CARBON CAPTURE AND SEQUESTRATION – "ESSENTIAL," BUT TOO LITTLE, TOO LATE?

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Synopsis: Carbon dioxide removal (CDR), including carbon capture and sequestration, was once derided as little more than a corporate ploy to prolong reliance on fossil fuels. But CDR is now recognized by leading global authorities as essential to any effort to accomplish Paris Agreement objectives. Notwithstanding this recognition, many authorities caution that the world may be too late to sufficiently scale and deploy CDR strategies at the magnitude necessary for the existing challenge to reduce carbon emissions necessary to avoid irreversible climate impacts, and they could be correct. This article assesses these claims; puts in context the magnitude of CDR climate advocates argue is necessary relative to its current utilization; the existing regulatory, economic, and political barriers and incentives to broad-scale CDR viability and deployment; and recommends strategies to accomplish the necessary ramp-up. While such scaling is unlikely to be feasible within the timeline urged by Paris, CDR represents a vital step in the overall effort to mitigate the worst impacts of climate change.

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I. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) and the California Air Resources Board (CARB) are now reiterating what climate research has demonstrated for decades: Greenhouse gas emissions are not falling fast enough to prevent catastrophic climate impacts. Despite ambitious and increasing emission reduction targets and pledges globally, the world is far off track from meeting the objectives of the Paris Agreement (i.e., limiting global temperature increase to no more than 2.0°C and, ideally, 1.5°C).[1] Accordingly, climate authorities worldwide assert that carbon dioxide remove (CDR) strategies must be part of the global effort.

This article presents and examines the following issues:

1. the widely accepted contention that CDR is now "essential;"

2. whether the world is already "too late" to effectively deploy CDR strategies according to timelines set forth by Paris;

3. if the scaling of operating CDR technologies necessary by mid-century to avert irreversible climate impacts is possible[2];

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1. Simon Evans, *Direct CO2 capture machines could use 'a Quarter of Global Energy' in 2100*, CARBONBRIEF (Jul. 22, 2019, 10:00 AM), https://www.carbonbrief.org/direct-co2-capture-machines-could-use-quarter-global-energy-in-2100/ ("The 2015 Paris Agreement set a goal of limiting human-caused warming to 'well below' 2C and an ambition of staying below 1.5C. Meeting this ambition will require the use of 'negative emissions technologies to remove excess CO2 from the atmosphere, according to the (IPCC)."). *See* Corbin Hiar, *Exxon CEO says carbon removal is climate cure with oil perks*, CLIMATEWIRE (Jun. 28, 2022, 6:48 AM), https://subscriber.politicopro.com/article/eenews/2022/06/28/exxon-ceo-says-carbon-removal-can-save-oil-industry-00042607.

2. GLOB. CCS INST., GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO 2, 4 (2022) https://www.globalccsinstitute.com/wp-content/uploads/2023/01/Global-Status-of-CCS-2021-Global-CCS-Institute-1121-1-1.pdf ("[T]here remains a massive gap between today's CCS fleet and what is required to reduce global anthropogenic emissions to net zero. Limiting global warming to 2°C requires installed CCS capacity to

4. the existing regulatory, economic, and political barriers and incentives to broad scale CDR viability and deployment; and

5. recommendations to accomplish an unprecedented ramp-up of CDR technologies to facilitate them serving their newly proclaimed essential role in meeting Paris objectives.

Deploying CDR technologies at the scope and scale necessary to meet the carbon reduction targets of the Paris Agreement is likely impossible. Yet, even without meeting Paris' timeline, CDR technologies constitute an essential component of ongoing carbon reduction because of the continued magnitude of both ongoing global emission levels as well as legacy emissions already in the atmosphere.[3] Without meaningful CDR operating to reduce CO_2 emissions, climate research indicates catastrophic tipping points may be in store for human civilization.[4]

Many of the examples, analyses, and regulatory structures highlighted in this article come from California. The state has been among the most aggressive jurisdictions in the world in setting climate and emission reduction targets. California has held itself to exacting monitoring and reporting regimes. Still, recent inventories show California, like most U.S. jurisdictions, is far from being on track to hit its aggressive targets.[5] The state's regulatory blueprint to accomplish economy-wide carbon reduction targets recently underwent a public and contentious comprehensive update and adoption by CARB.[6] California Governor Gavin Newsom recently proposed and pressed through the legislature arguably the most aggressive statutory package of climate laws proposed in the U.S. While California illustrates many issues raised in this article, the dynamics, barriers, incentives, and proposed policy solutions are offered for universal application.

The second section of this article examines the contention that CDR is essential to meeting Paris' carbon reduction objectives and suggestions that the world may already be "too late" to deploy CDR technologies at a scope and scale sufficient to meet the goal.[7]

The third section defines CDR in its various iterations – natural and mechanical – focusing on three specific CDR approaches: carbon capture and sequestration (CCS); carbon capture, utilization, and sequestration (CCUS); and direct air capture (DAC). It will also address the metric of "carbon neutrality" where the amount of CDR required is measured relative to the imbalance between new emissions and carbon absorption through natural processes, the incorporation of CDR

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increase from around 40Mtpa today to over 5,600 Mtpa by 2050. Between USD$655 billion and USD$1,280 billion in capital investment is needed by 2050.").

3. *Id.* at 2.

4. *Id.* at 2.

5. Nadia Lopez*, Slashing greenhouse gases: California revises climate change* strategy, CALMATTERS (Nov. 16, 2022), https://calmatters.org/environment/2022/11/california-revises-climate-change-plan/.

6. CAL. AIR RESOURCES BD., 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY (2022), https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf.

7. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 2. "Large infrastructure projects like CCS facilities or pipeline networks usually take seven to 10 years from concept study through feasibility to design, construction then operation. There is no time to waste." *Id.* at 12.

being necessary to remove emissions in excess of natural absorption to bring the total to at least "net zero," or zero new emissions added.[8]

The fourth section looks at the economics of CDR. More specifically, assessing the economic viability of CDR through government subsidy[9] or utilization of CDR for expanded fossil fuel production and profit,[10] a highly contentious and even politically fatal proposition that can doom CDR projects. As discussed later in this article, the Petra Nova CDR "success story" underscores the challenges of making CDR economically viable in the short-term.

The fifth section examines regulatory permitting required for any CDR project and how that process likely inhibits if not precludes timely establishment of CDR operations.

The sixth and final section offers recommendations to attempt to confront the contention and likely resignation that we are, in fact, too late to deploy CDR at the scale and on timeframes necessary to accomplish Paris carbon-reduction objectives. However, it is imperative to recognize that "too late" with regard to Paris does not mean the world can now abandon the deployment of CDR at the scale to which it is now recognized as essential to avoid catastrophic tipping points.

II. CARBON DIOXIDE REMOVAL: "ESSENTIAL" BUT "TOO LATE"?

A. Carbon Dioxide Removal Is "Essential"

Carbon emissions policy has shifted focus towards carbon removal as a means to mitigate climate change. What was once derided by environmental advocates as a ploy to enable prolonged reliance on fossil fuel use[11] is now widely recognized as imperative to accomplishing not only "carbon neutrality," but "carbon negativity" required to address legacy emissions and achieve Paris Agreement targets. Likewise, the IPCC stated in its Sixth Assessment Report (AR6) that reliance on CDR is "unavoidable if net zero CO_2 or GHG emissions are to be

8. "The amount of carbon removal that will be required depends on how quickly companies and governments can slash emissions from oil and gas and other sources." Hiar, *supra* note 1.

9. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 12. "Creating an enabling environment for investment in CCS facilities and other net zero aligned assets – particularly in supporting infrastructure – through both policy and funding, should be a high priority for governments between now and 2030." *Id.* "The global CCS industry must grow by more than a factor of 100 by the year 2050, to achieve Paris Agreement climate targets." *Id.* at 11.

10. Tony Briscoe*, California hopes to fight global warming by pumping CO_2 underground. Some call it a ruse,* L.A. TIMES (July 25, 2022), https://www.latimes.com/environment/story/2022-07-25/is-carbon-capture-and-storage-a-cover-for-oil-production; *see* 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY, *supra* note 6. "As is the case with CCS, mechanical CDR technologies will need government or other incentive support to get over technology and market barriers." *Id.* at 93.

11. 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY, *supra* note 6. "Over the past decade I have seen CCS move from being falsely identified only as a coal fired power generation technology to being increasingly embraced as a vital element of meeting the climate challenge due to its versatility of application, demonstrated effectiveness and ability to deal with enormous volumes of emissions." GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 3.

achieved."[12] "Fourteen countries . . . had CCS in their Nationally Determined Contributions ("NDCs") [under the Paris Agreement] as of July 2021."[13] The U.S. Department of Energy (DOE) noted that "CCS and carbon removal are both 'crucial and necessary' to meet the country's climate ambitions."[14] At the same time, CARB released a draft update to the "Scoping Plan," California's aforementioned blueprint for achieving its economy-wide emission reduction goals, and declared CCS "a necessary tool to reduce GHG emissions and mitigate climate change. . . ."[15]

Research institutes and think tanks affirm the imperative of CDR in accomplishing Paris objectives. The Global CCS Institute wrote that "CCS is a necessary element of the technology suite that must be deployed if the world is to achieve the Paris Objectives,"[16] and that

> [w]e know based on reputable analysis, including from the IPCC, that carbon dioxide removal will be required to meet the Paris targets. We also know that nature-based solutions alone will not be enough. . . . It is also increasingly apparent that direct air capture will need to play a significant role.[17]

Even as the calls for CDR deployment have strengthened and spread, the challenges of deployment have become more apparent:

> As impressive as the past year's progress with accelerating the CCS project pipeline is, the stark reality is that enormously more CCS facilities are required – at least a 100-fold increase over the 27 in operation today – by 2050. Without this, the world is extremely unlikely to achieve the key targets in the Paris Agreement with the well documented serious consequences of such an outcome.[18]

Bridging the gap between CDR deployment and capacity is the remaining focus of this article.

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12. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2022 MITIGATION OF CLIMATE CHANGE 36 (2022), https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf.

13. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 22.

14. Corbin Hiar & Carlos Anchondo, *Biggest CCS failure clouds Supreme Court ruling,* E&E NEWS (July 11, 2022), https://www.eenews.net/articles/biggest-ccs-failure-clouds-supreme-court-ruling/. "'DOE will continue to focus on developing carbon management technologies that can be applied to both power generation and industrial sources of CO_2, as well as to capturing and removing CO_2 directly from ambient air,' the DOE spokesperson said." *Id.*

15. 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY, *supra* note 6, at 84. "Now, as California attempts to meet ambitious climate goals, environmental officials are embracing carbon capture and storage, saying the state cannot achieve carbon neutrality without it." Briscoe, *supra* note 10. On December 15, 2022, CARB adopted the final version of the 2022 Scoping Plan, largely unchanged from the Draft Scoping Plan cited herein. *CARB approves unprecedented climate action plan to shift world's 4th largest economy from fossil fuels to clean and renewable energy*, CAL. AIR RES. BD. (Dec. 15, 2022), https://ww2.arb.ca.gov/news/carb-approves-unprecedented-climate-action-plan-shift-worlds-4th-largest-economy-fossil-fuels.

16. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 2.

17. *Id.*

18. *Id.*

B. Are We "Too Late"?

The cost and magnitude of expansion of CDR necessary to meet Paris objectives may be infeasible within the agreement's timeline. The current operating assumption is that technologies for both CCS and DAC work.[19] Yet the scale of current deployment of these technologies is a fraction of what would be required for CDR to have a chance to meet carbon reduction targets in Paris. CARB staff, among others, are sounding the alarm:

> State, national, and global decarbonization analyses indicate a significant role for carbon management infrastructure, yet relatively few projects are operational. Future research, development and demonstration projects must refine and commercialize capture systems for more complex applications, especially those with limited decarbonization options. It has only been in the last few years that attention has seriously turned to mechanical CDR. As new information and modeling on climate change have been made available, the science has become clearer that avoiding the most catastrophic impacts of climate change requires both reducing emissions and deploying CDR.[20]

The estimates of the magnitude of CDR deployment required in the second half of this century are staggering:

The IPCC also estimated that 5-10 gigatonnes (Gt)[21] of carbon dioxide (CO_2) must be removed from the atmosphere each year in the second half of this century to:

- offset residual emissions that are very difficult to abate,
- hard to avoid emissions such as those from agriculture and air travel, and
- reduce the total load of greenhouse gases in the atmosphere to below the carbon budget for 1.5°C of global warming correcting for the overshoot.[22]

Experts have expressed concern about the economic costs to execute rapid transition to a renewable energy-based system.[23] But CDR could extend the transition time for the switch to a 100% zero-carbon system. Among other things, this affords states added compliance flexibility with renewable portfolio and clean energy standards.

