Texas Carbon Management Roadmap

POLICY CONSIDERATIONS FOR TEXAS

AUTHORS

Emma Thomley

Ryan Kammer

GREAT PLAINS INSTITUTE

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EXECUTIVE SUMMARY

Overview

Texas is set to remain a leader in energy and industrial innovation through deploying technologies that capture, remove, transport, utilize, and store carbon dioxide (CO_2). **Texas is a global leader in energy production with unmatched industrial capacity, well-developed infrastructure, and a workforce with extensive energy expertise.** The *Texas Carbon Management Roadmap* (Texas Roadmap) establishes a near-term framework for coordinated state, industry, and community action to deploy these technologies responsibly while sustaining economic growth, protecting public health, and supporting Texas's energy workforce.

The Texas Roadmap was developed by the Great Plains Institute (GPI), with support from the Cynthia and George Mitchell Foundation, and reflects extensive research, policy analysis, and engagement with nearly 100 stakeholders across industry, government, academia, labor, nonprofits, and community organizations. The process helped ensure that the roadmap's recommendations reflect varied perspectives on carbon management deployment within the state of Texas. The roadmap draws on technical analyses of capture, transport, utilization, and storage potential in Texas, reviews of state and federal policy and regulation, and evaluations of workforce, infrastructure, and permitting readiness. **This collaborative and data-driven process identifies near- and mid-term actions that can support regulatory certainty, attract private investment, and ensure carbon management contributes to both Texas's economic growth and environmental stewardship.**

Texas's opportunity and modeling insights

Texas possesses unique advantages that make it a national and global hub for carbon management and provides the foundation for large-scale deployment. The state has an extensive energy and industrial infrastructure, a robust energy workforce, suitable geology for carbon storage and utilization, and deep experience in energy production. Texas also has some of the world's first commercial carbon capture, direct air capture (DAC), and low-carbon hydrogen facilities, with additional projects under development across multiple regions of the state. Quantitative modeling informing the roadmap indicates that scaling carbon management could enable Texas to capture, transport, and store hundreds of millions of metric tons of CO_2 by midcentury; depending on policy, infrastructure, and market conditions. Economic studies also suggest that widespread deployment could generate billions of dollars in cumulative investment and support tens of thousands of jobs in construction, operations, and supply-chain management across the state.

Federal incentives, such as the Section 45Q tax credit, have been critical in catalyzing early project development nationwide. However, sustaining growth in Texas will depend on policy certainty, regulatory capacity, and cross-agency coordination. The roadmap identifies actions to modernize permitting, expand access to financing, and ensure Texas leverages federal funding to build a competitive advantage in carbon capture, DAC, hydrogen, and utilization and storage.

Expanding carbon management can also strengthen Texas's position in both domestic and export markets for low-emission fuels, materials, and industrial products. Incorporating carbon management into long-term planning for water, energy, and land use is essential to balance economic development with environmental stewardship. As deployment increases, ongoing modeling and monitoring will help the state understand impacts on infrastructure, labor needs, and natural systems.

Technology highlights

CARBON CAPTURE

Texas has a large portion of the nation's industrial and energy-related emissions, making carbon capture an essential tool for reducing emissions from power generation, refining, and manufacturing. The state's technical potential creates strong opportunities for near-term deployment. The roadmap identifies multiple policy levers to encourage continued investment, expand eligibility for state incentives, and address permitting and financing barriers that can delay project development.

DIRECT AIR CAPTURE (DAC)

Texas has multiple DAC projects under development and exceptional potential for additional DAC deployment due to its abundant renewable and low-carbon energy resources, favorable geology for storage, and access to skilled labor and industrial supply chains. The roadmap highlights opportunities to pair DAC projects with waste heat sources, while identifying potential for eligibility for carbon capture incentives.

HYDROGEN AND CARBON MANAGEMENT

Hydrogen production, particularly when paired with carbon capture and storage (CCS), is an opportunity for Texas to leverage its existing energy leadership into new low-emissions markets. The roadmap identifies actions to expand eligibility for hydrogen incentives, strengthen safety standards, and build international export capacity.

CARBON TRANSPORT

A robust, safe, and integrated CO_2 transport network is critical to enabling economy-wide deployment of carbon management. **Texas hosts the largest CO_2 transport network in the United States, with over 2,000 miles of existing CO_2 pipelines connecting industrial and geologic sources of CO_2 with geologic storage and enhanced oil recovery sites**. Texas has extensive pipeline infrastructure and technical expertise, but additional investment and safety measures will be needed to accommodate growth in CO_2 volumes and development in new regions of the state. The roadmap emphasizes expanding safety regulations, improving public awareness, and supporting efficient and transparent infrastructure expansion.

CARBON STORAGE

Texas's geologic formations offer some of the most promising CO_2 storage potential in the United States. The state's existing regulatory framework, including the recent grant of Class VI primacy from the US EPA, provides a strong foundation for the long-term management of CO_2 storage sites. The roadmap outlines actions to ensure adequate funding and staffing for the Railroad Commission of Texas (RRC), improve permitting timelines, enhance induced seismicity monitoring, address legacy wells, and explore options for long-term liability transfer to support durable storage and build investor confidence.

CARBON UTILIZATION

Emerging markets for CO_2 utilization, ranging from fuels and building materials to advanced manufacturing, present additional economic opportunities for Texas. The roadmap recommends targeted assessments and demonstration projects to evaluate market readiness and establish university-industry partnerships that can accelerate the commercialization of CO_2-derived products, including sustainable aviation fuel and other high-value applications.

Near-term implementation

In the near term, advancing carbon management in Texas will require strong policy leadership and sustained coordination across state agencies, local governments, industry, civil society, academia, and communities on incentives, regulatory certainty, and safety and transparency. **The Texas Roadmap recommends establishing a Texas Carbon Management Policy Council (the Council) to support this effort and guide implementation of the Texas Roadmap's recommendations.** The Council would identify near-term opportunities and policy priorities, and coordinate policy and regulatory discussions to ensure that Texas remains competitive and responsive to technological innovation, market developments, and evolving federal policy and incentives.

The Council could consider the following priorities identified in the Texas Roadmap as an initial focus for the state. These priorities represent the most immediate opportunities for state leadership to support deployment and investment of carbon management technologies.

STRENGTHEN COMPETITIVENESS THROUGH INCENTIVES

Investment and export opportunities will be critical to advancing carbon management in Texas. The state can build upon existing policy tools to attract investment, expand project deployment, and strengthen its position as a leader in energy innovation. Through updating incentives and evaluating economic impacts, Texas can help ensure that state investments provide strong returns and support the state's long-term success in low-carbon markets.

Priority recommendations

- Evaluate the potential role of natural gas with carbon capture as a clean firm power resource in future planning and modeling efforts
- Commission comprehensive carbon management economic studies
- Convene the Texas Hydrogen Production Policy Council to advance international export opportunities

ENSURE PERMITTING CERTAINTY AND REGULATORY READINESS FOR CO_2 STORAGE

Texas must ensure its regulatory framework is prepared for the responsible expansion of carbon storage within the state. Establishing transparent, efficient permitting processes and strengthening agency capacity will give operators and investors confidence in the state’s oversight and long-term management of carbon storage projects.

Priority recommendations

- Monitor Class VI funding and staffing at the RRC
- Clarify permitting timelines for Class VI well permits
- Consider establishing a framework for long-term CO_2 storage liability transfer

BUILD PUBLIC CONFIDENCE THROUGH SAFETY AND TRANSPARENCY

Public confidence will be essential to the success of carbon management deployment. Strengthening safety oversight, expanding public access to project and regulatory information, and aligning with national best practices can ensure transparency and trust as new projects deploy across the state.

Priority recommendations

- Monitor the need for Seismic Response Areas (SRAs) for Class VI wells
- Develop a centralized, user-friendly online carbon management hub
- Support incorporating recommended practices on pipeline safety from standard-developing organizations

Through proactive leadership, Texas can continue to shape the nation's energy future by supporting industrial and energy innovation, protecting public health and the environment, and strengthening its position as a global energy and industrial leader. The following list provides a summary of recommendations across all areas of the Texas Roadmap.

Recommendations

CARBON CAPTURE

- Support continued federal investment in Section 45Q tax credit for carbon oxide sequestration
- Modernize and expand state incentives
- Create state grant and revolving loan programs for carbon management projects
- Commission comprehensive carbon management economic studies
- Support the development of a voluntary, technology-neutral Energy Attribute Certificate (EAC) framework that can incorporate CCS
- Ensure carbon management is integrated into the state's long-term regional water resource planning
- Commission a statewide study on air pollutant reductions and health co-benefits from carbon capture, including methods to mitigate amine degradation potential
- Advocate for federal regulatory clarity on permitting requirements for carbon capture retrofits
- Monitor air, waste, and water permitting capacity at TCEQ
- Evaluate the potential role of natural gas with carbon capture as a clean firm power resource in future planning and modeling efforts

DAC

- Support a targeted feasibility assessment to identify high-potential waste heat pairing opportunities for DAC
- Ensure DAC is eligible for carbon capture incentives in Texas

HYDROGEN

- Support continued federal investment in the 45V Hydrogen Production Tax Credit
- Expand hydrogen participation across all Texas Emissions Reduction Plan (TERP) programs
- Task the Texas Hydrogen Production Policy Council with providing legislative recommendations on incentives
- Convene the Texas Hydrogen Production Policy Council to advance international export opportunities
- Support public understanding of hydrogen through targeted education and outreach
- Strengthen safety and emissions standards
- Examine opportunities for produced water for hydrogen use

CARBON TRANSPORT

- Support incorporating recommended practices on pipeline safety from standard-developing organizations
- Enhance public awareness and safety outreach for CO_2 pipelines in regions without prior CO_2 infrastructure

CARBON UTILIZATION

- Conduct a targeted market and policy assessment for carbon utilization in Texas
- Commission a university-industry partnership to demonstrate the economic viability of CO_2-derived aviation fuel

CARBON STORAGE

- Participate in training programs
- Monitor Class VI funding and staffing at the RRC
- Clarify permitting timelines for Class VI well permits
- Include a survey in the application process to assess if undocumented wells requiring corrective action are present within the Area of Review (AOR)
- Monitor the need for Seismic Response Areas (SRAs) for Class VI Wells
- Develop additional educational resources on induced seismicity and the developed mitigation regulations and strategies
- Consider establishing a framework for long-term CO_2 storage liability transfer

WORKFORCE DEVELOPMENT

- Conduct a statewide manufacturing-workforce analysis for carbon management technologies
- Conduct regional workforce mapping and planning to address geographic labor mismatches
- Develop a Texas Carbon Management Workforce Advisory Council
- Develop carbon-management-specific registered apprenticeship programs in the state
- Provide competitive reskilling grants for carbon management workforce support
- Leverage the Texas skills development fund to support workforce participation in energy projects

COMMUNITY ENGAGEMENT

- Increase public communication on carbon management permitting
- Develop a centralized, user-friendly online carbon management hub
- Establish a clear definition of "significant public interest" in air permitting
- Establish regular communication requirements for carbon capture projects within the designated impact area
- Expand public access to information on proposed CO_2 pipeline projects
- Increase public engagement opportunities during Class VI processes for carbon storage projects
- Establish and promote best practices for meaningful community engagement in air permitting
- Encourage work with developers and communities to develop Community Benefits Agreements and Plans

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Study authors

Emma Thomley, State and Regional Policy Specialist

Ryan Kammer, Research Manager

Supplemental writing and contributions

Vilas Annavarapu, Environmental Justice Fellow

Alejandro Calderon, Labor Engagement Manager

Alana Hadland, Industry Program Coordinator

Nate Morris, State and Regional Outreach & Education Manager

Kelley Reierson, State & Regional Coordinator

Patrice Lahlum, Vice President

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About GPI

A nonpartisan, nonprofit organization, GPI accelerates the transition to net-zero carbon emissions for the benefit of people, the economy, and the environment. Working across the US, we combine a unique consensus-building approach, expert knowledge, research and analysis, and local action to find and implement lasting solutions. Our work strengthens communities and provides greater economic opportunity through the creation of higher-paying jobs, expansion of the nation's industrial base, and greater domestic energy independence while eliminating carbon emissions.
Learn more: www.betterenergy.org

Industrial Innovation and Carbon Management team

The goal of the GPI's Industrial Innovation & Carbon Management team is to accelerate commercial deployment of industrial innovation and carbon management solutions across US states to take full economic advantage of our nation's energy resources, protect and create high-wage jobs, encourage meaningful community engagement, and ensure we meet midcentury goals for reducing US and global carbon emissions.

Through our initiatives, the Carbon Capture Coalition, the Industrial Innovation Initiative (convened with the World Resources Institute), and the Carbon Action Alliance, we work with a wide range of stakeholders, including state and federal agencies, industry, nonprofits, local communities, and others. Our state and regional team leads policy development and stakeholder engagement to support the deployment of carbon management solutions tailored to state and regional needs.

ABBREVIATIONS

45Q – Section 45Q Tax Credit for Carbon Sequestration
45V – Section 45V Clean Hydrogen Production Tax Credit
AoR – Area of review
ATR – Autothermal reforming
CCS – Carbon capture and storage
CDR – Carbon dioxide removal
CO_2 – Carbon dioxide
DAC – Direct air capture
DOE – US Department of Energy
EOR – Enhanced oil recovery
EPA – US Environmental Protection Agency
ERCOT – Electric Reliability Council of Texas
GHG – Greenhouse gas
GHGRP – Greenhouse Gas Reporting Program
GREET – Greenhouse gases, Regulated Emissions, and Energy use in Technologies
IEA – International Energy Agency
IPCC – Intergovernmental Panel on Climate Change
L-DAC – Liquid solvent-based direct air capture
$MMtCO_2$ – Million metric tons of CO_2
NNSR – Nonattainment New Source Review
NO_X – Nitrogen oxides
NSR – New Source Review
O&M – Operations and maintenance
PHMSA – Pipeline and Hazardous Materials Safety Administration
PIP – Public Involvement Plan
PISC – Post-injection site care
PLA – Project Labor Agreement
PM – Particulate matter
PSD – Prevention of significant deterioration
RAP – Registered Apprenticeship Program
RRC – Railroad Commission of Texas
SAF – Sustainable aviation fuel
S-DAC – Solid sorbent-based direct air capture
SMR – Steam methane reforming
SO_2 – Sulfur dioxide
SO_X – Sulfur oxides
SRA – Seismic Response Area
TCEQ – Texas Commission on Environmental Quality
TERP – Texas Emissions Reduction Plan
TWC – Texas Workforce Commission
UIC – Underground Injection Control
US – United States
USDW – Underground source of drinking water

INTRODUCTION

The *Texas Carbon Management Roadmap* provides a strategic framework to guide the responsible deployment of carbon management technologies across the state. It offers practical, near-term policy and regulatory actions for state agencies, industry, and other stakeholders to strengthen Texas's competitiveness, attract investment, and deliver community benefits, while laying the groundwork for long-term opportunities.

Texas is a global leader in energy production, with unmatched industrial capacity, well-developed infrastructure, and a workforce with extensive energy expertise. [1] These assets, combined with a market-oriented regulatory environment, position the state to lead in the next generation of energy and industrial technologies, including carbon management. Carbon management refers broadly to the capture, removal, transport, use, and storage of carbon dioxide (CO_2), primarily in its gaseous or supercritical form, though some strategies involve solid or liquid pathways. The following stages make up the full value chain of the carbon management industry:

Carbon capture is the process of separating CO_2 from various emissions sources, such as power plants or industrial facilities. [2]

Carbon dioxide removal (CDR) refers to human-created processes that remove CO_2 or carbon directly from the atmosphere or ocean, such as through direct air capture or biomass carbon removal and storage. [3]

Carbon transport refers to moving CO_2 via pipeline, barge, rail, or truck to the end use. [4]

Carbon utilization is the use of captured CO_2 or carbon monoxide as a feedstock to produce products, such as low- and zero-emissions fuels and building materials. [5]

Carbon storage is the process of injecting CO_2 into suitable geologic formations where it is permanently stored. [6] As global energy markets evolve and demand for lower-emissions fuels and products increases, Texas can maintain and enhance its competitive advantage by proactively supporting the deployment of carbon management across its energy and industrial sectors. [7]

Texas has already recognized the opportunity to lead in carbon management. The state has taken early and meaningful steps to support deployment, including passing some legislation to enable carbon storage, securing federal approval for its first Class VI CO_2 injection wells, and receiving 'primacy'—the authority to permit those injection wells from the US Environmental Protection Agency (EPA). [8]

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[1] US Energy Information Administration, "Texas State Profile and Energy Estimates."

[2] Munson and Hancu, "Point Source Carbon Capture Program."

[3] Jones and Jacobson, "Carbon Dioxide Removal Program."

[4] Pett-Ridge, Kuebbing, Allegra C. Mayer, et al., *Roads to Removal: Options for Carbon Dioxide Removal in the United States*.

[5] National Energy Technology Laboratory, "About Carbon Utilization."

[6] National Energy Technology Laboratory, "Carbon Storage FAQs."

[7] Krutnik et al., "Global Energy Perspective 2023: Sustainable Fuels Outlook."

[8] Great Plains Institute, "State Legislation"; US Environmental Protection Agency, "EPA and Texas Railroad Commission Sign Memorandum of Agreement on Geologic Storage of Carbon Dioxide."

These actions demonstrate Texas's commitment to creating a supportive environment for carbon management projects and position the state to build upon its strengths as federal, private sector, and international interest in carbon management accelerates.

GPI developed this roadmap, which includes detailed policy analysis, technical review of Texas's opportunities, and consultation with a broad network of Texas-based stakeholders, including representatives from academia, industry, workforce voices, environmental and energy nonprofit organizations, and community advocacy organizations.

Economic rationale and market drivers

Carbon management is gaining momentum across the US, including Texas, through a combination of federal incentives, private sector demand, and infrastructure readiness. [9] This growth has occurred, in large part, due to recent, bipartisan-supported enhancements to the 45Q federal tax credit. [10] With more than 270 projects announced, 132 of which are in advanced development, and over $77.5 billion in capital investment, the industry is expected to have an increasing presence in the US industrial economy. [11] At the same time, many of these projects remain in early stages, and their success will depend on continued and increased federal and state support, timely permitting, and local acceptance. While not every project will move forward, this trend underscores the scale of private capital and industrial interest in the sector.

These technologies are increasingly seen not only as tools for environmental compliance, but also as strategic assets in modern industrial and energy development. US consumers and global trade partners in Europe and Asia are placing greater value on innovative, lower carbon goods and power produced with lower carbon intensity. [12] With $455 billion in goods exported globally, accounting for 17.6 percent of the state 's GDP, continuing to meet this demand through innovative, low-carbon products will allow Texas to maintain its global leadership in energy production. [13] However, Texas faces competition from other US states and international producers that are also positioning themselves to meet these markets.

Carbon capture is one of the only technologies available to effectively manage emissions from several industrial processes essential to modern economies, such as cement manufacturing. [14] These technologies can also be paired with power generation to produce energy with net-zero or net-negative carbon emissions. However, costs remain high, deployment timelines uncertain, and policy frameworks unsettled, which means their role in Texas's energy mix is not guaranteed.

To maximize Texas's natural-resource advantage and maintain competitiveness in global markets

[9] Krutnik et al., "Global Energy Perspective 2023: Sustainable Fuels Outlook"; Global CCS Institute, *Global Status of CCS 2024*.

[10] Carbon Capture Coalition, *Primer: 45Q Tax Credit for Carbon Capture Projects*.

[11] Global CCS Institute, *Global Status of CCS 2024*.

[12] Voigt et al., "Green Awakening"; Frey et al., "Do Consumers Care about Sustainability & ESG Claims?"; Council of the European Union, "Fit for 55."

[13] Office of the United States Trade Representative, "Texas."

[14] IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector*; "Summary for Policymakers."

for energy, hydrogen, chemicals, and ammonia, the state must lead in developing, commercializing, and scaling cleaner technologies, industrial processes, and energy systems. As the world economy moves toward border adjustments that measure or price product carbon intensity, carbon management will be essential to producing lower-emission hydrogen, ammonia, fuels, building materials, and reliable, dispatchable power. [15]

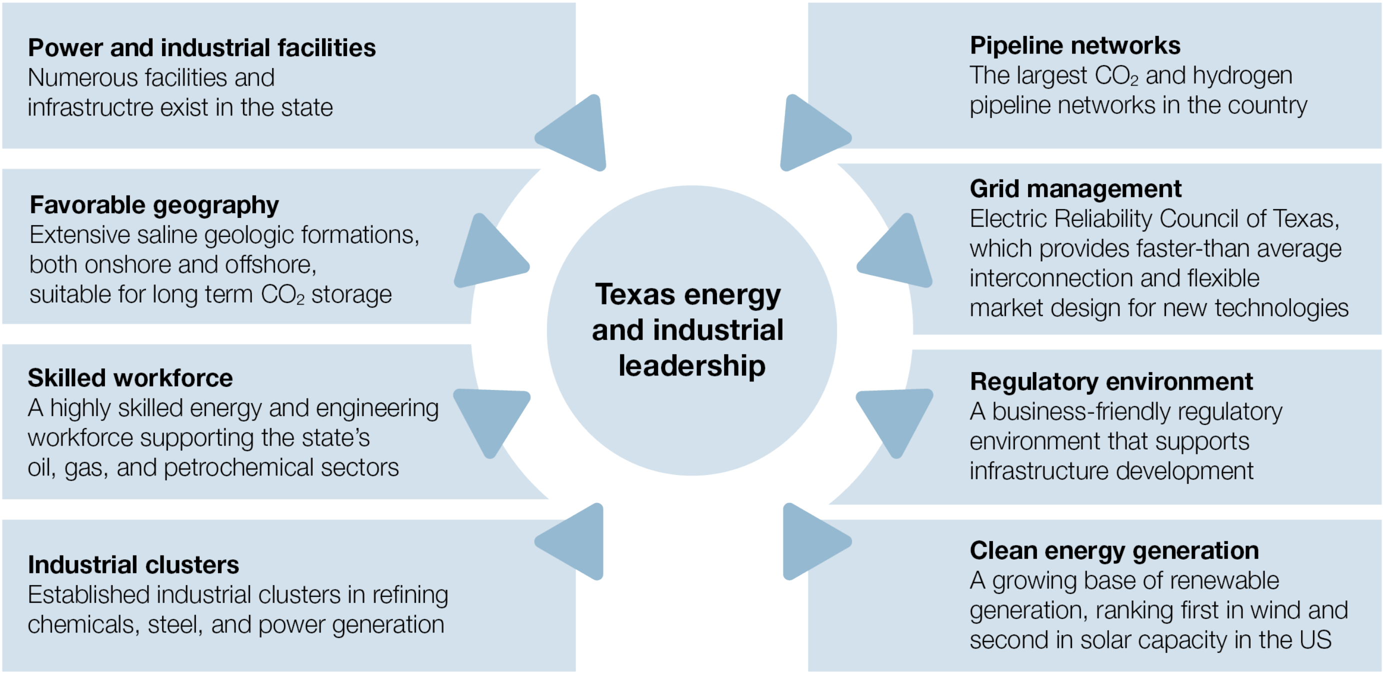
Supporting this development is becoming increasingly important with the rise of artificial intelligence and data center infrastructure, where technology companies are seeking clean, firm, and flexible power sources. [16] Yet, realizing this potential will depend on whether Texas can align technology deployment with grid reliability, affordability for households, and environmental safeguards.

Texas is uniquely positioned to capitalize on this market shift, supported by a combination of energy infrastructure and workforce expertise. Figure 1 highlights several of the state's key advantages that provide a foundation for large-scale carbon management deployment.

These factors have already attracted multiple large-scale carbon management projects to Texas, including carbon storage hubs and one of the world's first commercial DAC projects. [17]

Still, Texas will need to address community concerns about new infrastructure, ensure permitting agencies are adequately staffed, and manage competition from other states actively pursuing similar investments.

Figure 1. Advantages supporting carbon management in Texas



[15] US Department of Energy, "Hydrogen with Carbon Management"; National Energy Technology Laboratory, "About Carbon Utilization."

[16] Simon et al., *Carbon Capture for Natural Gas-Fired Power Generation*.

[17] Occidental and 1PointFive, *Occidental and 1PointFive Secure Class VI Permits for STRATOS Direct Air Capture Facility*.

Expanding carbon management in Texas has several economic advantages, including:

- Attracting private capital and federal investment [18]
- Supporting high-wage jobs in construction and operations [19]
- Strengthening export competitiveness for manufacturers and producers [20]
- Reducing emissions from the state's energy and industrial base [21]
- Assisting with pollutant reduction, as growth in power generation grows to meet rising demand [22]
- Delivering affordable and reliable low-carbon energy to state households [23]

However, these benefits are contingent on targeted and sustained action. Project costs, public perception, and regulatory hurdles all pose risks to deployment. Strategic policy and regulatory support can help Texas capture its share of investment and maintain leadership in energy innovation, but success will require balancing economic opportunities with infrastructure readiness, workforce training, and environmental and community considerations.

Roadmap objectives and structure

The Texas Roadmap is designed to support informed decision-making by state policymakers, regulatory agencies, industry, nonprofit organizations, and other Texas stakeholders working to advance energy, economic, and infrastructure growth. It offers targeted policy and regulatory recommendations on the responsible deployment of carbon management technologies to help position Texas as a national and global hub for investment and innovation in this space.

The Roadmap's objectives are to:

- Explore near- and mid-term opportunities for carbon management deployment
- Ensure permitting and regulatory clarity
- Recommend policy actions that support project development and private investment
- Outline the potential for emissions reduction from critical industrial and power sectors
- Promote workforce development and regional economic growth
- Support meaningful stakeholder and community engagement.

The Texas Roadmap is organized across the following areas: carbon capture, DAC, hydrogen and carbon management, carbon transport, carbon utilization, carbon storage, workforce development, community engagement, and stakeholder engagement. Each section presents policy, regulatory, and advisory recommendations, grounded in technical analysis and stakeholder input and tailored to Texas's unique regulatory, economic, and political context.

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[18] Bright, "The Inflation Reduction Act Creates a Whole New Market for Carbon Capture"; US Department of Energy, "Learn How the Federal Government Is Investing in Carbon Management."

[19] Jones et al., "Carbon Capture and Storage Workforce Development."

[20] Miles, "Low-Carbon Fuels."

[21] Great Plains Institute, "Texas Carbon Capture Opportunities."

[22] Brown et al., *Air Pollutant Reductions from Carbon Capture*; Bennett et al., *Carbon Capture Co-Benefits*.

[23] University of Houston Fellows, "CCUS Key For Energy Security And Clean, Affordable Energy."

In addition to the topics and technologies discussed in depth in the Texas Roadmap, several other carbon management strategies fall outside the scope of this report but could offer significant economic and job potential in Texas. These include, but are not limited to, biomass carbon removal and storage, geochemical CO_2 removal such as mineralization-based approaches, and marine CO_2 removal.

The Texas Roadmap outlines many ways the state can position itself as a leader in carbon management. The state could consider carrying these recommendations forward in a coordinated, strategic, and enduring way through establishing a Texas Carbon Management Policy Council.

Recommendation: Establish a Carbon Management Policy Council

The legislature should establish a Carbon Management Policy Council. This council would guide implementation of the Texas Roadmap by evaluating and prioritizing policy options and:

- Include expertise from state agencies, industry stakeholders, academia, economic development and non-governmental organizations, and community representatives
- Deliver ongoing recommendations to relevant agencies and the Legislature, focused on maximizing economic gains, ensuring regulatory clarity
- Meet regularly and publish periodic status reports to ensure transparency and accountability

CARBON CAPTURE

Carbon capture is the practice of capturing carbon from industrial and energy production processes before it is released into the atmosphere. Carbon capture equipment can be added to existing facilities or incorporated into the design of new facilities, with both applications currently in development for various projects across Texas.[24]

With more 45Q-eligible facilities than any other state, extensive CO_2 transport and storage infrastructure, and a strong energy workforce, Texas is uniquely positioned to lead the next wave of carbon capture deployment. Dozens of commercial-scale projects are already underway or under evaluation, backed by federal incentives and private investment. However, realizing this opportunity at scale will require sustained support for the 45Q tax credit, targeted policy actions to improve project economics across diverse sectors, and coordinated efforts to streamline permitting and reduce deployment barriers. This section includes the following recommendations.

Recommendations:

- Support continued federal investment in Section 45Q tax credit for carbon oxide sequestration
- Modernize and expand state incentives
- Create state grant and revolving loan programs for carbon management projects
- Commission comprehensive carbon management economic studies
- Support the development of a voluntary, technology-neutral Energy Attribute Certificate (EAC) framework that can incorporate CCS
- Ensure carbon management is integrated into the state's long-term regional water resource planning
- Commission a statewide study on air pollutant reductions and health co-benefits from carbon capture, including methods to mitigate amine degradation potential
- Advocate for federal regulatory clarity on permitting requirements for carbon capture retrofits
- Monitor air, waste, and water permitting capacity at TCEQ
- Evaluate the potential role of natural gas with carbon capture as a clean firm power resource in future planning and modeling efforts

Carbon capture methods

There are various methods for removing CO_2 from a flue gas that are in operation or under development, with most involving removing the CO_2 post-combustion.

When the concentration of CO_2 in the flue gas is high, like in ethanol fermentation emissions, the carbon capture system may only require dehydration and compression to prepare CO_2 for transport and storage. For applications of low-purity CO_2 sources, where the CO_2 concentration often ranges from three to 20 percent, the CO_2 must be separated from the flue gas through a chemical or mechanical process.[25]

The primary methods for separating CO_2 from low-purity sources include amine solvents, sorbents, membranes, and cryogenic

[24] Global CCS Institute, *Global Status of CCS 2024*.

[25] Moniz et al., *Unlocking Private Capital for Carbon Capture and Storage Projects in Industry and Power*.

technologies, with amine solvents considered to have the highest technology readiness levels and has been in operation for some use cases.[26] These technologies can typically remove 90 to 95 percent of the CO_2 from the flue gas, depending on the flue gas and capture technology specifications, though higher capture rates may be feasible in some applications.[27]

Other carbon capture approaches focus on removing carbon from hydrocarbons before combustion using technologies such as pyrolysis, which is the thermal decomposition of hydrocarbons in the absence of oxygen. Pyrolysis can be applied to resources like biomass and natural gas, resulting in liquid or solid materials that can be sequestered and/or utilized. This effectively prevents the formation and subsequent emission of CO_2 into the atmosphere.

