The Business, Entrepreneurship & Tax Law Review

Volume 7 | Issue 1 Article 10

Buried Hope: Assessing The Future Of Carbon Sequestration In the U.S. Under The Updated 45Q Tax Credit

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ABSTRACT

The urgent need to combat climate change has prompted governments worldwide to explore innovative policy measures to reduce greenhouse gas emissions. One such measure is the process of carbon capture and sequestration in which carbon dioxide is captured either directly from the atmosphere or prior to its release. This article will analyze updates to the 45Q tax credit passed in the Inflation Reduction Act of 2022, in which Congress increased tax incentives for industries that use carbon capture technology. This analysis will explain carbon capture technology, survey use of the technology, and discuss the viability of the latest updates to the 45Q tax credit. Ultimately, this article predicts that the changes will not produce any meaningful adoption of traditional carbon capture technology in its current form. Without more efficient technology, increased economic incentives will not motivate industries to begin capturing and storing their carbon dioxide. However, changes to the 45Q credit alongside government investment will likely drive down the costs of direct air capture sequestration and could create a profitable market for carbon captured directly from the air.

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I. Introduction

By the year 2050, humanity will need to cut its carbon dioxide emissions to zero in order to limit global average temperature rise to 1.5 °C above pre-industrial levels.[1] As global average temperatures rise, humans face more frequent and intense severe weather events as well as more extreme heatwaves and prolonged rainy seasons.[2] These dramatic events are occurring against a backdrop of subtly changing climate patterns. For instance, there has been an annual decrease in the number of cold days and nights worldwide, with an increase in warm days and nights.[3] Our biomes and seasons have begun to shift in latitude and elevation which has led to a disruption in global ecological systems.[4] These changes are demonstrated by shifts in the world around us: species extinctions,[5] forest dieback,[6] ocean acidification and circulation shift,[7] the steady submersion of low-lying islands,[8] the destruction of coastal reefs,[9] etc. Limiting temperature rise to a maximum of 1.5 °C reduces these negative externalities and keeps our climate stable.[10]

A seismic shift in our collective consumption habits alongside rapid technological advancement is needed to limit global average temperature rise to 1.5 °C.[11] In 2016, the Paris Agreement ("the Agreement"), a landmark international climate treaty signed by 193 countries and the European Union, set a framework for limiting global average temperature rise to a maximum of 2 °C.[12] The Agreement aims to increase the ability of countries to develop technological solutions and calls on member countries to abide by a portfolio of mitigation measures to combat climate change.[13] In response to the Agreement, the Intergovernmental Panel on Climate Change ("IPCC") determined global CO2 emissions must fall to 45% of 2010 levels by 2030 and reach 'net zero' by 2050.[14] Several measures will have to be taken to avert the worst climatic outcomes, such as a substantial reduction in fossil fuel consumption; a shift to renewable energy sources; the enhancement of biological carbon sinks; and overall dramatic transitions in energy, land, and urban

1. *For a Livable Climate: Net-Zero Commitments Must be Backed by Credible Action*, U.N., https://www.un.org/en/climatechange/net-zero-coalition (last visited Nov. 19, 2022).
2. Ove Hoegh-Guldberg et al., Impacts of 1.5°C of Global Warming on Natural and Human Systems 177 (2018), https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Chapter_3_LR.pdf.
3. *Id.* at 189.
4. *Id.* at 216.
5. *Id.* at 218.
6. *Id.* at 220.
7. *Id.* at 223–24.
8. *Id.* at 232.
9. *Id.* at 227.
10. *Id*. at 254.
11. Stéphanie Bouckaert et al., Net Zero by 2050 – A Roadmap for the Global Energy Sector 3 (2021), https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.
12. Paris Agreement to the United Nations Framework Convention on Climate Change art. 2, Apr. 22, 2016, T.I.A.S. No. 16-1104.
13. *Id.* at art. 4.
14. Joeri Rogelj et al., Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development 95 (2018), https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Chapter_2_LR.pdf.

infrastructure.[15] Part of the mitigation portfolio includes the use of carbon capture and storage technologies ("CCS") or carbon capture, utilization, and storage technologies ("CCUS").[16] CCS is utilized by industries that emit large amounts of CO2 to capture emissions before they are released into the air.[17] Scientists estimate 14% of emissions reductions must come from carbon capture technologies to limit global temperature rise to 2 °C by 2060.[18]

The purpose of this article is to explore the viability of carbon capture and sequestration technologies in the United States after recent changes under the Inflation Reduction Act of 2022 ("The Act"). The Act revamped a tax credit for industries that capture their CO2 before emission; as such, the credit now offers significantly more incentive to industries that utilize carbon capture technologies. This article seeks to evaluate whether these changes to the tax credit will be enough to spur widespread adoption of carbon capture technology. In section two, I will explain the technology and how it is used. In section three, I will discuss the evolution of the tax credit for industries utilizing carbon sequestration technology—the 45Q tax credit. In section four, I will explore the implications of the government's recent overhaul of the tax credit and forecast how the changes will affect the use of CCS technology in the United States.

II. CARBON SEQUESTRATION TECHNOLOGY

A. What is Carbon Sequestration and Storage?

Carbon sequestration is the process by which carbon oxide or dioxide is removed from the Earth's atmosphere and stored in the Earth.[19] The process is done in two ways: biologically and artificially.[20] Carbon is removed from the air biologically through natural processes such as photosynthesis or natural ocean absorption.[21] While our oceans absorb around 25% of carbon dioxide ("CO2") from human emissions, forests and grasslands absorb similar amounts of carbon and store it in the soil.[22] Alternatively, CO2 can be artificially sequestered under the Earth's crust using CCS technology.[23]

According to the United States Geological Survey, geologic carbon sequestration "is a method of securing carbon dioxide in deep geologic formations to prevent its release to the atmosphere and contribution to global warming as a greenhouse

15. MYLES ALLEN ET AL., SUMMARY FOR POLICYMAKERS 12–17 (2018), https://www.ipcc.ch/sr15/chapter/spm.

16. JUAN CARLOS ABANDES ET. AL., IPCC SPECIAL REPORT – CARBON DIOXIDE CAPTURE AND STORAGE 3 (2005), https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_summaryforpolicymakers-1-1.pdf.

17. *Id.*

18. BRAD PAGE, THE GLOBAL STATUS OF CCS 5 (2018), https://www.globalccsinstitute.com/wp-content/uploads/2020/10/Global-Status-of-CCS-Report-2018_FINAL.pdf.

19. *What is Carbon Sequestration?*, U.S.G.S., https://www.usgs.gov/faqs/what-carbon-sequestration (last visited Nov. 19, 2022).

20. *What is Carbon Sequestration?*, NAT'L GRID, https://www.nationalgrid.com/stories/energy-explained/what-carbon-sequestration (last visited Nov. 19, 2022).

21. *What is Biological Carbon Sequestration?* UC DAVIS, https://climatechange.ucdavis.edu/climate/definitions/carbon-sequestration/biological (last updated Nov. 5, 2021).

