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POLICY PAPER

Advancing Large Scale Carbon Management: Expansion of the 45Q Tax Credit

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SUMMARY

This paper provides a comprehensive overview of the opportunities for application of the expanded federal tax incentives for carbon capture utilization and storage (CCUS), as well as the additional implementation challenges facing CCUS project developers and policymakers.

The Bipartisan Budget Act (BBA) passed by Congress on February 8, 2018 included expanded provisions for carbon dioxide (CO_2) capture, utilization, and storage (CCUS). These provisions, based on Senate Bill S. 1535 (FUTURE Act) and its companion legislation in the House, expand and reform the Section 45Q tax credits originally enacted in 2008. They include an increase in the credit value for qualifying projects, a longer time horizon for developers to claim the credit, a more expansive definition of qualifying utilization projects beyond enhanced oil recovery (EOR), and eligibility of direct air capture. The provisions act like a production tax credit and are designed to encourage innovation in and adoption of low-carbon technologies related to CCUS, including direct air capture (DAC) of CO_2 and conversion of CO_2 into useable products.

The new 45Q provisions have the potential to significantly enhance the development and market diffusion of CCUS technologies and processes in both industrial and power applications, creating commercial opportunities both in the U.S. and abroad. The provisions provide greater market and financing certainty to help attract additional follow-on investment from the private sector. They will also likely help accelerate the pace of innovation in CCUS technologies and processes, and could mitigate asset risk for fossil fuel producers by enabling continued use of fossil fuels in a carbon-constrained world.

While the 45Q provisions represent a major step forward for emissions reductions, the size and duration of the credits may be insufficient to incentivize retrofits for the variety of facilities that are eligible, including many coal and natural gas plants. Also, the long-term post-injection monitoring, reporting and verification requirements could become an impediment for some operators, possibly limiting the universe of those that might otherwise take advantage of the credits.

To address these and other issues, a more comprehensive policy framework may be needed to maximize the value of the credits. Nonetheless, the new provisions are a critical step forward and will enable substantial emissions reductions for many facilities, especially industrial sites. Given the short time to begin construction on projects, developers, states, and investors must act expeditiously to maximize the commercial and financial opportunities enabled by the expanded 45Q provisions and thereby kick-start larger scale deployment of CCUS.

KEY FINDINGS

The expanded 45Q tax credits represent a major new policy to support the deployment of CCUS technology in the United States by:

- greatly increasing the value of the available credits and removing the cap for total available credits;
- establishing eligibility for direct-air capture of CO_2 and non-EOR CO_2 utilization options; and
- extending the period of eligibility to January 1, 2024 for new projects to commence construction.

- Numerous industrial CCUS projects could become commercially viable, especially ethanol, ammonia, and hydrogen plants, where the value of the credit may exceed the cost of capture.

Opportunities for CCUS deployment in the power generation sector (at both coal or natural gas generation facilities) may be more limited, primarily because the value of the credits over the 12 years of eligibility for each qualifying project is likely to be less than the costs for many potential new or retrofit CCUS projects. Other market factors, such as facility age, configuration and performance, as well as market structures for cost recovery, also will limit applicability.

- In total, an estimated ~50-100M tons CO_2 per year may be captured and stored through expanded 45Q-related deployment. This number will be sensitive to many factors, including public acceptance, the ability to transfer tax credits, the availability of CO_2 pipeline infrastructure, and the readiness of storage sites.

- Project deployment and commercialization under the expanded 45Q provision will enable further rapid innovation and stimulate additional private sector R&D investment into advanced technologies that could substantially reduce CCUS costs.

- 45Q's expanded tax credits will serve U.S. industry and consumers well and position the U.S. internationally in trade, market opportunities, and climate negotiations, and may serve as a policy model for other countries.

RECOMMENDATIONS

- The IRS should quickly issue the necessary implementation guidance, including clarification for qualifying projects regarding the commencement of construction.
- Because of the January 2024 timeline to commence construction, companies, states, and investors should act quickly to determine both how to best take advantage of these credits and what actions to take to maximize their utility.
- Tax credit exchange markets should begin to incorporate 45Q credit exchange mechanisms into their business plans.
- Congress should consider additional measures to facilitate and accelerate CCUS deployment, including addressing uncertainties regarding long-term post-injection carbon management, including monitoring, reporting and verification.
- Stakeholders should consider the adoption of a universal registry specifically designed to facilitate transactions between suppliers and buyers of CO_2, with transparent and verifiable data, possibly through use of blockchain technology.
- DOE should significantly increase the level of federal R&D invesment in CCUS and large-scale carbon removal technologies to accelerate the pace of innovation. Given the trajectory of capacity additions in the electric power sector, R&D investments should reflect a larger focus on natural gas generation.

THE CLIMATE IMPERATIVE FOR CO_2 CAPTURE AND REMOVAL FROM THE ENVIRONMENT: AN ALL-OF-THE-ABOVE APPROACH

In late 2015, the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (the Paris Agreement) committed to a climate goal to limit the increase in global average surface temperature to less than two degrees Celsius (2°C) from pre-industrial levels, with an added ambition to limit warming to less than 1.5 degrees Celsius. One hundred ninety-six nations each formulated Nationally Determined Contributions (NDCs) to reduce net greenhouse gas (GHG) emissions to work toward this goal. Despite this concerted effort, it is estimated that the NDCs would achieve only approximately one-third of the necessary emissions reductions for a least-cost pathway to meet the Paris goal.[1]

Global energy-related carbon dioxide (CO_2) emissions were flat from 2014 to 2016,[2] but in 2017 emissions increased by 1.4 percent.[3] The monthly average atmospheric CO_2 concentration in April 2018 exceeded 410 ppm for the first time in recorded history,[4] and now stands at approximately 411 ppm.[5] Closing this emissions gap between actual performance and the NDCs, and moving beyond NDCs toward the 2°C goal will require significant innovation across the entire landscape of clean energy technologies, policies, and business models.

Achieving deep reductions in net GHG emissions will entail not only increased energy efficiency and greater reliance on carbon-free energy sources, but also carbon capture, utilization, and storage (CCUS) technologies applied to fossil fuel resources. Recent analyses suggest that emissions pathways consistent with the 2°C goal will require large-scale deployment of CCUS (potentially as many as 2,500 facilities globally by 2040).[6,7] Specifically, 87 percent of IPCC models indicate the need for carbon dioxide removal (CDR), in addition to other strategies, to maintain global average temperature increase below the 2°C goal.[8] These modeling results show that deployment of CDR technologies such as direct air capture (combined with utilization and storage) will be needed to meet mitigation targets.[9,10,11] Some estimates suggest that 14 percent of cumulative emissions reductions will need to be met with CCUS.[12]

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1 https://wedocs.unep.org/bitstream/handle/20.500.11822/22101/EGR_2017_ES.pdf?sequence=1&isAllowed=y

2 https://www.iea.org/newsroom/news/2017/march/iea-finds-co2-emissions-flat-for-third-straight-year-even-as-global-economy-grew.html

3 https://www.iea.org/newsroom/news/2018/march/global-energy-demand-grew-by-21-in-2017-and-carbon-emissions-rose-for-the-firs.html

4 https://scripps.ucsd.edu/programs/keelingcurve/2018/05/02/carbon-dioxide-in-the-atmosphere-hits-record-high-monthly-average/

5 https://scripps.ucsd.edu/programs/keelingcurve/

6 https://jacksonlab.stanford.edu/sites/default/files/nclimate3202.pdf

7 http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/uploads/global-status/1-0_4529_CCS_Global_Status_Book_layout-WAW_spreads.pdf

8 https://www.nature.com/articles/s41558-017-0045-1

9 https://energy.gov/sites/prod/files/2017/01/f34/Carbon%20Capture%2C%20Utilization%2C%20and%20Storage--Climate%20Change%2C%20Economic%20Competitiveness%2C%20and%20Energy%20Security_0.pdf

