Field Trials, Schemes and Calls for Transparency: November Geoengineering Updates

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Recent Geoengineering research activities

In mid-September, a US$ 110 million **U.S. Federal Support Programme for CCUS**[1] was announced by the United States Department of Energy (US-DOE)'s Office of Fossil Energy. The funding opportunity is explained as *"commitment to strengthening coal while protecting the environment"*[i]. The federal programme consists of three pillars:

Programme	Description	Project sites	Budget
1	Conducts Front-End Engineering Design (FEED) studies for retrofitting post-combustion CO_2 capture technology on five coal and four natural gas powered plants.	9 plants	US$ 55 M
2	Formation of Regional Carbon Sequestration Partnerships (RCSP). Research and development (R&D) to foster and accelerate the deployment of new regional CCUS initiatives.	4 regions	US$ 20 M

3	Assessment of: commercial-scale CO_2 storage sites, CO_2 capture technologies, and CO_2 purification technologies.	Not yet available	US$ 35 M

Table 1: Overview of the US-DOE US$ 110 million funding programme

Programme 2 is focussing on Regional Carbon Sequestration Partnerships (RCSP) and the four selected projects have been given the task to form regional partnerships[ii]. However, most partnerships have been in place since 2003 and the programme may be better described as continued financing for such RCSPs as **SECARB** (Southeast Regional Carbon Utilization & Storage Partnership) or **PCOR** (Plains Carbon Dioxide Reduction Partnership)[iii].

The FEED studies in programme 1 are expected to provide data on the deployment of different CO_2-capture technologies and their economic viability.

Among the project sites is the **Elk Hills Power Plant**, a natural gas-fired plant, located in Kern County, California. The California Resources Corporation, the owner of Elk Hills, plans to capture 75% of the emitted CO_2 by retrofitting the plant with post-combustion CO_2 capture technology and suggests delivering the captured CO_2 for Enhanced Oil Recovery (EOR). Elk Hills has seen similar plans in the past: The **Hydrogen Energy California Project** intended to capture CO_2 at the plant and to transport it via a pipeline for EOR. The project was cancelled in 2016, because it failed to find customers for the captured CO_2.

Another project site, **Project Tundra** at the 705 MW Milton R. Young plant in North Dakota, received the second seven-figure federal grant for studies on retrofitting the coal-fired plant with a post-combustion CO_2 capture system. In 2018, the US-DOE supported the determination of costs, the design and the testing of a carbon capture retrofit at the plant with US$ 6 million. In 2019, the US-DOE announced US$ 9.8 million of funding; additional US$ 15 million will be provided by the North Dakota's Lignite Research Fund. Project Tundra intends to capture 95% of the emitted CO_2 and would involve an investment of US$ 1 billion[iv]. Information on how the financing of the US$ 1 billion investment may be ensured is not available.

Case studies	**Costs per MW**	**Costs for 705 MW**
Costs for carbon capture: Project Tundra aims to invest US$ 1 billion in CO_2 capture technology at Milton R. Young, a 705 MW plant.	US$ 1.14 million	US$ 1,00 billion
Costs for onshore wind: In 2017, the 2 GW Wind Catcher onshore wind park in Texas was financed at US$ 2.9 billion.	US$ 1.45 million	US$ 1.02 billion

Costs for offshore wind: In 2017, average investment costs for offshore wind were at US$ 3.7 million per MW.	US$ 3.7 million	US$ 2.61 billion

Table 2: Investment comparison[v]

The proposed US$ 1 billion investment in carbon capture technology for Project Tundra should be critically scrutinised for economic reasons relative to investments in emissions reductions and renewable energy. It also raises major concerns for the following reasons:

- The extraction process and transportation of coal creates additional CO_2 emissions;
- More coal is burnt – and additional pollution caused – to fuel the energy-intensive CO_2-capture process;
- The negative public health effects of coal would be ongoing[vi].