22. NATIONAL GRID, *supra* note 20.

23. Vincent Gonzalez et al., *Carbon Capture and Storage 101*, RES. FOR THE FUTURE 1 (May 2020), https://media.rff.org/documents/CCS_101.pdf.

gas."[24] This is done as CCS technologies capture CO2 from industrial emissions processes before the CO2 can be released into the air.[25] The CO2 is captured at the emission source; compressed into a liquid; transported by pipeline, ship, truck, or rail;[26] and injected deep within the Earth's crust into underground geologic formations.[27] The CO2 solvent is pumped about half a mile deep into the Earth's crust,[28] into a layer of permeable and porous bedrock overlain by an impermeable layer of rock to effectively seal the carbon dioxide under the Earth's crust.[29] Currently, the United States is considering three types of geologic formations for deposit: depleted oil and gas reservoirs, deep saline reservoirs, and unmineable coal seams.[30] Well-regulated subsurface storage of CO2 is projected to retain 98% of the CO2 under the Earth's crust,[31] and is currently the best large-scale permanent CO2 storage method. [32]

There are three ways to capture CO2 before releasing it into the atmosphere: post-combustion capture, pre-combustion capture, and oxyfuel capture.[33] In post-combustion capture, exhaust gases containing a mixture of CO2, nitrogen, and other compounds are treated with a solution that selectively absorbs the CO2, producing a concentrated liquid that can be easily transported via pipeline.[34] Pre-combustion capture removes the CO2 from the fossil fuel before it is burned.[35] Oxyfuel combustion involves "burning the fuel with nearly pure oxygen instead of air."[36] Regardless of the capture type, all captured carbon is dehydrated and compressed, then purified to a 99% CO2 gas concentrate to be liquified.[37] The result after compression and chilling is a CO2-dense solvent.[38]

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24. DOUGLAS W. DUNCAN & ERIC A. MORRISSEY, THE CONCEPT OF GEOLOGIC CARBON SEQUESTRATION 1 (2011), https://pubs.usgs.gov/fs/2010/3122/pdf/FS2010-3122.pdf.
25. *CCS is a Climate Change Technology*, GLOB. CCS INST., https://www.globalccsinstitute.com/about/what-is-ccs (last visited Nov. 19, 2022).
26. DAVID KEARNS ET AL., TECHNOLOGY READINESS AND COSTS OF CCS 20 (Mar. 2021), https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Technology-Readiness-and-Costs-for-CCS-2021-1.pdf.
27. *Id.*
28. ANGELA C. JONES & ASHLEY J. LAWSON, CONG. RSCH. SERV., R44902, CARBON CAPTURE AND SEQUESTRATION (CCS) IN THE UNITED STATES 9 (Oct. 5, 2022).
29. Duncan & Morrissey, *supra* note 24.
30. JONES & LAWSON, *supra* note 28.
31. Juan Alcalde et al., *Estimating Geological Co2 Storage Security to Deliver on Climate Mitigation*, 9 NATURE COMMC'NS 1, 1 (2018).
32. JACK SUTER ET AL.,CARBON CAPTURE, TRANSPORT, & STORAGE SUPPLY CHAIN DEEP DIVE ASSESSMENT 4 (Feb. 24, 2022), https://www.energy.gov/sites/default/files/2022-02/Carbon Capture Supply Chain Report - Final.pdf.
33. Hisham Eldardiry & Emad Habib, *Carbon Capture and Sequestration in Power Generation: Review of Impacts and Opportunities for Water Sustainability*, 8 ENERGY, SUSTAINABILITY & SOC'Y 1, 3 (2018).
34. ANGELO BASILE ET AL., MEMBRANE TECHNOLOGY FOR CARBON DIOXIDE (CO2) CAPTURE IN POWER PLANTS 121 (Angelo Basile & Suzana Pererira Nunes eds., 1st ed. 2011).
35. *Pre-Combustion Carbon Capture Research*, OFF. OF FOSSIL ENERGY AND CARBON MGMT., https://www.energy.gov/fecm/pre-combustion-carbon-capture-research (last visited Mar. 8, 2023).
36. Rohan Stanger et al., *Oxyfuel Combustion for CO2 Capture in Power Plants*, 40 INT'L J. OF GREENHOUSE GAS CONTROL 55, 55 (Sept. 2015).
37. Jack Suter et al., *supra* note 32.
38. JUAN CARLOS ABANADES ET AL., SPECIAL REPORT ON CARBON DIOXIDE CAPTURE AND STORAGE 109 (2005), https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf.

After liquification, the CO2 is transported.[39] Transport by steel pipeline is the cheapest and most practiced method of transporting CO2.[40] The United States has around 50 dedicated CO2 pipelines that run roughly 5,000 miles and transport 70 million tonnes of CO2 per year.[41] It is necessary to liquify the CO2 because transportation of the CO2 gas would require larger pipelines and further treatment during transport.[42] The pipelines run from industrial plants to geological storage and can be shared by other local emitters in order to maximize their use.[43]

As opposed to underground sequestration, the CO2 can also be reused.[44] Captured CO2 is most commonly used as an oil production stimulant—the CO2 solution is transported and injected into nearly depleted oil reservoirs to increase output.[45] This process, known as Enhanced Oil Recovery ("EOR"), leads to 30 to 60 percent greater oil production from the well.[46] In this process, CO2 is captured at an industrial source, transported via pipeline to an existing oil field, then pumped into the oil reservoir to increase the well's productivity and lifespan.[47] Natural gas processing plants have been using CCUS technology for EOR since the 1970s,[48] and it is virtually the only practical way to reuse CO2 captured prior to emission.[49]

Another method of carbon capture is through Direct Air Capture ("DAC").[50] DAC technology captures existing CO2 from the air using giant fans that act as a massive vacuum.[51] After being sucked from the air, the captured CO2 is sequestered or reused.[52] While conceptually simpler than traditional CCS infrastructure, DAC is prohibitively expensive at an estimated cost of $500 per ton of carbon dioxide removed.[53] Because the cost of DAC has been so high, the industry has been stymied with a mere 18 DAC facilities across the globe with only one operating in a large-scale capacity.[54] Currently, these 18 facilities capture 1,000 metric tons ("Mt.") of CO2 per year while the Net-Zero by 2050 Scenario requires at least 60 million metric tons to be captured.[55]

While global scientists working under the banner of the IPCC acknowledge CCS as a necessary weapon in the fight toward net zero emissions, use of the

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39. *About CCUS*, INT'L ENERGY AGENCY (Apr. 2021), https://www.iea.org/reports/about-ccus.
40. *Id.*
41. *Id.*
42. Jack Suter et al., *supra* note 32.
43. *CCS Explained: Transport*, GLOB. CCS INST., https://www.globalccsinstitute.com/ccs-explained-transport (last visited Mar. 8, 2023).
44. Ed Burke & Dennis K. Burke, *Carbon Capture: Store It and Sell It*, OIL & ENERGY ONLINE (July 19, 2019), https://oilandenergyonline.com/articles/all/carbon-capture-store-it-and-sell-it.
45. *Enhanced Oil Recovery*, OFF. OF FOSSIL ENERGY & CARBON MGMT., https://www.energy.gov/fecm/enhanced-oil-recovery (last visited Nov. 19, 2022).
46. *Id.*
47. *Id.*
48. CONG. RSCH. SERV., IF11455, THE TAX CREDIT FOR CARBON SEQUESTRATION (SECTION 45Q) 1 (last updated June 8, 2021).
49. JONES & LAWSON, *supra* note 28, at 10.
50. Sara Budinis, *Direct Air Capture*, INT'L ENERGY AGENCY (Sept. 2022), https://www.iea.org/reports/direct-air-capture.
51. *Id.*
52. *Id.*
53. Catherine Clifford, *From Milligrams to Gigatons: Startup that Sucks Carbon Dioxide from the Air is Building a Big Plant in Iceland*, CNBC (June 28, 2022), https://www.cnbc.com/2022/06/28/climeworks-carbon-dioxide-removal-company-building-iceland-plant.html.
54. Budins, *supra* note 50.
55. *Id.*

technology is criticized on numerous fronts.[56] Critics broadly dismiss the use of CCS as a "Band-Aid" fix that does not provide an actual solution to the driver of climate change: the emission of greenhouse gases.[57] Environmentalist groups slam use of the technologies by oil and gas producers as a way for the industry to perpetuate consumption of fossil fuels in order to prolong humanity's reliance on their product.[58] While oil and gas producers may be able to prevent their carbon emissions, critics point out, consumers who use their products do not.[59] Overarchingly, carbon capture is mocked by critics as a false solution that is economically infeasible, practically unnecessary, and a dangerous distraction during a critical time in the race to reduce CO2 emissions before it is too late.[60]

