CCS and DAC continue to fail to deliver despite over a century of R&D

August 21, 2023

Photo credit: Alberta Newsroom

By Anja Chalmin

2nd Geoengineering Map Update

The Geoengineering Map Update summarises the latest developments on the Geoengineering Monitor Map highlighting new trends for civil society and climate justice movements to follow in their efforts to oppose geoengineering.

Critical Updates

- **CCS:** Some CCS projects intend to combine DAC with CCS (DACCS). There are attempts to circumvent protests against CO_2 pipelines by planning CCS/DACCS projects on large leased lands. Flagship CCS projects have not lived up to expectations.
- **DAC:** While long-announced or ongoing DAC projects are not progressing, new projects are being announced, including DAC combined with nuclear power, DACCS projects in East Africa, and new technical approaches to DAC.
- **Geoengineering companies interested in commercialising carbon credits** present the geoengineering projects they initiate as safe and long-term CO_2 storage options – even though there are no independent studies to back this claim. Possible concerns and risks are being concealed, even in the face of numerous studies raising concerns.

CCS DACS and BECCS latest developments

Despite the lack of reliable evidence that CO_2 injected underground will stay there, and despite the failure of previous CCS flagship projects to meet expectations, the number of planned CCS projects continues to grow, wasting huge amounts of taxpayers' money and energy on a technology that despite having been around for a century, has had no meaningful impact on rising emissions and is still in its infancy.

The US-based Institute for Energy Economics and Financial Analysis confirms what the Geoengineering Map shows that carbon captured in CCS projects is mostly used for enhanced oil recovery (EOR). EOR involves pumping captured CO_2 into ageing oil and gas fields to extract otherwise inaccessible fossil fuels – resulting in increased oil production and additional emissions, and extending the life of fossil fuel power plants.

Despite its long history, CCS is still very much a fledgling technology and is failing to deliver. Many companies in

the fossil fuel industry, including Enhance Energy, paint the opposite picture of CCS, claiming it is about climate protection and long-term storage of captured CO_2.

USA: Public funding to expand CO_2 transport and storage infrastructure

In May 2023, the US Department of Energy (US-DOE) announced US$ 251 million to expand the US CO_2 transport and storage infrastructure. The funding will be split between twelve projects. Nine projects seek to support the development of large-scale commercial carbon storage projects, including four hubs in Houston, Texas, and the remainder in Colorado, Georgia, Illinois, North Dakota and Wyoming. Three projects will conduct studies on regional CO_2 pipeline networks in Texas, Michigan and Georgia.

One of the Texan projects, the Bluebonnet CCS Hub, will be implemented by 1PointFive, a subsidiary of Occidental, the largest oil producer in the Permian Basin. 1PointFive was formed in 2020 to commercialize direct air capture (DAC), carbon capture and storage (CCS) and carbon capture use and storage (CCUS). The Bluebonnet CCS Hub is located in Chambers, Liberty and Jefferson counties near refineries, chemical plants and manufacturing facilities along the Texas Gulf Coast from Beaumont to Houston. The project aims to inject 1.2 billion tonnes of captured CO_2 into saline formations along the coast. The US-DOE has funded the development of the Bluebonnet CCShub with US$ 16.48 million to complete site characterization, permitting and environmental approvals. The hub is expected to be operational in 2026.

USA: 1PointFive signs major land lease agreements for development of DACCS/CCS project in Texas and Louisiana

In 2022, 1PointFive announced a lease with King Ranch for approximately 42,900 hectares in Kleberg County, Texas. At this site, 1PointFive plans to develop a DACCS project with 30 DAC units. Each unit is to capture one million tonnes of CO_2 annually, and a total of three billion tonnes of captured CO_2 are to be injected into geological formations. The DAC technology will be provided by Carbon Engineering. Kleberg County is close to industrial emitters in the Gulf Coast region. Therefore, 1PointFive expects to capture, transport and inject underground additional CO_2 from industrial emitters. King Ranch has already leased land to the fossil fuel industry in the past, including exploration and drilling rights to an oil company for the past 90 years.