Considering these extra costs and emissions, a US$ 1 billion investment in renewable energy seems a much more effective tool to reduce CO_2 emissions compared to the proposed carbon capture solution. The US-DOEs *"commitment to strengthening coal while protecting the environment"* does not sufficiently clarify the fate of the captured CO_2: CCUS does not effectively remove and store CO_2. For example, if CO_2 is used to produce synthetic fuel, the CO_2 will be released back to the atmosphere as soon the product is consumed. The effectiveness of storing CO_2 underground or using it for EOR has been broadly questioned due to the risk of CO_2-leakages or the further increase in production of crude oil (and CO_2)[vii].

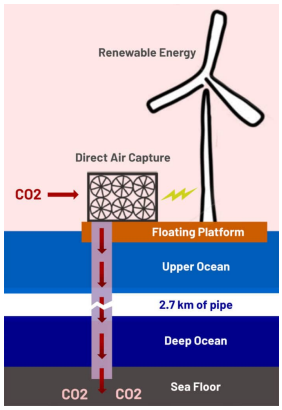

Figure 1: Setup for the proposed open-ocean trial.

A few days after the US-DOE announcement, the Canadian Pacific Institute for Climate Solutions (PICS) announced CAD 1.5 million of funding for a four-year project named "**Solid Carbon: A Climate Mitigation Partnership Advancing Stable Negative Emissions**"[viii]. The project plans to design a floating platform that would capture CO_2 from ambient air and inject it beneath the seafloor for CO_2 sequestration. The project is headed by Ocean Networks Canada (ONC), an initiative founded by the University of Victoria (BC). The project partners include research institutions from Canada, the USA and Germany. In addition, the Texas-based K&M Technology Group will contribute oil and gas drilling expertise, and Carbon Engineering its Direct Air Capture (DAC) technology.

Table 3: Comparing energy use efficiency

1.311 kWh can serve:
• to capture 1 tonne of CO_2 with Carbon Engineering's DAC technology
• to complete more than 650 load of laundry
• to cover domestic energy consumption of an individual in British Columbia for over 1.5 months[ix]

The Canadian start-up **Carbon Engineering Ltd.** was founded by David Keith (Harvard University) and is based in British Columbia. The company's CO_2 capture technology uses a strong hydroxide solution as a chemical sorbent. According to a paper, published by David Keith[x] in 2018, the CO_2 capture and separation process alone needs 1.311 kWh per tonne of CO_2. This figure does not yet take into account additional energy requirements, e.g. the compression of CO_2 and pumping it through a 2.7 km pipe beneath the seafloor.

The research partnership plans to deliver a demonstration project in the

Cascadia Basin, off the shore of Vancouver Island, in 2025 and has started to look for investors. The project's long-term goal is to produce a large fleet of floating platforms by 2050. This concept requires adding large structures to the ocean which could cause issues for marine life, shipping and fisheries. The energy requirement would be enormous; the entire annual domestic energy consumption in British Columbia would be required to capture and separate 35 million tonnes of CO_2, excluding the energy required to compress and pump it beneath the seafloor. Moreover, the question of the fate of the CO_2 must be asked: Leaking pipes or leaking CO_2 from the seafloor will further aggravate ocean acidification.

The Canadian Government announced the project "**Carbon Capture, Utilization and Storage in Mine Tailings**". The objective of the project is to mineralize CO_2 in silicate-rich mine tailings, e.g. in tailings from nickel, diamond, or platinum mining. The research programme is led by the University of British Columbia and involves field trials at two Canadian mines: Trials in the **Gahcho Kué Diamond Mine**, owned by the De Beers Group and situated in the Northwest Territories, will focus on capturing CO_2 from flue gases produced by the mine's power plant. The **FPX Nickel Corporation** owns and operates three nickel mines in north-western British Columbia. One of the sites will be selected for trials, capturing CO_2 from ambient air[xi].

Call for more transparency in geoengineering research

Last month, the **European Geothermal Emission Control Project (GECO)** was celebrating its 1st birthday. The research programme is based upon the European **CarbFix** project at the Hellisheidi Geothermal Power Plant, nearby Reykjavik, Iceland. Since 2012, Hellisheidi is used as a pilot site for capturing CO_2 and H_2S. The captured gases are injected into basaltic formations nearby the plant, with the purpose of storing the gases in mineral form in the bedrock. In 2018, a group of authors argued that the injections at Hellisheidi led to induced seismic activity[xii] – one of the risks associated with underground storage of CO_2.