However, one expert projects that the necessary "huge pace and scale" of increased CDR utilization are "expansion of up to 30% each year and deployment

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19. Andrew Moseman & Howard Herzog, *How efficient is carbon capture and storage?*, MIT CLIMATE PORTAL (Feb. 23. 2021), https://climate.mit.edu/ask-mit/how-efficient-carbon-capture-and-storage#:~:text=CCS%20projects%20typically%20target%2090,will%20be%20captured%20and%20stored.

20. 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY, *supra* note 6, at 220-21.

21. One gigaton is 1,000,000,000 tons. *Gigatonne*, ENERGY EDUCATION, https://energyeducation.ca/encyclopedia/. For purely illustrative purposes, one gigaton is roughly the equivalent of "200 million elephants, enough elephants to stretch from the Earth to the moon." *Id.* Other rough equivalents of a single gigaton include "5.5 million blue whales, 3 million Boeing 747 jets, [and] 2 million international space stations." *Id.*

22. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 10.

23. Evans, *supra* note 1. "[D]espite 'huge uncertainty' around the cost of DAC, [a] study suggests its use could allow early cuts in global greenhouse gas emissions to be somewhat delayed, 'significantly reducing the climate policy costs' to meet stringent temperature limits." *Id.*

reaching 30 [gigatons of CO_2 per year] towards the end of the century."[24] Some openly question the feasibility of such a ramp-up, with the only comparable effort being the unprecedented, government-driven evolution and maturation of the solar photovoltaic industry.[25]

"Reaching 30Gt CO_2/yr of CO_2 capture – a similar scale to current global emissions – would mean building some 30,000 large-scale DAC factories . . . [f]or comparison, there are fewer than 10,000 coal-fired power stations in the world today."[26]

A commonly referenced estimate is that CDR deployment would need to "grow by more than a factor of 100 by year 2050 to achieve Paris Agreement climate targets."[27]

With these stakes established, the remainder of this article explores the various forms of CDR, highlights both incentives and barriers to its meaningful deployment, recognizes cautionary proclamations over undue reliance on CDR technologies yet to be proven at the necessary scale, and offers recommendations for scaling up deployment as soon as possible setting aside Paris timeframes.

III. FORMS OF CARBON DIOXIDE REMOVAL

A. Carbon Dioxide Removal, Generally – Mechanical v. Natural/Biological

Carbon dioxide removal refers to extraction of CO_2 from the air, whether residual legacy gases in ambient air or newly produced emissions.[28] This process of removal can be natural by operation of the earth's carbon cycle (e.g., trees absorbing CO_2) or by human-initiated mechanical intervention.[29] The focus of this article is mechanical CDR – deployment of technologies that capture and concentrate ambient CO_2, whether from an industrial production stream or in the atmosphere.[30]

B. Forms of Mechanical CDR: CCS, CCUS, and DAC

Under the umbrella term of mechanical CDR, this article examines three specific approaches: CCS, CCUS, and DAC. "[Mechanical carbon removal] is not a new concept or technology."[31] "Twenty years of CCS testing shows it is a safe and reliable tool. . . . Moreover, there has been a U.S. Department of Energy CCS

24. *Id*.

25. *Id.* "Is the rate of scale-up even feasible? Typical rules of thumb are increase by an order of magnitude per decade [growth of around 25-30% per year]. [Solar] PV scale-up was higher than this, but mostly due to government incentives . . . rather than technology advances." *Id.*

26. *Id*.

27. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 11.

28. 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY, *supra* note 6, at 216.

29. *Id.* at 200.

30. *Id.* at 92, 245.

31. *Id.* at 221.

research program under way for more than two decades. These all form a foundation of information for future efforts."[32]

1. Carbon Capture and Sequestration

Carbon capture and sequestration, the most prevalent type of CDR,

> is a process by which large amounts of CO_2 are captured, compressed, transported, and sequestered. CCS projects are paired with a source of emissions as the CCS project captures CO_2 as it leaves a facility's smokestack. CCS projects are often paired with large GHG-emitting facilities such as energy, manufacturing, or fuel production facilities.[33]

Concentrated (often liquified) CO_2 is injected into geologic formations such as depleted fossil fuel reservoirs or saline formations deep underground where it cannot escape or leak back into the atmosphere.[34]

According to the Global CCS Institute, there are 27 operational CCS projects worldwide.[35] "This technology can be built on time and on budget [to recover its costs via tax incentives and other compensation for sequestered quantities of carbon], which kind of distinguishes it from other technologies around fossil fuels that are trying to reduce [the] carbon footprint of those fuels."[36] The Global CCS Institute is, by its own characterization, a think tank whose "diverse international membership includes governments, global corporations, private companies, research bodies and non-governmental organizations; all of whom are committed to CCS as an integral part of a net-zero emissions future."[37] Other CDR stakeholders would likely have differing perspectives than the institute on many issues.[38]

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32. 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY, *supra* note 6, at 221.

33. *Id*. at 84; *see* BATTELLE MEM'L INST., MONETIZING YOUR CARBON EMISSIONS WITH 45Q TAX CREDITS (2021), https://www.battelle.org/success/white-papers/monetizing-carbon-emissions.

34. MONETIZING YOUR CARBON EMISSIONS WITH 45Q TAX CREDITS, *supra* note 33. "For geologic storage, CO_2 is injected into a deep geological formation where it can be safely and permanently stored. These formations are typically deeper than 2650 feet to maintain the CO_2 in a supercritical state. Supercritical CO_2 is best because the CO_2 has the viscosity of a gas for easy injection and a liquid-like density for more efficient storage. The deep formation must have sufficient ability to allow the CO_2 to enter the formation (permeability) and sufficient space to store the CO_2 (porosity). Above the storage formation, there must be an impermeable caprock layer that prevents the stored CO2 form leaking out. Deep saline reservoirs and depleted oil and gas reservoirs are good candidates for CCUS projects. These formations can be found in sedimentary basins throughout the United States." *Id.*

35. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 3; Anne C. Mulkern, *Calif. may rely on carbon capture to meet 2045 net-zero goal*, CLIMATEWIRE (Jun. 30, 2022), https://subscriber.politicopro.com/article/eenews/2022/06/30/calif-may-rely-on-carbon-capture-to-meet-2045-net-zero-goal-1-00042920.

36. Hiar & Anchondo, *supra* note 14.

37. *About Us*, GLOB. CCS INST., https://www.globalccsinstitute.com/about/; *see Our Members*, GLOB. CCS INST., https://www.globalccsinstitute.com/membership/our-members/ (list of Global CCS Institute members).

38. Nicholas Kusnetz, *Carbon Capture Takes Center Stage, But Is Its Promise an Illusion?*, INSIDE CLIMATE NEWS (Mar. 9, 2022), https://insideclimatenews.org/news/09032022/carbon-capture-and-storage-fossil-fuels-climate-change/.

2. Carbon Capture, Utilization, and Sequestration

It is not uncommon for analyses to use the acronyms CCS and CCUS interchangeably, but the distinction is important and even essential in many political contexts. The "u" stands for "utilization."[39] To what use or purpose is the operator of the CCS facility putting the concentrated carbon? When the "u" is included, the carbon is utilized for the additional production of fossil fuels from a resource that was at or was nearing the end of its useful production life.[40] Termed "enhanced oil recovery" or "EOR," the sequestration injection process is into a depleted underground oil and gas reservoir to stimulate additional production that may not have been possible absent the pressurization caused in the newly injected carbon stream.[41] Aside from such utilization, or not, there is no difference between CCS and CCUS; the process of capture and concentration are the same.[42] The only question is where the captured carbon goes and for what purpose.

In some jurisdictions, however, the prospect of using CCS for enhanced and prolonged fossil production spells political doom for CCS. In California, for example, while state authorities recognize oil production and refinement cannot be phased out completely and that CCS is needed to help meet climate goals, a group of prominent environmental and environmental justice groups protested a legislative proposal by Governor Newsom to streamline permitting of CCS facilities if any use of CCS served to prolong the phase out of all fossil fuel production in the state.[43] Governor Newsom's legislative package ultimately included and the legislature adopted an express ban on CCS for EOR in California.[44] But California

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39. *What is Carbon Capture and Storage? – CCS Explained*, NAT'L GRID GROUP PLC, https://www.nationalgrid.com/stories/energy-explained/what-is-ccs-how-does-it-work#:~:text=As%20well%20as%20CCS%2C%20there,%2C%20plastics%2C%20concrete%20or%20biofuel.

40. *Carbon Capture, Utilisation and Storage*, INT'L ENERGY AGENCY, https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage (last updated Oct. 17, 2022).

41. Christophe McGlade, *Can CO2-EOR really provide carbon-negative oil?*, INT'L ENERGY AGENCY (Apr. 11, 2019), https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage; *About CCUS*, INT'L ENERGY AGENCY (Apr. 2021), https://www.iea.org/reports/about-ccus (noting use of CCUS for EOR is not new). Use of CCUS for EOR is not new: "[s]ome of these facilities have been operating since the 1970s and 1980s, when natural gas processing plants in the Val Verde area of Texas began supplying CO2 to local oil producers for enhanced oil recovery operations." *Id.*

42. Eva Amsen, *CCS and CCU. Mind explaining what these are again?*, NESTE (Apr. 21, 2021), https://journeytozerostories.neste.com/circular-economy/ccs-and-ccu-mind-explaining-what-these-are-again#a4c4fad1.

43. Curt Barry, *Newsom Faces Battle as He Urges Lawmakers to Toughen Climate Goals*, INSIDE EPA'S CLIMATE EXTRA (Aug. 12, 2022), https://insideepa.com/climate-news/newsom-faces-battle-he-urges-lawmakers-toughen-climate-goals. Out of approximately six CCS projects proposed for California's Central Valley – the main region in the state considered to have appropriate geologic sequestration reservoirs – only one proposes utilization of the carbon for EOR. *EPA Urged to Reject Carbon Capture Projects in Central California*, CTR. FOR BIOLOGICAL DIVERSITY (June 29, 2022), https://biologicaldiversity.org/w/news/press-releases/epa-urged-to-reject-carbon-capture-projects-in-central-california-2022-06-29/. California Resources Corporation proposes to capture 1.5 million tons of CO_2 each year and use it to stimulate production in its Elk Hills oil field to produce 51 million more barrels of oil over two decades. MONETIZING YOUR CARBON EMISSIONS WITH 45Q TAX CREDITS, *supra* note 33.

