CARBON CAPTURE AND STORAGE: THE KEY TO A NET-ZERO ECONOMY

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ABSTRACT

The United States has committed to net-zero by 2050—by that date, the world's largest economy will take at least as much carbon out of the atmosphere as it emits. Our world was built and runs on carbon-based energy, so transitioning to zero carbon is an unprecedented challenge for our economy. Some technologies that are driving the clean energy transition are already being deployed, such as increased use of solar and wind power, but the greater challenges remain: What will power our civilization when the sun and the wind are unavailable, and how will we stop emissions from sectors that will still need to burn some amount of carbon fuels?

Carbon capture and storage (CCS) is the most plausible answer to these key questions and the key technology on which the world's transition to net-zero depends. The United States, as the world's largest economy and the leading producer of oil and gas, will play a crucial role in demonstrating carbon capture technology. Its fastest growing state, Texas, is attracting more clean energy investment than any other state and is in prime position to win the race to develop a thriving carbon capture industry. The Texas Gulf Region has established natural gas facilities, pipeline infrastructure, geologic carbon storage capacity, and project management skills giving it the natural advantage in scaling up the deployment of carbon, capture, and storage in the United States. This Article will discuss the necessity of CCS in reaching net-zero carbon emissions in the United States, state and federal policy enabling the implementation of CCS, and Texas's key advantages in leading the global charge toward carbon capture and a new, net-zero economy.

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I. INTRODUCTION

The United States has committed to a carbon pollution-free power sector by 2035 and a net-zero emissions economy by 2050.[1] The human race has always depended on burning carbon-based fuels, from the first wood campfires lit by humans to the industrial heat and the combustion engines that make our modern global civilization possible.[2] Human welfare and prosperity, health, and lifespan have marched in tandem with our rising combustion of fossil fuels, releasing carbon dioxide and energy to drive our world.[3] But the world is now aiming to

1. U.S. DEP'T OF STATE & EXEC. OFF. OF THE PRESIDENT, THE LONG-TERM STRATEGY OF THE UNITED STATES: PATHWAYS TO NET-ZERO GREENHOUSE GAS EMISSIONS BY 2050 1, 5 (2021), https://bidenwhitehouse.archives.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf [https://perma.cc/C4GK-2AHX].

2. VACLAV SMIL, ENERGY AND CIVILIZATION: A HISTORY 1, 7 (2017).

3. CHARLES C. MANN, THE WIZARD AND THE PROPHET: TWO REMARKABLE SCIENTISTS AND THEIR DUELING VISIONS TO SHAPE TOMORROW'S WORLD 254–58 (2018).

bring net emissions of carbon dioxide down to zero to keep warming to 1.5 degrees Celsius and avoid the most severe consequences of climate change.[4]

Severing the link between carbon and human prosperity will require capturing and storing carbon dioxide on a staggering scale.[5] To be sure, there are many other technologies that will assist. The United States's Inflation Reduction Act is allocating massive funds to electrify huge parts of the global economy, such as transportation, industry, and home heating that currently depend on burning fossil fuels.[6] And an increasing portion of that electricity can come from zero-carbon sources such as solar and wind.[7] But moving life-critical parts services, such as transport and heating, to dependence on electricity will only increase the importance of unfailing, reliable electricity service, and an increased use of renewables such as solar and wind will increase the need for sources, such as natural gas, that can ramp up to support the grid when renewables are not available.[8] Decarbonizing natural gas, in turn, will require capturing and storing the carbon that is emitted when gas is burned to maintain a stable power grid.[9] And other crucial sectors of the economy, such as cement, chemicals, and steelmaking, inevitably produce carbon dioxide emissions that must be captured and stored to reach net-zero emissions.[10]

So even as the world makes progress on cutting carbon emissions with existing technologies, such as wind, solar, and electric cars, its ultimate victory over climate change depends on widespread deployment of carbon capture and storage, a technology that is still in its infancy. Global policymakers have recognized the central importance and ambition of this challenge. The International

4. Press Release, The White House, Fact Sheet: President Biden to Catalyze Global Climate Action Through the Major Economies Forum on Energy and Climate (Apr. 20, 2023), https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2023/04/20/fact-sheet-president-biden-to-catalyze-global-climate-action-through-the-major-economies-forum-on-energy-and-climate/ [https://perma.cc/9342-K9H7].

5. *See id.*

6. Inflation Reduction Act of 2022, Pub. L. No. 117-169, 136 Stat. 1818; James M. Auslander et al., *U.S. Senate Passes the Inflation Reduction Act, Committing $370 Billion to Action on Climate and Energy*, NAT'L L. REV. (Aug. 9, 2022), https://www.natlawreview.com/article/us-senate-passes-inflation-reduction-act-committing-370-billion-to-action-climate [https://perma.cc/GC78-WNFQ].

7. James W. Coleman, *Pipelines & Power-Lines: Building the Energy Transport Future*, 80 OHIO ST. L.J. 263, 268–71 (2019) [hereinafter Coleman, *Pipelines & Power-Lines*].

8. *Id.* at 270.

9. RAIMUND MALISCHEK ET AL., TRANSFORMING INDUSTRY THROUGH CCUS 7, 8, 48 (2019), https://iea.blob.core.windows.net/assets/0d0b4984-f391-44f9-854f-fda1ebf8d8df/Transforming_Industry_through_CCUS.pdf [https://perma.cc/9UTY-JN3C].

10. *See id.* at 12.

Energy Agency stated that, without carbon capture and storage "our energy and climate goals will become virtually impossible to reach."[11] The International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC)—which is the United Nations body for assessing the science related to climate change—have said that without carbon capture, the cost of achieving climate goals could double.[12] As Robert Stavins, the director of Harvard's Environmental Economics program, put it: without carbon capture and storage, it is "very difficult to come up with scenarios that pass the laugh test that can limit warming to two degrees Celsius."[13]

Carbon capture and storage is necessary to meet the world's climate goals. Fortunately, the United States is well positioned to show that this technology is achievable, driving the transition to a net-zero economy. The United States is by far the world's largest producer of both oil and natural gas,[14] which gives it both the motive and the opportunity to rapidly develop carbon capture and storage technology. It has the motive because its growing exports of oil and gas will be most valuable in a net-zero future if carbon capture technology makes continued fossil-fuel use consistent with global climate goals.[15] It also has the opportunity because carbon capture and storage requires much of the same technology necessary for fossil-fuel production: separating and sequestering carbon molecules, sending them via air-tight pipelines, and then storing them in

11. Nerijus Adomaitis, *Global Climate Goals 'Virtually Impossible' Without Carbon Capture - IEA*, REUTERS (Sep. 24, 2020, at 7:36 CDT), https://www.reuters.com/article/idUSKCN26F0IO/ [https://perma.cc/QXJ9-ZHKE] ("A sharp rise in the deployment of carbon capture, utilization and storage (CCUS) technology is needed globally if countries are to meet net-zero emissions targets designed to slow climate change, the International Energy Agency (IEA) said on Thursday.").

12. Kevin Bullis, *The Cost of Limiting Climate Change Could Double Without Carbon Capture Technology*, MIT TECH. REV. (Apr. 18, 2014), https://www.technologyreview.com/2014/04/18/173317/the-cost-of-limiting-climate-change-could-double-without-carbon-capture-technology/ [https://perma.cc/N58E-CNFD].

13. *Id.*

14. James W. Coleman, *The Third Age of Oil and Gas Law*, 95 IND. L.J. 389, 418–19 (2020) [hereinafter Coleman, *Third Age of Oil*]; James W. Coleman, *Rebuilding the Texas Railroad Commission*, OGEL (2022) [hereinafter Coleman, *Texas Railroad Commission*], www.ogel.org/article.asp?key=4020.

15. *See* James W. Coleman, *State Energy Cartels*, 42 CARDOZO L. REV. 2233, 2235–36 (2021).

underground reservoirs that are often the same reservoirs from which oil and gas were extracted.[16]

Texas, the capital of global energy production, which has often led energy revolutions, is particularly well positioned to lead a carbon capture renaissance. The combination of the state's large cluster of high-carbon emitters, proximal capacity to geologic carbon storage capacity, and an existing backbone of pipeline infrastructure places it in a unique position to directly provide clean energy to the Texas grid using carbon capture and storage.[17] One particularly influential model estimates that 75 percent of geologic sequestration will take place in the Texas Gulf Region.[18] Texas could be a role model for the nation in how the cost of the U.S. energy transition to net-zero could be reduced using carbon capture and storage.[19]

Just as carbon capture fills an essential gap in the world's hopes of achieving its climate goals, this Article fills an essential gap in the legal literature on climate policy.[20] The literature has well explored some of the key challenges in deploying

16. *See Understanding Carbon Capture and Storage*, BRIT. GEOLOGICAL SURV., https://www.bgs.ac.uk/discovering-geology/climate-change/carbon-capture-and-storage/ [https://perma.cc/ES2Q-K8YX].

17. *See* John Hall, *A Carbon Industry Is Coming to Texas. We Should Prepare for It Now*, HARC (June 10, 2025), https://harcresearch.org/news/texas-carbon/ [https://perma.cc/8JNB-RDND]. Furthermore, Texas has proven uniquely capable of deploying new energy technologies, which has made it the nation's runaway leader in deployment of solar and wind power. Gavin Maguire, *Texas Tops US States for Renewable Energy and Battery Capacity*, REUTERS (Jan. 9, 2025, at 10:41 CST), https://www.reuters.com/business/energy/texas-tops-us-states-renewable-energy-battery-capacity-maguire-2025-01-09/ [https://perma.cc/6WYX-YKLP]. Solar and wind renewable energy is only available to the grid when the sun shines and the wind blows, so fossil-fuel generated energy is needed to keep the grid running when they are unavailable.

18. ERIC LARSON ET AL., NET-ZERO AMERICA: POTENTIAL PATHWAYS, INFRASTRUCTURE, AND IMPACTS 41 (2021), https://netzeroamerica.princeton.edu/img/Princeton%20NZA%20FINAL%20REPORT%20SUMMARY%20(29Oct2021).pdf [https://perma.cc/5XC9-HWC3].

19. *See id.* at 6.

20. *See infra* Part IV.

other technologies such as solar,[21] wind,[22] and nuclear power,[23] as well as electrification of sectors such as transportation and home heating.[24] By contrast, carbon management—capture and storage—is relatively unexplored. To be sure, there are important articles on aspects of carbon management, including how to site carbon transport pipelines,[25] how to assign liability for long-term storage of carbon dioxide,[26] and who owns the pore space under land with a severed mineral estate.[27] This Article fills this crucial gap by comprehensively exploring the key policy challenges facing carbon capture and storage and explaining how they can be surmounted to make the world's climate goals achievable.

21. *See, e.g.*, Daniel A. Lyons, *Federalism and the Rise of Renewable Energy: Preserving State and Local Voices in the Green Energy Revolution*, 64 CASE W. RSRV. L. REV. 1619, 1630–32 (2014).

22. *See, e.g.*, *id.* at 1634–36; Alexandra Klass et al., *Grid Reliability Through Clean Energy,* 74 STAN. L. REV. 969, 974–82 (2022); Danielle Stokes, *Renewable Energy Federalism*, 106 MINN. L. REV. 1757, 1761–62, 1778–88 (2022); Uma Outka, *The Renewable Energy Footprint*, 30 STAN. ENV'T L.J. 241, 246–54 (2011).

23. *See, e.g.*, Lincoln L. Davies, *Beyond Fukushima: Disasters, Nuclear Energy, and Energy Law*, 2011 BYU L. REV. 1937, 1975 (2011); Sandra Roettgering, *Regulation, Radiation, and Rationality: Calculating an Intersection of Law and Economics to Enable Nuclear Power Innovation in the United States*, 14 SEATTLE J. TECH. ENV'T INNOVATION L. 1, 37 (2023); HELEN COOK, THE LAW OF NUCLEAR ENERGY 3 (2d ed. 2018); James E. Hickey, Jr., *Reviving the Nuclear Power Option in the United States: Using Domestic Energy Law to Cure Two Perceptions of International Law Illegality*, 35 HOFSTRA L. REV. 425, 425–26 (2006).

24. *See, e.g.*, Alexandra B. Klass, *Public Utilities and Transportation Electrification*, 104 IOWA L. REV. 545, 547–48 (2019); HENRY LEE & ALEX CLARK, CHARGING THE FUTURE: CHALLENGES AND OPPORTUNITIES FOR ELECTRIC VEHICLE ADOPTION 9–10 (2018), https://www.hks.harvard.edu/publications/charging-future-challenges-and-opportunities-electric-vehicle-adoption [https://perma.cc/2PT6-Q4Y7]; Heather Payne, *The Natural Gas Paradox: Shutting Down a System Designed to Operate Forever*, 80 MD. L. REV. 693, 719–20 (2021); Shelley Welton, *Clean Electrification*, 88 U. COLO. L. REV. 571, 607 (2017).

25. *See, e.g.*, Tara K. Righetti, *Siting Carbon Dioxide Pipelines*, 3 OIL & GAS, NAT. RES., & ENERGY J. 907 (2017) (presenting an example of an article on the regulatory framework for siting carbon pipelines).

26. *See, e.g.*, Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change and Carbon Sequestration: Assessing a Liability Regime for Long-term Storage of Carbon Dioxide*, 58 EMORY L.J. 103, 111 (2008); Felix Mormann, *Public–Private Sharing of Carbon Sequestration Risk*, 7 NATURE SUSTAINABILITY 839, 840 (2024).

27. *See, e.g.*, Joseph A. Schremmer, *Pore Space Property*, 2021 UTAH L. REV. 1, 2–3 (2021); Keith B. Hall, *Reconciling Property Rights with Carbon Capture and Storage*, 10 BELMONT L. REV. 382, 383–84 (2023); Tara Righetti et al., *The Carbon Storage Future of Public Lands*, 38 PACE ENV'T L. REV. 181, 186–87 (2021); Joseph A. Schremmer, *Getting Past Possession: Subsurface Property Disputes as Nuisances*, 95 WASH. L. REV. 315, 317–18 (2020).

This Article proceeds in four Parts. Part II lays out the details of the CCS process, and how it must be deployed in the United States to reach net-zero by 2050.[28] Part III discusses how federal policy is fostering the energy transition through grant and loan funding, tax incentives, Class VI carbon well permitting, and carbon transportation siting.[29] Part IV discusses key state policies to regulate and enable carbon capture and storage, including the terms of leakage liability transfer, property rights, state primacy for Class VI well permitting, and clean energy portfolio standards.[30]

Finally, Part V explores what further steps Texas can take to ensure that carbon capture enables clean power twenty-four hours a day, seven days a week on its independent electricity grid.[31] The dominant source of power generation in Texas is natural gas.[32] This Part also describes how power generated by natural gas using CCS in the state can provide reliable base load and peaking power needed to complement renewable energy for a stable grid.[33] Further, Part V will discuss how Texas's past use of ratepayer-backed securitization could provide a model to fund deployment of carbon capture while limiting the impact on ratepayers.[34] Other potential sources of funding include contracts for differences and the recently established Texas Energy Fund, as well as the Greater Houston program.[35] Texas has the ability to be at the forefront of yet another energy revolution; build a new, cleaner fossil-fuel industry; and set a precedent showing the nation and the world how to provide a growing economy with reliable, affordable, and secure zero-carbon energy.

II. CARBON, CAPTURE, AND STORAGE IS THE KEY TECHNOLOGY FOR ACHIEVING A NET-ZERO ECONOMY

The International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC) (which is the United Nations body for assessing the science related to climate change) have said that a delay in the deployment of CCS

28. *See infra* Part II.

29. *See infra* Part III.

30. *See infra* Part IV.

31. *See infra* Part V.

32. *Texas: State Profile and Energy Production Estimates*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/state/?sid=TX#tabs-3 [https://perma.cc/BAV3-REMX].

33. *See infra* Part V.A.

34. *See infra* Part V.C.

35. *See infra* Part V.D.

at scale will have a significant impact on the ability to achieve net-zero by 2050.[36] The IPCC has found that it will cost more than twice as much to keep global warming to two degrees Celsius without CCS.[37] The CCS process involves capturing carbon dioxide from large point generation sources using fossil fuels in power plants and heavy industrial facilities.[38] Carbon dioxide is subsequently compressed and transported, largely by pipeline, to sites where it is injected into deep geological formations for permanent storage either in saline aquifers or in oil and gas reservoirs.[39]

Emerging CCS technologies also include direct air capture, in which carbon dioxide is captured directly from the atmosphere and not connected to a point source.[40] Without CCS, the IEA estimates that current power and industrial plants could emit a further 600 gigatons of carbon dioxide, or approximately 17 years of current global energy sector emissions.[41] The International Energy Agency Net-Zero Scenario suggests that carbon captured from energy-related and heavy industry process emissions could be as much as 40 percent of total emissions captured in 2050.[42]

36. INT'L ENERGY AGENCY, NET ZERO BY 2050: A ROADMAP FOR THE GLOBAL ENERGY SECTOR 98 (2021) [hereinafter NET ZERO BY 2050], https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf [https://perma.cc/Q58Y-JVJT]; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE 36 (Priyadarshi R. Shukla et al. eds., 2022), https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf [https://perma.cc/R8XQ-Y7C2].

37. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: SYNTHESIS REPORT 24–25 (The Core Writing Team, Rajendra K. Pachauri & Leo Meyer eds., 2014), https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf [https://perma.cc/UWS8-RBNR].

38. *See* Katie Lebling et al., *7 Things to Know About Carbon Capture, Utilization and Sequestration*, WORLD RES. INST. (May 16, 2025), https://www.wri.org/insights/carbon-capture-technology [https://perma.cc/M9W4-YFBG].

39. *See id.*

40. *See* EXXONMOBIL, 2024 ADVANCING CLIMATE SOLUTIONS: EXECUTIVE SUMMARY 22, 69, 71 (2024), https://corporate.exxonmobil.com/-/media/global/files/advancing-climate-solutions/2024/2024-advancing-climate-solutions-report.pdf [https://perma.cc/J56W-NYZJ].

41. INT'L ENERGY AGENCY, ENERGY TECHNOLOGY PERSPECTIVES 2020: SPECIAL REPORT ON CARBON CAPTURE UTILISATION AND STORAGE: CCUS IN CLEAN ENERGY TRANSITIONS 13, 56–57 (2020), https://iea.blob.core.windows.net/assets/181b48b4-323f-454d-96fb-0bb1889d96a9/CCUS_in_clean_energy_transitions.pdf [https://perma.cc/2GE9-BR7E].