Geologic carbon sequestration may also be dangerous. While cited as a necessary weapon in the fight against climate change, large-scale CO2 sequestration may trigger earthquakes.[61] Modern science has dispelled the notion that earthquakes need only be feared where tectonic plates meet; rather, earthquakes occur "nearly everywhere in continental interiors," indicating that the Earth's crust is littered with small fault lines that are potentially active.[62] These small faults demonstrate the "critically stressed" nature of the Earth's crust.[63] Injecting CO2 and storing it within geologic formations half a mile below the Earth's surface may put pressure on these stresses and "may induce earthquakes as the stress is released through activation of existing, or the creation of new, faults and/or fractures."[64] Not only would sequestration projects risk natural disaster, but they also might risk futility with the destruction of their enterprise and the release of CO2 back into the atmosphere.

B. Industries Utilizing CCS and CCUS Technologies

Carbon capture and utilization technologies, such as enhanced oil recovery, capture and reuse CO2 emitted during industrial processes, such as in the production of concrete and jet fuel.[65] These technologies are utilized at large industrial facilities—e.g., petrochemical, cement, and power generating plants—and can reduce CO2 emissions by 80-90% per plant while simultaneously making good use

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56. Paul Brown, *Carbon Capture and Stroage Won't Work, Critics Say*, ECO-BUSINESS (Jan. 19, 2021), https://www.eco-business.com/news/carbon-capture-and-storage-wont-work-critics-say.
57. *Id.*
58. *Id.*
59. *Id.*
60. Dana Drugmand & Carroll Muffett, *Why Carbon Capture is Not a Climate Solution*, CTR. FOR INT'L ENV'T L., https://www.ciel.org/wp-content/uploads/2021/07/Confronting-the-Myth-of-Carbon-Free-Fossil-Fuels.pdf (last visited Nov. 19, 2022).
61. Mark D. Zoback & Steven M. Gorelick, *Earthquake Triggering and Large-Scale Geologic Storage of Carbon Dioxide*, 109 PROCEEDINGS OF THE NAT'L ACAD. OF SCIS. OF THE U.S. 10164, 10164 (June 18, 2012).
62. *Id.*
63. Mark D. Zoback et. al, *Steady-State Failure Equilibrium and Deformation of Intraplate Lithosphere*, 44 INT'L GEOLOGY REV. 383, 383 (July 14, 2010).
64. Maren Kjos Karlsen et al., *Quantifying the Relation Between Carbon Capture and Storage (CCS) and Earthquake Risk*, UNIVERSITETET I BERGEN (Jan. 10, 2022), https://www.uib.no/klimaenergi/150671/quantifying-relation-between-carbon-capture-and-storage-ccs-and-earthquake-risk.
65. *Japan's Roadmap to "Beyond-Zero" Carbon*, MINISTRY OF ECON., TRADE & INDUS., https://www.meti.go.jp/english/policy/energy_environment/global_warming/roadmap/innovation/ccus.html (last visited Nov. 19, 2022).

of a former waste product.[66] Several applications of CCUS are utilized today, "including chemical absorption of CO_2 from ammonia production and natural gas processing, CO_2 use in the production of fertilizer, and long-distance pipeline transport and injection of CO_2 for [enhanced oil recovery]."[67] CCUS is a natural fit for these industries because their production processes already require CO_2 separation in the creation of their products; thus, plants are easily retrofitted with capture technology.[68] For example, the fertilizer industry captures and reuses 130 metric tons of CO_2 emissions per year[69] in the production of urea, a nitrogenous compound used in fertilizers.[70] In the concrete and cement industries, CO_2 emitted in the firing of limestone and clay can be captured and sequestered in hardened concrete.[71] Overall, however, the industrially feasible uses for captured CO_2 are severely limited.[72] Due to the restricted number of ways in which captured carbon can be reused, the Net Zero Scenario mandates 95 percent of captured carbon be sequestered in the ground with just five percent or less reused in the production of other products.[73]

In other industrial areas where carbon capture technology could be most effectively utilized, such as chemical industries and gas-fired power plants, the technology has not yet been developed to the level necessary to make utilization cost effective.[74] Unlike in fuel processing and fertilizer production plants, installation of capture systems in these industries is extraordinarily cost-prohibitive because there is no carbon capture and separation inherent in the production systems.[75] Installation of capture systems is thus unattractive due to high installation costs and a lack of physical space in these plants.[76]

CCS technologies can be utilized in power generation facilities such as coal-fired power plants if the financial incentives of adoption are worth it.[77] With or without financial incentives, however, carbon capture reduces the plant's efficiency and net power output.[78] As such, carbon capture technologies have been sparsely utilized in coal-fired power plants.[79] In 2012, new coal combustion plants that wished to use CCS technologies in their electricity generation would have faced a 60-80 percent increase in costs.[80] Existing power plants face even higher costs due

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66. Ana-Maria Cormos & Abel Simon, *Dynamic Modeling and Validation of Post-Combustion Calcium-Looping Process*, 33 COMPUT. AIDED CHEM. ENG'G, 1645, 1645 (2014).
67. *CCUS Technology Innovation*, INT'L ENERGY AGENCY, https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-technology-innovation (last visited Nov. 19, 2022).
68. CHRISTOPHER SHORT ET AL., THE GLOBAL STATUS OF CCS: 2010 12 (2010), https://www.globalccsinstitute.com/archive/hub/publications/12776/global-status-ccs-2010.pdf.
69. Mathilde Fajardy, *CO2 Capture and Utilisation*, INT'L ENERGY AGENCY (Sept. 2010), https://www.iea.org/reports/co2-capture-and-utilisation.
70. *Urea*, BRITANNICA, https://www.britannica.com/science/urea (last visited Nov. 19, 2022).
71. *What is CCUS Technology & How Does it Work?*, INTEGRATED FLOW SOLS. (May 27, 2021), https://ifsolutions.com/what-is-ccus-technology-how-does-it-work.
72. Justin Jacobs, *Put Up or Shut Up': Can Big Oil Prove the Case for Carbon Capture?* FIN. TIMES (Oct. 19, 2022), https://www.ft.com/content/b8d6848d-1e8a-4c57-b65b-52105b48b178.
73. Fajardy, *supra* note 69.
74. *Id.*
75. SHORT ET AL., *supra* note 68, at 124.
76. Abdallah Dindi et al., *Policy-Driven Potential for Deploying Carbon Capture and Sequestration in a Fossil-Rich Power Sector*, 56 ENV'T SCI. & TECH. 9872, 9878 (2022).
77. *Id.* at 9872.
78. *Id.* at 9875
79. *Id.* at 9873.
80. Edward S. Rubin et al., *The Outlook for Improved Carbon Capture Technology*, 38 PROGRESS IN ENERGY AND COMBUSTION SCI. 1, 8 (2012).

