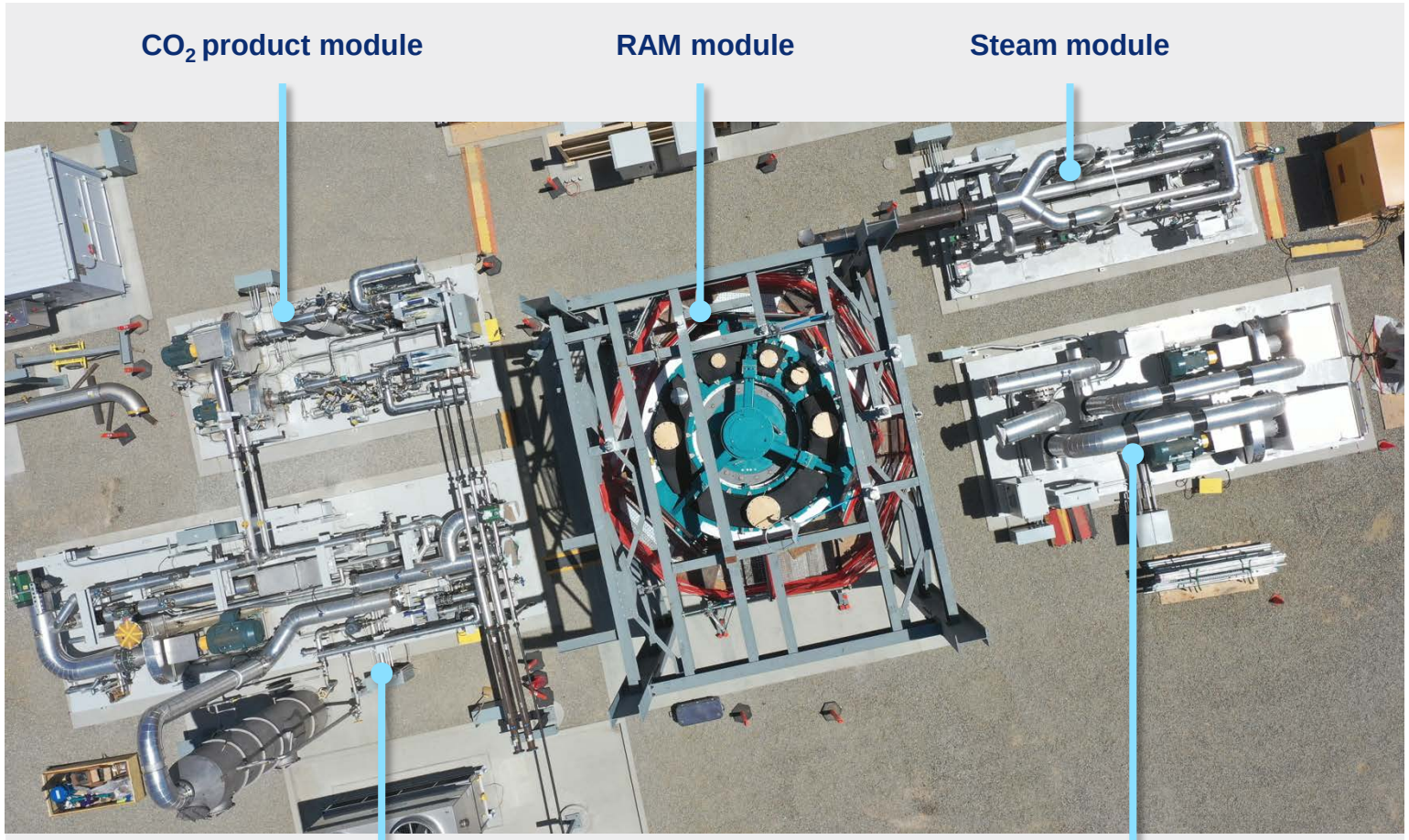
Skid-mounted modular design carbon capture plant

New metallic organic framework (MOF) sorbent beds

95% CO_2 product purity and lower steam ratio compared to conventional solvent technology