42. NET ZERO BY 2050, *supra* note 36, at 124.

A. *How Carbon Capture and Storage Works*

Hydrocarbons such as oil and gas have energy stored in the bonds between their hydrogen and carbon molecules which is released when they are burned in the presence of oxygen, releasing energy, water vapor, and carbon dioxide.[43] As a result, carbon dioxide is an inevitable byproduct of hydrocarbon fuels. Thus, carbon capture and storage is the only available technology to decarbonize emissions from coal and natural gas generated power.[44] It will be cost prohibitive or impossible to achieve net-zero emissions in power generation and heavy industry without CCS.[45] The majority of CCS operating facilities are located in the United States primarily due to existing carbon dioxide pipelines used in enhanced oil recovery from depleted oil and gas reservoirs.[46] In enhanced oil recovery, carbon dioxide is pumped underground to help drive more oil and gas to the surface.[47]

The IPCC modeled four scenarios showing emission reductions required to limit global temperature rise to 1.5 degrees Celsius.[48] In the second scenario, which incorporates steep reductions in emissions in the 2020s and 2030s, CCS accounts for 348 billion tons of carbon reduction through 2100.[49] In the third scenario, which models moderate reductions in emissions, CCS accounts for 687 billion tons of carbon reduction through 2100.[50] In the fourth scenario, energy demand and emissions generated from the industrial and power sectors are projected to increase through 2030, causing delayed decarbonization.[51] In this scenario, more significant levels of CCS would be required, accounting for 1,218 billion tons of carbon, or

43. *See Hydrocarbon Combustion*, ENERGY EDUC., https://energyeducation.ca/encyclopedia/hydrocarbon_combustion [https://perma.cc/UV97-HNHP].

44. *See* NET ZERO BY 2050, *supra* note 36, at 21, 23.

45. *See id.* at 15–16.

46. CONG. BUDGET OFF., CARBON CAPTURE AND STORAGE IN THE UNITED STATES 1 (2023), https://www.cbo.gov/system/files/2023-12/59345-carbon-capture-storage.pdf [https://perma.cc/VK4K-VE8E].

47. *See* Philip Budzik & Dana Van Wagener, *Oil Prices Drive Projected Enhanced Oil Recovery Using Carbon Dioxide*, U.S. ENERGY INFO. ADMIN. (July 30, 2014), https://www.eia.gov/todayinenergy/detail.php?id=17331 [https://perma.cc/SM4U-L5UW].

48. MYLES ALLEN ET AL., SUMMARY FOR POLICYMAKERS 14 (2018), https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SPM_version_report_LR.pdf [https://perma.cc/7CTT-BRNK].

49. *Id.*

50. *Id.*

51. *Id.*

an annual average of 15 billion tons—more than a third of the world's annual carbon emissions—to decarbonize through 2100.[52]

Existing U.S. CCS projects and those under development are involved in power generation, natural gas processing, as well as hydrogen, chemical, and fertilizer production.[53] Initial carbon capture and storage efforts have often been aimed at industries such as ethanol refining, ammonia production, and natural gas processing that produce relatively pure streams of carbon dioxide that can be captured.[54] These facilities capture carbon and then transport it to be injected for permanent storage in geologic saline formations and in aging oil fields for use in enhanced oil recovery.[55] Power plants and industrial facilities use post-combustion capture, precombustion capture or oxy-fuel combustion capture processes in capturing carbon.[56]

In the post-combustion process, carbon is extracted from flue gas following combustion of fossil fuels or biomass using chemical solvents, capturing around 85 to 90 percent of carbon in the process.[57] Heat is applied via steam to the solvent, which releases the carbon dioxide.[58] The concentrated stream of carbon dioxide "is then compressed and piped to a [sequestration] site."[59] Post-combustion can be applied to already constructed plants (retrofit) without significant impact on the underlying facility.[60] Post-combustion is the most proven method of capturing carbon to date given similar industrial processes.[61]

Precombustion captures carbon by combining fuel with air or steam to produce hydrogen for combustion and separate carbon.[62] Carbon can subsequently be captured, and pure hydrogen burned in an integrated gasification combined-

52. *See id.*

53. *See* Sonal Patel, *Capturing Progress: The State of CCS in the Power Sector*, POWER MAG. (Jan. 2, 2024), https://www.powermag.com/capturing-progress-the-state-of-ccs-in-the-power-sector/ [https://perma.cc/NA5Z-VGPF].

54. ANGELA C. JONES & ASHLEY J. LAWSON, CARBON CAPTURE AND SEQUESTRATION (CCS) IN THE UNITED STATES, at summary (2022), https://crsreports.congress.gov/product/pdf/R/R44902/17 [https://perma.cc/XJ4R-4QZD].

55. *Id.*

56. *Id.*

57. *Id.* at 4.

58. *Id.*

59. *Id.*

60. *Carbon Capture*, UKCCSRC, https://ukccsrc.ac.uk/ccs-explained/carbon-capture/ [https://perma.cc/A82X-9A7S].

61. *See id.*

62. JONES & LAWSON, *supra* note 54, at 5.

cycle plant to generate electricity.[63] A key benefit to this process is that the hydrogen produced is a transportable fuel.[64] While there are potential efficiency gains from integration of the technology into power plants, to date it has only been demonstrated at the megaton-per-year scale.[65]

Oxy-fuel combustion capture separates oxygen from air that is used in the combustion process, which produces a flue gas that is mostly carbon dioxide and water.[66] Subsequently, carbon dioxide can readily be separated, transported, and sequestered.[67] Oxy-fuel combustion projects are nascent and still at the early verification and pilot stage.[68]

An innovative power plant design is currently under development, which uses supercritical carbon dioxide, rather than steam, to drive the electricity generating turbine.[69] The Allam cycle combusts fossil fuels in pure oxygen producing water and carbon dioxide, which can be recycled back into the electricity generating process, or transported and stored.[70] Developers of the Allam cycle technology suggest that it is economically comparable to "natural gas combined cycle power plants without CCS."[71]

After carbon dioxide has been captured at point source, it is purified and compressed into a concentrated stream, which can be subsequently transported, typically by pipeline, similar to transporting natural gas or oil.[72] Siting of pipelines are under state jurisdiction and subject to federal government safety regulation.[73] Shipping rates are negotiated between originators and shippers.[74] However, rates may be subject to regulation if pipelines are considered to be open access with siting under eminent domain.[75]

One open question is whether development of a national carbon dioxide pipeline network connecting emitters and storage using CCS will require federal

63. *Id.*
64. *Carbon Capture*, *supra* note 60.
65. *Id.*
66. JONES & LAWSON, *supra* note 54, at 6.
67. *Id.*
68. *Id.*
69. *Id.* at 7.
70. *Id.*
71. *Id.*
72. *Id.* at 8.
73. *Id.*
74. *Id.*
75. *Id.*

legislation, including federal siting and further federal incentives.[76] Pipeline companies have built a nationwide network of oil pipelines even though oil pipelines, like carbon dioxide pipelines, are sited at the state level.[77] On the other hand, interstate natural gas pipelines are sited by the federal government, which may suggest that carbon dioxide pipelines should also be sited by the federal government.[78]

The final phase of the CCS process is injection and sequestration.[79] Carbon is permanently stored in geological formations, including oil and gas and deep saline reservoirs, as well as unmineable coal seams.[80] Carbon is injected into depths greater than 800 meters, and generates pressure which protects it from migration outside the geological formation.[81] Injection technology is virtually the same as existing technology used in the oil and gas industry.[82] The United States Environmental Protection Agency (EPA) regulates underground injection as part of its mandate to protect underground sources of drinking water through the Underground Injection Control program.[83] Traditional Class II oil and gas production wells are used to inject carbon for enhanced oil recovery, and Class VI wells are used for sequestration in saline geologic formations.[84] Class II wells injecting for permanent carbon sequestration will ultimately need to transition to Class VI wells.[85]

The Petra Nova power-generating station was the first coal-fired power plant in the United States built to incorporate CCS capability.[86] The cost of the CCS retrofit was around $1 billion.[87] It began capturing approximately 5,000 tons of

76. *See id.*

77. *See* Alexandra B. Klass & Danielle Meinhardt, *Transporting Oil and Gas: U.S. Infrastructure Challenges*, 100 IOWA L. REV. 947, 948 (2015); James W. Coleman, *Policymaking by Proposal: How Agencies Are Transforming Industry Investment Long Before Rules Can Be Tested in Court*, 24 GEO. MASON L. REV. 497, 511–12 (2017); James W. Coleman, *Beyond the Pipeline Wars: Reforming Environmental Assessment of Energy Transport Infrastructure*, 2018 UTAH L. REV. 119, 135–36 (2018).

78. *See* sources cited *supra* note 77.

79. JONES & LAWSON, *supra* note 54, at 2.

80. *Id.* at 9.

81. *Id.*

82. *Id.*

83. *Id.* at 23.

84. *Id.*

85. *Id.* at 24.

86. *Id.* at 17.

87. *Id.*

carbon per day in 2017 using post-combustion capture technology.[88] It captures around 90 percent of the carbon produced when coal is burned to produce electricity and is capable of capturing 1.4 million tons per year.[89] The captured carbon is transported by pipeline to the West Ranch oil field in Texas.[90] The facility was deactivated in May 2020 when oil prices plummeted during the COVID-19 pandemic, making the economics of the project nonviable, as oil produced through enhanced oil recovery had reduced significantly in value.[91] However, the Japanese energy company, JX Nippon, officially restarted the project in September 2023.[92]

Other CCS projects at power plants currently being developed include NET Power in Odessa, Texas, which plans to burn natural gas with oxygen, and is expected to be online in 2026.[93] Others with uncertain launch dates could soon receive funding from a Department of Energy fund for studies to support integrated CCS projects.[94] These include Duke Energy Indiana's EFFICIENT project in Edwardsport, Indiana, which would add CCS to a combined cycle power plant fueled by either natural gas, syngas gasified by coal, or a blend of the two.[95] Lake Charles Power Station in Westlake, Louisiana is a combined cycle natural gas plant expected to capture at least 95 percent of carbon dioxide emissions of around 2.4 million tons per year.[96] Cypress Carbon Capture in Hahnville, Louisiana plans to add CCS to the Taft natural gas plant, and expects to capture 90 percent of emissions, or 3 million tons of carbon dioxide a year.[97] The Polk Power Station in Mulberry, Florida also plans to add CCS to its facility to capture up to 95 percent of emissions, or 3.7 million tons per year.[98]

88. *Id.*

89. *Id.*

90. *Id.*

91. *Id.*

92. News Release, JX Nippon Oil & Gas Exploration Corporation, *Restart of the Large-Scale Petra Nova Carbon Capture Facility in the U.S.* (Sep. 13, 2023), https://www.eneos-xplora.com/english/newsrelease/upload_files/20230913EN.pdf [https://perma.cc/FN5G-3KB9].

93. *Emerging Carbon Capture Projects at U.S. Power Plants*, REUTERS (May 12, 2023, at 9:25 CDT), https://www.reuters.com/sustainability/emerging-carbon-capture-projects-us-power-plants-2023-05-12/ [https://perma.cc/G64U-S2KQ].

94. *Id.*

95. *Id.*

96. *Id.*

97. *Id.*

98. *Id.*

Broadly, CCS technology is capable of being deployed at a commercial scale today.[99] However, cost is the key barrier to widespread deployment.[100] Carbon capture equipment is costly to build and energy-intensive to operate.[101] The energy penalty or parasitic load for power plants, which supply their own energy in operating CCS equipment, can be as much as 20 percent of its production capacity.[102] While the transportation and injection parts of the process are less technologically challenging or costly, they still face regulatory challenges, rights-of-way questions, and future ownership and liability issues around sequestered carbon.[103] Carbon utilization as a commercially viable product will ultimately reduce the cost of capture and storage. While the principal source of revenue from using carbon is currently derived from enhanced oil recovery—using carbon dioxide to push more oil out of old formations—other uses of carbon in the chemical, plastic, building material, cement, and fuels industries are in the research and development stage.[104]

B. *Deploying Carbon Capture and Storage in the United States*

CCS is key to maintaining U.S. industry competitiveness and high wage jobs, while achieving an energy transition to net-zero by 2050. The United States is by far the world's leading producer of the world's hydrocarbon fuels: oil and natural gas.[105] This critical resource, which has been key to U.S. geopolitical strength over the past century,[106] will only be useful in a net-zero future if paired with widespread carbon capture and storage.

In carbon intensive industries where decarbonization is not possible solely by switching to electric power, CCS is essential.[107] Geologic formations in the

99. *See* GREG KELSALL, CARBON CAPTURE UTILISATION AND STORAGE - STATUS, BARRIERS AND POTENTIAL (2020), https://cdrlaw.org/wp-content/uploads/2020/10/Carbon-capture-utilisation-and-storage-status-barriers-and-potential-CCC304-Exec-Sum.pdf [https://perma.cc/UHF4-XRCV].

100. *See id.*

101. *See id.*

102. JONES & LAWSON, *supra* note 54, at 2.

103. *Id.* at 4.

104. *Id.* at 11–12.

105. Coleman, *Third Age of Oil*, *supra* note 14, at 318; Coleman, *Texas Railroad Commission*, *supra* note 14.

106. KPMG, THE GEOPOLITICS OF OIL AND GAS 7 (2023), https://kpmg.com/content/dam/kpmg/au/pdf/2023/geopolitics-of-oil-and-gas.pdf [https://perma.cc/AAF3-W72M].

107. *See* Fred Pearce, *Can the World's Most Polluting Heavy Industries Decarbonize?*, YALE ENV'T 360 (Sep. 23, 2021), https://e360.yale.edu/features/can-the-worlds-most-polluting-heavy-industries-decarbonize [https://perma.cc/ULT9-34TF].

United States have significant capacity to permanently store thousands of years of carbon emissions.[108] As it is expensive to ship carbon across the country, the economics can only work in regions where both the carbon emitters and the storage sites are mutually located, and pipelines can be constructed to connect the two.[109] Fourteen carbon and hydrogen hubs across the United States have been identified, which will play an important role in carbon management.[110] Carbon and hydrogen hubs are regions consisting of areas with a high concentration of large industrial emitters that use high quantities of fossil fuels on site for industrial energy production.[111] Large geologic saline and fossil formations for permanent storage are located in these regions.[112] The hub model includes facilities capable of being retrofitted for carbon capture in the near-to-medium term.[113]

U.S. industrial and power facilities emit approximately 2.5 billion tons of carbon per year with the largest emitters, coal power plants, gas power plants, and refineries, producing around 1.8 billion tons per year.[114] Of the 5,224 facilities emitting this level of carbon per year in the United States, 1,197 are able to be carbon capture retrofitted, and meet minimum eligibility requirements to qualify for a federal tax credit.[115] The Section 45Q tax credit of the U.S. tax code provides for a performance-based tax credit awarded to carbon capture projects that have successfully captured, transported, and stored carbon in deep geologic saline or fossil basins, or utilized it to produce decarbonized end products.[116] An additional 542 facilities have been identified as near-to-medium term potential capture retrofit candidates over the next 10 to 15 years, of which 203 are in the three highest emitting sectors.[117]

Although the U.S. government estimates that the price of carbon emissions should be set at around $40 per ton to cover mitigation costs and avoid a climate catastrophe, seasoned economists have estimated that carbon price levels of $200 per ton would be required in the near term to limit global warming to two degrees

108. ELIZABETH ABRAMSON ET AL., AN ATLAS OF CARBON AND HYDROGEN HUBS FOR UNITED STATES DECARBONIZATION 33 (2022) [hereinafter ABRAMSON ET AL., AN ATLAS], https://scripts.betterenergy.org/CarbonCaptureReady/GPI_Carbon_and_Hydrogen_Hubs_Atlas.pdf [https://perma.cc/ECW2-2RHB].

109. *See id.* at 34.

110. *Id.* at 5.

111. *Id.* at 8.

112. *Id.*

113. *Id.*

114. *Id.* at 11.

115. *Id.*

116. *Id.*

117. *Id.*

Celsius.[118] The estimated cost range of capturing carbon for the 542 near-to-medium term facilities is approximately $46 to $60 per ton for coal power plants, $53 to $63 per ton for gas power plants, and $43 to $68 per ton for refineries.[119] Economically viable transport costs of carbon from point source to geologic storage range from $10 to $20 per ton.[120] Variations are largely due to trunk size, transport volume, and the number of small feeder lines that connect to individual capture facilities.[121] However, a regional scale common-use transport network minimizes capital investment of the required buildout.[122] CCS is economically viable for industries with access to local storage in geologic saline formations and petroleum basins, such as in Texas and Louisiana, which have low-to-moderate capture costs and are able to claim the Section 45Q tax credit.[123]

In the United States, the Department of Energy estimates that underground geological storage formations are capable of storing from 2.6 trillion to 22 trillion tons of carbon.[124] Delineation of storage capacity by geological formation type is as follows: 186 to 232 billion tons in oil and gas reservoirs, 54 to 113 billion tons in unmineable coal seams, and 2,379 to 21,633 billion tons in saline formations.[125] Analysis shows that many regions with a large number of carbon capture emitters are also located in areas with significant geologic storage capability, which reduces transport costs.[126] Storage potential in saline formations and enhanced oil recovery fields is estimated to be largest in the state of Texas, comprising 1,372,789.7 tons of saline storage, 30 percent of U.S. capacity, and 4,875.4 tons of enhanced oil recovery storage potential, comprising 48 percent of U.S. capacity.[127]

118. WILLIAM D. NORDHAUS, THE SPIRIT OF GREEN: THE ECONOMICS OF COLLISIONS AND CONTAGIONS IN A CROWDED WORLD 280 (2021).

119. ELIZABETH ABRAMSON, DANE MCFARLANE & JEFF BROWN, TRANSPORT INFRASTRUCTURE FOR CARBON CAPTURE AND STORAGE 7 (2020) [hereinafter ABRAMSON, MCFARLANE & BROWN, TRANSPORT INFRASTRUCTURE], https://www.betterenergy.org/wp-content/uploads/2020/06/GPI_RegionalCO2Whitepaper.pdf [https://perma.cc/S5UP-B899].

120. *Id.* at 11.

121. *See id.*

122. *Id.*

123. *Id.* at 12.