to outdated technology, physical space constraints, and the resulting need to upgrade existing equipment.[81] Carbon capture is thus unrealistic for existing power plants because it reduces the plant's efficiency and increases capital costs.[82] Nonetheless, CCS technologies will prove necessary in the transition[83] towards a decarbonized future as the United States gets over 85 percent of its energy from fossil fuels.[84] High enough tax incentives for the implementation of CCS in coal-fired power plants decreases the cost of CO2 avoided and can be an effective step toward a decarbonized future.[85]

Modeled global pathways which limit global warming to 1.5 °C mandate 70-85 percent renewable energy dependence coupled with use of CCS technologies in nuclear and fossil fuel electricity production.[86] The use of these technologies "has the potential to reduce overall mitigation costs and increase flexibility in achieving greenhouse gas emissions reductions" according to the IPCC.[87] Ultimately, the development and implementation of these technologies is necessary to reach global climate goals, unless the technology is rendered unnecessary by a swift and total transition to renewable energy.[88]

However, as it currently stands, CCS is sparsely utilized in any industry because it is prohibitively expensive,[89] and impractical, to implement in existing factories.[90] Currently, capture costs increase when CO2 is captured from a highly diluted source;[91] as such, it is more difficult and expensive to capture emissions that are less CO2-dense. For example, coal and gas power plants face higher combined costs of capture, transport, and storage because their emissions are less CO2-dense.[92] The use of CCS in coal-fired power plants is so inefficient that it "could increase residential utility bills by as much as $100."[93] One study of CCS at power plants in Australia found that use of the technology would drive up the cost of electricity 95 to 175 percent.[94] In 2020, the cost to use CCS in coal and gas power plants ranged between $80-90 per metric ton of captured carbon, while the combined cost for gas processing, ammonia, and ethanol plants—industries that have carbon dioxide separation inherent in the production of their products—had capture costs that

81. *Id*.
82. *Id*.
83. John Muyskens & Juliet Eilperin, *Biden Calls for 100 Percent Clean Electricity by 2035. Here's How Far We Have to Go*, WASH. POST (July 30, 2020), https://www.washingtonpost.com/climate-environment/2020/07/30/biden-calls-100-percent-clean-electricity-by-2035-heres-how-far-we-have-go ("Biden's new plan, which carries a price tag of $2 trillion, would eliminate carbon emissions from the electric sector by 2035…").
84. Rubin et al., *supra* note 80, at 2–3.
85. Dindi et al., *supra* note 76.
86. ALLEN ET AL., *supra* note 15, at 15.
87. JUAN CARLOS ABANADES ET AL., *supra* note 16.
88. JIM SKEA ET AL., CLIMATE CHANGE 2022 – MITIGATION OF CLIMATE CHANGE 28 (2022), https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf.
89. Matt Bright, *The Inflation Reduction Act Creates a Whole New Market for Carbon Capture*, CLEAN AIR TASK FORCE (Aug. 22, 2022), https://www.catf.us/2022/08/the-inflation-reduction-act-creates-a-whole-new-market-for-carbon-capture.
90. Dindi et al., *supra* note 76, at 9873.
91. Bright, *supra* note 89.
92. *Id.*
93. Sara Sneath, *The Cost to Capture Carbon? More Water and Electricity*, THE GUARDIAN (Oct. 15, 2022), https://www.theguardian.com/environment/2022/oct/15/emissions-capture-carbon-cost-water-electricity.
94. MICHAEL SALT AND CHRISTINA NG, CCS FOR POWER YET TO STACK UP AGAINST ALTERNATIVES 4 (Mar. 2023).

ranged between $30-50 per metric ton.[95] Ultimately, the feasibility of utilizing CCS technology to mitigate carbon output depends on the nature of the heavy industry, the processes required to create its product, and the potential government incentive to capture and store its carbon emissions.[96] For most industries, the costs outweigh the benefits.

There are 30 operational CCS facilities worldwide that collectively capture and sequester 42.58 million metric tons of CO2 per year.[97] However, the Net Zero by 2050 Scenario requires the world to be sequestering close to 1.3 billion metric tons per year by 2030, with the vast majority to be injected and stored beneath the Earth's crust.[98] Globally, most CCS operations are in natural gas processing plants, the power sectors, and the natural gas liquification industry.[99] The United States has 12 operational CCS projects, largely at ethanol, natural gas and hydrogen, and fertilizer production plants.[100] Overall, the world is far from where it needs to be—2,000 large-scale CCS plants need to be in operation across the globe by 2050 to reach mitigation targets.[101] The world needs substantial investment in CCS technology in order to meet sequestration targets. However, without practical financial incentives for adoption, CCS will continue to be widely shunned as wasteful, inconvenient, and impractical.[102]

III. THE 45Q TAX CREDIT

In 2008, Congress passed the Energy Improvement and Extension Act to encourage investment in renewable energy and incentivize consumers to adopt green technology.[103] The Act gave tax breaks for energy-efficient investments; deductions for energy-efficient commercial buildings and home improvement projects; extended credits for homebuilders constructing energy-efficient houses; and created a new tax credit for industrial CO2 sequestration.[104] The new tax credit is colloquially known by its Internal Revenue Code section as the 45Q tax credit.[105]

A. The Original 45Q Credit

Under the 2008 law, a taxpayer would receive a tax credit of $20 per metric ton of CO2 permanently sequestered in the ground, and a $10 credit for each metric ton

95. *Id*.
96. *See generally* Dindi et al., *supra* note 76.
97. *Global Status of CCS – Facilities and Trends*, GLOB. CCS INST. (2022), https://status22.globalccsinstitute.com/2022-status-report/global-status-of-ccs.
98. Sara Budinis et al., *Carbon Capture, Utilisation and Storage*, INT'L ENERGY AGENCY (Sept. 2022), https://www.iea.org/reports/carbon-capture-utilisation-and-storage-2.
99. Oliver Gordon, *Global CCS Capacity Grows 44% in a Year*, ENERGY MONITOR (Nov. 2, 2022), https://www.energymonitor.ai/tech/carbon-removal/global-ccs-capacity-grows-44-in-a-year.
100. CONG. RSCH. SERV, *supra* note 48, at 2.
101. *Carbon Capture and Storage: Challenges, Enablers and Opportunities for Deployment*, GLOB. CCS INST. (July 30, 2020), https://www.globalccsinstitute.com/news-media/insights/carbon-capture-and-storage-challenges-enablers-and-opportunities-for-deployment.
102. Mark Toner, *Does CCS Make Economic Sense?*, AUSTL. ACAD. OF TECH. SCI. & ENG'G (Nov. 10, 2021), https://www.atse.org.au/news-and-events/article/does-ccs-make-economic-sense.
103. *Energy Improvement and Extension Act 2008 - Tax Incentives*, INT'L ENERGY AGENCY (Nov. 5, 2017), https://www.iea.org/policies/1817-energy-improvement-and-extension-act-2008-tax-incentives.
104. H.R. 1424, 110th Cong. (2008).
105. CONG. RSCH. SERV., *supra* note 48.