44. CAL. PUB. RES. CODE § 3132 (West 2022) (stating "an operator shall not inject a concentrated carbon dioxide fluid produced by a carbon dioxide capture project" or carbon dioxide capture and "sequestration project

is not the norm. Of 12 large-scale carbon storage facilities in the United States, 11 use captured carbon for oil production.[45]

3. Direct Air Capture

Utilizing the same underlying technology—carbon removal and concentration via various alternative chemicals' absorption and adsorption process with varying efficiency levels -- as CCS, DAC removes existing CO_2 from the atmosphere and concentrates it for sequestration or use.[46] Thus, DAC, unlike CCS, is not tied or bound to an industrial source of carbon.[47] The technology relies on "fans, filters, and pipes to remove carbon dioxide from the [ambient air], condense the gas into a liquid," and sequester it permanently.[48] Unlike CCS, therefore, DAC potentially can eliminate the need to transport sequestered carbon since the DAC facility is situated on or in immediate proximity to a sequestration facility.[49]

Direct air capture exemplifies CDR approaches proven technologically feasible but only at a minor fraction of what will be required.[50] Currently, the most robust operating DAC facility removes less than 1% of the carbon emitted by a single coal-fired power plant.[51] And, the cost of such scaled-up efficiency and deployment remains unknown and a significant factor of concern, although EPA has appropriated $3.7 billion dollars for the future establishment of four demonstration DAC regional hubs.[52]

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into a Class II well for purposes of enhanced oil recovery, including the facilitation of enhanced oil recovery from another well"). "Newsom officials are acknowledging concerns among some Democratic lawmakers, environmentalists and equity groups about CCUS by adding that 'the state must avoid projects that worsen climate change. Specifically, this proposal would prohibit an operator from using concentrated carbon fluids for purposes of enhanced oil recovery.'" Barry, *supra* note 43.

45. Briscoe, *supra* note 10; *see* Angela C. Jones & Ashley J. Lawson, CARBON CAPTURE AND SEQUESTRATION (CSS) IN THE UNITED STATES, CONG. RSCH SERV. (Oct. 5, 2022), https://crsreports.congress.gov/product/pdf/R/R44902 (stating "most projects use the injected CO2 to increase oil production from aging oil fields, known as enhanced oil recovery (EOR), while some facilities capture and inject CO2 with the aim to sequester the CO2 in underground geologic formations").

46. Sara Budinis, *Direct Air Capture*, INT'L ENERGY AGENCY (Sept. 2022), https://www.iea.org/reports/direct-air-capture.

47. Hiar, *supra* note 1.

48. *Id.*

49. Malin Edvardsson, *CCS, BECCS and DAC – What is the Difference?*, BIOLIN SCIENTIFIC (Mar. 10, 2020), https://www.biolinscientific.com/blog/what-is-the-difference-between-ccs-beccs-and-dac.

50. Hiar, *supra* note 1.

51. *Id.* ("[T]he largest existing facility can only remove 4,000 metric tons of carbon per year, less than 1 percent of the annual emissions of a single coal-fired power plant. Nevertheless, climate scientists believe the world needs to significantly expand its carbon removal capacity to have a shot at avoiding the collapse of coral reef ecosystems, widespread extreme heat waves and other impacts associated with warming of more than 1.5 degrees Celsius above preindustrial levels. The amount of carbon removal that will be required depends on how quickly companies and governments can slash emissions from oil and gas and other sources.").

52. *Biden-Harris Administration Announces $3.7 Billion to Kick-Start America's Carbon Dioxide Removal Industry*, DEP'T OF ENERGY (Dec. 13, 2022), https://www.energy.gov/articles/biden-harris-administration-announces-37-billion-kick-start-americas-carbon-dioxide; *see* Dr. Jennifer Wilcox, DIRECT AIR CAPTURE, DEP'T OF ENERGY (May 25, 2022), https://www.eesi.org/files/Jennifer_Wilcox_Slides_052522.pdf.

Experts caution against undue reliance on DAC, noting its high cost and unproven delivery at the scope and scale projected by California and others.[53] A particular line of climate research warns of "mitigation deterrence" arising from DAC reliance.[54] Characterizing direct emission reductions as "mitigation" against climate change, researchers refer to reliance on DAC as "mitigation deterrence" or the diluting of incentives to cut fossil fuel use today.[55] "Heavy reliance on negative emissions is problematic because the feasibility of large-scale CDR is highly uncertain. The promise of carbon removal could be used to delay or deter action in the present, but it could then fail to show up at scale when needed."[56]

California regulators are signaling that the state will be relying heavily on DAC in the second half of this century. Some have recognized that the state may have been overly optimistic in its projections for the time it will take for carbon removal technologies to become scalable and deployable.[57] Accordingly, California's environmental agencies have had to significantly revise their modeling.[58] The state nonetheless projects that one-third of their total emissions reductions will come from DAC in 2050 and beyond.[59]

C. "Net-Zero" Emissions

Removing carbon from industrial emission streams and the atmosphere itself accelerates emission reductions to accomplish "net-zero" or even negative levels of carbon contributions by combining emission reduction regimes with CDR efforts. Initially, progress towards emission reduction targets were gauged by quantitive numerics.[60] For example, the Executive Order by California Governor Arnold Schwarzenegger in 2005,[61] widely regarded as one of the first authoritative

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53. ENERGY AND ENVIRONMENTAL ECONOMICS, CPUC IRP ZERO-CARBON TECHNOLOGY ASSESSMENT 59, 67 (2022), https://www.ethree.com/wp-content/uploads/2023/03/CPUC-IRP-Zero-Carbon-Technology-Assessment.pdf.

54. Neil Grant & Dr. Ajay Gambhir, *Guest post: emissions should fall 'twice as fast' in case negative emissions fail,* CARBONBRIEF (Jun. 28, 2021), https://www.carbonbrief.org/guest-post-emissions-should-fall-twice-as-fast-in-case-negative-emissions-fail/.

55. *Id.*

56. *Id.*

57. CAL. AIR RESOURCES BD., DRAFT 2022 SCOPING PLAN (2022), https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp.pdf ("While the modeling [for the Scoping Plan alternatives] included CCS as being available in the first half of this decade, implementation barriers now indicate that is unlikely, and those emissions will be emitted into the atmosphere. For the Final 2022 Scoping Plan, the modeling will reflect updated assumptions for the earlier deployment of CCS for any sector in California.").

58. *Id.*

59. Mulkern, *supra* note 35. "About one-third of emissions reductions in 2045 would come from greenhouse gas removal techniques," under a proposed plan from staff at the California Air Resources Board. *Id.* The CEO of Exxon Mobil, Darren Woods, referred to DAC as the "holy grail," but noted concerns. Hiar, *supra* note 1. "If you can overcome some of those technology hurdles, get your costs down, you've got technology then that can address this in a very cost-efficient way." *Id.*

60. THE GREENHOUSE GAS PROTOCOL, A CORPORATE ACCOUNTING AND REPORTING STANDARD 54, https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf.

61. State of California Executive Order S-3-05 (Jun. 1, 2005), https://www.library.ca.gov/wp-content/uploads/GovernmentPublications/executive-order-proclamation/5129-5130.pdf.

enactments on climate,[62] called for California to reduce its greenhouse gas emissions to 1990 levels by 2020, 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050.[63] Strict numerics: it is based on a calculated estimate of emission levels in 1990 as a baseline and specific, successive percentage reductions therefrom by dates certain.[64]

But it is much more common now to have climate authorities such as the IPCC and CARB speak in terms of "carbon neutrality" and "net-zero emissions," allowing for additional flexibility for the deployment of different technological solutions while addressing system reliability needs.[65] Roughly speaking, these terms target the point at which ongoing emissions are equivalent to or less than capture and sequestration processes.[66] These qualitative terms are tied to quantitative values – ultimately, zero – but the respective variables in "netting out" to zero are defined by the respective jurisdiction. For example, if DAC was sufficiently scaled, emission reductions could be zero if the DAC operation removed at least as much carbon as is emitted in a given time frame.[67] "CCS often emerges as an essential part of the lowest cost pathway to net zero."[68] Together, CCS and DAC enable surpassing carbon neutrality and, at least in theory, achieve carbon negativity by capturing legacy emissions already in the atmosphere. It is now widely accepted that accomplishing the Paris Agreement objectives will necessitate reliance on carbon removal for carbon emissions negativity.[69]

The tension between these quantification approaches surfaced in the 2022 California legislative session. One proposed law called for California to be carbon

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62. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 10. "The International Energy Agency (IEA) reports that, by late April 2021, 44 countries and the European Union had announced net zero emissions targets. . . . These commitments cover approximately 70 percent of global CO_2 emissions." *Id.*

63. State of California Executive Order S-3-05, *supra* note 61.

64. The California Legislature codified the 2020 and 2030 standards in 2006. *See AB 32 Global Warming Solutions Act of 2006*, CAL. AIR RESOURCES BD., https://ww2.arb.ca.gov/resources/fact-sheets/ab-32-global-warming-solutions-act-2006.

65. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 173. "In line with [the AR6] report, the Draft 2022 Scoping Plan considers carbon dioxide removal (CDR) as a complement to technologically feasible and cost-effective GHG emissions mitigation, and the size of its role will depend on the degree of success in reducing GHG emissions at the source across the economy. The modeling shows that emissions from the [California economy-wide] sources will continue to persist even if all fossil related combustion emissions are phased out. These residual emissions must be compensated for to achieve carbon neutrality. Options for CDR include both sequestration in natural and working lands and mechanical approaches like direct air capture." *Id.*

66. *Id.* "(C)arbon neutrality is achieved when the flux of GHGs from the sources equal the sinks." *Id.* at 21.

67. INT'L ENERGY AGENCY, A NEW ERA FOR CCUS (2020), https://iea.blob.core.windows.net/assets/181b48b4-323f-454d-96fb-0bb1889d96a9/CCUS_in_clean_energy_transitions.pdf.

68. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 11.

69. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 74 ("Ultimately, the role for mechanical CDR will depend on the success of reducing emissions directly at the source in the [California economy-wide] sectors and the ability of the [natural landscapes] to sequester carbon. However, mechanical CDR also provides an opportunity to not just achieve carbon neutrality, but also remove legacy GHG emissions from the atmosphere. As such, increased deployment of DAC can help achieve net negative emissions.").

neutral no later than 2045.[70] Another bill proposed to increase California's statutory goal for 2030 emissions reductions from 40% below 1990 levels to 55%.[71] The first bill passed; the second one failed.[72] While that may seem inconsistent, the reason is simple: even the most devout climate hawks in California do not see a viable path to hitting 40% reductions below 1990 emission levels by 2030, let alone 55%.[73] The 2030 standard is a strict quantitative measurement of verifiable emissions reductions; the 2045 qualitative "neutrality" standard allows any deficiency in emissions reductions to be offset by carbon removal strategies.[74] Audits of California's emission reduction progress shows real emission cuts are woefully deficient relative to reduction targets.[75] Fearing the aforementioned "mitigation deterrence" effect of reliance on CDR, climate advocates in California insisted that codification of the 2045 "neutrality" standard be paired with a companion goal of 85% emissions reductions from 1990 levels by the same deadline.[76] While accepting some level of flexibility inherent in a "neutrality" metric, this combination ensures that a minimum level of emission reduction occurs in reaching neutrality by the target end date.[77] Applying these same dynamics generally, the question becomes whether the global community can and will bring carbon removal technologies online in an economically viable and scalable way sufficient to generate meaningful reductions needed due to insufficient direct emissions decreases necessary for the Paris Agreement objectives.

D. Hard-to-Abate Industry Emissions

Greenhouse gas emission reductions and CDR are an economy-wide imperative; the issue is not limited to the energy sector. Policy debates concerning CCS and DAC tend to address the fossil fuel industry and whether removing carbon

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70. Stephanie Elam, *California regulators approve plan to achieve carbon neutrality by 2045*, CNN (Dec. 16, 2022), https://www.cnn.com/2022/12/16/us/california-carbon-neutrality-plan2045/index.html#:~:text=California%20regulators%20approve%20plan%20to%20achieve%20carbon%20neutrality%20by%202045,-By%20Stephanie%20Elam&text=California's%20air%20regulators%20approved%20an,Gavin%20Newsom%20earlier%20this%20year.

71. LATHAM & WATKINS, CALIFORNIA LEGISLATURE PASSES FOUR AGGRESSIVE CLIMATE BILLS AND AUTHORIZES EXTENSION OF DIABLO CANYON (2022), https://www.lw.com/admin/upload/SiteAttachments/Alert%203007.v2.pdf.

72. Zach Bright, *Newsom Scores Climate Agenda Wins as Legislature Wraps*, BLOOMBERG (Aug. 31, 2022), https://news.bloomberglaw.com/environment-and-energy/newsoms-climate-agenda-moves-toward-passage-as-legislature-ends.