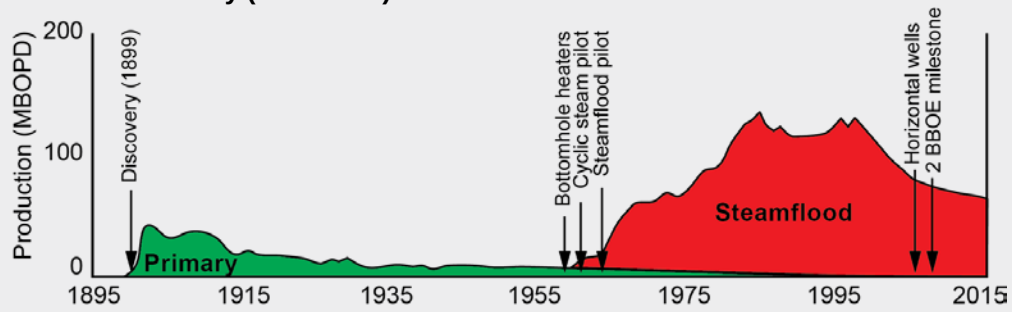
Project location — Kern River Oilfield

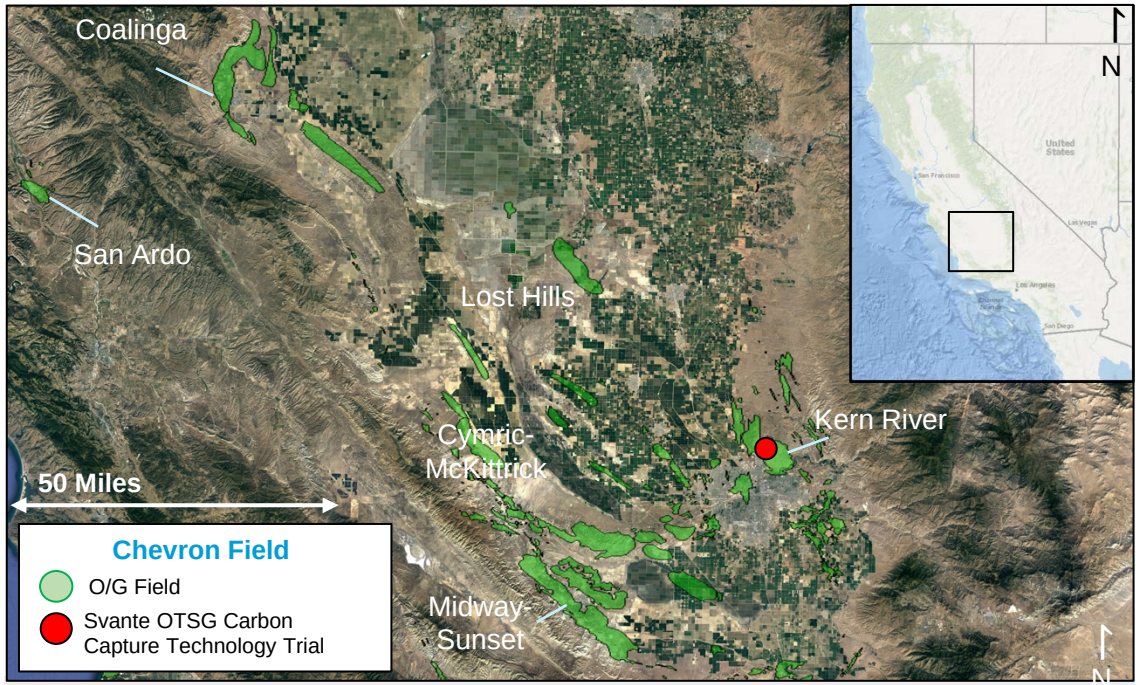
Reducing the carbon intensity of our operations through scalable demonstration projects

2.3 BBOE cumulative production

60% OOIP (3.7 BBOE)

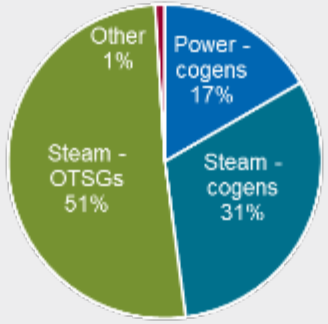
Production history (1899-2015)





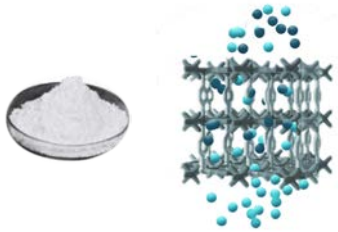
SJVBU GHG emissions

2022



Svante Carbon Capture Technology

Vision for next generation commercial scale plant

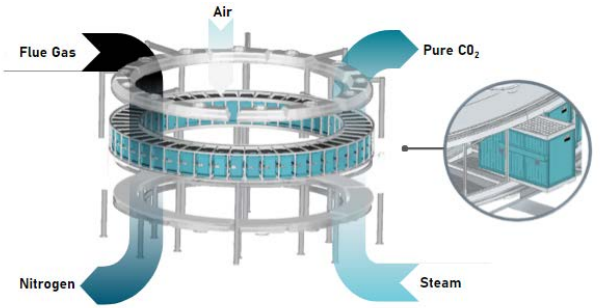


Solid Sorbents (MOFs)

Engineered to have high selectivity over water & high capacity for CO_2.

Rotary Adsorption Machine (RAM) with Filters Inside

Solid sorbents laid onto thin sheets of film & stacked to create a filter.