While the roadmap does not explore considerations for which methods are most suitable for applications of carbon capture in Texas, a detailed description of the status and application of many carbon capture technologies can be found in the Global CCS Institute's *State of the Art: CCS Technologies 2025*.[28]

Federal incentives

Federal incentives have played a central role in advancing carbon management in Texas, shaping project economics and influencing the pace of deployment.

45Q TAX CREDIT

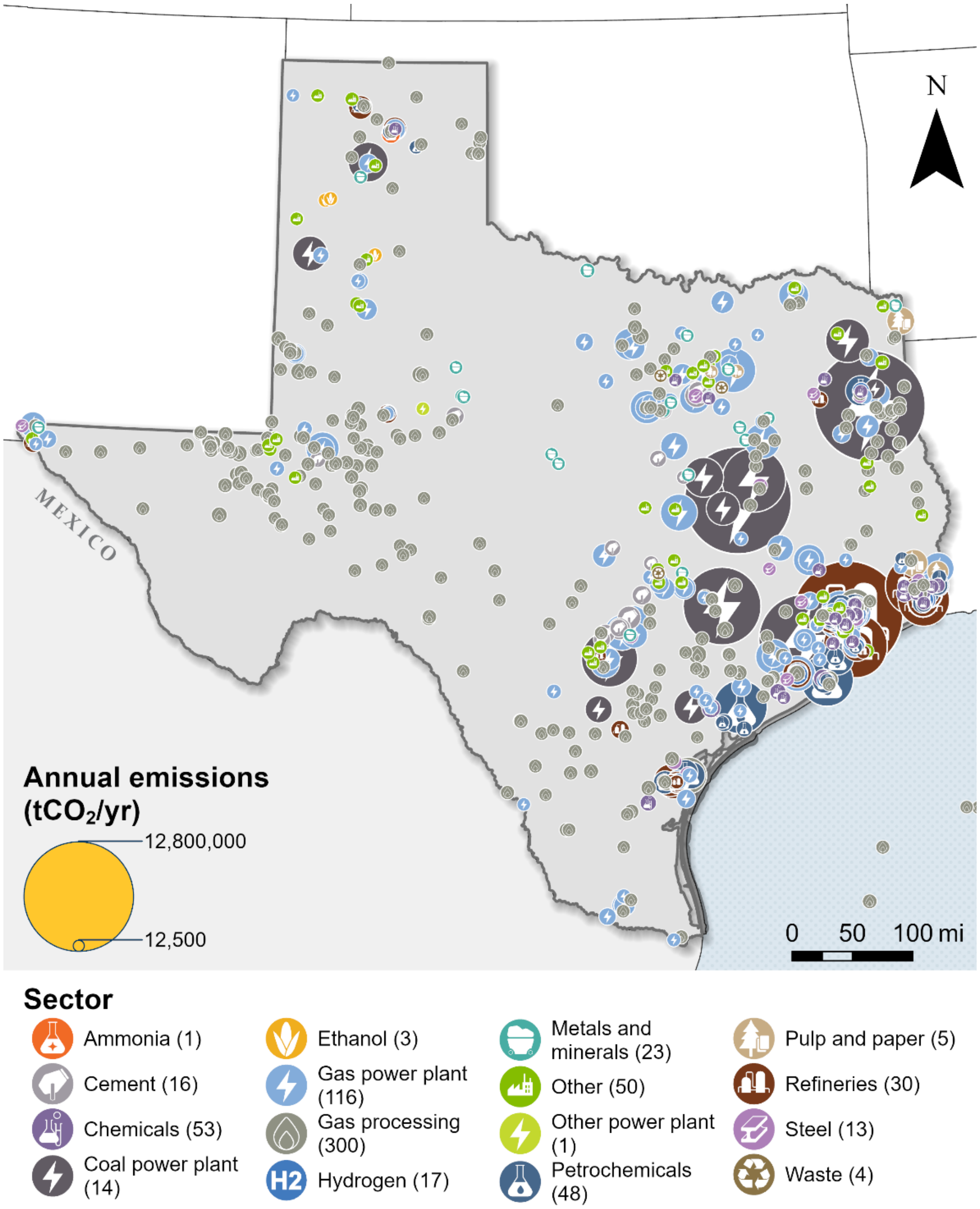
Nearly all point source CO_2 emissions in Texas are emitted at facilities that are eligible for the 45Q tax credit. This federal tax credit is the largest economic incentive available for carbon capture projects and underpins many projects looking to deploy carbon capture. The credit provides $85 per ton of CO_2 captured from eligible industrial and power facilities that is permanently stored in geologic saline formations or utilized in enhanced oil recovery fields or other utilization methods. This credit, increased in 2022 and updated under the 2025 One Big Beautiful Bill Act, forms the backbone of project economics for most carbon capture projects, including many in Texas.

[26] United States Government Accountability Office, Technology Assessment: Decarbonization - Status, Challenges, and Policy Options for Carbon Capture, Utilization, and Storage.

[27] National Energy Technology Laboratory, "Understanding Scales and Capture Rates for Point-Source Carbon Capture Technology Development"; Schmitt et al., Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity.

[28] Barlow et al., State of the Art: CCS Technologies 2025.

Figure 2. 45Q-eligible facilities in Texas



Source: EPA GHGRP (2024)

To be eligible for 45Q, power plants must capture and store or utilize at least 18,750 metric tons of CO_2 (tCO_2) in a year, while industrial facilities must capture and store or utilize at least 12,500 metric tons of CO_2.[29] Of the 850 facilities with reported emissions, 693 facilities are eligible for 45Q, representing over 99 percent of point source emissions in Texas (figure 2).[30]

[29] Credit for Carbon Oxide Sequestration.

[30] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

Texas is also entering a period of significant new construction in the power and industrial sectors, presenting further opportunities for capture. ERCOT load growth, rising data center demand, LNG export buildout, and Gulf Coast hydrogen and ammonia expansions are all driving development.[31] More than 100 new natural gas power plants have been proposed, along with other major projects, such as Chevron's $5 billion blue hydrogen and ammonia facility.[32]

This tax credit could generate billions of dollars in investment value in the state, while substantially reducing the emissions of these facilities.

Projects must begin construction before January 1, 2033, to claim the tax credit, providing a clear but narrowing window of opportunity for projects to complete permitting, secure financing, and begin construction. Given the long lead times typical of large industrial projects, Texas developers will require investment commitments well in advance of the deadline.

While Texas has more facilities eligible for 45Q than any other state, current credit levels are not high enough to make carbon capture cost-effective for many of these facilities. Costs vary widely depending on the industry, and sectors like cement, steel, and natural gas power face higher capture and retrofit expenses that exceed the value of the current credit.[33]

Additionally, recent analysis suggests that the relative value of the credit has eroded due to inflation increasing construction, materials, and insurance costs.[34] As a result, the costs of storing CO_2 have increased substantially from 2020 to mid-2024, by an estimated $51 per metric ton in some cases. Although the credit is scheduled to be adjusted for inflation starting in 2027, using 2025 as the base year, this adjustment will not fully compensate for the cost increases. Without further policy updates, the real value of the credit may continue to lag behind rising project costs, reducing its effectiveness in driving new deployment in Texas.

A targeted increase in 45Q would help bridge these gaps, likely making hundreds more projects financially viable and unlocking more private investment and job growth across the state.

Recommendation: Support continued federal investment in Section 45Q tax credit for carbon oxide sequestration

Texas stakeholders should continue to advocate for enhancements to 45Q. A stronger 45Q credit will increase project viability, attract private capital, and help Texas maintain its leadership in energy and industrial innovation. Actions may include:

- Submitting public comments and congressional testimony
- Participating in industry or multi-stakeholder coalitions advocating for carbon management incentives

[31] Electric Reliability Council of Texas, *Report on Existing and Potential Electric System Constraints and Needs*; Texas Economic Development & Tourism Office, "Recent Project Announcements"; Ati et al., "Unlocking Clean Hydrogen in the US Gulf Coast."

[32] Gottlieb, "Chevron Plans $5B Blue Hydrogen and Ammonia Project in Texas"; Public Utility Commission of Texas, "The Texas Energy Fund"; Texas Economic Development & Tourism Office, "Recent Project Announcements"; Bird, "Inventory of Proposed Gas Power Plants in Texas."

[33] Moniz et al., *Unlocking Private Capital for Carbon Capture and Storage Projects in Industry and Power*.

[34] Carbon Capture Coalition and Brown Brothers Energy and Environment, *45Q Research Brief: Ensuring the Continued Success of the American Carbon Management Industry*.

- Sharing Texas-specific data on project economics and job impacts
- Urging formal support from the governor's office and state legislators

OTHER FEDERAL FUNDING

The DOE has historically funded projects advancing the development of carbon management technologies, including projects in Texas.[35] These public-private partnerships have been instrumental in the US becoming a global leader in carbon management technologies. However, in 2025, the DOE announced significant funding reductions and reallocations across several carbon management projects, including multiple projects in Texas, which may affect deployment timelines.[36]

State incentives for capture and storage

Texas has several incentive programs in statute that were designed to support carbon capture, but most are narrowly defined, time-limited, or underutilized.

CLEAN ENERGY PROJECT FRANCHISE TAX CREDIT

Texas offers a clean energy project franchise tax credit under Texas Tax Code §171.602 for projects implemented in connection with the construction of a new facility. To be eligible, a project must receive a certificate of compliance from the Railroad Commission of Texas (RRC), be fully constructed and operational, have an interconnection agreement with ERCOT, and be verified by the University of Texas Bureau of Economic Geology to store at least 70 percent of associated CO_2 emissions. The credit amount is equal to the lesser of 10 percent of the project's total capital costs (excluding financing) or $100 million, and any unused credit may be carried forward for up to 20 consecutive reports. The credit can also be assigned to one or more taxable entities. Issuance is deferred until the expiration of any relevant Chapter 313 or Chapter 403 agreements, which may delay availability for certain projects. The definition of a clean energy project includes coal-fueled, natural gas-fueled, or petroleum coke-fueled electric generating facilities.[37] As a result, despite its potential value, this credit is unlikely to drive near-term, large-scale deployment of carbon capture without further adjustments or updates.

ADVANCED CLEAN ENERGY PROJECT GRANT AND LOAN PROGRAM

In 2007, the State of Texas established the Advanced Clean Energy Project Grant and Loan Program, administered by the State Energy Conservation Office.[38] Under this program, the State Energy Conservation Office was authorized to award grants covering up to 50 percent of private investment and to make or guarantee low-interest loans for qualified advanced clean energy projects, including those that captured and stored CO_2.[39] Funding for the program was structured through a dedicated account that could receive appropriations, tax revenues, bond proceeds, donations, and interest earnings. However, the window for "advanced clean energy project" eligibility was limited to projects that

[35] US Department of Energy, "(BETA) Carbon Management Projects (CONNECT) Toolkit."
[36] Howland, "DOE Cancels $3.7B in Carbon Capture, Decarbonization Awards."
[37] Verification, Monitoring, and Certification of Clean Energy Project, 2015.
[38] Advanced Clean Energy Project Grant and Loan Program; State Energy Conservation Office, Title 4. Subtitle D. Chapter 447.
[39] Clean Air Act.

applied for permits between January 1, 2008, and January 1, 2020, effectively constraining the program following 2020.[40]

Although the statute remains, there is no clear evidence of appropriations or funding beyond the eligibility period, meaning that the program has not been active post-2020 and effectively expired in practice when the eligibility window closed.

PROPERTY TAX EXEMPTION

Texas provides a property tax exemption for qualifying pollution control equipment, under Texas Tax Code §11.31, which is administered by the Texas Commission on Environmental Quality (TCEQ).[41] In 2007, HB 3732 clarified that equipment used to capture and geologically store anthropogenic CO_2 in Texas is eligible for this exemption.[42] The exemption is part of TCEQ's Tax Relief for Pollution Control Property program. Projects must confirm with TCEQ that the equipment serves a pollution control purpose.[43] The program is still in place; however, only two projects, one in 2015 and one in 2023, have applied for this exemption.[44]

SEVERANCE TAX FOR EOR

Since 2009, Texas has offered a severance tax incentive for enhanced oil recovery (EOR) projects that use anthropogenic CO_2 under Texas Tax Code § 202.0545.[45] Operators can qualify for a 50 percent reduction on the reduced EOR tax rate of 2.3 percent, which lowers the overall severance tax to 1.15 percent. The CO_2 must be captured from an industrial source in Texas, measurable at the point of capture and stored in state. The RRC must verify that the storage is expected to retain at least 99 percent of the injected CO_2 for 1,000 years and has a monitoring and verification plan. Although this incentive does not apply to all types of carbon capture, it reduces costs from certain EOR projects.

SALES AND USE TAX EXEMPTION

Texas Tax Code §151.334 provides a sales and use tax exemption for tangible personal property components used in connection with an "advanced clean energy project" or a "clean energy project."[46]

To qualify, the equipment must capture CO_2 from an anthropogenic source, transport or inject it, or prepare it for transportation or injection. The CO_2 must be stored in Texas, either through an enhanced oil recovery project that qualifies for a severance tax rate reduction, or in a manner expected to keep at least 99 percent of the CO_2 stored for 1,000 years. Statutory definitions limit eligibility to large, fossil-fueled electric generation projects meeting specific capacity, pollutant-reduction, and capture requirements, with clean energy projects also required to be capable of supplying CO_2 for EOR. In practice, these constraints exclude many modern carbon capture projects, including DAC, industrial retrofits, bioenergy with CCS, and smaller-scale facilities.

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[40] Clean Air Act.

[41] Taxable Property and Exemptions.

[42] Advanced Clean Energy Project Grant and Loan Program.

[43] Texas Commission on Environmental Quality, "Tax Relief for Pollution Control Property," August 1, 2025.

[44] Texas Commission on Environmental Quality, "Tax Relief for Pollution Control Property," August 1, 2025.

[45] Franchise Tax Credit for Clean Energy Project; Oil Production Tax.

[46] Verification, Monitoring, and Certification of Clean Energy Project, 2015; Clean Air Act; Limited Sales, Excise, and Use Tax.

Recommendation: Modernize and expand state incentives

Texas has several statutory incentives intended to support the development and deployment of carbon capture and related technologies. While these programs were designed to advance clean energy investment, many were created under earlier market conditions or with limited eligibility parameters. As a result, their use to date has been narrow, and their potential to support current carbon management opportunities remains largely untapped.

Updating and clarifying these existing provisions would allow Texas to strengthen its policy framework without creating new programs, providing a more consistent and efficient pathway for investment. Section 45Q remains the primary near-term driver for project economics, but complementary state-level incentives could help close remaining cost gaps and enhance Texas's competitiveness across energy and industrial sectors.

Options for consideration include:

- **Expand eligibility for the Clean Energy Project Franchise Tax Credit:** Texas could support high-impact carbon capture projects through modest updates to the clean energy project franchise tax credit that retain the original intent and fiscal constraints. Specifically, the Legislature could additionally allow eligibility for retrofit projects or expand the definition of "clean energy project" to include other facilities that permanently store a high percentage of carbon or CO_2.
- **Reactivate the Advanced Clean Energy Project Grant and Loan Program:** Reactivating the Advanced Clean Energy Project Grant and Loan Program could support private sector investment in carbon capture and other industrial innovations. While the program would require new funding to resume grantmaking or lending, the legal and administrative framework is already in place, minimizing the lift required to relaunch it. An appropriation consistent with the original program caps could allow the state to support projects without creating a new program or agency. This program also provides flexibility for the state to select the most competitive advanced clean energy project that will support the state's goals.
- **Assess barriers to the Property Tax Exemption:** TCEQ could initiate a review, in coordination with the comptroller and industrial stakeholders, to determine why the §11.31 pollution control property tax exemption is underused (or not being used) by carbon capture projects. This assessment could clarify whether the exemption is being overlooked due to lack of awareness, administrative complexity, inconsistent local implementation, or legal ambiguity. Findings from this effort could improve the uptake of the exemption without creating new programs or requiring additional funding.
- **Expand the Sales and Use Tax Exemption:** Texas could broaden the existing sales and use tax exemption for carbon capture equipment by updating the "clean energy project" definition in Natural Resources Code §120.001 (or by creating a new "qualifying carbon capture project" definition) to include industrial facilities, DAC plants, and bioenergy with carbon capture and storage. Updates could remove the 200 MW minimum

capacity, allow any facility type that permanently stores captured CO_2 in secure geologic formations, and eliminate the requirement to be capable of supplying CO_2 for EOR, unless the project elects to do so. The Legislature could also amend §151.334 to reference the updated or new definition, and to recognize secure geological storage or other durable storage methods that meet state or federal standards as an eligible pathway alongside EOR. These changes would allow more projects to qualify without creating a new incentive program, making the exemption more relevant to the current range of carbon management technologies being developed in Texas.

A selection of these updates would modernize Texas's carbon capture incentives, reduce administrative barriers, and encourage investment in a broader range of carbon management technologies across the state.

Potential for additional incentives

While these legislative actions reflect early and ongoing state support, Texas does not currently offer direct scalable tax credits or grants for carbon capture across multiple industries. Additional support such as targeted grants, state-backed loan programs, technical assistance, and pilot cost sharing could help bridge the deployment gap in industrial sectors where capture remains uneconomical under current federal incentive levels.

Texas could build upon its proven use of revolving loan programs to provide long-term, low-cost financing for carbon management and other advanced energy projects. The LoanSTAR Revolving Loan Program has delivered more than $600 million in loans for energy efficiency retrofits, with repayments generating over $800 million in taxpayer savings. [47] More recently, the Texas Energy Fund created a state-backed vehicle for financing new dispatchable generation, reflecting policymakers' comfort with loan-based tools for large-scale infrastructure. [48] A similar structure could be adapted to carbon capture, CO_2 transport, storage, and related technologies that require high upfront capital but generate steady long-term revenues through federal incentives like 45Q and market returns.

Recommendation: Create state grant and revolving loan programs for carbon management projects

Texas could establish complementary grant and loan programs to support carbon management deployment across the state. Together, these tools would address different stages of project development, from early demonstrations to large-scale deployment, while minimizing long-term fiscal risk.

- **Create competitive grants for first-of-a-kind capture projects.** Texas could create a small, time-limited competitive grant program to support first-of-a-kind carbon capture installations in hard-to-abate industrial sectors such as steel, cement, and chemicals manufacturing. These sectors face higher costs and greater technical risk than power generation, and federal incentives alone may not be sufficient to make early projects viable. Targeted, state-administered grants (capped in total

[47] Texas Comptroller of Public Accounts, "LoanSTAR Revolving Loan Program."

[48] Public Utility Commission of Texas, "The Texas Energy Fund."

funding and awarded through a competitive process) could bridge near-term financing gaps, attract private and federal cost-share funding, and secure the long-term economic benefits of being a first-mover. Grants could operate as partial cost shares rather than full project funding, with legislative direction on maximum state contribution and matching requirements. Hosting the nation's earliest commercial-scale industrial capture projects would help anchor new supply chains, create high-skill jobs, and strengthen Texas's competitive edge in markets that increasingly value low-carbon products.

- **Establish Carbon Management Revolving Fund**: A dedicated Carbon Management Revolving Fund or a broader Energy Innovation Fund would help support gaps left by federal programs. Eligible projects could include first-of-a-kind capture at cement, steel, and chemical facilities, low-emission hydrogen production, DAC, shared carbon transport infrastructure, and Class VI storage wells. By offering below-market loans, credit enhancements, or partial principal forgiveness, the fund could attract private capital, leverage federal cost-share opportunities, and recycle repayments to build a durable pool of state financing without creating ongoing obligations.

Together, these programs would position Texas to lead in carbon management innovation, leveraging early state investments to catalyze private and federal funding while delivering long-term economic, workforce, and environmental benefits for the state.

Economic impact of carbon management

The full economic impact of large-scale carbon management in Texas has not been comprehensively quantified, yet early indications suggest it could be substantial. Some preliminary work has begun to estimate this potential, including a 2024 analysis commissioned by the Texas Association of Business, which estimated that a single large-scale CCUS project could generate $1.8 billion in total economic activity, support 7,500 full-time equivalent jobs at an average wage of $45 per hour, and provide more than $33 million annually in local and state tax revenue. County-level impacts ranged from $317 million to $3.7 billion. However, the study modeled generic project scenarios in only 12 Southeast Texas counties, excluding other areas with a high potential for carbon management in the state. The study also did not distinguish between retrofit and new-build opportunities. [49]

A full statewide assessment, including both retrofits and new builds, as well as carbon dioxide removal, has yet to be conducted. Such analysis should also account for broader benefits like increased competitiveness, supply chain growth, export potential, and resilience against future emissions regulations.

Recommendation: Commission comprehensive carbon management economic studies

Texas should commission two complementary or combined studies to evaluate the potential economic impact of wide-scale carbon management deployment in the state:

[49] Texas Association of Business and Angelou Economics, *CCUS Economic Impact Study*.

- Retrofit study: Led by relevant state agencies, this study would quantify the economic opportunity from retrofitting existing industrial and power facilities with carbon capture. This analysis could also consider announced projects on retrofits.
- New-build study: Led by relevant state agencies, this study would quantify the economic opportunity from incorporating carbon capture into proposed new power and industrial facilities. This analysis could also consider announced projects on new builds.

Together, these studies would provide Texas decision makers with a comprehensive view of carbon management's total economic potential, beyond the value of 45Q, and position the state to capture the maximum benefit from both public and private investment.

Carbon capture energy use

Carbon capture systems require energy, in the form of heat and electricity, to separate CO_2 from the emissions streams. [50] Across system types, the energy penalty generally ranges from 10 to 30 percent, with pre-combustion capture typically requiring more energy than post-combustion systems. [51]

Post-combustion capture is currently the most widely deployed approach for capturing emissions resulting from combusting fossil fuels during industrial or power processes, with pre-combustion approaches maturing. [52]

Although any facility installing capture will face higher fuel costs and lower net output, there are ways to mitigate this energy penalty, and ongoing research is narrowing the gap. [53]

In Texas, retrofitting facilities with carbon capture systems will increase on-site energy demand across multiple sectors, raising fuel use and reducing net output. If many facilities pursue retrofits concurrently, the combined effect could tighten ERCOT's reserve margins and increase natural gas demand, reinforcing the need for coordinated planning across industries. To manage these impacts, Texas operators may need to evaluate how efficiency upgrades, low-carbon energy sources, and system-wide planning fits into its approach to carbon capture deployment.

At the same time, new market tools are being explored that could help CCS facilities offset some of their added costs. ERCOT is currently evaluating a proposed Energy Attribute Certificate (EAC) framework that would expand eligibility for tradable certificates beyond renewables to include other generation types, potentially including CCS-equipped facilities. [54] Under the proposal, certificates could reflect attributes such as lower-carbon output if supported by third-party verification. If market

[50] Metz et al., "IPCC Special Report on Carbon Dioxide Capture and Storage."

[51] Barlow et al., *State of the Art: CCS Technologies 2025*; Alizadeh et al., "Comprehensive Review of Carbon Capture and Storage Integration in Hydrogen Production: Opportunities, Challenges, and Future Perspectives."

[52] DXP, "Pre-Combustion vs. Post-Combustion Carbon Capture Technologies"; Barlow et al., *State of the Art: CCS Technologies 2025*.

[53] Obi et al., "Minimizing Carbon Capture Costs in Power Plants: A Dimensional Analysis Framework for Optimizing Hybrid Post-Combustion Systems"; Hosseinifard et al., "Achieving Net Zero Energy Penalty in Post-Combustion Carbon Capture through Solar Energy: Parabolic Trough and Photovoltaic Technologies."

[54] Baker and Goff, "NPRR 1264: Creation of a New Energy Attribute Certificate Program."

demand develops, this could create an additional revenue stream to help counterbalance higher operating costs. Participation would be voluntary; however, the potential program could become an important mechanism for customers who want to recognize CCS as part of a broader low-carbon portfolio. The concept remains in early development. ERCOT is assessing its potential role as a data provider while the broader administrative structure is still under discussion.[55] Program design details would be addressed through subsequent ERCOT discussions and stakeholder processes if the effort moves forward.

Support the development of a voluntary, technology-neutral Energy Attribute Certificate (EAC) framework that can incorporate CCS

Texas stakeholders should support a coordinated effort to design and launch a voluntary, technology-neutral market framework that could enable CCS-equipped power and industrial facilities to participate in a potential Energy Attribute Certificate program.

This effort would convene a cross-sector working group, led by an independent third party, to shape the operational design of CCS within a potential EAC framework. The group would focus on creating clear rules, credible accounting, and practical participation pathways so CCS attributes can become verifiable, tradable products that attract corporate demand and provide an additional revenue stream for early CCS projects. It would also develop registry requirements, participation rules, contract and offtake models, and buyer engagement strategies to build market confidence and de-risk early transactions as ERCOT's EAC discussions progress. Finally, the group would define consistent methodologies for quantifying emissions reductions from CCS and translating them into certifiable EACs, including standards for measurement, verification, and third-party validation aligned with established greenhouse gas reporting and Scope 2 guidance.

Carbon capture water use

All carbon capture systems have some degree of water demand, primarily for cooling. The magnitude of this demand depends on the capture technology, cooling technology, and type of facility.[56] Technology-level assessments show wide ranges, with CCS processes consuming between 0.5 and 3.2 m^3 of freshwater per metric ton of CO_2, depending on technology and cooling design, excluding BECCs which often has higher water demand.[57] Natural gas combined cycle power plants using post-combustion capture are on the higher end of this range, with an estimated water footprint of 2.6 m^3/metric ton of CO_2.[58]

Certain pre-combustion systems can recover process water that partially offsets freshwater demands. Gasification processes can condense and recover moisture released during syngas production and cooling, which can then be treated and reused within the facility. Some biomass pyrolysis pathways also produce condensable liquids that include water that, once separated, can contribute to internal process needs. These water recovery streams do

[55] Rosel, "NPRR Comments - Creation of a New Energy Attribute Certificate Program."

[56] Rosa et al., "The Water Footprint of Carbon Capture and Storage Technologies."

[57] Rosa et al., "The Water Footprint of Carbon Capture and Storage Technologies."

[58] Rosa et al., "The Water Footprint of Carbon Capture and Storage Technologies."

not eliminate the overall water intensity of pre-combustion systems, but in some designs, they can reduce net freshwater withdrawals, which may be beneficial in regions with limited water availability.

Water use is particularly relevant in Texas, where existing water supplies are projected to decline by approximately 18 percent by 2070, while demand increases due to population growth and industrial needs. [59] In 2023, power generation accounted for about 4 percent of Texas's estimated water use and manufacturing for about 8 percent. Adding carbon capture to facilities could increase these percentages slightly. [60] While adding CCS to existing facilities may increase these percentages modestly, it could still contribute to cumulative stress in regions already experiencing scarcity.

While water demand remains a challenge for some capture systems, mitigation strategies are available and proven. Hybrid or dry cooling systems can reduce consumptive water use, brackish groundwater and reclaimed municipal wastewater can substitute for freshwater, and improvements in solvent formulations and heat recovery designs can improve water efficiency. [61]

With appropriate siting, cooling choices, and use of alternative water sources, CCS can be deployed without creating unmanageable water burdens. That said, it is important for Texas to encourage a coordinated deployment of carbon capture and water use to ensure local stress on water demand does not compound.

Since new water supplies and cooling infrastructure can take years to plan and permit, it is prudent for Texas to begin assessing water needs for CCS now, rather than waiting until many facilities attempt to retrofit at once. Early planning could assess if retrofits will place stress on water resources and provide guidance on using brackish or reclaimed water, where possible, or temporarily pausing capture systems to avoid compounding strain during drought conditions. Texas water planners have already projected that demand will exceed supply within coming decades, underscoring the importance of integrated planning across sectors to ensure resilient water management. [62]

Recommendation: Ensure carbon management is integrated into the state's long-term regional water resource planning.

Texas policymakers, water agencies, and industry leaders should work together to integrate carbon capture and DAC into broader regional water resource planning. Competing uses for increasingly strained water supplies may necessitate policy solutions that prioritize equitable allocation and resilience. Texas should encourage coordinated planning across municipalities, industries, and basins to ensure carbon capture deployment does not exacerbate water stress and aligns with long-term water sustainability goals.

Long-term water use planning should also include support for research and development for technologies that could treat produced water

[59] Texas Water Development Board, *Water for Texas: 2022 State Water Plan*.

[60] Texas Water Development Board, "Texas Water Use Estimates Summary for 2023"; Texas Water Development Board, "Historical Water Use Survey Data."

[61] Eldardiry and Habib, "Carbon Capture and Sequestration in Power Generation: Review of Impacts and Opportunities for Water Sustainability."

[62] Cardone and Howe, *Advancing One Water in Texas*.

to the quality necessary for utilization in carbon capture projects.

Carbon capture and air quality

While carbon capture is primarily designed to reduce CO_2 emissions, retrofitting facilities with carbon capture systems can potentially reduce associated co-pollutants, such as particulate matter (PM), nitrogen oxides (NO_X), and sulfur dioxide (SO_2), particularly when these co-pollutants are present at amounts that may damage or decrease the efficiency of the capture system. [63]

Although many studies on the potential for air quality co-benefits of carbon capture are national in scope, several include direct modeling of facilities in Texas or cover regions that include the state. These findings help inform how carbon capture can be deployed in ways that maximize public health benefits and minimize unintended harms for communities in Texas.

A 2023 study by GPI evaluated the air quality and public health benefits of retrofitting 54 industrial facilities with amine-based carbon capture systems across 10 US regions. In the Texas and Louisiana region, just five representative facilities (four located in Texas) were estimated to provide between $73.4 million and $165.4 million in annual health benefits from avoided premature deaths, hospitalizations, and missed workdays due to reduced exposure to harmful pollutants. [64]

Similarly, a 2023 study by the Clean Air Task Force modeled air quality improvements at four large industrial facilities equipped with carbon capture retrofits, including two in Texas, the ExxonMobil refinery in Beaumont and the Texas Lehigh cement plant in Buda. The retrofit at the Beaumont facility was projected to reduce NO_X emissions by 33 percent, SO_2 emissions by more than 99 percent, and PM by approximately 95 percent. At the Buda cement plant, SO_X reductions exceeded 99 percent and filterable and condensable PM were reduced by 97.5 and 93 percent, respectively. Modeled health benefits, using EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), suggested potential annual health benefits of $24 to $55 million for the refinery and $62 to $139 million for the cement facility. [65]

However, these outcomes are facility-specific and depend on factors such as the type of capture technology and existing pollution control equipment. For example, the Beaumont refinery already had some pollution controls in place, reducing the marginal NO_x reductions achieved through carbon capture retrofits.

