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There is an opportunity to use the unprecedented circumstances surrounding the COVID-19 crisis to implement thoughtful solutions for rebuilding and recharging the U.S. economy. Addressing the country's immediate public health and economic needs remains the top priority at present, but policymakers should consider beginning now to set the stage for long-term recovery by developing strategies that integrate economic and climate objectives.

This paper argues that such strategies should include meaningful investment in research, development, demonstration, and commercial deployment activities to advance direct air capture (DAC) technology. As a complement to reducing new emissions, the ability to remove carbon dioxide that is already in the atmosphere—including through DAC—will likely be necessary to achieve climate goals. At the same time, investments in energy and climate innovation will be critical to the nation's long-term economic growth, technology leadership, and global competitiveness. As with other high-potential, high-impact technologies, federal action in the early stages of DAC development can play a pivotal role in helping this nascent industry improve efficiency, reduce costs, and grow markets.

Recommendations for DAC Research, Development, and Demonstration

Congress first dedicated funding for the advancement of DAC technologies as part of FY 2020 appropriations. The funding, $35 million for R&D efforts by the Department of Energy, will be spread across multiple DOE offices and represents a significant step forward in federal support for DAC. In light of the recent economic downturn, however, in addition to appropriation funding, other federal investment is needed to support the full innovation lifecycle for DAC technology and to realize associated jobs benefits. An analysis by the Rhodium Group found that the build out and operation of a single DAC plant with the capacity to capture 1 million tons of carbon dioxide per year would create more than 3,400 jobs, with nearly 300 of these jobs associated with the operation and maintenance of the completed facility. A DAC industry would support high-quality jobs in steel, cement, chemicals, industrial equipment manufacturing, construction, engineering, and electric power, among others.

One of the reasons that the European DAC company Climeworks has grown is because it received considerable innovation funding from the European Union (including from EU Horizon 2020 and incubators). Similar to Europe and past U.S. innovation investments that have generated strong economic returns and energy savings, the federal government should continue to fund technologies that can provide new market opportunities for U.S. innovators, entrepreneurs, and heavy industry. This includes leveraging a wide array of resources, including the National Science Foundation's Engineering Research Centers to advance DAC technology.

Congress should consider the following funding proposals for early-stage DAC R&D:

- ***Appropriate an additional $20 million over five years for the NSF Engineering Research Centers and an additional $44 million over five years for grants and cooperative agreements through the NSF to support very early stage research by drawing in new talent and ideas to address current shortcomings with DAC technology.[i] This would help ensure that the***

foundational needs of a U.S. DAC industry are supported, particularly with the engagement of new professionals and additional stakeholders through well-established government institutions.

- ***Initiate or expand DOE applied R&D into advanced concepts for sorbents and materials used in DAC systems. Innovations to make key system components more efficient can help further drive down DAC costs and enable successful demonstrations and deployment.***

- ***Enlist the Departments of Defense and Homeland Security in efforts to develop DAC and ocean carbon capture technologies by continuing funding for the National Defense Authorization Act Section 223 Direct Air Capture and Blue Carbon Removal Technology Program.***

Later-stage R&D, particularly technology demonstrations, can improve the operational performance of DAC systems and help drive down costs. Cost estimates for DAC currently vary, in part because there are few demonstration facilities. Later-stage R&D would provide greater cost and performance certainty, not only to government researchers and project developers, but also to potential investors.

For later-stage R&D, BPC recommends the following:

- ***$23 million over five years for DOE to conduct techno-economic assessments of DAC technologies currently being tested by the private sector. Such assessments, conducted on a regular basis, can help identify opportunities for efficiency and performance improvements and provide important information to developers and interested stakeholders.***

- ***$20 million over five years for DOE to collect operational data than can help reduce costs and identify R&D priorities. With better data, federal programs can be modified to provide more effective support and to increase the odds of project success for current developers.***

- ***Expansion of CarbonSAFE, a DOE program that is designed to accelerate the commercial deployment of carbon capture and storage technology, to include a greater number and variety of accessible carbon storage sites. Identifying and developing such sites will be a key complement to a burgeoning U.S. DAC industry since effectively and efficiently storing carbon dioxide captured from the air (whether in geologic formations or long-lasting products) is essential to achieve durable climate benefits.***

- ***Federal investment for DOE to investigate opportunities for applying advanced manufacturing technologies, such as additive manufacturing, to improve the functionality and reduce the cost of DAC systems. Manufacturing DAC components more efficiently would help reduce overall system costs and further progress toward cost-competitive commercialization.***

- ***Federal investment for the DOE to explore options for using diverse low-carbon resources and technologies (e.g., waste heat, advanced nuclear, and others) as cost-effective energy sources for DAC systems, thereby maximizing net climate benefits.***

To support the commercial deployment of DAC technologies, BPC recommends:

- ***Federal investment for the DOE to fund front end engineering design (FEED) studies to provide better cost estimates and identify technical issues. Such studies could be modeled after the FEED studies that have been undertaken for carbon capture, utilization and storage (CCUS) technology (as provided for in appropriations for DOE's Office of Fossil Energy).***

- ***Improvements to the existing Title 17 Innovative Clean Energy Loan Guarantee Program, which is administered by DOE's Loan Programs Office (LPO).***

Financial Mechanisms to Support the DAC Industry

Financial mechanisms could also be leveraged to help the DAC industry mature. BPC recommends extending the Section 45Q tax credit; enhancing private activity bonds for carbon capture, use, and storage (CCUS); applying master limited partnerships to clean energy; and restarting the direct pay Treasury Department cash grant program.