Nanoengineered Carbon Capture Filters

Solid sorbents laid onto thin sheets of film & stacked to create a filter.

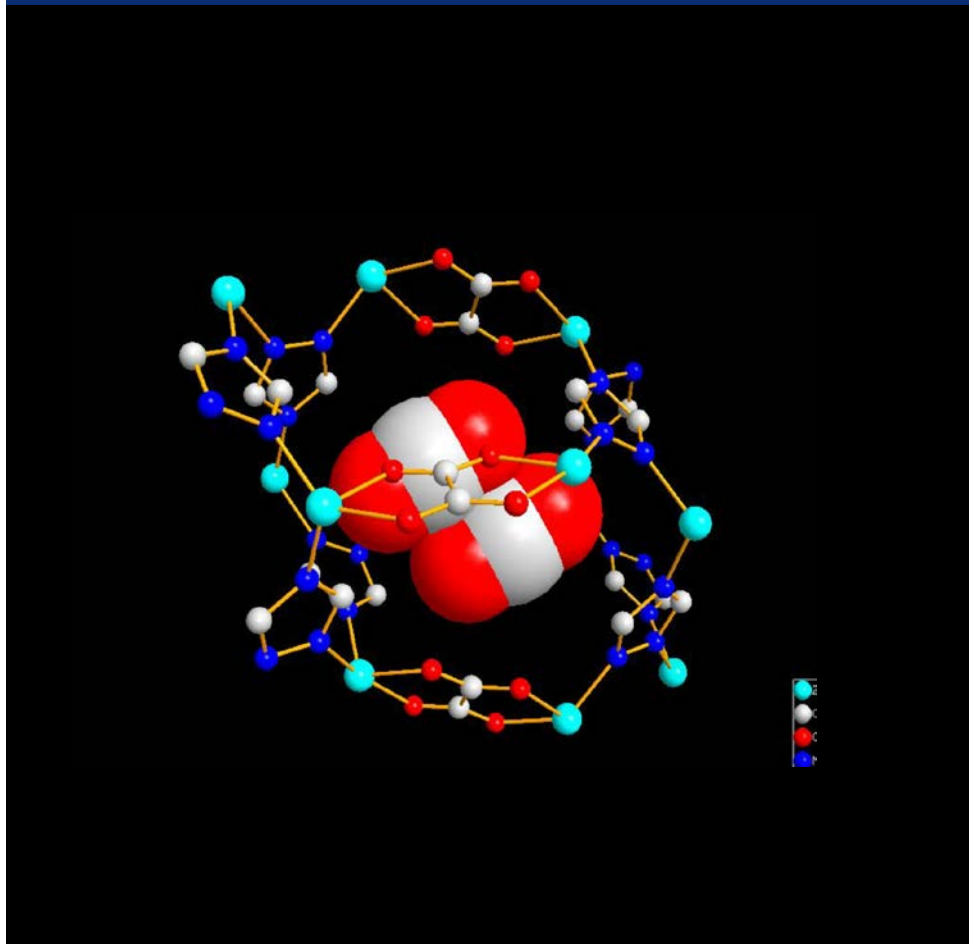
Carbon Capture Plant

The overall design, integration and optimization of the entire CO_2 capture plant that goes around the machine and process cycle.

CALF-20 Metal Organic Framework

Current Status of Process Development

CALF-20 MOF

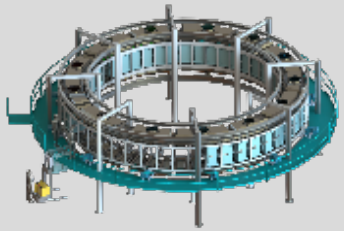


- Current application range between 8-25 % CO2
- Main process characteristics:
  - Intrinsically lower regeneration energy compared to absorption process
  - No secondary degradation products detected due to stability of the structure reducing environmental impact to a minimum (emissions to air, waste, etc.)
  - Regeneration taking place at vacuum allowing the use of non-utilized low value heat for regeneration not usable by current state of the art technologies
  - Flexible performance for processes allowing tight load following
- Carbon Capture plants using Svante Carbon Capture Ecosystem with CALF-20 currently in FEL2/FEL3
- Process improvements currently being validated:
  - Further reduce vacuum pressure regeneration reducing energy requirements further
  - Simplification of cycles reducing electricity consumption
- Research into developing new MOF for lower concentrations