Additionally, a 2024 study from the University of Texas at Austin found that certain carbon capture systems could lead to increased ammonia emissions, which can contribute to the formation of secondary particulate matter. [66] This underscores the importance of selecting the right technology for the right site and ensuring that systems are designed and maintained to minimize unintended emissions.

A wide view of the potential air quality impacts, positive or negative, of installing carbon capture technologies exists in the literature. A primary area of concern is the degradation of the amine

[63] Bennett et al., *Carbon Capture Co-Benefits*.

[64] Bennett et al., *Carbon Capture Co-Benefits*.

[65] Brown et al., *Air Pollutant Reductions from Carbon Capture*.

[66] Waxman et al., "What Are the Likely Air Pollution Impacts of Carbon Capture and Storage?"

solvent during the capture process, which can lead to the development of nitrosamines, ammonia and other pollutants.[67] Operators can utilize additional pollution controls, including water and/or acid washes, which can limit the potential for ammonia and nitrosamine development.[68] Continued research efforts will further advance understanding of best practices and improvements for mitigating potential co-pollutants related to carbon capture.

While several studies have quantified the potential public impacts of carbon capture on air quality in Texas, most focus on a limited number of facility types and cover only a small fraction of facilities eligible for the 45Q tax credit. As a result, there is no comprehensive estimate of statewide changes to air quality and public health from carbon capture deployment across Texas's industrial and power sectors.

Recommendation: Commission a statewide study on air pollutant reductions and health co-benefits from carbon capture, including methods to mitigate amine degradation potential

Texas should commission a comprehensive study to assess the potential impacts on air quality and public health of carbon capture deployment at industrial and power facilities across the state. The study would estimate cost savings from reduced criteria pollutants, such as PM_{10} or $PM_{2.5}$ emissions, and how the total reduction across facilities could lead to reduced asthma rates, hospital visits, and premature deaths, particularly in areas near large emitters. It would then assess any additional pollution controls needed to minimize other pollutants and maximize those benefits. The study should explicitly include the impact and importance of using pollution control technologies to avoid ammonia and nitrosamine emissions.

Study results could help Texas evaluate how investments in emissions-reducing technologies could lower healthcare-related expenditures, reduce strain on publicly funded health programs, and improve quality of life for Texans. By quantifying these benefits in economic terms, the study would inform fiscally responsible, health-focused carbon management policy.

Carbon capture air permitting

Carbon capture projects require air permits. At a minimum, projects must comply with Federal Clean Air Act requirements related to construction and operation of emissions sources, including those associated with carbon capture equipment. These requirements are typically implemented by state environmental agencies and may include review processes, such as New Source Review (NSR), Prevention of Significant Deterioration (PSD), and Nonattainment New Source Review (NNSR)—depending on facility location, the amount and

[67] United States Energy Association, "Workshop on Measurement, Monitoring and Controlling Potential Environmental Impacts from the Installation of Point Source Capture"; Rochelle, "Air Pollution Impacts of Amine Scrubbing for CO_2 Capture"; Bennett et al., *Carbon Capture Co-Benefits*; Buvik et al., "A Review of Degradation and Emissions in Post-Combustion CO_2 Capture Pilot Plants."

[68] Rochelle, "Air Pollution Impacts of Amine Scrubbing for CO_2 Capture"; Brown et al., *Air Pollutant Reductions from Carbon Capture*; Mertens et al., "Understanding Ethanolamine (MEA) and Ammonia Emissions from Amine Based Post Combustion Carbon Capture: Lessons Learned from Field Tests"; Bennett et al., *Carbon Capture Co-Benefits*; Heo et al., "Implications of Ammonia Emissions from Post-Combustion Carbon Capture for Airborne Particulate Matter."

type of emissions involved, and whether the facility is classified as a major or minor source. [69]

In Texas, carbon capture projects that modify or add to existing emissions sources are primarily regulated by TCEQ, which implements federal air permitting requirements under delegated authority from the US EPA. These projects generally fall under TCEQ's NSR program and may trigger PSD or NNSR permitting, depending on the facility's location and the scale of emissions involved. [70]

In attainment areas, PSD permitting applies to new or modified sources exceeding emissions thresholds and requires: [71]

- A best-available control technology analysis that considers both technical feasibility and economic reasonableness
- An air quality analysis using air dispersion modeling to ensure the project will not cause or contribute to violations of national ambient air quality standards (this requirement does not apply to GHGs)
- A public notice process, which includes a 30-day comment period [72]

In nonattainment areas, including Houston and Dallas-Fort Worth, carbon capture projects may instead trigger NNSR permitting. This review requires installation of lowest achievable emission rate technology and the purchase of emissions offsets. [73]

Facilities classified as major sources (emitting over 75,000 tons per year CO_2 equivalent) must also comply with the Energy Act of 2020 - Title V, Carbon Removal operating permit requirements. [74] While a Title V permit does not need to be issued before startup, the application must be submitted in advance. [75] In practice, many carbon capture retrofits and most DAC plants won't meet Title V thresholds unless they're tied to a very large combustion source. However, projects at existing major sources will need to address Title V through a permit modification, and new capture facilities could trigger Title V if on-site combustion equipment increases emissions over the 75,000 tons per year CO_2e threshold or makes them major for other pollutants.

If carbon capture equipment may emit hazardous air pollutants, the project may be subject to Maximum Achievable Control Technology standards. [76] Due to uncertainty around whether these emissions are attributed to the capture unit or host facility, developers often opt for a proactive maximum achievable control technology review. Discussions through the development of this roadmap suggest this is

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[69] US Environmental Protection Agency, "Regulatory and Statutory Authorities Relevant to Carbon Capture and Sequestration (CCS) Projects"; US Environmental Protection Agency, "New Source Review (NSR) Permitting."

[70] Texas Commission on Environmental Quality, *Fact Sheet - Air Permitting*, June 2021.

[71] Texas Commission on Environmental Quality, "Prevention of Significant Deterioration and Nonattainment Fact Sheet"; Texas Commission on Environmental Quality, "Prevention of Significant Deterioration and Nonattainment Major Source Significant Emissions Fact Sheet."

[72] Public Notice of Air Quality Permit Applications.

[73] Texas Commission on Environmental Quality, "Prevention of Significant Deterioration and Nonattainment Fact Sheet."

[74] Prevention of Significant Deterioration Applicability for Greenhouse Gases Sources; Texas Commission on Environmental Quality, *Fact Sheet - Air Permitting*, June 2021.

[75] Texas Commission on Environmental Quality, *Fact Sheet - Air Permitting*, June 2021.

[76] Texas Commission on Environmental Quality, *Air Permit Reviewer Reference Guide - APDG 6110*.

common, but no formal guidance has been issued on this topic.

Recommendation: Advocate for federal regulatory clarity on permitting requirements for carbon capture retrofits

Texas agencies, industry leaders, and research institutions should jointly urge the EPA to issue clear guidance on how carbon capture retrofits are treated under air permitting rules. The guidance would clarify what constitutes a "modification" under the Clean Air Act and how applied maximum achievable control technology standards would reduce uncertainty, avoid unnecessary permitting steps, and accelerate project deployment, without compromising environmental standards.

TCEQ's guidance indicates that only limited activities (e.g., site planning or temporary staging) are permitted before air permits are issued. [77] While TCEQ's review periods for air permits are less than one year, staffing challenges and a growing number of carbon management projects could strain agency capacity. [78]

Adequate staffing and resources will be critical to ensure timely, effective reviews and maintain public trust in the permitting process.

Recommendation: Monitor air, waste, and water permitting capacity at TCEQ

The state should closely monitor the carbon capture permitting process for potential bottlenecks and evaluate whether additional resources or staffing are needed to ensure timely and effective air, water, and waste permit reviews associated with certain infrastructure that may be associated with a carbon capture project. Proper staffing and resources for permitting authorities can lead to efficient, robust permitting, which can decrease project timelines, without impacting the rigor of the permitting process.

Carbon capture opportunities and landscape

Texas's emissions landscape provides plentiful opportunities for carbon capture. In 2024, 850 facilities reported CO_2 emissions data to the US EPA under the Greenhouse Gas Reporting Program (GHGRP). These facilities emitted an estimated 367 million metric tons of CO_2 ($MMtCO_2$) in 2023 across the power and industrial sectors. [79]

Texas has been at the forefront of carbon capture for decades, including utilizing carbon capture at gas processing facilities, hydrogen and chemical plants, and power plants (figure 3). [80] The mechanism for removing CO_2 from the flue gas varies across these facilities, with most of the captured CO_2 being injected into the subsurface for enhanced oil recovery or permanent storage.

POWER SECTOR

The power sector accounted for approximately 51 percent of the state's total reported point-source CO_2 emissions in 2023. [81] Carbon capture

[77] Texas Commission on Environmental Quality, "Air Permits to Construct."

[78] Texas Commission on Environmental Quality, "Issue 10: Workforce Challenge"; Texas Commission on Environmental Quality, *Fact Sheet - Air Permitting*, June 2021.

[79] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

[80] Clean Air Task Force, "US Carbon Capture Activity and Project Table"; Global CCS Institute, *Global Status of CCS 2024*.

[81] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

offers one of the most immediate opportunities for large-scale emissions reductions and continued use of firm dispatchable power resources.

Coal

Texas currently has 13 coal-fired power plants, which together emitted roughly 76 $MMtCO_2$ in 2023. All 13 facilities are eligible for 45Q, although three are scheduled for retirement before 2030, reducing the practical number of capture candidates to 10. With no new coal power plant construction planned in the state, opportunities for carbon capture deployment in the coal fleet are limited to retrofits on existing plants that have long-term operational horizons.

The Petra Nova project at WA Parish Generating Station is a key example of a post-combustion carbon capture project in the power sector. The facility captures CO_2 from a 240 MW slipstream of flue gas from Unit 8.[82] Petra Nova began operations in January 2017, was shuttered in 2020, and restarted in September 2023.[83] The project transports CO_2 to nearby oil fields, where it is used for enhanced oil recovery. From 2017 to 2020, the project captured 3.4 $MMtCO_2$, and In February 2025, ENEOS announced the project had cumulatively captured 5 $MMtCO_2$.[84]

Natural gas

Texas operates approximately 120 natural gas-fired power plants, which collectively emitted 111 $MMtCO_2$ in 2023.[85] Of these, 116 facilities (99.9 percent of sector emissions) are eligible for 45Q, highlighting substantial technical potential for carbon capture retrofits across the natural gas fleet. In addition, as of April 2025, as many as 130 new gas-fired power projects have been proposed across the state, reflecting continued investment in dispatchable generation capacity to meet rising electricity demand.[86]

Natural gas with carbon capture could play an important role in supporting a clean firm power portfolio for Texas. Firm, low-emission resources can complement variable generation and enhance system reliability as the state's energy mix evolves. Incorporating natural gas power with CCS into long-term energy planning would allow the state to utilize existing infrastructure, technical expertise, and policy tools to advance low-emission energy systems while maintaining reliability and a competitive edge.

Recommendation: Evaluate the potential role of natural gas with carbon capture as a clean firm power resource in future planning and modeling efforts

Led by relevant state agencies, this assessment should consider system reliability, emissions reduction potential, cost competition, and the state's broader infrastructure and workforce advantages.

INDUSTRIAL SECTOR

Major emitting sectors in Texas include refineries, petrochemicals, gas processing, hydrogen,

[82] US Department of Energy, Office of Fossil Energy and Carbon Management, "Petra Nova - W.A. Parish Project."

[83] National Energy Technology Laboratory, "NETL-Supported Petra Nova Project Celebrates Three Years of Sustainable Operation"; Reuters, "Carbon Capture Project Back at Texas Coal Plant after 3-Year Shutdown"; US Energy Information Administration, "Petra Nova Is One of Two Carbon Capture and Sequestration Power Plants in the World."

[84] ENEOS Explora Inc., *Petra Nova Captures More Than Five Million Tons of Carbon Dioxide*; Reuters, "Carbon Capture Project Back at Texas Coal Plant after 3-Year Shutdown."

[85] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

[86] Bird, "Inventory of Proposed Gas Power Plants in Texas."

cement, chemicals, and pulp and paper. The remaining sectors each account for less than one percent of the total CO_2 emissions in the state.

Ammonia

Texas has one ammonia production facility, which emitted approximately 0.7 $MMtCO_2$ in 2023. The facility is 45Q-eligible, positioning it well for early capture opportunities, given the sector's high-purity CO_2 streams and established capture technologies.

Cement

The state's 16 cement plants collectively emitted 10.8 $MMtCO_2$ in 2023, with all 16 plants eligible for the 45Q tax credit. While capture costs for cement are higher than for high-purity streams, the concentration and scale of emissions make the sector an important target for advancing low-carbon building materials and developing early demonstration projects.

Chemicals

Fifty-eight chemical facilities emitted roughly 6 $MMtCO_2$ in 2023. Of these, 53 are 45Q-eligible, representing about 99 percent of the sector's total emissions. Capture at chemical plants can build upon existing process expertise and integration opportunities within industrial clusters along the Gulf Coast.

Celanese Corporation began capturing CO_2 at its Clear Lake, Texas, location in 2024. This project utilizes the captured CO_2 to produce low-carbon methanol, which can then be used to create other end products. According to Celanese Corporation, the project is expected to capture 180,000 metric tons of CO_2 and produce 130,000 metric tons of low-carbon methanol annually. [87]

Ethanol

Three ethanol plants in Texas emitted a combined 0.3 $MMtCO_2$ in 2023. [88] All are eligible for the 45Q credit. In addition to emissions reported to GHGRP, these facilities also produce high-purity biogenic CO_2 streams that could offer low-cost capture and storage options that contribute to net-negative emissions.

Hydrogen

Seventeen hydrogen production facilities collectively emitted approximately 11.5 $MMtCO_2$ in 2023. [89] All 17 of these facilities are 45Q-eligible. Hydrogen production from steam methane reforming and autothermal reforming offer near-term opportunities for large-scale carbon capture deployment, supporting both industrial decarbonization and emerging low-carbon hydrogen markets.

Metals and minerals

Twenty-six metals and minerals facilities collectively emitted roughly 1.3 $MMtCO_2$ in 2023. [90] Twenty-three facilities, representing about 99 percent of total sector emissions, are eligible for 45Q. Capture in this sector remains nascent but could expand as technologies for furnaces and process emissions mature.

Refineries and petrochemicals

Refineries and petrochemical plants together represent one of the largest industrial opportunities for capture in Texas. Forty-seven of the 48 petrochemical facilities in Texas are 45Q-eligible, accounting for 43.8 $MMtCO_2$ in annual

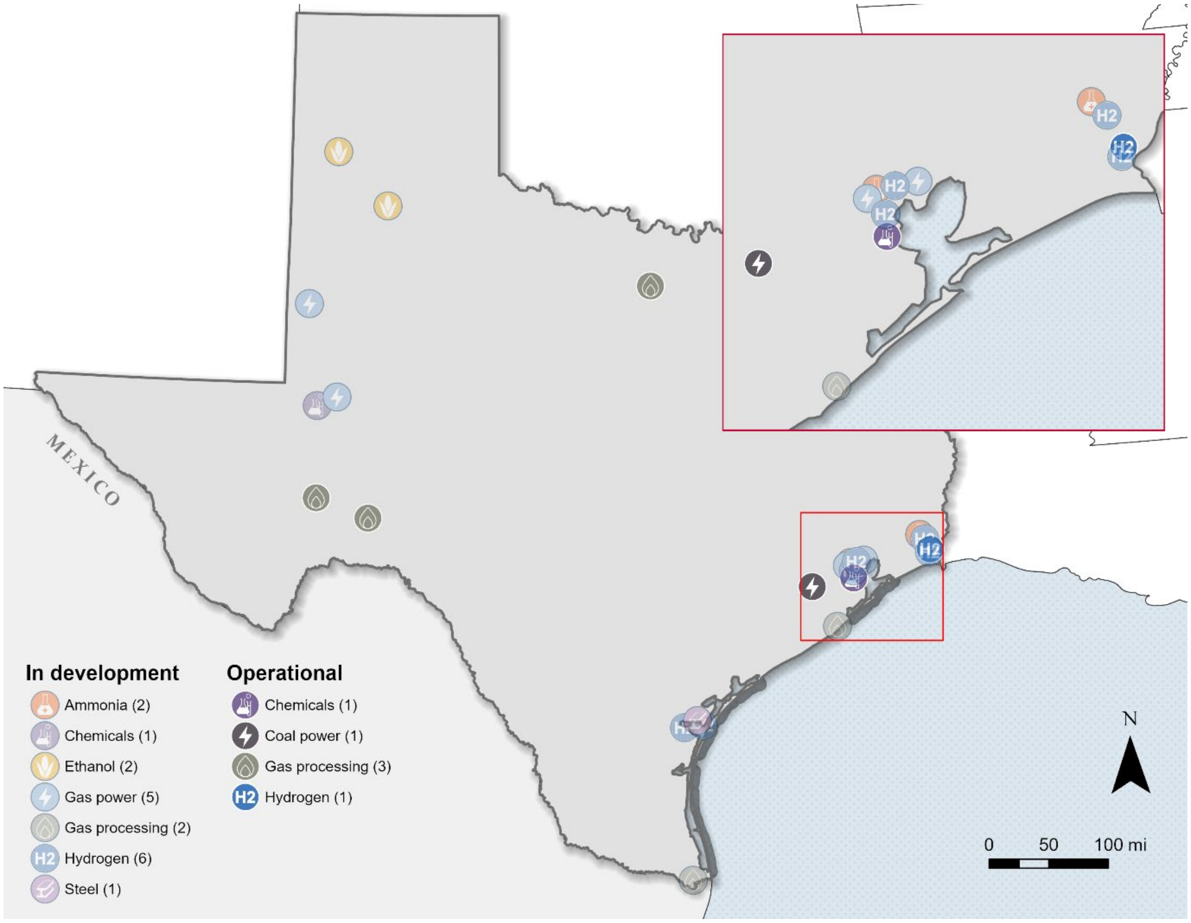
[87] Celanese Corporation, "Celanese Begins Carbon Capture and Utilization Operations at Clear Lake, Texas, Facility."

[88] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

[89] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

[90] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

Figure 3. Announced and operational projects in Texas



Sources: GCCSI (2024) and CATF (2024).

Note: Project announcements are a rapidly evolving landscape and can include projects at a variety of stages in development.

emissions.[91] Refineries similarly offer high-volume, concentrated emission sources located near existing pipeline infrastructure and potential storage sites.

Air Products captures CO_2 from two steam methane reformers at the Valero Refinery in Port Arthur. The CO_2 is then transported and used for enhanced oil recovery. This project began in 2013 and can capture approximately one million metric tons of CO_2 per year.[92]

Gas processing

Gas processing represents the single largest sector of industrial capture potential in Texas, with nearly 350 facilities reporting emissions in 2023.[93] The state has a long history of CO_2 capture in this sector—one of the world's first commercial capture projects, the Terrell Gas

[91] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

[92] Air Products, "Carbon Capture"; Global CCS Institute, *Global Status of CCS 2024*.

[93] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

Plant, has operated since 1972. [94] More recently, the BKV Barnett Zero project began operations in 2023 and is expected to capture up to 0.21 $MMtCO_2$ per year, illustrating ongoing innovation and investment. [95]

Texas carbon capture deployment potential

Texas has a significant number of opportunities for carbon capture, transport, and storage deployment. To better understand how these opportunities could develop over time, GPI collaborated with Carbon Solutions to model the potential buildout of carbon capture, transport, and storage across this region in the near-term (e.g., next ten to fifteen years) and into the midcentury. This work was conducted as part of a broader analysis of the Southeast and Gulf Coast regions of the United States, with full results and methodology provided in *Carbon Capture and Storage Opportunities in the Southeast and Gulf Coast*.

The scenarios estimate where and how capture projects, CO_2 pipelines, and storage sites could be deployed under cost-optimized conditions. Although the modeling did not incorporate specific policy inputs, many of the actions recommended in the Texas Roadmap could help create the conditions needed for deployment at this scale. Modeling incorporated both onshore and offshore saline formations suitable for long-term CO_2 storage.

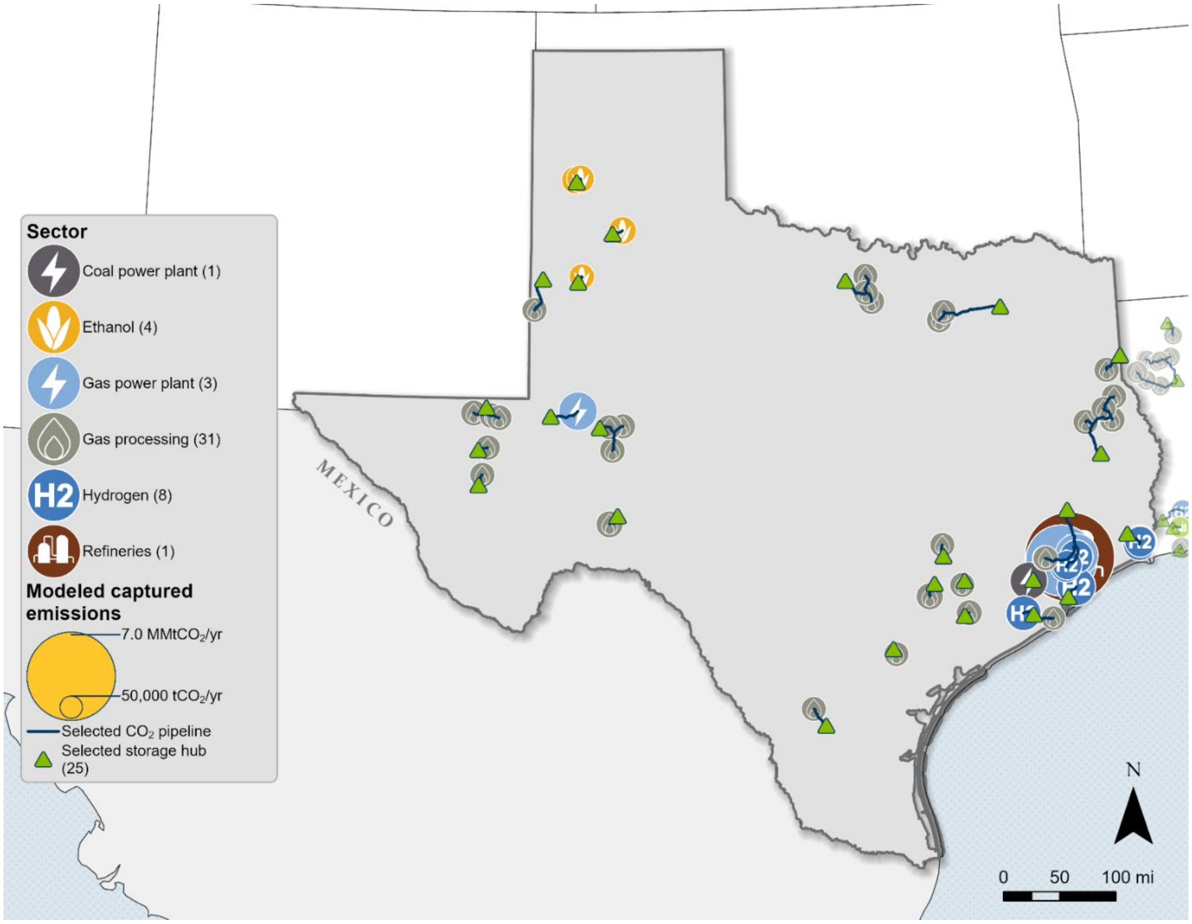
While the scenarios highlight opportunities with the best modeled potential for deployment of CCUS, they are limited by what was incorporated into the models used and therefore may not be indicative of what capture facilities, storage complexes, and pipeline routes are ultimately deployed.

The scenarios highlight areas with the highest modeled potential, but they are not forecasts of actual project development. Results are constrained by the assumptions and datasets used and do not capture factors such as site-specific configurations, financing conditions, permitting capacity, public engagement, or access to pore space. Despite these uncertainties, Texas's concentration of large emitters, world-class storage resources, and extensive energy infrastructure position the state to lead national CCS deployment.

[94] Center for Climate and Energy Solutions, "Carbon Capture."

[95] BKV Corporation, "BKV and EnLink Midstream Commence First Carbon Capture and Sequestration Project in the Barnett Shale."

Figure 4. Results for the Texas portion of the near-term deployment scenario



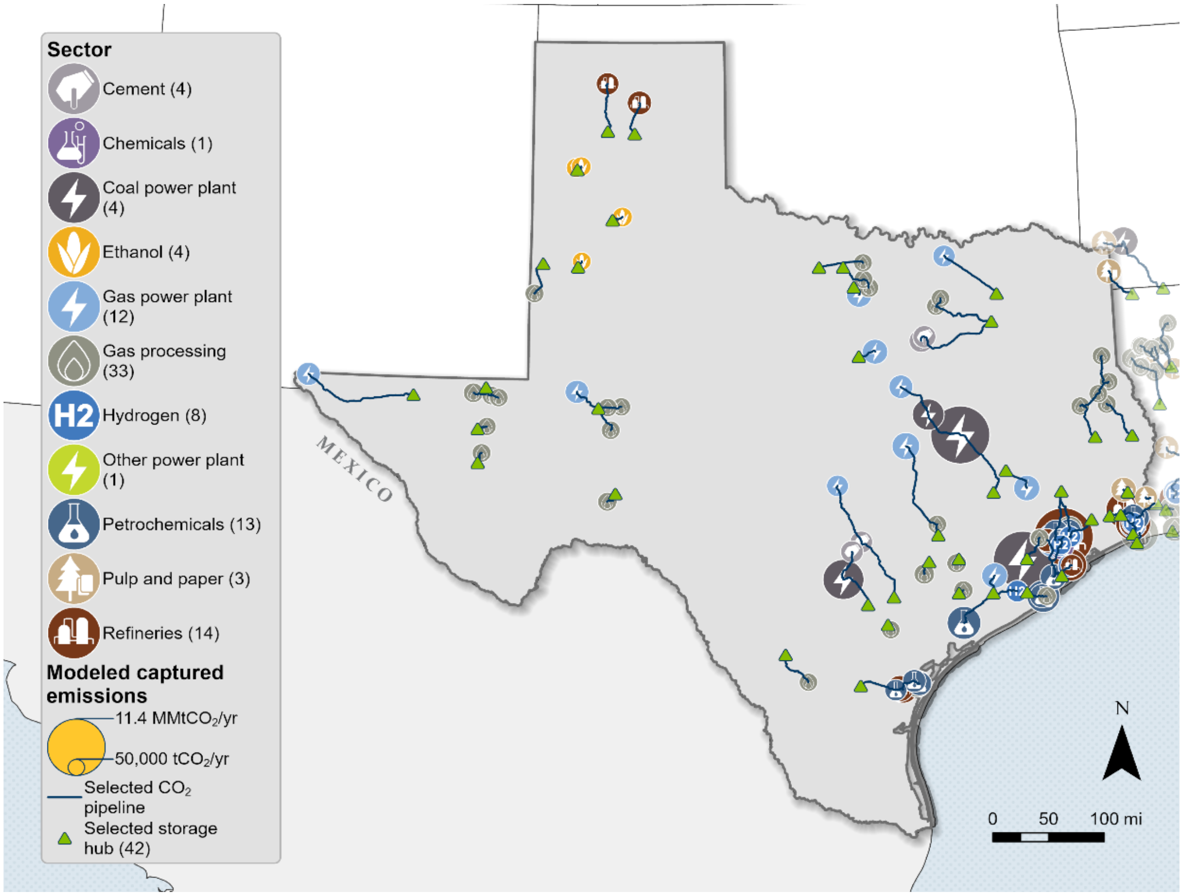
Transparent items are included in the modeling scenario but reside in other states. Facility counts include number of Texas facilities in the scenario.

NEAR-TERM DEPLOYMENT OPPORTUNITIES

The near-term scenario represents the initial phase of CCS build-out across Texas and includes low-cost capture opportunities, as well as existing and announced projects that represent the best opportunities for deployment in the next ten to fifteen years (figure 4).

Approximately 29 $MMtCO_2$ per year could be captured and permanently stored from 48 facilities in this scenario, primarily in the Gulf Coast and Permian Basin regions. About 650 miles of new CO_2 pipeline would connect these facilities to 25 onshore saline storage sites. Facility types include hydrogen and ammonia production, natural gas processing, and ethanol plants that have reached commercial cost levels for carbon capture. The scenario highlights early opportunities clustered along the Gulf Coast, with numerous industrial emitters and substantial geologic storage potential.

Figure 5. Results for the Texas portion of the midcentury deployment scenario



Transparent items are included in the modeling scenario but reside in other states. Facility counts include number of Texas facilities in the scenario.

MIDCENTURY DEPLOYMENT

The midcentury scenario expands upon the near-term build-out, reflecting an assumed broader technology maturity and capture cost reductions. Modeled results show that 97 facilities across Texas, connecting to 42 onshore and offshore storage sites by nearly 1,960 miles of CO_2 pipeline, could capture approximately 162 $MMtCO_2$ per year (figure 5). Larger multi-facility networks appear near Houston, Corpus Christi, and in the Permian Basin, suggesting potential hubs for regional storage operations as deployment scales.

The modeled scenarios showcase Texas's potential opportunity under coordinated policy, regulatory, and industry action. They represent technically and economically optimized pathways, not forecasts of specific projects or routes. Actual development will depend on additional factors not captured in the models, including site-specific facility configurations, financing conditions, permitting capacity, public engagement, access to pore space, and use of existing transport infrastructure. Despite these limitations, the state's concentration of large emitters, world-class storage potential, and established energy infrastructure position it to lead national CCS deployment.

DIRECT AIR CAPTURE

Direct air capture (DAC) technologies are a type of carbon removal used to remove CO_2 directly from the ambient air rather than from a point-source location. [96] Like carbon capture, the removed CO_2 can be utilized or stored geologically. DAC facilities have flexible siting requirements, as they are not tied to emissions sources and need only be located close enough to CO_2 utilization or storage infrastructure to remain cost- and emissions-effective.