124. JONES & LAWSON, *supra* note 54, at 9.

125. U.S. DEP'T OF ENERGY'S NAT'L ENERGY TECH. LAB'Y, CARBON STORAGE ATLAS 3 (5th ed. 2015), https://www.netl.doe.gov/sites/default/files/2018-10/ATLAS-V-2015.pdf [https://perma.cc/6H9T-D4G2].

126. ABRAMSON, MCFARLANE & BROWN, TRANSPORT INFRASTRUCTURE, *supra* note 119, at 18.

127. *Id.* at 19.

Estimates show the potential for up to 107,000 new jobs to be created over the next 15 years through capital investment in carbon capture retrofits and retrofit operations.[128] Post-2035, such investment could produce up to 131,000 jobs.[129] An investment of $112 billion over the next five years could result in significant job growth in the declining coal power industry.[130] Up to 32,730 annual initial project jobs and 20,780 annual ongoing operations jobs could be created in the coal power industry, up from 70,831 jobs in 2021.[131] This investment equates to capturing approximately 355 billion tons of carbon.[132]

A $56 billion investment over the same period in gas power could result in 16,570 annual initial project jobs and 9,850 annual ongoing jobs, up from 111,196 jobs in 2021.[133] This investment equates to capturing 114 billion tons of carbon.[134] A $38.2 billion investment in carbon transport would also create 19,853 annual initial project jobs for the buildout of the transport system.[135]

Eight regions in the United States, emitting 1.7 billion tons of carbon per year, have been identified for concentrated near-term development.[136] The Gulf Coast and the Midwest and Illinois Basin regions are the largest emitters of carbon in the United States with significantly higher stationary fuel combustion and a larger number of industrial and power facilities.[137] The Houston Hub Region has one of the largest concentrations of fossil-fuel and petrochemical operations in the country, emitting 156.2 million tons of carbon per year.[138] Given its proximity to carbon utilization potential in Texas and the Gulf Coast, as well as carbon transport infrastructure, Houston is extremely well positioned for industrial decarbonization using CCS.[139] There are 57 facilities in this hub eligible for the Section 45Q federal

128. JOHN LARSEN ET AL., THE ECONOMIC BENEFITS OF CARBON CAPTURE: INVESTMENT AND EMPLOYMENT OPPORTUNITIES FOR THE CONTIGUOUS UNITED STATES 9 (2021), https://rhg.com/wp-content/uploads/2021/04/The-Economic-Benefits-of-Carbon-Capture-Investment-and-Employment-Opportunities_Phase-III.pdf [https://perma.cc/R65B-RJ7K].

129. *Id.*

130. *Id.* at 15.

131. *Id.*

132. *Id.* at 13–15.

133. *Id.* at 15.

134. *Id.* at 13.

135. *See id.* at 13–15; ABRAMSON ET AL., AN ATLAS, *supra* note 108, at 14.

136. ABRAMSON ET AL., AN ATLAS, *supra* note 108, at 28.

137. *See id.*

138. *Id.* at 32.

139. *Id.*

tax credit, and 39 facilities have been identified as candidates that can be retrofitted over the next 10 to 15 years.[140]

Given the significant storage capacity in the Texas Gulf, 1.6 trillion tons in geologic saline formations, as well as geologic fossil basins, the Houston area has the potential to be a major carbon storage location for carbon capture throughout the country.[141] Existing rights-of-way of natural gas pipelines, which cover around 7,892 miles, oil pipelines covering 11,494 miles, and carbon pipelines covering 171 miles, are located in the Houston hub.[142] Collocating new carbon and hydrogen pipelines along pipeline routes with existing rights-of-way will reduce the cost of buildout and accelerate the permitting process.[143]

Princeton University has modeled five technical pathways in which the United States could reach net-zero by 2050.[144] The model is consistent with historical spending on energy in relation to economic activity, on average 4 to 6 percent of gross domestic product.[145] Projections show future energy spending levels equal or less than a percentage of current U.S. GDP.[146] The granular nature of the model incorporates specific actions needed to achieve the goal, as well as a sector-by-sector analysis of requirements and impacts on energy infrastructure, capital investment, and land use both at the state and local levels.[147]

The five pathway options modeled vary by energy supply mix needed to meet energy demands at the lowest 30-year net present value of energy-system costs.[148] All five pathways modeled rely on significant levels of CCS.[149] One of the five pathways modeled allows for additional energy supply generated by fossil fuels utilizing CCS, presuming that supply-side wind and solar renewable energy will not be able to meet total energy demand requirements.[150] This scenario envisions a greater deployment of CCS as oil and gas contributions to the supply of energy in 2050 are projected to be more significant than in other scenarios.[151]

140. *Id.* at 32–33.
141. *Id.* at 33.
142. *Id.* at 34.
143. *See id.*
144. LARSON ET AL., *supra* note 18, at 5.
145. *Id.*
146. *Id.* at 6.
147. *Id.* at 5.
148. *See id.* at 9–10.
149. *See id*.
150. *See id.* at 9.
151. *See id.* at 9–10.

Roughly equal amounts of energy are derived from fossil, nuclear, and renewables in this scenario.[152]

All pathways will also require significant capital investment of two to four times a business-as-usual case.[153] The fossil-fuel dominated scenario alone will require approximately $2 trillion of energy supply-side investment before 2030, and approximately $7.5 trillion by 2050.[154] Early-stage project development capital—funds required two to ten years before a project even becomes operational—could be as high as $185 billion through 2030 and $600 billion through 2050.[155] Policy will be a key factor in attracting such early-stage, at-risk capital.[156]

The sectors in which CCS are deployed include gas and biomass-fired power generation, cement production, natural gas reforming, and biomass fuels production.[157] The projections show geologic sequestration of 1 to 1.7 billion tons of carbon per year by 2050.[158] Carbon is captured from over 1,000 facilities, with around 110,000 km of new carbon pipeline infrastructure installed ranging in cost from $170 billion to $230 billion.[159] The transport and storage component of the process is estimated to cost between $17 to $23 per ton stored.[160] In the fossil-fuel dominated scenario, 200 capture plants are projected to be online by 2030 scaling up to 1,670 in 2050.[161] An estimated 75 percent of geologic sequestration is expected to occur in the Texas Gulf Region, totaling approximately 1.24 billion tons per year.[162] An estimated investment of $13 billion would be required before 2035 to develop storage basins for sequestration in the Texas Gulf Region.[163]

Energy and economic models show that the most significant impact of CCS in reaching net-zero will be derived from the electric power sector.[164] The IPCC

152. *See id.*
153. *See id.* at 52.
154. *See id.*
155. *See id.* at 50, 53.
156. *See id.* at 6.
157. *Id.* at 38.
158. *Id.*
159. *See id.*
160. *See id.*
161. *Id.* at 39.
162. *Id.* at 41.
163. *See id.* at 38.
164. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CARBON DIOXIDE CAPTURE AND STORAGE 11 (2005), https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf [https://perma.cc/8RUQ-PRMM].

has estimated that carbon avoidance costs for the complete CCS system for electricity generation would range from $40 to $90 per ton of carbon avoided for a natural gas combined cycle power plant, and $70 to $270 per ton of carbon avoided for a pulverized coal plant.[165] Power plants with capture used for enhanced oil recovery would range from $20 to $60 per ton of carbon avoided for a natural gas combined cycle power plant, and $50 to $240 per ton of carbon avoided for a pulverized coal plant.[166]

III. KEY FEDERAL POLICIES TO DRIVE CARBON CAPTURE & STORAGE

Given the wide-ranging nature of carbon policy in the United States, regulations as well as private sector incentives for the development of CCS projects occur both at the federal and state levels. At the federal level, private sector incentives have been incorporated into the bipartisan Infrastructure and Jobs Act of 2021, as well as the Inflation Reduction Act recently passed in August 2022.[167] Permitting, liability, and property rights necessarily are covered at both the federal and state levels.

A. *The Energy, Bipartisan Infrastructure, and Inflation Reduction Acts*

As part of the Consolidated Appropriations Act of 2021, the 2020 Energy Act authorized investments in commercial demonstration of clean energy and industrial carbon management technologies.[168] It also established a program at the Department of Energy to fund decarbonization of carbon intensive heavy industry.[169] As part of the bipartisan Infrastructure Investment and Jobs Act package passed in 2021, the Energy and Infrastructure Act was incorporated to fully fund over a five-year period, research, development, demonstration, and deployment of investments authorized in the 2020 Energy Act.[170] This legislation also established a program of low-interest federal loans and grants to enable the private sector to finance carbon transport and storage infrastructure.[171]

Specific carbon management provisions in the Infrastructure Investment and Jobs Act included funding for large-scale pilot programs, as well as demonstration

165. *Id.*

166. *Id.*

167. *See* Infrastructure Investment and Jobs Act, Pub. L. No. 117-58, 135 Stat. 429 (2021); Inflation Reduction Act of 2022, Pub. L. No. 117-169, 136 Stat. 1818 (2022).

168. ABRAMSON ET AL., AN ATLAS, *supra* note 108, at 75.

169. *Id.* at 76.

170. *Id.* at 75.

171. *Id.*

programs.[172] A carbon capture technology program for front-end engineering and design was included to advance technology to bring down project investment costs.[173] A carbon utilization program was added to explore how carbon can become a marketable commodity, as it has been for years in enhanced oil recovery.[174] The Storing CO_2 and Lowering Emissions (SCALE) Act was also introduced to finance carbon transport and storage infrastructure.[175]

The Inflation Reduction Act of 2022 was the most ambitious legislative action to progress clean energy in U.S. history.[176] It includes multiple tax incentives and billions of dollars in grant and loan programs.[177] The overarching objective of the Act is to build a low-carbon energy system in the United States with lower energy costs and a growing clean energy sector with incremental job growth of up to 1 million new jobs.[178]

In addition to increased tax incentives discussed below, the Inflation Reduction Act increased existing loan authority to the Department of Energy's Loan Programs Office that invests in clean energy projects by approximately $100 billion.[179] It also added a new $250 billion loan program used to repurpose or replace previous energy infrastructure, or to improve efficiency of infrastructure currently in operation.[180] The Loan Programs Office provides a bridge to bankability in financing innovative and high-impact clean energy technologies, which have yet to gain full market acceptance to obtain private sector financing.[181]

172. *Id.* at 77.

173. *See id.*

174. *See id.* at 77–78.

175. *Id.*

176. THE WHITE HOUSE, BUILDING A CLEAN ENERGY ECONOMY: A GUIDEBOOK TO THE INFLATION REDUCTION ACT'S INVESTMENTS IN CLEAN ENERGY AND CLIMATE ACTION 9 (2023), https://bidenwhitehouse.archives.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf [https://perma.cc/B2T6-Y8L9].

177. *Id.*

178. *See id.*; Press Release, U.S. Dep't of the Treasury, Fact Sheet: How the Inflation Reduction Act's Tax Incentives Are Ensuring All Americans Benefit from the Growth of the Clean Energy Economy (Oct. 20, 2023), https://home.treasury.gov/news/press-releases/jy1830 [https://perma.cc/9AMH-BZBR].

179. THE WHITE HOUSE, *supra* note 176, at 10.

180. *Id.* at 25.

181. *Inflation Reduction Act of 2022*, U.S. DEP'T OF ENERGY (Sep. 22, 2023), https://www.energy.gov/lpo/inflation-reduction-act-2022 [https://perma.cc/3333-ZRND].

B. *Tax Incentives: Section 45Q*

To encourage CCS investment, Congress enacted legislation in 2018 to increase the Section 45Q tax credit for development and deployment of CCS projects.[182] Section 45Q of the U.S. tax code provides for a performance-based tax credit awarded to carbon capture projects that have successfully captured, transported, and stored carbon in deep geologic saline or fossil basins, or used it to produce decarbonized end products, such as cement, fuels, and chemicals.[183] The tax credit is envisioned to incentivize private-sector investment in CCS technology used for electric power generation, natural gas processing, refining, and the production of ethanol, chemicals, steel, and cement.[184] In the CCS process, capturers of carbon are generally the sponsors of the projects and owners of the carbon capture equipment attached to an emitter's facility.[185] They are eligible to claim the 45Q tax credit.[186] Each project participant role will involve a variety of third-party investors, capital providers, and partners focused on ensuring economic success.[187]

In the Inflation Reduction Act, Congress made significant amendments to the Section 45Q tax credit for CCS.[188] Notably, it extended a developer's ability to start the construction of a project from 2026 to 2033.[189] It also raised the tax credit amount for carbon per ton captured and permanently stored from $50 per ton to $85 per ton.[190] The tax credit for carbon captured and stored as a tertiary injectant for use in enhanced oil recovery increased from $35 per ton to $60 per ton.[191] Both

182. *See* JONES & LAWSON, *supra* note 54, at 1; ABRAMSON, MCFARLANE & BROWN, TRANSPORT INFRASTRUCTURE, *supra* note 119, at 15.

183. ABRAMSON, MCFARLANE & BROWN, TRANSPORT INFRASTRUCTURE, *supra* note 119, at 15.

184. *Id.*

185. Austin Lee et al., *The Way Forward: A Legal and Commercial Primer on Carbon Capture, Utilization, and Sequestration*, 16 TEX. J. OIL GAS & ENERGY L. 43, 67 (2021).

186. *Id.*

187. *Id.* at 67–68 (discussing participants, economic drivers and objectives for CCUS projects).

188. THE WHITE HOUSE, *supra* note 176, at 67.

189. *See Clean Energy Tax Provisions in the Inflation Reduction Act*, THE WHITE HOUSE, https://bidenwhitehouse.archives.gov/cleanenergy/clean-energy-tax-provisions/ [https://perma.cc/HK6C-GSXY].

190. CARBON CAPTURE COALITION, THE INFLATION REDUCTION ACT (IRA) OF 2022 2 (2022), https://carboncapturecoalition.org/wp-content/uploads/2022/08/IRA-2022-Fact-Sheet-8.16.pdf [https://perma.cc/AQM5-Z5Z2].

191. *Id.*

rates are subject to prevailing wage and apprenticeship requirements to ensure CCS projects provide well-paying jobs and training opportunities.[192]

The 45Q credits can be claimed for 12 years after a facility is placed in service before 2033.[193] A significant enhancement included in the bill, the direct pay option makes the tax credit fully refundable for nontaxable entities; state, local or tribal governments; the Tennessee Valley Authority; and the Alaskan Native Corporation as per Section 13801.[194] Other taxable entities will be entitled to the direct pay option for five consecutive years of the total tax credit period if elected before the end of 2027.[195] Credits will also be eligible to transfer to other taxable entities with corporate tax liability under Section 13801 (amendment Section 6418).[196] The direct pay and transferability options will allow project developers to fully monetize 45Q tax credits, which will make CCS projects immensely more attractive for investors.

The provisions of the Inflation Reduction Act also relaxed the annual carbon capture threshold for electricity generating facilities from 500,000 tons of carbon per year to 18,750 tons per year.[197] However, tax credits are still subject to being recaptured in the event of carbon leakage during use or storage.[198]

For carbon capture projects, tax credits are currently the primary means of economic support. Policy action could increase the market for these tax credits, allowing new investors to take advantage of them and provide stronger support for CCS projects. Allowing greater flexibility for tax-exempt pension funds and charitable institutional investors, as well as allowing individual investors to take advantage of energy tax credits, would increase the market demand and

192. *See* JESSE D. JENKINS ET AL., PRELIMINARY REPORT: THE CLIMATE AND ENERGY IMPACTS OF THE INFLATION REDUCTION ACT OF 2022 27 (2022), https://repeatproject.org/docs/REPEAT_IRA_Prelminary_Report_2022-08-04.pdf [https://perma.cc/RR8K-JQBH]. For a breakdown of the report's sources and data, see Jesse D. Jenkins et al., *REPEAT Project Section-by-Section Summary of Energy and Climate Policies in the 117th Congress*, REPEAT PROJECT (2022), http://bit.ly/REPEAT-Policies [https://perma.cc/87LC-BFBH].

193. THE WHITE HOUSE, *supra* note 176, at 68.

194. *See id.* at 67–68.

195. *See id.* at 68.

196. *Id.* at 67.

197. *The Inflation Reduction Act Includes Significant Benefits for the Carbon Capture Industry*, GIBSON DUNN (Aug. 16, 2022), https://www.gibsondunn.com/the-inflation-reduction-act-includes-significant-benefits-for-the-carbon-capture-industry/ [https://perma.cc/TU64-V8U5] (explaining Inflation Reduction Act's impacts in terms of federal income tax credits, carbon capture project qualifications, and avenues for monetizing 45Q credits).

198. *See* Lee et al., *supra* note 185, at 71.

consequently sources of cash flow that would make CCS projects more economically viable.[199]

The contribution of 45Q credits for CCS projects—particularly in the power sector—could be quite substantial.[200] Section 45Q credits are estimated to reduce the cost of electricity prices by $0.091 per kWh for coal generated power, and $0.030 per kWh for natural gas generated power.[201] The benefits achieved through these energy credits suggest that coal and natural gas fired power plants with CCS could potentially sell power at negative prices—that is, they could earn so much from credits that it would be profitable to pay other companies to take their electricity—creating even lower prices than renewable resources with zero marginal cost.[202]

There are currently no state policies or mandates that require industrial facilities to use low-emissions CCS-enabled dispatchable electric generation capacity, or CCS. In the absence of a federal carbon tax or cap-and-trade regime, CCS projects must be profitable to encourage emitters and developers to install capture equipment.[203] Currently, the principal revenue source for CCS is 45Q. The increased level of the 45Q tax credit in the Inflation Reduction Act is improving the financial case for these projects to be implemented.

C. *Class VI Carbon Injection Well Permitting*

The EPA oversees Underground Injection Control (UIC) to protect underground sources of drinking water.[204] Class VI carbon injection wells require a permit from the EPA to construct and operate through site closure.[205] To the extent states have been granted Primary Enforcement Authority (Primacy) from

199. ERNEST J. MONIZ ET AL., ENERGY FUTURES INITIATIVE, TURNING CCS PROJECTS IN HEAVY INDUSTRY & POWER INTO BLUE CHIP FINANCIAL INVESTMENTS 78–79 (2023), https://efifoundation.org/reports/turning-ccs-projects-in-heavy-industry-into-blue-chip-financial-investments/ [https://perma.cc/HKQ2-AB27].

200. Emily Grubert & Frances Sawyer, *US Power Sector Carbon Capture and Storage Under the Inflation Reduction Act Could Be Costly with Limited or Negative Abatement Potential*, 3 ENV'T RSCH.: INFRASTRUCTURE & SUSTAINABILITY 8–11 (2023).