To develop a CCS project in Livingston Parish, Louisiana, 1PointFive has leased approximately 12,000 hectares from the Weyerhaeuser Company, one of the world's largest timberland companies. The project is located in northeastern Livingston Parish, east of Baton Rouge, and seeks to inject captured CO_2 into geological formations. While Weyerhaeuser will continue to manage the land underground CO_2 pipelines will run across the leased land. The project is expected to be operational in early 2025.

1PointFive also announced a lease agreement with Manulife Investment Management for approximately 11,000 hectares in Allen Parish in southern Louisiana. At this site, 1PointFive also plans to develop a CCS project and to inject captured CO_2 into geological formations. Manulife Investment Management is the global asset management arm of Manulife Financial Corporation. "*1PointFive and Manulife Investment Management are also exploring other locations and projects throughout the region and country with the potential to add additional acreage for carbon removal and sequestration.*"

USA, 1PointFive & Oxy Low Carbon Ventures: Stratos project starts construction

Announced in 2019, construction of the project started in May 2023 after several delays since 2021. Commissioning has been pushed back to 2025. The Stratos project is located in the Occidental field in the Permian Basin of Ector County, Texas, and covers an area of approximately 40 hectares. Stratos combines DAC and CCS (DACCS) – CO_2 is to be captured from the atmosphere and injected into saline formations in Ector County. Carbon

Engineering's DAC technology will also be used at this 1PointFive site.

Gorgon LNG project is Australia's largest industrial emitter / CCS project falls short of expectations

The commissioning of the Gorgon LNG project was subject to the condition, that Chevron must capture and inject at least 80 percent of the site's CO_2 emissions over a five-year period starting in July 2016. The US oil and gas giant has now admitted that its flagship CCS project is struggling, reaching only about a third of its projected capacity – even though the LNG project has been operating and producing for six years. According to Chevron, the CCS project has so far captured a total of 7.8 million tonnes of CO_2. The LNG project is currently Australia's largest industrial emitter – the annual emissions from the LNG plant have increased from 5.5 million tonnes in 2021 to 8.3 million tonnes t in 2022. In 2006, the Western Australian Environment Protection Agency (EPA) advised against approving the Gorgon LNG project due to unacceptable harms, including greenhouse gas emissions. In 2021, the Conservation Council of Western Australia (ineffectual) called for the plant to be shut down until the CCS could be proven to work. The project was once touted as the world's largest CCS project. Now it joins a long list of CCS projects that have fallen far short of expectations.

Papua New Guinea: Front End Engineering Design (FEED) study for CCS project

The Papua LNG project is led by TotalEnergies in partnership with ExxonMobil, Santos and JX Nippon and aims to export 5.6 million tonnes of LNG per year. The project will consist of nine production wells, one water injection well and one CO_2 reinjection well. A 320-kilometer pipeline will connect the gas processing plant at the onshore field to the liquefaction plant at Caution Bay, near Port Moresby. The final investment decision is expected in late 2023/early 2024.

Thailand: FEED study for CCS project

Thailand's national oil and gas company PTT Exploration and Production (PTTEP) has initiated a CCS project that is expected to be operational in 2026. The project will be located at the Arthit offshore gas field, an exploration field operated by PTTEP in the Gulf of Thailand. A feasibility study and a pre-FEED have been completed and a FEED study is underway.

Canada's Alberta Carbon Trunk Line (ACTL) reaches only a tenth of its announced maximum capacity

This Canadian CCS project combines CO_2 capture and transport with EOR. Enhance Energy, an Alberta-based oil and gas company, announced the ACTL with a CO_2 capture capacity of up to 15 million tonnes per year. The carbon capture and pipeline assets were built and are operated by Wolf Carbon Solutions. The CCS system captures CO_2 at NWR's Sturgeon Refinery and Nutrien's Redwater Fertilizer facility, and transports the captured CO_2 via a 240-kilometer pipeline to central Alberta for EOR. After years of delays, the project has now been in operation for three years. In June 2023, Wolf announced that the project is currently transporting 1.6 million tonnes of CO_2 per year, only eleven percent of the announced annual capacity. This is despite the fact that CO_2 capture is a century-old technology in the US, more than CAD$ 850 million of public money has been invested in the project, and the total cost of the ACTL is US$ 1.2 billion.