Texas has diverse geography, extensive CO_2 transport and storage infrastructure, a strong energy workforce, and leadership in both renewable and traditional energy production, making the state well suited to lead the next wave of DAC deployment. Early commercial-scale DAC projects are already advancing in the state, supported by federal incentives, DOE funding, and growing private investment. However, realizing this opportunity at scale will require continued federal support, targeted state-level action to improve project economics, and strategic siting to align with low-carbon energy, water availability, and storage access. This section includes the following recommendations.

Recommendations:

- Support a targeted feasibility assessment to identify high-potential waste heat pairing opportunities for DAC
- Ensure DAC is eligible for carbon capture incentives in Texas

DAC methods

DAC technologies vary in design, energy and water requirements, operational requirements, and ideal deployment environments. [97] The two most studied DAC technologies are liquid solvent-based systems (L-DAC) and solid sorbent-based systems (S-DAC). [98] L-DAC uses a liquid solvent to chemically bind CO_2, which is then regenerated through heat, while S-DAC uses a solid material that adsorbs CO_2 and is regenerated through heat or vacuum. Technology selection depends on site-specific factors, such as climate, energy availability, water resources, and proximity to CO_2 transport and storage infrastructure.

Although system design varies, one standard by which all DAC technologies are evaluated is that they must achieve net-negative emissions, removing more CO_2 from the atmosphere than produced throughout the system's lifecycle from removal to storage or utilization. The main factor in achieving net-negative emissions is minimizing emissions from the power source for the system, typically by using renewable energy like wind or solar, or other low-carbon options, like natural gas paired with carbon capture. DAC can be used by companies to help meet regulatory emissions targets, meet voluntary climate commitments, or generate carbon removal credits in compliance or voluntary carbon markets. [99] When paired with hydrogen production, DAC can also be converted

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[96] IEA, *Direct Air Capture: A Key Technology for Net Zero*.

[97] Bouaboula et al., "Comparative Review of Direct Air Capture Technologies: From Technical, Commercial, Economic, and Environmental Aspects."

[98] US Department of Energy, "DOE Explains...Direct Air Capture."

[99] IEA, *Unlocking the Potential of Direct Air Capture*.

into low-carbon synthetic fuels as a method to decarbonize sectors like aviation. [100]

While this roadmap does not contain a review of all technologies, detailed descriptions of leading systems, their operational needs, and performance can be found in resources such as Lawrence Livermore National Laboratory's *Roads to Removal* and the International Energy Agency's (IEA) *Direct Air Capture 2023*. [101]

DAC opportunities

Texas has plentiful opportunities to deploy DAC technologies due to its diverse geography, existing energy infrastructure and workforce, and access to geologic storage. [102] As international markets increasingly demand low-carbon products, early investment in DAC will help prepare Texas industries to meet emerging standards and remain competitive in global trade.

Texas's natural environment and weather conditions vary across the state, making certain regions especially suitable for particular DAC technologies.

Some assessments suggest that areas in the West and North Central Texas are especially well-suited for S-DAC. [103] The *Roads to Removal* report also identifies at least two thirds of counties in Texas having varying levels of suitability for S-DAC, based on geologic storage and availability of wind and solar technologies, estimating a removal potential of 4.3 billion metric tons of CO_2 per year (). [104] Areas along the Gulf Coast, like Houston, have medium-to-high favorability for both main types of DAC. [105] This is largely due to warm temperatures and moderate humidity, conditions that are favorable for L-DAC performance.

Specific planning and infrastructure alignment will be critical to help minimize costs and maximize the effectiveness of the technology when planning to deploy in Texas.

Additionally, DAC facilities can leverage Texas's existing CO_2 transport and storage infrastructure to reduce costs and improve project viability,

[100] Brazzola et al., "The Role of Direct Air Capture in Achieving Climate-Neutral Aviation"; Gray et al., "The Role of Direct Air Carbon Capture in Decarbonising Aviation."

[101] Pett-Ridge, Kuebbing, Allegra C. Mayer, et al., *Roads to Removal: Options for Carbon Dioxide Removal in the United States*; IEA, *Direct Air Capture: A Key Technology for Net Zero*.

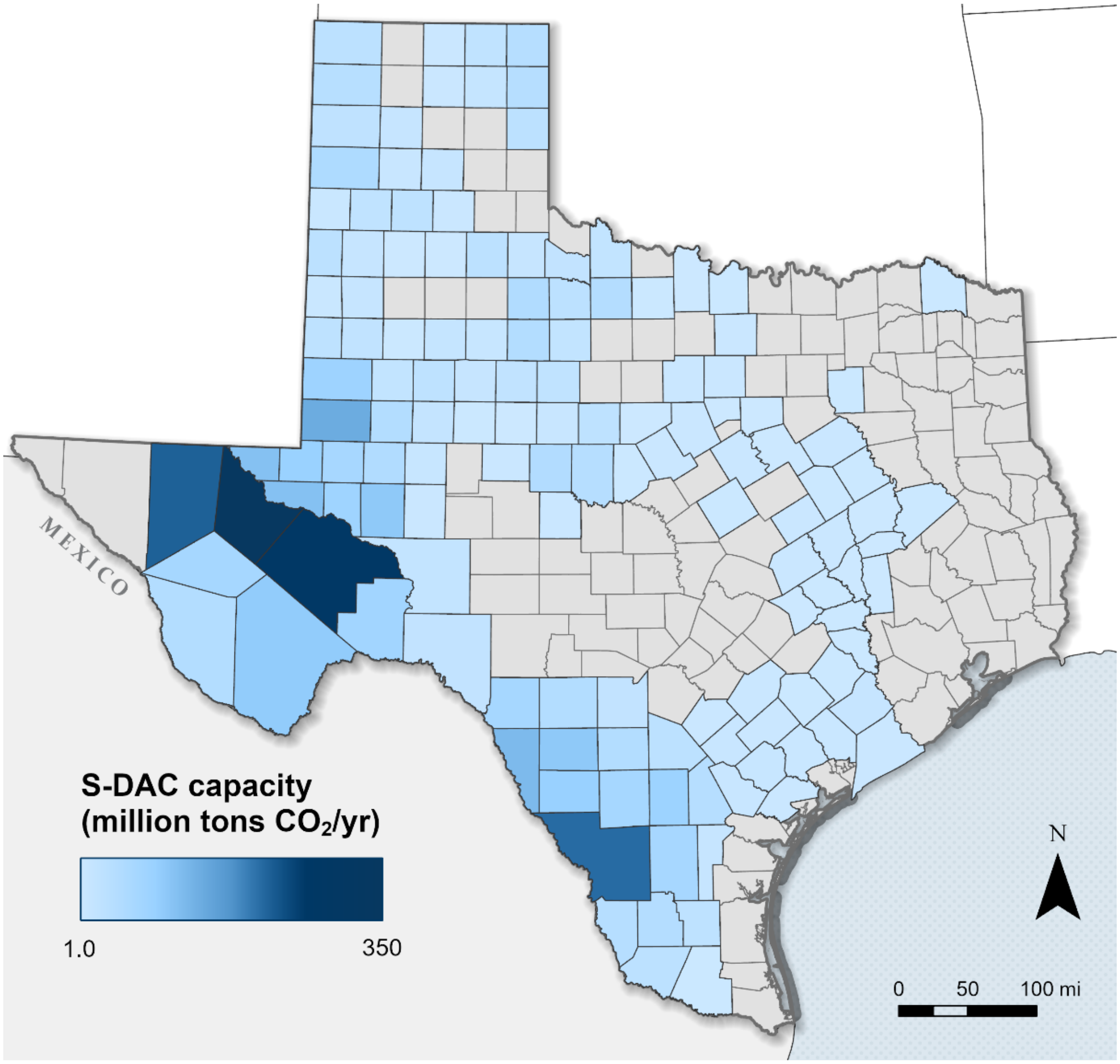
[102] Abramson et al., *An Atlas of Direct Air Capture: Opportunities for Negative Emissions in the United States*; Pett-Ridge, Kuebbing, Allegra C Mayer, et al., *Roads to Removal: Options for Carbon Dioxide Removal in the United States*.

[103] Boerst et al., "Strategic Siting of Direct Air Capture Facilities in the United States."

[104] Pett-Ridge, Kuebbing, Allegra C. Mayer, et al., *Roads to Removal: Options for Carbon Dioxide Removal in the United States*.

[105] Pett-Ridge, Kuebbing, Allegra C. Mayer, et al., *Roads to Removal: Options for Carbon Dioxide Removal in the United States*.

Figure 6. Annual capacity for S-DAC deployment, by county



Source: Figure made by GPI with data from Pett-Ridge et al., *Roads to Removal* (2023).

particularly for modular or small-scale projects. Siting near existing storage wells and pipelines can lower capital requirements, fill available capacity in existing infrastructure, and create cost-sharing opportunities for other developers. These synergies can enhance the financial feasibility of early DAC deployment while supporting more efficient use of Texas's pipeline and storage network.

DAC and low-carbon energy

Texas is well-positioned to provide DAC systems with the low-carbon energy they require. The state leads the nation in wind energy production and can produce abundant, low-cost natural gas that could be utilized to pair DAC with natural gas with carbon capture. [106] Texas's primary electric grid, managed by ERCOT, has historically maintained quicker approval timelines than other independent system operators. [107]

However, Texas's grid is facing growing constraints. Interconnection queues have increased in length, with some projects waiting up to four years for approval, due in part to transmission capacity and the need for grid planning. [108] The interconnection queue currently has 290 GW of generation and 120 GW of storage, which is more than triple the state's current peak demand. [109]

Delays are compounded by limited transmission buildout, especially in high renewable deployment regions like West Texas, where projects frequently face thermal overloads, voltage stability issues, and infrastructure bottlenecks. [110] Additionally, surging electricity demand from data centers, hydrogen production facilities, and electrified industrial operations will intensify grid planning complexity and strain available capacity, particularly in ERCOT's West and South zones. [111]

These conditions suggest that new, high-load technologies, like DAC, could face interconnection challenges, including delays or increased costs, unless paired with behind-the-meter, low-carbon electricity generation, sited strategically to avoid bottlenecks, or co-located with dedicated low-carbon electricity. [112]

While Texas's deregulated market offers more flexibility than other states, timelines for renewable project development and financial close often don't align with DAC project schedules. Despite these hurdles, roadmap stakeholders agreed that Texas remains one of the easiest states to access clean power, including behind-the-meter solutions.

Another potential and underutilized source of low-carbon energy for DAC in Texas is the use of waste heat from electric power and industrial facilities, including through combined heat and power systems. [113] Combined power and heat facilities are particularly relevant for DAC systems that typically need both electricity and heat to operate. Smaller modular DAC units could benefit from co-locating at facilities where heat is already being produced but otherwise goes unused. Using this waste heat improves overall system efficiency and can reduce the cost and carbon intensity of DAC deployment. [114] Waste heat recovery could offer a range of benefits for operators and the state by creating jobs, improving industrial energy efficiency and competitiveness, lowering fuel and electricity costs, and reducing overall emissions. Facilities

[106] US Energy Information Administration, "Texas State Profile and Energy Estimates"; US Energy Information Administration, "Net Generation for All Solar, Annual"; US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

[107] Rand et al., *Queued Up: 2024 Edition*.

[108] Electric Reliability Council of Texas, *Report on Existing and Potential Electric System Constraints and Needs*.

[109] Electric Reliability Council of Texas, *Report on Existing and Potential Electric System Constraints and Needs*.

[110] Electric Reliability Council of Texas, *Report on Existing and Potential Electric System Constraints and Needs*; Rand et al., *Queued Up: 2024 Edition*.

[111] Electric Reliability Council of Texas, *Report on Existing and Potential Electric System Constraints and Needs*.

[112] Electric Reliability Council of Texas, *Report on Existing and Potential Electric System Constraints and Needs*.

[113] Abramson et al., *An Atlas of Direct Air Capture: Opportunities for Negative Emissions in the United States*.

[114] Abramson et al., *An Atlas of Direct Air Capture: Opportunities for Negative Emissions in the United States*.

that capture and reuse waste heat are often more resilient to power outages and can support grid stability.[115] Texas has more than 100 combined power and heat facilities and more than 150 industrial sites with potential for waste heat recovery, particularly along the Gulf Coast.[116]

Texas requires critical governmental facilities to consider combined power and heat in some cases, and the Houston Advanced Research Center also provides guidance on opportunities through DOE's Southcentral Combined Heat and Power Technical Assistance Partnership.[117] However, the roadmap did not identify an existing resource evaluating the true potential for waste heat recovery and DAC deployment in Texas. Additionally, Texas does not offer dedicated systems for industrial or power sector operators to pair their waste heat with DAC systems and enhance credit quality under voluntary carbon markets.

Recommendation: Support a targeted feasibility assessment to identify high-potential waste heat pairing opportunities for DAC

Texas could consider supporting a targeted feasibility assessment that identifies the potential for the co-location of DAC and recoverable waste heat. This assessment would move beyond general facility counts to evaluate the location, temperature range, and consistency of waste heat streams suitable for DAC. It would also examine proximity to CO_2 transport and storage infrastructure, to inform siting decisions for DAC projects seeking to utilize waste heat. The study could also identify barriers that currently prevent DAC developers from accessing industrial heat.

The study would provide actionable data to guide incentives, siting, and early project development. While the study could be focused on how DAC can utilize waste heat, the results of the study would be valuable for other potential applications in Texas, offering a broad impact for the state.

DAC water use

Water requirements for DAC systems vary significantly, based on technology type, climate, and siting decisions.[118] L-DAC systems generally require more water than S-DAC systems due to their continuous need for solvent regeneration and cooling. Some L-DAC systems may use several tons of water per ton of CO_2 captured, depending on system design and availability of water recycling or cooling infrastructure. In contrast, S-DAC systems typically have lower water demands, though they may still require water for humidification or thermal regeneration, depending on the site conditions.

In water-constrained regions or areas experiencing drought, these differences are critical to technology selection and project planning. Arid and semi-arid areas of West Texas, which have abundant solar and wind resources, face groundwater scarcity and increasing competition from agricultural and energy uses, making the lower water intensity of S-DAC systems a distinct advantage. Meanwhile, along the Gulf Coast and in East Texas, DAC projects

[115] US Department of Energy, *Combined Heat and Power in Resilience Planning and Policy*.

[116] Texas Comptroller of Public Accounts, "Combined Heat and Power in Texas"; Abramson et al., *An Atlas of Direct Air Capture: Opportunities for Negative Emissions in the United States*.

[117] Texas Comptroller of Public Accounts, "Combined Heat and Power in Texas."

[118] Keith et al., "A Process for Capturing CO_2 from the Atmosphere."

may have greater access to surface or industrial water sources, making L-DAC more viable. However, operators must still assess local permitting requirements, potential impacts on aquifers or local users, and the availability of non-potable or recycled water. Region-specific siting that accounts for water needs and sources will be essential to ensure that DAC deployment in Texas remains both environmentally responsible and economically feasible.

As mentioned in the carbon capture section, the roadmap recommends that Texas policymakers, water agencies, and industry leaders pursue long-term regional water planning that explicitly accounts for both carbon capture and direct air capture. This coordinated approach is essential to balance competing water demands, ensure that DAC deployment does not worsen existing water stress, and align project siting with broader state and regional water sustainability goals.

Federal incentives for DAC

Federal incentives, such as 45Q and US DOE project funding, have helped create a foundation for DAC development across the US, including Texas. The 45Q tax credit offers $180 per metric ton of CO_2 removed and permanently stored in geologic formations or utilized in the development of products or for enhanced oil recovery. [119] Additionally, the DOE established the Regional Direct Air Capture Hubs through funding from the Infrastructure Investment and Jobs Act, including the South Texas DAC Hub. [120]

However, these federal programs and incentives are not likely to cover the full cost of deploying future commercial DAC projects. In general, high capital costs, inflation, and rising interest rates have substantially increased costs for carbon management projects since 2020, which likely holds true for DAC as well. [121] Additionally, the status of federal funds for many projects is currently under review by the DOE, creating additional uncertainty for project viability.

Adjusting 45Q to account for rising costs, as recommended in the carbon capture section, could improve DAC project viability by closing cost gaps and attracting the private investment needed for large-scale deployment in Texas.

State incentives for DAC

Texas has begun to explore ways to support direct air capture through legislation and integration with existing clean energy programs, but the state does not currently offer broadly accessible, dedicated financial mechanisms for DAC deployment. While the federal 45Q tax credit provides the largest incentive for DAC projects in the near term, credit levels alone may not be sufficient to close the cost gap for large-scale deployment, particularly given DAC's high capital and operational costs. Texas has an opportunity to complement federal incentives with modest, targeted state actions that could

[119] Carbon Capture Coalition, Primer: 45Q Tax Credit for Carbon Capture Projects; Credit for Carbon Oxide Sequestration; Carbon Capture Coalition, The One Big Beautiful Bill Act of 2025.

[120] Occidental et al., "Occidental and ADNOC's XRG Agree to Evaluate Joint Venture to Develop South Texas Direct Air Capture Hub"; US Department of Energy, "Regional Direct Air Capture Hubs"; 1PointFive, "1PointFive's South Texas Direct Air Capture Hub Awarded U.S. Department of Energy Funding."

[121] Carbon Capture Coalition and Brown Brothers Energy and Environment, 45Q Research Brief: Ensuring the Continued Success of the American Carbon Management Industry; Moniz et al., Unlocking Private Capital for Carbon Capture and Storage Projects in Industry and Power.

attract early projects and position the state as a national leader in DAC.

State procurement is a straightforward way to support DAC and should be considered as an incentive for DAC developers. Texas has not historically engaged in procurement programs of this kind for carbon removal. However, procurement and other state-level approaches can help reduce first-mover costs and encourage deployment. In 2023, Texas legislators considered proposals that would have provided DAC support, including a sales and use tax exemption for DAC facilities and their components. [122] This indicates there may be interest in advancing similar measures in the future. There are few commercial DAC facilities in operation or development in Texas, so an exemption would likely have a low near-term fiscal impact while helping reduce first-mover costs for developers. As the market grows, the exemption could position Texas to continue attracting investment in DAC.

Recommendation: Ensure DAC is eligible for carbon capture incentives in Texas.

Several of the incentive updates outlined in the Carbon Capture section, including expanding eligibility for the Sales and Use Tax Exemption, the property tax exemption, and other modest state support measures, could also apply to DAC facilities. Because CO_2 captured through DAC is chemically identical to CO_2 from industrial point sources once purified, updating these incentives to explicitly include DAC would allow shared use of CO_2 transport and storage infrastructure, improve project economics, and reduce duplicative investment.

Air permitting DAC in Texas

Direct air capture projects follow the same federal Clean Air Act and TCEQ permitting processes outlined in the Carbon Capture section, but several factors can influence how these requirements apply in practice.

Unlike many carbon capture retrofits, DAC facilities are often located on greenfield sites, giving developers more control over site design and permitting from the outset. Depending on the scale of on-site emissions from processes, such as sorbent regeneration or compression, a DAC project may qualify as a minor source, which can shorten review timelines. However, projects with significant combustion equipment, or those located in nonattainment areas, may still trigger major source review requirements.

DAC deployment in Texas

Texas is emerging as a national leader in DAC. Multiple commercial-scale projects are under development across the state, using various DAC technologies to remove CO_2 from the ambient air. [123] These projects are supported by public-private partnerships, federal funding, and led by oil and gas and tech companies. As of June 2025, four major DAC projects have been proposed in the state. In the Permian Basin, the Stratos facility in Ector County (developed by Occidental Petroleum subsidiary 1PointFive) is under construction and is expected to begin operations in the near future. Stratos recently received Class VI permits from the US EPA (the first Class VI permits approved for a DAC facility), and the

[122] Texas Legislature, “Texas Legislature Online - 88(R) History for HB 1158.”

[123] 1PointFive, “South Texas DAC Hub.”

facility is designed to capture up to 500,000 metric tons of CO_2 annually. [124]

In South Texas, 1PointFive is also developing the South Texas DAC Hub, and is partnering with King Ranch in Kleberg County. US DOE has awarded the project $50 million, with potential to award it up to $650 million. The hub aims to remove 500,000 metric tons of CO_2 per year and has the potential to scale up to 30 $MMtCO_2$ removal and store 3 billion metric tons of CO_2. [125] The project recently announced an agreement with XRG to evaluate a joint venture opportunity in the South Texas DAC Hub, which includes XRG considering investing up to $500 million in the project. [126]

In West Texas, Skytree, Verified, and Greenalia are developing Project Concho. The project is located in Tom Green County and is set to be fully powered by wind. The facility is aiming to capture 50,000 metric tons annually and scale to 500,000 tons by 2030. [127]

Other carbon dioxide removal considerations

While this section focuses on DAC, Texas has significant potential to deploy a broader portfolio of carbon removal approaches. Expanding and scaling these technologies could yield additional economic, environmental, and social benefits. Existing and potential carbon removal incentives, such as tax credits, grants, or procurement programs, could be designed to support DAC alongside other approaches, using approach-neutral, performance-based criteria. To advance this broader agenda, Texas could:

- Allocate funding to assess deployment and scaling potential for a diversity of carbon removal approaches
- Include carbon removal experts on the Carbon Management Policy Council
- Ensure programs and incentives are developed with technology-neutral, performance-based criteria to support innovation across technologies

[124] Occidental and 1PointFive, *Occidental and 1PointFive Secure Class VI Permits for STRATOS Direct Air Capture Facility*.

[125] 1PointFive, “1PointFive’s South Texas Direct Air Capture Hub Awarded U.S. Department of Energy Funding.”

[126] 1PointFive, *Occidental and ADNOC’s XRG Agree to Evaluate Joint Venture to Develop South Texas Direct Air Capture Hub*.

[127] Verified Carbon, “Project Concho.”

HYDROGEN AND CARBON MANAGEMENT

Hydrogen is an energy carrier that produces no carbon emissions at the point of use and is increasingly viewed as a strategic tool to reduce emissions in hard-to-abate sectors. [128]

Texas has been at the forefront of US hydrogen production for decades, with deep expertise, existing infrastructure, and abundant energy resources that make it uniquely positioned to lead in low-emissions hydrogen deployment. [129]

The roadmap includes hydrogen production primarily in the context of carbon management, specifically where hydrogen is produced from natural gas and paired with CCS to reduce lifecycle emissions. This section includes the following recommendations.

Recommendations:

- Support continued federal investment in the 45V Hydrogen Production Tax Credit
- Expand hydrogen participation across all Texas Emissions Reduction Plan (TERP) programs
- Task the Texas Hydrogen Production Policy Council with providing legislative recommendations on incentives
- Convene the Texas Hydrogen Production Policy Council to advance international export opportunities.
- Support public understanding of hydrogen through targeted education and outreach
- Strengthen safety and emissions standards
- Examine opportunities for produced water for hydrogen use

Hydrogen production pathways

Hydrogen is commonly used in a range of industrial applications, including petroleum refining, ammonia production, and chemical manufacturing. [130] It can also serve as a lower-emissions fuel in sectors where electrification is less practical, such as heavy-duty transportation, maritime shipping, and steelmaking. [131]

While geologic hydrogen production is being explored, hydrogen has traditionally been produced from other compounds, typically hydrocarbons or water. Primary commercial production methods of hydrogen are steam methane reforming (SMR) and electrolysis. [132] SMR is the most common pathway and uses high-temperature steam to extract hydrogen from natural gas. When paired with CCS, the majority of CO_2 emissions can be captured, lowering the carbon intensity of the resulting hydrogen. [133] However, emissions reductions are heavily influenced by capture rate.

Additional methods are emerging for producing hydrogen through a natural gas feedstock, including autothermal reforming (ATR) and

[128] Great Plains Institute, "Hydrogen 101."

[129] Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*.

[130] Fuel Cell & Hydrogen Energy Association, "Hydrogen in Industrial Application."

[131] Fuel Cell & Hydrogen Energy Association, "Hydrogen Basics."

[132] Great Plains Institute, "Hydrogen 101."

[133] Conklin and Beresnyak, "Unraveling the Hydrogen Rainbow"; Saunders, "Getting to Clean: The Carbon Capture Imperative for Blue Hydrogen."

methane pyrolysis. ATR uses a similar process to steam methane reforming, but much of the required heat for the process is generated internally, increasing the amount of capturable CO_2 and creating a more cost-effective process. [134] Methane pyrolysis uses heat to “crack” natural gas, creating a usable hydrogen component and various forms of carbon. [135]

The emissions reduction potential of hydrogen produced using methods that use a natural gas feedstock is highly dependent on ensuring that upstream methane leakage is low. [136] Various studies have indicated that natural gas production in Texas, particularly in the Permian Basin, have emissions intensities related to produced natural gas that are higher than the national average. [137] The oil and gas sector has acknowledged this challenge and taken steps to improve performance through collaborative initiatives and technology adoption. The Texas Methane & Flaring Coalition, a voluntary group of industry participants, has advanced efforts to improve flaring data, share best practices, and reduce routine flaring, setting a goal of eliminating routine flaring by 2030. [138] Reported flaring volumes have declined since 2019, supported by infrastructure improvements and operational efficiencies. [139] At the same time, continued monitoring and independent verification are needed to ensure that reported reductions translate to real, sustained emissions cuts. Achieving durable reductions will likely require a combination of voluntary initiatives, technological improvements, and regulatory oversight to ensure consistent performance across the sector.

Texas has the resources and infrastructure to support all production pathways. In the context of SMR, ATR, and methane pyrolysis, the state’s abundant natural gas supply and growing CCS infrastructure position it to support scalable, lower-carbon hydrogen development.

Additionally, hydrogen derivatives, such as ammonia, methanol, and others, play a crucial role in enabling hydrogen to be more easily transported, stored, and integrated into existing chemical markets and infrastructure. [140]

Texas and hydrogen

Texas has been a national leader in hydrogen production for decades. Nearly one-third of US hydrogen is produced in the state, primarily through conventional SMR using Texas’s abundant natural gas supply. [141] The state also hosts the country’s largest hydrogen pipeline

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[134] Clean Air Task Force and Hensley Energy Consulting, *Preliminary Performance Comparisons of Hydrogen Production by AutoThermal Reforming and Steam Methane Reforming of Natural Gas with Low CO_2 Emissions – Preliminary Estimates of Cost of H_2 from Auto-Thermal Reforming*; Moniz et al., *Unlocking Private Capital for Carbon Capture and Storage Projects in Industry and Power*.

[135] Modern Hydrogen, “Our Process.”

[136] IEA, “Comparison of the Emissions Intensity of Different Hydrogen Production Routes.”

[137] Environmental Defense Fund, “Permian Methane Analysis Project”; Khutal et al., *Life Cycle Analysis of Natural Gas Extraction and Power Generation: US 2020 Emissions Profile*.

[138] Texas Oil & Gas Association, *Texas Methane and Flaring Coalition Announces Goal of Ending Routine Flaring by 2030*.

[139] The Railroad Commission of Texas, “Christian Applauds Report of 50% Reduction in Methane Intensity Amid Record Production.”

[140] Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*.

[141] H.R. No. 590.

infrastructure, with over 1,100 miles, concentrated along the Gulf Coast. The state is home to the largest US operations of major global hydrogen producers, including Air Products, Linde, and Air Liquide. [142]

Texas's hydrogen production has traditionally served industrial markets, including petroleum refining and chemical manufacturing. [143] These sectors remain central to the state's economy and offer near-term opportunities for reducing emissions through CCS-enabled hydrogen production. As previously highlighted, hydrogen is gaining interest as a low-emissions fuel for harder-to-electrify sectors, including long-haul transportation, maritime shipping, and steelmaking.

Several recent projects illustrate how deploying hydrogen and carbon management at scale could occur in Texas. ExxonMobil's proposed Baytown Project would produce low-emissions hydrogen and ammonia by capturing approximately 98 percent of the CO_2 generated through the ATR process. The project would be supported by co-located CCS infrastructure and includes an offtake agreement with Marubeni for low-carbon ammonia exports. [144] As of November 2025, the company has paused plans to build this project, citing weak customer demand. [145]

Woodside's proposed Beaumont Project, formerly OCI Clean Ammonia, would supply global markets with low-emissions ammonia, produced using Texas-based hydrogen and CCS. [146] Additionally, the nation's largest gas-electric municipal utility, CPS Energy in San Antonio, would deploy methane pyrolysis technology from Modern Hydrogen to produce clean hydrogen for energy and solid carbon to enhance asphalt. [147]

These examples highlight Texas's competitive advantage in developing co-located hydrogen and CCS hubs that share infrastructure, reduce cost and permitting risk, and enable the production of low-emissions hydrogen and hydrogen derivatives. Texas primacy for Class VI wells, as described further in the Carbon storage section, can provide greater regulatory certainty for CCS-integrated hydrogen projects.

With growing demand for low-emissions hydrogen in both domestic and international markets, Texas is well-positioned to build on its existing strengths and capture the economic, infrastructure, and export opportunities associated with this emerging sector.

The opportunity for a robust low-emission hydrogen economy in Texas is also gaining global attention, as detailed in a recent report highlighting opportunities for Dutch businesses. [148] While the report was drafted prior to changes to 45V, the report's post-election analysis concluded that the foundation of the Texas hydrogen ecosystem remains strong. Moving forward, low-emission hydrogen produced in the state will likely need to be verified and certified to meet evolving domestic

[142] Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*.

[143] Medlock and Hung, *Developing a Robust Hydrogen Market in Texas*; Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*.

[144] ExxonMobil, *Marubeni & ExxonMobil Low-Carbon Ammonia Deal*.

[145] Dang, "Exxon Freezes Plans for Major Hydrogen Plant amid Weak Customer Demand."

[146] Woodside Energy, "Beaumont New Ammonia."

[147] Nazir, "CPS Energy and Modern Hydrogen Launch Clean Hydrogen Project."

[148] Netherlands Enterprise Agency, *Texas as Powerhouse of the Clean Hydrogen Economy: Opportunities for Dutch Businesses*.

and international standards for lifecycle emissions, ensuring continued market access and competitiveness.

Texas's growth potential

Texas has a strategic opportunity to expand its leadership in hydrogen by aligning production with emerging market trends and maximizing available federal incentives with targeted state incentives. With the modified 45V Clean Hydrogen Production Tax Credit (45V) creating a near-term window for project development, Texas can attract new investment, accelerate infrastructure buildout, and position itself as a global supplier of certified low-emissions hydrogen. At the same time, evolving domestic and international standards for lifecycle emissions are shaping long-term competitiveness, reinforcing the need for Texas to scale hydrogen production methods that meet market-driven certification requirements.