of CO2 used for EOR.[106] For visualization purposes, one metric ton of CO2 weighs as much as a great white shark at 2,204.6 lbs.,[107] and can be pictured by imagining a 27' x 27' x 27' cube—one as tall, long, and wide as a telephone pole.[108] Driving a car from Los Angeles to New York City produces about the same amount of CO2, or using 113 gallons of gasoline, or 2.3 barrels of oil.[109] The average US household burns a metric ton of CO2 powering itself over the course of two months.[110] Of course, carbon is much more difficult to remove than it is to produce—it takes two and a half acres of U.S. forestland to sequester 2.13/Mt.[111]

The original 45Q tax credit was only available to industrial taxpayers who sequestered 500,000/Mt. of CO2 per year.[112] That is to say, access to the original 45Q was only available to those who prevented the equivalent of over one million barrels of oil from consumption, or 56 million gallons of gas, or 1.2 billion miles from being driven. These colossal entry barriers were not offset by irresistible financial gain—the increase in the cost of production for industrial commodities such as steel and cement would have risen by 9-13% and 35-47%, respectively, from 2009 to 2010, if their production plants were retrofitted with CCS.[113] This cost increase does not factor in the additional costs of installation, transportation, and injection.[114] Ultimately, the $20 tax credit could not have incentivized the adoption of industrial carbon sequestration technology on a large scale.

Fortunately, the 45Q credit was renovated in the Bipartisan Budget Act of 2018.[115] The credit's value was increased from $20/Mt. to $50 for geologic sequestration, and from $10/Mt. to $35 for CO2 reused with CCUS.[116] The minimum eligibility threshold was reduced from 500,000/Mt. per year to 100,000.[117] The credit was expanded in type, allowing the taxpayer to capture the carbon through photosynthesis or chemosynthesis, such as through growing algae or bacteria, or through chemically converting the carbon to a material or chemical compound in which the carbon is securely stored.[118] Additionally, Congress broadened the scope of the credit to allow for carbon monoxide capture as well as dioxide.[119] While these were welcome changes to a largely obsolete tax credit, capture costs alone exceeded

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106. Brown Winick, *45Q Carbon Sequestration Tax Credit: What It Is & How to Get It*, BROWNWINICK L. (July 15, 2022), https://www.brownwinick.com/blog/45q-carbon-sequestration-tax-credit-what-it-is-how-to-get-it.
107. Kathryn, Tso, *How Much is a Ton of Carbon Dioxide?*, MIT CLIMATE PORTAL (Dec. 2, 2020), https://climate.mit.edu/ask-mit/how-much-ton-carbon-dioxide.
108. *Id.*
109. *Id.*
110. *Assumptions and References for Household Carbon Footprint Calculator,* EPA (last visited Mar. 19, 2023), https://www.epa.gov/ghgemissions/assumptions-and-references-household-carbon-footprint-calculator.
111. Grant M. Domke et al, *Tree Planting has the Potential to Increase Carbon Sequestration Capacity of Forests in the United States,* 117 Proceedings of the National Academy of Sciences 24649, 24649 (2020).
112. CONG. RSCH. SERV., *supra* note 48.
113. SHORT, *supra* note 70, at 125.
114. *Id.*
115. CONG. RSCH. SERV., *supra* note 48.
116. *45Q Tax Credit*, CARBON CAPTURE COAL., https://carboncapturecoalition.org/45q-legislation (last visited Nov. 19, 2022).
117. *Id.*
118. *Drilling Down – Examining the Section 45Q Tax Credit*, KPMG (Mar. 5, 2020), https://home.kpmg/us/en/home/insights/2020/03/examining-section-45q-tax-credit.html.
119. *Id.*

$50/Mt. in most industries in 2018; thus, potential benefits of the credit were dwarfed by the total cost of installation, capture, transportation, and storage of the captured carbon.[120]

The United States had nine operating CCS plants in 2018 that collectively sequestered 25 million metric tons of CO2 per year.[121] While access to the 45Q tax credit was easier and more attractive thanks to the 2018 changes, the cost per metric ton of sequestered carbon dwarfed any potential profits.[122] Except for the fertilizer industry, all carbon-sequestering industries had CCS costs that well exceeded $50/Mt.[123] Overall, industries had no incentive to adopt carbon capture technologies without government incentives.[124] Still today there is no value in emissions abatement unless the associated costs of capture, transportation, and storage are covered.[125] Entrance into the world of industrial carbon capture is a daunting prospect that requires heavy investment in long-term assets like transportation infrastructure and geological storage.[126] While some industries can find a use for their recycled carbon, realistically, the carbon sequestration enterprise is only worthwhile if industries can realize a profit off their captured CO2.

B. The New and Improved 45Q

Congress dramatically updated the 45Q tax credit as part of the Inflation Reduction Act of 2022.[127] Along with the 45Q overhaul, the Act introduced tax credits for producers of clean hydrogen, nuclear energy, and other domestic clean energy systems.[128] The Act gives tax credits for the commercial use of low-carbon fuel sources and offers tax credits to consumers who purchase electric vehicles, use clean energy sources to power their homes, and refurbish their homes with energy-efficient home improvements.[129]

Geologic sequestration credits were boosted from $50/Mt. to $85 and from $35/Mt. to $60 for reused CO2.[130] Credits for geologically sequestered CO2 captured through Direct Air Capture were more than tripled from $50/Mt. to $180 and increased from $50/Mt. to $130 for DAC-captured CO2 that is reused.[131] Furthermore, Congress expanded the credit's accessibility by creating a "direct pay" option for taxpayers who qualify for the credit, allowing them to receive the 45Q credit as

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120. Sara Budinis et al., *An Assessment of CCS Costs, Barriers and Potential*, 22 ENERGY STRATEGY REVS. 61, 69 (2018).
121. PAGE, *supra* note 18, at 53.
122. *See generally* William J. Schmelz et al., *Total Cost of Carbon Capture and Storage Implemented at a Regional Scale: Northeastern and Midwestern United States*, 10 INTERFACE FOCUS 1, 14 (2020).
123. Ian Tiseo, *First-of-a-kind Carbon Capture and Storage Costs Worldwide as of 2018, by Select Industry*, STATISTA (July 21, 2020), https://www.statista.com/statistics/1025385/first-of-a-kind-ccs-globally-by-industry/#statisticContainer.
124. GLOBAL CCS INSTITUTE, *supra* note 100.
125. *Id.*
126. *Id.*
127. *See generally* CARBON CAPTURE PROVISIONS IN THE INFLATION REDUCTION ACT OF 2022 (2022), https://cdn.catf.us/wp-content/uploads/2022/08/19102026/carbon-capture-provisions-ira.pdf.
128. *Inflation Reduction Act (IRA) Summary: Energy and Climate Provision*, BIPARTISAN POL'Y CTR. (Aug. 4, 2022), https://bipartisanpolicy.org/blog/inflation-reduction-act-summary-energy-climate-provisions.
129. *Id.*
130. *Id.*
131. *Id.*

a fully refundable direct payment.[132] For-profit, tax-paying entities can utilize the direct pay option for five years after the CCS technology is installed and in operation.[133] Most importantly, 45Q's entry barriers were dramatically reduced: the minimum capture threshold was lowered from 500,000/Mt. to 18,750; for industrial facilities, the minimum capture threshold was lowered from 100,000/Mt. to 12,500; and the threshold for Direct Air Capture facilities was lowered from 100,000/Mt. to 1,000.[134] Ultimately, the tax credit can be realized for 12 years after the CCS equipment is installed and operational.[135]

The 45Q tax credit has been refurbished to encourage adoption of climate-friendly infrastructure; however, the question remains as to whether Congress's efforts will be enough to drum up enthusiasm for industrial carbon sequestration. As we have seen, CCS technology and its associated infrastructure is wildly expensive and plagues its users with reductions in efficiency.[136] Will the latest round of 45Q changes be enough to convince investors they might yet realize a profit from the carbon sequestration scheme?