10 https://www.iea.org/topics/ccs/

11 https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

12 http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/uploads/global-status/1-0_4529_CCS_Global_Status_Book_layout-WAW_spreads.pdf

In the absence of a price on carbon (or equivalent policy measures), this scale of deployment of CCUS and CDR will not occur. For the U.S., the recent enactment of the expanded 45Q tax credit provides an alternative policy mechanism. The 45Q credit is a financial benefit for removing CO_2 from the environment rather than placing a charge on the CO_2 that is emitted to the environment, but the incentive effect is similar and the magnitude of the effect is comparable.[13,14,15,16] For example, in 2013, the Interagency Working Group on the Social Cost of Carbon (SCC) issued a Technical Support Document proposing a SCC of $36 (2007$) per metric ton of CO_2 effective in 2015.[17] In 2014, DOE used these values, adjusted to 2012$, to issue energy efficiency standards for commercial refrigeration equipment.[18] The adjusted value, at a 3% discount rate, was an SCC of $39.70 per ton for emissions in 2015.[19] The basis for the use of the SCC in assessing the benefits and costs of the standard was subsequently upheld in court.[20,21]

The U.S. has not acted to establish an overall carbon budget and some form of carbon charge or equivalent requirement to reduce emissions. In a carbon-constrained world, any stabilization target or climate goal defines a carbon budget, which limits allowable emissions at the same time it threatens existing assets.[22,23] Recent corporate shareholder votes are in part a response to this risk.[24] Mark Carney, Governor of the Bank of England, underscored this concern in a major address in September 2015:[25]

> "If that estimate [of the 2^{o}C climate budget] is even approximately correct it would render the vast majority of reserves 'stranded' — oil, gas and coal that will be literally unburnable without expensive carbon capture technology, which itself alters fossil fuel economics."

His statement specifically identified CCUS as an important option for continued use of fossil fuels in a carbon-constrained world, and one which could help shield global finance and the body public from shocks and dislocations in a transition to deep decarbonization. The new 45Q credits could provide a key path forward to simultaneously address the use of fossil fuels in a carbon-constrained future, as well as the pressing need for deep decarbonization options.

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13 https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html

14 https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf

15 https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf

16 https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing_FullReport.pdf

17 https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.

18 https://www.energy.gov/articles/new-energy-efficiency-standards-commercial-refrigeration-equipment-cut-businesses-energy

19 https://www.regulations.gov/document?D=EERE-2010-BT-STD-0003-0104

20 https://fas.org/sgp/crs/misc/carbon.pdf

21 https://www.eenews.net/stories/1060041382

22 https://www.earth-syst-sci-data-discuss.net/essd-2017-123/essd-2017-123.pdf

23 https://www.ipcc.ch/news_and_events/docs/COP20/LCAHLD.pdf

24 https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf

25 https://www.bankofengland.co.uk/-/media/boe/files/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability.pdf?la=en&hash=7C67E785651862457D99511147C7424FF5EA0C1A

INVESTMENTS IN CCUS TECHNOLOGY INNOVATION

The U.S. Department of Energy (DOE) Office of Fossil Energy has supported applied research projects for CCUS since 1997, which has helped the technology progress to its current state of commercial availability.[26] This effort featured the seven Regional Carbon Storage Partnerships, which have injected over 10 million tons of CO_2 through 19 small injection projects and eight large projects. The Office of Fossil Energy has also supported long-lived programs in pre- and post-combustion capture, in the development of advanced power cycles, and the National Risk Assessment Program, which provides quantitative tools to evaluate the probability and severity of CO_2 leakage for potential operators. In addition, DOE's Advanced Research Projects Agency-Energy (ARPA-E) has supported programs in advanced (transformational) CO_2 capture, and the Office of Science has supported three Energy Frontier Research Centers in CO_2 storage, CO_2 capture, and advanced materials.

There are significant opportunities to accelerate the pace of innovation in CCUS and CDR technologies. For example:

- As part of the U.S. commitment to Mission Innovation, the Obama Administration proposed to expand annual R&D invesments in CCUS and large-scale carbon removal from a baseline of $331M in FY 2017 to a level of $845M by FY 2021;
- Current studies are underway, including a National Academy of Sciences review, and a multi-university roadmapping effort organized by Arizona State University, to develop a more detailed R&D portfolio plan.

Current Deployment of Commercial-Scale CCUS Technologies

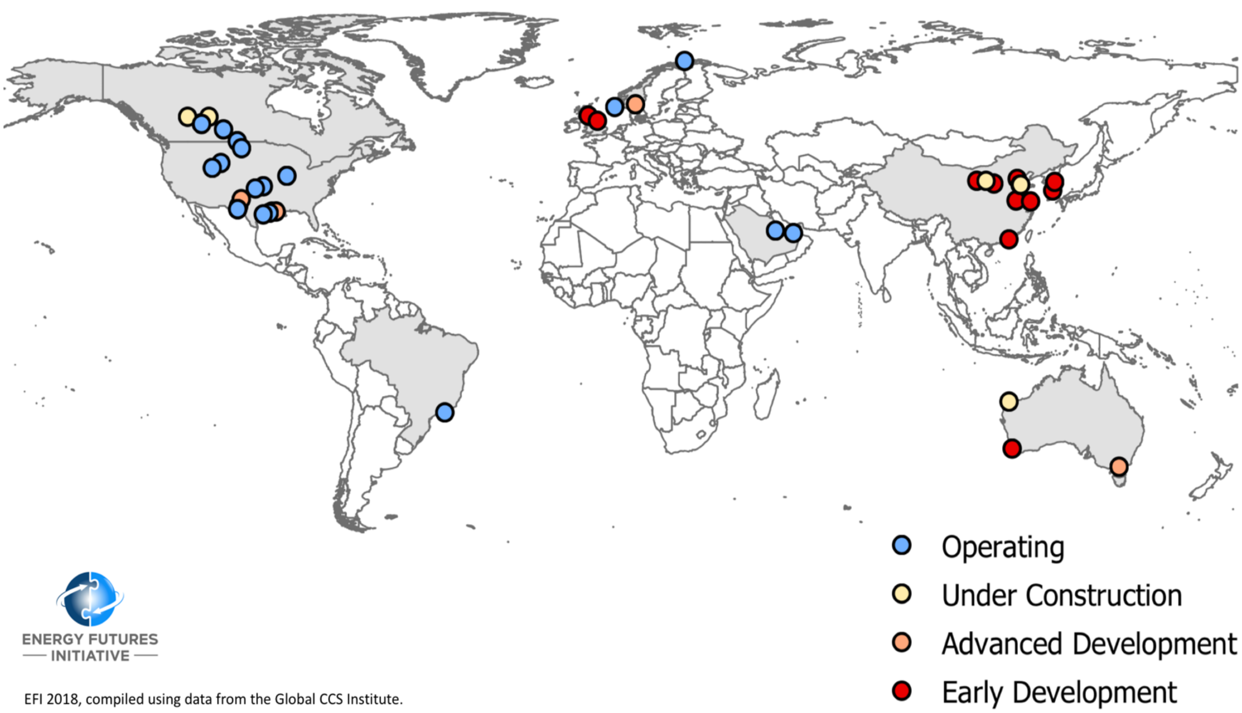
Moving innovations into the marketplace requires the alignment of many players, programs, and policies across the research, development, demonstration and deployment (RDD&D) spectrum. The innovation process itself tracks the RDD&D stages and helps define the science-to-product (or value chain improvement) evolution of ideas, knowledge, and capabilities, including the need to overcome potentially significant barriers along the way to commercialization. This process can be highly non-linear, and often involves a series of feedbacks initiated from learning by doing and using, which promotes continuous improvement from invention to diffusion.

A key element of a successful innovation process is the stage of initial commercial deployment. It is at this stage that operational reliability and durability is demonstrated, learning benefits are attained, and the technologies can be fully de-risked to attract private sector investment. Government policy incentives, in the form of time-limited tax incentives, can have a significant impact in successfully accelerating this process.

