POWER-TO-TRANSPORT: USING CURTAILED WIND TO RUN CCU PROCESSES

Habiba Daggash, Centre for Environmental Policy, Imperial College London
h.daggash16@imperial.ac.uk
Clemens Patzschke, Department of Chemical Engineering, Imperial College London
Clara Heuberger, Centre for Process Systems Engineering, Centre for Environmental Policy, Imperial College London
Lingqiao Zhu, Centre for Process Systems Engineering, Imperial College London
Dr Niall Mac Dowell, Centre for Environmental Policy, Centre for Process Systems Engineering, Imperial College London

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The Paris Agreement signaled global commitment to limit average global temperature rise to 2˚C and to make efforts to achieve 1.5˚C increase (UNFCCC, 2015). The IPCC AR5 cites carbon capture and storage (CCS) as a necessary technology to achieve this (IPCC, 2014). However, several drawbacks including high upfront investment costs, significant energy penalty and long-term permanent storage challenges have limited the uptake of CCS on the required scale (Styring, et al., 2011). Carbon capture and utilisation (CCU) provides an alternative route to recycle CO_2 into chemical feedstock and/or synthetic transport fuels (e.g. methanol, DME) that can displace fossil-derived fuels. As the carbon is only *transformed*, CCU must be integrated with capture/storage to actually offset subsequent emissions from the vehicles consuming them. The mitigation of decentralised emissions poses significant challenges and necessitates the use of carbon dioxide removal technologies (CDR), one of which is direct capture of CO_2 from the atmosphere (DAC). This work investigates two possible options for CCU integrated with DAC: Option A is the storage of curtailed wind as methanol which can be used in road vehicles to displace gasoline emissions (power-to-transport), and Option B is the use curtailed wind directly to run a DAC plant in order to capture decentralised carbon emissions and provide CO_2 feedstock for CCU processes. A high-level analysis has been carried out to determine the gasoline substitution and emissions offset potential of both options, the overall conversion efficiency of the power-to-transport process, and the economics of each option. The UK was used as a case study and the methanol synthesis process described by (Rihko-Struckmann, et al., 2010) was used as the reference. Work by (Messiou, 2012) investigated the curtailment levels for the UK electricity system with increased wind generation; the 'medium integration' scenario assumed the UK had 5 times the current wind generation capacity. A corresponding curtailment level of 2.5% (of total electricity dispatched) was determined, this has been used as the base case in our analysis. The gasoline substitution potential of methanol produced via option A was ~0.12% (equivalent to ~0.05 $MtCO_2$/y) with the overall power-to-transport efficiency being ~11%. Surplus energy (~64% of the curtailed electricity) was required to run the DAC plant and an associated air separation unit. The methanol production plant was found to be economically infeasible unless current methanol price increased by a factor of 1.8 to $988/t, the cost of hydrogen fell by a factor of 2.3 to $1811/t or a carbon price of $313/t was in effect. For option B, the emissions offset potential of the DAC process was ~0.18% for the same curtailment, capturing ~0.07 $MtCO_2$/y. Therefore, the utilisation of curtailed electricity for direct capture of CO_2 from the atmosphere results in greater avoided emissions than if it was stored as methanol.

References

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