73. Barry, *supra* note 43 ("CARB officials have repeatedly said that achieving the current 40 percent target will be extremely difficult and require more than doubling annual GHG reductions through 2030.").

74. *Id.*

75. Emily Hoeven, *California's Climate Goals Likely Out of Reach,* CALMATTERS (Feb. 24, 2021), https://calmatters.org/newsletters/whatmatters/2021/02/californias-climate-goals-unlikely/. "While California's vibrant clean energy economy is supporting strong job numbers, it is failing to deliver the necessary annual emissions reductions, as slowing renewable energy growth, underwhelming transportation sector gains, and a worrisome cross-sector over-dependence on natural gas pose major challenges for the state." *2021 California Green Innovation Index*, NEXT 10 (Dec. 14, 2021), https://www.next10.org/publications/2021-gii.

76. CAL. HEALTH AND SAFETY CODE § 38562.2 (West 2022).

77. *Id.*

from production and post-combustion emissions fosters perpetuation of environmental harms from fossil generation and slows the transition to renewable sources.[78] Yet, in terms of accomplishing net-zero and carbon-neutral objectives by 2050 or earlier, regulators are directing greater scrutiny on 'hard-to-abate' industries such as cement, steel, and glass production.[79] The issue for such sectors is that their product manufacturing process require such intense heat production that there are few or no known alternatives to the burning of fossil fuels.[80]

"There are fewer commercially available and economically viable electrification options to replace industrial processes that require higher-temperature heat. For these processes, onsite combustion may continue to be needed, and decarbonization will require fuel substitution to hydrogen, biomethane, or other low-carbon fuels."[81] Cement production poses particularly vexing challenges to reducing emissions.[82]

In defending the inclusion of CCS and DAC in the latest draft version of California's Scoping Plan, staff for CARB unapologetically noted that CDR technologies will be essential for these industries in reaching California's objective of carbon neutrality no later than 2045.[83] A DAC startup CEO characterizes the use of DAC as to such industries aptly: "DAC and other negative emissions technologies are the right solution once the cost and feasibility becomes too great . . . I see us as the backstop for challenging abatement."[84]

E. Unsettled Legal Issues

Several recurring unsettled legal questions arise in siting and approving CDR projects. These include what constitutes "permanent" sequestration of carbon, confirming a legal ownership interest in the space proposed to hold the carbon, and unifying multiple overlying surface ownership rights, among others. Such

78. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 3, 11, 55.

79. *See generally* GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2. "Increasingly, the focus for the application of CCS is in the industrial or 'difficult to decarbonize" sectors. For the most part CCS is the 'go-to- solution where electrification is not a viable solution, often when high heat or chemical reactions dependent on the presence of carbon are required." *Id.* at 2.

80. *Id.*

81. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 167 (citing Griffiths et al., *Industrial decarbonization via hydrogen: A critical and systematic review of developments, socio-technical systems and policy options* ENERGY RSCH. & SOC. SCI. (2021), https://doi.org/10.1016/j.erss.2021.102208).

82. *Id.* at 68. "Cement plants have emissions associated with combustion and process-related activities. Combustion emissions account for approximately 40 percent of the total emissions at the cement plants. The remaining emissions are related to process-related activities. Due to the high heat content needed to produce cement, there is currently no feasible alternative to combustion." *Id.*

83. Mulkern, *supra* note 35. "CCS is a must for certain types of businesses, Rajinder Sahota, CARB's deputy executive officer for climate change and research, said at the meeting Friday." *Id.* "[C]arbon capture and use/sequestration will be a likely component of any strategy to fully decarbonize cement manufacturing." DRAFT 2022 SCOPING PLAN, *supra* note 57, at 209. "While the state plan suggests CCS will account for only a small portion of greenhouse gas reductions, the Air Resources Board says it is essential to curtail emissions in such processes as cement manufacturing – operations that cannot be electrified and powered by renewable energy." Briscoe, *supra* note 10.

84. Evans, *supra* note 1.

issues represent recurring property rights and safety issues regardless of the respective local or state jurisdiction within which they may arise.

1. Defining "Permanent" Sequestration

"Permanent" sequestration of carbon represents one such issue. What constitutes "permanence" for geologic sequestration purposes, who is responsible for the sequestration facility and its integrity, and what financial security is required relative to maintaining the facility on a permanent basis? The term is not uniformly accepted. For example, an applicant for the universally required Class VI underground injection control permit from EPA necessary to inject and sequester carbon geologically must demonstrate the 'permanent ability' of the sequestration field to contain the injected carbon for 50 years.[85] But if that same facility is to qualify for credit under California's Low Carbon Fuel Standard (LCFS), it must demonstrate permanence relative to a 100-year timeframe.[86]

The issue of "permanence" arose legislatively in California in 2022 in several contexts including the integrity of the sequestration facility, monitoring/reporting obligations, and financial security duration.[87] While early drafts of various legislative vehicles imposed such obligations "in perpetuity," industry objection and proposals for a finite timeframe resulted in a compromise legislative directive for a time period to be determined by the appropriate oversight agency that is not less than 100 years.[88]

2. Legal Ownership of "Pore Space" Sequestration Area

Another unsettled area that routinely arises is the definition and distinct legal ownership of the subterranean formation into which the carbon will be injected, commonly known as "pore space."[89] While "surface rights" and "mineral rights"

85. ENV'T PROTECTION AGENCY, GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE, UNDERGROUND INJECTION CONTROL (UIC) PROGRAM CLASS VI WELL PLUGGING, POST-INJECTION SITE CARE, AND SITE CLOSURE GUIDANCE ii, 32 (2016), https://www.epa.gov/sites/default/files/2016-12/documents/wp-pisc-sc_guidance_final_december_clean.pdf.

86. *California Low Carbon Fuel Standard*, INT'L ENERGY AGENCY, (Oct. 12, 2021), https://www.iea.org/policies/11671-california-low-carbon-fuel-standard ("Direct air capture facilities do not need to be located in the State to generate credits – they can be anywhere in the world – but must comply with the CCS Protocol, including monitoring of CO2 storage for up to 100 years.").

87. CAL. HEALTH AND SAFETY CODE § 39741 (West 2022); CAL. PUB. RES. CODE §§ 2213, 3132 (West 2022).

88. CAL. PUB. RES. CODE § 71464 (West 2022) (relating to ensuring drilling in and around the sequestration field will not result in release of the sequestered carbon). "Show proof to the state board that there is binding agreement among relevant parties that drilling or extraction that may penetrate the geologic storage reservoir are prohibited to ensure public and environmental health and safety for a period of time that is sufficiently long enough to demonstrate that the risk of carbon dioxide leakage poses no material threat to public health, safety, and the environment and to achievement of net zero greenhouse gas emissions in California and that terminates no earlier than 100 years after the last date of injection of carbon dioxide into a geologic storage reservoir." *Id.*

89. Curt Barry, *California Lawmakers Gut Bill Backed by Labor, Industry to Bolster CCUS*, INSIDE EPA'S CLIMATE EXTRA (June 24, 2022), https://insideepa.com/climate-news/california-lawmakers-gut-bill-backed-labor-industry-bolster-ccus (quoting California State Senator Caballero "Ultimately, we need to come to some

are long recognized and severable property interests, there is no bright line legal recognition of pore space nor the ability to independently own it as a severable land interest.[90] Recognition of and the alienability of pore space was included in early drafts of California Governor Newsom's late session proposal, but never made it into final legislation.[91] In fact, the final legislation states that a severance of "mineral rights" from "surface rights" does not convey a proposed "sequestration reservoir" unless the severance document expressly so states.[92] Resolution of ownership in this newly designated and discrete property interest will be essential to providing certainty to operators of sequestration fields to ensure no competing property interests may contest the legal authority to geologically sequester the carbon.

3. "Unitization" of Conflicting Overlying Surface Ownership Rights

Additionally, even though one landowner may want to establish an injection facility under his or her real property, the subterranean field may extend underground with multiple overlying land interests. "Unitization" refers to the ability to secure the right to the entire sequestration field, even if not all landowners will support its establishment.[93] Legislative proposals have called for procedures to compel but compensate hold-out surface owners when a defined critical mass of property owners approve of the project proposal.[94]

IV. ECONOMIC VIABILITY AND FINANCING OF CDR

A. There Is No Commercial Justification for Carbon Removal

Absent regulatory mandate, public finance subsidies, or additional EOR-driven operational revenues, according to authorities, there is no incentive for private operators to capture and sequester carbon.[95] And yet, the imperative of CCS and DAC to meet the objectives of the Paris Agreement, according to authorities

conclusion about pore space…"). "This proposal also defines subsurface pore space ownership and outlines pore space ownership options for purposes of geologic carbon sequestration projects." Barry, *supra* note 43.

90. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 177-78 (strategizing to achieve success was "[clarifying] pore space ownership and pore space utilization rules and processes as they apply to geologic carbon sequestration.").

91. CAL. PUB. RES. CODE § 71462 (West 2022).

92. *Id.*

93. The term "unitization" has long been employed in the oil and gas sector, designed to increase efficiency of extraction operations. In this context, it would similarly increase efficiency for sequestration injection operations.

94. CAL. PUB. RES. CODE § 71461 (West 2022) (calling for a framework by the Secretary of the Natural Resources Agency allowing three-fourths of interest holders to force unitization of an entire sequestration reservoir).

95. Briscoe, *supra* note 10 ("'There is no commercial value to sticking CO_2 into the ground,' [a CCS policy analyst] said. The only value comes from avoiding penalties or fees, or the tax incentives that are designed to do that. But those are public policy incentives. There's no private commercial rationale to do it.").

such as the IPCC and CARB are undeniable.[96] According to at least one estimate, "[l]imiting global warming to 2°C requires installed [global] CCS capacity to increase from around 40Mtpa today to over 5,600 Mtpa by 2050. Between USD$655 billion and USD$1,280 billion in capital investment is needed by 2050."[97] In other words, the current scale of CCS operations much increase by 140 times by 2050 at the noted cost estimates.

The equipment necessary to capture carbon and compress it, as well as the infrastructure or equipment to transport it, are expensive.[98] "'Currently, there are only two pathways to finance such an undertaking [of the necessary capture, transportation, and sequestration infrastructure]: massive government subsidies or allowing private industry to fund these projects by linking them to oil wells that will produce crude.'"[99] The one domestic CCS facility with documented performance successes relied on both heavy government subsidy as well as EOR revenues.[100] And yet, as discussed below, it has gone dormant with no indication of re-commencing operations.

1. The One and Only U.S. "Success" Story: Petra Nova

The domestic CCS "success story" to which everyone points actually casts a cloud of doubt over the commercial viability of CCS. Petra Nova was a $1 billion project constituting the world's biggest post-combustion capture system.[101] Construction began in 2014, and it started operations in late 2016 after significant backing from the DOE.[102] But it stopped operating less than four years later, its operator, NRG Energy Inc., blaming economic volatility in the wake of the COVID-19 pandemic.[103]

Petra Nova captured carbon from some of the emissions of a 610 MW coal-fired plant outside of Houston.[104] In its first years of operation, Petra Nova captured 92.4% of the carbon from emissions processed.[105] According to DOE, in all it captured more than 3.5 million metric tons of carbon dioxide, the equivalent of annual emissions from nine natural gas-fired plants.[106] The concentrated carbon

96. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 20 ("International climate agencies, like the IPCC, agree that a transition to a net zero economy will require a large scale-up of CCS facilities. Consequently, financing CCS is a critical component of emissions reductions.").

97. *Id.* at 12.

98. Briscoe, *supra* note 10 ("One of the main challenges to ramping up production has been the cost of equipment needed to capture and pressurize carbon dioxide, as well as the logistical hurdle of transporting the material to a storage site. The virtually liquified gas can be conveyed either through pipelines or via trucks or train.").

99. *Id.* "As is the case with CCS, mechanical CDR technologies will need government or other incentive support to get over technology and market barriers." *See* DRAFT 2022 SCOPING PLAN, *supra* note 57, at 73-74.