USA: ADM's Industrial CCS project in Illinois set

to be expanded / Broadwing CCS cancelled

The Illinois Industrial CCS project is conducted by Archer Daniels Midland (ADM) captures CO_2 at ADM's corn-to-ethanol plant in Decatur, Illinois, and conducts EOR in the Mt. Simon sandstone formation, one mile from ADM's Decatur plant. In 2022, ADM announced plans to expand its CO_2 injection activities into the Mt. Simon formation by capturing CO_2 at its corn-to-ethanol plants in Clinton and Cedar Rapids, Iowa. Wolf Carbon Solutions will be responsible to build and operate a 450-kilometer pipeline connecting ADM's Clinton and Cedar Rapids plants to existing CO_2 injection sites in the Mt. Simon. The project is expected to start construction in 2024 and be operational in 2025.

Plans for ADM's Broadwing project appear to have been abandoned. ADM had planned a 280 MW natural gas power plant with CCS in Decatur, Illinois. All information on the Broadwing project has disappeared from ADM's website.

USA: Tallgrass Energy's Trailblazer pipeline to be converted for CO_2 transport

Tallgrass Energy, an energy and infrastructure company, plans to convert its 650-kilometer Trailblazer natural gas pipeline to transport CO_2. The pipeline will be part of a project to capture, transport and inject more than ten million tonnes of CO_2 per year from industries in Nebraska, Colorado, and Wyoming. The captured CO_2 is to be injected into geological formations near Cheyenne, Wyoming. Tallgrass Energy and ADM announced an agreement that will allow Tallgrass to capture CO_2 at ADM's corn-to-ethanol plant in Columbus, Nebraska, and connect the site to the Trailblazer pipeline. There has been no word yet on exactly where the CO_2 will be injected underground. Tallgrass Energy's CCS Hub was awarded US$ 4.11 million in funding from the Wyoming Energy Authority.

Converting the natural gas pipeline to a CO_2 pipeline raises safety concerns because natural gas pipelines are designed for lower pressure than CO_2 pipelines, but CO_2 is transported at a higher pressure than natural gas. Residents are also concerned that the 40-year-old Trailblazer pipeline is showing signs of age. There is currently no regulatory framework for such a project and none is expected until the planned transition of the Trailblazer pipeline next year.

Canadian tar sands producers' CCS project faces delay

The Pathways Alliance, which represents 95 percent of Canada's tar sands producers, has announced a CCS project to capture CO_2 at more than 20 tar sands facilities in the Fort McMurray region of Alberta. The captured CO_2 will be compressed and transported through a 400-kilometer pipeline to an injection site near Cold Lake, Alberta. The first phase seeks to build a CO_2 capture network in the tar sands production region in the Fort McMurray area of northern Alberta. The network will later be made available to other industries in the region. The first project phase was scheduled from 2021 to 2023 and aimed to capture 22 million tonnes of CO_2 per year. In June 2023, the project is still in evaluation, including geological surveys in the Cold Lake area. The construction of the 400-kilometer pipeline has not yet begun. The estimated investment is CAD$ 16.5 billion.

Canada: International CCS Knowledge Centre

In 2016, BHP Billiton and SaskPower signed an agreement to establish the International CCS Knowledge Centre. In April 2023, the Government of Alberta supported the project with CAD$ 3 million, aiming to create the world's first open-source repository of CCS/CCUS knowledge and information. The centre will collect lessons learned from past, present, and future Canadian CCS projects to promote and improve CCS.