Nevertheless,

GECO aims to further advance the technology trialled at Hellisheidi, in terms of costs, resource consumption, and purity of the captured CO_2.
The CarbFix technology will be established and tested at four additional geothermal demonstration sites, each with a distinct geology: **Nesjavellier** plant in Iceland, **Castelnuovo** in Italy, **Kizildere** plant in Turkey, and the Ruhr Metropolitan Underground Laboratory (**TRUDI**) in Germany. Little information is available on detailed project planning and the progress at the respective project locations – even though the project is financed by EU taxpayers and has been running since October 2018. The blog on the project website is empty; the news section has rarely been updated. The GECO demonstration sites also provide little information.

In 2009, Members of the **Oxford Geoengineering Programme** at the University of Oxford proposed a set of principles for the governance of geoengineering, the so-called “Oxford Principles”.

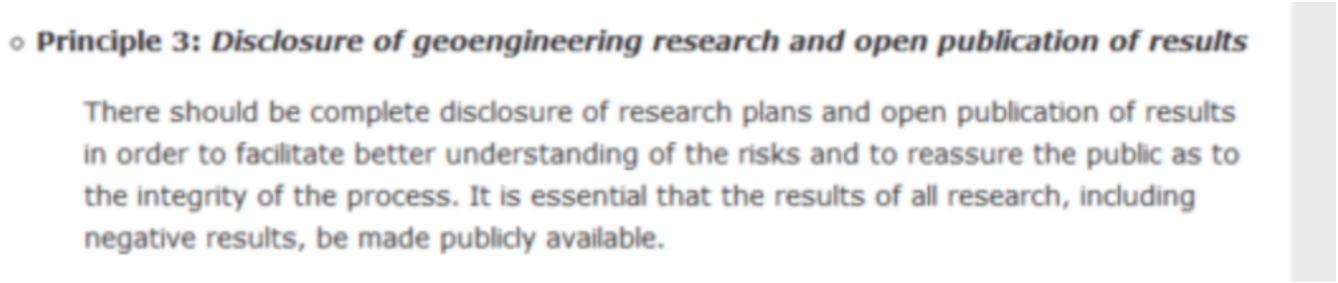

Figure 2: Excerpt from the “Oxford Principles”[xiii]

Principle three has not yet been implemented by the GECO project. The situation is similar for further Geoengineering programmes, for example for the projects **Greenhouse Gas Removal by Enhanced Weathering (GGREW)** and **Greenhouse Gas Removal Instruments & Policies Project (GRIP)**.

GRIP was carried out at the University of Oxford and looked into policy issues related to carbon capture, enhanced weathering, and natural carbon sinks. The duration of the project was from 2016 to 2019; to date, the results of the project are not readily available to the public[xiv].

GGREW

has been running since 2017 and is also carried out at the University of Oxford, in cooperation with partner universities in UK. The project aims to explore the technological, environmental, economic and social feasibility of enhanced weathering in oceans. The project activities include research, modelling, laboratory experiments in Oxford and Israel, and field experiments[xv]. A detailed research plan is not available, although more than half of the project duration has passed.

Recent proposals for shading the Great Barrier Reef

The **Great Barrier Reef Foundation** refers to the Great Barrier Reef as the rainforest of the sea, because it is home to many species. The foundations' annual working plan 2019/2020 is a reef protection programme to reduce the impact of and adapt to climate change and local stresses. The programme encompasses an environmental assessment and a proof of concept phase for decreasing solar radiation on reefs. The assessment includes technical, environmental and regulatory considerations and will consider shading the reef through clouds, mist, fog, or surface films. The project's budget to date is AUD 1.6 million[xvi].