IV. THE IMPACT OF THE NEW 45Q

A. *Traditional Industries*

The Inflation Reduction Act's changes to the 45Q tax credit will make a significant difference to industries that seek to take advantage of it. Specifically, lowered entry barriers alongside a direct pay option could allow small-scale industries to realistically use CCS and realize an economic benefit. However, the feasibility of small-scale industries unilaterally entering the carbon capture business should still be questioned. CCS systems increase water and power consumption[137] while decreasing efficiency.[138] Smaller industries will naturally have a harder time shouldering this burden. Furthermore, under the current 45Q scheme, industrial emitters seeking to geologically sequester do not receive anything until they are storing the carbon under the ground.[139] All credit-seekers, therefore, must have the entire carbon sequestration process online before they receive any reimbursement: existing plants must be retrofitted with capture and conversion technologies, there must be a way to transport the carbon dioxide, and a destination to transport it to. These are steep economic and logistical barriers that may not be realistically surmountable.

Small-scale industries without the financial capability to invest in long-term assets like carbon dioxide pipelines or geologic storage may not be out of luck. Oftentimes emission-intensive facilities are clustered together in tight geographic areas.[140] Clustering allows similar industries to share infrastructure and

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132. *Id.*
133. CARBON CAPTURE PROVISIONS IN THE INFLATION REDUCTION ACT OF 2022, *supra* note 126, at 2.
134. Bright, *supra* note 89.
135. CARBON CAPTURE PROVISIONS IN THE INFLATION REDUCTION ACT OF 2022, *supra* note 126.
136. *See* discussion *supra* Section II(B).
137. Sneath, *supra* note 93.
138. *Climate Efficiency*, NOAH FRIENDS OF THE EARTH, http://ccs-info.org/climate-efficiency.html (last visited Nov. 19, 2022).
139. Bright, *supra* note 89.
140. Bill Gross, *To Decarbonize Heavy Industry, We Must Focus on Industrial Clusters*, WORLD ECON. F. (Jan. 17, 2022), https://www.weforum.org/agenda/2022/01/decarbonizing-heavy-industry-industrial-clusters.

resources,[141] and those industries can likewise share transport and storage infrastructure to achieve cost savings.[142] Transportation can be achieved using old natural gas and oil pipelines or through the construction of new pipelines.[143] However, pipelines, old and new, are plagued with issues. Existing natural gas pipelines would need to be retrofitted with pressurization retrofits to pump the carbon effectively, and the added pressure could lead to ruptures.[144] This could still prove to be more cost-effective than the construction of entirely new pipelines.[145] New pipelines are difficult to build because they are frequently opposed by landowners[146] and can be plagued by construction disruptions, delays, and higher costs.[147]

Despite the potential hurdles, the recent changes to the 45Q credit have piqued the interest of some small, non-traditional carbon sequestration industries. Citing lowered entry barriers and increased monetary incentives, landfill operators are eyeing CCS technology to capture the part-methane-part-CO2 emissions from their landfills.[148] Specifically, lowered entry barriers make the enterprise viable because landfills emit between 10,000 and 100,000/Mt. per year, and the new entry threshold for landfills is 12,500/Mt. per year.[149] Indeed, the only barrier that realistically remains for these small-scale industries is access to transportation infrastructure and geologic storage capabilities. These externalities can be minimized if there is easy access to geologic storage.

While some small-scale emitters may find an opportunity to harness the 45Q credit when they are clustered with other industries, those that lack a support group may do well to search below their feet for the answer as to how and where to transport captured CO2. The United States Department of Energy estimates that the U.S. has geologic storage capacity of anywhere "between 2.6 trillion and 26 trillion metric tons of CO2."[150] These geologic formations are vast and span much of the country; sedimentary basins suitable for storing carbon lie beneath the Midwest, Great Plains, Coastal Plain, and Deep South regions almost uniformly.[151] Other storage capabilities lie in saline formations, non-mineable coal deposits, shale basins,

141. *Id.*
142. Peter A. Brownsort et al., *Reducing Costs of Carbon Capture and Storage by Shared Reuse of Existing Pipeline—Case Study of a CO2 Capture Cluster for Industry and Power in Scotland*, 52 INT'L J. OF GREENHOUSE GAS CONTROL 130, 130 (Sept. 2016).
143. Rod Nickel et al., *N. America's Old Pipelines Seek New Life Moving Carbon in Climate Push*, REUTERS (Feb. 23, 2022), https://www.reuters.com/business/sustainable-business/n-americas-old-pipelines-seek-new-life-moving-carbon-climate-push-2022-02-23.
144. *Id.*
145. *Id.*
146. Gretchen Morgenson et al., *'Our Horses are Ready': Native Americans and White Farmers Form an Unlikely Alliance to Oppose a Pipeline in the Dakotas*, NBC NEWS (Oct. 25, 2022), https://www.nbcnews.com/news/us-news/native-americans-white-farmers-join-forces-oppose-summit-carbon-captur-rcna52523.
147. Reuters Staff, *Factbox: U.S. Oil and Natgas Pipelines Delayed by Legal and Regulatory Battles*, REUTERS (Feb. 1, 2022, 12:07 AM), https://www.reuters.com/article/us-usa-canada-pipelines-factbox-idUSKBN2A11EI.
148. April Reese, *Landfill Operators Take a Closer Look at Carbon Sequestration Projects in Wake of Inflation Reduction Act*, WASTEDIVE (Oct. 24, 2022), https://www.wastedive.com/news/carbon-capture-landfill-45q-inflation-reduction-act/634592.
149. *Id.*
150. JONES & LAWSON, *supra* note 28, at 9.
151. U.S. DEP'T OF ENERGY, CARBON STORAGE ATLAS 24 (Sept. 2015).

basalt formations, and off the United States' coasts.[152] Smaller-scale emitters, thus, may not be logistically prevented from sequestering their CO2 emissions if they have easy access to geologic storage. The wide availability of potential storage sites could enable large and small industries alike to forgo the logistical and monetary costs of pipeline transport.

Industries will be further enabled to enter the CCS arena if capture technologies continue to improve, and costs continue to drop. Without factoring in transportation costs, current capture costs for the natural gas processing industry are $15-$25/Mt.; and power generation facilities, the second largest user of CCS technology, face costs of $50-$100/Mt.[153] Capture costs will drop as technology and transportation infrastructure improves. Recent investment by the public and private sectors will likely fuel innovation and drive down costs at all stages of CCS. The Infrastructure Investment and Jobs Act of 2022 allocated $12 billion to the Department of Energy to fund capture projects and infrastructure,[154] and $6.5 billion for DAC and CO2 storage.[155]

Capture, infrastructure, and the resulting operating costs will determine whether CCS technology becomes feasible for small-scale industries. If this tax credit is to be realistically accessible, the government must continue to fund innovation for technological development to drive capture and infrastructure costs down. Current costs of traditional CCS infrastructure are too high to expect existing small industries to unilaterally implement them. Clustered industries with access to geologic storage may be able to band together and share infrastructure costs, but those that stand alone are unlikely to enter the CCS market.