26 https://energy.gov/fe/science-innovation/carbon-capture-and-storage-research

The American Recovery and Reinvestment Act of 2009 (ARRA) provided $781 million lump sum funding to cost-share a series of commercial scale demonstrations of technologies for CCUS in both industrial and electric power generation application. This funding supported a total of four projects, all of which are currently in commercial operation. Including the ARRA investments, at present there are 17 large-scale CCUS facilities operating around the world, with another five under construction, four under advanced development, and 11 under early development (Figure 1).[27]

Figure 1.
Large-scale CCUS Facilities, February 2018



As of February 2018 there were 37 large-scale CCUS facilities either operating or in the construction or planning phase. North America currently holds global leadership in operating facilities, while most of the new facilities in the construction or planning phases are in the Asia-Pacific region.

The Evolution of the CCUS and CDR Tax Credits

The existence of incentives for initial commercial deployment, such as loan guarantees and tax credits, creates a virtuous circle in the innovation process as incentives, along with the new knowledge gained from initial deployments, can guide and encourage further innovation at earlier stages of the R&D

[27] https://www.globalccsinstitute.com/projects

cycle. The current state of CCUS technologies benefited not only from the sustained government investment in early stage and applied RD&D, but also from tax credits for the initial round of commercial deployments.

The CCUS tax credit, commonly referred to as the 45Q credit (Section 45Q of the Internal Revenue Code) originated nearly a decade ago in the Energy Improvement and Extension Act of 2008. As originally authorized, the credit was only available for two types of CCUS projects: $10 per metric ton of CO_2 that was captured and used for enhanced oil recovery (EOR), and; $20 per metric ton of CO_2 that was captured and sequestered in saline geological formations. Qualifying projects had to have sufficient scale to capture and store at least 500,000 metric tons of CO_2 during the taxable year. The original credit excluded CO_2 conversion projects other than EOR. The entire program was slated to expire when 75 million metric tons of CO_2 emissions had been claimed by the credit.

Early experience identified several issues with the original 45Q tax credit, including both its value level (too low to effectively mitigate project costs in the absence of a carbon price) and the financial uncertainty imposed by the project cap of 75 million metric tons of CO_2.[28,29] As of June 2015, the Internal Revenue Service reported that approximately 35 million metric tons of CO_2, almost half, had been claimed by 45Q.[30]

In 2015 and again in 2016, the Obama Administration proposed new tax authorities to address these shortcomings, including provisions similar to the FUTURE Act 45Q provisions. On July 13, 2016, Senators Heidi Heitkamp (D-ND) and Sheldon Whitehouse (D-RI) introduced Senate bill S.3179 “Carbon Capture Utilization and Storage Act” that sought to reform 45Q by expanding the eligibility for qualifying CCUS projects and providing greater certainty for project developers and financers. Congressman Mike Conaway (R-TX) introduced a related bill in the House with a different approach; his legislation would have created something similar to production tax credits for CCUS, where the product incentive flowed only to projects that reduced their carbon pollution through CCUS related technologies. No action was taken on either proposal by the 114th Congress.[31]

A similar bill was introduced in 2017. The S.1535 bill or “Furthering Carbon Capture, Utilization, Technology, Underground Storage, and Reduced Emissions Act” (FUTURE Act), was sponsored by Senators Heidi Heitkamp (D-ND), Sheldon Whitehouse (D-RI), Shelly Moore Capito (R-WV), and John Barrasso (R-WY). Again, Representative Conaway (R-TX) introduced a companion bill in the House. The proposed legislation would encourage innovation and adoption of low-carbon technologies related to CCUS, including novel uses for CO_2 in EOR and the creation of useable products.[32] The bill garnered widespread support from a diverse coalition of stakeholders including coal, oil and gas

28 https://www.heitkamp.senate.gov/public/_cache/files/7fe84fdc-f526-466d-aa83-4d3d392b0d3b/ccus-act-one-pager-115th-congress-.pdf

29 https://www.congress.gov/115/bills/s1535/BILLS-115s1535is.pdf

30 https://www.irs.gov/pub/irs-drop/n-15-44.pdf

31 https://www.govtrack.us/congress/bills/114/s3179

32 https://www.heitkamp.senate.gov/public/index.cfm/2017/7/heitkamp-whitehouse-capito-lead-bipartisan-coalition-to-reintroduce-bill-promoting-carbon-capture

companies, utilities, labor organizations, and environmental groups and was incorporated into the Bipartisan Budget Act of 2018, signed into law in February 2018.[33,34,35]

The revised 45Q credit includes provisions that:

- Provide a 10-year ramp from current values to the below cited values in 2026. Thereafter, the credits will increase indexed to inflation (See Figure 2 for more information);[36]
- Raise the current tax credit value for CO_2 that is captured and used for EOR or natural gas recovery, ramping to $35 per metric ton in 2026;
- Raise the current tax credit value for CO_2 that is captured and sequestered in saline geological formations to $50 per metric ton in 2026;
- Allow for many small projects to qualify for the utilization credit of $35 per metric ton credit in 2026 (use CO_2 for purposes other than EOR, e.g., conversion into useable products such as concrete, plastics, and chemicals);
- Establish direct air capture (DAC) of CO_2 as a qualifying source under 45Q;
- Establish eligibility criteria for projects:
    - Power generators must capture an annual minimum of 500,000 metric tons of CO_2;
    - Industrial plants and DAC plants must capture an annual minimum of 100,000 metric tons of CO_2;
    - Industrial pilot facilities must capture a minimum of 25,000 metric tons of CO_2;
    - Applies to new CCUS projects (including new CCUS retrofits of existing facilities) where construction begins before January 1, 2024 (Note: The U.S. Treasury will ultimately set the terms and conditions for what constitutes beginning and active construction).
- Ensure that qualified projects can claim the credit for 12 years, starting from the date the equipment was first placed into service;
- Eliminate the 75 million metric tons of CO_2 cap for projects entering service after date of enactment (current recipients of the 45Q credits remain capped); and

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33 https://www.heitkamp.senate.gov/public/index.cfm/2018/2/heitkamp-capito-whitehouse-barrasso-announce-bipartisan-carbon-capture-technology-bill-signed-in-to-law

34 https://www.heitkamp.senate.gov/public/_cache/files/5d299cce-c3f5-48cd-b22c-39b8addab92d/7-12-future-act-supporters-115th-congress-.pdf

35 https://www.heitkamp.senate.gov/public/_cache/files/c733f03c-0c50-4131-b8fe-f61f81953d2f/7-12-future-act-statements-of-support-115th-congress-.pdf

36 https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html

- Allow the tax credit to be transferred from upstream carbon capture equipment owners to those involved with downstream operations such as sequestering the carbon in geological formations, using it for EOR, or using it for conversion into usable products.

The incentive effect of the 45Q tax credit can be further leveraged by combining the tax credit with the DOE Title XVII Loan Guarantee Program. The LPO is authorized to issue loan guarantees to the initial set of commercial projects deploying innovative technologies, including advanced fossil energy projects employing CCUS. Applicants can combine the loan guarantee with federal tax credits such as the 45Q credit. The expanded credits could improve both the size and the certainty of project revenue streams, enhancing the creditworthiness of projects and ability to secure LPO-guaranteed debt financing and private sector equity investment.

Figure 2.

