Climate Finance and Policy Group
Energy and Technology Policy Group

The future costs of direct air carbon capture and storage

Policy brief based on: Sievert K., Schmidt T.S., Steffen B. (2024). Considering technology characteristics to project future costs of direct air capture. Joule *8*, 1-21 https://doi.org/10.1016/j.joule.2024.02.005

Summary

A cost projection based on technology-inherent characteristics shows that Direct Air Carbon Capture and Storage (DACCS) technologies will see substantial cost reductions, though most likely will not fall below ca. $ 230 /t CO2 even at Gt scale. Reducing CO_2 emissions remains the key priority to mitigate dangerous climate change. Nevertheless, by 2050, the cost of DACCS could be in the order of magnitude of emissions reductions from sustainable aviation fuels. Comparing the cost of DACCS with expected future carbon prices, such as those projected for the EU Emissions Trading System (ETS) by 2050, further underlines the importance of DACCS in achieving the Paris climate goals. With no single technology emerging as the frontrunner, a technology portfolio will need to be deployed, requiring strong private and public sector demand-pull.

The project

Several low-carbon technologies, such as solar PV or batteries, have experienced massive cost reductions in the recent past. However, non-mature technologies will also be needed to meet the Paris climate targets. The costs of emerging technologies, such as Direct Air Capture (DAC) technologies, remain highly uncertain. To address this uncertainty, we develop a new method for projecting future costs of novel technologies, considering the technological characteristics of these technologies and their components, and apply it to three DAC technologies combined with CO_2 transport and storage to provide probabilistic estimates of the future cost of net CO_2 removal.

The observation

Based on multi-component experience curves, the analysis provides cost projections for three DAC technologies. The comparison of these systems reveals notable initial cost differences. Yet, the overlapping cost ranges at 1 Gt-CO_2/year capacity across all technologies suggest that these rankings are preliminary. At 1 Gt CO_2/year cumulative capacity, we project DACCS costs of \$341/tCO_2 (\$226–544 at 90% confidence) for liquid solvent DACCS, \$374/tCO_2 (\$281–579) for solid sorbent DACCS, and \$371/tCO_2 (\$230–835) for CaO ambient weathering DACCS (see Figure). Given the uncertainty involved, all three DACCS technologies should be rapidly deployed to see what cost improvements will be achieved. Our projections give an estimate of potential cost reductions, complementing recent literature on deployment projections.

The implications

The results challenge the widely accepted \$100/tCO_2 DACCS target established by Frontier's Advance Market Commitment and the U.S. Department of Energy. This target, intended to average the costs of various carbon dioxide removal (CDR) strategies, has led to overly optimistic expectations that may not be realistic for DACCS. While DACCS will very likely be part of the portfolio of CDR measures needed to limit global warming to well below 2°C, it is crucial to avoid unrealistic cost projections. Although none of the studied DACCS technologies meets the U.S. policy target of \$100/tCO_2 at 1 Gt scale, they all show potential to be competitive with other emission reduction technologies for sectors that are "hard-to-abate". For instance, the abatement costs of sustainable aviation fuels could be in the range from \$245 to \$409/tCO_2 by 2050 according to one study.[1] The feasibility of DACCS is further emphasized when contrasted with carbon prices such as the \$370-704/tCO_2 projected in the EU ETS by 2050.[2]

Messages for policy

For faster deployment, DACCS could benefit from strong demand-pull. To date, very few stringent DACCS policies have been enacted. Key examples of deployment policies include the U.S. Inflation Reduction Act, which raised the 45Q tax credit to \$180/tCO_2 and extended construction deadlines by seven years,[3] and the U.S. Department of Energy's funding for direct air capture hubs.[4] Additionally, private sector actions, including Advance Market Commitments, complement these policies, driving DACCS deployment by generating extra revenue streams. In the European Union, there is no dedicated policy for DACCS deployment that would approach the scale of the US policy yet, though a potential integration of DACCS into the EU ETS could provide incentives mid- to long-term[2].

Considering the uncertainty and possible shifts in cost rankings, a diversified DACCS technology portfolio remains crucial. This portfolio should also include radically new approaches that have not been proven in any commercial-scale plant yet (and hence have not been studied in this project). Here again, policy can be instrumental, with the U.S. CREATE Act to accelerate CDR R&D, and the EU Innovation Fund being steps to build upon.

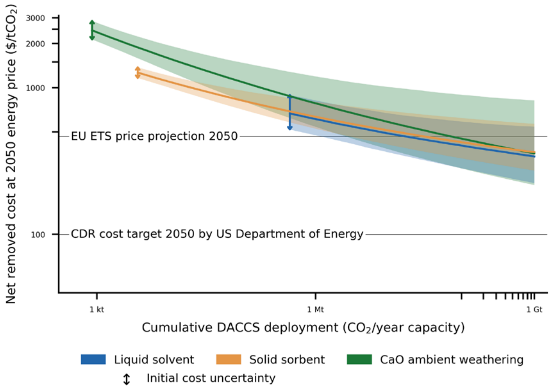

Figure. Net removed cost trajectories for liquid solvent DACCS, solid sorbent DACCS, and CaO ambient weathering DACCS at 2050 energy prices, on a log-log scale.

About the authors

Katrin Sievert is a PhD student in the Climate Finance and Policy Group at ETH Zurich and the Institute for Science, Technology and Policy. Her research focuses on cost projections and financing needs across the carbon capture, transport and storage supply chain, and abatement costs in difficult-to-decarbonize transport sectors. Katrin holds a Bachelor's and Master's degree in Management and Technology, specializing in Energy Economics and Energy Technology, from the Technical University of Munich.

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This project has received funding from the European Union Horizon 2020 research and innovation programme Marie Sklodowska-Curie (MSC) grant agreement No. 847585, ETH Zurich ISTP Incubator program, Swiss State Secretariat for Education, Research and Innovation (SERI) contract No. 22.00541.

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European Commission

Horizon 2020
European Union funding
for Research & Innovation

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