LafargeHolcim CO_2MENT Colorado Project

primary project goal

Electricore Inc. is a consortium of both public and private entities working to accelerate the implementation of carbon capture technology at a cement production site in Florence, Colorado. The CO_2MENT project facility is owned and operated by LafargeHolcim, which will implement Svante's VeloxoTherm™ adsorption technology in a first-of-a-kind (FOAK) commercial-scale carbon capture facility designed by Kiewit Engineering Group Inc., slated to capture more than 1.5 million tonnes of carbon dioxide (CO_2) per year.

technical goals

- Complete feasibility studies (FEL-1 and FEL-2) to estimate facility performance and project execution strategy.
- Complete a hazard and operability (HAZOP) analysis to assess project risks and develop a risk management plan.
- Perform an energy cost optimization study and a complete techno-economic analysis (TEA).
- Complete a pre-front-end engineering design (pre-FEED) study.
- Complete the overall project execution strategy of carbon capture facility and surrounding infrastructure (pipeline connections, storage site facilities, renewable, etc.).

technical content

The VeloxoTherm process developed by Svante is comprised of a rapid-cycle temperature swing adsorption (RC-TSA) process that uses a patented architecture of structured adsorbent beds (SABs) and a novel process design and embodiment to capture CO_2 from industrial and natural gas-fired flue gas streams. SABs possess unique physical and transport properties that serve to greatly improve the performance of gas separation, enabling fast cycle times and small equipment sizes that deliver attractive capture economics. Figure 1 shows the commercial-scale rotary adsorption machine (RAM) design at the core of the technology. Svante uses metal organic framework (MOF) solid adsorbents that have very high surface-to-volume ratios, instead of liquid chemicals (amines or potassium hydroxide), to capture CO_2. This new class of advanced sorbent materials, MOF CALF-20, has been developed by Svante and lab-tested under U.S. Department of Energy (DOE) Cooperative Agreement No. DE-FE0031732 and field-tested in Q3-2020 at a LafargeHolcim cement plant in Vancouver, Canada. The material will also be used in Q3-2022 at an engineering-scale demonstration plant of about 25 tonnes per day (TPD) using natural gas post-combustion flue gases in Chevron's Kern River, California, under DOE Cooperative Agreement No. DE-FE0031944.

The VeloxoTherm adsorption system is planned for use at LafargeHolcim's portland cement plant in Florence, Colorado. This location is beneficial, as it is near several ideal CO_2 storage locations, including a local saline aquifer and the Sheep Mountain natural CO_2 reservoir.

program area:
Point Source Carbon Capture

ending scale:
Pre-FEED

application:
Post-Combustion Industrial PSC

key technology:
Sorbents

project focus:
Rapid-Cycle Temperature-Swing Adsorption Process at Cement Plant

participant:
Electricore Inc.

project number:
FE0031942

predecessor projects:
N/A

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partners:
Svante Inc.; Kiewit Engineering Group; LafargeHolcim; Oxy Low Carbon Ventures; Total S.A.