At the other end of the spectrum, large-scale emitters such as petroleum giants could see a windfall from the recent changes to 45Q. In the wake of the 45Q changes, ExxonMobil announced its plans to invest $15 billion in CCS technology through 2027 in their push to create a new industry of carbon capture.[156] Historically, oil and petroleum giants have been virtually the only beneficiaries of 45Q's meager offerings because they were able to capture CO2 and reuse it in EOR. Of course, if these companies continue to reuse captured CO2 for EOR, they will now receive $65/Mt. instead of $35. However, petroleum giants may look to new horizons with the most recent changes to 45Q. As a result of the 45Q changes, ExxonMobil has announced a partnership deal to capture and geologically sequester 2 million metric tons of CO2 per year from a Louisiana blue ammonia producer.[157] This deal may be the first of many. Petroleum giants are uniquely poised to reap the benefits of 45Q because they have the technology and infrastructure access that allow them to capture and transport the carbon emissions of smaller industries.

152. *See generally Geologic CO2 Sequestration*, USGS, https://co2public.er.usgs.gov/viewer (last visited Nov. 19, 2022) (displaying an interactive map showing storage capacities of land and the geological makeup of that land).
153. Adam Baylin-Stern & Niels Berghout, *Is Carbon Capture too Expensive?*, INT'L ENERGY AGENCY (Feb. 17, 2022) https://www.iea.org/commentaries/is-carbon-capture-too-expensive.
154. Jacobs, *supra* note 72.
155. U.S. DEP'T OF ENERGY, THE INFRASTRUCTURE INVESTMENT AND JOBS ACT: OPPORTUNITIES TO ACCELERATE DEPLOYMENT IN FOSSIL ENERGY AND CARBON MANAGEMENT ACTIVITIES 1–2 (Sept. 29, 2022), https://www.energy.gov/sites/default/files/2022-09/FECM Infrastructure Factsheet-revised 9-27-22.pdf.
156. Tim Mullaney, *The Big New Exxon Mobil Climate Change Deal that Got an Assist from Joe Biden*, CNBC (Nov. 19, 2022), https://www.cnbc.com/2022/11/19/a-big-new-exxon-mobil-climate-deal-that-got-assist-from-joe-biden.html.
157. *Id.*

Skyrocketing demand for zero-emissions products,[158] coupled with the recent 45Q overhaul, may create a new revenue stream by which oil giants capture and transport the carbon emissions of smaller industries for geologic storage.

B. Direct Air Capture

The 2022 updates to the 45Q credit may have given the Direct Air Capture industry new life. Geologically sequestered carbon captured with DAC is now worth $180/Mt., up from $50,[159] and the U.S. government pledged $3.5 billion of funding to fund new DAC ventures that aim to capture a million tons of carbon per year.[160] However, the cost of capturing carbon directly from the air is still dangerously unclear, with price estimates ranging anywhere from [161] to $500[162] In 2019, it was forecast that DAC plants need a $236/Mt. market incentive to break [163] Despite the cost uncertainty, the 2022 45Q changes have spurred the announcement of multiple record-breaking DAC facilities[164] This demonstrates considerable industry confidence and indicates that the new tax incentives have investors sure of their profit margins.

DAC facilities are inherently flexible, unlike their traditional CCS counterparts that must be installed inside high-emissions industrial plants. DAC facilities need not be located near a source of CO2—they can be built almost anywhere.[165] This flexibility alongside increased monetary incentives and lowered entry barriers could be what the DAC industry needs to flourish. Freedom to build a removal facility anywhere incentivizes DAC entrepreneurs to build on or close to geologic sequestration sites in order to maximize profit margins.[166] DAC facilities could then remove CO2 from the air, shed transportation costs, and inject the CO2 nearby or onsite. Furthermore, dramatically lowered 45Q entry barriers could enable smaller-scale facilities to come online. The tax credit, formerly accessible only after 100,000/Mt. was sequestered, is now accessible after a minimum of 1,000/Mt. is removed from the air and stored beneath the Earth's crust.

Beyond revenue from government grants and the tax credit, DAC entrepreneurs may find another source of revenue in selling carbon offset credits. A carbon offset

158. Rob Bland et al., *Accelerating Toward Net Zero: The Green Business Building Opportunity*, MCKINSEY SUSTAINABILITY (June 14, 2022), https://www.mckinsey.com/capabilities/sustainability/our-insights/accelerating-toward-net-zero-the-green-business-building-opportunity.

159. BIPARTISAN POLICY CENTER, *supra* note 127, at 1.

160. U.S. DEPT. OF ENERGY, *Biden Administration Launches $3.5 Billion Program To Capture Carbon Pollution From The Air* (last visited Apr. 20, 2023), https://www.energy.gov/articles/biden-administration-launches-35-billion-program-capture-carbon-pollution-air-0.

161. Robert F. Service, *Cost Plunges for Capturing Carbon Dioxide from the Air*, SCI. (June 7, 2018) http://www.sciencemag.org/news/2018/06/cost-plunges-capturing-carbon-dioxide-air.

162. Clifford, *supra* note 53.

163. John Larsen et al., *Capturing Leadership – Policies for the US to Advance Direct Air Capture Technology*, RHODIUM GRP. 24 (May 2019), https://rhg.com/wp-content/uploads/2019/05/Rhodium_CapturingLeadership_May2019-1.pdf.

164. *Occidental and 1PointFive, King Ranch Reach Lease Agreement to Support up to 30 Direct Air Capture Plants on Leased Acreage*, OXY (Oct. 31, 2022), https://www.oxy.com/news/news-releases/occidental-and-1pointfive-king-ranch-lease-agreement-to-support-up-to-30-direct-air-capture-plants-on-leased-acreage.

165. JONES & LAWSON, *supra* note 28, at 13.

166. *See* Justine Calma, *King Ranch Will be the Site of the Largest Carbon Capture Project Yet*, THE VERGE (Nov. 1, 2022), https://www.theverge.com/2022/11/1/23434500/oil-giant-occidental-carbon-removal-dac-king-ranch-texas.

credit "is a transferable instrument certified by governments or independent certification bodies to represent an emission reduction of one metric tonne of CO2, or an equivalent amount of other [greenhouse gases]."[167] Countries, cities, and businesses worldwide face mounting global pressure to reduce their greenhouse gas emissions; as a result, there is a growing market for carbon offset credits that can be purchased to superficially neutralize one's carbon footprint.[168] These credits are sold by organizations that remove the CO2 from the air in a verifiable way, such as reforestation projects and sustainable energy brokers.[169] The carbon offset credit market is projected to balloon exponentially due to corporate demand for credits,[170] and the enterprise was recently blessed by the United States at the 2022 U.N. Climate Change Conference in which John Kerry, Special Envoy for Climate, alongside executives from Microsoft and Pepsi, announced plans to create a new platform for carbon credit trading.[171] While emphasis has been placed on developing a marketplace for carbon credits purchased from clean energy sources in developing countries,[172] the demand for carbon credits is only expected to grow, and it is likely that DAC facilities will be uniquely positioned to enter this marketplace and sell credits from their sequestered CO2.