South Africa: Various CCS-related updates

In March 2023, South African and British researchers published a study on using the depleted oil reservoir in the Bredasdorp Basin off the coast of South Africa for CCS.

In March 2023, the South African National Energy Development Institute (SANEDI) announced awards to South African researchers for studies in the field of Carbon Capture and Storage.

An article published in Carbon Capture Science & Technology in June 2023, explains that the South African Centre for Carbon Capture and Storage (SACCCS) CCS demonstration project "*was delayed and postponed to a date that has not yet been announced [...] owing to the Covid-19 pandemic*". Since 2009, the World Bank CCS Trust Fund has been supporting the development of a pilot CO_2 capture project and a pilot CO_2 storage site in South Africa, in close cooperation with SACCCS and SANEDI, and nearly US$ 30 million in funding. In 2017, the World Bank CCS programme announced plans to establish a pilot post-combustion capture project at Eskom's Kusile coal-fired power station in Mpumalanga province and a pilot storage site in the Zululand Basin in KwaZulu-Natal Province. Neither project has yet been implemented.

Alberta, Canada: Evaluation of 25 potential CC(U)S projects

In Canada, the Alberta Department of Energy is currently evaluating approximately 25 potential CC(U)S projects, primarily to assess the suitability of geological formations for CO_2 injection. The areas under evaluation cover a large part of Alberta, with some projects scheduled for first CO_2 injection as early as the fourth quarter of 2023.

Italy & Serbia: CCS Postgraduate Master's Degree Programme

The Sapienza University of Rome, Italy, and the University of Zagreb, Serbia, are jointly offering a postgraduate master's degree in geological CO_2 storage. The course is designed to provide an overview of CCS operations and research, including topics such as technical considerations for CO_2 injection, safety monitoring, storage capacity estimation, economics and planning of CCS projects.

USA: Summit Carbon Solutions 'Midwest Carbon Express' (Bioenergy with Carbon Capture and Storage – BECCS)

Summit Carbon Solutions (SCS) was incorporated in February 2021. The company planned to start construction of the Midwest Carbon Express in Q2 2023, with commissioning in Q2 2024. Construction start has now been delayed to late 2023 and commissioning to late 2024/early 2025. This SCS project aims to capture, transport and inject about twelve million tonnes of CO_2 annually from ethanol plants. As of June 2023, SCS has partnered with more than 35 ethanol plants in five states. Planned costs have risen to US$ 5.5 billion (total costs of US$ 4.5 billion were discussed by 2022). The Midwest Carbon Express faces opposition from Indigenous communities, landowners and environmental groups, e.g., because CCS has failed to reduce CO_2 emissions, and because of the health and environmental risks associated with CO_2 pipelines. In April 2023, SCS began selling carbon credits from the project, although the project has not yet received approval for construction.

USA: Heartland Greenway (BECCS)

The Heartland Greenway BECCS project involves the construction of a 1,300 miles pipeline network to pump captured and liquefied CO_2 from more than 30 ethanol or other industrial plants to the Mt. Simon sandstone formation in central Illinois. Navigator CO_2 Ventures, BlackRock Global Energy & Power Infrastructure Fund and Valero Energy Corporation announced the Heartland Greenway project in March 2021. In May 2023, Navigator

signed an agreement with the carbon crediting platform Puro.earth (900,000 credits at €115 each). In the same month, Navigator signed an agreement with Infinium for the supply of 0.6 million tonnes of CO_2 per year for Infinium's eFuel production. The BECCS project is expected to start construction in 2024 and to be operational in 2025.

Direct Air Capture – new companies, projects and approaches to removing CO_2 from the Earth's atmosphere

Direct air capture (DAC) attempts to remove CO_2 from the atmosphere, usually using filters or solvents, but other approaches are being developed. As CO_2 is present in low concentrations in air and is inert ('unreactive'), DAC is very energy-hungry. If the captured CO_2 is used as a feedstock for consumables such as synfuels (CCUS), the captured CO_2 is typically released back into the atmosphere once these commodities are consumed. If the captured CO_2 is used for CCS projects, it is often used for enhanced oil and gas recovery (EOR/EGR), increasing oil and gas production and CO_2 emissions.