201. *Id.* at 13.

202. *See id.* at 1, 13.

203. MONIZ ET AL., *supra* note 199, at 37.

204. *Protecting Underground Sources of Drinking Water from Underground Injection (UIC)*, U.S. ENV'T PROT. AGENCY (June 13, 2025), https://www.epa.gov/uic [https://perma.cc/HA7G-EU4R].

205. *Class VI – Wells Used for Geologic Sequestration of Carbon Dioxide*, U.S. ENV'T PROT. AGENCY (July 15, 2025), https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-carbon-dioxide#ClassVIWell [https://perma.cc/9DZ8-6YDS].

the EPA, Class VI well permits can be obtained directly from state authorities.[206] The lifecycle of a Class VI project comprises five phases: the pre-permitting phase, the pre-construction phase, the pre-operation phase, the injection phase, and the post-injection phase.[207]

The EPA's Class VI permitting process is very comprehensive. The process includes a completeness review, technical review, preparation of a draft permit, a public comment period, as well as the preparation of the final permit.[208] As of March 1, 2024, the EPA has issued eight Class VI permits, of which four are currently in operation.[209] "In 2015, the EPA issued four Class VI permits associated with the FutureGen project in Illinois, but the project was canceled before well construction."[210] In 2017, the EPA issued two Class VI permits to the Archer Daniels Midland (ADM) ethanol plant in Decatur, Illinois.[211] In 2024, the EPA issued permits for two wells to store captured CO_2 from offsite fertilizer production at Wabash Carbon Services in Indiana.[212] While the EPA aims to complete Class VI application and issue permits within a 24-month period, the first two Class VI permits that were granted took approximately three years from application submission to issuance.[213] The two Class VI permits issued in January 2024 took approximately two and a half years to be granted.[214] The entire permitting process, including pre-application actions, can take up to six years.[215]

Of the three states with Class VI permitting authority, North Dakota has issued eight Class VI permits for three facilities.[216] The Red Trail Energy (RTE) storage facility, which injects CO_2 captured from ethanol production, was

206. *Id.*

207. *Id.*

208. *Id.*

209. ANGELA C. JONES, CLASS VI CARBON SEQUESTRATION WELLS: PERMITTING AND STATE PROGRAM PRIMACY 7 (2024), https://sgp.fas.org/crs/misc/R48033.pdf [https://perma.cc/57TT-JSHR].

210. *Id.*

211. *Id.*

212. *Id.*

213. *See Class VI – Wells Used for Geologic Sequestration of Carbon Dioxide*, *supra* note 205.

214. *See* Philip K. Lau, *Carbon Capture, Utilization, and Storage: Class VI Wells and US State Primacy*, MAYER BROWN (June 9, 2022), https://www.mayerbrown.com/en/insights/publications/2022/06/carbon-capture-utilization-and-storage-class-vi-wells-and-us-state-primacy [https://perma.cc/KUZ2-46H2].

215. *Id.*; *Class VI – Wells Used for Geologic Sequestration of Carbon Dioxide*, *supra* note 205.

216. JONES, *supra* note 209, at 2, 7.

permitted in 2022.[217] The Dakota Gasification Company (DSG) storage facility, which injects CO_2 from a natural gas facility, was permitted in 2023.[218] The Blue Flint storage facility, which injects CO_2 from ethanol productions facilities, was permitted in 2023.[219] Wyoming issued three Class VI permits to the Frontier Carbon Solutions project for a storage hub that will sequester CO_2 gathered from various capture projects.[220] Louisiana has not yet issued any Class VI permits.[221] As of April 2024, 130 Class VI permit applications are pending for 44 projects in 12 states and 1 tribal reservation.[222] All of the permits are in the pre-construction phase.[223]

The permit application must include site characterization and an evaluation of site geology.[224] Similar to oil and gas exploration, geophysical subsurface data must be accurately mapped and modeled to include injectivity and porosity specifications, as well as potential plume formation and migration.[225] However, contrary to the fossil-fuel industry, the return on finding an acceptable injection site is modest in comparison.[226] It is essentially capped at the 45Q tax recovery rate of $85 per ton.[227] Potential federal funding for the development of commercially appropriate subsurface characterization data considered to be "certified" for the purposes of EPA permitting application requirements could accelerate the permitting timeline, as well as reduce the cost to project developers.[228]

D. *Carbon Transportation Permitting*

One of the most difficult challenges for the nascent carbon capture and storage industry will be permitting and constructing pipelines to bring carbon from the sites where it is produced to the reservoirs where it is ultimately sequestered.[229]

217. *Id.*
218. *Id.*
219. *Id.*
220. *Id.* at 8.
221. *Id.*
222. *Id.*
223. *Id.*
224. *See* MONIZ ET AL., *supra* note 199, at 103.
225. *See id.*
226. *Id.*
227. *See id.*
228. *Id.* at 103–04.
229. *See* NAT'L PETROLEUM COUNCIL, MEETING THE DUAL CHALLENGE: A ROADMAP TO AT-SCALE DEPLOYMENT OF CARBON CAPTURE, USE, AND STORAGE 6-1 (2021), https://www.energy.gov/sites/default/files/2022-10/CCUS-Chap_6-030521.pdf

Unlike natural gas pipelines, but like oil pipelines and power lines, carbon dioxide pipeline siting is generally regulated by the states.[230] U.S. companies successfully built a national network of pipelines using state siting processes, but there are increasing challenges for siting all infrastructure projects and considerable controversy about how to efficiently permit new energy transport projects.[231]

One approach would be to maintain state siting and hope that projects could be timely approved given the benefits they promise in reducing carbon emissions, providing reliable zero-carbon energy to support the power grid, and providing the economic benefits they promise because of federal credits and increased oil production. But thus far, it has proven difficult to achieve all the state permits necessary for these interstate pipelines. One of the two biggest proposed projects, the Navigator Pipeline, recently was canceled after its permit was denied by one of the states, South Dakota, that it was supposed to pass through.[232] The other large carbon pipeline transport project, from Summit Carbon Solutions, has also run into state permitting challenges.[233] Communities in which these pipelines would likely be built are also expressing concern after a pipeline rupture in Satartia, Mississippi in February 2020.[234] Current estimates indicate the existing 5,300 miles of carbon dioxide pipelines in the United States could grow to over 68,000 miles to meet net-zero climate goals by 2050.[235] However, safety data show that carbon dioxide

[https://perma.cc/6MM7-3N85]; ABRAMSON, MCFARLANE & BROWN, TRANSPORT INFRASTRUCTURE, *supra* note 119, at i–ii.

230. Righetti, *supra* note 25, at 924, 937; MARTIN LOCKMAN, PERMITTING CO2 PIPELINES: ASSESSING THE LANDSCAPE OF FEDERAL AND STATE REGULATIONS 9 (2023), https://scholarship.law.columbia.edu/cgi/viewcontent.cgi?article=1208&context=sabin_climate_change [https://perma.cc/D9XD-7AX5].

231. *See* Righetti, *supra* note 25, at 955.

232. Corey Lavinsky, *Cancellation of Navigator CO2 Pipeline Raises Critical Issues for Several Industries*, S&P GLOB. (Oct. 25, 2023, at 4:44 UTC), https://www.spglobal.com/commodityinsights/en/market-insights/blogs/energy-transition/102523-navigator-co2-carbon-capture-heartland-greenway-pipeline-cancellation [https://perma.cc/8MLA-XDDK].

233. Leah Douglas, *Navigator CO2 Ventures Cancels Carbon-Capture Pipeline Project in US Midwest*, REUTERS (Oct. 20, 2023, at 12:48 CDT), https://www.reuters.com/sustainability/climate-energy/navigator-co2-ventures-cancels-carbon-capture-pipeline-project-us-midwest-2023-10-20/ [https://perma.cc/867D-ZZRT].

234. Julia Simon, *The U.S. Is Expanding CO2 Pipelines. One Poisoned Town Wants You to Know Its Story*, NPR (Sep. 25, 2023, at 9:05 ET), https://www.npr.org/2023/05/21/1172679786/carbon-capture-carbon-dioxide-pipeline [https://perma.cc/B624-7UQB].

235. EMMA THOMLEY & RYAN KAMMER, CARBON DIOXIDE (CO_2) TRANSPORT INFRASTRUCTURE: BUILDING A CO_2 TRANSPORTATION NETWORK FOR CARBON CAPTURE 1 (2023), https://carbonactionalliance.org/wp-content/uploads/CO2-Transport-Infrastructure-Factsheet-1-30-2023.pdf [https://perma.cc/XJC2-58QT].

pipelines have historically been and can be operated at the highest level of safety.[236] Safety regulations are implemented at the federal level.[237]

If the federal government wants to ensure that its financial support for carbon capture actually results in deployment of a carbon capture industry, it may need to consider whether some kind of federal permitting system is also required. One option that has been explored in the context of power-line siting, which is also done at the state level, has been to provide a federal backstop—if the state denies or delays a permit for too long, the federal government may, in some circumstances, step in to grant a permit.[238]

A more thoroughgoing federal approach would simply replace state siting with federal siting for interstate carbon transport pipelines.[239] Like natural gas pipelines, such pipelines would need a single federal permit. The challenge is that even natural gas pipelines have proven very challenging to build as states have found innovative ways of stopping the federal approval, including by denying Clean Water Act water quality certifications.[240] If the federal government wants to take over siting to speed up permitting of carbon pipelines, it will also have to reform the federal siting process to ensure it is no longer subject to state vetoes.[241]

E. *EPA Power Plant Carbon Rules*

Since the finding in 2009 that greenhouse gases (GHG) threaten the public health and welfare of current and future generations, the EPA has worked to safeguard the public against GHG emissions.[242] In 2022 the Supreme Court decided in *West Virginia v. EPA* that requiring the replacement of fossil-fuel plants with wind and solar power went beyond the EPA's reach.[243] However, the Court maintained that the EPA retained its authority to determine emissions standards based on technology that allows plants to operate more cleanly.[244] In May 2023,

236. *Id.*

237. *Id.*

238. *See* James W. Coleman, *Permitting the Energy Transition*, 75 CASE W. RSRV. L. REV. 69, 86–87, 91–92 (2024) [hereinafter Coleman, *Permitting the Energy Transition*].

239. *See* Coleman, *Pipelines & Power-Lines*, *supra* note 7, at 296–97.

240. *See id*. at 284–85.

241. Coleman, *Permitting the Energy Transition*, *supra* note 238.

242. Endangerment and Cause or Contribute Findings for Greenhouse Gasses Under Section 202(a) of the Clean Air Act; Final Rule 74 Fed. Reg. 66496, 66499 (Dec. 15, 2009) (to be codified at 40 C.F.R. ch. 1).

243. 597 U.S. 697, 735 (2022).

244. *Id.* at 725; LISSA LYNCH & DAVID DONIGER, THE EPA'S POWER PLANT CARBON RULES CAN BE BUILT TO LAST 2 (2023), https://www.nrdc.org/sites/default/files/2023-04/power-plant-carbon-rules-ib.pdf [https://perma.cc/JYD7-ZWSD].

the EPA issued proposed guidelines and carbon emissions limits for coal and natural gas power plants under Section 111 of the Clean Air Act.[245] The purpose is to regulate GHG emissions derived from the power sector, which comprises 25 percent of overall domestic emissions.[246] The Inflation Reduction Act also determined congressional intent for the EPA to set clear standards for the reduction of carbon pollution from power plants.[247]

The proposed regulations are technology-based and meant to leverage clean energy incentives provided in the Inflation Reduction Act, as well as cost-effective available control technology.[248] The proposed regulation levels set limits on new and existing natural gas-fired combustion turbines, as well as existing coal, oil, and gas steam generating units.[249] The limits were established to provide up to $85 billion of climate and health net benefits and avoid up to 617 million tons of carbon dioxide emitted from coal and new natural gas plants, as well as 407 million tons from existing natural gas plants through 2042.[250]

The proposed emissions guidelines regarding natural gas combustion turbines apply to new as well as large and frequently used existing combustion turbines.[251] New combustion turbines fall under three categories: low load "peaking" turbines, intermediate load turbines, and base load turbines.[252] Base load combustion turbines on the CCS pathway will be required to have 90 percent CCS levels by 2035.[253] Existing combustion turbines larger than 300 MW and a capacity factor of greater than 50 percent will also be required to capture 90 percent of carbon dioxide using CCS by 2035.[254]

Section III(b) of the Clean Air Act sets federal emissions standards that apply directly to new plants.[255] Section III(d) sets emissions standards that apply to

245. U.S. EPA, CLEAN AIR ACT SECTION 111 REGULATION OF GREENHOUSE GAS EMISSIONS FROM FOSSIL FUEL-FIRED ELECTRIC GENERATING UNITS 3 (May 2023), https://www.epa.gov/system/files/documents/2023-05/111%20Power%20Plants%20 Stakeholder%20Presentation2_4.pdf [https://perma.cc/F3LK-CBXL].

246. *Id.* at 3–5.

247. David Doniger, *EPA's New Power Plant Rules Stand on Strong Legal Footing*, BLOOMBERG L. (Apr. 24, 2023, at 3:00 CDT), https://news.bloomberglaw.com/us-law-week/epas-new-power-plant-rules-stand-on-strong-legal-footing.

248. *See* U.S. EPA, *supra* note 245, at 4.

249. *Id.*

250. *Id.*

251. *See id.* at 14.

252. *Id.* at 9.

253. *Id.* at 11.

254. *Id.* at 14.

255. LYNCH & DONIGER, *supra* note 244, at 2.

existing plants and are accomplished through state plans.[256] States are required to submit plans for creating, applying, and enforcing emissions guidelines at least as stringent as the EPA's for existing sources within 24 months.[257] Affected plants within each state must be assigned to subcategories based on retirement timelines, emissions specifications, and operational parameters.[258] However, state plans will have more flexibility in implementation, as the new guidelines allow states and plant operators to devise their own plans and use of particular technology to meet the standards.[259] Although for states that choose to comply using CCS, the EPA will provide accounting procedures for carbon pollution from point of capture to permanent sequestration.[260]

In April 2024, the EPA issued final Clean Air Act performance standards and emission guidelines for new gas-fired combustion turbines, and existing coal, oil, and gas-fired steam generating units establishing fixed carbon pollution limits.[261] The standards are technology-based, and meant to leverage clean energy incentives provided in the Inflation Reduction Act, as well as cost-effective available control technology.[262] The rules address coal plants based on their remaining useful life, and for new gas plants, required emissions controls depend on yearly operational levels.[263] They are intended to limit up to 90 percent of carbon emissions emitted from new base load gas-fired, as well as existing coal-fired plants, by affecting construction design.[264] When combined with other policies such as the 45Q tax credits from the Inflation Reduction Act, the new rules are expected to reduce power plant carbon emissions 75 percent by 2035 and 83 percent by 2040 below 2005 levels.[265] Section 45Q tax credits are intended to

256. *Id.*

257. U.S. EPA, *supra* note 245, at 18, 19.

258. MIKE O'BOYLE ET AL., MAINTAINING A RELIABLE GRID UNDER EPA'S PROPOSED 111 RULES RESTRICTING POWER PLANT EMISSIONS 28 (2023), https://energyinnovation.org/wp-content/uploads/2023/11/Maintaining-a-Reliable-Grid-Under-EPAs-Proposed-111-Rules.pdf [https://perma.cc/E57G-E68G].

259. LYNCH & DONIGER, *supra* note 244, at 3.

260. *Id.*

261. *Greenhouse Gas Standards and Guidelines for Fossil-Fuel Fired Power Plants*, U.S. ENV'T PROT. AGENCY (July 10, 2025), https://www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power [https://perma.cc/EYQ5-TXFB].

262. U.S. EPA, *supra* note 245, at 4.

263. Dan Lashof, Lori Bird & Jennifer Rennicks, *4 Things to Know About US EPA's New Power Plant Rules*, WORLD RES. INST. (May 3, 2024), https://www.wri.org/insights/epa-power-plant-rules-explained [https://perma.cc/FZP8-G65T].

264. U.S. EPA, *supra* note 245, at 8, 11, 16.

265. Lashof, Bird & Rennicks, *supra* note 263.

provide utilities with the economic incentive to install CCS technology while reducing compliance costs.[266]

The EPA determined the limits and emission guidelines based on proven pollution control technologies applicable to power plants, which are able to produce substantial reductions in carbon pollution at economically feasible cost levels.[267] Guidelines are principally based on the use of CCS technology that can be directly applied at source to individual power plants that use fossil fuels to generate electricity.[268] The rules also provide utilities and power companies with options for meeting these standards providing for ample time to plan and invest for compliance and providing for reliable supplies of affordable electricity.[269]

While utilities are able to comply with the new rule using CCS technology, if other types of technology develop over the operating period, they will have the flexibility to substitute CCS technology with other technologies that also comply with the new standards.[270] The EPA estimates the utilization of CCS technology will reduce carbon emissions from power plants by 88 percent, or 1.38 billion tons of CO_2 emissions over the next 23 years, which equates to 328 million gasoline powered cars a year.[271]

Emissions reductions, benefits, and costs were evaluated in a Regulatory Impact Analysis (RIA), which concluded that the climate and health benefits of the ruling substantially outweigh the compliance costs.[272] The RIA projects net climate and health benefits of $370 billion between 2024 and 2047.[273] In 2035 alone, the RIA estimates that health co-benefits could include up to 1,200 avoided premature deaths; 870 avoided hospital and emergency room visits; 360,000 avoided cases of

266. *See id.*

267. *See id.*

268. *See id.*

269. *See id.*; Emily Martinez Lieban & Brian C. Bunger, *EPA Finalizes GHG Powerplant Rule, Setting Stage for "Major Questions" Showdown*, HOLLAND & KNIGHT (May 14, 2024), https://www.hklaw.com/en/insights/publications/2024/05/epa-finalizes-ghg-powerplant-rule-setting-stage [https://perma.cc/MQT7-UZ5C].

270. *See* Lieban & Bunger, *supra* note 269.

271. *See* Lashof, Bird & Rennicks, *supra* note 263.

