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Emergency responses to the climate crisis: The case of direct air capture of CO_2

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Global emissions of CO_2 have been rising at 1–2% per year, and the gap between emissions and what is needed to stop warming at aspirational goals like 1.5ºC is growing. To stabilize warming at 1.5ºC, most studies find that societies must rapidly decarbonize their economy while also removing CO_2 previously emitted to the atmosphere. In response to these realities, dozens of national governments, thousands of local administrative governments, and scores of scientists have made formal declarations of a climate crisis that demands a crisis response. In times of crisis, such as war or pandemics, many barriers to policy expenditure and implementation are eclipsed by the need to mobilize aggressively around new missions; and policymaking forged in crisis often reinforces incumbents such as industrial producers. Though highly motivated to slow the climate crisis, governments may struggle to impose costly polices on entrenched interest groups and incumbents, resulting in less mitigation and therefore a greater need for negative emissions.

We model wartime-like crash deployment of CO_2 direct air capture (DAC) as a policy response to the climate crisis, calculating (1) the crisis-level financial resources which could be made available for DAC; (2) deployment of DAC plants paired with all combinations of scalable energy supplies and the volumes of CO_2 each combination could remove from the atmosphere; and (3) the effects of such a program on atmospheric CO_2 concentration and global mean surface temperature.

Government expenditure directed to crises has varied, but on average may be about 5% of national GDP. Thus, we calculate that an emergency DAC program with annual investment of 1.2–1.9% of global GDP (anchored on 5% of US GDP; $1–1.6 trillion) removes 2.2–2.3 $GtCO_2\ yr^{-1}$ in 2050, 13–20 $GtCO_2\ yr^{-1}$ in 2075, and 570–840 $GtCO_2$ cumulatively over 2025–2100. Though comprising several thousand plants, the DAC program cannot substitute for conventional mitigation: compared to a future in which policy efforts to control emissions follow current trends (SSP2-4.5), DAC substantially hastens the onset of net-zero CO_2 emissions (to 2085–2095) and peak warming (to 2090–2095); yet warming still reaches 2.4–2.5ºC in 2100. Only with substantial cuts to emissions (SSP1-2.6) does the DAC program hold temperature rise to 2ºC.

Achieving such massive CO_2 removals hinges on near-term investment to boost the future capacity for upscaling. With such prodigious funds, the constraints on DAC deployment in the 2–3 decades following the start of the program are not money but scalability. Early deployments are important because they help drive the technology down its learning curve (indeed, in the long run, initial costs matter less than performance ceilings); they are also important because they increase the potential for future rapid upscaling. Deployment of DAC need not wait for fully decarbonized power grids: we find DAC to be most cost-effective when paired with electricity sources already available today: hydropower and natural gas with renewables; fully renewable systems are more expensive because their low load factors do not allow efficient amortization of capital-intensive DAC plants.