USA: Nuclear powered DAC project in Illinois

The 'Nuclear Powered DAC project in Illinois' is led by US Constellation Energy and is located at Constellation's Byron Generating Station in Byron, Illinois. The project is being conducted in partnership with 1PointFive, Carbon Engineering Ltd., The Worley Group, Pacific Northwest National Laboratory, and the University of Illinois Urbana-Champaign. The objective of the project is to perform a FEED study for a nuclear-powered DAC facility, including project design, project cost estimation, and life cycle analysis. The project is based on Carbon Engineering's liquid sorbent DAC technology and is expected to capture 0.25 million tonnes of CO_2 per year. The US-DOE has awarded US$ 2.5 million to the project.

USA: Carbon Engineering & Aerion joint project abandoned?

Carbon Engineering Ltd, a DAC company founded by David Keith in 2009, and Aerion a Reno, Nevada based company, a developer of supersonic business jets, announced a joint synfuel project based on Carbon Engineering's DAC and AIR TO FUELS™ technology. In 2020, the companies signed a memorandum of understanding to explore the use of Carbon Engineering's synfuel and a potential synfuel facility for Aerion jets. Since then, there has been no news on this project. It is therefore assumed that the project is no longer being pursued.

Kenya: Octavia Carbon

Octavia Carbon is a Direct Air Capture (DAC) company founded in Kenya in 2022 by Martin Freimüller. The company has developed a DAC prototype that is expected to capture five to ten tonnes of CO_2 per year. Octavia Carbon is working to increase the capacity per machine to 100 tonnes of CO_2 per year and by 2024 Octavia Carbon aims to produce at least one of these machines per day. Local geothermal energy will be used to power the DAC machines. The captured CO_2 is to be compressed and mineralised in basalt rocks in the Kenyan Rift Valley. It is not yet publicly disclosed where the CO_2 injection into the Kenyan Rift Valley will take place. Octavia also plans to sell the captured CO_2 for industrial use. But the company expects to finance itself primarily through carbon credits, which it plans to sell for between US$ 300 and US$ 500 per tonne of CO_2, starting in 2024. The company has raised US$ 0.5 million in four rounds of funding, including from Catalyst Fund, Carbon Business Council, Direct Air Capture Coalition and Shared Future Fund.

USA / Kenya: Cella Mineral Storage

New York-based Cella Mineral Storage Inc. was founded in 2022 by Claire Nelson and Corey Pattison. The company aims to capture atmospheric carbon, inject it into volcanic rock in Kenya's Rift Valley, and to sell carbon credits. The exact location of the chosen site in northern Kenya has not yet been disclosed. According to Cella, Kenya's Rift Valley was chosen because of the country's high geothermal potential and the volcanic basalt rock. According to

press reports, a new 140 MW geothermal power plant will be commissioned in Q2 2023 and a pilot plant in Q3 2024. Cella plans to partner with a direct air capture company. The DAC technology provider has not yet been disclosed. According to Cella, the total storage potential of the Kenyan Rift Valley is estimated at 400 billion tonnes of CO_2. In June 2023, Cella Mineral Storage raised US$ 3.3 million in a funding round led by Counteract and Grantham Foundation.

USA: Global Thermostat

The US-based DAC company Global Thermostat was founded in California in 2010 and has recently moved to Commerce City, north of Denver, Colorado. In April 2023, Global Thermostat unveiled its new DAC demonstration project in Commerce City. The company's former demonstration site in Huntsville, Alabama and the pilot project in Menlo Park, California, were closed in 2022, mainly for financial reasons. In 2021, Global Thermostat announced that it will supply the DAC technology for the Highly Innovative Fuels' Haru Oni project in Chile. However, for unknown reasons, these plans did not materialise – in 2023, Highly Innovative Fuels announced its collaboration with DAC manufacturer Mosaic Materials.