Federal incentives: 45V Clean Hydrogen Production Tax Credit

The 45V tax credit offers a federal incentive of up to $3.00 per kilogram of low-carbon hydrogen, creating a critical window of opportunity for Texas to capitalize on federal investment. By taking steps to help the state's hydrogen industry, Texas can ensure that federal investments flow to local projects, while strengthening the state's economy and diverse energy portfolio and positioning it as a global hydrogen hub.

Lifecycle emissions can vary significantly within each production method, depending on energy inputs, process design, and facility location. For 45V, the US DOE's Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model can be used to evaluate well-to-gate carbon intensity of hydrogen production on a project-specific basis. [149] GREET is increasingly used to determine eligibility for federal incentives and international certifications and allows hydrogen producers and policymakers to make informed comparisons between pathways.

Hydrogen producers looking for lower emissions through carbon capture must choose between the 45Q and 45V tax credits for their projects, as these two credits cannot be combined. [150] The roadmap does not analyze which option will be better for projects in Texas, as this will vary depending on project specifics and is an individual business decision for each company to consider. Changes to the 45Q and 45V tax credits from the 2025 passage of the One Big Beautiful Bill Act are expected to have an impact on project considerations. [151] It will be important to continue closely monitoring federal developments to determine how changes will impact Texas companies and inform their long-term investment decisions.

The federal passage of H.R. 1, the One Big Beautiful Bill Act, in July 2025, modified the 45V Clean Hydrogen Production Tax Credit. Notably, qualified facilities are now required to begin construction before January 1, 2028, shortening

[149] US Department of Energy, "GREET."

[150] Sadler, "Stacking Rules, Bonus Credits, and the Future Industrial Markets the IRA Aims to Create."

[151] H.R. 1 - One Big Beautiful Bill Act, H.R. 1; Fuel Cell & Hydrogen Energy Association, "One Big Beautiful Bill Act: Hydrogen and Fuel Cell Industry Impacts."

the timeline granted by the original 2022 Inflation Reduction Act by five years. [152]

In the near term, 45V presents Texas with an opportunity to bring significant federal incentives and private investment to the state, particularly given the state's strong history of supporting business growth through regulatory efficiency and consistent and strategic incentive structures. Over a longer time horizon, Texas will be a key voice in advocating for extending 45V to ensure Texas and the US remain global leaders in the production of low-emission hydrogen and hydrogen-derived products.

Recommendation: Support continued federal investment in the 45V Hydrogen Production Tax Credit

Texas stakeholders should continue to advocate for enhancements to 45V. A stronger and more stable 45V credit will increase project viability, attract private capital, and help Texas maintain its leadership in low-emissions hydrogen production. Given the accelerated construction deadline and evolving program rules, Texas stakeholders should also push for greater certainty and alignment between federal timelines and project development needs. Supportive actions may include:

- Submitting public comments and congressional testimony
- Participating in industry or multi-stakeholder coalitions advocating for hydrogen incentives
- Sharing Texas-specific data on project economics, workforce potential, and global competitiveness
- Urging formal support from the governor's office and state legislators
- Highlighting Texas's success in hydrogen projects

The 45Q tax credit also presents a parallel opportunity for Texas to strengthen its leadership in carbon management. As noted in the Carbon Capture section, continued advocacy for enhancements to 45Q will be essential to ensuring that hydrogen production, paired with carbon capture, remains competitive in global markets.

State incentives

Texas has several hydrogen and carbon management projects supported by federal incentives and private investment. However, the current incentive structure may not fully close cost gaps in all cases or provide long-term market certainty. The federal 45V and 45Q tax credits are the greatest near-term driver of low-emissions hydrogen production through carbon management, but do not make all project types economical. Texas has an opportunity to further complement federal incentives through existing and new state programs that strengthen the economic case for hydrogen production, distribution, and use.

One of the state's most established tools for emissions reduction is TERP. TERP provides grants and incentives to reduce nitrogen oxides and other pollutants from engines, vehicles, and related infrastructure. The program is administered by TCEQ and funded through legislative appropriations and dedicated fees. [153] Several TERP programs already include hydrogen

[152] H.R. 1 - One Big Beautiful Bill Act, H.R. 1.

[153] Texas Comptroller of Public Accounts, "Motor Vehicle Tax Guide"; Texas A&M Engineering Experiment Station, "Texas Emissions Reduction Program."

as an eligible alternative fuel, creating a foundation Texas can build on to expand low-emissions hydrogen deployment beyond transportation.

The Alternative Fueling Facilities Program funds the construction or expansion of fueling and charging facilities for alternative fuels, including hydrogen, in eligible counties. This program supports the buildout of publicly accessible hydrogen fueling stations and helps establish fueling corridors that reduce adoption barriers for heavy-duty vehicles. [154]

The Rebate Grants Program provides funding to replace or repower on-road, heavy-duty diesel vehicles and certain non-road equipment with near-zero or zero-emission alternatives. Hydrogen-powered vehicles qualify under this program, and applicants may also receive support for associated refueling infrastructure. By offsetting higher upfront costs, this program helps fleets transition to hydrogen while meeting NO_x reduction targets. [155]

The Texas Hydrogen Infrastructure, Vehicle, and Equipment Grant Program offers competitive grants in eligible counties for hydrogen vehicles, equipment, and refueling infrastructure. Applications score higher for larger reductions in NO_X emissions, and at a lower cost per ton. The last round of $16 million in grants was awarded to eight projects in 2024, and the next round of grants is projected to open in January 2026. [156] By building this existing framework beyond mobile sources, Texas could expand support to stimulate additional low-emissions hydrogen deployment across other sectors and applications.

The Governmental Alternative Fuel Fleet Grant Program allows state and local agencies to purchase or lease alternative-fuel vehicles and install fueling infrastructure. Hydrogen is an eligible fuel, allowing public-sector fleets to lead by example in adopting low-emissions technologies and expanding early market demand. [157]

The Emissions Reduction Incentive Grants and Diesel Emissions Reduction Incentive programs fund replacement or repower projects for locomotives, marine vessels, and non-road engines. While not hydrogen-specific, both programs permit alternative-fuel technologies that meet emissions-reduction thresholds, offering potential support for hydrogen-powered maritime, rail, or industrial applications. [158]

Together, these programs provide a strong base for state support of hydrogen and carbon management. Expanding eligibility to include hydrogen end uses beyond mobile sources, such as industrial fuel switching, backup power, and hydrogen-based energy storage, would align state policy with federal priorities and private-sector momentum. Updating program metrics to account for both NO_x and CO_2 reductions would further incentivize low-emissions hydrogen deployment across the value chain.

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[154] Alternative Fueling Facilities Program.

[155] Texas Emissions Reduction Plan.

[156] Texas Commission on Environmental Quality, “Grants for Hydrogen Infrastructure, Vehicles, and Equipment.”

[157] Texas Commission on Environmental Quality, “Grants for Alternative Fuel Government Fleets.”

[158] Texas Commission on Environmental Quality, “TERP Grant Programs.”

Recommendation: Expand hydrogen participation across all Texas Emissions Reduction Plan (TERP) programs.

Texas should ensure hydrogen eligibility is consistent across TERP programs and extend funding to a wider range of hydrogen applications.

In addition to TERP, Texas recently launched the Jobs, Energy, Technology, and Innovation (JETI) Program to attract large capital-intensive projects through property tax abatements. The program is administered by the Governor's Office and the Comptroller and provides 10-year school district tax limitations for qualifying projects that meet investment and job creation thresholds. [159] Hydrogen and carbon management facilities could qualify if they meet eligible industry codes and scale requirements. [160] Aligning JETI's eligibility criteria with emerging low-emissions hydrogen and carbon capture projects would create another powerful state incentive to attract investment and anchor hydrogen hubs.

By coordinating JETI's property tax benefits with TERP's emissions-reduction grants and federal incentives like 45V and 45Q, Texas can create a layered incentive structure that supports the entire hydrogen value chain, from production and storage to transportation and end use.

Beyond TERP and JETI, Texas does not currently offer broadly accessible financial mechanisms to support widespread deployment of low-emissions hydrogen, although some counties do provide tax abatements. Texas has an opportunity to fill these financial gaps through several mechanisms, including grants, loans, or tax incentives.

A recent example in Texas was HB 5600, which was considered during the 89th legislative session but not enacted. [161] This bill sought to establish a clean hydrogen development fund to incentivize the development of a low-emissions hydrogen industry in the state, including tax benefits, loans, and grants for projects, workforce development, powered motor vehicles, and items used to produce hydrogen.

Other states are starting to recognize the value of targeted incentives to accelerate hydrogen deployment and could provide useful policy models for Texas. Some examples include:

- Targeted tax credits for specific types of hydrogen production and use. Clarifying the desired end use for hydrogen helps send a clear demand signal to hydrogen producers. For example, requiring that the hydrogen be used in manufacturing, aviation fuel, heat and energy generation, or transportation to qualify. [162]
- Dedicated grant funding to support hydrogen development activities, such as developing and testing technology for the capture and reuse of emissions at industrial sources, producing renewable diesel and ammonia fertilizer and on-the-farm energy storage, or funding specific projects such as low-emissions hydrogen production, storage, and refueling stations. [163]

[159] Texas Comptroller of Public Accounts, "Jobs, Energy, Technology and Innovation Act (JETI)."

[160] Cabrales, "Economic Incentives for the Texas Hydrogen Industry."

[161] H.B. 5600.

[162] House Bill 500.

[163] Omnibus Environment and Natural Resources Appropriations, S.F. No. 3.

Texas could also consider leveraging its significant purchasing power to establish public procurement practices that send a clear demand signal for products made with lower-emissions hydrogen, such as steel purchased for public infrastructure projects and other hydrogen-derived products purchased by the state. In parallel, Texas could also consider playing a facilitating role in connecting private companies to establish offtake agreements. By ensuring that low-emissions hydrogen producers have guaranteed purchasers for future supply, the state can help maintain and expand business certainty. [164] This could also create a positive feedback loop, attracting more companies across the hydrogen value chain to Texas.

Texas has recognized the strategic importance of hydrogen in its energy future and has taken proactive steps to support its development. In 2023, the Texas Legislature established the Texas Hydrogen Production Policy Council through House Bill 2847. [165] This council was tasked with evaluating and recommending policies for hydrogen production, transportation, and storage within the state. In its report from December 2024, the council outlined several key recommendations to support Texas's position in the hydrogen economy. [166] These include maintaining and refining the existing regulatory framework, developing infrastructure to support hydrogen production and distribution, and fostering economic opportunities through targeted investments. The council's efforts underscore Texas's commitment to being a leader in hydrogen energy development and its recognition of the sector's potential to drive economic growth and environmental benefits. However, the Council's term is slated to end in 2030. [167]

Recommendation: Task the Texas Hydrogen Production Policy Council with providing legislative recommendations on incentives

The Council can build on its 2024 report with a brief containing targeted recommendations to inform the legislature about which state incentives would provide the most significant financial return for Texas, ensuring future legislation is creating clear, impactful demand signals and revenue mechanisms.

Based on the Council's findings, Texas could consider complementary social market signals to support maintaining and expanding the hydrogen value chain. These signals could include leveraging universities and institutions for proactive research, development, and deployment, particularly to fill gaps in federal funding.

Global competitiveness: international and domestic markets

To maintain and expand long-term global competitiveness, it will be important for Texas to align its hydrogen production standards with evolving international requirements. Meeting the emissions intensity thresholds established by key export markets, such as the European Union and Asia, will be critical. As global demand shifts toward requiring higher standards for emissions intensity and certification, Texas hydrogen

[164] Douglas, "Hydrogen Offtake Contracts."

[165] H.B. 2847.

[166] Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*.

[167] H.B. 2847.

producers should be prepared to align with these benchmarks to maintain access to key international markets.

Exporting low-emissions hydrogen will also involve long-term offtake agreements and secure logistics with international partners, including import terminals and pipelines to reach inland markets. European countries are eager to partner with Texas to help develop viable markets, such as a joint effort between the Netherlands and Texas initiated in 2022. The two parties agreed to explore the development of a Transatlantic Hydrogen Corridor between the Netherlands and the Texas Gulf Coast. [168]

Domestically, a similar shift is underway, as purchasers of hydrogen-based products are increasingly factoring in lifecycle emissions and certifications. Changing consumer expectations and state-level emissions targets and resiliency goals are beginning to reshape procurement policies and priorities across multiple sectors.

Texas can adapt hydrogen production methods to meet emerging demand without changing the quality of the commodity products, thereby strengthening the state's position and expanding its share in both domestic and international markets.

Recommendation: Convene the Texas Hydrogen Production Policy Council to advance international export opportunities

The Council can provide clear, consensus-based recommendations to the legislature on how to maintain and expand Texas's global hydrogen leadership. The Council should evaluate opportunities to form trans-Atlantic partnerships to advance hydrogen trade, coordinate infrastructure development, and align standards and regulations with European markets. Additionally, the Council should assess whether a low-carbon hydrogen certification or standard is needed to enhance Texas's competitiveness in international markets and encourage export opportunities. Additionally, the Council could consider facilitating collaboration among hydrogen companies and Texas ports, to help lower barriers to entry and risk for companies through shared knowledge and infrastructure.

End uses

Hydrogen is gaining traction for its potential to reduce emissions across multiple sectors, including industry, transportation, and power generation. Industrial uses for hydrogen in the US include petroleum refining, metal treatment, ammonia and fertilizer, and other hydrogen-derived chemicals. [169]

Among the hydrogen-derived chemicals, ammonia is a significant, central product in the hydrogen ecosystem. More than half of the hydrogen produced globally is used to produce ammonia, which is essential for fertilizer and food production. [170]

The emissions intensity of ammonia is directly tied to the emissions intensity of the hydrogen used to produce it. The conventional way to make ammonia is the Haber-Bosch process, which synthesizes ammonia from hydrogen and nitrogen. [171]

Due to conventional methods using the Haber-Bosch process, ammonia production is highly

[168] Netherlands Enterprise Agency, *Texas as Powerhouse of the Clean Hydrogen Economy: Opportunities for Dutch Businesses*.

[169] US Energy Information Administration, "Hydrogen Explained - Use of Hydrogen."

[170] The Fuel Cell & Hydrogen Energy Association, "Hydrogen in Industrial Applications."

[171] Appl, *The Haber-Bosch Heritage: The Ammonia Production Technology*.

concentrated in areas with low-cost natural gas and coal supply, such as the US Gulf Coast, China, and Russia.[172]

Given its natural gas resources and hydrogen infrastructure, Texas is uniquely positioned to bolster domestic production of hydrogen derivatives. In the case of ammonia, this would not only bolster domestic supply chain resilience and national food security but also give a competitive edge in exporting low-emissions intensity ammonia to global markets. Global demand for low-emissions ammonia is growing, particularly as a fuel for maritime shipping, industrial applications, and power generation.[173]

Texas is already advancing the production of lower-emissions ammonia to meet demand from international markets. For example, First Ammonia is developing a flagship electric ammonia project in Victoria, Texas. As of January 2025, the company had selected Worley to complete the front-end engineering design.[174] In late 2024, the project announced Series B funding, including investments from Mercuria Holdings, a Development Bank of Japan affiliated company, and Tokyo-based investment company Manies Group.[175]

Texas is also advancing production of low-emissions ammonia by developing hydrogen projects with carbon capture and storage. These provide valuable case studies as the state expands its leadership in this emerging sector. For example, the Woodside Energy Beaumont New Ammonia project is under construction, with lower-carbon ammonia production expected in the second half of 2026.[176] Woodside's CEO and Managing Director noted that the project is an opportunity to meet growing global demand for ammonia, which is expected to double by 2050, with nearly two-thirds of that growth anticipated to come from low-emissions ammonia.

These projects clearly demonstrate that Texas is already at the forefront of the global shift toward lower-emissions hydrogen and hydrogen-derived products, including ammonia. Integrating carbon capture and storage can also create a positive feedback loop, allowing co-located facilities to share infrastructure and creating additional opportunities to produce low-emissions hydrogen and hydrogen derivatives.

Regulatory oversight

While Texas's established hydrogen regulations provide a strong foundation, future production and infrastructure growth will require continued oversight and public engagement.

CURRENT OVERSIGHT LANDSCAPE

Texas's hydrogen industry is well established and has operated for over 50 years without a major incident.[177] Three key entities currently provide regulatory oversight at the federal and state levels, along with multiple other local entities. At the federal level, the Occupational Safety and Health Administration oversees worker and process safety. At the state level, TCEQ oversees environmental regulations, and the RRC oversees

[172] Homann et al., *Roadmap for Distributed Green Ammonia in Minnesota*.

[173] S&P Global Commodity Insights, "Ammonia Market to Triple by 2050 with Nearly All Growth Coming from Low-Carbon Supply."

[174] Worley, "Leading Design for the First Commercial Scale Electric Ammonia Plant on the US Gulf Coast."

[175] First Ammonia, "First Ammonia Series B Advances Its Flagship Facility in Victoria, Texas and Establishes Ties to Asia."

[176] Woodside Energy, "Beaumont New Ammonia."

[177] Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*.

pipeline transportation and underground storage. These established regulatory structures have successfully supported conventional hydrogen production and should be maintained and leveraged to expand low-emissions hydrogen production in Texas. While these regulatory structures provide the safe and effective operation of hydrogen projects, public understanding of hydrogen remains limited. Many stakeholders are unfamiliar with how safety, emissions, and water use are addressed under existing frameworks, creating space for misperceptions and concern.

Recommendation: Support public understanding of hydrogen through targeted education and outreach

The roadmap recommends identifying state agency officials, elected representatives, and external partners at local organizations who can help develop targeted education programs to help inform constituents on hydrogen and address concerns and uncertainty, particularly regarding how emissions, safety, and water use regulations intersect with hydrogen production. One direction could be to disseminate the recommendations and ongoing findings of the Texas Hydrogen Production Policy Council, ensuring this information is accessible and digestible to a broad audience. Proactive public education and outreach can help build community understanding and acceptance of hydrogen's benefits and tradeoffs, including the role hydrogen has played in the state for decades, creating jobs and providing economic opportunity.

FUTURE OVERSIGHT CONSIDERATIONS

The Hydrogen Production Policy Council's 2024 report includes several regulatory framework recommendations that warrant ongoing consideration and development, especially as hydrogen production technologies evolve and hydrogen transportation, storage, and end use expand. [178] It will be important to take proactive measures to prevent fragmented hydrogen safety and siting requirements across jurisdictions, such as adopting a firm position on federal standards like the National Fire Protection Association's Hydrogen Technologies Code. [179] Additionally, understanding the interaction between federal and state regulatory frameworks will be crucial for strategic planning. [180]

Recommendation: Strengthen safety and emissions standards

Texas should adopt the National Fire Protection Association Hydrogen Technologies Code, or other international fire code or similar programs, and establish a clear, statewide minimum safety standard for hydrogen production, storage, transportation, and end-use.

Water use

Water use along the hydrogen production chain is an important consideration, evidenced by communities in Texas voicing opposition to hydrogen projects that intend to draw on local freshwater supply. [181] An advantage of using

[178] Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*.

[179] National Fire Protection Association, "NFPA 2 - Hydrogen Technologies Code."

[180] Castaline et al., *Federal and Texas Jurisdiction Over Hydrogen Pipeline Transportation: A Comprehensive Analysis and Pathways for Enhancement*.

[181] Baddour, "Water Scarcity and Clean Energy Collide in South Texas."

hydrogen as a fuel instead of combusting fossil fuel is that water is not needed as a coolant in the electrolyzer system or in fuel consumption, significantly reducing the amount of local water needed for operations. [182] Alternative sources, including produced water, brackish water wells, treated industrial wastewater, or desalinated seawater, can further reduce reliance on freshwater and address community concerns, supporting sustainable deployment. [183] The amount of water consumed will ultimately vary depending on factors across various stages of the supply chain. In addition to estimating emissions intensity, the GREET model can be used to calculate water consumption for various hydrogen production methods. [184]

Recommendation: Examine opportunities for produced water for hydrogen use

Led by relevant state agencies, the state should commission a study evaluating the feasibility, environmental implications, and regulatory needs for using produced water and other non-freshwater sources in hydrogen production. The study could:

- Map potential water sources, including produced water, brackish groundwater, treated industrial wastewater, and desalinated seawater, that could supply hydrogen facilities without drawing on freshwater resources
- Assess treatment technologies and costs required to make these sources suitable for use in various hydrogen production methods, including electrolysis and reforming with carbon capture
- Evaluate regulatory barriers and opportunities under existing RRC and GLO authorities, such as produced water reuse rules, permitting brackish water wells, and rights associated with state-owned lands and minerals
- Identify infrastructure and research needs to enable safe and economical use of alternative water sources, including pipelines, treatment facilities, and pilot demonstration projects

Findings from this study could inform future RRC and GLO rulemakings and help establish clear guidelines for integrating non-freshwater use into hydrogen development, thereby reducing community concerns and promoting sustainable, responsible growth of the hydrogen industry in Texas.

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[182] Fuel Cell & Hydrogen Energy Association, “Hydrogen and Water Usage.”

[183] Ramirez et al., “Hydrogen Reality Check: Distilling Green Hydrogen’s Water Consumption.”

[184] US Department of Energy, “GREET.”

CARBON TRANSPORT

While CO_2 can be transported via truck, barge, and rail, pipelines are the most common form of CO_2 transportation over long distances and at high volumes.[185] Texas has a long history of CO_2 pipeline operation in the state, dating back to the development of the enhanced oil recovery process in the 1970s.[186] This development has led to Texas having the largest network of CO_2 pipelines in the US, with 2,325 miles of CO_2 pipeline in service (figure 7).[187] This section includes the following recommendations.

Recommendations:

- Support incorporating recommended practices on pipeline safety from standard-developing organizations
- Enhance public awareness and safety outreach for CO_2 pipelines in regions without existing CO_2 infrastructure

CO_2 pipelines in Texas

More than a dozen companies operate CO_2 pipelines in Texas, ranging from less than a mile to hundreds of miles of CO_2 pipeline. Nearly 75 percent of CO_2 pipeline mileage in Texas is classified as part of an interstate pipeline, connecting to Louisiana, New Mexico, and Oklahoma.[188]

These pipeline networks are distributed across several regions of Texas, including the Permian Basin and along the Gulf Coast. While much of the transported CO_2 is derived from geologic sources, anthropogenic CO_2 has been transported via pipeline in Texas for decades.[189]

CO_2 pipeline safety

The RRC has safety responsibility over intrastate CO_2 pipelines, while the federal Pipeline and Hazardous Materials Safety Administration (PHMSA) has oversight for interstate pipelines.[190]

PHMSA and the RRC require operators to report incidents if they result in an explosion or fire, five gallons or more of CO_2 is released, injury, death,

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[185] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "General Pipeline FAQs."

[186] Wallace et al., *A Review of the CO_2 Pipeline Infrastructure in the U.S.*

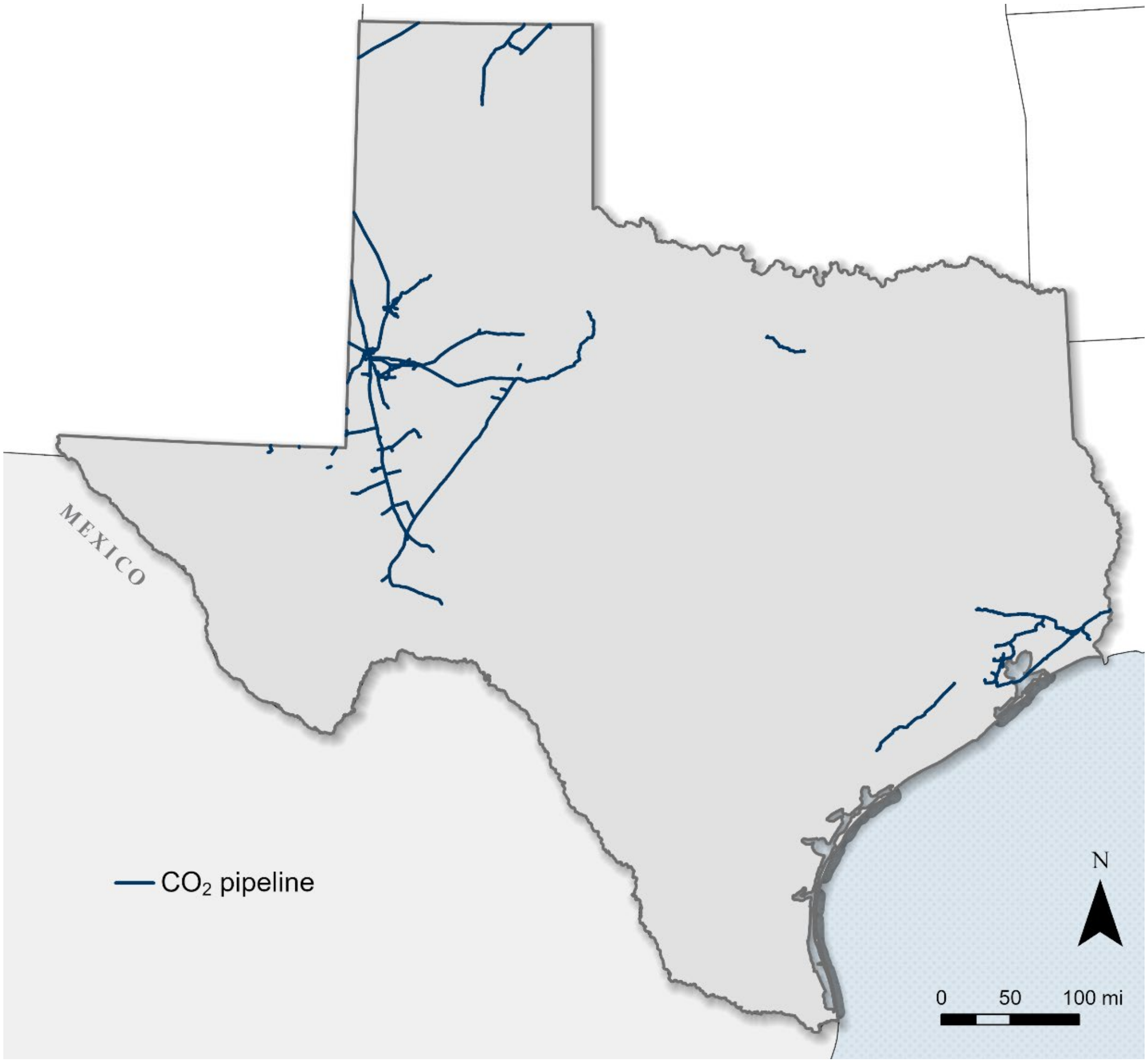
[187] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, *Active CO_2 Pipelines in the NPMS*; The Railroad Commission of Texas, "Pipeline Layers By County."

[188] The Railroad Commission of Texas, "Pipeline Layers By County."

[189] "SACROC Research Project | Gulf Coast Carbon Center."

[190] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, *Gas Transmission and Hazardous Liquid Pipeline Safety Programs Participating States in the Federal/State Cooperative Partnership*; The Railroad Commission of Texas, "Pipeline Safety."

Figure 7. CO_2 pipelines in Texas with a status of "in service"



Source: Railroad Commission of Texas, Pipeline Layers by County (2025).

or estimated property damage exceeding \$50,000. [191] In Texas, fifty-three incidents have been reported for CO_2 pipelines since reporting began in 1994, averaging roughly 400 barrels of CO_2 released per incident. Over 80 percent of incidents reported fewer than 100 barrels of CO_2 released, and only five incidents reported more than 1,000 barrels of CO_2 released. The largest reported incident occurred in 2004, with roughly 7,400 barrels of released CO_2 reported. [192] When transported at the pressure and temperature of a typical pipeline, a barrel of CO_2 equates to roughly 0.1 metric ton. Some of the pipelines in Texas transport millions of metric tons of CO_2 per year, meaning a very small fraction of CO_2 has been released through pipeline incidents, relative

[191] Annual, Accident, and Safety-Related Condition Reporting.

[192] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "Distribution, Transmission & Gathering, LNG, and Liquid Accident and Incident Data."

to the amount of CO_2 transported. [193] CO_2 pipeline accidents have not resulted in an injury or fatality in the state of Texas. [194]

Following a serious incident involving a CO_2 pipeline rupture in Satartia, Mississippi, PHMSA began reviewing portions of 49 CFR Part 195—the federal code that provides regulations for the construction and operation of hazardous liquid and CO_2 pipelines. [195]

While PHMSA was conducting a review of its Part 195 regulations, the American Petroleum Institute (API) released RP 1187, a recommended practice focused on mitigating risks related to geohazards, one of the primary causes of the Satartia incident. [196] Recommended practices published by standard-developing organizations, including API, are commonly integrated into PHMSA rulemaking. [197] While many operators adhere to recommended practices put forth by standards-developing organizations without their inclusion in PHMSA's regulations, incorporating these recommended practices into PHMSA's regulations allows these standards to become a regulatory requirement that operators adhere to.

On January 15, 2025, PHMSA announced proposed new rules for hazardous liquid and CO_2 pipelines, which would have expanded the regulations to include requirements for pipelines transporting CO_2 as a gas, added new requirements for emergency response training, expanded requirements for communicating with the public in the event of an emergency, required more detailed modeling related to dispersion of CO_2 from a rupture, among other changes. [198] The proposed rules were withdrawn after submission, but prior to, final publication in the Federal Register and have not been advanced, as of October 2025.

On May 21, 2025, PHMSA published an advance notice of proposed rulemaking related to the cost-effectiveness of repair requirements for pipelines. [199] On June 4, 2025, PHMSA published an advance notice of proposed rulemaking soliciting feedback related to repealing or amending pipeline safety regulations, particularly as it relates to "eliminat[ing] undue burdens on the identification, development, and use of domestic energy." [200] Neither advance notice of proposed rulemaking appears to continue or

[193] Kammer, *A Review of the Safety Record of CO_2 Pipelines in the United States*; National Petroleum Council, *Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage - Chapter Six - CO_2 Transport*; Wallace et al., *A Review of the CO_2 Pipeline Infrastructure in the U.S.*

[194] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "Distribution, Transmission & Gathering, LNG, and Liquid Accident and Incident Data."

[195] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "PHMSA Announces New Safety Measures to Protect Americans From Carbon Dioxide Pipeline Failures After Satartia, MS Leak."

[196] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, *Failure Investigation Report - Denbury Gulf Coast Pipelines, LLC*; American Petroleum Institute, *API Recommended Practice 1187 (API RP 1187), Pipeline Integrity Management of Landslide Hazards*.

[197] What Documents Are Incorporated by Reference Partly or Wholly in This Part?; US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "Standards Incorporated by Reference."