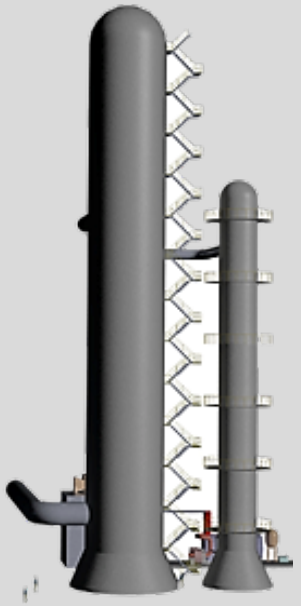
Svante Technology Comparison

	Svante's Solid Adsorbent
Technology Description	– Separation relies on adsorption of CO_2 onto a solid surface – Regenerated using direct steam in an intensified temperature/concentration swing process that enables very rapid cycles
Modularization and Scalability	Adaptable and cost efficient at all scales due to the repeatability of the modular design
Ability to Deal with Intermittency of Emitters	High – rapid cycle speed
Toxic Fugitive Emissions	None – solid sorbent
Capital Intensity	Low – modular construction
Potential for Further Cost Reduction	New solid-state technology poised for significant cost reduction learning curve

System comparison



Svante's Solid Adsorbent Technology



Conventional Carbon Capture Technology Using Liquid Solvents

Svante technology evolution

technology is in year 6 of piloting, focus is acceleration of learnings in development of industrial solutions

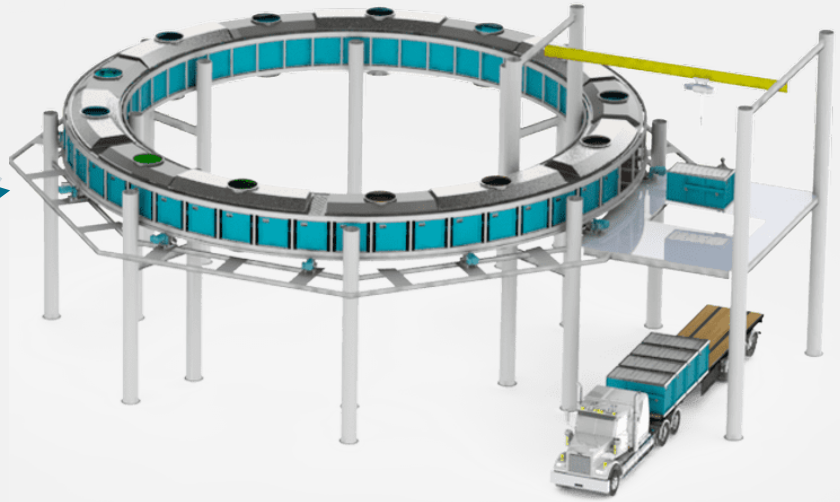
Lafarge 200 Demo Unit 1 TPD* (B.C. Canada)

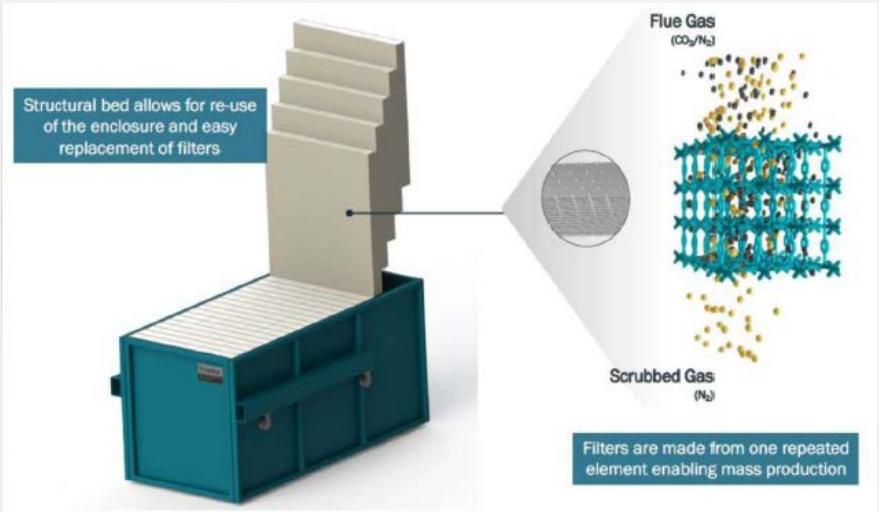
2016 – Current: Cenovus 30 TPD* Pilot Facility (SK, Canda)

2020 – Current: Chevron 25 TPD* Pilot Facility (Bakersfield, CA)

2023: Kick off feasibility studies for scale install at Pascagoula and Richmond Refineries

2023+: Svante developed 500 and 2,000 TPD* scale designs and signed agreement for large scale MOF Production





*approximate design

Technical approach

The project will be conducted in three (3) budget periods

- ☑ **Budget Period 1**
  - ☑ Process Engineering
  - ☑ Design Criteria
  - ☑ Sorbent Certification
- ☑ **Budget Period 2**
  - ☑ Detailed Engineering
  - ☑ Procurement, Fabrication and Installation
  - ☑ Pre-Startup Safety Review, Commissioning and Test Planning
- ❑ **Budget Period 3**
  - ❑ Engineering Scale Testing and Analysis, **(In Progress)**
  - ❑ Technology Assessment