Ease of accessibility, lowered entry barriers, and increased 45Q cash incentives alongside a burgeoning market for removed CO2 could be enough to incentivize growth of the DAC market. While cost estimates remain perilously unknown, they are projected to drop to $150/Mt. to $200/Mt. in the next five to ten years.[173] In the meantime, DAC technology will continue to become more cost effective as the government and private industries continue to finance innovation, and costs will drop further if the plants can be powered through cheaper renewable energy. With demand for carbon offset credits poised to grow as businesses scramble to brand themselves carbon neutral, DAC facilities may have carved out a profitable enterprise due to the latest 45Q tax credit changes.

C. The Future

The changes to the 45Q tax credit have certainly piqued the interest of carbon capture entrepreneurs. In the wake of the August 2022 changes to the 45Q credit, unparalleled CCS ventures and record-breaking DAC projects have been announced in the United States. Large and small industries alike have a newfound interest in mitigating their CO2 emissions due to the increased financial incentives and lowered entry barriers. Investors have turned their attention to DAC after its

167. *What is a Carbon Offset?*, CARBON OFFSET GUIDE, https://www.offsetguide.org/understanding-carbon-offsets/what-is-a-carbon-offset (last visited Nov. 19, 2022).
168. *The Untapped Power of Carbon Markets in Five Charts*, BLOOMBERG NEF (Sept. 16, 2022), https://about.bnef.com/blog/the-untapped-power-of-carbon-markets-in-five-charts.
169. *15+ Best and Popular US Carbon Offset Providers*, CONSERVE ENERGY FUTURE, https://www.conserve-energy-future.com/best-popular-us-carbon-offset-providers.php (last visited Nov. 19, 2022).
170. BLOOMBERG NEF, *supra* note 167.
171. Tim McDonnell, *Carbon Offsets are Making a Combeack at COP27*, QUARTZ (Nov. 10, 2022), https://qz.com/carbon-offsets-are-making-a-comeback-at-cop27-1849762633.
172. *Id.*
173. Nelson Bennett, *Texas Dominates Direct Air Capture with Canadian Tech*, BIV (Nov. 1, 2022), https://biv.com/article/2022/11/texas-dominates-direct-air-capture-canadian-tech.

financial incentive was more than tripled. The foot is on the gas for carbon capture projects, but perhaps the pedal is not yet to the metal.

The government and private industries alike must continue to finance development in carbon capture technology if it is to play any serious role in the race to reduce CO2 emissions. Traditional CCS costs are still too high for this technology to be even moderately accessible. Indeed, no new power plants have been built equipped with CCS technology as of March 2023.[174] It is not realistic to imagine that industries will clamor to retrofit factories due to the technology's high investment costs and resulting decreases in efficiency. While 2022 has brought a 44 percent increase in the number of planned CCS facilities, this only translates to 242 million tons of CO2 captured and sequestered per year when the proposed plants are online.[175] The IPCC mandates nearly 1.3 billion metric tons be captured and sequestered per year by 2030.[176] Likewise, DAC facilities should be sequestering 60 million metric tons of CO2 per year by 2030; however, the world currently captures a mere 1,000/Mt.[177] While the 45Q updates have spurred the announcement of 30 DAC facilities in Texas that will have the capacity to capture and sequester up to 30 million metric tons of CO2 per year, one would not be faulted for remaining skeptical.

However, all is not doom and gloom. Carbon capture is a budding industry that is continually showered in government and private investment. Technology giants like Google and Meta invested nearly a billion dollars in carbon capture technology in 2022.[178] The United States government demonstrated it is committed to driving CCS costs down with the announcement of nearly $18 billion in carbon capture funding in 2021.[179] Furthermore, oil and petroleum giants are under ever-increasing pressure to decarbonize; as such, these companies pour money into carbon capture investment in an attempt to prolong the life of their enterprises.[180] These industries have perhaps now been incentivized to use their economic prowess for good by which they turn a profit capturing and sequestering others' emissions. Ultimately, the Inflation Reduction Act's changes to 45Q were enacted in August of 2022, and, in the following three months, American entrepreneurs announced pioneering carbon capture projects in traditional industries and plans for the world's largest DAC facility—all to be built in the United States. That is a remarkable turnaround.

The future of the DAC industry may lie beyond the construction of massive, inefficient vacuums that suck CO2 from the air. Because the 45Q tax credit was changed in the Bipartisan Budget Act of 2018 to allow for direct air capture through photosynthesis, researchers and investors have been exploring the use of algae to

174. Salt & Ng, *supra* note 94.
175. Jeff McMahon, *Carbon Capture Surges in 2022, but Not Nearly Enough*, FORBES (Oct. 23, 2022), https://www.forbes.com/sites/jeffmcmahon/2022/10/23/carbon-capture-surges-in-2022-but-not-nearly-enough/?sh=27382f876a73.
176. Budinis et al., *supra* note 97.
177. Budinis, *supra* note 50.
178. Stephen Shankland, *Google, Facebook, Stripe Have a $925M Plan to Capture Carbon Pollution*, CNET (Apr. 13, 2022), https://www.cnet.com/news/google-facebook-stripe-have-a-925m-plan-to-capture-carbon-pollution.
179. UNITED STATES DEPARTMENT OF ENERGY, *supra* note 155, at 1.
180. Anja Chalmin, *The Fossil Fuel Industry has a Stake in the Majority of Known CCS and CCUS Projects*, GEOENGINEERING MONITOR (Nov. 15, 2021), https://www.geoengineeringmonitor.org/2021/11/fossil-fuel-industry-and-investments-in-ccs-ccus.

capture CO2 from the air.[181] With capture costs of $50-100/Mt., this method of DAC is far cheaper than traditional methods.[182] Investors eyeing 45Q would see far higher profit margins cultivating algae to capture CO2 from the air because they would not be burdened by unwieldy, cost-ineffective DAC plants, and their CO2 removal method would simultaneously produce oxygen for the world. Investment alongside practical incentives for use can lead to novel advances in the art of carbon capture by which meaningful technological strides are made.

V. CONCLUSION

While it is not a solution to the driver of climate change, carbon sequestration technology will be a necessary tool in the transition away from fossil fuels. Congress's 2022 changes to the 45Q credit might have enabled some industries to realistically access it; however, traditional CCS technology is still too inefficient for most industries. Despite the United States' commitment to jump-starting use of the technology, the world is on track to fall dramatically short of carbon sequestration targets. Further investment and innovation is needed if CCS is to be adopted at a meaningful scale. If that happens, CCS can be a useful transitory tool as humanity gradually shakes its dependence on fossil fuels, but it cannot be a substitution for actual change. While the recent renovation to the 45Q tax credit has created new investment opportunities and potentially enabled entirely new industries to come online, humanity is still far from where it needs to be in the race against time.

181. Shelley Schlender, *Most Efficient Source of Fuel May Be Tiniest Organism*, VOA (Jan. 28, 2020), https://www.voanews.com/a/science-health_most-efficient-source-fuel-may-be-tiniest-organism/6183319.html; *see also* Loz Blain, *Brilliant Planet Plans Cheap, Gigaton-Scale Carbon Capture Using Algae*, NewAtlas (Apr. 26, 2022), https://newatlas.com/environment/brilliant-planet-algae-carbon-sequestration (explaining the process of algae carbon capture and its development outside the U.S.).
182. Blain, *supra* note 179.