Chile: HIF Global / Haru Oni project

Highly Innovative Fuels Global (HIF Global), headquartered in Santiago, Chile, was founded in 2016 and aims to deploy "CO_2-neutral" synfuel plants around the world. Implementation is most advanced in Chile, where the first litres of synfuel were produced in December 2022 at the HIF Chile Haru Oni project site in the windy Magallanes region. According to a project description online until 2022 (https://www.haruoni.com/#/en), Haru Oni was to produce "*CO_2-neutral*" fuel from captured CO_2, water, and wind energy, and to be the world's first industrial-scale plant to capture the required CO_2 directly from the air (DAC). In April 2023, a video report on the Donut Media channel revealed that the DAC component at the Haru Oni site is still missing and that the CO_2 was being delivered by truck. HIF has since admitted, that the CO_2 is from a biogenic source, presumably from the fermentation process of a brewery. In 2021, it was announced that Global Thermostat would supply the DAC technology. In March 2023, HIF issued a press release announcing a possible cooperation with DAC manufacturer Mosaic Materials to test the DAC technology. The press release makes it clear that Mosaic Materials' DAC technology is still under development. Given the announced targets of 55 and 550 million litres of synfuel in two and four years respectively, it is surprising that HIF is unable to clearly communicate which CO_2 feedstock will be used. The energy supply for this site is also not yet secured, as a building application for a 65-turbine wind farm (325 MW), submitted by HIF in February 2022, was withdrawn in October 2022 due to numerous significant deficiencies. The planned increase in current annual production by a factor of 430 to 55 million litres by 2025 and by a factor of 4,300 to 550 million litres by 2027 is unlikely because the necessary structures are not yet in place or under construction. In addition, the efficiency of synfuel is not competitive with electric cars, as synthetic gasoline requires many times more renewable energy to achieve the same performance as battery electric vehicles. Furthermore, the operation of the internal combustion engine with e-fuels continues to emit exhaust gases (among them the CO2 previously captured), soot and nitrogen oxides, as well as noise.

USA: Partanna Global

Partanna Global was founded by Rick Fox and Sam Marshall to commercialize a building material that remove CO_2 from the atmosphere. According to Partanna, the binders in the building material used require (atmospheric) carbon to harden. In addition, the MgO-based building material developed is partly made from waste materials such as steel slag (a by-product of steel production) and brine (a waste product of desalination plants). In 2022, Partanna built 1,000 homes in the Bahamas using its building materials. At the end of 2022, the carbon market Verra sold CO_2 credits on this basis. Another carbon credit was issued in April 2023 for the supply of 5,000 pavers for an area of the Bretton Woods Recreation Centre in Maryland. In May 2023 the company raised US$ 12 million in a financing round led by Cherubic Ventures.

USA / Norway: Verdox

Verdox is a spin-off from researchers at the Massachusetts Institute of Technology (MIT). Founded by Brian Baynes, Alan Hatton and Sahag Voskian, the company has developed an electrical system that can capture CO_2 from

ambient air or exhaust gases. The air flows between thin electrode plates and the CO_2 adheres to the charged plates. When the plates are discharged, the CO_2 is released. The process can be carried out at room temperature and normal atmospheric pressure. According to MIT, the process requires about 1 GJ of energy per tonne of CO_2 captured. Since 2022, Verdox has been preparing to test its DAC system at Norsk Hydro's site in Sunndal, Norway. The test facility was commissioned in Q1 2023 and the first CO_2 capture is expected in 2023. Verdox has raised more than US$ 100 million in funding over seven financing rounds.

To compare, the technology used by Swiss DAC manufacturer Climeworks AG requires 1,800-2,500 kWh of thermal energy and ~600 kWh of electricity to capture one tonne of CO_2. This translates into 8.7 GJ to 11.2 GJ per tonne of CO_2.