100. Hiar, *supra* note 1.

101. *Id.*

102. *Id.*

103. Hiar & Anchondo, *supra* note 14.

104. *Id*.

105. *Id.*

106. *Id.*

stream was shipped almost 100 miles away, where it was pumped underground for EOR.[107] But in May 2020, the company shut down Petra Nova citing negative oil prices.[108] But even with global economic conditions rebounding, Petra Nova's CCS operations have not come back online, even though the companion coal and natural gas plants have remained operational, notwithstanding the noted 92.4% carbon removal efficiency, highly touted by DOE[109] NRG has no plans at this time to re-commence operations at Petra Nova.[110]

B. Department of Energy Demonstration Grants

The Petra Nova saga illustrates the complicated economics and politics of CCS. Instrumental to Petra Nova's launch was a $195 million DOE grant, announced with great fanfare by Obama Energy Secretary Steven Chiu in 2010.[111] And lawmakers have since enacted many measures designed to facilitate more widespread use of CCS on fossil fueled generation units and industrial facilities.[112]

The DOE is very proactive in highlighting its aggressive push for demonstration projects for CDR. The Bipartisan Infrastructure Law provided $3.5 billion for a series of CCS demonstration projects and an additional $3.5 billion for the development of four large-scale DAC hubs in specified regions.[113] Of particular note, DOE publicly vets its efforts to make these demonstration projects a reality, currently investing in four front-end engineering design studies exploring existing sources of clean heat for DAC: nuclear, geothermal, and industrial waste heat.[114] The locations of the four DAC hubs have yet to be identified.

C. Federal and State Tax Credit Incentives

Tax incentives at both the federal and state levels are the most incentive-based government catalysts to encourage expedited investment in and maturation

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107. Hair & Anchondo, *supra* note 14. "'The reviled CO_2 is being captured and put to use doing what Texans know best how to do, and that is to produce even more energy from our oil fields,' Texas Gov. Greg Abbott (R) said during the project's opening ceremony." *Id.*

108. *Id.* ("Then in May 2020, NRG quietly shutdown the Petra Nova project. The company later suggested the decision to place the system in reserve status was prompted by the pandemic-induced drop in the oil price, which had briefly gone negative for the first time in history.").

109. *Id.*

110. *Id.* "'Options are being explored for improving the economics to allow for restart of the facility,' spokesperson Ann Duhon said in an email. 'Although oil prices have rebounded from where they were when the facility was mothballed, there is a long lead time to restart the carbon capture facility and it is not economic to operate for short periods based solely on fluctuations in oil prices." *Id.*

111. Hiar & Anchondo, *supra* note 14.

112. *Id.*

113. *Biden-Harris Administration Announces $3.7 Billion to Kick-Start America's Carbon Dioxide Removal Industry*, *supra* note 53. "In the United States, the U.S. Department of Energy announced financing specifically for DAC in March 2020 and March 2021. Additionally, almost $9 billion in CCS support was included in the USD 1 trillion Infrastructure Investment and Jobs Act passed by the Senate in August 2021. This includes funding to establish DAC hubs." DRAFT 2022 SCOPING PLAN, *supra* note 57, at 73-74.

114. Wilcox, *supra* note 52.

of CDR technologies and implementation strategies.[115] This is true notwithstanding previously haphazard renewal and extension of credits by lawmakers and calls for greater values and flexibility for credits. The most common and widely utilized incentive for CDR and a universally recognized prerequisite for CDR project viability is the federal 45Q tax credit.[116] The credit provides a monetary value for each metric ton of CO_2 injected into the ground,[117] either through sequestration alone or for EOR.[118] Initially implemented in 2008, uncertainty over the period of time that the credit would be available as well as concern with the adequacy of the amount of the credit have been a constant focus of industry lobbyists with Congress.[119] President Trump signed the Bipartisan Budget Act of 2018 that increased the amount of the 45Q credit from $20 to $50 per metric ton for geologically sequestered carbon and from $10 to $35 per metric ton for carbon utilized for EOR.[120] At the end of the Trump Administration, 45Q was extended for an additional two years.[121] At that time, to qualify for 45Q, construction of the new capture facility had to begin before January 1, 2026.[122]

The Inflation Reduction Act of 2022[123] (IRA or Act) is the strongest affirmation and expansion of the CCS 45Q credit to date. First and foremost, the Act responds to a long-time call from industry to increase the credit for sequestered CO_2 from $50 per metric ton to $85 per metric ton.[124] If the carbon stream is for EOR, the amount is $65 per metric ton[125] and if the carbon stream being sequestered is from DAC technology, the per metric ton credit may be as high as $180.[126] These maximum amounts for all categories are contingent upon compliance with

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115. Hiar & Anchondo, *supra* note 14.

116. *Id.*

117. *Id*. "As of November 2019, more than half of the global large-scale CCS facilities (representing approximately 22 MMT CO_2/yr in capacity) were in the U.S., mostly as a result of sustained government support for the technologies. This support includes the federal 45Q tax credit for CCS and research and deployment grants from federal agencies." DRAFT 2022 SCOPING PLAN, *supra* note 57, at 67.

118. Hiar, *supra* note 1. "45Q is a section of the tax code that provides incentives, in the form of tax credits, to encourage companies to invest in carbon capture and storage solutions that reduce carbon emissions to the atmosphere. To qualify for tax credits, captured CO_2 must be either stored underground in secure geologic formations, used for CO_2-enhanced oil recovery (CO_2-EOR), or utilized in other projects that permanently sequester CO_2." MONETIZING YOUR CARBON EMISSIONS WITH 45Q TAX CREDITS, *supra* note 33.

119. Michael Rodgers, *US tax credit encourages investment in carbon capture and storage*, WHITE & CASE (Jan. 29 2021), https://www.whitecase.com/insight-our-thinking/us-tax-credit-encourages-investment-carbon-capture-and-storage.

120. *Id.*

121. *Id.*

122. *Id.*

123. Inflation Reduction Act of 2022 § 13104, 26 U.S.C. 45Q (2022).

124. *Id*. *See* Alejandro De La Garza, *The Inflation Reduction Act Includes a Bonanza for the Carbon Capture Industry*, TIME (Aug. 11, 2022), https://time.com/6205570/inflation-reduction-act-carbon-capture/. If the project is financed with tax-exempt bonds, there will be a deduction of the credit up to 15%, brought down from 50% under existing law. Molly F. Sherlock et al., *Tax Provisions in the Inflation Reduction Act of 2022(H.R. 5376)*, CONG. RES. SERV. (Aug. 10, 2022), https://crsreports.congress.gov/product/pdf/R/R47202.

125. Inflation Reduction Act of 2022 § 13104, 26 U.S.C. 45Q.

126. *Id.*

specified prevailing wage levels and programs for organized labor apprenticeship.[127] (Such requirements are not a factor on permitting of facilities, but rather affect the value of the tax credit for each unit of carbon ultimately sequestered.)

Another response to industry is extension of the date before which construction of the facility must commence. Previously, the construction must have commenced prior to January 1, 2026, but the Act extends that deadline to January 1, 2033.[128]

The Act also significantly reduces threshold sequestration quantities of CO_2 for qualifying facilities.[129] Particularly as to hard-to-abate industries, the IRA reduces the capture quantity requirements for all other industrial facilities to 12,500 metric tons.[130] Additionally, for DAC facilities the threshold is now 1,000 metric tons annually, down from 100,000 metric tons,[131] and specified post-combustion electricity generation plants, the threshold is now 18,750 metric tons annually, down from 500,000 metric tons.[132]

The IRA also resolves another unintended limitation on the prior iteration of 45Q, the inability of tax-exempt entities such as rural cooperatives and municipal utilities that have no federal tax liability to avail themselves of the tax credit. The Act now allows for such entitles to claim direct cash refunds as opposed to tax credits.[133] Even for-profit entities may opt for direct payments under 45Q but only for a five-year period.[134] Finally, further expanding and incentivizing business model flexibility, the Act allows taxpayers to transfer 45Q credits to an unrelated taxpayer beginning January 1, 2023.[135] It is unclear where the "break even" point for financial incentives to at least equal the cost of implementing CCS, critical variables (e.g., the source of the carbon emissions, selection of the capture methodology, location, etc.) being diverse and sometimes proprietary to the operator and source of carbon. But the steady increase of the amounts available under 45Q demonstrate heightened interest by both operators and lawmakers.

State-level incentives, where present, also play an important role in catalyzing the technology and facilities.

> [I]ncentive programs are one of the most important tools the state has in advancing our low carbon future, especially for climate vulnerable communities. The programs ensure clean technology and energy is accessible and are critical to closing opportunity gaps. These programs also leverage private-sector investment, seeking to build

127. *Id.*
128. *Id.*
129. Inflation Reduction Act of 2022 § 13104, 26 U.S.C. 45Q.
130. *Id.*
131. *Id.*
132. *Id.*
133. Inflation Reduction Act of 2022 § 13104, 26 U.S.C. 45Q.
134. *Id.*
135. *Id.*

> sustainable, growing markets for clean and efficient technologies, and they are particularly necessary to support GHG emission reduction strategies for priority sectors, sources, and technologies.[136]

California adopted its own tax credit as part of CARB's LCFS CCS Protocol (Protocol), although no entity has yet sought to demonstrate compliance with the Protocol that would permit access to the credit.[137] Other state incentives previously adopted or under consideration include Kansas (income tax reduction and abatement of property taxes applicable to power plant and sequestration site); New Mexico (advanced energy tax credit for coal facilities that capture and sequester or control CO_2 emission); and Texas (allowing taxpayers to claim a deduction of up to 10% of the amortized cost of equipment used in a clean coal project).[138] The respective role of state incentives and allowance or prohibition of EOR, when paired with 45Q, are worthy of comparison but such analysis is, unfortunately, beyond the scope of this article.

V. REGULATORY REVIEW: NECESSARY BUT A POTENTIALLY FATAL BARRIER ABSENT REFORM

This section addresses the complex, time consuming, and often redundant entitlement and permitting requirements for CDR projects throughout the United States and why they collectively form one of the greatest barriers to deployment of CDR. In addition to federal permitting mandates, each state operates a distinct mosaic of environmental review, land use entitlement, and regulatory permitting mandates at multiple jurisdictional levels. Uncertainties and inconsistencies with untested regulatory regimes, indefinite review times, and litigation exposure challenging approvals inject added risks into CDR project proposals.

A. General Land Use Entitlements

As with most development, construction and operation of a CCS or DAC facility involves disturbance of land and creates environmental impacts.[139] Aside from carbon-removal-specific approvals (e.g., air emissions permits for capture equipment and related energy source), construction and operation of such facilities likely involves general land use entitlements at all jurisdictional levels – federal, state, regional, and local. Such requirements will be specific to the respective site,

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136. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 216. "Strategies for Achieving Success: . . . Evaluate and propose, as appropriate, financing mechanisms and incentives to address market barriers for CCS and CDR." *Id.* at 177. For a more comprehensive survey and analysis of various financing options, *see* Edward Hirsch & Thomas Foust, *Policies and Programs Available in the United States in Support of Carbon Capture and Utilization*, 41 ENERGY L. J. 91 (2020).

137. *Carbon Capture and Sequestration Protocol Under the Low Carbon Fuel Standard*, CAL. AIR RESOURCES BD. (Aug. 13, 2018), https://ww2.arb.ca.gov/resources/documents/carbon-capture-and-sequestration-protocol-under-low-carbon-fuel-standard.

138. *Pathway 7: Carbon Capture and Negative Emissions – Carbon Capture and Sequestration*, LEGAL PATHWAYS TO DEEP DECARBONIZATION, https://lpdd.org/pathway/tax-incentives-for-ccs/.

139. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 41-55.

the jurisdiction(s) on and in which it lies, the proposed facilities, and whether it is on public or private land.[140]

All CDR projects will be subject to environmental review and impact analysis that will vary according to federal and state rules.[141] The environmental analysis required for the project will be relative to whatever local permitting or other approvals are required for the CCS or DAR project.[142] These may include a use permit for the land, air permits for the equipment operations, species or aquatic resource permits for land disturbance of protected habitats for the facilities themselves or conveyance pipelines, and other applicable public agency authorities that apply in the respective jurisdictions.[143]

On the federal level, the proposed project will have to comply with the National Environmental Policy Act (NEPA) if the project traverses federal lands or will utilize federal funding for construction or operations.[144] For example, a developer or operator availing themselves of federal tax credits such as section 45Q does not itself implicate NEPA review, but a major grant from DOE for construction of a CDR project, absent a statutory exemption, would. Additionally, most states have their own environmental review regime. In California, for example, proposed projects must comply with the California Environmental Quality Act (CEQA).[145] To comply with CEQA, the project must either be found to be "exempt," or else all potentially significant impacts on the environment must be identified, quantified, and mitigated to the maximum extent feasible.[146] The CEQA analysis in the form of a "negative declaration," "mitigated negative declaration," or "environmental impact report" (EIR) must be processed and certified by the "lead agency," the entity with most authority over the project, usually the local city or county in which the project is sited.[147] Even if significant environmental impacts persist after imposition of all feasible mitigation, the lead agency may still approve the project and certify the EIR via adoption of findings of countervailing public benefits in a "statement of overriding considerations."[148]

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140. DRAFT 2022 SCOPING PLAN, *supra* note 57.

141. CAL. AIR RESOURCES BD., FINAL ENVIRONMENTAL ANALYSIS FOR THE 2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY 8 (2022), https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp-appendix-b-final-environmental-analysis.pdf.

142. *Id.* at 32.

143. *Id.* at 50.

144. Final Rulemaking, *Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO2) Geologic Sequestretion Wells*, 75 Fed. Reg. 77,229 (2010) (to be codified at pts. 124, 144-45). However, the processing and issuance of a Class VI injection well, discussed below, is exempt from NEPA review. *Id.* "The SDWA UIC program is exempt from performing an Environmental Impact Statement (EIS) under section 101(2)(C) and an alternatives analysis under section 101(2)(E) of NEPA under a functional equivalence analysis." W. Neb. Res.Council v. EPA, 943 F.2d 867, 871-72 (8th Cir. 1991).

145. *See generally CEQA: The California Environmental Quality Act*, CAL. GOVERNOR'S OFF. OF PLANNING AND RSCH., https://opr.ca.gov/ceqa/; CAL. PUB. RES. CODE §§ 21000 - 21189.3 (West 2023).

146. CAL. PUB. RES. CODE §§ 21000 - 21189.3.

147. *Id.*

148. *Id.*

Environmental review regimes such as NEPA and CEQA are frequently exploited by project opponents such as business competitors, organized labor, or nearby residents for non-environmental purposes.[149] Attorneys' fees recovery provisions further incent such exploitation and add to the cost and processing time for projects.[150]

B. EPA Class VI Underground Injection Control Permit for Sequestration

Both CCS and DAC projects require permits to inject carbon into underground reservoirs, and CCS projects may require extensive pipeline infrastructure to transport carbon from its source to the sequestration site, necessitating regulatory review and permitting for such infrastructure.[151] The primary authorization required for a domestic CCS or DAC project is a Class VI permit from the United States Environmental Protection Agency (EPA) under its underground injection control (UIC) authority under the Federal Safe Drinking Water Act.[152] The timeframe for EPA to process Class VI applications remains one of the greatest unidentified variables in the regulatory process, and the regulated community reportedly is concerned that the lack of experience processing Class VI applications will lead to greater delay and uncertainty.

Although EPA has initial authority over all UIC wells, states and tribes may apply for "primacy" over permitting authorization and enforcement.[153] Under delegated primacy, the subject state or tribe operates in EPA's stead as a project's permitting and enforcement authority to ensure the safe establishment and operation of the well.[154] To date, this delegation function as to Class VI wells has been granted to North Dakota and Wyoming, with Louisiana and, most recently, Texas having applications pending with EPA.[155] The Infrastructure and Investment and

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149. Alastair Bland, *Weakling or Bully? The Battle Over CEQA, the State's Iconic Environmental Law*, CALMATTERS (June 23, 2020), https://calmatters.org/economy/2019/05/weakling-or-bully-ceqa-environmental-law-california-development-battles/.

150. *See* CAL. CIV. PROC. CODE § 1021.5 (West 2023).

151. *See generally Protecting Underground Sources of Water from Underground Injection (UIC)*, ENVT' PROTECTION AGENCY, https://www.epa.gov/uic.

152. *See generally Class VI – Wells used for Geologic Sequestration of Carbon Dioxide*, ENV'T PROTECTION AGENCY, https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-carbon-dioxide; ENV'T PROTECTION AGENCY, UNDERSTANDING THE SAFE DRINKING WATER ACT 3 (2004) https://www.epa.gov/sites/default/files/2015-04/documents/epa816f04030.pdf.

153. *Primary Enforcement Authority for the Underground Injection Control Program*, ENV'T PROTECTION AGENCY, https://www.epa.gov/uic/primary-enforcement-authority-underground-injection-control-program-0.

154. *Id.* ("Primary enforcement authority, often called primacy, refers to state, territory, or tribal responsibilities associated with implementing EPA approved UIC programs. A state, territory, or tribe with UIC primacy, or primary enforcement authority oversees the UIC program in that state, territory, or tribe. . . . States seeking UIC program primacy must demonstrate to EPA that the state has: jurisdiction over underground injection; regulations that meet the federal requirements . . . and the necessary administrative, civil and criminal enforcement penalty remedies.").

155. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 29; *Primary Enforcement Authority for the Underground Injection Control Program*, *supra* note 155; Keith Goldberg, *Texas Aims to Take Charge of Carbon Capture Projects*, LAW360 (Sept. 14, 2022, 9:44 PM), https://www.law360.com/articles/1526346/texas-aims-to-take-charge-of-carbon-capture-projects.

Jobs Act provides funding to EPA that may enable staff capacity and training for CDR including potentially providing grants to state with primacy.[156]

EPA maintains a listing of all active, pending, and withdrawn Class VI permit applications on its website.[157] As of June 2022, EPA had issued six Class VI permits, all in Illinois, only two of which were then active, and EPA was reviewing an additional nine applications.[158] In April 2022, there are 71 permit applications or issuances active with EPA.[159] EPA resources also include guidance documents[160] and an extensive outline intended to help with the very elaborate Class VI application documentation and process.[161]

C. Infrastructure Requirements for CCS

Locations of carbon capture facilities – especially for hard-to-abate industries – may be far away from sequestration reservoirs, necessitating extensive pipelines for transport of the concentrated carbon. Those pipeline networks must also undergo regulatory approval.[162] Calls for national, regionally significant pipeline infrastructure implicate both federal and multi-jurisdictional review and approval mandates. "Driving infrastructure development to support a net zero economy should be a priority of governments everywhere."[163] Analogizing to the need for government subsidy of or incentives for development of major infrastructure such as "road, rail, telecommunications, electricity generation and distribution, space exploration and more recently, renewable energy," experts call for similar support for and investment in CCS and DAC infrastructure nationwide.[164] "[T]heir support or direct investment was required to de-risk and initiate industries. . . . As these industries matured and became commercial, government intervention was replaced by increased private sector investment."[165]

Combining the recent broad recognition of the essential role carbon removal will play in accomplishing global climate goals with the significant approval and construction time required to establish such projects, advocates are sounding the

156. Request for Comments, *Carbon Capture, Utilization and Sequestration Guidance*, 87 Fed. Reg. 8,808, 8,810 (2022).

157. *Class VI Wells Permitted by EPA*, ENV'T PROTECTION AGENCY, https://www.epa.gov/uic/class-vi-wells-permitted-epa.

158. EPA, EPA REPORT TO CONGRESS: CLASS VI PERMITTING 15 (2022), https://www.epa.gov/system/files/documents/2022-11/EPA%20Class%20VI%20Permitting%20Report%20to%20Congress.pdf.

159. *Id.*

160. *Class VI Guidance Documents*, ENV'T PROTECTION AGENCY, https://www.epa.gov/uic/class-vi-guidance-documents.

161. ENV'T PROTECTION AGENCY, CLASS VI PERMIT APPLICATION OUTLINE (2022), https://www.epa.gov/system/files/documents/2022-07/class_vi_permit_application_outline.pdf.

162. DEP'T OF ENERGY, SITING AND REGULATING CARBON CAPTURE, UTILIZATION AND STORAGE INFRASTRUCTURE (2017), https://www.energy.gov/fecm/articles/siting-and-regulating-carbon-capture-utilization-and-storage-infrastructure-workshop.

163. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 12.

164. *Id.* A DAC startup CEO likening DAC to eventually serving as "essential infrastructure' such as waste disposal or sewage." Evans, *supra* note 1.

165. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 12.

alarm: "There is no time to waste."[166] In 2020, a Stanford University report identified more than 70 facilities in California that could benefit from CCS, most of which were located either in the San Francisco Bay region or Los Angeles.[167] But the greatest and safest potential sequestration facilities in California are in its Central Valley region, more than 100 miles from the facilities identified in the report.[168] Individual projects would be unlikely to undertake a CCS program to scrub industrial emissions if the issue of transporting the concentrated carbon stream over 100 miles to a sequestration facility remained unresolved. Those 100 miles would traverse multiple property ownerships, governmental jurisdictions, and geologic impediments. Obtaining the concession of each landowner to impact/traverse their land and all land use approvals from each impacted state and local jurisdiction would make up-front investment in the essential infrastructure project highly uncertain as to approval, timeline, and susceptibility to multiple independent litigation challenges. One extreme option to eliminate or at least streamline this process is taking the land via eminent domain by the state or federal government, but such a political process is highly contentious and there is no evidence of political will for such extraordinary measures at this point.

However, there is a recent trend of "CCS networks" "sharing CO_2 transport and storage infrastructure, pipelines, shipping, port facilities, and storage wells."[169] These economies of scale for CCS infrastructure allow smaller projects to participate and benefit.[170] Also, given that heavy industries tend to congregate and be concentrated in close proximity due to land use regulation, CCS networks can facilitate broader CCS implementation.[171] Finally, the lowering of the qualifying threshold for the 45Q tax credit is designed to make CCS more attractive to smaller industrial with newly established access to 45Q.

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166. *Id.* ("Large infrastructure projects like CCS facilities or pipeline networks usually take seven to 10 years from concept study through feasibility to design, construction then operation. There is no time to waste. Creating an enabling environment for investment in CCS facilities and other net zero aligned assets – particularly in supporting infrastructure – through both policy and funding, should be a high priority for governments between now and 2030.").

167. ENERGY FUTURES INITIATIVE & STANFORD UNIVERSITY, AN ACTION PLAN FOR CARBON CAPTURE AND STORAGE IN CALIFORNIA: OPPORTUNITIES, CHALLENGES, AND SOLUTIONS – SUMMARY FOR POLICYMAKERS S-7 (October 2020), https://sccs.stanford.edu/sites/g/files/sbiybj17761/files/media/file/EFI-Stanford-CA-CCS-SFPM-rev2-12.11.20.pdf; Briscoe, *supra* note 10.

168. Briscoe, *supra* note 10. "The state climate plan also calls for this technology to be installed on a majority of the state oil refineries by 2030, in an effort to curb emissions while still meeting local demand for gasoline and diesel. But this would probably require billions of dollars in investments to install equipment that would siphon carbon emission from smokestacks and build a network of pipelines from Los Angeles and Bay Area refining hubs to the Central Valley." *Id.*

169. GLOBAL STATUS OF CCS 2021 – CCS ACCELERATING TO NET ZERO, *supra* note 2, at 18.

170. *Id.*

171. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 174-75.

D. Regulatory Streamlining Efforts

1. State Streamlining Efforts

States know how to streamline and insulate must-have projects from standard regulatory exposure and litigation risk. From fast-tracking a new National Football League stadium or expansion of critical infrastructure, streamlining provisions may include abridged or elimination of environmental review, curtailment of grounds for litigation challenges to approvals, expedited permitting review and processing, and dedicated and consolidated authorities to oversee project approval on specified terms and timeframes. California is no exception, and varying degrees of legislative streamlining illustrate the perceived "urgency" of disparate climate strategies.

