Direct Air Carbon Capture and Storage (DACCS) and Direct Air Carbon Capture and Utilization (DACCU)

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Abstract

In 2015, the Paris Agreement set the goal to pursue efforts to limit global average temperature increase below 1.5°C above preindustrial levels. Different bodies have independently assessed that this is achievable under optimistic scenarios with a cost: mandatory requirement is the introduction in the energy system of effective negative emission technologies (NETs) in addition to plans for the deployment of point source carbon capture and storage, renewable or nuclear energy. Today, few governments are timidly planning research and development programmes for GHG removal (GGR) technologies. In the UK for example, after invitation of the government, The Royal Society has recently released a policy-setting report where *three possible pathways of NETs are identified among which the option with largest potential (**75 $MtCO_2$/year**) consists of the combined adoption of BioEnergy with Carbon Capture and Storage (BECCS) and Direct Air Carbon Capture and Storage (**DACCS).*** BECCS is known with good accuracy. Conversely, DACCS is still largely uncertain since the majority of information come from order-of-magnitude estimates (*1*), forecasts (*2*), theoretical calculations (*3*) and proof-of-principle experiments (*4*, *5*). The analyses from these studies are often biased since they are produced by companies tending to promote their specific products. The theoretical feasibility of large scale DAC (without storage) was first proposed by Lackner (*6*) (founder of Kilimajaro Energy Inc) and Keith (*7*) (founder of Carbon Engineering Ltd). Other companies have joined later, such as Climeworks Ltd, Global Thermostat LLC and more recently a number of start-ups and research groups proposing processes at technology readiness level (TRL) 1-2. All these actors still need to prove that their DAC ideas can work at large scale. Climeworks Ltd is the only company that has claimed to have actually stored CO_2 underground, with 165 tCO_2 sequestered in an Icelandic geological reservoir over 3 years (*8*). Unfortunately, this result is unlikely to be replicable since it relies on the specificity of Icelandic waters and rocks and for the share of national renewable energy that it would need. Additionally, the economics of DACCS is uncertain, with costs for capture but excluding storage ranging from \$50 (*2*) to \$600 per tCO_2 (*9*). At the time of writing this contribution, EU carbon credits are valued around \$30 per tCO_2 and there is no sound basis to state any threshold which would make DACCS viable. DAC is proposed also in combination with processes that use CO_2, called Direct Air Carbon Capture and Utilization (DACCU). In this solution carbon is kept in a loop. When the overall product life-cycle is assessed, no chemicals have been identified for which DACCU is a NET to date. In most cases DACCU leads to net increase of carbon emissions because of its energy intensity. However, DACCU can still be an option in locations where the CO_2 demand is high and renewable energy in excess. On a market viewpoint, only fuel are chemicals produced at a scale which is large enough to be a real option for climate change mitigation through CO_2 utilization (*10*) but this comes along with their high cost. Among the negative emission tools, those involving DAC sound attractive on paper but they are also the least explored. If the governmental policies on GGR has to include DAC, governments run the risk of following unreliable plans based on biased data.

References: 1. K. Z. House *et al.*, *Proc. Natl. Acad. Sci.* **108**, 20428–20433 (2011); 2. M. Fasihi, O. Efimova, C. Breyer, *J. Clean. Prod.* **224**, 957–980 (2019); 3. D. W. Keith, G. Holmes, D. St. Angelo, K. Heidel, *Joule*. **0** (2018), doi:10.1016/j.joule.2018.05.006; 4. T. Wang, K. S. Lackner, A. Wright, *Environ. Sci. Technol.* **45**, 6670–6675 (2011); 5. J. A. Wurzbacher, C. Gebald, N. Piatkowski, A. Steinfeld, *Environ. Sci. Technol.* **46**, 9191–8 (2012); 6. K. S. Lackner, *Sci. Am.* **302**, 66–71 (2010); 7. D. W. Keith, M. Ha-Duong, J. K. Stolaroff, *Clim. Change*. **74**, 17–45 (2006); 8. P. A. E. Pogge von Strandmann *et al.*, *Nat. Commun.* **10**, 1983 (2019); 9. J. Tollefson, *Nat. 2019 5587709* (2018); 10. S. Deutz *et al.*, *Energy Environ. Sci.* **11**, 331–343 (2018).