IEAGHG Information Paper: 2015-IP23; Status Report on Direct Air Capture

The technology that captures CO_2 directly from the air, or Direct Air Capture (DAC) has been the subject of some debate over the years. It was not specifically covered in the IPCC SRCCS[1] in 2005 but the debate on its applicability and cost has arisen since. Although, there was not deemed to be sufficient new research to include it in the latest update of CCS science in IJGGC[2]. There are a small number of proponents of the technology that have continued to raise DAC above the parapet and not allow it to be forgotten.

In 2012, IEAGHG published an information paper (2012-IP4m, Direct Air Capture – An Update) that followed the publication of a status report on DAC published by The American Physical Society[3]. The report was not a sole work but was a multi author report, with knowledgeable authors drawn from North America and Europe. The APS it seems routinely produces reports on timely topics so as to inform the debate with the perspectives of physicists and other scientists working in the relevant issue areas, including energy and the environment. What lead to DAC being chosen is not known but it was selected as the topic for this detailed study at that time.

The key messages from the study on DAC were:

- DAC is not currently an economically viable approach to mitigating climate change.
- In a world that still has centralized sources of carbon emissions, any future deployment that relies on low carbon energy sources for powering DAC would usually be less cost-effective than simply using the low-carbon energy to displace those centralized carbon sources. Thus, coherent CO_2 mitigation postpones deployment of DAC until large, centralized CO_2 sources have been nearly eliminated on a global scale.
- DAC may have a role to play eventually in countering emissions from some decentralized emissions of CO_2 such as from buildings and vehicles (ships, planes) that prove expensive to reduce by other means.
- Given the large uncertainties in estimating the cost of DAC, century-scale economic models of global CO_2 emissions that feature “overshoot trajectories” and rely on DAC should be viewed with extreme caution.
- High-carbon energy sources are not viable options for powering DAC systems, because their CO_2 emissions may exceed the CO_2 captured.
- The storage part of CO_2 capture and storage (CCS) must be inexpensive and feasible at huge scale for DAC to be economically viable.
- This report provides no support for arguments in favour of delay in dealing with climate change that are based on the availability of DAC as a compensating strategy.

In essence the report put the deployment of DAC into the post 2030-2050 period when either all fossil based plants have been fitted with CCS or fossil fuels have been phased out altogether and there is a need to counter the effects on warming from non CCS fossil fuel plants.

The report did spark some controversy as I reported in 2012, the main issue was the costs. Research published by MIT at GHGT-10 on the costs of air capture was critical of the costs of \$100 to \$500/t CO_2 quoted in the literature by DAC proponents[4]. Whilst the cost quoted in the APS report for DAC was \$600/t CO_2 avoided, Howard Herzog from MIT and a co-author of the published MIT research on DAC

[1] https://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf
[2] http://www.sciencedirect.com/science/journal/17505836/40
[3] Direct Air Capture of CO_2 with Chemicals A Technology Assessment for the APS Panel on Public Affairs June 1, 2011, see http://www.aps.org/policy/reports/assessments/upload/dac2011.pdf,
[4] http://sequestration.mit.edu/pdf/2011_GHGT10_Ranjan.pdf

felt that the cost assumptions used were too simplistic in the APS report, despite the fact that they showed the costs of DAC were significantly higher than PC Capture.

As noted in 2012 IP4 he and a group of researchers undertook their own analysis which was published in 2012[5]. The Proceeding of the National Academy of Science of the USA. The main conclusions from this analysis are:

- DAC is significantly more expensive than other low carbon mitigation options and thus will not be competitive with CO_2 capture at power plants and other large point sources.
- Costs of DAC are likely to be of the order of $1000/t of CO_2 avoided.

Although I note the analysis was not universally accepted that the costs would be so much higher than the ACS study[6].

Overall, the consensus is that the costs of DAC will be higher than conventional post combustion capture the issue among scientists is by how much.

This debate has not stopped research on DAC, as is discussed in a recent article in Nature[7].

Carbon Engineering, in Canada have now constructed a pilot scale DAC test facility, see figure below. The plant uses fans to push air through towers containing potassium hydroxide solution, which reacts with CO_2 to form potassium carbonate; the remaining air, now containing less CO_2, is currently emitted. Further treatment of the solution separates out the captured CO_2, regenerating the capture solution for fi future reuse.

Carbon Engineering's demonstration plant in British Columbia

[5] http://www.pnas.org/content/108/51/20428.abstract
[6] https://sequestration.mit.edu/pdf/2012_PNAS_StorageCapacity_LetterToEditor.pdf
[7] http://www.nature.com/news/commercial-boost-for-firms-that-suck-carbon-from-air-1.18551