start date:
11.09.2020

percent complete:
90%

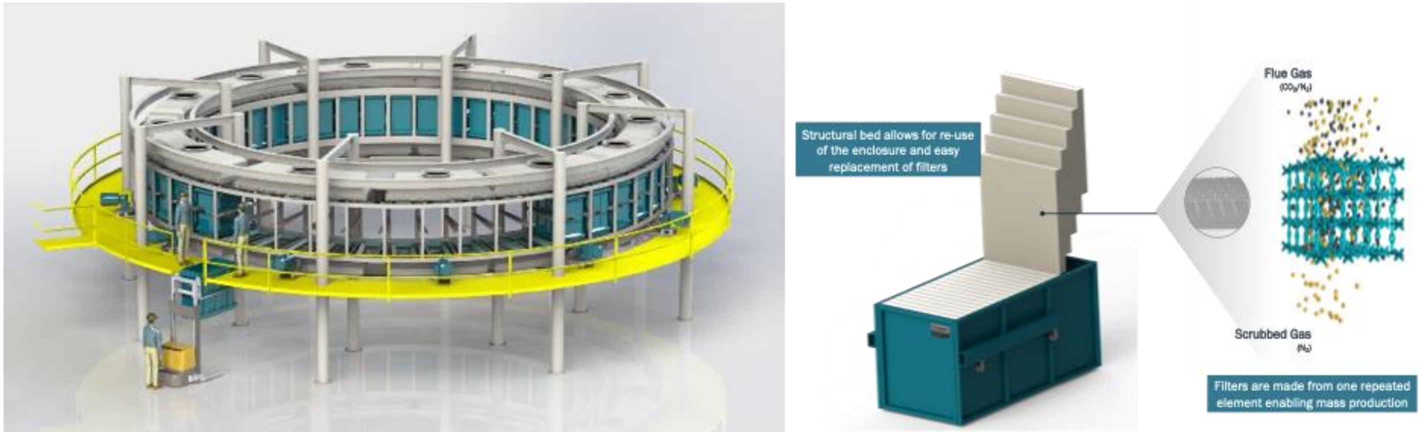

Figure 1: Svante VeloxoTherm™ commercial-scale rotary adsorption machine.

The MOF CALF-20 sorbent material exhibits unique resistance to sulfur oxide (SO_X), nitrogen oxide (NO_X), and oxygen impurities, as well as moisture swing. The sorbent process parameters used for the FEL-1 and FEL-2 design studies are reported in Table1.

TABLE 1: SORBENT PROCESS PARAMETERS

Sorbent	Units	Current R&D Value	Target R&D Value
True Density @ STP	kg/m^3	350-380	350-380
Bulk Density	kg/m^3	NA	NA
Average Particle Diameter	mm	0.31-0.35	0.31-0.35
Particle Void Fraction	m^3/m^3	NA	NA
Packing Density	m^2/m^3	2300-2500	2300-2500
Solid Heat Capacity @ STP	kJ/kg-K	1.4-1.6	1.4-1.6
Thermal Conductivity	W/(m-K)	0.25-0.35	0.25-0.35
Manufacturing Cost for Sorbent	$/kg	30-35	20-25
Adsorption			
Pressure	bar	1-1.1	1-1.1
Temperature	°C	50	50
Equilibrium Loading (20% CO_2)	g mol CO_2/kg	1.7-1.9	1.7-1.9
Heat of Adsorption	kJ/mol CO_2	35-38	35-38
Desorption			
Pressure	bar	0.8-1.0	0.8-1.0
Temperature	°C	120-140	120-140
Equilibrium CO_2 Loading (20% CO2)	g mol CO_2/kg	0.3-0.4	0.3-0.4
Heat of Desorption	kJ/mol CO_2	35-38	35-38
Proposed Module Design			
Flow Arrangement/Operation	—	Rapid cycle rotary valves moving bed	
CO_2 Recovery, Purity, and Pressure	% / % / bar	90-95 95 150	

Definitions:

STP – Standard Temperature and Pressure (15°C, 1 atm).

Sorbent – Adsorbate-free (i.e., CO_2-free) and dry material as used in adsorption/desorption cycle.

Manufacturing Cost for Sorbent – "Current" is market price of material, if applicable; "Target" is estimated manufacturing cost for new materials, or the estimated cost of bulk manufacturing for existing materials.

Adsorption – The conditions of interest for adsorption are those that prevail at maximum sorbent loading. These may be assumed to be 1 atm total flue-gas pressure (corresponding to a CO_2 partial pressure of 0.13 bar) and 40°C.

Desorption – The conditions of interest for desorption are those that prevail at minimum sorbent loading. Operating pressure and temperature for the desorber/stripper are process-dependent.

Pressure – The pressure of CO_2 in equilibrium with the sorbent. If the vapor phase is pure CO_2, this is the total pressure; if it is a mixture of gases, this is the partial pressure of CO_2.

Packing Density – Ratio of the laminated sorbent composite sheet area/filter bed volume.

Equilibrium Loading – The basis for CO_2 loadings is mass of dry sorbent measured with 20% CO_2 in nitrogen (N_2) mixture without moisture.

Flow Arrangement/Operation – Gas-solid module designs include fixed, fluidized, and moving bed, which result in either *continuous*, *cyclic*, or *semi-regenerative* operation.