Section 45Q of the Internal Revenue Code provides a performance-based tax credit to power plants and other industrial facilities, including DAC, that capture and store or use carbon dioxide that would otherwise be emitted into the atmosphere. In 2018, the Section 45Q tax credit was updated through the Bipartisan Budget Act, which increased the tax credit to $35 per metric ton for carbon dioxide used in enhanced oil recovery (EOR) applications and $50 per metric ton for carbon dioxide captured for geologic storage by 2026. The $35-per-metric-ton tax credit is also available for non-EOR uses of carbon dioxide, and the $50-per-metric-ton credit is available for direct air capture of carbon dioxide for geologic storage. Since updates were made in 2018, the tax credits have not been available for use due to delays in the issuance of final IRS guidance.

> ***BPC recommends a five-year extension of the Section 45Q tax credit to account for implementation delays and to continue supporting a potentially critical low-carbon technology.***

This extension could have major economic and carbon sequestration benefits over the next few decades. According to a recent DOE analysis, providing tax credits for CCUS will create between 4.3 and 6.1 million new jobs between 2020 and 2050, while also sequestering millions of tons of carbon dioxide. A study by the Clean Air Task Force found that by 2030, nearly 49 million metric tons of carbon dioxide could be captured and stored annually at U.S. coal- and gas-fired power plants.

Introduced in 1968, private activity bonds (PABs) are tax exempt, municipal bonds that are used to attract private investment for projects that deliver some public benefit. The kinds of projects that currently qualify for PAB financing include projects to help fund and refinance student loans, as well as projects involving airports, private universities, hospitals, affordable rental housing, mortgages for first-time, lower-income borrowers, and more. Notably, PABs have also been used to install emissions control equipment on power generation facilities. However, apart from some special conditions that allowed the Petra Nova carbon capture project in Texas to utilize PABs, this tool is generally not accessible to carbon capture projects. Bonds are a valuable form of financing because they can be paid back over longer periods of time, which in turn reduces overall financing costs for commercial-scale projects.

> ***To better enable carbon capture, use, and storage projects, BPC recommends that Congress expand the Carbon Capture Improvement Act of 2019, to authorize the issuance of PABs for qualified carbon capture facilities, including DAC projects. This legislation has been introduced in the House (H.R. 3861) and Senate (S. 1763) with bipartisan support.***

A master limited partnership (MLP) is a business structure that is taxed as a partnership, but that allows ownership interests to be traded like corporate stock on a market. Historically, MLPs have been available to investors in fossil-based projects but have remained inaccessible to clean energy investors. Broadening MLP eligibility to clean energy, including DAC projects, will close this gap and allow a broader range of technologies to access lower-cost financing. This could also help reduce the cost of equity and improve access to capital for energy projects that utilize carbon capture and other advanced technologies.

> ***BPC recommends that Congress pass the Financing Our Energy Future Act to help companies that undertake DAC projects form master limited partnerships. This legislation has been introduced in the House (H.R. 3249) and Senate (S. 1841) with bipartisan support.***

The current COVID-19 crisis has created a challenging project financing environment. The Section 45Q tax credit has historically been successful in supporting CCUS projects, but in the context of a larger economic slowdown, tax equity markets get smaller and take a higher proportion of the available credit value as a transaction cost.

> ***To address this challenge, BPC recommends that cash grants be offered to CCUS project developers in lieu of the Section 45Q tax credit. We recommend an approach similar to the program outlined in Section 1603 of the American Recovery and Reinvestment Act of 2019 (ARRA), with a sunset date 24 months from enactment.***

A restart of the ARRA cash grant program should be limited to 24 months to incentivize rapid uptake by project developers and spur immediate results in terms of project starts, job creation, and economic activity.

Conclusion

Direct air capture is an emerging technology with tremendous potential to revolutionize the energy industry and expand the solutions available for tackling climate change. DAC also has potential to deliver substantial benefits in terms of job retention and job creation across heavy industries that rely on a robust domestic workforce. Measures to address the full innovation and commercialization pathway for DAC should be considered in effort to support economic recovery.

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[i] "Carbon Dioxide Removal RD&D Initiative: DAC Budget Estimates for Year 2 of a 10-Year Initiative," Energy Futures Initiative. 2019. Please note that a majority of the early-stage and later-stage recommendations are drawn from this source, unless otherwise cited.