Success criteria

Successful completion
of all work proposed

Completion of engineering scale VeloxoTherm™ testing
with natural gas flue gas

State-point data table

EH&S report

Techno-economic analysis

Submission of a final report
that details pathway to achieve DOE's performance goals
(CO_2 capture with 95% CO_2 purity at a cost of $30/tonne of CO_2 captured by 2030)

Progress and current status

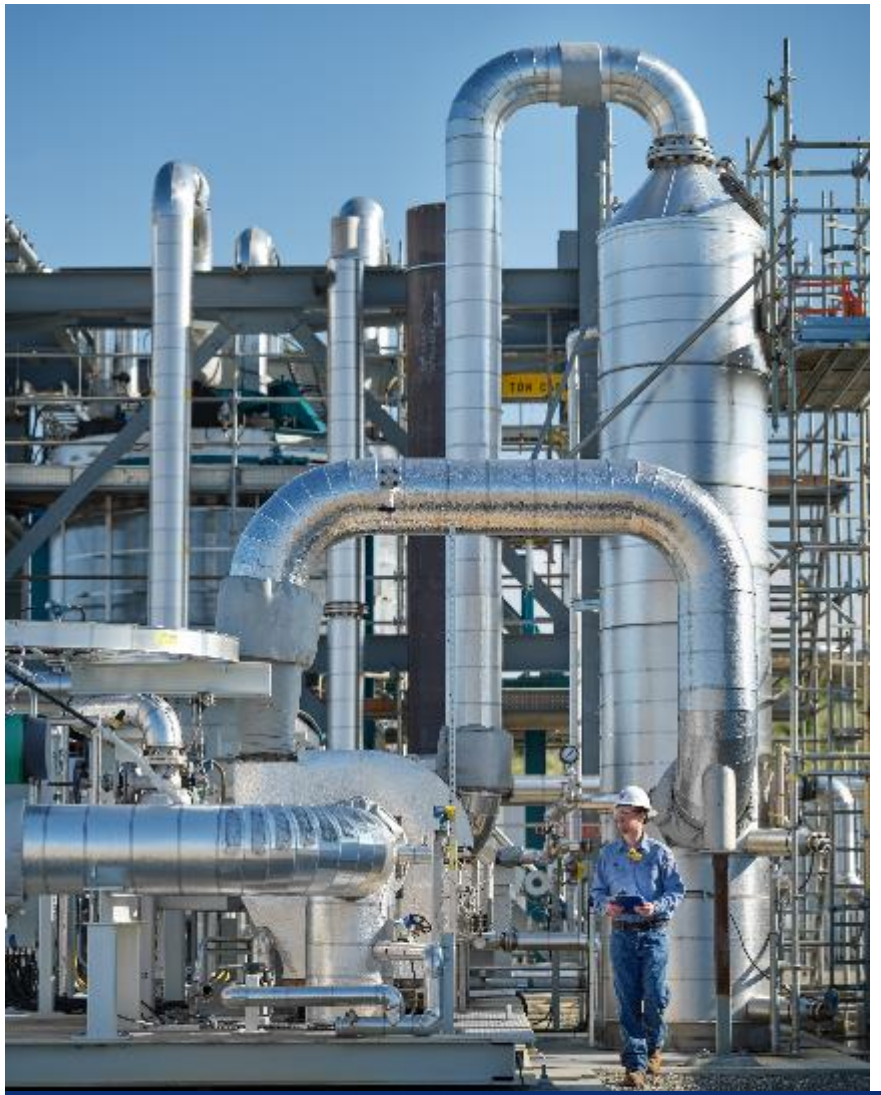
Project has completed construction and is in operation:

- Initial commissioning with test beds completed
- Full site commissioning completed
- Plant Start-up and Ramp-up completed
  - Includes operator training, commissioning and plant start-up to name-plate capacity
- Operation of the 14% Indicative Coal Flue Gas Feed Testing in progress (30-day run)