Tax Credit Value Available for Different Sources and Uses of CO_2

	Minimum Size of Eligible Carbon Capture Plant by Type ($ktCO_2$/yr)			Relevant Level of Tax Credit in a Given Operational Year ($USD/$tCO_2$)									
Type of CO_2 Storage/Use	Power Plant	Other Industrial Facility	Direct Air Capture	2018	2019	2020	2021	2022	2023	2024	2025	2026	Beyond 2026
Dedicated Geological Storage	500	100	100	28	31	34	36	39	42	45	47	50	Indexed to Inflation
Storage via EOR	500	100	100	17	19	22	24	26	28	31	33	35	Indexed to Inflation
Other Utilization Processes[1]	25	25	25	17[2]	19	22	24	26	28	31	33	35	Indexed to Inflation

[1] Each CO_2 source cannot be greater than 500 $ktCO_2$/yr

[2] Any credit will only apply to the portion of the converted CO_2 that can be shown to reduce overall emissions

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Source: Closely adapted from Simon Bennett and Tristan Stanley, Commentary: US budget bill may help carbon capture get back on track, International Energy Agency.

OPPORTUNITIES FOR APPLYING 45Q TO LARGE SCALE CARBON MANAGEMENT PROJECTS

Passage of the 45Q tax credit expansions creates opportunities to expand deployment of CCUS. The three major application areas are industrial CCUS, power generation CCUS and various forms of CDR.

Industrial CCUS Applications

Industrial facilities are likely to be the initial focus of project activity. For industry and manufacturing, CCUS is a critical pathway to GHG emissions reduction in that currently there are few alternative options. Heavy industry accounts for an estimated 21 percent of total GHG emissions in the United States, and represent a major challenge to reducing CO_2 emissions.[37,38] At present there are 29 million tons of CO_2 captured globally from major industrial sources, 87 percent of which is used for EOR. Of these EOR projects, 78 percent are located in the United States.[39] Industrial applications where CCUS could accomplish significant emissions reductions include the production of upstream oil and gas, cement, iron and steel, refining, petrochemicals, and fertilizers.[40]

Some industrial sites have streams of CO_2 that are highly concentrated and can be captured and stored for relatively low cost (estimates range from $20-35 per ton). Many of these sites lie within 100 miles of an existing CO_2 pipeline, EOR opportunities, or viable saline formation storage resources (Figure 3).[41,42,43] DOE estimates the potential CO_2 emissions reduction from these sites alone to be 43 million tons per year for saline formations, with a 32 million ton per year subset of those suitable for EOR consideration.

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37 http://mission-innovation.net/wp-content/uploads/2016/11/Carbon-capture-innovation-challenge.pdf

38 https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

39 https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html

40 http://mission-innovation.net/wp-content/uploads/2016/11/Carbon-capture-innovation-challenge.pdf

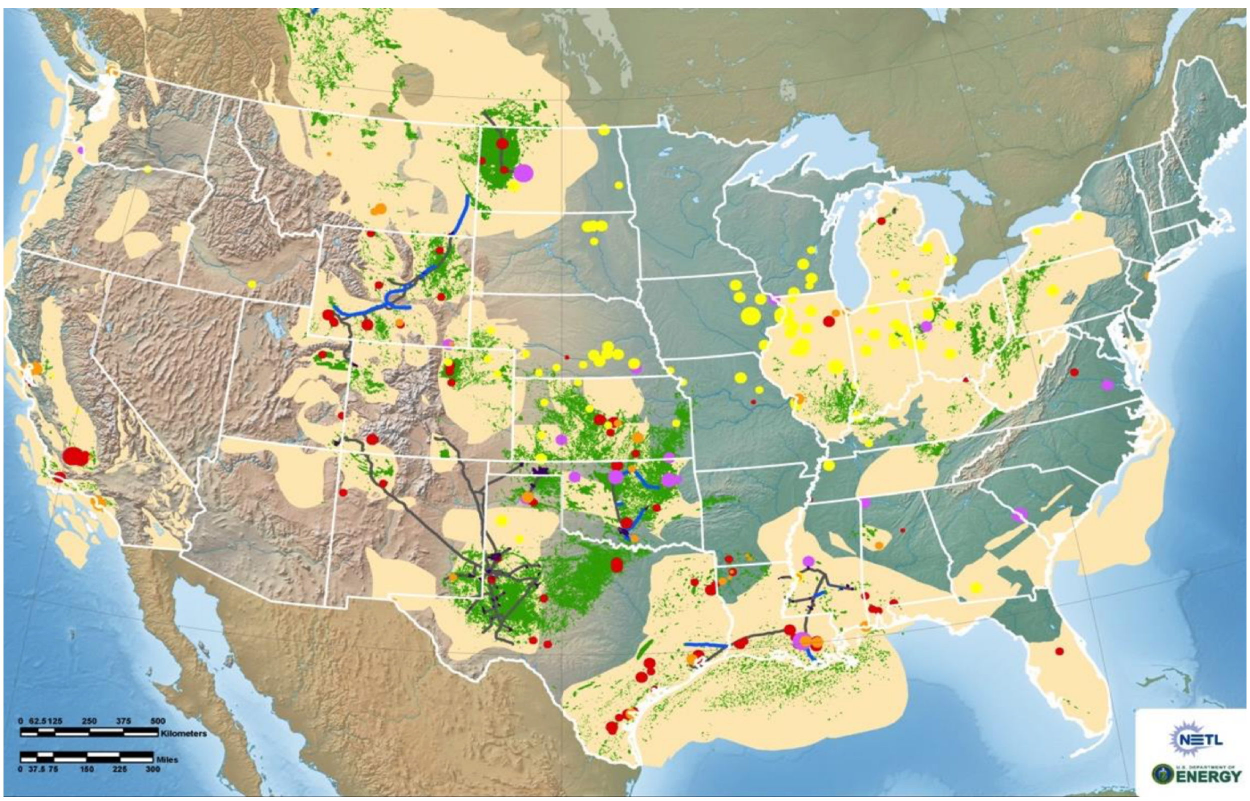
41 http://www.natcarbviewer.com

42 http://www.betterenergy.org/sites/default/files/White_Paper_21st_Century_Infrastructure_CO2_Pipelines_0.pdf

43 https://www.epw.senate.gov/public/_cache/files/e/a/eae08931-a714-434e-84f0-6a2edcebfc0e/BAC13A21C743DCE907756A4A3EFA9C49.friedmann-testimony-09.13.2017.pdf

Decarbonizing U.S. industry and associated manufacturing will have long-lasting implications in the carbon-constrained global economy following the Paris Agreement. American manufacturing continues to serve as an important engine of the U.S. economy. U.S. manufacturers produce around 17.5 percent of the total share of globally manufactured goods (second only to China), and manufacturing contributes approximately $2.1 trillion (12 percent of GDP) to the U.S. economy.[44] However, the U.S. has witnessed a significant decline in manufacturing jobs in the last several decades, which fell from 18.9 million in 1980 to 12.2 million in 2014.[45] CCUS could create new market opportunities and revenue streams for manufacturing companies by capturing and selling CO2 for EOR or other novel processes that use the gas at appreciable scale.

Figure 3.
Opportunities for Rapid Large-scale Carbon Management in U.S. Heavy Industry



Opportunities for rapid large-scale carbon management in U.S. heavy industry. The green fields represent oil fields suitable for EOR, while the beige zones represent saline formations that may serve as storage sites. Yellow circles = ethanol plants, orange circles = refineries, purple circles = chemical plants, and red circles = petroleum operations. Black lines represent existing CO2 pipelines, and blue lines represent proposed extensions. Source: Testimony to the Senate Environment & Public Works Committee, Expanding and Accelerating the Deployment and Use of Carbon Capture, Utilization, and Sequestration