[198] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "USDOT Proposes New Rule to Strengthen Safety Requirements for Carbon Dioxide Pipelines."

[199] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "Proposed Rule - Pipeline Safety: Repair Criteria for Hazardous Liquid and Gas Transmission Pipelines."

[200] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "Pipeline Safety."

further develop the efforts of the proposed rulemaking from January 2025.

However, Texas can ensure the strong safety record of CO_2 pipelines in the state continues through supporting continued development of CO_2 pipeline safety regulations by PHMSA.

Recommendation: Support incorporating recommended practices on pipeline safety from standard-developing organizations

Supporting the inclusion of recommended practices provided by standard-developing organizations, like RP 1185 and RP 1187 from API, in PHMSA's rulemaking can ensure that regulations remain adaptive to current technological advances and best practices of the industry and community needs. In the absence of federal rulemaking, Texas can be a leader in the safe operation of pipelines by incorporating recommended practices from organizations, like API, in the enforcement of state regulations by the RRC for intrastate pipelines.

Continual development of CO_2 pipeline safety regulations in response to incidents and the advancement of new safety technologies ensures the safety record of CO_2 pipelines remains strong. Additionally, developing regulations that address the concerns of the public can enhance public acceptance of pipelines as a safe mode of transportation of CO_2.

The safe operation of CO_2 pipelines requires preparing emergency responders to effectively mitigate releases of CO_2 from pipeline leaks and ruptures. PHMSA's Pipeline Emergency Response Grant program offers funding to state, county, and local governments to train emergency responders for pipeline incidents in regulatory-defined high consequence areas. For fiscal years 2022 through 2024, PHMSA recommended grants totaling $1.6 million to assist the Texas Division of Emergency Management and the West Central Texas Council of Governments to provide pipeline emergency response training across the state. [201] These federal, state, and local partnerships and grants are critical for developing the emergency response capabilities necessary to ensure the safe operation and emergency response of CO_2 pipelines across Texas.

As outlined further in the Community engagement section of the roadmap, operators are encouraged to meaningfully engage with communities impacted by CO_2 pipelines to ensure the community understands the safety operations of the pipeline and its associated risks. Meaningful engagement should also include operators and regulators understanding and responding to community concerns through knowledge sharing, making modifications to siting or risk-management plans, and addressing community-specific concerns. Additionally, educating communities on the safety of CO_2 pipelines and preparing emergency responders can support community buy-in for projects. While discussions with stakeholders throughout the roadmap's development indicated communities near existing CO_2 pipeline infrastructure may be familiar with their safety considerations, additional education in regions expected to see infrastructure growth may be beneficial.

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[201] US Department of Transportation Pipeline and Hazardous Materials Safety Administration, "Pipeline Emergency Response Grant Awards - 2022-2024."

Recommendation: Enhance public awareness and safety outreach for CO_2 pipelines in regions without existing CO_2 infrastructure

The RRC can take a leading role in creating public-facing resources and safety outreach programs around CO_2 pipelines, particularly in regulatory-defined high consequence areas such as schools, hospitals, and densely populated areas where new CO_2 pipeline development is expected as carbon management projects expand within the state. The state should consider working with third-party organizations to ensure safety training and public awareness programs are appropriate, available, and tailored to local communities. These resources should be accessible, culturally appropriate, and translated into relevant languages to ensure that all communities are informed and prepared.

CO_2 pipeline siting

Texas allows CO_2 pipelines to obtain common carrier status if they are available to the public for hire and agree to the regulations set in Chapter 111 of the Natural Resources Code. [202] This includes publishing tariffs associated with transporting CO_2 through the common carrier pipeline with the RRC. Currently, 1,628 miles (70 percent) of CO_2 pipelines are classified as common carrier in the state of Texas. [203]

Common carrier pipelines also require specifications to be shared with the RRC on acceptable amounts of non-CO_2 constituents (e.g., water, NO_x, SO_2, methane, among others) for an entity to utilize the pipeline. Requiring certain specifications for the transported CO_2 can ensure the safe construction, operation, and maintenance of the CO_2 pipeline, as the presence of non-CO_2 constituents in the transported fluid or gas can cause corrosion and impact the integrity of the pipeline.

In Texas, CO_2 pipelines with common carrier status have the right and power of eminent domain. [204] While operators may register a pipeline as common carrier on their T-4 permit—a permit required by the RRC to operate within the state— the right to eminent domain is established through state statute. [205] Additionally, pipeline operators must show there is "a reasonable probability that the pipeline will actually be used by the public" to obtain common carrier status and exercise eminent domain. [206] Landowners may challenge the designation of the common carrier status of a pipeline in the Texas state court system. [207]

[202] Texas Natural Resources Code - Common Carriers, Public Utilities, and Common Purchasers.

[203] The Railroad Commission of Texas, "Pipeline Layers By County."

[204] Texas Natural Resources Code - Common Carriers, Public Utilities, and Common Purchasers.

[205] The Railroad Commission of Texas, "Pipeline Eminent Domain and Condemnation."

[206] Righetti, "Siting Carbon Dioxide Pipelines"; *Denbury Green Pipeline-Texas, LLC v. Texas Rice Land Partners, Ltd.*

[207] Matsushita et al., "The Texas Supreme Court Clarifies 'Common Carrier' Status Criteria."

CARBON UTILIZATION

After CO_2 or carbon has been removed from the atmosphere or captured from a point source, it can be used directly for or transformed into various products.[208] Currently, CO_2 is mainly used in the fertilizer industry and for CO_2 EOR, but other applications like CO_2-based synthetic fuels, chemicals, and building materials are in development and increasing in use.[209]

Many utilization technologies and techniques are still in the research and development phase and currently face economic barriers to scale, particularly due to high capital costs and immature market demand.

Globally, utilization of CO_2 in product manufacturing could reach hundreds of millions of metric tons per year by 2060.[210] Texas is well-positioned to meet this growing demand. This section includes the following recommendations.

Recommendations:

- Conduct a targeted market and policy assessment for carbon utilization in Texas
- Commission a university-industry partnership to demonstrate the economic viability of CO_2-derived aviation fuel

Federal incentives for utilization

The value of 45Q for permanently stored CO_2 used during the EOR and other utilization processes was increased from $60 per metric ton to $85 per metric ton with the passage of the One Big Beautiful Bill Act in July 2025. This change could improve project economics and lead to increased CO_2 utilization activity in Texas, though it is too early to determine the scale of its impact. While the higher credit reduces the cost gap for utilization projects, it may not fully offset the high capital and operational costs faced by many early-stage technologies.

State incentives for utilization

Texas does not currently offer utilization-specific incentives outside of enhanced oil recovery. Given the varied economic potential, durability, and emissions benefits of different utilization pathways, the state could evaluate targeted mechanisms, such as:

- Tax credits or exemptions for carbon-derived products with verifiable market demand and measurable emissions benefits
- State-backed demonstration grants for high-potential technologies with clear commercial pathways
- Procurement policies that help establish early markets for carbon or CO_2-based materials

These approaches could be structured to complement existing carbon management strategies and advance Texas's broader industrial and economic development goals. It is not yet clear which policy tools would deliver the highest return for the state, in terms of both economic growth and emissions reductions, for carbon or CO_2-based products that are still emerging.

[208] Carbon Capture Coalition, "Environmental Benefits of Carbon Reuse."

[209] IEA, "CO2 Capture and Utilisation."

[210] International Energy Agency, *Putting CO2 to Use: Creating Value from Emissions*.

An assessment of Texas's market opportunities and policy options would help the state focus resources on the most promising pathways, avoid committing to large-scale programs too early, and build a clear understanding of what could best support both economic growth and emissions reductions.

Recommendation: Conduct a targeted market and policy assessment for carbon utilization in Texas

A relevant state agency should commission a short-term market and policy assessment, or pilot program, to determine if and where targeted state investment in CO_2 utilization would be most cost-effective. This effort should compare the lifecycle emissions benefits and economic potential of priority utilization pathways, evaluate applicable state and local policy tools, and test a small-scale incentive, such as a grant or procurement target, for one or two products to gather cost and performance data before considering broader implementation.

Sustainable aviation fuel

Sustainable aviation fuel (SAF) is designed to power aircraft with properties similar to conventional jet fuel but with a smaller carbon footprint. [211] CCS can play a strategic role in the production of SAF by reducing the carbon intensity of the fuel production process through point-source capture at SAF production facilities, electricity generating facilities, or providing CO_2 as a feedstock for synthetic fuels. [212] Similar applications of CCS can also play a role in conventional aviation fuel production. For example, jet fuel with measures applied to reduce its lifecycle CO_2 emissions by 10 percent are recognized as Lower Carbon Aviation Fuels in the International Civil Aviation Organization Carbon Offsetting and Reduction Scheme for International Aviation program. CCS is among the measures that can enable this reduction. [213]

SAF has the potential to bring economic opportunities to Texas in the form of job creation and increased global competitiveness. Rhodium Group estimates that the average number of jobs associated with a 50 million gallon per year SAF facility is between 1,645 and 7,640, depending on the SAF technology used. [214] Additionally, major airlines have made public net-zero commitments, and Texas can leverage its existing infrastructure and aviation expertise to capitalize on these commitments. [215] While sixty billion gallons of aviation fuel are consumed globally each year, announced global capacity for SAF only totals roughly 4.3 billion gallons per year. [216] As such, there is an opportunity for Texas to become an established supplier serving this global market.

Several Texas-based companies are already producing SAF, including Cemvita Corporation, in Houston, which uses CO_2 as a feedstock. In 2023, Cemvita announced an agreement to supply United Airlines with one billion gallons of SAF from its first full-scale plant. [217] Other SAF

[211] US Department of Energy, "Sustainable Aviation Fuel."

[212] Rosales Calderon et al., *Sustainable Aviation Fuel State-of-Industry Report: Hydroprocessed Esters and Fatty Acids Pathway*.

[213] International Civil Aviation Organization, "Lower Carbon Aviation Fuels."

[214] O'Rear et al., "Sustainable Aviation Fuels: The Key to Decarbonization Aviation."

[215] Carbon Credit Capital, *Net Zero Leaders In The Aviation Industry*.

[216] O'Rear et al., "Sustainable Aviation Fuels: The Key to Decarbonization Aviation."

[217] Cemvita, *United Signs Agreement to Buy Up To One Billion Gallons of Sustainable Aviation Fuel from Cemvita*.

producers in Texas include Pathway Energy, in Port Arthur, and Infinium, in Reeves County.[218]

The Texas state government has a modest incentive structure in place for SAF. The Franchise Tax Credit for Clean Energy Projects, for which certain SAF projects are benefiting, credits the lesser of $100 million or 10 percent of the total capital cost of the project.[219] The current state statute is more focused on benefiting SAF projects using natural gas refined in Texas than other forms of SAF production.[220] However, other elements of the statute (like the clean fuel incentive surcharge) may create additional indirect market incentives for SAF developers more broadly.

Given the nascent nature of the CO_2-to-SAF pathway compared to other SAF technologies, Texas could consider expanding existing tax credit programs and grants to more explicitly include and attract CO_2-derived SAF companies. However, a Texas-led research and demonstration effort, helmed by academic institutions and private industry, may be a more feasible first step. Such an effort could validate the industry's market potential to Texas policymakers and attract additional investment. Such an effort could position Texas as a national leader in the emerging CO_2-to-SAF market by validating the economic potential of these technologies through real-world cost and performance data.

Recommendation: Commission a university-industry partnership to demonstrate the economic viability of CO_2-derived aviation fuel

This effort should focus on:

- Analyzing the technical and economic feasibility of scaling production of CO_2-derived aviation fuel within the state
- Quantifying potential job creation, capital investment, and export opportunities from CO_2-derived aviation fuel
- Identifying key infrastructure needs and siting advantages (e.g., access to captured CO_2, proximity to aviation hubs)
- Recruiting industry leaders active in Texas to supply operational data or participate in demonstration projects
- Quantify market demand and viability

Chemicals

Captured or removed CO_2 can be used to create chemicals, like methanol, syngas, formic acid, and malic acid, which are used for a variety of products, including fertilizer, plastics, and cleaning products. Of these products, methanol is estimated to have the most potential in terms of market penetration and volumes of CO_2 utilized per year.[221] Interest in producing chemicals from captured or removed CO_2 has increased in the last several years. As of 2021, this sector represents the largest carbon utilization sector, in terms of developers (corporations, startups, and research institutions) worldwide.[222]

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[218] Jenkins, "Infinium Announces Construction of SAF and eFuels Production Facility in Texas"; The Chemical Engineer, "Drax to Expand US Business with Deal to Supply Wood Pellets to Texas SAF Startup."

[219] Senate Research Center, "H.B. 3837 Bill Analysis."

[220] Title 5. Sanitation and Environmental Quality.

[221] Sick et al., *Implementing CO_2 Capture and Utilization at Scale and Speed: The Path to Achieving Its Potential*.

[222] Sick et al., *Implementing CO_2 Capture and Utilization at Scale and Speed: The Path to Achieving Its Potential*.

Texas has a robust chemicals industry, with 58 total facilities. [223] According to a 2023 analysis from the Texas Comptroller's Office, new chemical manufacturing investment was predicted to generate $43 billion in additional output and 182,000 permanent new jobs by 2025. [224] The state has already attracted some low-carbon chemicals producers, including low-carbon methanol facilities operated by ETFuels and Orsted. Both companies plan to utilize captured CO_2 in their production. [225]

Some state-level support for chemical producers exists in Texas that could benefit those utilizing CO_2, specifically those producing alternative fuels using methanol. TCEQ has a Grants for Alternative Fueling Facilities program, for which natural gas and combinations of hydrogen, biodiesel, biodiesel blends, propane, and methanol facilities are eligible. [226] While this grant is not directly targeted at producers utilizing CO_2 in their processes, these producers could still financially benefit from the program. Given CO_2-derived methanol's projected market penetration by 2050, this is a worthwhile industry for the state to continue supporting through this grant program.

Building materials

Captured or removed carbon can be used to produce lower-carbon versions of building materials, such as construction aggregates, asphalt binder, and concrete. [227] Capturing or removing CO_2 and storing it in these materials is considered a long-term form of CO_2 storage, as the CO_2 will remain locked in these materials for at least 100 years. Building materials produced with captured or removed CO_2 are also estimated to be one of the most promising forms of carbon utilization in terms of market penetration. [228]

The cement and concrete industries are an economic powerhouse in Texas, generating over $810 billion in annual revenue and employing over 100,000 people. [229] There is also an ever-growing demand for these products in the state due to Texas's population boom. [230] According to Polaris Market Research, the global market for CO_2-derived construction materials will reach around $961 million by 2034. [231] For Texas producers exporting to other states or to global customers with decarbonization targets, specialization in low-carbon materials can give these producers an edge in the market.

Texas is already home to major producers of low-carbon concrete, including Amrize and Cemex. [232] The state has smaller producers, like Lauren

[223] US Environmental Protection Agency Office of Atmospheric Protection, "Greenhouse Gas Reporting Program (GHGRP)."

[224] Texas Comptroller of Public Accounts, "Natural Gas Overview."

[225] Habibic, "Ørsted Nets up to $100 Million in Federal Funding for E-Methanol Plant in Texas"; Tullo, "Low-Carbon Methanol Planned for Texas."

[226] Texas Commission on Environmental Quality, "Grants for Alternative Fueling Facilities."

[227] International Energy Agency, *Putting CO2 to Use: Creating Value from Emissions*.

[228] Sick et al., *Implementing CO_2 Capture and Utilization at Scale and Speed: The Path to Achieving Its Potential*.

[229] Texas Aggregates & Concrete Association, "Economic Impact Of Concrete Batch Plants In Texas."

[230] Texas Aggregate Concrete Association, "About TACA."

[231] Polaris Market Research and Consulting, "Carbon Capture Construction Materials Market to Reach USD 961.68 Million by 2034, Booming at an Exceptional 42.5% CAGR."

[232] Amrize, "About ECOPact"; Cemex, "Vertua-Leading Sustainable Construction."

Concrete, which uses technology from CarbonCure to inject CO_2 into fresh concrete and is supplying the City of Austin with low-carbon concrete for municipal projects.[233] If more Texas cities adopt low-carbon concrete requirements, as Austin has, they could accelerate demand for CO_2-derived materials and help grow early markets for local producers.[234]

[233] Lauren Concrete, "Lauren Concrete Achieves 1k Tons of CO_2 Savings."

[234] Bramble, "Council Celebrates Earth Day with Plan to Transition to Low-Carbon Concrete."

CARBON STORAGE

Carbon storage is the practice of permanently storing captured CO_2 in deep underground geologic formations. Storage can occur in depleted oil and gas reservoirs, saline geologic formations, or other secure geologic settings that can prevent the upward migration of CO_2. Once injected, the CO_2 is trapped through physical and geochemical processes, ensuring long-term containment.

With extensive sedimentary basins, decades of geological expertise, and existing subsurface infrastructure, Texas is uniquely positioned to lead the next wave of large-scale carbon storage deployment. Many of the same basins that have fueled the state's oil and gas production also have the potential for significant CO_2 storage, supported by a workforce skilled in subsurface engineering and resource management. Multiple commercial-scale storage projects are already advancing in Texas, backed by federal incentives and growing private investment. However, realizing this potential at scale will require more than geological capacity; it will depend on clear regulatory frameworks, well-managed technical risks, such as induced seismicity and orphaned wells and adequate resources for permitting, long-term stewardship, and oversight. This section includes the following recommendations.

Recommendations:

- Participate in training programs
- Monitor Class VI funding and staffing at the RRC
- Clarify permitting timelines for Class VI well permits
- Include a survey in the application process to assess if undocumented wells requiring corrective action are present within the Area of Review (AOR)
- Monitor the need for Seismic Response Areas (SRAs) for Class VI Wells
- Develop additional educational resources on induced seismicity and the developed mitigation regulations and strategies
- Consider establishing a framework for long-term CO_2 storage liability transfer

Geology and historical context

Texas has a long history of exploration and production of its geologic resources. Oil and gas exploration and/or production have occurred in every county in the state and date back more than 100 years. [235] The state continues to be the highest producer of oil and natural gas in the US, producing over two billion barrels of crude oil and 9.8 trillion cubic feet of natural gas in 2023. [236]

Many of the same sedimentary basins that have provided abundant oil and gas production in Texas may be suitable for permanent storage in saline geologic formations. As the name entails, saline geologic formations are geologic formations that do not contain oil and gas resources, instead filled with briny fluids that have salinity levels high enough that they are not considered potential sources of drinking water.

As it relates to the ability of saline geologic formations to permanently store CO_2, these formations are typically deep enough that the

[235] Olien, "The History of Oil Production in Texas"; The Railroad Commission of Texas, "Well Layers By County."

[236] US Energy Information Administration, "Natural Gas Dry Production"; US Energy Information Administration, "Crude Oil Production."

pressure in the formation keeps injected CO_2 in the supercritical state, a phase where the injected CO_2 has a high density, which is typically around 2,400 feet or deeper. Additionally, saline geologic formations that are suitable for CO_2 storage will be deeper than the deepest potential underground source of drinking water (USDW) and include a regionally expansive caprock that does not allow for the upward migration of the injected CO_2, ensuring the CO_2 remains in the storage formation.

Texas also has significant offshore storage potential off the Gulf Coast. The Texas General Land Office has made over one million acres of offshore pore space leases available and awarded seven offshore leases, including the largest storage lease to date of over 270,000 acres with ExxonMobil. [237] The Texas General Land Office estimates the revenue from leasing offshore pore space could generate over $10 billion over thirty years. [238]

CO_2 storage regulation and permitting

CLASS VI PRIMACY

The EPA regulates the construction, operation, and closure of injection wells through its UIC program under the Safe Drinking Water Act. The program's primary goal is to protect USDWs. [239] There are six classes of injection wells, with Class VI wells designed for the permanent injection of CO_2 into deep geologic formations. [240]

The EPA administers Class VI permitting in states that have not yet assumed primacy, and states may seek primary enforcement authority, or primacy, by demonstrating that their regulatory programs meet or exceed federal requirements.

Class VI primacy gives the state more direct oversight of permitting and enforcement and can potentially streamline project permitting. Many states already hold primacy for other well classes and have pursued primacy for Class VI wells as geologic storage activity increases.

Texas' primacy application process began in 2009, when the Texas legislature passed Senate Bill 1387, directing the state to apply. [241] With the passage of House Bill 1284 in 2021, the Texas Legislature clarified that the RRC would have oversight of the Class VI well program, if/when the state received primacy. [242] Following this internal rule development and public comments, the state formally submitted its application to the EPA in December 2022. [243]

In anticipation of Class VI primacy, in 2022, the RRC adopted a new set of rules under 16 Texas Administrative Code, Chapter 5, Subchapter C,

[237] Texas General Land Office, "Texas Land Commissioner Buckingham Secures Largest Carbon Sequestration Lease in the United States"; Meckel, "CCS Landscape - Gulf Coast"; Texas General Land Office, "Commissioner Buckingham Announces Planned State Land Carbon Dioxide Storage Lease Sale for 2023."

[238] Texas General Land Office, "Commissioner Buckingham Secures $10 Billion for Texas Students with Historic State Land Carbon Capture and Storage Leases."

[239] US Environmental Protection Agency, "Class VI - Wells Used for Geologic Sequestration of Carbon Dioxide," April 16, 2025.

[240] US Environmental Protection Agency, Office of Water, "Primary Enforcement Authority for the Underground Injection Control Program."

[241] S.B. No. 1387, S.B. No. 1387; The Railroad Commission of Texas, "Geologic Storage of Carbon Dioxide."

[242] H.B. 1284.

[243] Texas Register, *Carbon Dioxide*.

to align Texas's program with the federal requirements.[244]

The rules established comprehensive technical and administrative requirements for Class VI well permitting. These included detailed provisions for permit applications, such as requirements for site characterization, computer modeling of the CO_2 plume and pressure front, evaluation of the Area of Review (AoR), and submission of plans for corrective action and emergency response. The rules also set standards for well construction, casing, and cementing, to ensure containment of injected CO_2 and the protection of USDWs.[245]

In addition, the 2022 rules required operators to demonstrate financial responsibility sufficient to cover potential costs related to corrective actions, well plugging, post-injection site care and monitoring (PISC), and eventual site closure. The framework included requirements for mechanical integrity testing, continuous monitoring of the CO_2 plume and pressure front, and periodic reevaluation of site conditions to ensure long-term storage integrity. The rules also introduced a public notice and comment process for Class VI permit applications, providing opportunities for public input before a permit could be issued.[246]

After receiving feedback from the US EPA, the RRC underwent further rulemaking, adopting additional rules in September 2023.[247] Changes included revisions to the definitions section, one clarifying that CO_2 captured from DAC systems qualifies as anthropogenic CO_2. The term "stratigraphic test well" was added to distinguish exploratory wells from injection wells, with new language specifying that such wells must be constructed to Class VI standards if they are later converted for injection. The RRC also revised the definition of "good faith claim" to reflect a "continuing possessory right" in pore space, addressing concerns raised by industry and mineral interest holders.[248]

In terms of permitting and application requirements, the rules clarify that operators must now apply for a permit before drilling stratigraphic test wells, notify the UIC section, and comply with updated reporting and construction standards. If a stratigraphic well is intended for conversion to a Class VI well, it must be built to the appropriate specifications from the outset. Additional amendments clarified that operators must regularly reevaluate the AoR at least every five years, or more frequently if monitoring data indicates changes in plume behavior or injection pressure.

Financial responsibility requirements were also updated to align with EPA expectations. The amended rules now allow either the "owner or operator" to demonstrate financial assurance, with new definitions added for both terms. The amendments incorporated EPA-cited provisions from 40 CFR §144.52(b)(2) and (3), and further clarified technical standards for site characterization, well construction, corrective action, mechanical integrity testing, and post-injection site care.[249]

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[244] Certification of Geologic Storage of Anthropogenic Carbon Dioxide (CO_2) Incidental to Enhanced Recovery of Oil, Gas, or Geothermal Resources.

[245] The Railroad Commission of Texas, "Texas Class VI Primacy Application Package."

[246] The Railroad Commission of Texas, "Texas Class VI Primacy Application Package."

[247] The Railroad Commission of Texas, "Amendments to 16 TAC Chapter 5, Relating to Carbon Dioxide (CO2)."

[248] The Railroad Commission of Texas, "Amendments to 16 TAC Chapter 5, Relating to Carbon Dioxide (CO2)."

[249] The Railroad Commission of Texas, "Amendments to 16 TAC Chapter 5, Relating to Carbon Dioxide (CO2)."

While the RRC did not propose changes to the public comment and environmental justice provisions in §5.202, several stakeholders urged the RRC to include more robust environmental justice analyses and community engagement requirements in future rulemakings or program agreements with the EPA.[250] Staff then submitted finalized rule amendments to the EPA in 2023.[251] On April 29, 2025, Texas and the US EPA signed a memorandum of agreement, formalizing the framework for how the RRC and EPA will coordinate implementation, oversight, data sharing, and enforcement of the Class VI program in the state once primacy was obtained.[252]

On June 9, 2025, the EPA signed a Proposed Rule to approve Texas's primacy application.[253] Public comments were received through August 1, with a public hearing occurring on July 24, 2025.[254]

Texas received primacy for Class VI wells on November 12, 2025, with the RRC administering the Class VI program, joining Arizona, Louisiana, North Dakota, West Virginia, and Wyoming as the states who have received primacy for Class VI wells.[255]

Assuming primacy for Class VI wells places new responsibilities on the RRC and requires substantial technical capacity and regulatory oversight. In return, the state gains greater control over the development of its geologic resources, reduces reliance on the federal permitting process, and can provide greater regulatory certainty for project developers, which may further support project development in Texas.

As outlined elsewhere in the roadmap, Texas's substantial storage potential and the growing number of projects in development underscores the need for a responsive and resourced regulatory system. Given the potential volume of applicants and the scale of potential deployment, the RRC will need sufficient technical, legal, and administrative staffing, including experts in geology, reservoir modeling, and well engineering to ensure timely permitting and robust oversight. Ensuring that staff are well-trained and up to date with national standards and best practices is critical for maintaining safe operations, building public trust, and supporting timely project approvals. Access to targeted training also helps regulators understand emerging technologies, risk management practices, and federal expectations under the Class VI well program. The Ground Water Protection Council offers a Class VI Regulator Training program, which provide comprehensive instruction on permitting, inspection, and monitoring of geologic CO_2 storage wells.[256]

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[250] The State of Texas, *Texas Register*, 48:4907–5120.

[251] The Railroad Commission of Texas, "Geologic Storage of Carbon Dioxide."

[252] US Environmental Protection Agency, "EPA and Texas Railroad Commission Sign Memorandum of Agreement on Geologic Storage of Carbon Dioxide."

[253] US Environmental Protection Agency, "Primary Enforcement Authority for the Underground Injection Control Program."

[254] US Environmental Protection Agency, "Texas Class VI Underground Injection Control Program Primacy Hearing."

[255] US Environmental Protection Agency, Office of Water, "Primary Enforcement Authority for the Underground Injection Control Program"; US Environmental Protection Agency, "EPA Grants the State of Texas Primacy to Protect Underground Water Resources."

[256] Ground Water Protection Council, *Class VI Work Group*.

Recommendation: Participate in training programs

Texas Class VI permitting staff should participate in structured training programs designed for CO_2 storage regulators. Participation in these programs, like that offered by the Ground Water Protection Council, can help Texas regulators develop the knowledge and skills needed to implement a safe, effective, and nationally recognized Class VI program.

Without dedicated funding and proper staffing, the agency may face permitting delays, backlogs, or constrained stakeholder engagement, slowing deployment of carbon storage projects just as momentum builds across the state. Proactive investment in staff capacity will enable the RRC to conduct timely, thorough, and credible permit reviews, reducing uncertainty for developers and ensuring that Texas remains a competitive and responsible leader in carbon storage. It can also build public confidence in the oversight process and help streamline interagency coordination.

Recent appropriations for the RRC for the 2026-27 biennium total approximately $461.5 million from state appropriations in Senate Bill 1, and more than $593 million when including all available fund sources. [257] These funds include targeted investments, such as $100 million for oil and gas well plugging and $20 million for information technology modernization to improve data reporting, GIS capabilities, and underground injection oversight. While these investments strengthen the agency's overall regulatory capacity, the appropriations do not specify resources dedicated to Class VI primacy implementation. Authorized staffing levels will increase from 2024-25 to 2026-27, but it is unclear whether this increase includes specialized staff for new Class VI responsibilities. [258]

Recommendation: Monitor Class VI funding and staffing at the RRC

As the RRC establishes Class VI permitting timelines and processes, the Texas Legislature should evaluate whether additional targeted funding is needed to support timely and rigorous permit reviews. This evaluation should account for the anticipated volume of applications, the complexity of proposed projects, and the specialized expertise required for effective oversight, including geological, reservoir modeling, risk analysis, and well integrity expertise. If gaps are identified, the legislature should be prepared to allocate resources to expand the RRC's technical, legal, and administrative capacity to maintain efficient permitting and strong regulatory oversight.

Recommendation: Clarify permitting timelines for Class VI well permits

Stakeholders noted that the permitting timeline for Class VI wells remains a source of uncertainty for project developers. Now that Texas has received Class VI primacy, the RRC should provide clear, accessible information on expected permitting timelines (a floor and a ceiling). Establishing a transparent, regularly updated public dashboard, similar to the US EPA's Class VI permitting dashboard, would give developers better predictability in project planning, help identify potential bottlenecks, and build public trust in the state's review process. The RRC should also make clear if factors such

[257] The Railroad Commission of Texas, "Texas Legislature Makes Historic Investments in RRC's Mission," June 23, 2025; General Appropriations Act.

[258] General Appropriations Act.

as project size, design, and site complexity influence review time, as there is currently no public guidance on how these factors may affect the permitting process in Texas.

DIGITAL INNOVATION IN PERMITTING

As Texas begins to review Class VI permits, advances in digital tools, such as artificial intelligence (AI), are beginning to shape how permitting is conducted. The Texas Responsible Artificial Intelligence Governance Act, effective 2026, will require state agencies to disclose their use of AI. [259] While AI adoption for state-level environmental permitting remains in early stages, municipalities, like Austin, have already deployed AI to accelerate building-permit reviews. Similar tools are emerging across the private sector to assist with complex infrastructure and regulatory filings and could eventually help streamline well-class permitting and data analysis for the RRC and the TCEQ, supporting faster, more transparent reviews as project volumes grow. [260]

CLASS VI PERMITS

Interest in permanent storage of CO_2 in saline geologic formations has increased in Texas over the past few years. As of December 17, 2025, 20 Class VI projects involving 67 well applications and spanning multiple regions of Texas have been submitted to the EPA (figure 8). [261] This includes two issued permits, with an additional permit in the public comment period at the time of this report. While these permits were submitted to the EPA, the approval of Texas's primacy application means that the review and approval of pending and future permits is now under the RRC.