Progress and current status

Field construction work is complete and now in operation

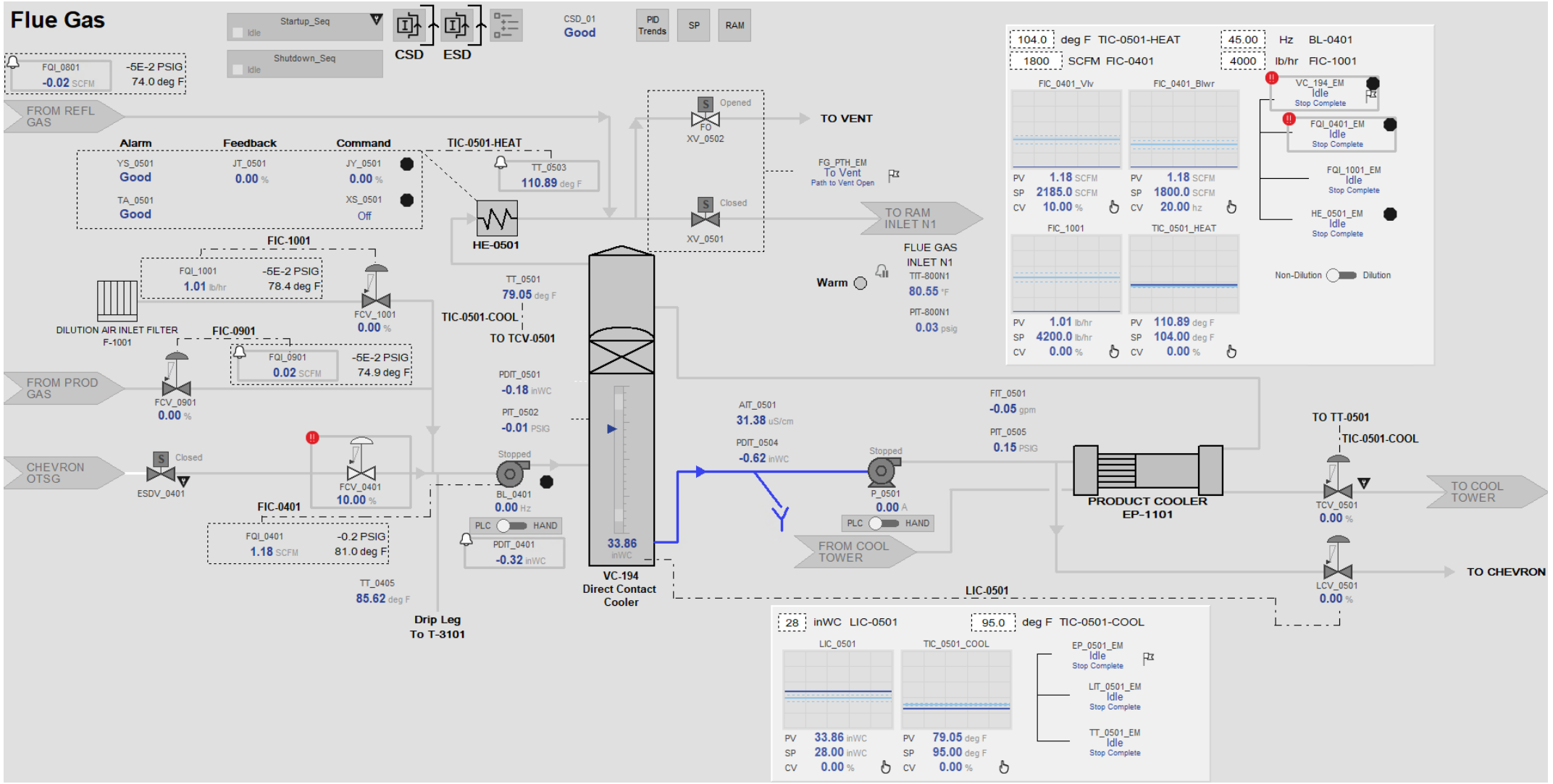
Completed and commissioned skids



Field construction work is complete and now in operation

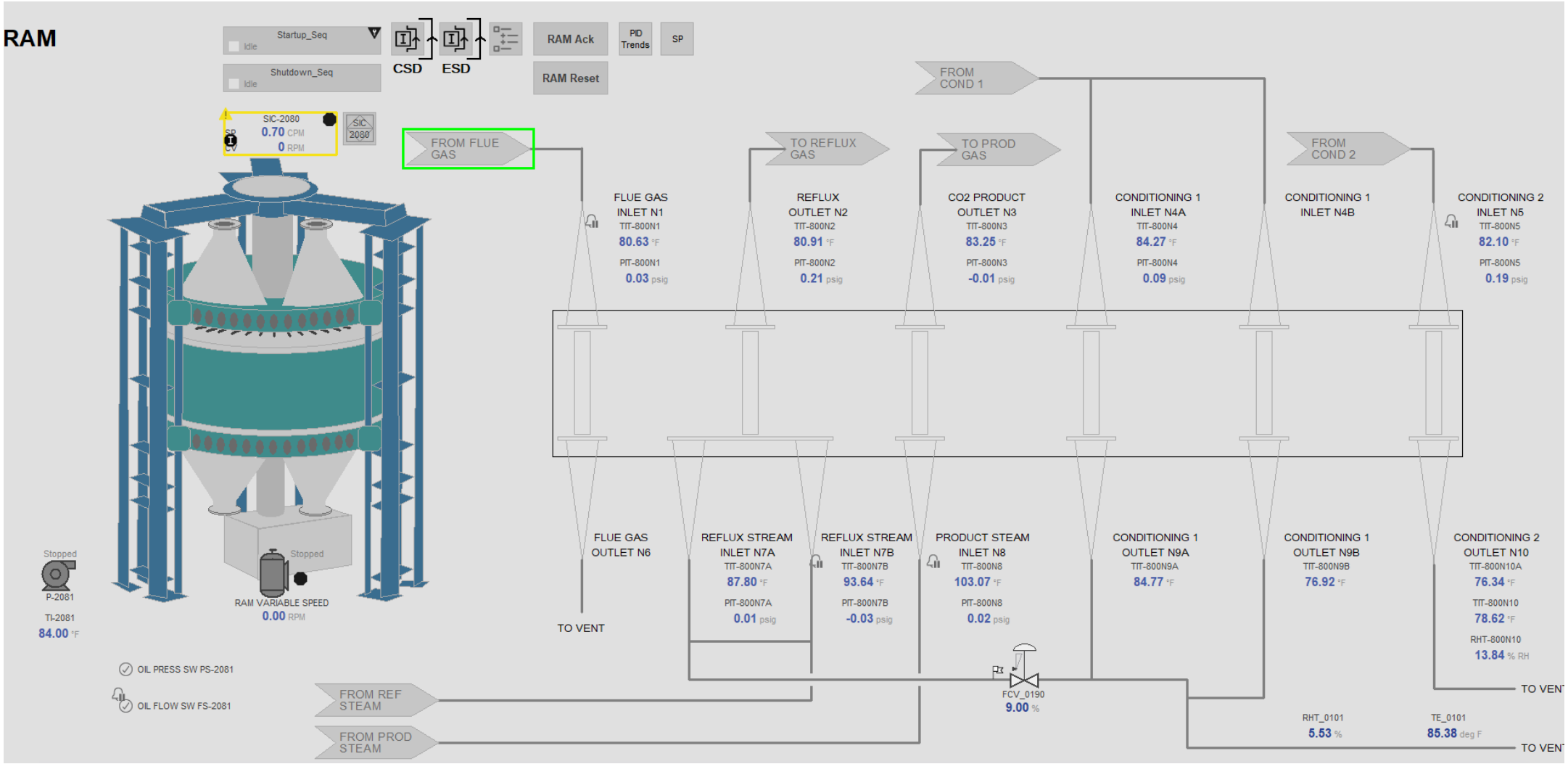
Progress and current status of project

HMI of Plant Operation



Progress and current status of project

HMI of Plant Operation



Structured absorbent bed (SAB) manufacturing progress

MOF SABs in RAM

2nd set of SAB in storage at Svante

Project milestones – budget periods 2 & 3

Milestone log					
Budget period	Task	Milestone description	Planned completion date	Actual completion date	Verification method
2	4.0	Detailed Engineering	12/31/2021	12/31/2021	RPPR File
2	4.1	Rotary Seal Validation Testing	07/26/2021	09/14/2021	Design Validation Test Report Submitted
2	5.1	Sorbent Procurement (Phase II)	12/31/2021	01/14/2022	Purchase Order and Receiving Report
2	5.3	SAB Manufacturing	09/30/2022	06/14/2022	Hardware Shipment
2	5.4	Shop testing and inspection report	05/31/2022	05/31/2022	Shop testing and inspection report file
2	5.5	System Installation	08/18/2022	08/08/2022	Turnover Package
2	6.1	Pre-Startup Safety Review (PSSR)	09/30/2022	08/08/2022	Continuation Application
2	6.3	Test Plan	07/18/2022	07/19/2022	Final Test Plan
3	7.1	Start-up and operator hand-off	08/21/2023		RPPR File
3	7.2	Parametric testing and steady state operation performance report	02/06/2024		Updated Test Report
3	7.3	14% Indicative Coal Flue Gas Feed Testing	10/15/2023		Preliminary Test Report
3	7.4	4% Indicative NGCC Flue Gas Feed Testing	11/15/2023		Updated Test Report
3	7.6	System Decommissioning	05/15/2023		Final Report file
3	8.1	Technology EH&S Risk Assessment	05/28/2024		Topical Report and summary in Final Report
3	8.2	Techno-Economic Analysis (TEA)	02/06/2024		Topical Report and summary in Final Report
3	8.3	State-Point Data Table	08/26/2024		State-Point Data Table file
3	1.0	Draft Final Report	05/28/2024		Final Report file