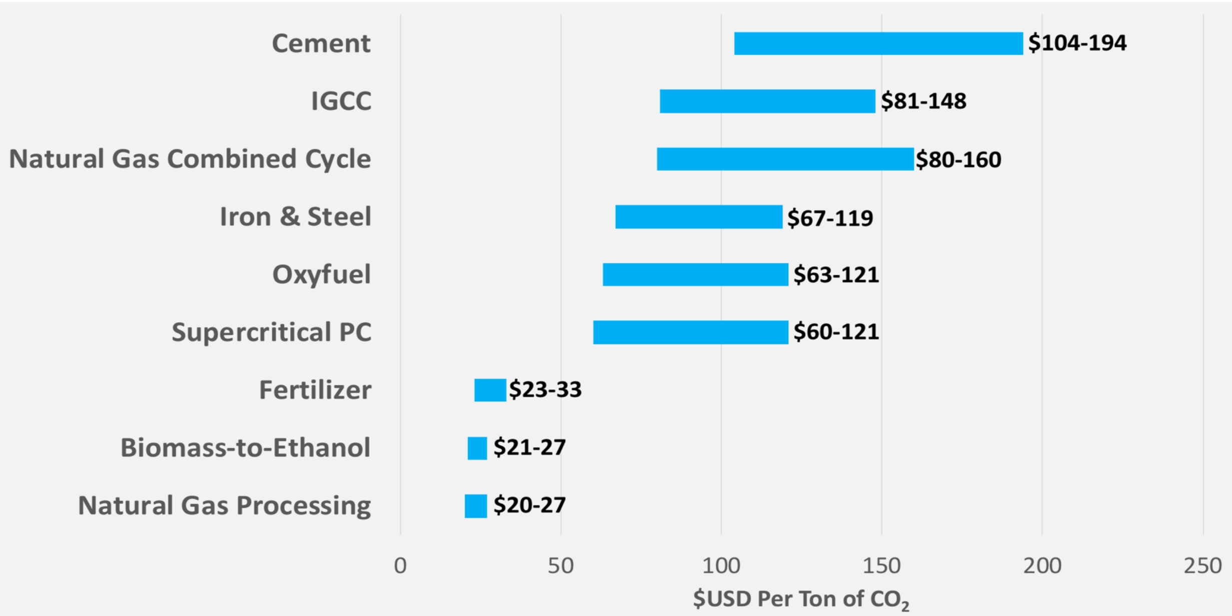
44 https://energy.gov/sites/prod/files/2017/01/f34/Carbon%20Capture%2C%20Utilization%2C%20and%20Storage--Climate%20Change%2C%20Economic%20Competitiveness%2C%20and%20Energy%20Security_0.pdf

45 https://www.brookings.edu/blog/the-avenue/2016/03/15/voter-anger-explained-in-one-chart/

The costs of CCUS chiefly vary by the kind of facility where capture originates,[46,47,48] with the range of costs dependent on location, plant design, capture technology selection, drilling and compression costs, and cost of capital. Figure 4 illustrates the first-of-a-kind cost ranges associated with different classes of industrial and power facilities.[49] These costs are similar to those from other studies.[50,51] Many operators indicate that the second project of the same kind can achieve operating cost reductions of 20 to 30 percent.[52]

Figure 4.

Estimated and Measured First-of-a-Kind Costs for CCS Applied to Different Plants



Source: Adapted from the Global CCS Institute, 2017. EFI, 2018.

The costs of implementing CCS technologies can vary considerably across different plant types, technology mix, and geographies in the power and industrial sectors. These costs are for new-build systems and retrofits with current technology, and include capture, compression, transportation, and storage costs. They do not include revenues from EOR or utilization. Source: Global CCS Institute, The Global Status of CCS: 2017

Not surprisingly, those facilities that produce a pure stream of CO2 – ethanol, petrochemical, ammonia, and natural gas processing – are the most likely candidates for projects (see Figure 3).[53]

46 http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/uploads/global-status/1-0_4529_CCS_Global_Status_Book_layout-WAW_spreads.pdf

47 https://www.iea.org/media/workshops/2012/ccsmexico/3IMcCoy.pdf

48 http://hub.globalccsinstitute.com/sites/default/files/publications/201688/global-ccs-cost-updatev4.pdf

49 http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/uploads/global-status/1-0_4529_CCS_Global_Status_Book_layout-WAW_spreads.pdf

50 https://www.cmu.edu/epp/iecm/rubin/PDF%20files/2015/Rubin_et_al_ThecostofCCS_IJGGC_2015.pdf

51 https://www.energy.gov/sites/prod/files/2017/01/f34/Carbon%20Capture%2C%20Utilization%2C%20and%20Storage--Climate%20Change%2C%20Economic%20Competitiveness%2C%20and%20Energy%20Security_0.pdf

52 http://www.rff.org/files/document/file/RFF-May24-CCUS%20event%20summary.pdf

53 http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/uploads/global-status/1-0_4529_CCS_Global_Status_Book_layout-WAW_spreads.pdf

At $50 per ton for saline formation storage and $35 per ton for EOR and carbon-to-value (C2V), the expanded 45Q tax credits provide substantially higher revenues during the first 12 project years of operation than the estimated costs of retrofitting those plants for CCUS.

Ethanol plants: Most ethanol plants in the U.S. lie near excellent potential and assessed CO_2 storage sites. Some of these facilities have EOR opportunities but many do not, suggesting saline storage as a preferred business model. Ethanol projects would have additional pathways for financing beyond 45Q, including collecting renewable identification numbers (RINS) under the Renewable Fuel Standard and tradable credits under the Low Carbon Fuel Standard in California. These attributes suggest that ethanol plants will be among the first facilities to pursue active carbon management through CCUS. The Archer-Daniels Midland plant in Decatur, IL (Figure 5) already captures and stores its byproduct CO_2, providing an operational model for these plants.

Fertilizer and petrochemicals: These facilities require large volumes of hydrogen as a feedstock. That hydrogen commonly comes from steam-methane reforming of natural gas, which produces a near-pure stream of CO_2. The low cost of capture and compression for these streams, most of which lie near good storage sites, suggest early adoption of CCUS. The Air Products project in Port Arthur, TX (Figure 5) and Coffeeville Refinery in Enid, Kansas already capture and store their CO_2, providing operational models for future projects.

CCUS Applications for Power Generation

In the power sector, CCUS is one of the only technologies that can mitigate emissions from coal- and gas-fired generators. U.S. coal plants are relatively older than the rest of the generation fleet, with 88 percent of coal-fired capacity having been built between 1950 and 1990. As such, the capacity-weighted average of operating coal plants is 39 years,[54] which is roughly 10 years older than the overall age of the gas-fired generation fleet across North America.[55] The opportunity to retrofit existing coal- or gas-fired power plants with CCUS can provide a critical strategy for decreasing power sector emissions. A recent IEA analysis stated that any power sector CCUS project stimulated by the passage of the FUTURE Act would not be expected to come online until the 2025-2030 timeframe and that such power sector CCUS projects, even at the full credit value, would be limited in number without additional supportive policy measures.[56]

DOE estimates suggest that tens of millions of tons from many thousands of megawatts generation could host CCUS projects under the new 45Q provisions.[57] Given the costs for CCUS retrofits, however, it is unclear how many coal or gas plants might be viable sites for future CCUS projects. A recent University of Texas analysis of 45Q and its potential impacts on the economics of natural gas combined cycle (NGCC) and coal power plants with or without CCS suggested that whether plants equipped with CCS are economical hinged on their ability to obtain long-term

[54] https://www.eia.gov/todayinenergy/detail.php?id=30812
[55] https://www.nerc.com/pa/rapa/pa/performance%20analysis%20dl/2016_sor_report_final_v1.pdf
[56] https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html
[57] https://www.energy.gov/sites/prod/files/2017/01/f34/Carbon%20Capture%2C%20Utilization%2C%20and%20Storage--Climate%20Change%2C%20Economic%20Competitiveness%2C%20and%20Energy%20Security_0.pdf

financial compensation for selling CO_2 for EOR. The analysis suggested that coal plants could be competitive with regular NGCC plants today if they could sell the captured CO_2 (90 percent capture rate) for EOR at an average rate of $15 per ton over the lifetime of the plant, and also claim the $35 per ton tax credit for 12 years. Over the same timeframe and with the same credits, NGCC with CCS could be competitive with NGCC without CCS if the plant were able to sell the captured CO_2 (90 percent capture rate) for EOR.[58,59] An additional analysis identified 27 power plants (nine coal plants and eighteen NGCC plants) located within 10 miles of CO_2 pipelines. These 27 plants, if retrofitted with CCS at a 90 percent capture rate, could collectively avoid one gigaton of CO_2 emissions during the span of the 12-year tax credit.[60,61]

While these analyses suggest that there are opportunities for coal and NGCC generation with CCS to be cost competitive, owners and investors will need confidence that these facilities could continue to remain cost competitive over the period of time required for capital recovery. In states with regulated markets, the willingness of Public Utility Commissions to pass through the costs of CCS in rates throughout the capital recovery period will be an important consideration. In states and regions with organized markets, time periods for capital recovery are much longer than forward capacity market commitment periods. Owners will need confidence that they can continue to bid successfully into those markets over the entire capital recovery period. Prospects for future carbon charges will increase investor willingness to deploy CCUS.