A collaboration between the University of Melbourne, the Australian Institute of Marine Science and the Great Barrier Reef Foundation developed a **Floating Sunscreen**. The surface film consists of calcium carbonate and is designed to sit at the water surface, directly above the reef. Researchers at the Sydney Institute of Marine Science have suggested **Marine Cloud Brightening above the Great Barrier Reef** as a protection measure for the reef. The German company gM-Engineering has recently proposed a trial with **Iron Salt Aerosols** in the Bass Strait, north of Tasmania. The approach combines marine cloud brightening and ocean fertilization. The company is presently looking for sponsors to fund the trial.

Further updates on new and ongoing geoengineering initiatives

The **UAE Rain Enhancement Programme** was established back in 1983. The National Centre of

Meteorology (NCM) is the responsible governmental body for cloud seeding activities in the United Arab Emirates. Recently, NCM conducted a new test campaign: airborne cloud seeding was carried out with salt crystals, coated with a titanium dioxide nanoparticle layer. The research aircraft based at Al Ain airport have conducted flights over the Northern and Eastern parts of UAE.

The Australia-based **Ocean Nourishment Foundation Ltd** (ONF) announced plans to fertilize the ocean in Moroccan waters. ONF states that the addition of nutrients has been discussed with local fisherman and that ONF is “about to demonstrate to the fishermen of **El Jadida** in Morocco the techniques of injecting new nutrients into surface waters of the deep oceans”.

The **Gorgon CCS Project** on Barrow Island, Australia, started injecting CO_2 in the Dupuy Formation, a saline aquifer. The commissioning of the CCS project was several times delayed due to technical problems. The natural gas plant emits annually up to 10 million tons of CO_2; the CCS project aims to reduce the amount of emitted CO2 to 6 million tons per year.

The **Northern Lights CCS Project**, carried out by Equinor (former Statoil), Shell and Total, intends to transport captured and liquefied CO_2 over 700km by ship from Oslo area to a hub nearby Equinor’s Kollsnes plant. From Kollsnes the CO_2 will be sent offshore by a 110km pipeline and injected into a depleted well in the Johansen formation (Norwegian sector of the North Sea, about 30km off the shore of Norway). In September, Equinor signed preliminary Memoranda of Understanding for handling the captured CO_2 with seven potential industrial partners: Air Liquide, Arcelor Mittal, Ervia, Fortum Oyj, HeidelbergCement AG, Preem, and Stockholm Exergi.

The Swiss **Climeworks AG** announced its merger with Antecy B.V. The Dutch company develops CO_2 capture and DAC technology.

SINTEF, a Norwegian research organization, and C-Capture, a spinoff from the department of chemistry at the University of Leeds, announced a six-month collaboration at SINTEFs **Tiller research facility**. C-Capture will send its carbon capture technology to the Tiller plant in order to validate its solvent by comparative analysis with alternative carbon capture approaches.

The Canadian company **CarbonCure Technologies Inc.** formed partnerships with concrete producers in Hawaii, for example HC&D Ready Mix, and with Linde, a large industrial gas supplier. CarbonCure provides technology to existing concrete plants that allows producers to inject captured CO_2 into wet concrete while it's being mixed. According to CarbonCure, the CO_2 forms a mineral with calcium ions and remains captured in the concrete. The new partnerships aim to introduce the CarbonCure technology to new countries in Europe and Asia.

Yale University announced the foundation of the **Carbon Offset Laboratory (COLab)**. The new laboratory will focus on the development of technologies, such as reduction of greenhouse gas emissions, carbon storage, carbon sequestration, and solar radiation management.

A Chinese government delegation, led by the Chinese Ministry of Ecology and Environment, studied CCS in Australia[xvii]. The delegation visited various CCS projects, among them the **Global CCS Institute** in Melbourne and the **PICA project at the Loy Yang plant**. PICA was established in 2008 and is testing post-combustion CO_2 capture technologies.

Resources for further information:

Geoengineering Monitor: https://www.geoengineeringmonitor.org/ – information and background on climate geoengineering technologies, research, experimentation and implications

Interactive Geoengineering Map: https://map.geoengineeringmonitor.org/ – contains details and references for the

above mentioned (**highlighted in bold characters**) and further climate geoengineering projects.

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