272. *See, e.g.*, U.S. EPA, REGULATORY IMPACT ANALYSIS FOR THE PROPOSED NEW SOURCE PERFORMANCE STANDARDS FOR GREENHOUSE GAS EMISSIONS FROM NEW, MODIFIED, AND RECONSTRUCTED FOSSIL FUEL-FIRED ELECTRIC GENERATING UNITS; EMISSION GUIDELINES FOR GREENHOUSE GAS EMISSIONS FROM EXISTING FOSSIL FUEL-FIRED ELECTRIC GENERATING UNITS; AND REPEAL OF THE AFFORDABLE CLEAN ENERGY RULE 7-4 (2024) [hereinafter REGULATORY IMPACT ANALYSIS], https://www.epa.gov/system/files/documents/2024-04/utilities_ria_final_111_2024-04.pdf [https://perma.cc/5M7J-7KVA].

273. *See id.* at ES-11.

asthma symptoms; 48,000 avoided school absence days; and 57,000 avoided lost workdays.[274]

The new standards will be phased in over time. Existing steam electric generating units will have compliance deadlines ranging from 2030 to 2032 depending on the type of unit.[275] Efficiency-based requirements for new combustion turbines will apply as soon as the unit commences operation.[276] New base load combustion turbines will be required to meet emission standards based on 90 percent capture of CO_2 emissions by January 1, 2032.[277]

The rule establishes three subcategories for new combustion turbines based on intensity of operation.[278] New base load turbines, which are turbines that generate at least 40 percent of maximum annual capacity, are subject to an initial "phase one" requirement, which is determined based on efficient design and operation of combined cycle turbines.[279] Base load turbines are also subject to a "phase two" requirement in which they must obtain 90 percent capture of CO_2 by 2032.[280] New intermediate load turbines that operate 20 to 40 percent of the time must meet a performance threshold of an efficient simple cycle turbine, or 1,150 pounds of CO_2 per megawatt hour.[281] For peaking plants that operate less than 20 percent of the time, the rules require the use of lower-emitting fuels such as natural gas, rather than diesel or high-emitting alternatives, which is already common practice.[282] For existing coal-fired power plants and other steam generating units, the rule outlines a process in which states must submit plans to the EPA for establishing state level standards.[283]

The design of the rules reflects extensive engagement with grid operators, experts in grid reliability, as well as federal agencies responsible for grid reliability to ensure they are in keeping with the need for reliable and affordable electricity.

274. *See id.* at 4-51.

275. *See* O'BOYLE ET AL., *supra* note 258, at 6.

276. *See* Lieban & Bunger, *supra* note 269.

277. *Greenhouse Gas Standards and Guidelines for Fossil-Fuel Fired Power Plants*, *supra* note 261.

278. *See* Lashof, Bird & Rennicks., *supra* note 263; REGULATORY IMPACT ANALYSIS, *supra* note 272, at 3–4.

279. *See* sources cited *supra* note 278.

280. *See* sources cited *supra* note 278.

281. *See* sources cited *supra* note 278.

282. *See* sources cited *supra* note 278.

283. Frank Sturges & Paula Leverett Cobb, *EPA Delivers Carbon Emission Reductions from Power Plants, but Work Remains*, CLEAN AIR TASK FORCE (May 2, 2024), https://www.catf.us/2024/05/epa-delivers-carbon-emission-reductions-power-plants-work-remains/ [https://perma.cc/Z725-8GSU].

A plan was developed by the EPA to support grid reliability, which incorporates extended compliance timeframes for coal-fired unit obligations, provisions for states to prioritize grid reliability, and emissions trading and averaging. It is estimated that power companies will be able to meet grid reliability requirements while complying with the new standards, with a less than one percent impact on retail electricity prices. EPA modeling shows a decrease in retail electricity prices over time even with higher load growth.[284]

During the rulemaking process, the EPA conducted extensive outreach to communities with environmental justice concerns, including Tribal Nations.[285] The resulting feedback from these stakeholders was considered and incorporated into the development of the standards.[286] The EPA also recognized the concerns of environmental justice organizations and community representatives regarding potential health, environmental, and safety impacts of CCS.[287] Of note, the standards do not require installation or operation of any particular technology.[288] The EPA remains committed to working with federal partners to ensure that CCS is deployed and implemented in such a way that involves community input and protection of public health, safety, and the environment.[289]

While these rules address carbon emissions from existing coal and future natural gas electricity generating plants, they do not address the largest source of current carbon emissions from electricity generation, which are existing natural gas plants. The EPA has delayed implementing regulatory standards for existing natural gas plants until potentially 2025.[290] New standards for existing natural gas power plants could strengthen the regulations, making them less vulnerable to legal challenges.

In comparison to the 2023 draft rule, the emissions performance standards for intermediate loan turbines operating 20 percent to 40 percent of the time, were substantially watered down due to the removal of hydrogen blending, as well as lowering the requirement to a simple cycle turbine.[291] While the maximum operation time of this category of plants was reduced from 50 percent in the draft

284. REGULATORY IMPACT ANALYSIS, *supra* note 272, at 3–33.

285. *See id.* at ES-14 to ES-15; U.S. EPA, *supra* note 245, at 28.

286. REGULATORY IMPACT ANALYSIS, *supra* note 272, at ES-14 to ES-15; U.S. EPA, *supra* note 245, at 28.

287. REGULATORY IMPACT ANALYSIS, *supra* note 272, at ES-14; U.S. EPA, *supra* note 245, at 28.

288. *See* REGULATORY IMPACT ANALYSIS, *supra* note 272, at ES-2 to ES-3.

289. *See id.* at ES-14 to ES-15.

290. *See* Lashof, Bird & Rennicks, *supra* note 263.

291. *Id.*

to 40 percent, which lowered the number of qualifying plants and the total amount of carbon generation from this category, the EPA will likely revisit and strengthen these requirements in the future.[292]

The new requirements are expected to face challenges from Congress, utilities, and potentially future administrations.[293] Prior to finalizing the new rules, members of Congress suggested they may employ the Congressional Review Act, which only requires a simple majority to pass or overturn legislation.[294] However, such efforts would be subject to veto power. Although, if the rules are officially published in the Federal Register within 60 working days of a new Congress, they could be subject to additional review and votes.[295]

The rules are already being challenged in the courts, and may likely end up at the Supreme Court, "just as the Obama-era Clean Power Plan rules did in *West Virginia vs. EPA*."[296] Edison Electric Institute, a trade group for investor-owned utilities, is challenging the EPA's finding that CCS should be the basis for complying with parts of the new rule.[297] In its lawsuit against the EPA, Edison Electric Institute contends that CCS technology has not been adequately demonstrated for broad deployment or that 90 percent of carbon capture is currently achievable with the technology.[298] Edison also claims there is not sufficient time to permit, finance, and build the infrastructure needed to comply by 2032.[299] Electric Generators for a Sensible Transition, comprised of several independent and municipal power companies, including American Electric Power, American Public Power Association, Appalachian Power, Arizona Public Service, Duke Energy, Kentucky Power, Ohio Valley Electric Corporation, Public Service Co. of Oklahoma, Southwestern Electric Power, Talen Generation, Talen Montana Holdings, Vistra, and Wheeling Power, have also challenged the rules at the appeals court.[300]

The U.S. Court of Appeals for the District of Columbia Circuit already rejected a request filed by 25 Republican attorneys general led by West Virgina

292. *Id.*

293. *Id.*

294. *Id.*

295. *Id.*

296. *Id.*

297. Ethan Howland, *EEI Joins AEP, Duke, Other Utilities in Suing EPA Over Power Plant Greenhouse Gas Rule*, UTIL. DIVE (May 23, 2024), https://www.utilitydive.com/news/eei-aep-duke-utilities-epa-power-plant-greenhouse-gas-carbon/ [https://perma.cc/S8RC-LZQP].

298. *Id.*

299. *Id.*

300. *Id.*

for an administrative stay to the rule which went into effect in July 2024.[301] The court gave the EPA until mid-June to respond to the challenger's requests for a longer pause on the rule.[302] The court has also rejected a request from the National Rural Electric Cooperative Association, a utility industry group, for a lengthier stay.[303] Southwest Power Pool and PJM Interconnection, a regional transmission organization, have also warned that the EPA's new rules pose reliability risks.[304]

A group of 21 Democrat-led states including New York, California, and Arizona, and five Democratic-led cities including Chicago and Denver, claim the rule would benefit them by mitigating the costly and deadly impact of climate change.[305] They have asked to defend the rule in court together with the EPA.[306]

Once the guidelines are published in the Federal Register, states will have two years to develop and submit state-specific plans for submission to the EPA for review and approval.[307] The EPA will subsequently have one year to take action on the plan to approve, disapprove, or approve with conditions.[308] A state plan essentially sets standards of performance for each unit within the state based on the emission guideline.[309] It also governs implementation and enforcement of the standards.[310] Should a state choose not to submit a plan, the EPA will develop a federal plan for units in the state.[311]

IV. KEY STATE CARBON MANAGEMENT POLICY AND REGULATION

Permits, liability, and property rights are areas in which state governments will need to establish a regulatory framework in order for CCS to be deployed at scale.[312] The government will be able to provide a more attractive business

301. Clark Mindock, *US Appeals Court Won't Pause EPA Power Plant Emissions Rule for Now*, REUTERS (May 17, 2024, at 12:50 CDT), https://www.reuters.com/legal/government/us-appeals-court-wont-pause-epa-power-plant-emissions-rule-now-2024-05-17/ [https://perma.cc/JU9N-DSML].

302. *Id.*

303. *Id.*

304. Howland, *supra* note 297.

305. Mindock, *supra* note 301.

306. *Id.*

307. Sturges & Cobb, *supra* note 283.

308. *Id.*

309. *Id.*

310. *Id.*

311. *Id.*

312. *See* MoonSook Park, *The Government's Multi-Faceted Role in Resolving the Main Legal Issues Regarding Carbon Capture and Sequestration*, 94 N.D. L. REV. 481, 483–509 (2019).

environment by establishing definitive permitting systems covering each phase of the CCS process, including capture, transportation, and storage.[313] Siting requirements for transportation pipelines in particular will be essential as they cover multiple jurisdictions and in many cases require eminent domain.[314] As the storage of carbon is a relatively new scientific process, a regulatory system that permits exploration, injecting, and storing, as well as the closure of sites after saturation, will be needed to regulate the storage aspects of the CCS process.[315]

A. *Liability for Long-Term Carbon Storage*

Given the potential long-term risks related to leakage, it will be necessary to establish a liability and compensation system to provide precise clarification for operators and investors.[316] While operators must be responsible for leakage accidents during CCS, transfer of liability to the government over the longer-term would be consistent with the storage time frame of hundreds to thousands of years.[317] Potential liability events identified by the EPA include contamination of drinking water sources, leaks into the air from injection and monitoring wells, large accidental releases of carbon dioxide, elevated carbon dioxide concentration levels in soils affecting plants and animals, as well as potential earthquakes caused by pressure from injection of carbon dioxide.[318] Potential migration of carbon dioxide within a reservoir causing subsurface trespassing, public nuisance actions, as well as possible inverse condemnation claims of property owners against the state alleging that escaped carbon dioxide has contaminated their property, pose additional liability risks not considered by the EPA.[319] Enacting state legislation and liability control measures will increase development of CCS projects benefitting both the economy and the environment, as well as the long-term viability of the energy industry.[320]

Several state legislatures have created frameworks and processes for assuming liability and responsibility for carbon sequestration sites after they have

313. *Id.* at 484.

314. *Id.* at 487.

315. *Id.* at 488–89.

316. *Id.* at 494.

317. *Id.* at 494–95, 498.

318. *See* TEXANS FOR LAWSUIT REFORM FOUND., LIABILITY PROTECTION FOR CARBON DIOXIDE SEQUESTRATION IN TEXAS 16 (2022), https://tlrfoundation.org/wp-content/uploads/2024/08/Liability_Protection_for_Carbon_Dioxide_Sequestration_in_Texas.pdf [https://perma.cc/VP6C-P583].

319. *Id.* at 16–17.

320. *See id.* at 1.

been plugged.[321] Prior to assuming liability, most states have rigorous project completion requirements that must be certified, including compliance with state and federal laws, stability of stored carbon, plugging of the injection well, mechanical integrity of the equipment, and the establishment of carbon dioxide trust fund accounts.[322]

Indiana HB 1209, which went into effect in July 2022, provides that the state will assume ownership and responsibility of CCS facilities upon the issuance of a certificate of completion.[323] This includes assumption of future liability of the facility as well as responsibility for future regulatory compliance.[324] A state carbon dioxide storage facility trust fund is used to pay for long-term management and monitoring of CCS projects.[325] It is funded by storage projects that are required to pay the Indiana Department of Environmental Management a fee of eight cents per ton of sequestered carbon dioxide.[326]

In Louisiana, the state takes title to sequestered carbon dioxide 10 years after storage operations have ceased.[327] A certificate of completion is issued simply based on the storage operator maintaining that the reservoir is reasonably expected to have mechanical integrity and the carbon dioxide is reasonably expected to stay in place.[328] Subsequently, the storage operator, as well as owners and generators of carbon dioxide stored, are released from liability, subject to the availability of funds in the Louisiana Carbon Dioxide Geologic Storage Trust Fund to provide remediation of liability.[329]

Montana's law was enacted in 2009 and provides that a certificate of completion may not be issued until 25 years after carbon dioxide injections have terminated.[330] Subsequently, the Board of Oil and Gas Conservation will monitor the reservoir for an additional 25 years, during which time the storage operator will retain liability.[331] Storage operators in Montana essentially remain liable for any issues that arise in the storage reservoir and sequestered carbon dioxide for 50

321. *See id.* at 6.
322. *Id.*
323. *Id.*
324. *Id.*
325. *Id.* at 6–7.
326. *Id.*
327. *Id.* at 7.
328. *Id.*
329. *Id.*
330. *Id.* at 8.
331. *See id.*

years following the termination of injections.[332] However, under certain circumstances the board may reduce the time frame to 30 years post-cessation of injections prior to transferring liability to the state.[333]

The Nebraska Geologic Storage of Carbon Dioxide Act was enacted in 2021 to create a regulatory framework for CCS projects ensuring they do not cause pollution, create a nuisance, and that carbon dioxide does not discharge from a storage facility.[334] The state will assume liability and title of CCS storage facilities upon the issuance of a certificate of project completion issued by the Nebraska Oil and Gas Conservation Commission.[335] Until such time, the storage operator remains liable for carbon dioxide injected into and stored in a geologic storage reservoir and subject to regulatory requirements.[336] CCS laws in Nebraska are similar to those in North Dakota.[337]

In North Dakota, a certificate of project completion may not be issued until after carbon dioxide injection operations have ceased for 10 years, at which point liability can be transferred to the state.[338] The storage operator must also confirm that stored carbon dioxide is stable or is unlikely to migrate beyond the storage reservoir boundary.[339] The statute specifies that responsibility and liability will remain with the state "until such time as the federal government assumes responsibility for the long-term monitoring and management of storage facilities," which presumes it will occur.[340] Storage operators pay a fee to the North Dakota Industrial Commission, which pays for long-term monitoring and management of closed storage facilities.[341]

In Wyoming, the state will assume title and liability for captured and sequestered carbon dioxide, as well as the facility used to inject and store it, after a certificate of completion has been issued and the site has been monitored for 20 years.[342] After title has been transferred to the state, the storage operator is released from continued regulatory requirements.[343] Future monetary damages are also

332. *Id.* at 9.
333. *Id.*
334. *Id.*
335. *Id.* at 10.
336. *Id.*
337. *Id.*
338. *Id.* at 11.
339. *Id.*
340. *Id.*
341. *Id.*
342. *Id.*
343. *Id.*

limited to available funds in the Wyoming Geologic Sequestration Special Revenue Account.[344] Although, it is unclear as to whether the storage operator would be liable for the balance in the event that funds were not available.[345]

In 2009, Texas passed HB 1796, the Clean Air Act, in which it will assume carbon dioxide leakage liability of offshore carbon dioxide injection and storage sites at the completion of projects.[346] Operators are required to monitor sites and carbon dioxide until the site is transferred to the state.[347] The title is transferred to the Texas School Land Board's permanent school fund, which is a government department that manages the sale and mineral leasing of half the public land in which profits are used to finance public schools in Texas.[348] HB 1796 also created the Texas Emissions Reduction Plan Fund which will be funded by fees for carbon dioxide storage set by the School Land Board for long-term monitoring and management of CCS offshore sites.[349] The Bureau of Economic Geology at the University of Texas at Austin subsequently acts as scientific advisor by reviewing and monitoring the sequestered carbon dioxide.[350]

Texas also passed SB 1387 in 2009, which amended the Water Code and the Natural Resources Code and established the regulatory framework for CCS projects in Texas.[351] It requires project developers that are drilling and operating anthropogenic carbon dioxide injection wells and facilities for geologic storage to obtain permits from the Texas Railroad commission.[352] The bill outlines the permitting process, imposition of fees, and the requirement for the provision of satisfactory evidence of financial responsibility each year.[353]

Texas does not yet have any legislation for transfer of onshore liability.[354] However, SB 1387 created the Anthropogenic Carbon Dioxide Storage Trust Fund to cover long-term monitoring of onshore CCS injection and storage sites.[355] The

344. *Id.* at 12.

345. *Id.*

346. *See id.* at 14.

347. Holly Javedan, Regulation for Underground Storage of CO_2 Passed by U.S. States 5 (2013) (unpublished working paper) (on file with the Drake Law Review).

348. *Id.*; TEX. HEALTH & SAFETY CODE ANN. § 382.507 (West 2023).

349. Javedan, *supra* note 347, at 7.

350. TEXANS FOR LAWSUIT REFORM FOUND., *supra* note 318, at 20.

351. *Id.* at 13.

352. *Id.*

353. *Id.* at 13–14.

354. Javedan, *supra* note 347, at 5.

355. *Id.* at 7.

Texas Railroad Commission is responsible for this fund.[356] Each project is charged a $75,000 application fee, as well as $50,000 per year for each well post-injection and pre-closure.[357] Establishing a resilient regulatory process for CCS will be difficult due to the interconnectedness and complexity of the processes, long-term storage requirements, and the ramifications of risks due to potential leakage.