Natural gas generation: On a strict cost basis, natural gas power generators (either single- or combined-cycle) would seem unlikely candidates for CCUS. Although the first-generation capture technologies have shown to be a viable technology that can be scaled commercially, cost barriers would require additional financial incentives or revenue streams.[62] However, the low price of natural gas and the increased integration of natural gas power to balance variable renewable power may require some states and regions to consider additional financial or rate-structure support for natural gas CCUS projects.

Most capture technologies have very low tolerance for sulfur or particulate pollution. This provides some advantage to most gas power plants, which have very low pollution profiles. In addition, some advanced technologies designed for natural gas power systems could have lower costs (see below). Assessed together, it is hard to estimate the number of gas plants that may choose to pursue the expanded tax credits. Additional RD&D on technology enhancents to reduce the cost of carbon capture technology for NGCC plants may be needed to facilitate deployment of natural gas CCUS systems.

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58 https://utexas.app.box.com/s/5lug4gox3hp6bjglx9lkmhzlz64fgr5e

59 https://docs.google.com/spreadsheets/d/1UpbRk9FaRf-54Err5SlUDzxA1Fqrdakc0HHGfsf8zik/edit#gid=1663842444

60 https://www.forbes.com/sites/joshuarhodes/2018/04/19/how-clean-coal-could-make-a-tidy-profit/#49cb75456545

61 https://docs.google.com/spreadsheets/d/1NCpheKYO7FDLxWmtkUhfA4DhuFVNMtOgZG_bnCv40hM/edit#gid=590236025

62 https://www.energy.gov/sites/prod/files/2017/01/f34/Carbon%20Capture%20Opportunities%20for%20Natural%20Gas%20Fired%20Power%20Systems_0.pdf

Coal generation: Many factors affect the cost and performance of CCUS on coal plant retrofits. This includes the vintage of the plant, its design, its heat rate, and availability of CO_2 transport infrastruture. Additional concerns include available space, water resource adequacy, proximity of storage resources, and even altitude. Given these factors, and on a pure cost basis, most coal plants do not appear suitable for CCUS retrofits. In the U.S., most plants have sub-critical boilers – their low efficiency challenges the economics of capture. Also, any potential plant must already have advanced sulfur and particulate pollution controls to avoid fouling of the capture technology.

It is likely that only the most efficient, youngest, and lowest polluting coal plants will be viable candidates for CCUS projects. For example, a typical 500 MW supercritical coal plant burning bituminous coal, and operating at an 80 percent capacity factor, emits approximately 2.8 million tons of CO_2 per year. If retrofitted for a 90 percent capture rate, a single unit coming online after 2026 could accrue tax credit revenues of about $125 million each of 12 years for saline formation storage. The same unit could collect about $90 million of credits for EOR application, plus the additional revenues from CO_2 sales (commonly $15-25 per ton CO_2, or an additional $40-70 million). The PetraNova Project in Houston, TX (Figure 5) provides an operational model for future projects.

Advanced technology costs: The cost data in Figure 4 do not reflect potential cost reductions that may be achievable with advanced power and carbon capture technologies. A number of companies claim to have novel materials and systems of solvents, sorbents, and membranes with all-in costs 30 to 60 percent lower than those in Figure 4. In addition, new power cycles (e.g., the Allam cycle or chemical looping) claim market prices for integrated power plus CCUS that are even lower. While there is significant uncertainty regarding the cost reduction potential of advanced technologies, it is clear that the expanded 45Q tax credits provide a specific market

Figure 5.
Selection of Operating CCS Plants in the United States

Photos of the Archer Daniels Midland project (left), Port Arthur project (center), and Petro Nova project (right). The Archer Daniels Midland project can store roughly 1 million tons of CO_2 per year in the Mt. Simon Sandstone, Illinois Basin, which has an estimated storage potential of over 250 million tons of CO_2 per year.[1] In October 2017, DOE reported that Port Arthur had captured and transported its 4-millionth metric ton of CO_2,[2] while Petra Nova had captured more than 1 million tons of CO_2 used for EOR.[3] Note: As existing projects, these facilities are not eligible for the expanded 45Q credits. Source: Images from U.S. Department of Energy.

[1] https://www.energy.gov/fe/articles/doe-announces-major-milestone-reached-illinois-industrial-ccs-project

[2] https://www.energy.gov/fe/articles/doe-supported-co2-capture-project-hits-major-milestone-4-million-metric-tons

[3] https://www.energy.gov/fe/articles/doe-supported-petra-nova-captures-more-1-million-tons-co2

incentive to accelerate the deployment of advanced technology and to balance the technology risk with the value of the credit.

Finally, combining CCUS with biomass-fired power plants offers a unique opportunity in that CO_2 removal may provide both energy and "negative emissions" services. Today, only one large-scale commercial facility, the Illinois Basin Decatur Project, combines CCUS with biomass energy production.[63] If biomass power stations in the U.S. host future CCUS projects, they may result in a net drawdown of CO_2 from the air, providing early demonstration of bioenergy with CCS (BECCS) likely needed to achieve the Paris goals.[64]

Carbon Dioxide Removal (CDR) Applications

The current cost of CDR applications, such as DAC, reportedly range from $300-600 per ton CO_2, significantly higher than the value of the expanded 45Q credits. While most observers believe that the cost of DAC can be significantly reduced over time with continued innovation, it is very uncertain whether DAC will become economically viable (with the 45Q credits) within the current statutory timeframe for eligibility.

Estimates of the Scale of 45Q Tax Expenditures

Based on the range of factors described above, it is reasonable to believe that many industrial projects, some natural gas and coal power projects, and some advanced fossil energy projects will begin construction before January 2024 and become eligible to receive the 45Q credits – an estimate as large as 100 million tons per year of CO_2. If so, the U.S. Treasury would provide between $3.5 and $5 billion per year of tax credits starting in 2025. Although this may seem large, it is roughly equivalent to the wind production tax credits, which the Joint Committee on Taxation assessed to be $23.7 billion over 5 years (2016-2020).[65] Other estimates suggest that the revamped 45Q credits could lead to $1 billion in new investments by 2024 and add 10 to 30 million tons of additional CO_2 capture capacity, increasing total global capture by up to two-thirds.[66,67]

63 https://www.iea.org/publications/freepublications/publication/20YearsofCarbonCaptureandStorage_WEB.pdf

64 http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf

65 Joint Committee on Taxation, annual tax expenditure tables, https://www.jct.gov/publications.html?func=select&id=5

66 https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html

67 http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/uploads/global-status/1-0_4529_CCS_Global_Status_Book_layout-WAW_spreads.pdf

MAKING 45Q CREDIT MORE EFFECTIVE AND EFFICIENT

Although the tax credits provide substantial incentives for CCUS, additional challenges may limit the magnitude of deployment. Many believe that a more comprehensive approach has merit.[68] Indeed, the comprehensive approach for policy support proved effective for renewable entry into power markets, and included tax credits, portfolio standards, feed-in tariffs, renewable energy certificates (RECS), investment in innovation, loan guarantees, net metering, and preferred loading priority. All of these helped bring wind and solar into power markets -- an equally comprehensive approach is currently being debated for the role of bulk power storage and batteries in power markets.