There are multiple levels of agency review of CDR projects beyond the EPA Class VI review at both the federal and state levels, and there have been multiple calls in California for coordination and streamlining of entitlement efforts with only limited success.[172] Governor Newsom's 2022 legislative proposal called on lawmakers to adopt five specific climate-related measures, one of which contained a model "unified permit application" for CCS and DAC projects to be administered by a state agency and into which all local agencies would be required to fold their local approvals and jurisdictional authorities.[173] It appeared to be an effort to direct all CCS and DAC applications to a single, centralized, state-level agency with comprehensive experience to evaluate and facilitate CDR, on which the state has declared it will increasingly rely to achieve aggressive climate goals. But as the proposed language underwent non-public debate and negotiation (all jurisdictional legislative committees having long since been adjourned for the session), the language of the measure became increasingly watered down. As shown below, the measure ultimately became voluntary at the discretion of the applicant and specifically stated that any newly established permitting process will not abridge or curtail the independent and segregated authority of agencies to exercise their full review of any proposed CCS project, including full CEQA review and potential litigation exposure.[174]

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172. *Id.* at 146 ("Recent legislation, such as SB 350 (De Leon and Leno, Chapter 457, Statutes of 2015), has recognized the need for CARB, the California Energy Commission (CEC), and the California Public Utilities Commission (CPUC) to work together to ensure the state's energy and climate goals were integrated in procurement decisions by load serving entities as part of the Integrated Resource Plan. Moving forward, it is especially critical that similar approaches are adopted to break down silos across state agencies to ensure policies and program s are aligned with multiple state priorities outlined in this plan. Finally, supportive legislative direction may also benefit emerging areas of policy, such as CO2 removal, to provide agency authority and roles for these nascent efforts, including streamlining of permitting, while ensuring that protections for communities are in place.").

173. Barry, *supra* note 43, at 2.

174. CAL. HEALTH AND SAFETY CODE § 39741; CAL. PUB. RES. CODE §§ 2213, 3132.

The Governor's initial CCS/CCUS legislative proposal was dated August 9, 2022.[175] The draft language included the addition of a new section 39741.2 to the California Health and Safety Code and provided, in relevant part:

> [O]n or before January 1, 2025, the state board shall, in consultation with relevant state and local agencies, adopt regulations for a ***model unified permit program*** for the construction and operation of carbon dioxide capture and sequestration projects ***to streamline the issuance of permits or other authorizations*** for the construction and operation of those projects. The permit program ***shall establish an application*** that ***requires the submission of all information required by permits and other authorizations from relevant state and local agencies*** necessary for the construction and operation of a carbon dioxide capture and sequestration project.
>
> . . .
>
> The model unified permit program ***shall be used*** by relevant state and local agencies when issuing a permit or other authorization for the construction and operation of a carbon dioxide capture and sequestration project. [***Emphasis*** added.][176]

Pursuant to the draft language, the "model unified permit program" was just one component of a broader "Carbon Capture, Utilization, and Storage Program" to be established by CARB in accord with specified requirements.[177] According to the draft legislation, the purpose of the program was to "(1) Facilitate the development, deployment, and commercialization of CCUS technologies," and "(2) Advance the deployment of carbon dioxide and sequestration projects."[178] And in carrying out the program, CARB was to prioritize, among other things, "[r]educing the emissions of greenhouse gases" and "[r]educing fossil fuel production in the state."[179]

But what the legislature adopted and the governor signed was quite different. In the waning hours of the 2022 legislative session in a maneuver known as "gut-and-amend," the final negotiated language was inserted into an existing legislative proposal, SB 905 (Skinner), that was previously focused on pilot projects for utilization of CCS specifically in the cement industry.[180] The ultimately adopted SB 905[181] includes the "unified" permitting regime, but with significant qualifiers that arguably eliminate any notion of consolidated or streamlined review by making

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175. Rachel Becker & Julie Cart, *Newsom to Legislature: Act fast to enact new climate change targets*, CALMATTERS (Aug. 9, 2022), https://calmatters.org/environment/2022/08/climate-change-newsom-legislature/.

176. Proposed language, S.B. 438, 2023-2024 Reg. Sess. (Cal. 2023).

177. Barry, *supra* note 43 ("CARB would also be required under the proposal to 'develop a model unified permitting program for geologic carbon sequestration projects to be used by state and local agencies with applicable permitting authority and would create a tracking system for all CCUS technologies and geologic carbon sequestration projects deployed throughout the state.'").

178. Proposed language, S.B. 438, 2023-2024 Reg. Sess.

179. CAL. HEALTH AND SAFETY CODE § 39741; CAL. PUB. RES. CODE §§ 2213, 3132. "'This proposal would establish a program at [CARB] focused on the dual objectives of advancing [CCUS] technologies and deploying geologic carbon sequestration projects,' the governor's memo says. 'In carrying out these objectives, the State Board would be required to prioritize greenhouse gas emission reductions, minimizing impacts to communities where these technologies and projects are developed, maximizing workforce development and employment in these communities, leveraging various funding sources, and reducing fossil fuel production in the state'". Barry, *supra* note 43.

180. CAL. HEALTH AND SAFETY CODE § 39741; CAL. PUB. RES. CODE §§ 2213, 3132

181. *Id.*

reliance on the program optional to the applicant and perpetuating all existing review processes, however inefficient or redundant:

> [O]n or before January 1, 2025, the state board shall, in consultation with relevant state and local agencies, adopt regulations for a unified permit application for the construction and operation of carbon dioxide capture, removal, or sequestration projects to expedite the issuance of permits or other authorizations for the construction and operation of those projects. The unified permit application ***shall solicit from applicants***, and direct to all relevant state agencies, all information needed to obtain permits and other authorizations from relevant state and local agencies necessary for the construction and operation of a carbon dioxide capture, removal, or sequestration project. ***An applicant's use of the unified permit application shall be optional.*** [***Emphasis*** added.][182]

Additionally, the uniform permit program was expressly prohibited from curtailing or otherwise abridging environmental review of any aspect of the project under CEQA,[183] and stated that although the intent of the program was "for the purpose of efficiency," it nonetheless "shall not displace the role of individual permitting agencies and shall not eliminate, abridge, or reduce the review or issuance of the individual permits covered by the application by the respective agencies."[184]

Thus, what was intended to facilitate integration, streamlining, and expedited review of CCS and CCUS at the state level by an experienced and empowered single expert agency became so watered down that it pays only lip-service to "efficiency" and efforts to "streamline duplicative administrative requirements or permit application questions."[185] Instead, it expressly codified that no permit process by any discrete permitting agency shall be abridged or reduced and in no instance shall CEQA review be at all curtailed.[186] In other words, it enshrined the status quo. Evolution of the bill was not so much a repudiation of the intended streamlining and efficiency, *per se*. Rather, interests vested in and empowered by discrete components of the overall review process appear not to have been willing to sacrifice their respective review or approval authority in the interest of that overall expediency.

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182. *Id.*

183. CAL. HEALTH AND SAFETY CODE § 39741; CAL. PUB. RES. CODE §§ 2213, 3132. "The unified permit application developed by the state board pursuant to subdivision (a) shall not impair, abridge, or alter any rights or obligations under the California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code), or its implementing regulations, with respect to the review or approval of a carbon dioxide capture, removal, or sequestration project." *Id.*

184. *Id.* "The unified permit application developed by the state board pursuant to subdivision (a) is for the purpose of efficiency but shall not displace the role of individual permitting agencies and shall not eliminate, abridge, or reduce the review or issuance of the individual permits covered by the application by the respective agencies. As part of the unified permit application, the state board shall, where possible, streamline duplicative administrative requirements or permit application questions." *Id.*

185. *Id.*

186. CAL. HEALTH AND SAFETY CODE §§ 39741, 39741.2.

Also worthy of note is that from the earliest version of Governor Newsom's proposed legislative package, it statutorily banned the use of CCS for EOR in California.[187] This was apparently in response to political pressure for environmental advocates' strong opposition to any perpetuation of fossil fuel production attributable to CCS. The EOR prohibition language bounced from various vehicles during negotiations but was ultimately codified in SB 1314 (Limon).[188]

Strikingly in political contrast, just two months before in June, Governor Newsom used a much more clandestine legislative tactic – burying broad reform provisions in a must-pass budget bill -- to push through extraordinary regulatory streamlining for a very narrow, select category of renewable generation projects.[189] The "back room" select negotiations infuriated excluded environmentalists and local government interest, among others.[190] AB 205,[191] the must-pass budget bill, gives developers the ability to "opt-in" for a streamlined environmental review and approval process for solar, wind, and other select specified clean energy generation projects under newly defined exclusive state jurisdiction that, among other things, usurps local land use authority from cities and counties, eliminates CEQA review, and even overrides the California Coastal Act in specified instances.[192] The takeaway appears to be that the imperative of streamlining for actual renewable generation projects warranted extraordinary abridgement of legislative procedure and public transparency to ensure adoption, whereas streamlining for CDR, or at least the politics thereof, was less essential or worthy of the expenditure of political capital. In any event, the extra-legislative measures employed by California's Governor and legislative leadership to accomplish passage of each measure attest to the political volatility and difficulty of accomplishing meaningful consolidation and streamlining, even in a jurisdiction where sympathetic political interests hold the governorship and super majorities in each legislative chamber.

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187. *Governor Newsom Signs Sweeping Climate Measures*, *Ushering in New Era of World Leading Climate Action*, OFF. OF GAVIN NEWSOM (Sept. 16, 2022), https://www.gov.ca.gov/2022/09/16/governor-newsom-signs-sweeping-climate-measures-ushering-in-new-era-of-world-leading-climate-action/.

188. CAL. PUB. RES. CODE § 3132. "An operator shall not inject a concentrated carbon dioxide fluid produced by a carbon dioxide capture project or carbon dioxide capture and sequestration project into a Class II well for purposes of enhanced oil recovery, including the facilitation of enhanced oil recovery from another well." *Id.* "Newsom officials are acknowledging concerns among some Democratic lawmakers, environmentalists and equity groups about CCUS by adding that 'the state must avoid projects that worsen climate change. Specifically, this proposal would prohibit an operator from using concentrated carbon fluids for purposes of enhanced oil recovery.'" Barry, *supra* note 43.

189. Julie Cart, *Legislators, Newsom Negotiating Behind Closed Doors Over Energy Deal*, CALMATTERS (June 23, 2022) https://calmatters.org/environment/2022/06/energy-deal-budget-talks/.

190. *Id.*; Julie Cart, *Wrangling Over Renewables: Counties Push Back on Newsom Administration Usurping Local Control*, CALMATTERS (Aug. 4, 2022) https://calmatters.org/environment/2022/08/renewable-energy-california-counties/.

191. A.B. 205, Gen. Assemb. (Cal. 2022).

192. *Id.*; CAL. PUB. RES. CODE § 25794.1(b) (West 2022).