B. *Property Rights: Clarifying Who Owns Pore Space for Carbon Storage*

Property rights regarding pore space in which carbon is stored underground is an issue with which state courts are contending. This question is particularly challenging in the United States where ownership of the oil and gas minerals are often separate from ownership of the rest of the property.[358] When pore space capable of storing carbon dioxide is left behind by oil and gas production, should that storage space belong to the owner of the minerals or the owner of the "surface"? Wyoming, Montana, and North Dakota have state legislation which provides that surface landowners own the pore space in the subsurface area.[359] These states have also passed legislation addressing "unitization" in which 60 to 80 percent of pore space ownership consent is required.[360] CCS in these states follows the same legislative framework applied in the oil and gas industry, which is known as "unitization."[361] In unitization, oil and gas development on properties belonging to several different landowners may be operated as a single, more efficient unit, with all properties sharing in oil production if a sufficient level of consent is achieved among affected landowners.[362]

Pore space ownership is an area of uncertainty in Texas. There is case law that suggests pore space belongs to the surface owner as in other states.[363] Texas also has legislation providing that anthropogenic carbon dioxide that has not been injected for enhanced oil recovery purposes is considered property of the storage operator.[364] This could give rise to subsurface trespassing for a CCS storage

356. *Id.*

357. *Id.*

358. *See* DAN LEFORT, JOHN G. MAUEL & JAY C. STIFFLER, LEGAL CHARACTERISTICS OF U.S. OIL AND GAS INTERESTS AND THE U.S. OIL AND GAS LEASE 2 (2013), https://www.pillsburylaw.com/a/web/650/Article201308ShaleInvestmentEnglishtranslation.pdf [https://perma.cc/7EE8-SRCB].

359. Javedan, *supra* note 347, at 8.

360. *Id.* at 8–9.

361. *Id.*

362. *See id.*

363. *See, e.g.*, XTO Energy Inc. v. Goodwin, 584 S.W.3d 481, 488–89 (Tex. Ct. App. 2017).

364. TEX. NAT. RES. CODE ANN. § 121.002(a)–(b) (West 2023).

operator in the event carbon dioxide migrates to an area where pore space rights have not been obtained.[365] Potential damages could be claimed in the event the injection of carbon dioxide precludes other pore space uses for oil and gas extraction or natural gas storage.[366] The courts in Texas have yet to resolve the issue of subsurface trespass claims, which will influence claims related to carbon dioxide migration.[367]

While Texas allows unitization for enhanced oil recovery, unitization specifically related to geologic sequestration of carbon dioxide has yet to be addressed.[368] Mandatory unitization of oil and gas property in Texas has not been successful historically due to concern over the respective rights of surface and subsurface owners.[369] Issues of conflicting use and compensation would need to be reconciled before a unitization bill for geologic storage of carbon dioxide might be achievable.[370]

Securing rights of way for carbon pipelines, which transfer carbon from the emitter to a carbon sequestration site, is essential in implementing CCS. U.S. eminent domain laws allow private companies to expropriate property if a project is deemed to be in the public interest and landowners are compensated.[371] These laws are primarily utilized by energy companies and utilities to lay pipelines and transmission lines to transport oil, gas, or power to consumers.[372] However, they are not currently applied to carbon pipelines as they are primarily regulated and sited at the state level.[373] Federal environmental regulations may also classify forms of carbon dioxide that are permanently sequestered as an air pollutant.

Carbon dioxide transport would likely be determined to be a public use allowing for condemnation in some circumstances.[374] Some have suggested that

365. TEXANS FOR LAWSUIT REFORM FOUND., *supra* note 318, at 17.

366. *Id.* at 17–18.

367. *Id.* at 18.

368. Univ. of Hou. Energy Fellows, *The Top Five Legal Barriers to Carbon Capture and Sequestration in Texas*, FORBES (Nov. 19, 2019, at 13:46 EST), https://www.forbes.com/sites/uhenergy/2019/11/19/the-top-five-legal-barriers-to-carbon-capture-and-sequestration-in-texas/.

369. *See, e.g.*, XTO Energy Inc. v. Goodwin, 584 S.W.3d 481, 488–89 (Tex. Ct. App. 2017).

370. Kenneth B. Medlock III & Keily Miller, Expanding Carbon Capture in Texas 16 (Jan. 2021) (unpublished working paper) (on file with the Drake Law Review).

371. *See* James W. Coleman & Alexandra B. Klass, *Energy and Eminent Domain*, 104 MINN. L. REV. 659, 671 (2019).

372. *Id.*

373. *See id.* at 680.

374. Univ. of Hou. Energy Fellows, *supra* note 368.

because carbon pipelines transport waste, they might not be seen as providing a public benefit that would satisfy state or local jurisdictional condemnation authority.[375] But carbon transport provides multiple public benefits, including safe disposal of waste that prevents carbon from entering the atmosphere and driving climate change.[376] Carbon may also be a useful product once it is transported to an oil field where it may be used to drive more oil out of the ground.[377] Indeed, state courts have held that, subject to certain generally applicable limitations, carbon dioxide pipelines may make use of eminent domain provisions.[378]

A more challenging question is whether eminent domain will be granted in states that do not have many industrial facilities hoping to capture carbon dioxide or oil and gas fields hoping to inject carbon dioxide. Sometimes a pipeline route from a carbon dioxide-producing state to a carbon-sequestering state must cross a third state, and the third state may be unwilling to approve the use of eminent domain if it believes there is no public benefit to its citizens.[379]

C. *State Primacy: Giving States Authority to Permit Carbon Injection Wells*

The four states with primacy over Classes I-VI Underground Injection Control (UIC) wells are Louisiana, North Dakota, West Virginia, and Wyoming.[380] The EPA is required to develop UIC program requirements that protect underground sources of drinking water as per the Safe Drinking Water Act (SDWA).[381] State primacy programs for Class I-VI wells are established under Sections 1422 and 1425 of the SDWA.[382] States seeking UIC program primacy must demonstrate they have jurisdiction over underground injection;

375. *Id.*

376. *See* Denbury Green Pipeline-Tex., LLC v. Tex. Rice Land Partners, Ltd., 510 S.W.3d 909, 912–13 (Tex. 2017).

377. *See* Tex. Rice Land Partners, Ltd. v. Denbury Green Pipeline-Tex., LLC, 363 S.W.3d 192, 195 (Tex. 2012).

378. *See* Denbury Green Pipeline-Tex., LLC v. Tex. Rice Land Partners, Ltd., 510 S.W.3d 909, 913 (Tex. 2017); Tex. Rice Land Partners, Ltd. v. Denbury Green Pipeline–Tex., LLC, 363 S.W.3d 192, 197 (Tex. 2012).

379. James W. Coleman, *The Jurisdictional Anticommons*, *in* GETTING TO YES ON LINEAR INFRASTRUCTURE PROJECTS 7, 8 (2021).

380. *Primacy Enforcement Authority for the Underground Injection Control Program*, U.S. ENV'T PROT. AGENCY (July 22, 2025), https://www.epa.gov/uic/primary-enforcement-authority-underground-injection-control-program-0#what_prim [https://perma.cc/T3N2-5JGS].

381. *Id.*

382. *Id.*

administrative, civil, and criminal enforcement penalty remedies; and regulations that meet the federal requirements for 1422 or 1425 programs.[383]

The State of Louisiana was the most recent state granted primacy in February 2024 to revise its Safe Drinking Water Act section 1422 UIC program to include Class VI injection well primary enforcement responsibility.[384] Louisiana is now the permitting authority for Class VI UIC wells located within the state and responsible for ensuring compliance of Class VI wells under the UIC program within the state.[385] The EPA will oversee Louisiana's administration of the SDWA Class VI program and continue to oversee Louisiana's administration of the programs for Class I-V UIC wells.[386] It will also remain the permitting authority for all well classes in the Indian lands within the state.[387]

Prior to having been granted primacy, Louisiana had one-third of Class VI applications, which have now been transferred to the state for processing.[388] Trailing slightly behind Texas, Louisiana has the second highest carbon dioxide capture capacity for proposed projects, totaling 46 million tons per annum.[389] Of the 79 proposed carbon capture projects in Texas, Louisiana, Mississippi, and Alabama, 32 propose to sequester up to 51 million tons per annum of carbon dioxide over the coming years.[390]

The Texas State Legislature passed HB 1284 in 2021 granting the Railroad Commission sole jurisdiction and regulatory authority over Class VI wells which it already possesses over oil and gas wells.[391] This bill allowed a single agency in the state to seek delegation authority from the EPA for Class VI injection wells.[392] Texas formally submitted an application for primacy to the EPA on December 19,

383. *Id.*

384. ANGELA C. JONES, CLASS VI CARBON SEQUESTRATION WELLS: PERMITTING AND STATE PROGRAM PRIMACY 12 (2024) https://www.congress.gov/crs_external_products/R/PDF/R48033/R48033.4.pdf [https://perma.cc/34QG-VHAC].

385. 40 C.F.R. § 147.950 (2024).

386. *See id.*

387. *See id.*

388. Carolyn Nuyen, *Louisiana Class VI Well Primacy Bodes Well for CCUS Projects in State and Across U.S.*, FACTSET (Jan. 24, 2024), https://btuanalytics.com/energy-transition/louisiana-class-vi-well-primacy-bodes-well-for-ccus-projects-in-state-and-across-u-s/ [https://perma.cc/8SHA-CQA8].

389. *Id.*

390. *Id.*

391. *See* H.B. 1284, 87th Leg., Reg. Sess. (Tex. 2021).

392. *See Geologic Storage of Carbon Dioxide (CO2)*, R.R. COMM'N OF TEX., https://rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/co2-storage/ [https://perma.cc/W7Z7-68LS].

2022.[393] The Railroad Commission subsequently made amendments to Class VI regulations in September 2023 to bring them in line with federal requirements.[394] Amendments included revising the definition of anthropogenic sources of carbon dioxide, pore space ownership documentation evidence, mechanical integrity requirements, as well as financial assurance responsibility.[395] Despite efforts to expedite the process, it could take another two years before the EPA ultimately grants primacy to Texas.[396]

It is imperative that Texas policymakers safeguard against potential impediments to CCS development. Claims that CCS encourages the production of fossil fuels and indirectly causes climate change could stimulate litigation that would demand recovery of damages and stifle development.[397] Public nuisance claims are also avoidable to the extent carbon dioxide is specifically deemed not to be a nuisance, as in Nebraska and North Dakota.[398] The Texas economy and the energy industry can only benefit from the development of CCS and protection of the environment.

The EPA is committed to incorporating Environmental Justice requirements into the Class VI well program.[399] All decisions encompass the importance of community safety and environmental burden to the health and well-being of all communities. In Louisiana's primacy approval, the EPA incorporated several environmental justice initiatives into its decision, including an enhanced public participation process, environmental hazards, susceptible subpopulations, and mitigating measures for already overburdened communities such as the installation of enhanced pollution controls and carbon dioxide monitoring.[400] In December 2022, the administrator of the EPA also sent letters to governors outlining expectations for the inclusion of analysis and proposed implementation plans to address environmental justice and equity concerns in new primacy applications.[401]

393. *Id.*

394. Simon Willis et al., *Texas Crawls Towards Primacy for CCS Permits*, VINSON & ELKINS (Sep. 21, 2023), https://www.velaw.com/insights/texas-crawls-towards-primacy-for-ccs-permits/ [https://perma.cc/CT8T-W76C].

395. *Id.*

396. *Id.*

397. *See* TEXANS FOR LAWSUIT REFORM FOUND., *supra* note 318, at 31.

398. *Id.*

399. *See, e.g.*, REGULATORY IMPACT ANALYSIS, *supra* note 272, at ES-14 to ES-15; U.S. EPA, *supra* note 245, at 28.

400. 40 C.F.R. § 147.950 (2024).

401. Letter from Michael S. Regan, Former Adm'r of the EPA, to Governors of All States (Dec. 9, 2022), https://www.epa.gov/system/files/documents/2022-12/AD.Regan_.GOVS_.Sig_.Class%20VI.12-9-22.pdf [https://perma.cc/YSE6-8ZQT].

In particular, primacy applications are meant to include the identification of environmental justice communities, conduct properly scoped environmental justice assessments, enhance transparency, and minimize adverse effects to underground sources of water.[402]

D. *Supporting Carbon Capture Through Renewable Portfolio Standards*

A Renewable Portfolio Standard (RPS) is typically a state policy instrument used to transition to clean energy.[403] RPS policies require electric utilities to a have a minimum level of electricity generation capacity derived from renewable energy.[404] Such policies can have a significant impact on renewable energy investment, generation capacity, sales by utilities, and accelerate the pace of energy transition in a state.[405] Twenty-seven states plus Washington D.C. currently have RPS policies in place with an average target of 26 percent renewable energy generation required by 2022.[406]

New Mexico incorporated an RPS policy into its 2019 Energy Transition Act, which requires renewable energy retail sales of public utilities to reach a minimum of 40 percent by 2025, 50 percent by 2030, 80 percent by 2040, and 100 percent by 2045.[407] Public utilities are also required to source renewable energy from a variety of sources.[408] In 2019, Colorado enacted legislation which will require utilities to generate 100 percent power from clean energy sources by 2050 if they serve more than 500,000 customers.[409]

In 2020, Wyoming enacted "Reliable and Dispatchable Low-Carbon Energy Standards," promoting the transition to clean energy by retrofitting existing fossil-fuel power plants with CCS and allowing cost recovery of investment in CCS from ratepayers.[410] The Wyoming statute HB 200 "defines 'dispatchable' and 'low-carbon electricity' as energy 'that is available for use on demand . . . or that can

402. *See Primacy Enforcement Authority for the Underground Injection Control Program*, *supra* note 380.

403. *See* Tara Righetti, Temple Stoellinger & Robert Godby, *Adapting to Coal Plant Closures: A Framework for Understanding State Resistance to the Energy Transition*, 51 ENV'T L. 957, 967 (2021).

404. *Id.*

405. *Id.*

406. RYAN FITZPATRICK ET AL., CLEAN ENERGY STANDARDS: HOW MORE STATES CAN BECOME CLIMATE LEADERS 4 (2018), https://thirdway.imgix.net/pdfs/clean-energy-standards-how-more-states-can-become-climate-leaders.pdf [https://perma.cc/F2HY-C6UG].

407. Righetti, Stoellinger & Godby, *supra* note 403, at 968.

408. *Id.*

409. *Id.*

410. *Id.* at 977.

have its power output adjusted according to market needs,' and 'is generated while using carbon capture, utilization and storage technology.'"[411] It also authorizes a utility to apply for rate recovery of CCS investment.[412] These examples suggest that future Renewable Energy Standards in states can be established or modified to incorporate energy produced using CCS as another form of clean energy.

Renewable energy sources suppling energy to the grid in Texas have been growing due to the Renewable Energy Credit program that was expanded in 2005, increasing the goal to 10,000 MW by 2025.[413] Public Utility Commission of Texas Substantive Rule 25.476 sets out rules for renewable and green energy verification for retail electric services.[414] If this rule were amended to incorporate CCS decarbonized energy from coal and natural gas power, such energy could be identified as "green" on the independent Texas electricity grid.[415]

E. *Using Securitization to Finance Energy Transition Costs*

Ratepayer securitization has become an attractive way for state regulators to finance capital-intensive infrastructure investments given escalating energy prices and the need for lowering GHG emissions.[416] Ratepayer obligation bonds are issued by bankruptcy-remote special purpose vehicles, which are typically given the highest rating of Aaa/AAA by Moody's or Standard & Poor's.[417] A unique feature of such securitization structures is that state legislation establishes a legal framework which allows utilities to impose a mandatory charge (based on electricity consumption) on its retail electric consumers' bills.[418] The frameworks also allows for the creation of a true-up adjustment, which is a state law property right which includes an irrevocable regulatory guaranteed that allows electricity rates to be adjusted to levels needed to cover timely debt service on the bonds.[419]

411. *Id.* (quoting WYO. STAT. ANN. § 37-18-101(a)(ii)–(iii) (2021)).

412. *Id.* (citing WYO. STAT. ANN. § 37-18-102(c)(iii) (2021)).

413. LISA MINTON, TEXAS ELECTRICITY RESOURCES: WHERE POWER COMES FROM – AND HOW IT GETS TO YOU 6 (2020), https://comptroller.texas.gov/economy/fiscal-notes/archive/2020/august/docs/fn.pdf [https://perma.cc/LWW5-ZYL8].

414. 16 TEX. ADMIN. CODE § 25.476 (2025).

415. *See id.*

416. Joseph S. Fichera & Rebecca Klein, *Lowering Environmental and Capital Costs with Ratepayer-Backed Bonds*, SABER PARTNERS, https://saberpartners.com/op-ed/lowering-environmental-and-capital-costs-with-ratepayer-backed-bonds/ [https://perma.cc/H6ZW-3RT8].

417. *See id.*

418. *See id.*

419. *See id.*

Several states, including New Mexico, Colorado, and Montana have adopted state policies to ease the cost of energy transition impact on ratepayers and local communities.[420] These policies allow utilities to finance an economically viable transition to clean energy through securitization.[421] Many utilities are opting to retire comparatively more expensive coal generation facilities and replace them with renewable energy.[422] This legislation authorizes public utility regulatory agencies to issue financing orders authorizing utility companies to issue ratepayer-backed bonds enabling them to transfer stranded asset (coal plants not fully amortized) costs from ratepayers to utility company investors.[423]

State securitization policies were originally developed to bridge the transition from regulated to deregulated energy markets, allowing public utilities to finance the cost of under-depreciated stranded assets by issuing lower interest rate bonds to fund investment in replacement generation assets with lower operating costs.[424] Lower interest rates are obtained as bonds are assigned higher credit ratings from rating agencies such as Moody's Investors Services and Standard & Poor due to state securitization features.[425] Although the savings obtained by utilities from lower borrowing rates may not be immediately felt by ratepayers, they can be passed on to shareholders and communities impacted by the transition.[426] Securitization policies allow states and public utilities to accelerate energy transition to lower cost power generating assets while protecting ratepayers from cost implications.[427]

In 2019, the Colorado Energy Impact Bond Act was enacted to negate the subsequent cost to ratepayers from transitioning away from stranded fossil energy assets.[428] It authorized the Colorado Public Utility Commission to allow utilities to issue low-cost energy assistance bonds in which the interest rate paid to investors on the bonds is passed on to consumers in the form of an "Energy Impact Assistance Charge," which is a charge included in their monthly electricity bill.[429] The bonds essentially cover costs associated with retiring electricity generating

420. Righetti, Stoellinger & Godby, *supra* note 403, at 969.

421. *See id.*

422. *See What's Driving the Decline of Coal in the United States*, CLIMATE NEXUS (Mar. 21, 2019), https://climatenexus.org/climate-issues/energy/whats-driving-the-decline-of-coal-in-the-united-states/ [https://perma.cc/3W5A-5QYR].