The 45Q credits could be made even more effective through additional policy measures or actions by companies and investors to address these issues. Additional analysis on this set of issues would provide insight into what steps might make the most difference to accelerate and expand CCUS deployment. However, the timeline to start construction is less than six years away – companies, states, and investors need to work quickly to bring projects to a point where construction can start.

Assessment of CO_2 storage resources

While some storage resources are well characterized (e.g., depleted oil and gas fields), many are not. The DOE's Carbon Storage Atlases provide some indication of where storage is possible, but are not the same as assessed or qualified sites. On that basis, Congress approved funding for the CarbonSAFE program, which provides block grants to local entities for CO_2 storage assessment. Those locations with well-characterized CO_2 storage resources will be advantaged in deployment.

Expansion of CO_2 Pipeline Infrastructure

Over 4,500 miles of pipeline transport CO_2 in the U.S. today.[69] The majority of these pipelines are common carrier networks, and most are operating at or near full capacity. To the extent that new CCUS projects can access existing CO_2 transportation infrastructure, it would greatly facilitate the ability of new CCUS projects to come online, and simplify the ability of carbon storage companies to aggregate services. The existing pipeline routes would become attractive for siting industrial carbon capture projects by de-risking future carbon management obligations. Otherwise, the absence of CO_2 pipelines will limit the ability of plants, companies, and states to take advantage of the expanded tax credits. This point was highlighted in the DOE's 2015 Quadrennial Energy Review,[70] which recommended incentives to build and operate new CO_2 pipelines.

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68 https://www.epw.senate.gov/public/_cache/files/6/b/6b085a12-ba1e-4233-9964-332de6849e6a/D4A31A1B8F439FF510518404B48F9E47.spw-041118.pdf

69 https://fas.org/sgp/crs/misc/R44902.pdf

70 https://www.energy.gov/policy/downloads/quadrennial-energy-review-first-installment

Regulation and Permitting

Once captured, CO_2 can be disposed by underground injection into either oilfields (to facilitate enhanced oil recovery - EOR) or into geological formations such as saline aquifers. CO_2 oilfield injection wells for EOR have decades of practice, while CO_2 injection wells for geologic storage are relatively new. CO_2 injection wells are regulated under the federal Safe Drinking Water Act (Underground Injection Control Program), with oilfield injection wells regulated under Class II of the program and geologic injection wells regulated as Class VI. The Class II program is administered through permits issued by the states (with thousands of total permits issued[71]); while the Class VI program is relatively new[72] (to date EPA has issued only one Class VI permit, and has qualified only one state to issue Class VI well permits). Operators of CO_2 injection wells also are subject to monitoring, reporting and verification (MRV) requirements established as part of the EPA Greenhouse Gas Reporting rule. Currently, Class II EOR wells injecting naturally-occurring CO_2 are subject to the sub-part RR MRV requirements; captured anthropogenic CO_2 for Class II EOR wells and all Class VI injection wells are subject to more extensive MRV requirements under sub-part UU. The relative newness of some of these regulatory constructs, particularly the distinction between the purposes of CO_2 subsurface injection into oilfields, will affect the rate and magnitude of deployment.

Permitting of new CO_2 pipeline infrastructure also poses challenges for new CCUS projects that cannot access current pipelines. The principal issues include obtaining rights-of-way and working with various federal and state permitting authorities that have jurisdiction over some aspect of the project. Regulatory uncertainty may limit project financing and slow efforts to deploy, potentially limiting the total number of projects and regions where CCUS can enter commercial markets. Recent policy proposals such as the USE IT Act are attempts to highlight this issue and ideally identify potential improvements to regulatory and permitting operation.[73]

Finally, the issue of regulatory requirements, if any, for CO_2 conversion and utilization (other than EOR) have yet to be addressed. Whether such projects will be subject to special permitting requirements (including MRV) likely will need to be determined on a case-by-case basis.

Long-term Post-Injection Monitoring and Liability

A common concern raised regarding commercial CCUS is the long-term stewardship of injected CO_2. Although the assignment of liability during operation is straightforward, it is less so after injection has completed. A number of states have already accepted long-term liability for some set of projects, notably Illinois and Texas.[74] Many different models and levels of obligation have

71 71 https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells

72 72 https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-co2

73 https://www.epw.senate.gov/public/_cache/files/0/f/0fd32eef-de44-4737-8453-5ff966ece095/4325D95E20EDABD6DA299ADEA7FA6745.use-it-act.pdf

74 https://www.energy.gov/sites/prod/files/2017/01/f34/Workshop%20Report--Siting%20and%20Regulating%20Carbon%20Capture%2C%20Utilization%20and%20Storage%20Infrastructure.pdf

been proposed for both the monitoring obligations of operators after injection is completed and mechanism for release or transfer of liability.[75,76,77]

Although most studies recognize that the risks are very low (both low probability and low consequence), questions about long-term obligations for long-term post-injection site monitoring could impede CCUS deployment; this could be problematic when operators lease subsurface rights and must make separate arrangements with landowners to conduct post-injection MRV activities. Long-term post-injection management could be organized through new institutional arrangements ranging from an industry-led voluntary agreement or a statutory risk-sharing initiative. Financial support could be organized in a fund (not unlike the Oil Spill Liability Trust Fund) financed by a small fraction of the 45Q credit value. A backstop mechanism to address long-term post-injection MRV would provide additional assurance that the 45Q credit results in permanent carbon removal from the environment, while providing greater certainty for private sector business models to proceed with CCUS projects.

Carbon Accounting and Registry

In many cases, accounting for CO_2 emissions avoided by a CCUS project is straightforward. In contrast, exchanges and registries are limited today, and do not have experience with CCUS. Given successful monitoring and successful structuring of tax credit exchanges, some kind of carbon registry is a likely product of the operation of many projects nationwide. The specifics of such a registry are unclear. However, blockchain technology may be a good approach to managing such a registry. Such a platform could help provide value for CCUS projects, whether the CO_2 be captured from point sources or removed from the atmosphere through direct air capture. The blockchain could thus serve as a verification method for the captured CO_2 and facilitate the transaction between suppliers and buyers. One new blockchain company, Nori, seeks to facilitate a carbon removal marketplace where suppliers who remove CO_2 from the atmosphere can connect with buyers who want to purchase verified carbon removal certificates.[78]

New CO_2 Storage Business Models

Most industrial and power plant operators lack the knowledge and ability to execute a large-scale CO_2 injection and monitoring program. To receive the expanded tax credits, they will likely partner with CO_2 services companies. Potential partners may be traditional oil and gas companies with CO_2 EOR experience (e.g., Occidental Petroleum, Denbury), traditional oil and gas service companies (e.g., Schlumberger, Baker Hughes), or new entities willing to shoulder the operational and post-operational responsibilities. They may also be CO_2 pipeline companies (e.g., Kinder-Morgan). The speed at which these large-scale carbon management service companies can enter the market will affect how quickly and how many projects will deploy.

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75 http://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=1645&context=wmelpr

76 https://link.springer.com/article/10.1007/s11053-016-9303-6

77 https://www.researchgate.net/publication/281407845_Legal_and_Regulatory_Developments_on_CCS

78 https://nori.com

Complementary and Alternative Financing Sources

The incentive effect of the 45Q tax credit can be amplified if coupled with financing incentives. One such approach is the combination of the tax credit with the DOE Title XVII Loan Guarantee Program. Another approach is to couple the tax credit with Private Activity Bonds (as proposed by Senators Portman [R-OH] & Bennett [D-CO])[79] or state incentives such as Green Bank financing. Authorization to expand eligibility under Master Limited Partnerships (as proposed by Senator Coons [D-DE])[80] could provide an alternative source of incentives that may be more appropriate to certain types of projects. Additional analysis on the impact of such policies would help assess the merits of these complementary financing approaches.