2. Federal Streamlining Efforts

On the federal agency front, the Council on Environmental Quality (CEQ)[193] proposed in a draft guidance document streamlined though thorough review of CCS projects, particularly as to a national network of pipeline infrastructure for the transport of carbon streams to regional sequestration facilities throughout the country.[194] Potentially crossing multiple states and innumerable local jurisdictions and private property ownerships, the regulatory compliance requirements for such vast infrastructure could be the greatest barrier to timely CDR deployment at the scale required. The proposed guidance builds off a CEQ report to Congress in June 2021.[195] That report affirmed the essential role of CCS, CCUS, and DAC in the United States meeting its targets relative to the Paris Agreement and discussed the need for and strategies to accomplish integrated regulatory review and streamlined processing for an extensive backbone network of CO_2 pipelines for delivery of carbon to regionally significant sequestration hubs, such as those being explored by DOE.[196]

As to that national network of carbon conveyance infrastructure via backbone pipeline networks, CEQ states:

> Carbon dioxide pipelines and permanent sequestration are critical to the future nationwide deployment of CCUS. Extensive analysis identifies the priority pathways and necessary pipeline infrastructure required to achieve CCUS and permanent sequestration at a climate-relevant scale across all industries, but significant investments, planning, and community engagement and analysis are required. An expanded carbon dioxide pipeline and sequestration network in the United States should be accompanied by close monitoring and enforcement of existing regulations and development of new tools to monitor and improve safety while also reducing the number of incidents that result in leakage of carbon dioxide.[197]

The CEQ report to Congress states that an existing 5,200 miles of dedicated CO_2 pipelines exist in the United States and that 52 million tons of CO_2 were supplied for EOR in 2019.[198] However, "[a]ccording to the Intergovernmental Panel on Climate Change, the scale of CDR required to stabilize global temperatures is on the order of 100-1,000 gigatons (Gt) of CO2 over the 21st century."[199]

The new proposed CEQ guidance "includes recommendations for federal agencies that would support the efficient, orderly, and responsible development

193. CEQ is a direct affiliate of the White House advising federal agencies on implementation of NEPA and other environmental matters. *Council on Environmental Quality,* THE WHITE HOUSE, https://www.whitehouse.gov/ceq/.

194. 87 Fed. Reg. 8,808.

195. COUNCIL ON ENV'T QUALITY, COUNCIL ON ENVIRONMENTAL QUALITY REPORT TO CONGRESS ON CARBON CAPTURE, UTILIZATION, AND SEQUESTRATION (2021) https://www.whitehouse.gov/wp-content/uploads/2021/06/CEQ-CCUS-Permitting-Report.pdf.

196. *Id.* at 6-8.

197. *See* 87 Fed. Reg. 8,808, at 8,810.

198. COUNCIL ON ENVIRONMENTAL QUALITY REPORT TO CONGRESS ON CARBON CAPTURE, UTILIZATION, AND SEQUESTRATION, *supra* note 195, at 6.

199. *Id.*

and permitting of CCUS projects at an increased scale in line with the Administration's climate, economic, and public health goals.'[fn] In the document, CEQ provides guidance to federal agencies on the processes for permitting and review of CCS projects and CO2 pipelines, public engagement, and assessing environmental impacts of CCS projects."[200] Amid concerns raised by environmental justice groups as to CCS/CCUS perpetuating reliance on fossil fuels, CEQ extended the public comment period on the draft rule from March 18, 2022, to April 18, 2022.[201] As of the drafting of this article, the guidance remains pending as "interim," with the public comment period having closed.

E. Environmental Justice

As efforts to combat climate have grown more robust, advocates for environmental justice implications to disadvantage communities have grown increasingly. As to CCS, environmental justice advocates focus primarily on two gating concerns. First, even if CCS successfully removes appreciable quantities of carbon from post-combustion emission streams, they contend those operations have additional criteria or hazardous air pollutants that are not removed and their deposition on surrounding communities is thus prolonged than if the fossil operations were more expeditiously phased out.[202] Second, they claim that sequestration is not a proven technology and that CO_2 leaks and potential seismicity triggers threaten surrounding communities.[203]

> Environmentalists long have been skeptical of carbon capture and storage over concerns about its costs and environmental impact. They point to a series of failed and expensive CCS projects as a sign of the risks that could prevent the technology from delivering deep emission reductions. Many would capture carbon dioxide from power plants and pump it into aging oil fields to stimulate more crude production.[204]

In one of the most coordinated displays of opposition to CCS/CCUS, more than 80 environmental justice groups signed onto a letter urging EPA Region IX Administrator Martha Guzman to deny Class VI injection permitting for any CCUS projects in California's Central Valley.[205] Noting the existing air quality

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200. 87 Fed. Reg. 8,808, at 8,808-11.

201. *Id.* at 8,808.

202. Curt Barry, *Groups Urge EPA to Deny Permit Requests for CCUS in Central California*, INSIDE EPA (June 29, 2022), https://insideepa.com/daily-news/groups-urge-epa-deny-permit-requests-ccus-central-california ("A coalition of more than 80 environmental, equity and public-health groups is urging EPA to deny permit request for carbon capture, use and storage (CCUS) projects in California's Central Valley, charging they will exacerbate fossil fuel pollution and elevating debate over whether the technologies should play a role in achieving the state's climate objectives.").

203. DRAFT 2022 SCOPING PLAN, *supra* note 57, at 69 ("It is important to recognize that the EJ Advisory Committee has raised multiple concerns related to the inclusion of CCS and mechanical CDR in the Draft Scoping Plan. Concerns range from potential negative health and air quality impacts, to safety concerns related to potential leaks, to viability of current technology.").

204. Benjamin Storrow, *Supreme Court Ruling Opens Door to Carbon Capture*, E&E NEWS (July 5, 2022) https://subscriber.politicopro.com/article/eenews/2022/07/05/supreme-court-ruling-opens-door-to-carbon-capture-00043852.

205. Barry, *supra* note 202.

challenges of Central Valley communities, the coalition highlighted their particular vulnerability: "'Frontline communities of color and low-income communities are already overburdened with air pollution, which human-caused climate impacts are only worsening. Instead of perpetuating old, dirty fossil fuel-based infrastructure in environmental justice neighborhoods, we should invest in clean, renewable energy and reliable, equitable storage'. . . ."[206] As noted above, however, advocacy by such groups in the context of Governor Newsom's late-session climate legislative push only advocated for express prohibition in the context of EOR.[207] The tempered position seemed to assert ongoing opposition to any delay of complete phase out of fossil fuels attributable to CDR in any form but recognize the likely necessity for CDR in other challenging industries for which a transition is more elusive.

VI. RECOMMENDATION/CONCLUSION

Notwithstanding the extreme cost and unproven nature of large-scale CDR, environmental justice advocates' decrying of CDR facilitating ongoing criteria pollutant emissions near disadvantaged communities, and concerns over the long-term integrity of sequestration facilities, nearly all authorities are looking to CDR. The fact remains that the world, like California, is not reducing global emissions urgently enough to meet the Paris objectives, and CDR is now considered my many a given.

However, as presented herein, there appears to be no path by which CDR is scaled and deployed in a timely and sufficient degree to secure milestones identified in Paris. Nonetheless, the world cannot wait to discover whether CDR can be scaled and deployed at the magnitudes projected to be required while these policy conflicts are debated in Congress, parliaments, and the United Nations, among others. Reliance is being committed in national and international policy enactments; reliability must quickly be proven (or disproven). Accordingly, this article offers the following recommendations of incentives and regulations, carrots and sticks, notwithstanding missing Paris objectives:[208]

- ***Federal Funding:*** The IRA and Infrastructure Investment and Jobs Act provided meaningful and much needed financial resources and incentives for CDR. According to authorities, more will be required.[209] But it will take ambitious project proposals and aggressive approval efforts to deploy all of the funds currently appropriated. Those funds should be put to work as soon as reasonably possible with more appropriations made as soon as is necessary to

206. *Id.*

207. *Id.*

208. The author recognizes that each of these proposed incentives and streamlining measures comes at the expense of some countervailing public policy priority, and he is not asserting that such counter arguments are without merit. Rather, given that emission reductions are proving deficient and that critical policy makers are ascribing substantial future reliance to DAC, the author asserts it is vital to determine urgently whether such future reliance has a legitimate basis in fact.

209. *See supra* note 25.

continue advancement of the respective technologies. The impact of the IRA should be monitored and adjustments and additions made to ensure the technology availability and deployment match need and sufficient resources are appropriated to ensure economic viability.

- ***State Primacy of Class VI Authority:*** The EPA should encourage and facilitate primacy delegation of the Class VI UIC well permitting, implementation, and enforcement authority to states, not unlike the National Pollutant Discharge Elimination System[210] program under the Clean Water Act, the implementation and enforcement of which the vast majority of states have assumed from EPA.[211] Respective states may then integrate federal review mandates with state and local procedures into a consolidated review regime, eliminating duplication and regulatory redundancies. EPA has made financial resources available to states carrying out these functions. And this should be especially true for infrastructure and sequestration facilities that benefit multiple states and regions.[212] The job creation and economic development potential of major infrastructure investment should also be a material incentive for states to undertake these programs.
- ***Integrated Federal and State Environmental Review:*** Even absent state primacy delegation, federal and state environmental review regimes under NEPA and corresponding state regimes for all aspects of capture, transport, and injection facilities should be consolidated and integrated into a single, if joint, public process and review with a finite timeframe for completion and elimination or substantial limitation of attorneys' fees recovery provisions.[213] CEQ previously published guidance on integrating NEPA and state-level environmental review.[214] But even in such a context, review must remain comprehensive and robust or it will be subject to judicial invalidation. The objective is to make the process predictable and finite, not toothless.

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210. *National Pollutant Discharge Elimination System*, ENV'T PROTECTION AGENCY https://www.epa.gov/npdes.

211. *Id.*

212. At the state level, it is common for jurisdictions to require project applicants to reimburse the jurisdiction for staff time and any specialty consultants to process the application. This is less common at the federal level. Federal agencies should be more open to recouping costs from project applicants, while maintaining objective control of the process, so as to ensure adequate resources for processing and public involvement.

213. 87 Fed. Reg. 8,808, at 8809 ("To facilitate the deployment of CCUS in the United States, in line with the Administration's climate and economic goals, agencies should consider developing programmatic environmental reviews, such as tiered documents or programmatic environmental impact statements (PEISs) under NEPA, or programmatic biological opinions under the ESA, where such analyses can facilitate more efficient and effective environmental reviews of multiple projects while maintaining strong community engagement.").

214. NAT'L ENV'T POLICY ACT, NEPA CEQA HANDBOOK, https://ceq.doe.gov/publications/NEPA-CEQA_Handbook.html.

- ***National Backbone Pipeline Infrastructure:*** As for a national, interstate pipeline network to transport consolidated carbon streams to regional sequestration facilities, federal eminent domain authorization should be established and a "general permit" regime should be adopted similar to the Nationwide Permit regime under the Army Corps of Engineers and EPA for the Clean Water Act Section 404 permitting program.[215] Such permitting regimes establish criteria and compliance mandates in advance and irrespective of any given project and individual projects opt-in by demonstrating compliance or consistency with the established criteria with minimum bureaucracy and individual project application and review processes.[216]
- ***Consolidated Federal Agency Permitting Review:*** To the degree Class VI permitting remains with EPA as opposed to primacy delegation to a state, all additional agency review of a sequestration facility for which a Class VI permit is sought should be integrated with the already extensive Class VI permit application and review process. This includes additional federal agency review and consolidated resolution of issues such as "permanence," future monitoring and financial assurances, long-term responsibility for facilities, application of NEPA, and consolidated review related to imperiled species and aquatic resources under a "general permit" or similarly streamlined and integrated regime.
- ***Consolidated State and Local Agency Review:*** Similarly, state agency review of environmental impacts, local land use permitting, and equipment permitting should be consolidated and integrated under the auspices of a single, specialized agency.[217] California's Governor Newsom accomplished this as to new selected renewable generation project via clandestine legislative maneuvering but was unable or unwilling to do the same for CDR, at least for now.[218]
- ***Finite Timeframes for All Stakeholders, Regulators and Applicants:*** An indefinite permitting review horizon and the risk of litigation time and expense can sideline potential investors and financing resources for CDR projects. Given the recognized essential role of CDR and urgency to prove its economic viability and scalability, all permitting and review processes at all jurisdictional levels should have reasonable but definite and finite timeframes for completion. This will include express and finite timeframes with which developers and operators would also have to adhere as well as concurrent, adequate, and proscribed review and comment periods for

215. *2021 Nationwide Permit Information*, U.S. ARMY CORPS OF ENG'RS, https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/Nationwide-Permits/.

216. *Id.*

217. That Governor Newsom felt empowered and without option but to adopt his most stringent streamlining and integration for the most select and desired renewable projects in a wholly non-public and clandestine budget process bears witness both to the political difficulty but also sense of urgency and essential nature of such measures.

218. *See supra*, Sections V.A, B.

environmental justice and Native American tribal land consultations.