423. *See* Righetti, Stoellinger & Godby, *supra* note 403, at 970.

424. *Id.*

425. *See* Fichera & Klein, *supra* note 416.

426. *See* Righetti, Stoellinger & Godby, *supra* note 403, at 970.

427. *Id.*

428. *Id.* at 971.

429. *Id.*

facilities, including the unamortized portion of retired coal assets, decommissioning and restoration, and funding for negatively impacted workers and communities.[430]

New Mexico's Energy Transition Act also provides for securitization financing of similar costs associated with retiring electricity generation facilities and transitioning to renewables.[431] In New Mexico, the Public Utility Commission authorizes utilities to issue bonds in which debt service is covered through a mandatory energy transition charge on a customer's electricity bill.[432] Similar to Colorado and New Mexico, the 2019 Montana Energy Impact Assistance Act authorizing the Montana Public Service Commission to issue ratepayer-backed bonds to cover the retirement of coal-fired generating assets replaced by "least-cost electric generating facilities."[433] However, it does not mandate a specific type of replacement energy electric generating facility.[434] Rather, it defines the facility type as "an incremental supply-side or demand-side resource that when included in an electric utility's generation portfolio produces the lowest cost among alternative resources."[435]

V. BUILDING THE ENERGY TRANSITION IN TEXAS, THE GLOBAL ENERGY CAPITAL

Texas is by far the largest state emitter of carbon dioxide in the nation. Texas emissions were 200 percent of the next largest state emitter in the country for both energy related emissions, as well as emissions from electric power generation.[436] The industrial sector accounted for about 36 percent of the state's emissions, and electric power generation accounted for about 27 percent.[437] Emissions were generated almost entirely from petroleum products and natural gas.[438]

Texas produces around 25 percent of energy-related industrial carbon dioxide emissions in the United States, and 12 percent in the electric power generation sector, both the highest in the country.[439] The second highest state

430. *See id.*

431. *See id.*

432. *Id.*

433. *Id.* at 972 (quoting MONT. CODE ANN. § 69-3-1602(2)(b)(ii) (2025)).

434. *Id.*

435. *Id.* (quoting MONT. CODE ANN. § 69-3-1603(10) (2025)).

436. *Energy-Related CO_2 Emission Data Tables Summary*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/environment/emissions/state/ [https://perma.cc/2WR3-NZCJ] (Table 1).

437. *See id.* (Table 9).

438. *See id.* (Table 1).

439. *See id.* (Tables 4 & 6).

energy-related emitter in the industrial sector is Louisiana at about 11 percent and for electric power generation, Florida is at approximately 6 percent.[440] The largest operational electricity generation installed capacity in Texas is derived from natural gas (37.7 percent) with the second largest being from wind (22.9 percent), and the third coming from solar (19 percent).[441] There are at least 176 natural gas-fired power plants in Texas.[442] Despite fast growing intermittent renewable energy, firm power generation sources that can provide stable energy supply, meeting peak electricity demand, and grid reliability will continue to be required.

There are a variety of ways that a clean energy transition could be financed in Texas, including various types of ratepayer securitizations, contracts for differences, and amendments to the recently established Texas Energy Fund. Enhanced 45Q revenue streams, state policy action, and financing programs designed to promote natural gas electricity generation projects with CCS could make Texas the first state in the United States with over 80 percent clean energy on its independent grid. Streamlining Texas policy for CCS projects in the state will accelerate a cleaner Texas grid and have a significant impact on overall reduction of carbon emissions in the United States.

A. *Natural Gas Power Generation*

Texas accounts for 15 percent of natural gas driven electric power consumption in the United States, greater than any other state.[443] Given that natural gas is the dominant fuel used to generate power in Texas, it is interesting to consider the cost of retrofitting natural gas power facilities on a levelized cost per metric ton of carbon captured basis. Deploying first-of-a-kind capture technology for natural gas power would have a cost of $118 per ton of carbon captured, inclusive of $15 per ton cost for transportation and storage.[444] However, if a 10 percent learning rate were applied for each capture unit project deployed, the cost is projected to decline to $83.6 per ton of carbon captured by the eighth capture project utilizing fully commercialized technology developed through the deployment of multiple projects.[445] Adjusted for an inflation rate of 16 percent due

440. *See id.* (Table 4); *State Electricity Profiles*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/electricity/state/ [https://perma.cc/2WR3-NZCJ].

441. *Fact Sheet*, ERCOT (July 2025), https://www.ercot.com/files/docs/2022/02/08/ERCOT_Fact_Sheet.pdf [https://perma.cc/B69Y-WTT7].

442. *Texas Comptroller Energy Tour: Natural Gas Overview*, COMPTROLLER TEX., https://comptroller.texas.gov/economy/economic-data/energy/2023/nat-gas.php [https://perma.cc/J35L-MPH8].

443. *Id.*

444. *See* MONIZ ET AL., *supra* note 199, at 28–29.

445. *Id.* at 29.

to significant increases in capital goods costs and higher natural gas and electricity prices, this figure rises to $92.66 per ton.[446] The increased 45Q tax credit rate of $85 per ton results in a declining differential of around $7.66 per ton, making CCS retrofits to natural gas power plants potentially more economically feasible.[447]

Although natural gas power plants with CCS have yet to become operational, power generation with CCS has the potential to allow natural gas plants in Texas to remain in operation while decarbonizing its power grid.[448] Although, CCS costs are still high, new technologies such as oxycombustion systems may contribute to significant improvements in capture efficiency and reduction in cost.[449] The levelized cost of energy is one way of determining whether a power project will be built, based on whether its costs will break even with output.[450] The levelized cost of energy calculation determines how much money must be made per unit of electricity (kWh or MWh) to recoup the lifetime costs of the project, including the discounted value of the initial capital investment, operational and maintenance costs, and fuel costs.[451] Fixed costs and variable costs are combined into a single measurement to simplify the assessment.[452]

Inclusive of 45Q tax benefits in the Inflation Reduction Act, the levelized cost of energy of a gas combined cycle plant with a CCS system has become more cost-competitive in comparison to a standalone gas combined cycle plant. This is the case for both retrofit and new-build projects.[453] As compared to a levelized cost range of $39 to $101 per MWh for a stand-alone natural gas combine cycle facility, retrofitting it with CCS would only slightly increase the levelized cost from $59 to $103 per MWh.[454] New build facilities would be even more cost competitive with

446. *Id.* at 27–28.

447. *See id.*

448. *See Making Natural Gas Emissions-Free Will Be a Challenge*, THE ECONOMIST (June 23, 2022), https://www.economist.com/technology-quarterly/2022/06/23/making-natural-gas-emissions-free-will-be-a-challenge.

449. *See generally* Saeed Talei et al., *Oxyfuel Combustion Makes Carbon Capture More Efficient*, 9 ACS OMEGA 3250 (2024) (covering how oxyfuel combustion leads to improvements in the efficient capture of carbon).

450. *See* Zach Stein, *Levelized Cost of Energy (LCOE)*, CARBON COLLECTIVE (July 2, 2022), https://www.carboncollective.co/sustainable-investing/levelized-cost-of-energy [https://perma.cc/Z6FM-BK2A].

451. *Levelized Cost of Energy*, ENERGY EDUC., https://energyeducation.ca/encyclopedia/Levelized_cost_of_energy [https://perma.cc/BDP6-X8CX].

452. *Id.*

453. LAZARD'S LEVELIZED COST OF ENERGY+ (LCOE+) 30 (2023), https://www.lazard.com/media/nltb551p/lazards-lcoeplus-april-2023.pdf [https://perma.cc/FC3H-9G6M].

454. *See id.* at 31.

a levelized cost of $40 to $86 per MWh.[455] The declining levelized cost of energy for natural gas combined cycle facilities with CCS together with renewable energy, increases the likelihood of ultimately achieving a decarbonized grid in Texas.

With a significant concentration of fossil-fuel and petrochemical operations, the Gulf Coast Region accounts for the largest proportion of emissions in the state.[456] Given its close proximity to geologic saline and fossil storage, as well as an established oil and gas transport infrastructure, this region is well positioned for industrial decarbonization using CCS.[457] Existing gas transport infrastructure could be conceivably upgraded to transport carbon, or perhaps more likely, the same rights of way could be used to develop new carbon pipelines.[458] Twenty-four gas power plants in the region, emitting 31.2 million tons of carbon per year, are capable of being retrofitted for carbon capture over the next 10 to 15 years.[459] They are also eligible for the 45Q tax credit.[460]

Several CCS projects and partnerships have already been initiated in the Gulf Coast Region over the past couple of years. Fourteen companies have collectively committed to advancing large scale CCS projects capable of storing up to 50 million tons of carbon a year by 2030 and 100 million tons by 2040.[461] The group of companies are comprised of established players in the oil and gas and chemical industries including Air Liquide, BASF, Calpine, Chevron, Dow, ExxonMobil, INEOS, Linde, LyondellBasell, Marathon Petroleum, NRG Energy, Phillips 66, Shell, and Valero.[462] ExxonMobil in particular has over 30 years of experience in CCS with around 20 percent of the world's CCS capacity, or 9 million metric tons per year.[463] The efforts of policymakers in Texas will be key in enabling the state to maintain its position as a global leader in energy.

455. *See id.*

456. *See* ABRAMSON ET AL., AN ATLAS, *supra* note 108, at 32–33.

457. *See id.* at 33.

458. *See id.* at 34.

459. *See id.* at 32–33.

460. *See id.*

461. *Industry Support for Large-Scale Carbon Capture and Storage Continues to Gain Momentum in Houston*, HOUSTON CCS ALL. (Jan. 20, 2022), https://houstonccs.com/newsroom/industry-support-for-large-scale-carbon-capture-and-storage-continues-to-gain-momentum-in-houston/ [https://perma.cc/YGH9-67Y7].

462. *Id.*

463. *ExxonMobil Planning Hydrogen Production, Carbon Capture and Storage at Baytown Complex*, EXXONMOBIL (Mar. 1, 2022), https://corporate.exxonmobil.com/news/news-releases/2022/0301_exxonmobil-planning-hydrogen-production-carbon-capture-and-storage-at-baytown-complex [https://perma.cc/KLT9-KA7R].

In November 2023, constitutional amendment SB 2627 created the Texas Energy Fund providing up to $5 billion in grants and low-interest loans to fund "dispatchable" electric generating facilities within the Electric Reliability Council of Texas (ERCOT).[464] "Dispatchable" generation sources in the state are principally natural gas generation facilities.[465] The fund will be administered by the Public Utility Commission of Texas and provide up to $5 billion in loans with a 20 year term, up to 60 percent of a project cost, and an interest rate of 3 percent.[466] If the fund were to prioritize projects incorporating CCS, clean power generated by dispatchable natural gas facilities would complement renewable sources bringing the Texas grid closer to around-the-clock clean energy.

B. *Building a Carbon Management Hub in Houston*

Houston is the energy capital of the world, and CCS could allow it to maintain its leadership position by decarbonizing that energy.[467] The Center for Carbon Management in Energy at the University of Houston has developed a CCS investment model for the Greater Houston area to reach net-zero by 2050.[468] It builds on existing resources while lowering emissions from power plants, refining and industry, and developing low-carbon products.[469] It is based on the premise that the Houston area has an unparalleled unique advantage given its large cluster of high carbon emitters, proximal capacity for geologic carbon storage in saline aquifers as well as enhanced oil recovery, and an existing backbone of pipeline infrastructure to build upon in connecting emitters with storage locations.[470] Houston also has a skilled workforce in place capable of implementing the transition.[471]

The model assumes a reduction of 52 million tons of carbon per year based on emissions generated from various point sources in three Houston counties:

464. *The Texas Energy Fund Becomes Law. Now What?*, VINSON & ELKINS (Nov. 13, 2023), https://www.velaw.com/insights/the-texas-energy-fund-becomes-law-now-what/ [https://perma.cc/48DE-9H33].

465. *Id.*

466. *Id.*

467. *See* CHARLES MCCONNELL, CARBON CAPTURE, UTILIZATION AND STORAGE – LYNCHPIN FOR THE ENERGY TRANSITION 3 (2021), https://uh.edu/uh-energy-innovation/uh-energy/energy-research/white-papers/white-paper-files/ccus-lynchpin-for-energy-transition-web.pdf [https://perma.cc/5QA6-NG9E].

468. *See id.* at 2–3.

469. *Id.* at 3.

470. *See id.* at 3–4.

471. *Id.* at 4.

Harris, Galveston, and Chambers.[472] Building on an earlier study by the National Petroleum Council, the UH Energy model breaks down the energy transition into three phases: Activation 2020–2030, Expansion 2030–2040, and Broad Deployment 2040–2050.[473] As the Texas Gulf Coast storage capacity both onshore and offshore is large enough to potentially store more than 50 percent of the national carbon reduction plan target, or 200 million tons of carbon per year, successful deployment of CCS in the greater Houston area can lead the way for nationwide decarbonization using CCS.[474] It can also position Houston as a global carbon utilization hub to supply the world with low-carbon products and technologies given its energy assets, port infrastructure, and energy intellectual capital.[475]

During the Activation phase, it is envisioned that natural gas electric power facilities and methane-based steam reforming hydrogen plants will be retrofitted with CCS technology.[476] They have the lowest cost for capture, connection to pipelines, and geologic storage.[477] The Expansion phase projects 6.4 million tons of carbon captured per year from remaining natural gas-fired power facilities and 13.5 million tons of carbon captured per year from refining, petrochemical, and other industrial facilities.[478] The Broad Deployment phase expands out from the original three counties, "to stretch south and east along the Gulf Coast."[479] It completes the 52 million tons of carbon captured per year by adding 11.4 million tons per year from industrial furnaces, and 7.8 million tons per year from refineries.[480]

This expansion would allow for carbon capture around the country to be stored in geologic formations in Texas.[481] While a substantial amount of capital would be required to complete the buildout of capture facilities, pipelines, and geologic storage infrastructure, Texas would benefit by becoming a leading player in the sustainable energy economy, bringing jobs and demand for CCS intellectual capital.[482]

472. *See id.* at 8.
473. *See id.* at 4–5.
474. *See id.* at 3–4; NAT'L PETROLEUM COUNCIL, *supra* note 229.
475. MCCONNELL, *supra* note 467, at 23.
476. *See id.* at 4.
477. *Id.* at 4, 15–18.
478. *Id.* at 19.
479. *Id.* at 5.
480. *See id.* at 5.
481. *See id.*
482. *See id.* at 3, 5.

The existing Denbury carbon transportation pipeline is expected to be the principal transport infrastructure utilized in the Activation phase.[483] This carbon pipeline is one of the most extensive currently in the United States with around 13 million tons per year of existing capacity to transport carbon.[484] It is capable of connecting Gulf Coast industries with both onshore and offshore storage.[485] Twelve million tons of carbon per year is projected to be removed during this phase.[486]

Sensitivity scenarios reveal that investment returns for carbon capture projects in which 100 percent of the carbon is used for enhanced oil recovery are highly sensitive to the price of oil and the amount produced.[487] A positive return would require oil prices in the range of $40 to $60 per barrel for the 20 year period modeled.[488] Investment returns on carbon capture projects in which 100 percent of the carbon captured is stored in saline formations were not initially economically viable given high upfront costs of installing carbon capture equipment as well as the 45Q tax credit level of $50 per ton.[489] However, given the increased Section 45Q rate of $122 per ton, as well as a reduction in project cost due to improved technology, investment returns appear to be much more achievable.

C. *Texas Electric Utility Securitization*

The Texas legislature authorized the issuance of securitization funding by electric utilities to finance the unprecedented cost of damage caused to Texas electric utilities by winter storm Uri in February 2021.[490] Costs which would otherwise have been passed on to ratepayers immediately were able to be spread over the term of the $2.1 billion of bonds issued by Texas Electric Market Stabilization Funding in June 2022.[491] Bond maturities ranged from 2024 to 2050

483. *Id.* at 17.

484. *Id.*; *Our Company*, DENBURY, https://www.denbury.com/our-company/?languageid=1 [https://perma.cc/36C6-NCAS].

485. MCCONNELL, *supra* note 467, at 17.

486. *Id.* at 16.

487. *See id.* at 12–14.

488. *Id.* at 14.

489. *Id.* at 13, 14–15.

490. *Rating Action: Moody's Assigns Definitive Aaa (sf) Ratings to ERCOT Sponsored Texas Stabilization Subchapter N Bonds, Series 2022 Recovery Bonds*, MOODY'S (June 15, 2022) [hereinafter *Moody's*], https://www.moodys.com/research/Moodys-assigns-definitive-Aaa-sf-ratings-to-ERCOT-sponsored-Texas-Rating-Action--PR_467037 [https://perma.cc/V5LW-4GZN].

491. *See id.*

reducing the monthly obligation of ratepayers to cover the cost.[492] An average interest rate of around 4.9 percent is passed on to ratepayers in the form of a separate monthly charge on their electricity bill.[493]

The issuer is a wholly owned subsidiary of ERCOT.[494] ERCOT operates and ensures the reliability of the electricity grid in Texas serving more than 26 million customers and dispatching approximately 90 percent of the state's electricity load.[495] ERCOT distributed the proceeds of the bonds to obligated load serving entities via designated responsible qualified scheduling entities.[496] Load serving entities are the utilities providing electricity directly to consumers and responsible for purchasing sufficient power through the wholesale markets to serve their individual retail and wholesale customers.[497] They are either municipal-owned utilities, electric power cooperatives, or retail electric providers that represent electric demand in the power system.[498]

Under the ERCOT Protocols, responsible scheduling entities are responsible for financially settling all payments and charges with ERCOT on behalf of obligated load serving entities they represent for all electricity that is bought and sold in the market.[499] Obligated load serving entities were required to use proceeds from the bonds to refund retail customers for extraordinary costs they incurred or were otherwise obligated to pay as a result of the storm.[500]

The bonds are securitized by an uplift property asset established by the Public Utility Corporation of Texas' Irrevocable Debt Obligation Order, which constitutes the right to impose, collect, and receive a non-bypassable uplift charge directly from consumers.[501] It is an itemized charge that appears on customers' electricity bills.[502] The Order authorized ERCOT to recover $2.1 billion in

492. *See* Offering Memorandum from Elec. Reliability Council of Tex. to Investors, at i (June 8, 2022) [hereinafter Offering Memorandum], https://www.ercot.com/files/docs/2022/06/17/Offering%20Memorandum.pdf [https://perma.cc/X8NH-XTEC].