Accelerated R&D Program to Maximize Near-Term Deployment Opportunities

DOE-supported R&D on carbon capture technologies has been an important contributing factor to achieving cost reductions in CCS from more than $100 per t$CO_2$ in 2005 to approximately $60 per t$CO_2$ at present.[81] Further reductions in the cost of carbon capture technology will enable greater participation in the 45Q program, especially if combined with other enhancements discussed in this paper. The time window for further innovation, however, is limited, as qualifying projects must commence construction by January 1, 2024. Deployment of CCS technologies can achieve cost reductions from first-of-a-kind technologies by as much as 30 percent in the power sector and 17 percent in the industrial sector.[82] Additional cost reductions are potentially feasible through expanded R&D. An accelerated, time-limited R&D program that is targeted for 3-5 years and funds a suite of projects will help further reduce costs, improve technology performance, and decrease technical risks for CCS project developers.

Public Acceptance

Some parts of the U.S. are familiar with injection and production of subsurface fluids. In these areas, overall acceptance of CCUS may prove straightforward, and even favored as a source of new jobs, revenues, and industries. Conversely, those regions with limited familiarity may find public acceptance difficult. In the past, some sites and jurisdictions found major public opposition to projects,[83] which were ultimately abandoned. While some evidence shows that careful outreach to public stakeholders can overcome questions,[84] doubts, and barriers (and ultimately win acceptance for projects), the heterogeneity of public response may well limit the viability of projects despite strong economic benefits.

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79 https://www.congress.gov/115/bills/s843/BILLS-115s843is.pdf

80 80 https://www.congress.gov/115/bills/s2005/BILLS-115s2005is.pdf

81 http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/uploads/global-status/1-0_4529_CCS_Global_Status_Book_layout-WAW_spreads.pdf

82 https://hub.globalccsinstitute.com/sites/default/files/publications/201688/global-ccs-cost-updatev4.pdf

83 https://www.energy.gov/sites/prod/files/2017/01/f34/Workshop%20Report--Siting%20and%20Regulating%20Carbon%20Capture%2C%20Utilization%20and%20Storage%20Infrastructure.pdf

84 https://fas.org/sgp/crs/misc/RL34601.pdf

CONCLUSION: IMPLICATION FOR THE U.S. AND GLOBAL ENERGY SECTORS

With passage of the 45Q expansion, the U.S. can establish itself as the global leader in the emerging field of large-scale carbon management as well as the preferred location for investment in CCUS, DAC, CO_2 utilization such as C2V, and other carbon management businesses and industries.

Enhances ability to achieve U.S. Paris commitments: The U.S. commitment to the Paris Agreement , prior to June of last year[85], was to reduce CO_2 emissions in 2030 by 26-28 percent from a 2005 baseline (it should be noted that formal withdrawal from the Paris Agreement cannot be final until November, 2020). Most analyses conclude that additional measures beyond 2017 policy are needed to achieve these goals. A number of states, cities and other local governments are continuing efforts to contribute to the U.S. Paris commitment, and although not a substitute for the U.S. NDC, the new 45Q provisions have the potential to achieve CO_2 reductions of tens to hundreds of megatons of CO_2 per year.

Provides a policy model: In 2014, 24 countries including the U.S. signed a Communique from the Carbon Sequestration Leadership Forum Ministerial meeting in Saudi Arabia, calling for additional policy measures to support CCUS deployment. The passage of 45Q expansion provides a policy model that other countries can consider in increasing their own ambitions or in achieving their 2030 Paris commitments.

Supports U.S. competitiveness in key markets: If the U.S. succeeds in deploying many new-build and retrofit CCUS projects, it will clearly establish itself as the global leader in carbon capture and storage, carbon conversion to value-added products, and low-carbon manufacturing. U.S. manufacturers of carbon capture heavy equipment will have early opportunities for deployment, providing a key export technology in a carbon-constrained world. U.S. practitioners of CCUS will set the global standard for large-scale carbon management, creating an opportunity for American companies. Application of CCUS to U.S. heavy industry would also shield many U.S. companies from carbon tariffs imposed by other countries.

Attracts increased private investment: Like the wind production tax credit (originated in 1992), the expanded 45Q credits provide greater certainty of revenue streams to companies that capture and store CO_2. Since the viability of project financing greatly increases, new commercial projects will advance, bringing private capital into these markets. This is likely to create construction and full-time operational jobs, additional tax revenues to states and regions, and bring new foreign direct investment into the United States. Since the projects will be local, the

85 https://www.gpo.gov/fdsys/pkg/DCPD-201700373/pdf/DCPD-201700373.pdf

commercial opportunities may stimulate regional innovation and be “place-based” as well. This will also create or expand existing tax credit exchanges as well, since many facility operators may not have sufficient tax appetite to make use of these credits themselves.

Encourages R&D investment and innovation: The new provisions establish a viable market for large-scale carbon management technologies and services. As that market grows, private investment will flow from corporate R&D centers, venture capital firms, and other sources as has happened for other clean energy technologies. These may further stimulate and create opportunities for public/private partnerships with the DOE Office of Fossil Energy and ARPA-E. In addition, innovation through deployment (learning by doing) will reduce costs and improve performance, providing improved competitiveness for the U.S. in global markets.

Reduces risk of stranded assets: Concern for the financial risk posed by stranded fossil assets in a carbon-limited economy has led recent shareholder votes for greater transparency in corporate climate planning and asset risk assessment. Since CCUS approaches can provide deep carbon reduction from fossil-fueled systems, the deployment of projects into U.S. energy infrastructure should reduce the risk of both stranded resource assets and early capital plant retirement. Ultimately, since it is possible to produce and use some fossil fuels with very low emissions, it may allow for continued investment in and expansion of these assets.

Moves towards a price on carbon: There have been a number of academic and government studies, including efforts in both the George W. Bush and Obama Administrations, estimating the social cost of carbon, to be used as a tool for policy analysis.[86] For example, the Climate Leadership Council has proposed a revenue-neutral “fee and dividend” based on a carbon charge of $40 per ton beginning in 2019.[87] In establishing the level of the tax incentive for CO_2 capture, the 115th Congress has tacitly placed a value on avoiding CO_2 in the atmosphere. Many in the scientific community believe that an economy-wide price on carbon is necessary to avoid substantial future costs for emissions mitigation as well as climate adaptation, including the economic dislocations resulting from climate change. The new 45Q provisions represent an important step forward in this direction, by supporting a low-cost, low-risk, low-impact pathway to deep decarbonization of the power, industrial, and transportation sectors.

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86 https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of

87 https://www.clcouncil.org/media/TheConservativeCaseforCarbonDividends.pdf

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ABOUT THE ENERGY FUTURES INITIATIVE

WHO WE ARE

The Energy Futures Initiative is a Washington-D.C.-based nonprofit dedicated to energy innovation under the direct management of former Energy Secretary Ernest J. Moniz.

WHAT WE DO

Led by principals with decades of experience and proven track records in government, academia and the private sector, EFI conducts objective, fact-based and rigorous technical, economic, financial and policy analyses supported by a multidisciplinary network of experts. We focus on solutions that are effective, pragmatic and acceptable to the broadest possible set of stakeholders.

STRATEGIC APPROACH

The EFI team of experts provide policymakers, industry leaders, NGOs and other leaders with analytically-based, unbiased policy options to advance a cleaner, safer, more affordable and more secure energy future. The EFI team and its global network of experts understand current energy markets, trends and needs, and will apply this collective talent and knowledge to a range of policy questions, including:

- Analyzing complex energy systems, providing public and private decision-makers with strategic insights and integrated policy solutions and politically viable implementation pathways.
- Advancing synergistic clean energy technologies and policies at home and around the world.
- Convening industry, labor, policymakers, philanthropists and NGOs to forge practical implementable climate change solutions.
- Promoting strong communities and a 21st century energy workforce, with a focus on city, state and regional innovation opportunities.

CONTACT EFI

For additional information about EFI’s analysis and reports:

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