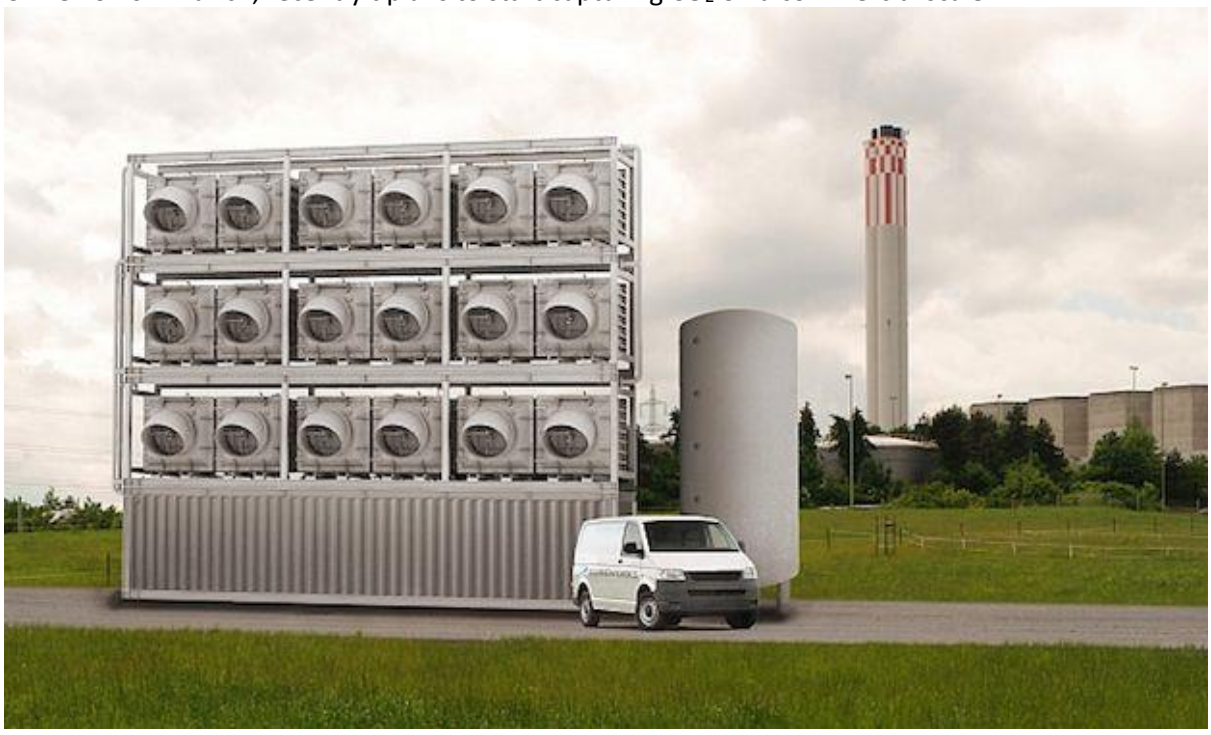
The pilot facility can capture and process around 1 tonne of CO_2 per day which represents a big step up from the company's earlier demonstration plant, which ran only the first step of capture and did not regenerate gaseous CO_2.The process is currently powered by electricity, which in British Columbia is mainly generated by hydroelectric sources.

According to Carbon Engineering the pilot plant will position the technology to be further scaled up. Also, the pilot plant will now run the whole process — from CO_2 capture to regeneration — for the first time. In terms of costs, they claim they will be in the range CO_2 quoted by the APS study ($600/t CO_2 avoided) for first of a kind plants. , with prices of $100–200 per tonne of CO_2 considered to be realistic for later larger plants that it is planning.

Since the construction of the pilot facility, Carbon Engineering have announced that it has signed an agreement with the province of British Columbia to assess the potential of turning the CO_2 into fuel to power local buses. Note: IEAGHG is looking separately at the energy requirements and GHG emissions of such processes and I will not debate the efficacy or such CO_2 recuse options further.

In a separate development a Swiss Company, Climeworks is also developing DAC technology. However the development activity is designed to develop a process that has commercial benefits for the company rather than with climate mitigation in mind.

Climeworks is a spin- off company from ETH set up to commercialize a patented system for CO_2 capture from ambient air, which has been developed at ETH Zurich[8]. It is developing a modular capture process and the capacity is scalable in multiples of 35 kg per hour (300 metric tons per year). Climeworks in Zurich, recently t plans to start capturing CO_2 on a commercial scale.



Climeworks CO_2 Capture Plant

Its plant in Hinwil, Switzerland, will capture 1,000 tonnes of CO_2 per year starting in mid-2016. Climeworks uses a granular sorbent to capture CO_2. The first a module that will sit on top of an incineration plant. Waste heat from the incinerator will be used to drive the captured CO_2 off the

[8] http://www.climeworks.com/

granules, which can then be reused. The company will sell the CO_2 to the firm Gebrüder Meier, which will use it to increase crop yields in greenhouses. The use of captured CO_2 in greenhouses has been used for many years in the Netherlands. Climeworks is also assessing the beverage industry as a source of potential customers.

In conclusion, I don't see anybody disputing the fact that post 2040 DAC could have a role to play in mitigating climate change if significant decarbonisation does not occur in the next two decades. In essence it is Plan B. But there does seem to be a divide between groups and individuals on how much the actual cost of the technology will be. One thing I think we can agree on is that it is likely to be higher than for conventional capture systems. Nevertheless DAC technology is being developed and tested at the pilot scale so we can deploy is as and when in the future.

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