The first application submitted, and subsequently the first Class VI application in Texas to receive authorization to construct, is the Brown Pelican project from Oxy Low Carbon Ventures LLC. [262] The applicant has been authorized to construct three injection wells that intend to inject into the Lower San Andres Formation on the Shoebar Ranch in Ector County. [263] The project intends to inject a total of

[259] Senate Research Center, *C.S.H.B. 149 Bill Analysis*.

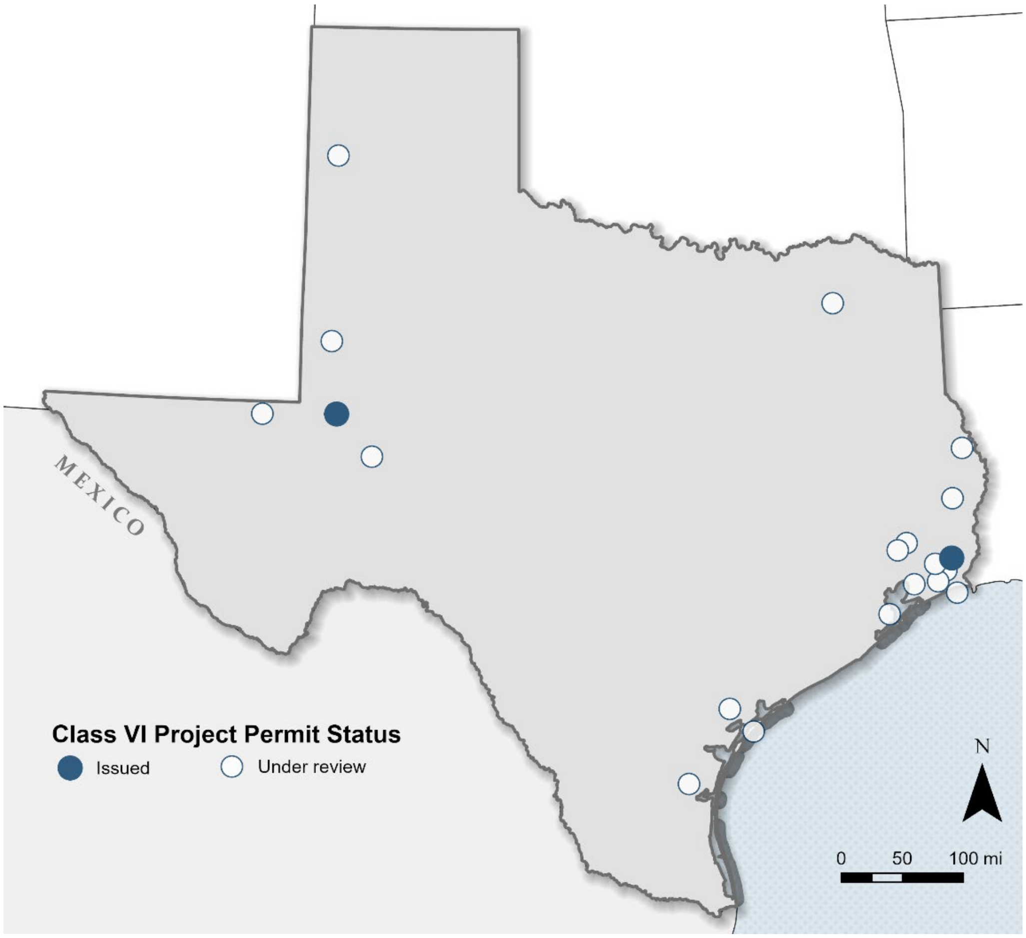
[260] Andrews, "Austin Launches AI-Driven Building Permit Software."

[261] US Environmental Protection Agency, "UIC Class VI Wells Permit Tracker."

[262] Occidental and 1PointFive, *Occidental and 1PointFive Secure Class VI Permits for STRATOS Direct Air Capture Facility*.

[263] US Environmental Protection Agency, *BRP CCS3 Final Permit*; US Environmental Protection Agency, *BRP CCS1 Final Permit*; US Environmental Protection Agency, *BRP CCS2 Final Permit*; The Railroad Commission of Texas, "Notices for CO2 Geologic Storage."

Figure 8. Class VI permit applications in Texas



Source: EPA Class VI Permit Tracker. Accessed 9/1/2005. All locations are approximate.

8.5 $MMtCO_2$ over a 12-year injection period, which will be provided from the 1PointFive Stratos DAC facility that is under construction in Ector County.[264] The permit was received by the EPA on May 2, 2022 and reached a final permit decision on April 7, 2025.[265]

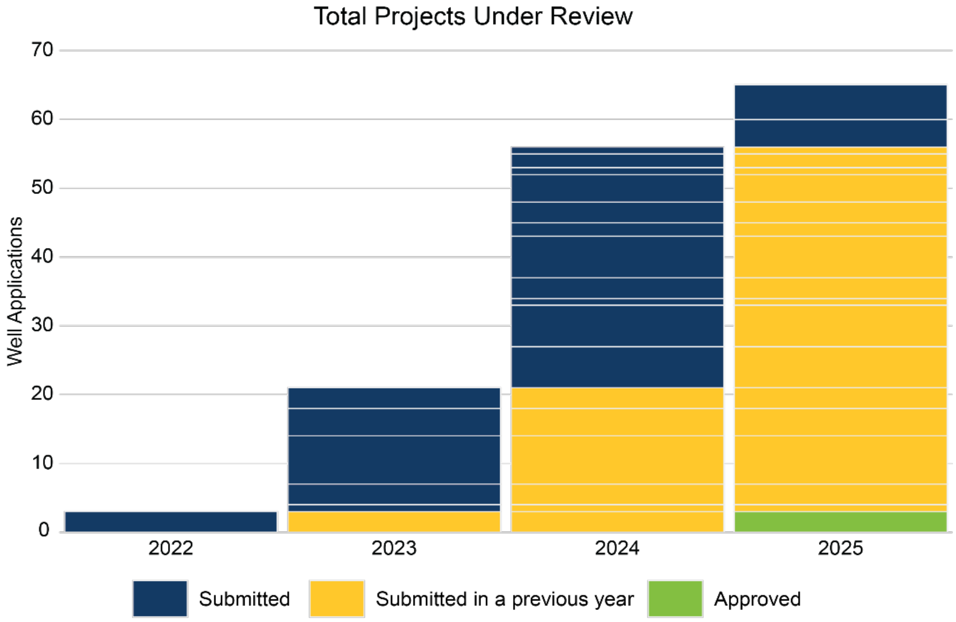
Texas has seen a steady increase in Class VI permit applications since the first application was submitted in 2022 (figure 9). Including Oxy Low Carbon Ventures, 17 companies or partnerships have submitted Class VI well applications in Texas, showing widespread interest. Many of the Class VI well applications have been submitted by oil and gas exploration and production corporations that are likely to have the expertise and experience related to geological characterization in Texas as well as access to sources of CO_2 across the state.[266]

[264] The Railroad Commission of Texas, "Notices for CO2 Geologic Storage."

[265] US Environmental Protection Agency, "UIC Class VI Wells Permit Tracker."

[266] US Environmental Protection Agency, "UIC Class VI Wells Permit Tracker."

Figure 9. Texas Class VI projects under review or approved, by year



Each bar represents a separate project permit application, while the height of the bar indicates the number of wells in the project permit application.

Technical considerations for carbon storage

ORPHANED WELLS

The history of exploration and production in the state provides both opportunities and challenges related to the development of the geologic storage of CO_2 in saline geologic formations.

As part of a Class VI well permit and operations, an operator must identify any wells within the AoR that may require corrective action prior to the construction and injection of CO_2 into the proposed Class VI well.[267] These wells pose a particular risk to carbon storage as they can be pathways for upward migration of CO_2 if they are not addressed.[268]

Texas began the State Managed Plugging Program, administered by the RRC, in 1984, to address these orphaned wells.[269] In Texas, the RRC classifies orphaned wells as any oil or gas well that has been inactive for a minimum of 12 months and the operator's Organization Report (P-5) has been delinquent for greater than 12 months.[270] As of June 2025, the program contained 9,270 wells in its orphaned well database.[271] When a well is classified as orphaned, the RRC assumes jurisdiction over the monitoring of the well and assesses its priority for being plugged, relative to other orphaned wells in

[267] US Environmental Protection Agency, "Class VI - Wells Used for Geologic Sequestration of Carbon Dioxide," April 16, 2025.

[268] US Environmental Protection Agency, *Underground Injection Control (UIC) Program Class VI Well Area of Review Evaluation and Corrective Action Guidance*.

[269] The Railroad Commission of Texas, "State Managed Well Plugging."

[270] The Railroad Commission of Texas, "Safeguarding the Environment for Texans - Well Plugging."

[271] The Railroad Commission of Texas, "Orphan Wells with Delinquent P-5 Greater Than 12 Months."

the state. This priority system, established in 2001, prioritizes wells to be plugged based on the available information for the well's completion, wellbore conditions, well location, and other environmental, safety, or economic concerns.[272] To date, the State Managed Plugging Program has plugged more than 46,000 wells.[273] As of the end of April 2025, the State Managed Plugging Program had plugged 906 orphaned wells and approved 1,366 total for plugging in FY2025, which began in September 2024. Over that same time period, the program notes that operators have plugged 4,403 wells without the use of state funds.[274] The 89th Texas Legislature appropriated $100 million for the State Managed Plugging Program to plug emergency and high priority wells.[275]

Federal initiatives have also been developed to address the plugging of orphaned wells. The federal Infrastructure Investment and Jobs Act established the Orphaned Wells Program Office, administered by the US Department of the Interior, to support states, Tribes, and federal land managers in their efforts to plug orphaned wells.[276] This office developed the State Orphaned Wells Program, which provides funding to states through Initial, Formula, and Performance grants to identify, characterize, plug, and remediate orphaned wells in their state.[277]

Texas received $25 million through the Initial Grant funds in August 2022, and an additional $79.7 million in Phase 1 of the Formula Grant funding disbursement in January 2024, and has plugged 1,223 wells through funds from the State Orphaned Wells Program.[278] On January 20, 2025, the Executive Order *Unleashing American Energy* paused the distribution of funds related to the Infrastructure Investment and Jobs Act, including for the State Orphaned Wells Program.[279] At this time, the status of this program is unknown.

Recommendation: Include a survey in the application process to assess if undocumented wells requiring corrective action are present within the Area of Review (AOR)

The RRC should require an instrumented survey of the AoR to identify if any undocumented wells are present. Expanding the AoR process to include this step will ensure the integrity of the geologic storage project is not compromised. In this context, "undocumented wells" refers to wells that are not recorded in state or federal databases and therefore may not be known to exist, as all active, inactive, orphaned, and plugged-and-abandoned wells are already

[272] The Railroad Commission of Texas, "Well Plugging Priority System."

[273] The Railroad Commission of Texas, "Safeguarding the Environment for Texans - Well Plugging."

[274] Lindley, "Monthly Report of State Managed Well Plugging Activities"; The Railroad Commission of Texas, "Safeguarding the Environment for Texans - Well Plugging."

[275] The Railroad Commission of Texas, "Texas Legislature Makes Historic Investments in RRC's Mission," June 23, 2025.

[276] US Department of the Interior, "Secretary Haaland Establishes Orphaned Wells Program Office to Implement Historic Investments from Bipartisan Infrastructure Law"; United States Code, "42 USC § 15907: Orphaned Well Site Plugging, Remediation, and Restoration."

[277] US Department of the Interior, "State Orphaned Wells Program."

[278] The Railroad Commission of Texas, "Federally Funded Well Plugging."

[279] Unleashing American Energy; Bowlin, "Trump Halts Historic Orphaned Well-Plugging Program."

included in the AoR and considered for corrective action plans.

INDUCED SEISMICITY

Another concern related to CO_2 storage is the possibility for the injection of CO_2 to cause seismic activity in the area near injection, known as “induced seismicity.” Induced seismicity can occur from an increase in pore pressure in a geologic formation receiving injected fluids, such as CO_2 or water. [280] Seismicity associated with wastewater disposal has been well-documented over the past two decades and has led to changing practices to reduce or manage the pore pressure within reservoirs and mitigate induced seismicity. [281]

Instances of induced seismicity have been identified for both CO_2 EOR and permanent storage in saline geologic formations. Notable CO_2 EOR projects that have recorded seismicity believed to be related to water and/or CO_2 injection include the Aneth, Cordel, and Weyburn oil fields. [282] The first permanent storage project in a saline geologic formation in the US, in Decatur, Illinois, has reported microseismicity related to CO_2 injection into the Mt. Simon formation, though felt seismicity has not been reported. [283] While research and operations indicate proper management of injection operations can mitigate induced seismicity, concerns remain, particularly from the public and the media. [284]

In response to increasing seismicity related to fluid injection, the RRC included consideration of seismic activity in the permitting process for saltwater disposal wells, beginning in November 2014. [285] Since then, the RRC has established three Seismic Response Areas (SRAs), which are areas defined as having increased seismic activity due to wastewater injection and, therefore, have increased attention placed on their activities and response to seismic activity in the area. [286] Disposal wells in these areas limit their injection amounts or are shut in to avoid

[280] US Department of Energy, “Induced Seismicity.”

[281] Keranen and Weingarten, “Induced Seismicity”; Schultz et al., “An Investigation of Seismicity Clustered near the Cordel Field, West Central Alberta, and Its Relation to a Nearby Disposal Well”; Silva et al., “Mechanisms for Microseismicity Occurrence Due to CO_2 Injection at Decatur, Illinois: A Coupled Multiphase Flow and Geomechanics Perspective”; Alghannam and Juanes, “Understanding Rate Effects in Injection-Induced Earthquakes”; Babarinde et al., “A Workflow to Assess the Efficacy of Brine Extraction for Managing Injection-Induced Seismicity Potential Using Data from a CO_2 Injection Site near Decatur, Illinois.”

[282] Rutledge, *Southwest Regional Partnership on Carbon Sequestration Phase II*; Gan and Frohlich, “Gas Injection May Have Triggered Earthquakes in the Cogdell Oil Field, Texas.”; Silva et al., “Mechanisms for Microseismicity Occurrence Due to CO2 Injection at Decatur, Illinois: A Coupled Multiphase Flow and Geomechanics Perspective”; Whittaker et al., “A Decade of CO2 Injection into Depleting Oil Fields: Monitoring and Research Activities of the IEA GHG Weyburn-Midale CO2 Monitoring and Storage Project.”

[283] Silva et al., “Mechanisms for Microseismicity Occurrence Due to CO2 Injection at Decatur, Illinois: A Coupled Multiphase Flow and Geomechanics Perspective”; Bauer et al., “Overview of Microseismic Response to CO2 Injection into the Mt. Simon Saline Reservoir at the Illinois Basin-Decatur Project”; ADM, “Seismic Monitoring and CCS”; Kaven et al., “Seismic Monitoring at the Decatur, IL, CO2 Sequestration Demonstration Site.”

[284] Stone, “Carbon Capture and Storage – What the Perils of Produced Water Disposal Can Teach Us”; Bush, “Texas’s Carbon Gamble: Will Storage Solutions Spark Growth or Disaster?”; Volcovici et al., “Earthquakes and Blowouts Undermine Case for Carbon Storage in Texas.”

[285] The Railroad Commission of Texas, *Response Plan to Seismic Events in Texas*.

[286] The Railroad Commission of Texas, “Mitigating Texas Earthquakes.”

induced seismic activity with a magnitude greater than 3.5. [287]

Recommendation: Monitor the need for Seismic Response Areas (SRAs) for Class VI wells

While CO_2 injection has different properties and operational considerations compared to saltwater disposal, monitoring the need to develop SRAs for Class VI injection wells could further advance public acceptance of the practice while protecting Texas from potential induced seismicity. A detailed study on the potential impacts of CO_2 injection rates and volumes in the formations that are expected to be used as injection zones in the region could inform the need and value of including Class VI wells in SRA regulations. In addition, Texas should move beyond ad hoc monitoring by establishing formalized, consistent guidance or rules regarding the RRC's approach to seismicity monitoring and response for Class VI wells.

Recommendation: Develop additional educational resources on induced seismicity and the developed mitigation regulations and strategies

While action has been taken by operators and the RRC to mitigate induced seismicity through reduced volumes and rates of injection in SRAs, general concerns on carbon management and the potential for induced seismicity remain among impacted stakeholders who are not intricately involved in the process. To alleviate these concerns, additional educational resources and opportunities to engage with the public and media around the advanced regulations that the RRC has developed, as well as the practices operators have implemented, could increase awareness around safe injection practices and further advance the social license to operate.

Pore space access

Before any CO_2 injection can begin, the operator must acquire the rights to the pore space, the open space between the grains in the geologic formation that will store the injected CO_2.

PORE SPACE OWNERSHIP

Most states that are addressing carbon management through legislation have clarified pore space ownership for geologic storage of CO_2 and have established that ownership resides with the surface estate, unless it has been explicitly stated otherwise. [288]

There is no statute clearly defining pore space ownership in Texas, leaving developers and others to rely on case law. [289] Texas courts have generally followed the American rule, which holds that pore space belongs to the surface estate rather than the mineral estate. [290]

This interpretation was recently reinforced in the 2025 Texas Supreme Court decision in Myers-Woodward, LLC v. Underground Service Markham, LLC and United Brine Pipeline

[287] The Railroad Commission of Texas, "Seismicity Response"; The Railroad Commission of Texas, "Gardendale Seismic Response Area: Operator Response Plan"; The Railroad Commission of Texas, "Stanton Seismic Response Area: Operator-Led Response Plan"; The Railroad Commission of Texas, "Northern Culberson-Reeves Seismic Response Area: Operator-Led Response Plan."

[288] Property; Subsurface Pore Space or Container Space; Preservation of Property Rights; Certificate of Project Completion; Property, Conveyances and Security Transactions, Title 34. Chapter 1. Article 1.

[289] Medlock, III and Miller, *Expanding Carbon Capture in Texas*; Windle, "Pore Space Primer: Who, What, When, Where, and How Much?"

[290] Windle, "Pore Space Primer: Who, What, When, Where, and How Much?"

Company, LLC. The court held that the voids left behind in salt formations after mineral extraction remain with the surface owner unless specifically conveyed.[291] Although the case did not concern CO_2 storage or saline aquifers, it may provide precedent to support the surface estate's claim to pore space.

Stakeholder feedback received during the roadmap's development indicated the Myers-Woodward, LLC v. Underground Service Markham, LLC and United Brine Pipeline Company, LLC ruling will provide sufficient clarity for operators to properly acquire pore space rights. However, some stakeholders indicated that legal uncertainty remains until ownership is established through statute or a specific case involving pore space and carbon storage occurs.

AGGREGATION OF PORE SPACE

Geologic storage can span multiple parcels of land with different owners, requiring operators to negotiate agreements with numerous landowners. Many states have implemented compulsory unitization policies, which allow projects to proceed once a threshold of landowners consenting to the project is met, typically between 60 and 80 percent of pore space acreage.[292]

While Texas does have unitization procedures, it does not currently authorize compulsory unitization for oil and gas or carbon storage projects. Given the state's vast available pore space, some stakeholders indicated this has not yet proven to be a large obstacle. However, as project deployment increases, many stakeholders during the roadmap development process noted the challenge of securing contiguous pore space may grow, potentially leaving high-quality formations underutilized, with some stakeholders sharing that it is a barrier to project development. Despite this risk, other stakeholders across Texas have voiced strong opposition to compulsory unitization.[293] Recognizing these divergent perspectives and the importance of balancing property rights with deployment needs, the roadmap does not make a recommendation on this issue.

Site closure and long-term risk management

Once an operator has concluded injecting CO_2 into a Class VI well, they must plug the well and begin post-injection site care. Once this process is complete, the operator can receive a certificate of project closure and financial assurances can be returned.[294]

Following site closure, operators and regulators must consider managing any long-term risk associated with the stored CO_2. When an injection site is properly selected, managed, and closed, the long-term risk of CO_2 is considered to be very low, with the IPCC stating that appropriately selected and managed sites will likely retain the injected CO_2 at 99 percent over 1,000 years.[295] While the federal government

[291] *Myers-Woodward, LLC v. Underground Services Markham, LLC and United Brine Pipeline Company, LLC*.

[292] Lewis and Bennett, *Issue Brief: Pore Space Unitization for Geologic Sequestration of Carbon Dioxide*.

[293] Medlock, III and Miller, *Expanding Carbon Capture in Texas*.

[294] US Environmental Protection Agency, *Geologic Sequestration of Carbon Dioxide Underground Injection Control (UIC) Program Class VI Well Plugging, Post-Injection Site Care, and Site Closure Guidance*.

[295] Lee et al., *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.

requires post-site injection care, it does not assume liability or stewardship for the injected CO_2.[296] As a result, state-level frameworks determine how long-term risk management obligations transfer from the operator to the state or another entity, or if they remain with the operator.

These long-term risk considerations typically include determining whether to establish long-term stewardship programs and funds for post-closure oversight and determining whether and when legal liability transfers from the operator to the state. While these two considerations are related, they are legally and procedurally distinct from one another.

LONG-TERM STEWARDSHIP

Stewardship generally refers to the state's responsibility for ongoing monitoring, reporting or emergency response after site closure. To cover these costs, many states have created special funds, often financed through a per ton fee. These funds are used for post-closure monitoring, site maintenance, emergency response, and administrative costs.[297]

Texas has established the Anthropogenic Carbon Dioxide Storage Trust Fund, financed through fees.[298] The trust fund is intended to cover the full range of activities needed to oversee and maintain geologic storage facilities and associated anthropogenic CO_2 injection wells. This includes permitting, inspection, monitoring, investigation, recordkeeping, and reporting, conducting long-term monitoring after site closure, addressing and repairing mechanical issues or leaks, plugging abandoned CO_2 injection wells, and providing training and technology transfer to support safe and effective operations. It also funds compliance and enforcement actions to ensure that geologic storage projects meet all regulatory and safety requirements.[299]

LONG-TERM LIABILITY

Long-term liability of CO_2 generally refers to the legal and financial responsibility over its continued subsurface containment. Many states have recognized that clear liability transfer mechanisms can de-risk projects for developers and investors. Additionally, although the risk of CO_2 release from a well-managed storage site is considered low, many states have recognized that project operators will likely not exist in perpetuity. Public trust may depend on having clear mechanisms in place for long-term risk management. This includes a transparent closure certification process, rigorous preconditions and limitations for liability transfer, and clarity around ongoing state oversight roles.

At least 15 states, including many states where operators have applied for Class VI permits, have developed their own frameworks to manage long-term liability and stewardship to ensure there is continued oversight and funding to cover any risk to the environment or public health.[300] These

[296] *40 CFR Part 146 - Underground Injection Control Program*.

[297] Establishment of Carbon Dioxide Storage Facility Trust Fund; Carbon Dioxide Storage Fund; Carbon Dioxide Storage Facility Trust Fund; To Clarify the Regulation of Carbon Capture and Sequestration; And to Establish the Carbon Dioxide Storage Fund; Geologic Storage Enterprise & Geothermal Resources, vols. HB25-1165.

[298] Ownership and Stewardship of Anthropogenic Carbon Dioxide, 2021.

[299] Ownership and Stewardship of Anthropogenic Carbon Dioxide, 2021.

[300] Certificate of Project Completion, Release, Transfer of Title and Custody, Filing.; Geologic Storage Enterprise & Geothermal Resources, vols. HB25-1165; Cessation of Storage Operations; Limited Liability Release; Carbon Dioxide Underground

frameworks vary widely, with most states establishing a fixed post-injection time period that also includes testing and monitoring to ensure the CO_2 plume has stabilized before transfer of liability can occur. Fixed post-injection timelines typically range from 10 years to 50 years or more after a project ceases injection. Testing usually requires a demonstration of plume stability, the proper plugging of wells, and that the site poses no danger to human health or the environment. In many cases, operators must also demonstrate that any outstanding claims have been resolved and that the site meets the standards for closure under federal or state Class VI regulations.[301]

Among states that have established long-term liability transfer in statute, there is also variation in what liability is transferred. Some states release the operator from all future regulatory requirements and legal liability associated with the stored CO_2 after storage and transfer, but many states retain exceptions such as ongoing liability for fraud, gross negligence, or violations prior to closure certification. These exceptions are critical in reducing moral hazard, or the risk that an operator may not do their due diligence in project execution or documentation, knowing that liability will eventually shift to the state. Additionally, the EPA has expressed concerns that overly broad liability waivers could conflict with its UIC program, including requirements for emergency orders to protect underground sources of drinking water under the Safe Drinking Water Act.[302] By retaining operator accountability for defined responsibilities and risks, these provisions aim to ensure that operators meet high standards of project operation and closure. This includes circumstances such as violations of duty prior to closure, provision of deficient or erroneous information, fluid migration that threatens underground sources of drinking water, or insufficient funds set aside in escrow or a CO_2 storage trust.[303]

However, broad liability transfers, if not carefully constructed, can send the wrong message to the public, suggesting that CO_2 storage carries unacceptable risks or that industry is being shielded from accountability. A conditional framework rooted in science and transparency avoids these pitfalls and provides guardrails that ensure operators remain committed to safe and secure storage practices, while also giving the state tools to responsibly manage long-term liability. For states not interested in pursuing liability, liabilities can be managed through insurance, surety bonds, or other financial assurances.[304]

As more projects are permitted, clarity will be useful in gaining investor confidence and public acceptance. While it remains unclear whether state-level differences in liability policy are impacting deployment, some experts and developers argue that the perception of legal and

Storage; Liability for Carbon Dioxide During Injection; Certificate Of Completion - Department Of Environmental Quality Participation - Transfer Of Liability; Public Health and Safety; Certificate of Project Completion.

[301] Establishment of Carbon Dioxide Storage Facility Trust Fund; Clean Air Act; Certificate of Project Completion; Certificate of Project Completion, Release, Transfer of Title and Custody, Filing.

[302] Great Plains Institute and Environmental Defense Fund, *Approaches to Long-Term Liability of Class VI Injection Wells*.

[303] Handler et al., *Locked Up for the Long Term: Risk Mitigation and Liability Assumption in the Geological Storage of CO_2*; Great Plains Institute and Environmental Defense Fund, *Approaches to Long-Term Liability of Class VI Injection Wells*.

[304] Great Plains Institute and Environmental Defense Fund, *Approaches to Long-Term Liability of Class VI Injection Wells*.

financial clarity could shape investment and siting decisions.[305]

Texas has considered long-term liability for geologic storage of CO_2. For onshore projects, the state outlines that the ownership of the stored CO_2 resides with the storage operator and the state does not outline any transfer of liability.[306]

For offshore storage in state-owned submerged lands, liability transfer is addressed in Texas Health and Safety Code §382.507-§382.508, which extend nine nautical miles from the Texas coastline.[307] These provisions establish a state-designated CO_2 repository, managed by the Texas School Land Board, in coordination with the RRC. Once the repository meets all applicable federal and state requirements for post-closure and the permanent storage of CO_2 is verified, the School Land Board acquires the right, title, and interest in the stored CO_2 on behalf of the Permanent School Fund. At that point, the CO_2 producer is relieved of liability for the stored CO_2 itself. However, this does not relieve the repository builder or operator from liability for any act or omission related to construction or operation, or the CO_2 producer from liability for any act or omission that occurred before the CO_2 was injected.[308]

Although opinions differ on the need for long-term liability transfer, establishing a long-term liability transfer mechanism in Texas could offer some benefits. For the public, particularly those concerned about CO_2 releases, it ensures enduring protection against the highly unlikely, but potential, risks associated with geologic storage over decades or centuries. For project developers, it provides clarity on the endpoint of liability and facilitates investment by reducing long-term financial uncertainty. And for the state, it creates an opportunity to generate funds through per-ton storage fees or similar mechanisms, which can be used for the state to protect its financial resources in the event of operator dissolution. It also allows the state the opportunity to streamline its regulatory approach across onshore and offshore storage, reducing confusion, facilitating project financing, and supporting long-term investment decisions.

If Texas were to assume long-term liability for Class VI storage wells, the Interstate Oil & Gas Compact Commission provides a draft model statute that includes mechanisms and safeguards for liability transfer that could be used as a model framework for Texas.[309]

Recommendation: Consider establishing a framework for long-term CO_2 storage liability transfer

Texas should consider establishing a consistent framework for long-term liability transfer from operator to state for both onshore and offshore geologic CO_2 storage. Under this framework, the state would assume liability for a storage site only after an operator has fulfilled a defined set of technical, regulatory, and financial requirements that demonstrate the CO_2 plume in the storage formation is stable, secure, and no

[305] Handler et al., *Locked Up for the Long Term: Risk Mitigation and Liability Assumption in the Geological Storage of CO_2*.

[306] Ownership and Stewardship of Anthropogenic Carbon Dioxide, 2021.

[307] U.S. Commission on Ocean Policy, "Primer on Ocean Jurisdictions: Drawing Lines in the Water"; Clean Air Act.

[308] Clean Air Act.

[309] Model Statute Workgroup of the IOGCC Legal and Regulatory Affairs Committee, "Final Draft Model Statute on Geologic Sequestration of Carbon Dioxide."

longer poses a risk to public health or the environment.

Additionally, if the state would like to establish a minimum timeframe before liability transfer may occur, the state should consider engaging a technically qualified third-party institution to support and help make a science-based determination.

Importantly, and as outlined in the draft model statutes from the Interstate Oil & Gas Compact Commission, the state should retain authority to reassert operator liability in rare but serious cases, such as fraud, misrepresentation, gross negligence, or threats to underground sources of drinking water for which the operator is found to be responsible, to ensure accountability and preserve public trust.