Final test plan

FINAL test plan covers the performance testing of SOPO objectives

1. Plant Start-up and Ramp-up – Includes operator training, commissioning and plant start-up to name-plate capacity based on an ~8% CO_2 feed flue gas composition.
2. 14% Indicative Coal Flue Gas Feed Testing – Includes the indicative coal-fired flue gas feed testing by recycling part of the CO_2 product back to the feed flue gas to increase the CO_2 concentration to ~14% under a steady state.
3. 4% Indicative NGCC Flue Gas Feed Testing – Includes the indicative natural gas-fired combined cycle (NGCC) flue gas feed testing by introducing air to dilute the feed gas CO_2 concentration to ~4% under a steady state.
4. Base Performance and Steady State Testing – Includes base performance on an ~8% CO_2 feed flue gas composition under a steady state. This will be the basis of the acceptance test.
5. Load Following & Intermittence Testing –Includes assessment of the project technology to provide quick start-up and shutdown capabilities, and simulated load following, and high turndown ratio performed on the slip stream of flue gas from the existing natural gas-fired steam generator at ~8% CO_2 concentration.

Thank you

Thank you to our project sponsors

U.S. Department of Energy

Office of Fossil Energy and Carbon Management

NETL – National Energy Technology Laboratory

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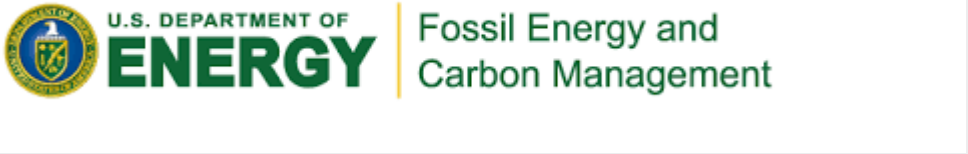

Acknowledgment and Disclaimer

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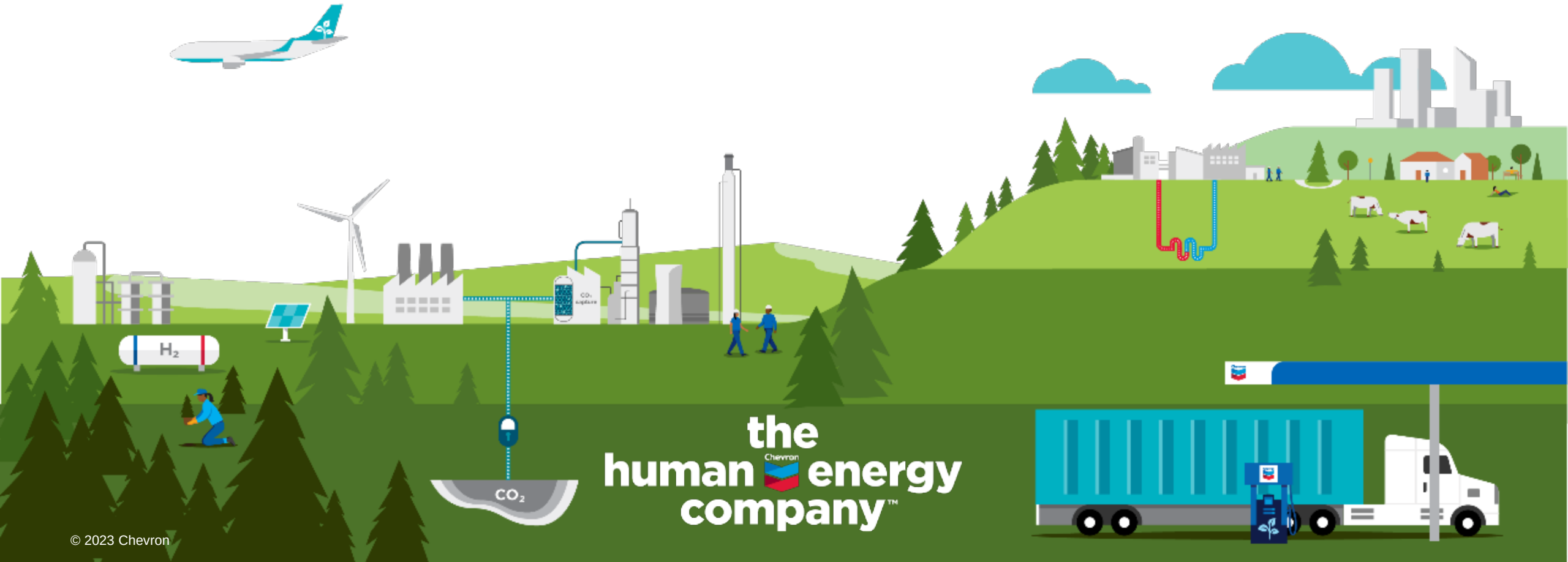
Questions and answers



Appendix

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