Editorial

A Case for Carbon Capture and Sequestration

I am not usually a great fan of carbon capture and sequestration (CCS) technologies. To be successful, CCS requires vast quantities of energy and, in the short-run, would only exacerbate the need for energy. Besides this, relying on CCS could make us complacent about climate change from greenhouse gas emissions (GHGs).

So why am I writing this editorial making a case for developing CCS; particularly for direct air capture? It boils down to my concern that the world will likely overshoot the GHG emissions target and we will need a technology that can reverse the course and help bring down the concentration of atmospheric CO_2.

Most CCS technologies deal with point sources of relatively high concentrations of CO_2. The capture technology in such cases is located at the site of these emissions. In contrast, direct air capture (DAC) is designed to remove CO_2 from the air at the source and can be located anywhere, preferably closer to a site for sequestration or other use. Thus, DAC can address global CO_2 emissions regardless of whether the emissions are from point sources or mobile units.[1,2] Because of the relatively low concentration of CO_2 in the air (~400 ppm) for the purpose of DAC, the capture technology must rely on strongly basic materials and a higher quality heat source to liberate the bound CO_2. In 2011, the American Physics Society published a report analyzing energy costs and concluded that under optimistic assumptions the cost of DAC would be $600/ton CO_2,[3] a figure substantially larger than earlier estimates by academics promoting DAC. All of these estimates were based on projections of the cost of the components and the price of clean electricity, so a large variability is not entirely unexpected.

Despite these challenges, several companies have developed prototypes of systems for DAC. They are motivated by the importance of CCS within the overall response to climate change and the possibility of getting carbon credits for air-captured CO_2. The cost estimates from these companies based on experiments with the prototypes are considerably lower, often less than $100 per ton-$CO_2$. A price on carbon will go a long way in promoting the deployment of DAC technologies and CCS in general. This cost would serve as an upper bound (as a "back-stop" technology) for the social cost of carbon.[4]

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Efforts are afoot to lower the costs associated with capturing CO_2 using amine-based solvents, as well as to develop alternative CO_2-capture methods using membranes or monoliths. Companies developing these technologies estimate the cost for capture at $50/ton or lower if low-temperature waste heat is available at no cost.

Some companies are exploring options for producing value-added products from captured CO_2. While finding an application that can use the captured CO_2 is attractive in that it could make the economics favorable, there is still a huge gap between the amount of CO_2 that needs to be captured to be meaningful for mitigating climate change (several billion tons per year) and what any application can use. According to the Global CCS Institute, between 80 and 120 million metric tons (MMt) of CO_2 are sold commercially each year for a wide variety of applications.[5] The largest single use is for enhanced oil recovery (EOR), which consumes upwards of 60 MMt/yr, mostly from natural sources.

The large gap makes it clear that the sale of captured carbon for specific applications can only be useful in initial instances of DAC, as these markets would be soon saturated. The real hope is that the learning gained from these experiences will drive down the cost of DAC, perhaps to $10/ton-$CO_2$. At this price, the cost of capturing the amount of CO_2 emitted from the burning of a gallon of gasoline (8.6 kg) would be only 8.6 ¢. In other words, DAC would provide an alternative to zero-emission hydrocarbon fuels without recycling the CO_2 into fuel by an energy intensive process and it could do this at a cost barely 3% more than the current price of gasoline.

Notes

[1] Lackner KS, Ziock HJ, Grimes P, "Carbon dioxide extraction from air: Is it an option?" Proceedings of the 24th International Conference on Coal Utilization & Fuel Systems (Clearwater, FL), ed. Sakkestad BA (Coal & Slurry Technology Association, Washington, DC), 885–896, 1999.

[2] Ishimoto, Yuki and Sugiyama, Masahiro and Kato, Etsushi and Moriyama, Ryo and Tsuzuki, Kazuhiro and Kurosawa, Atsushi, Putting Costs of Direct Air Capture in Context (June 7, 2017). FCEA Working Paper Series: 002, June, 2017. Available at SSRN: https://ssrn.com/abstract=2982422 or http://dx.doi.org/10.2139/ssrn.2982422

[3] American Physics Society. 2011. Direct Air Capture of CO_2 with Chemicals.

[4] Review of Environmental Economics and Policy, volume 12, issue 1, Winter 2018, pp. 170–182; doi: 10.1093/reep/rex029

[5] "Accelerating the Uptake of CCS: Industrial Uses of Captured Carbon Dioxide," Global CCS Institute, 2011.

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