Other Parameter Descriptions:

Chemical/Physical Sorbent Mechanism – Physisorption.

Sorbent Contaminant Resistance – High oxidation resistance below 50 parts per million (ppm) SO_X and NO_X.

Sorbent Attrition and Thermal/Hydrothermal Stability – Very stable under direct steam regeneration.

Flue Gas Pretreatment Requirements – Conventional Direct Contact Cooler (DCC).

Sorbent Make-Up Requirements – Three- to five-year lifetime without bed replacement.

Waste Streams Generated – No chemicals in depleted N_2 and typical cooling water blow-down.

The planned plant will utilize a solar energy and battery storage system power purchase agreement to provide supplemental energy to the plant, ensuring smooth operation without interruption during hours of high demand.

By completing the feasibility engineering study (FEL-2) for a fit-for-purpose design at the LafargeHolcim cement plant, this technology represents a significant step forward for large-scale deployment of carbon capture and storage. Given the near-term potential for increased 45Q tax credit pricing to $85/tonne and voluntary emissions credits, the business analysis pointed to significant potential realizable economic value for the project, as shown in Table 2.

TABLE 2: CARBON CAPTURE ECONOMICS

Economic Values	Units	Current R&D Value	Target R&D Value
Cost of Carbon Captured	\$/tonne CO_2	50	30
Cost of Carbon Avoided	\$/tonne CO_2	Site specific	Site specific
Capital Expenditures	\$/TPD	70,000-80,000	60,000-70,000
Operating Expenditures	\$/tonnes CO_2	26-28	20-23
Cost of Electricity	\$/tonnes CO_2	12-18	12-18

Definitions:

Cost of Carbon Captured – Projected cost of capture per mass of CO_2 captured under expected operating conditions.

Cost of Carbon Avoided – Projected cost of capture per mass of CO_2 avoided is site specific depending on the source of electricity and steam.

Capital Expenditures – Projected capital expenditures in dollars per tonne per day of capacity for the capture unit.

Operating Expenditures – Projected operating expenditures in dollars per unit of tonne of CO_2 produced including filter bed replacement and compression cost.

Cost of Electricity – Projected cost of electricity per unit of tonne of CO_2 produced for a range of price of electricity of 3.5–6 cents per kWh.

Scale of Validation of Technology Used in TEA – The technology numbers were validated for use in the TEA from pilot-scale data.

technology advantages

- Svante's technology has the potential to enable a 50% reduction in capital costs of the capture unit compared to first-generation approaches.
- Novel technology replaces large chemical solvent towers (conventional approach) with a single piece of compact equipment, significantly reducing capital expenses (CAPEX).
- Advanced sorbent material exhibits sharper temperature and pressure swing absorption and desorption, which allows for lower energy loads and faster kinetic rates.
- The proprietary material also exhibits unique resistance to SO_X and NO_X, oxygen impurities, and moisture swings.

R&D challenges

- Technology scaling of filter manufacturing to commercial scale.
- Technology scaling of RAM to commercial-scale.
- Cost and schedule uncertainties of project execution.
- Access to water, carbon-free electricity, and storage options.

status

All work for Budget Period 1 is nearing completion. The key finding was that significant work will be required during the next phase (FEED Study and Execution) to better define commercial and financial terms of the electricity and natural gas supplies and CO_2 storage, which will be critical for the successful Financial Investment Decision (FID) of this project.

available reports/technical papers/presentations

Electricore, Inc., 2020, "LH CO_2MENT Colorado Project." Project Kickoff Meeting. U.S. Department of Energy: National Energy Technology Laboratory (DOE/NETL). FE0031942. Pittsburgh, PA. November 9, 2020. *https://netl.doe.gov/projects/plp-download.aspx?id=11020&filename=LH+CO2MENT+Colorado+Project.pdf*.

Letourneau, C. & Jelen, D., "LafargeHolcim CO_2MENT Colorado Project." 2021 NETL Carbon Management and Oil & Gas Research Project Review Meeting. Pittsburgh, PA. August 3, 2021. *https://netl.doe.gov/sites/default/files/netl-file/21CMOG_CCUS_Jelen.pdf*