493. *See* Martin J. Luby, *Texas Must Protect Ratepayers in Billions of Winter Storm Financings*, UT NEWS (June 15, 2022), https://news.utexas.edu/2022/06/15/texas-must-protect-ratepayers-in-billions-of-winter-storm-financings/ [https://perma.cc/PJ3Z-TFYR].

494. Offering Memorandum, *supra* note 492, at 2.

495. *Id.* at 48.

496. *Id.* at i.

497. *Id.* at 50.

498. *Id.*

499. *Id.* at 49.

500. *See id.* at 3–4.

501. *See id.* at 9.

502. *See id.* at 3.

extraordinary costs and expenses incurred, plus upfront costs associated with the issuance of the bonds.[503] ERCOT expects the uplift charge to average 0.40 percent of the total electricity bill of a customer using an average of 1,000 kilowatt-hour (kWh), with an initial charge of approximately 0.60 percent.[504]

The creation of the uplift property backing the bonds includes a state non-impairment pledge which reinforces the protection of the uplift property asset.[505] The bonds have been awarded the strongest credit rating possible by Moody's Investors Service (Aaa) due to the strength of the state government statue and the Order.[506] The rating was also based on credit enhancement in the form of an uncapped true-up adjustment mechanism that requires a quarterly review to ensure adequate uplift charge collections to cover semiannual bond payments.[507] The benefit of having the highest rating possible by the credit rating agency Moody's is that the borrowing rate that is passed on to utility customers is substantially lower.[508]

Load serving entities in Texas have a formal reliability standard and mechanism to ensure they have the ability to procure sufficient energy on behalf of customers whether they are competitive retail providers, such as investor-owned utilities, publicly-owned municipal utilities, or community choice aggregating co-op utilities.[509] They can satisfy this obligation either through ownership of power generation facilities or through contractional relationships with independently owned power generators.[510] They are also able to bilaterally trade the resource reliability aspect of the obligation with other load serving entities.[511]

Market prices of electricity are derived from electricity generators' production costs.[512] Similar to the Texas Electric Market Stabilization Funding, the

503. *See id.* at 4.

504. *Moody's*, *supra* note 490.

505. *Id.*

506. *Id.*

507. *Id.*

508. Offering Memorandum, *supra* note 492, at 12, 31.

509. ZACH MING ET AL., THE LOAD-SERVING ENTITY RELIABILITY OBLIGATION: A MARKET DESIGN REFORM TO ENSURE ELECTRIC RELIABILITY IN TEXAS 3 (2021), https://www.nrg.com/assets/documents/energy-policy/e3-ercot-whitepaper-2021-09-29.pdf [https://perma.cc/LJL3-S6X2].

510. *Id.* at 15.

511. *Id.*

512. SONIA AGGARWAL ET AL., WHOLESALE ELECTRICITY MARKET DESIGN FOR RAPID DECARBONIZATION 10 (2019), https://energyinnovation.org/wp-content/uploads/2019/07/Wholesale-Electricity-Market-Design-For-Rapid-Decarbonization.pdf [https://perma.cc/FP8Z-BEFA].

transition cost to clean energy using CCS could be funded through bonds issued by ERCOT in which the required use of proceeds from the bonds is to refund retail customers for extraordinary costs they incur, or otherwise may be obligated to pay, resulting from the increased electricity prices through the application of CCS to electric generating facilities.[513]

D. *Using Contracts for Differences*

In the United Kingdom, contracts for differences are used to develop low carbon power infrastructure and minimize the cost to consumers.[514] Contracts for differences are contracts between low-carbon electricity generators and a government owned entity.[515] These contracts fix the prices received by generators over a number of years to reduce the risk for developers from wholesale market price fluctuations and to stimulate investment in clean energy technology.[516]

Generators receive a "strike price" per unit of power output.[517] In the event the strike price is lower than the wholesale price of electricity, generators will receive a subsidy from the government.[518] Conversely, they must refund any surplus they receive above the set price.[519] The subsidy and surplus payments received by the government are subsequently passed on to consumers through their electricity bills.[520] A "Contracts for Difference" allowance is added by the energy regulator to consumer electricity bills to cover the costs of low carbon energy suppliers.[521] From 2019 to 2023, the allowance increased household electricity bills by approximately 2.9 percent.[522]

While the U.K. scheme is focused on renewable technology, it could also be applied to other climate change technologies including carbon capture and storage. A similar type of system could be set up in Texas where a state entity could contract with developers of electricity generating technology with CCS. ERCOT would subsequently collect a levy from energy suppliers to cover payments to generators

513. *See* Offering Memorandum, *supra* note 492, at 3.

514. NICOLE WATSON & PAUL BOLTON, CONTRACTS FOR DIFFERENCE 4 (2024), https://researchbriefings.files.parliament.uk/documents/CBP-9871/CBP-9871.pdf [https://perma.cc/JLV3-DXFH].

515. *Id.* at 5.

516. *Id.*

517. *Id.* at 4.

518. *Id.* at 6.

519. *See id.*

520. *Id.*

521. *See id.* at 15.

522. *Id.*

when the strike price is above wholesale electricity prices they receive for power they produce.

E. *Voluntary Carbon Credits*

Some of the largest companies in the world are adopting net-zero targets and have pledged to zero-out remaining emissions that have not been addressed through process modification or fuel switching by purchasing carbon offsets, otherwise known as carbon credits.[523] Carbon credits are issued by companies and projects that are taking action to reduce GHG and are able to sell credits, which are financial instruments, to buyers that need to offset their own GHG emissions in order to reach their net-zero goals.[524] In the absence of government regulation requiring the issuance of compulsory carbon credits, voluntary carbon credit markets are emerging.[525] While the market is projected to grow from nearly $2 billion in 2022 to $100 billion in 2030, it is still nascent and complex.[526] Early valuations are extremely erratic as well, having ranged from $2 to $1,800 per ton.[527] One carbon credit equates to one metric ton of carbon dioxide that has been avoided or removed from the atmosphere.[528]

Carbon credits have been issued for carbon emissions avoidance and reduction by nature-based solutions, such as preservation of forest land, and engineered-technology based solutions such renewable energy, energy efficiency, fuel switching, and waste management.[529] They are also issued for carbon removal and sequestration solutions such as regenerative agriculture practices that sequester carbon in the land or plants, and technology based removal solutions, such as direct air capture and bio-energy with CCS.[530]

523. *See* Varsha Ramesh Walsh & Michael W. Toffel, *What Every Leader Needs to Know About Carbon Credits*, HARV. BUS. REV. (Dec. 15, 2023), https://hbr.org/2023/12/what-every-leader-needs-to-know-about-carbon-credits.

524. *Id.*

525. *Id.*

526. *Id.*

527. *Id.*

528. *Id.*; *see* JOGMECCHANNEL, *How Carbon Credits Can Incentivize CCS Projects*, at 18:50 (YouTube, Feb. 16, 2023) [hereinafter JOGMECCHANNEL, *Carbon Credits*], https://www.youtube.com/watch?v=VmKUwTQVr8Q&t=14s.

529. Walsh & Toffel, *supra* note 523.

530. *Types of Carbon Credits*, CLIMATE IMPACT X, https://uploads-ssl.webflow.com/641b1194b8c52067b6a71269/64eef1be3ef9727944d1d4c9_Types%20of%20Carbon%20Credits.pdf [https://perma.cc/KXM7-YMD5]; *How Carbon Credits Work*, CLIMATE IMPACT X, https://uploads-ssl.webflow.com/641b1194b8c52067b6a71269/64eef1be1b293c29018c884e_How%20Carbon%20Credist%20work.pdf [https://perma.cc/8LBY-93RW].

Carbon credit markets are not too dissimilar to emerging stock markets with various counterparties involved.[531] Currently, there are a number of carbon credit registries, carbon credit verifier or validation bodies, carbon credit rating agencies, and carbon credit brokers and marketplaces.[532] The quality of credits issued are evaluated on five principal attributes.[533] Additionality is a primary requirement, which is determined by whether a project would have occurred or been built in order to reduce or remove GHG had revenue not been generated from the sale of carbon credits.[534]

Quantification of the volume of carbon dioxide reduced, avoided, or removed by the project is also key.[535] The calculation of the quantity generated is based on standard quantification approaches.[536] However, projects often deviate from standard approaches, which can be addressed through the establishment of adequate buffer pools by the project or the purchase by buyers of extra credits to buffer potential reduction claims.[537]

Leakage and permanence are the next two principal risks assessed by buyers when determining the quality and valuation of carbon credit investments.[538] Leakage is the risk that emissions captured by the project are offset by the development of emissions generated by new projects or operations that would otherwise not have occurred.[539] For example, if paying to avoid deforestation, the project simply pushes the deforestation to another location.[540] Permanence risk addresses the possibility that emissions avoided or removed could be only temporary rather than permanent.[541] CCS is an example of carbon being stored on a permanent basis, and locked at least 800 meters underground, as opposed to trees sequestering carbon and subsequently being cut down, causing the release of carbon back into the atmosphere.

Buyers also consider Vintage as credits issued more recently are generally subject to more stringent certification standards which have a higher valuation.[542]

531. Walsh & Toffel, *supra* note 523.
532. *Id.*
533. *Id.*
534. *Id.*
535. *Id.*
536. *Id.*
537. *Id.*
538. *Id.*
539. *Id.*
540. *Id.*
541. *Id.*
542. *Id.*

Social and environmental co-benefits generated by projects such as reduction in health issues, enhancement of biodiversity, water quality, and jobs are also considered.[543]

The Integrity Council for the Voluntary Carbon Market (ICVCM) is an independent governance body for the voluntary carbon market.[544] They are a globally recognized institution responsible for establishing and enforcing global standards for high-quality carbon credits, and they validate carbon-crediting programs and methodologies that follow their defined Core Carbon Principles (CCP).[545] The ICVCM assesses carbon-crediting programs and credit issuance based on criteria laid out in their CCP Assessment Framework with the intension of developing greater integrity in the market by combining the highest quality aspects of existing assessment methodologies.[546]

There are 10 core carbon principals which define what it means for a carbon-crediting program to be of "high-integrity."[547] The principles include: (1) effective governance, (2) the tracking of mitigation activities, and carbon credits issued via a carbon credit registry, as well as (3) transparency, and (4) robust independent third-party validation and verification.[548] Emissions impact is evaluated by standards including: (5) additionality, (6) permanence, (7) robust quantification of emission reductions and removals, and (8) no double counting of issuance for achieving mitigation targets or goals.[549] Finally, the incorporation of a sustainable development assessment by determining if a carbon-crediting program has: (9) clear guidance, tools and compliance procedures to ensure mitigation activities contribute to social and environmental safeguards for sustainable impact development, and (10) is making a contribution toward a net-zero transition by mid-century by ensuring that mitigation activities are permanently reducing GHG emissions, and carbon-intensive practices.[550]

These principles were established to ensure the development of a creditable voluntary market in which buyers have confidence in the ability to identify and

543. *Id.*

544. *About the Integrity Council*, THE INTEGRITY COUNCIL FOR THE VOLUNTARY CARBON MKT., https://icvcm.org/about-us/ [https://perma.cc/PU2E-F77P].

545. *Id.*

546. *Id.*

547. *The Core Carbon Principles: Building Integrity and Transparency in the Voluntary Carbon Market*, THE INTEGRITY COUNCIL FOR THE VOLUNTARY CARBON MKT, https://icvcm.org/core-carbon-principles/ [https://perma.cc/3C7P-WUYL].

548. *Id.*

549. *Id.*

550. *Id.*

price high-integrity carbon credits that are making an authentic impact on emissions.[551] A high-integrity voluntary carbon market will attract and direct investment capital to the most impactful and cost-efficient climate mitigation activities, which is a key driver in the development of the principles.[552]

American Carbon Registry established one of the world's first carbon registry systems for carbon reduction and removal projects to record the issuance, transfer, and retirement of independently verified carbon credits.[553] They are also the first voluntary registry to establish a methodology for the quantification, monitoring, reporting and verification for CCUS-EOR projects.[554] The methodology was subsequently revised in 2022 to incorporate geologic saline and offshore sequestration.[555] Carbon credits for CCS projects are issued for a 10 year period.[556] However, to encourage the transition ultimately away from EOR toward saline sequestration, carbon credits issued for EOR projects are now only eligible until January 1, 2030, providing support for the development of technology and infrastructure in the short-term.[557]

Assessments of ownership, data collection, monitoring and reporting, quantification, permanence, liability, and additionality are all incorporated into American Carbon Registry's ultimate decision on whether a project is eligible for registration.[558] Ultimate ownership of the emissions reduction, and the chain of custody of parties involved in the capture, transport, and storage segments of the CCS process must be documented.[559] Pore space ownership, the right to inject and use oil and gas reservoirs for EOS projects, as well as surface access during the post-injection period required for monitoring are assessed.[560] Calculation procedures for quantification of emissions avoided or removed for all segments of the CCS process as compared to an industry standard baseline are evaluated.[561]

551. *Id.*

552. *Id.*

553. *Registry*, ACR, https://acrcarbon.org/registry [https://perma.cc/H2FE-2XX8].

554. JOGMECCHANNEL, *Carbon Credits*, *supra* note 528.

555. *Id.* at 2:35.

556. JOGMECCHANNEL, *Enabling CCUS Project Deployment Through Carbon Markets*, at 22:52 (YouTube, Feb. 16, 2023) [hereinafter JOGMECCHANNEL, *Enabling CCUS*], https://youtu.be/PPhEVgRTRnQ?si=oN3k43FwXWQHWfvg&t=1372.

557. *Id.* at 9:31; JOGMECCHANNEL, *Carbon Credits*, *supra* note 528, at 9:52.

558. JOGMECCHANNEL, *Enabling CCUS*, *supra* note 556, at 13:10.

559. *See* JOGMECCHANNEL, *Carbon Credits*, *supra* note 528, at 7:44.

560. JOGMECCHANNEL, *Enabling CCUS*, *supra* note 556, at 14:00.

561. *Id.* at 17:45.

Permanence is looked at on a site-specific basis including post-injection monitoring and modeling, as well as remediation plans should unintentional reversals occur.[562] Liability is also considered in terms of migration through well bores, fractures, or faults.[563] The carbon dioxide plume must be well-characterized through modeling and measurement during the injection period. Private insurance or reserve accounts can address potential liability risk.[564]

The methodology considers a project to be additional if it passes a regulatory surplus test, and is not mandated by existing law, regulations, or statutes that would affect its GHG emission reductions.[565] It must also exceed a performance threshold which is practice based, i.e., not common practice.[566] It must also exceed a technology standard in which the project is considered additional if the technology is uncommon.[567]

Verra, a voluntary carbon credit registry, has also developed a Verified Carbon Standard (VCS) Program with project level standards for activities as wide ranging as reducing deforestation, addressing plastic waste, and geologic carbon storage project activity.[568] While voluntary carbon credits have not been issued yet for geologic CCS projects on its registry, Verra has published a document providing project-level requirements for registration of carbon credits.[569] Similar to American Carbon Registry's requirements, geologic carbon storage projects must demonstrate ownership not only of the plant, equipment and processes of the capture site, transportation systems and storage sites, but also rights to pore space.[570] The project must be located in a jurisdiction with government regulatory oversight for storage site selection, well design, construction, and operating limits, monitoring requirements, and storage site closure requirements.[571]

562. *Id.* at 18:35.

563. *Id.* at 20:30.

564. *Id.* at 20:45.

565. *Id.* at 21:50.

566. *Id.* at 22:28.

567. *Id.* at 21:46.

568. *Area of Focus – Carbon Capture and Storage*, VERRA, https://verra.org/programs/verified-carbon-standard/area-of-focus-carbon-capture-storage/ [https://perma.cc/P8AV-RLSP].

569. VERRA, GEOLOGIC CARBON STORAGE (GCS) REQUIREMENTS 3 (2023), https://verra.org/wp-content/uploads/2022/12/GCS-Requirements-v4.0-FINAL.pdf [https://perma.cc/PL4Y-PBP8].

570. *Id.* at 5.

571. *See id.* at 8–10.

While the market is still nascent, voluntary carbon credits offer another potential source of revenue to enable CCS projects to become more economically viable.

VI. CONCLUSION

Given the natural advantage in the Texas Gulf Region of scaling up the deployment of CCS, as well as the recent amendments to the Section 45Q tax credit in the Inflation Reduction Act, private sector investment in CCS projects in Texas is likely to increase.[572] Enabling securitization funding to flatten the cost of decarbonization for ratepayers will also be strategic in the implementation of Texas's energy transition.[573] Enacting state policy similar to that in Wyoming, which allows cost recovery of investment in CCS for retrofitting existing fossil-fuel power plants, would accelerate the process. Given the long-established oil and gas infrastructure in the Texas Gulf Region, the significant geologic fossil and saline storage capacity, as well as the unique independent electricity grid, Texas is well positioned to lead the country is the energy transition using CCS technology for decarbonization.[574]

Improving the legal and regulatory framework of the CCS value chain will be critical to success in Texas.[575] Texas has already consolidated jurisdictional regulatory authority over permitting of Class VI injection wells to the Railroad Commission, which will streamline its application to the EPA for primacy.[576] Other considerations that will need to be addressed to enable CCS to develop in Texas include long-term liability for onshore sequestration, as well as post-site closure liability for offshore sites.[577] There has yet to be sufficient data collected on carbon dioxide plume activity in the post-injection phase that would assist in understanding potential liability obligations.[578]

Fiscal incentives such as potential revenue generated by leasing offshore pore space could advance CCS in the state.[579] Various U.S. Department of Energy and Texas state funding vehicles could also advance research and development in

572. *See* ABRAMSON ET AL., AN ATLAS, *supra* note 108, at 32–34; MCCONNELL, *supra* note 467, at 3–4.

573. *See supra* Part IV.D.

574. MCCONNELL, *supra* note 467, at 4.

575. Medlock III & Miller, *supra* note 370, at 3.

576. *Id.* at 5.

577. *Id.* at 6.

578. *Id.*

579. *Id.* at 7.

the field that would benefit the Texas economy.[580] Further research into carbon dioxide produced in industrial processes and power generation, hydrogen produced from hydrocarbon feedstocks using CCS, and CCS technologies would allow the Texas energy economy to continue to thrive in a clean energy environment.[581]

580. *Id.*
581. *See id*.