CLOSING THE CARBON CYCLE WITH SNYTHETIC FUELS AND CAPTURE OF CARBON DIOXIDE FROM AMBIENT AIR

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The development of energy systems is path dependent. Because these paths start in the past, current trajectories already constrain future scenarios. The latest IPCC report suggests that the world has waited too long, and that avoiding dangerous climate conditions will require net negative carbon emissions for a large part of the next fifty years. Reversing 100 ppm of past emissions would require the development of technologies to remove carbon dioxide from the air and about 1500 Gt of CO_2 storage capacity, which exceeds the emissions of the 20th century. Assuming that humanity succeeds in solving this existential challenge, one may conclude that air capture technology will be developed and carbon storage capacity will be a scarce commodity, reserved for storing carbon recovered long after it has been emitted. This eliminates fossil carbon as a viable source of energy. Carbon free energy sources including solar and nuclear energy will therefore be at a premium.

It is here that air capture could have another important role. The transport and storage of energy can take advantage of carbon-based, synthetic fuels, as long as air capture technology can recover their carbon emissions. Liquid, carbon-based fuels have the advantage of a long history of use, they are also genuinely attractive because they are easily handled, transported and stored. Advanced energy conversion devices like fuel cells would extend the efficiency of synthetic liquid fuels even more. This leads to scenarios in which most energy resources would initially produce electricity often without regard to instant demand profiles, with excess power being converted to liquid fuels. Electricity and synthetic fuels would then be the main energy carriers, with advanced electrochemical technologies converting one into the other. CO_2 produced in synthetic fuel consumption is recovered by air capture and reused in making fresh fuels.

For these scenarios to be relevant, air capture as well as energy conversion must become economically affordable. Today, it is the high cost of input electricity that is most limiting in the development of such a scenario. For air capture, the low concentration of carbon dioxide in air makes it is difficult to repurpose existing industrial gas separation technologies. However, novel technologies have the potential for affordable implementations. Our own approach uses humidity changes to allow sorption on a sorbent in the dry state and release of carbon dioxide in the wet state. The process is fast, reversible and efficient in terms of cost and energy. It is much simpler, and requires far less material than a different air-capture process, which based on a study by the American Physical Society would cost $600 per ton of CO_2 in a first-of-a-kind implementation. Using cost reductions experienced in windmills and solar panels as a guide, $600 per ton seems not very high for an initial cost. Solar energy prices dropped 100 fold and wind energy costs roughly 40 fold since the 1960s.

In summary, air capture, which will be driven by the need to remove carbon from the atmosphere, can also support the development of non-fossil energy resources by connecting them to liquid synthetic fuels which are the most efficient way of carrying large amounts of energy on board of a car, a plane or a ship.

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