Enhanced oil recovery

In the context of carbon management, CO_2 EOR is a tertiary oil production technique, typically developed after initial production and waterflooding of the reservoir have been completed, where CO_2 is injected into depleted oil reservoirs to help extract additional oil. If CO_2 from point-source emissions is used for this process, CO_2 EOR can permanently store CO_2 that would have otherwise been released into the atmosphere.[310]

Texas CO_2 EOR operations began in the early 1970's and continues to this day. CO_2 EOR activity is largely focused in the Permian Basin of West Texas, including the SACROC field, the first large-scale CO_2-injection project, which has produced over one billion barrels of oil while injecting roughly 175 $MMtCO_2$.[311] In 2023, an estimated 160,000 barrels of oil per day were produced in the Permian Basin through CO_2 EOR, which received CO_2 from four natural sources and the Val Verde and Century gas plants in Texas. An additional 30,300 barrels of oil per day were produced in the Southeast Gulf Coast region, which includes East Texas, Louisiana, and Mississippi. These operations utilize a combination of natural and industrial sources of CO_2, including one facility in Texas.[312]

The value of the 45Q tax credit for permanently stored CO_2 used during the EOR process was increased from $60 per metric ton to $85 per metric ton with the passage of the One Big Beautiful Bill Act in July 2025. This increase made the value of storage in oil and gas reservoirs through EOR activities equivalent to the value of CO_2 stored in saline formations.[313] While the full impact of this change is not known at this time, increasing the credit value for EOR is expected to increase the number of projects that are economically viable.

Operators in Texas inject CO_2 primarily produced and imported from natural domes in neighboring states rather than CO_2 captured from industrial and power sources. Using naturally occurring CO_2 does not lower the carbon intensity of produced barrels and cannot supply the volumes needed to access the estimated 18.28 billion barrels of crude oil that are economically

[310] National Energy Technology Laboratory, *Carbon Dioxide Enhanced Oil Recovery: Untapped Domestic Energy Supply and Long Term Carbon Storage Solution*.

[311] EnergyExcursions - The University of Texas at Austin, Hildebrand Department of Petroleum and Geosystems Engineering, *History of CO_2 Enhanced Oil Recovery in Texas*.

[312] Wallace, "The U.S. CO_2 Enhanced Oil Recovery Survey."

[313] Carbon Capture Coalition, *The One Big Beautiful Bill Act of 2025*.

recoverable with EOR.[314] Texas can enable that recovery and credibly cut barrel carbon intensity by building an in-state anthropogenic CO_2 supply chain from industrial and power facilities equipped with carbon capture.

[314] Advanced Resources International and US Department of Energy, *Basin Oriented Strategies for CO_2 Enhanced Oil Recovery: Permian Basin*; Advanced Resources International and US Department of Energy, *Basin Oriented Strategies for CO_2 Enhanced Oil Recovery: East & Central Texas*.

WORKFORCE DEVELOPMENT

Carbon management can support job retention and enable the creation of thousands of new high-wage jobs across Texas's energy, industrial, and manufacturing sectors.[315] As carbon management project announcements increase, Texas can proactively evaluate workforce capacity needs and plan to address them early, helping prevent labor shortages and maintain steady project timelines.

Developing a workforce for carbon management technologies requires diverse skills across the entire supply chain, including facility siting and development, pipeline build-out, injection well characterization, and drilling.

While Texas has a strong energy workforce, the growing energy demand across industries and sectors may require investment in accessible training pathways, talent retention, and upskilling efforts to ensure skills needed for carbon management are available.[316] This workforce preparation must be supported by strategies that ensure long-term job quality.

Early investments in workforce development will strengthen low-carbon and traditional energy sectors, ensuring the state has a workforce capable of meeting the growing domestic and global demand for both low-carbon and conventional energy. These investments can also minimize future retraining costs and workforce gaps and maximize the state's economic returns from carbon management. This section includes the following recommendations.

Recommendations:

- Conduct a statewide manufacturing-workforce analysis for carbon management technologies
- Conduct regional workforce mapping and planning to address geographic labor mismatches
- Develop a Texas Carbon Management Workforce Advisory Council
- Develop carbon-management-specific registered apprenticeship programs in the state
- Provide competitive reskilling grants for carbon management workforce support
- Leverage the Texas skills development fund to support workforce participation in energy projects.

Texas energy workforce

Texas has the largest energy workforce in the country. The state had 969,801 energy workers statewide in 2023, representing 11.6 percent of all US energy jobs. The state added 33,999 new positions in 2023, the highest net energy job growth in the nation, including over 4,000 in electric power generation and more than 8,400 in energy efficiency.[317] Additionally, according to data from the US Bureau of Labor Statistics, the state's manufacturing sector directly employs approximately 976,600 Texans, as of June 2025.[318]

[315] Jones et al., "Carbon Capture and Storage Workforce Development."

[316] Vegas et al., "Long-Term Load Forecast Update (2025-2031) and Methodology Changes"; US Department of Energy, *United States Energy & Employment Report 2024*.

[317] US Department of Energy, *United States Energy & Employment Report 2024*.

[318] US Bureau of Labor Statistics, "Industry Employment by State, Seasonally Adjusted."

Carbon management job opportunities

Carbon management can offer workforce opportunities across various industries and sectors that seek to capture, transport, utilize, remove, and store CO_2 in Texas.[319] Many of these industries are central to Texas's economy, including oil and gas, coal and gas power generation, ethanol, ammonia, gas processing, hydrogen, cement, refineries, iron and steel, pulp and paper, and waste.[320]

Deploying these technologies will create jobs to carry out the construction, operation, and maintenance of the facilities.[321] The main occupations that will be needed for carbon management project development are construction trades, metal workers, engineers, and general maintenance roles. These jobs, alongside others, are particularly relevant to Texas's future workforce readiness, as the state prepares to host some of the largest announced CCS, hydrogen, and DAC projects in the country. These projects will demand thousands of workers across construction, operations, and maintenance, underscoring the need for workforce investment and training in Texas. Carbon management is also expected to generate manufacturing jobs, as materials for the technologies must be produced, processed, and fabricated to be deployed.

However, there is currently no comprehensive analysis or study that breaks down specific occupations, sectors, or scale of manufacturing jobs that may emerge from carbon management deployment for Texas, which could slow efforts to align workforce capacity with carbon management needs in the future. A comprehensive analysis of manufacturing roles tied to carbon management technologies could provide valuable data to help guide workforce planning and infrastructure development in the state.

Recommendation: Conduct a statewide manufacturing-workforce analysis for carbon management technologies

A statewide analysis of carbon management manufacturing workforce opportunities could (1) list all relevant occupations, (2) complete an assessment of current skill sets and skill gaps, (3) map where talent and manufacturing capacity exist within the state, and (4) identify training gaps. The study could help the state identify both immediate and long-term needs on the manufacturing side of carbon management technology and guide strategic investment to support its development.

CARBON CAPTURE, TRANSPORT, AND STORAGE JOB OPPORTUNITIES

Recent modeling provides a compelling look at CCS job potential. According to the Rhodium Group, retrofitting 93 industrial and power facilities across Texas with carbon management technologies could create an annual average of over 28,000 direct jobs over a 15-year period. This includes nearly 15,000 capital investment jobs tied to the design, engineering, and construction of carbon capture systems, over 9,000 ongoing operations and maintenance jobs, and over 4,500 annual jobs associated with the transport and storage of captured CO_2. If realized, these projects could reduce CO_2 emissions by as much

[319] Townsend et al., *The Value of Carbon Capture and Storage (CCS)*.

[320] Great Plains Institute, "Texas Carbon Capture Opportunities."

[321] Jones et al., "Carbon Capture and Storage Workforce Development."

as 158 $MMtCO_2$ per year and unlock up to $62 billion in private investment for the state.[322] These estimates reflect only direct jobs related to retrofits and associated infrastructure and do not include existing facility jobs or the broader economic ripple effects of carbon management, such as indirect and induced employment.

Moreover, newly built facilities that integrate carbon management from the outset are likely to create even greater economic and workforce opportunities. Additionally, a study from Angelou economics analyzing the potential economic outcomes of four different CCUS projects in 12 counties illustrates that these projects could create 7,500 jobs and generate $1.8 billion in state-level impact.[323] However, further studies and regional assessments will be needed to capture the full scope of employment and economic opportunities across the state as the technology is deployed.

Carbon management project development jobs associated with capital investment (those needed for construction and retrofitting) span a broad range of occupations. These include construction trade workers, engineers, metal workers, machinery installers and repair technicians, and extraction workers. In addition, business-related roles—such as executives, operations specialists, data and operations research analysts, and sales representatives—are needed to support project development, logistics, and supply chain activities. Production workers, freight and commercial drivers, and other specialized roles also contribute to a successful project.

Once operational, the projects continue to require a sizable workforce. Ongoing occupations include machinery installers and maintenance workers, metal workers, production staff, commercial freight operators, and truck drivers. Facilities also rely on business operations staff, financial clerks, sales representatives, and material moving workers to support day-to-day activity. A smaller share of roles are held by operations specialties managers and extraction workers, reflecting the complexity of maintaining capture systems and moving CO_2 through pipelines to storage.

Project announcements reflect the growing demand for this technology and a skilled workforce in both retrofits and newly built facilities. The scale and scope of these projects have major implications for workforce development in Texas. As additional projects are announced, the demand for skilled labor is expected to grow.

HYDROGEN JOB OPPORTUNITIES

The development of low-carbon hydrogen and its supporting infrastructure could attract billions in investment and generate up to 180,000 jobs statewide.[324]

While no studies have specifically examined workforce opportunities related to hydrogen development with carbon management in Texas, national studies offer useful insights into the potential jobs these strategies could generate. For example, Rhodium's analysis of a hydrogen production facility retrofit project that captures 500,000 metric tons of CO_2 annually estimated

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[322] Jones et al., "Carbon Capture and Storage Workforce Development."

[323] Texas Association of Business, "Texas Association of Business Releases Groundbreaking Economic Impact Study on CCUS Projects in Texas."

[324] Texas Hydrogen Production Policy Council, *Hydrogen Energy Development in Texas*; Center for Houston's Future et al., *Houston as the Epicenter of a Global Clean Hydrogen Hub*.

the creation of 520 jobs during construction, along with 80 ongoing jobs for operations and maintenance. These jobs span a wide range of occupations, including construction trade jobs like construction laborers, managers, carpenters, electricians, plumbers and pipelayers, metal workers and assemblers for welding, soldering, and electrical equipment assembling, and civil, mechanical, and industrial engineers, many of which are already prevalent in Texas's energy and industrial sectors.[325]

Texas also has the potential to create jobs through hydrogen hubs, with the Gulf Coast Hydrogen Hub (HyVelocity) selected for up to $1.2 billion in federal funding.[326] Located in Houston and the Gulf Coast region, the hub could generate up to 45,000 jobs and reduce CO_2 emissions by 7 $MMtCO_2$ annually. However, the funding for hubs and project timelines remain uncertain, and changes to the 45V tax credit may present challenges for the hubs and broader hydrogen development in the state.[327]

DAC JOB OPPORTUNITIES

Deploying DAC technologies in Texas offers potential workforce opportunities in both the construction and long-term operation of DAC facilities. As with other carbon management technologies, the labor force required for DAC projects intersects with many existing energy sector jobs, with substantial potential to support local economies and provide high-wage, skilled jobs.

Although DAC deployment in the US remains limited, the industry is rapidly growing, and national studies, alongside project-specific data, offer valuable insights into the potential workforce impacts for Texas.

The job potential related to DAC facilities is typically divided into two primary categories:

- One-time jobs associated with construction, engineering, materials, equipment, and supply chains for building DAC plants, and
- Operations and maintenance (O&M) jobs, which are ongoing and required for the facility's day-to-day function once it becomes operational.

The Rhodium Group estimates that the construction of a 0.5 $MMtCO_2$ per year DAC facility, about the size of a potential large-scale commercial DAC plant in the US, could generate an average of 1,215 annual jobs over a five-year construction period. Once the facility is operational, approximately 340 jobs would be needed annually for ongoing operations and maintenance. Construction trades are the largest occupational category, comprising nearly 25 percent of the total facility jobs, with laborers, carpenters, and managers making up the bulk of these positions. Other critical job categories include engineers, business development roles, metal workers, and administrative staff. In operations and maintenance, roles are filled by machinery installers, maintenance technicians, and metal workers, alongside a smaller workforce involved in business operations and production tasks.[328]

Texas already has several publicly announced DAC projects that offer more concrete insights into potential workforce impacts, including

[325] Bower et al., "Clean Hydrogen Workforce Development."

[326] US Department of Energy, "Gulf Coast Hydrogen Hub."

[327] H.R. 1 - One Big Beautiful Bill Act, H.R. 1.

[328] Jones et al., "Direct Air Capture Workforce Development."

Project Stratos, the South Texas DAC Hub, and the Houston Area DAC Hub.

Project Stratos is one of the most advanced DAC developments in the US and exemplifies the workforce demand that can be expected from large projects. During its peak construction period, the project is expected to employ over 1,200 workers on-site from skilled trades, including boilermakers, carpenters, electricians, welders, and pipefitters. Once operational, Project Stratos is projected to support approximately 140 full-time operations and maintenance jobs. These positions span various functions, with 40 percent of roles in maintenance, 38 percent in operations, 11 percent in management and supervisory positions, and the remaining in engineering roles, support and technical roles, warehouse and logistics, and training and planning. [329]

The South Texas DAC Hub in Kleberg County is also expected to create a range of jobs during both the construction and operational phases. The construction of the facility is estimated to generate 1,180 to 1,830 annual jobs, including roles in solar installation, engineering, and equipment construction. Once operational, the plant will support 260 to 400 ongoing operations and maintenance jobs, contributing to long-term employment opportunities in the region. [330]

DAC projects will vary in their workforce opportunities depending on size and technology type. Given the growing potential for DAC deployment in Texas, closely monitoring project development will provide valuable insights into emerging workforce needs and trends, allowing Texas stakeholders to identify specific workforce gaps and plan workforce development strategies that are targeted and timely, such as training and educational programs that fit with the evolving demands of the industry.

Regional opportunities

Most carbon management opportunities in Texas are expected to cluster in traditional energy regions, such as the Permian Basin and along the Gulf Coast, where a skilled workforce already exists in oil, gas, and related industries. These areas may provide a ready labor pool for carbon capture, hydrogen, and related projects.

However, as carbon management activity expands into new regions, including areas further inland or near emerging industrial hubs, there may be gaps in workforce capacity or skillsets. In regions without an existing energy workforce, local labor may lack experience with specialized technologies, such as Class VI well operations, long-term site monitoring, hydrogen production, or DAC.

Additionally, the expected surge in energy demand in Texas means that carbon management projects will compete for labor with traditional and emerging energy sectors, including renewables, hydrogen, and grid infrastructure. Without strategic planning, the competition for skilled labor could result in workforce bottlenecks or project delays.

Mapping regional workforce availability and anticipated job growth can help identify where such gaps are most likely to occur, enabling more targeted workforce planning and industry partnerships.

[329] Provided by Occidental by request.

[330] Bower et al., *The Economic Benefits of Direct Air Capture Hubs - South Texas DAC Hub and Project Cypress*.

Recommendation: Conduct regional workforce mapping and planning to address geographic labor mismatches

The Texas Workforce Commission (TWC) or another designated state entity could lead a regional workforce assessment to identify geographic mismatches between potential carbon management project locations and local labor force capacity. This assessment would help developers and state agencies:

- Anticipate where workforce gaps may delay project timelines or increase costs
- Plan for workforce development investments in emerging regions
- Support recruitment strategies, including relocation incentives or per diem allowances
- Align training and certification programs with anticipated regional needs

Federal labor provisions for carbon management projects

At the federal level, labor provisions are embedded within tax credits that influence carbon management project economics. The 45Q tax credit includes labor provisions aimed at supporting job quality. To receive the full value of the credit, developers must meet prevailing wage requirements and ensure that a portion of construction labor is performed by qualified apprentices. Specifically, 12.5 percent of total labor hours must be completed by apprentices for projects to be eligible for the full credit, rising to 15 percent for projects that began construction in 2024 or later. [331] These provisions aim to ensure that projects contribute to high-road employment outcomes and align with broader workforce development goals.

Similar labor-related requirements apply to the 45V hydrogen production tax credit. While the specific details of 45V implementation may vary, the emphasis on prevailing wages and apprenticeships remains a consistent feature. [332] Developers planning projects in Texas must meet these federal standards to qualify for the full value of either credit, making labor compliance an important consideration during project planning and siting.

Texas workforce infrastructure and policy context

At the state level, Texas has historically enacted policies to encourage carbon management, such as tax incentives for CCUS projects, but has not yet tied these incentives to labor standards or workforce development requirements. [333] No state-level workforce policies currently target carbon management deployment specifically.

However, Texas has a well-developed workforce ecosystem that could support the sector's needs. The TWC serves as the state's lead agency for workforce development and coordinates the Texas Workforce Solutions Network, which includes 28 local workforce boards and more than 170 workforce centers. [334] These boards collaborate with employers,

[331] US Department of the Treasury, "FACT SHEET: How the Inflation Reduction Act's Tax Incentives Are Ensuring All Americans Benefit from the Growth of the Clean Energy Economy."

[332] US Department of the Treasury, "FACT SHEET: How the Inflation Reduction Act's Tax Incentives Are Ensuring All Americans Benefit from the Growth of the Clean Energy Economy."

[333] King, "81(R) HB 469 - Engrossed Version - Bill Analysis."

[334] Texas Workforce Commission, "About the Boards."

technical and community colleges, and training providers to align education and training with regional labor market demands.

TWC also administers the Skills Development Fund, a competitive grant program that supports customized training for employers. While the fund is not currently focused on carbon management, it could be leveraged to support workforce training for carbon capture, hydrogen, and related projects, if demand materializes.[335]

Given TWC's established infrastructure and partnerships, it is well-positioned to play a pivotal role in ensuring that Texas develops the skilled workforce required for the deployment of carbon management technologies. TWC's network and programs can be leveraged to provide the necessary training and workforce development that will enable Texas to capitalize on its carbon management potential.

Recommendation: Develop a Texas Carbon Management Workforce Advisory Council

Creating an advisory council hosted by the TWC and open to all workforce stakeholders, including industry, education, labor, and community members, could support a joint effort to develop the workforce needs of advancing CCS in the state. The council could discuss (1) meeting near-term labor demand and project development, (2) aligning training curricula, certifications, and instructor capacity, and (3) coordinating funding support for services that the workforce needs. Formalizing this coordination would streamline talent pipelines and accelerate project development in Texas.

Skillsets and transferable skills

Carbon management projects demand a wide range of technical and operational skillsets. Many of the skills needed to build and operate carbon management technologies are similar to those used by workers in the electric power generation and fuels industries, including construction labor and machine operation and maintenance.[336] According to the National Energy Technology Laboratory, the top six skill areas essential for successful deployment of carbon management technology are:

1. Engineering and technical skills
2. Geological and environmental expertise
3. Operations and maintenance
4. Data and digital skills
5. Policy and regulatory knowledge
6. Project management and communication[337]

As the demand for these skills grows, Texas must evaluate its current workforce, identify potential gaps, and take proactive steps to build a robust talent pipeline. This will not only support the growing carbon management sector but also drive investment in new technologies and create high-wage, family sustaining jobs. Moreover, workers in Texas's traditional energy and adjacent industries, who already possess many transferable skills, are well-positioned to use these skills on carbon management projects. To fully capitalize on this opportunity, the state can focus on workforce development programs that emphasize upskilling and reskilling, where needed.

[335] Texas Workforce Commission, "Skills Development Fund."

[336] US Department of Energy, "Workforce Analysis of Existing Coal Carbon Capture Retrofits."

[337] National Energy Technology Laboratory, "Carbon Capture, Utilization and Storage Workforce Resource."

Training and workforce development

Several training mechanisms are already in place for workforce development, including Registered Apprenticeships Programs (RAPs), career and technical education programs, pre-apprenticeships models, and workforce development initiatives. These mechanisms play a critical role in developing the workforce to meet the needs of carbon management deployment.

CAREER AND TECHNICAL EDUCATION AND PRE-APPRENTICESHIPS

Texas has a significant opportunity to strengthen its workforce pipeline through targeted investments in career and technical education and pre-apprenticeship programs. These programs serve a critical function by preparing individuals for apprenticeships and future workforce opportunities. [338] Pre-apprenticeships are usually a shorter-term training experience that focuses on skill-building, academic support, and hands-on exposure to skilled trades. These programs not only build essential skills but also provide academic support, ensuring that Texas has a ready and capable workforce to meet the state's carbon management goals.

The TWC administers dedicated grant funding to support pre-apprenticeship pathways, including preparatory instruction aligned with RAPs. Funding is available to community colleges, public school districts, and apprenticeship committees to build the foundational skills needed to succeed in apprenticeship and workforce programs. [339]

REGISTERED APPRENTICESHIP PROGRAMS

RAPs remain the most structured and established pathway to train workers for skilled occupations in Texas. RAPs provide hands-on, paid work experience alongside classroom instruction and result in a nationally recognized credential approved by the US Department of Labor or a State Apprenticeship Agency. In 2024, there were 25,473 active apprentices in the energy sector alone, reflecting a 43 percent increase in the past five years. [340] As of March 2024, there are 39 RAPs nationally that align with carbon management, such as the "carbon sequestration plant engineer" program. [341]

In Texas, apprenticeship programs continue to grow. In addition to having the largest energy workforce in the country, Texas is also the second-largest state with apprentices, with over 38,000 active apprentices in 2025. Texas has RAPs focused on carbon management in Austin, Houston, El Paso, Fort Worth, and Lubbock. [342] Many additional existing RAPs in the state can help meet workforce needs by preparing workers for relevant roles in adjacent industries. These include: [343]

- **Energy, energy production, energy transmission RAPs:** Apprenticeship programs in this sector focus on traditional skills needed in oil, gas, renewable energy, electrical linework,

[338] Boyd, "What Are Pre-Apprenticeships and Why Do They Matter."
[339] Texas Workforce Commission, "Apprenticeship Initiatives."
[340] US Department of Labor, "Apprenticeship Industries."
[341] US Department of Labor, "Data and Statistics."
[342] US Department of Labor, "Apprentices by State Dashboard."
[343] US Department of Labor, "Apprentices by State Dashboard."

and power plant operations. Workers trained in these programs will have similar skillsets needed for carbon management.

- **Construction and skilled trades RAPs:** Construction and skilled trades are foundational to the development of carbon management infrastructure. Apprenticeships in this sector cover a wide range of skills, including electricians, pipefitters, welders, etc. Texas has over 20,000 active apprentices in construction.
- **Manufacturing RAPs**: As the demand for carbon management technologies increases, so will the need for a skilled workforce to manufacture the materials and produce the components and machinery needed to support the technology. Texas has nearly 2,000 active apprentices in manufacturing.

RAPs also connect directly to federal tax incentives, as they can be used to meet apprenticeship requirements for projects to receive the full 45Q tax credit.

For Texas, this means that developers leveraging 45Q's prevailing wage and apprenticeship requirements could significantly boost the state's workforce development efforts in carbon management. Texans who build and operate carbon management projects now receive their training from companies that build out technologies or through broad construction, energy, and/or manufacturing registered apprenticeship programs that touch the needed skills only indirectly. Moreover, the US Department of Labor lists just 39 RAPs nationwide tied to "carbon sequestration plant engineer," which may not cover all critical roles needed for carbon management development.

Recommendation: Develop carbon-management-specific registered apprenticeship programs in the state

Launching more purpose-built RAPs that follow proven labor standards and focus on the workforce needs of carbon management can help create direct talent pipelines, leverage current workforce capital, and accelerate statewide deployment.

Recommendation: Provide competitive reskilling grants for carbon management workforce support

The TWC's skill development fund already co-finances customized training across the state. Carving out a dedicated carbon management grant stream within this fund would let training providers compete for cost-shared awards to retrain workers looking to expand their skillsets from traditional energy sectors into carbon management.

Organized labor

Organized labor has historically played a role in workforce training and project delivery across various sectors, particularly in large-scale infrastructure development. While Texas is a "Right to Work" state, where union membership cannot be a condition of employment, and union membership rates remain relatively low (4.5 percent of the workforce in 2023), certain unions in Texas and nationally may offer workforce development training relevant to carbon management.[344]

Labor unions often operate RAPs, which provide industry-recognized training that aligns with the

[344] National Right to Work Legal Defense and Education Foundation, Inc., "Right to Work States"; US Bureau of Labor Statistics, "Union Members in Texas – 2024."

needs of high-skill occupations in construction, operations, and maintenance. These programs may offer value to employers by delivering a pipeline of workers trained to national standards, reducing training costs, and improving worker retention and project quality.

In some cases, project developers choose to use Project Labor Agreements (PLAs) with one or more labor organizations that set basic terms for wages, working conditions, and hiring practices for a specific construction project. While PLAs are more common in states with higher unionization, they can also be structured to include both union and non-union workers. For developers operating in regions with labor shortages or where workforce quality and predictability are priorities, PLAs may help reduce risk by ensuring a steady supply of trained workers and minimizing work stoppages.

While organized labor has not historically played a prominent role in energy or infrastructure development in Texas compared to other states, labor-affiliated training programs, particularly in the skilled trades, may still be a relevant resource. Depending on project location, scale, and labor needs, developers may find it beneficial to engage with union-led training institutions or to consider PLAs on a case-by-case basis as one potential workforce development strategy.

Other workforce considerations

As carbon management projects move from planning to deployment, workforce readiness is a large factor in project delivery and cost control. Developers are increasingly facing delays from challenges in hiring and retaining skilled workers, particularly in rural and under-resourced areas.

The TWC administers the Skills Development Fund, which provides grants to employers and community college partners to support customized job training. While this program has been successful in addressing technical skills gaps, it does not currently provide funding for wrap-around services, such as transportation, childcare, or equipment access, that often determine whether individuals can participate in or complete training programs. [345] Many of these workforce gaps stem from non-technical barriers like a lack of transportation, childcare, or equipment access, which prevent individuals from completing training or remaining employed. Establishing a small fund to cover these wrap-around services would not only benefit developers by improving labor availability and reducing turnover, but also serve the state by increasing workforce participation, boosting local employment, and maximizing the return on existing training investments.

Recommendation: Leverage the Texas Skills Development Fund to support workforce participation in energy projects

Texas can strengthen its energy workforce and improve project outcomes by expanding the Skills Development Fund to cover non-technical barriers such as transportation, childcare, and equipment access. Allowing employers to access funds for wrap-around services if they hire locally, partner with approved training providers, and demonstrate job placement outcomes, would reduce project delays, support private investment, and deliver long-term economic benefits to the state by connecting more Texans to quality jobs in carbon management.

[345] Texas Workforce Commission, “Skills Development Fund.”

COMMUNITY ENGAGEMENT

Community engagement ensures local communities have a voice in decision-making processes, allowing their perspectives to be meaningfully considered.[346] Engaging communities effectively around carbon management projects can foster constructive relationships between project developers and residents and help move projects forward.[347] In Texas, where carbon management projects will span multiple regions, actively involving local organizations and residents can strengthen project legitimacy, address community concerns, and support responsible, equitable deployment of these technologies.

In addition to fostering support for projects, quality engagement can yield positive outcomes for communities, including remedying safety concerns, advancing economic opportunities, and encouraging local investment. Through intentional community engagement efforts, project developers can facilitate a smoother permitting process, benefit from local expertise, and build positive long-term relationships with the public.

While public engagement in environmental permitting is longstanding, state policies tailored to carbon management are relatively new and vary widely. Some states have begun adopting practices such as sharing early meeting notices, holding meetings in multiple formats at several times, and providing accessible materials. This section includes the following recommendations.

Recommendations:

- Increase public communication on carbon management permitting
- Develop a centralized, user-friendly online carbon management hub
- Establish a clear definition of “significant public interest” in air permitting
- Establish regular communication requirements for carbon capture projects within the designated impact area
- Expand public access to information on proposed CO_2 pipeline projects
- Increase public engagement opportunities during Class VI processes for carbon storage projects
- Establish and promote best practices for meaningful community engagement in air permitting
- Encourage work with developers and communities to develop Community Benefits Agreements and Plans

Public awareness, participation, and access to information on carbon management

Public awareness, participation, and access to information on carbon management are essential for building trust and supporting informed community engagement, which in turn can help support equitable deployment of these technologies.

[346] Penn State College of Agricultural Sciences, “What Is Community Engagement?”

[347] Ziegler and Forbes, *Guidelines for Community Engagement in Carbon Dioxide Capture, Transport, and Storage Projects*.

Public awareness of carbon management

Carbon management remains unfamiliar to many Texans.[348] However, several of the largest proposed facilities nationally are in Texas, generating growing interest and questions among local officials and residents. For many communities, a proposed project in their area may be their first exposure to carbon management technologies, and the lack of accessible, neutral information can contribute to confusion or skepticism.

A 2023 study found that support for DAC across communities, including Houston, was strongly linked to early engagement, procedural transparency, and clear local benefits.[349] Similarly, a study from Air Alliance Houston found that most community members surveyed were not well informed on the technology itself.[350] Another study of residents in the area highlighted gaps in understanding about carbon management and noted residents are "ill-equipped to advocate for themselves as significant investments in such projects begin to materialize."[351]

However, statewide polling data indicate that Texans respond favorably to carbon capture and storage when the technology is described in general terms. A March 2025 survey conducted by Public Opinion Strategies found that about 73 percent of registered voters expressed support for expanding CCS development in Texas after receiving a short explanation of how the technology works. Support was observed across political affiliations, age groups, and regions. These findings suggest general receptivity to CCS concepts, though they do not necessarily reflect prior awareness or detailed understanding among voters.[352]

Numerous stakeholders around Texas, including state agencies, academic institutions, and nonprofit organizations, have begun to develop educational resources on carbon management to bridge this gap.

TCEQ and the RRC have developed several public resources to support transparency and community understanding of carbon management permitting processes. TCEQ offers materials on air permitting requirements, including a general fact sheet outlining permit types and pathways, as well as guidance on greenhouse gas permitting under the New Source Review program.[353] The agency has also created resources to explain public participation procedures, such as plain-language notices and opportunities for community input at public meetings.[354] The RRC provides a dedicated page on geologic CO_2 storage, a broader overview of injection and storage permitting, and a portal for

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[348] Ward, "Houston Residents Lack Knowledge of Carbon Capture, Study Shows."

[349] Scott-Buechler et al., "Communities Conditionally Support Deployment of Direct Air Capture for Carbon Dioxide Removal in the United States."

[350] Spike et al., *Perspectives on Carbon Capture Technology in Houston: A Qualitative Assessment and a Possible Path Forward*.

[351] Pohjankoski, "Carbon Capture in Houston."

[352] Bolger, *Texas Statewide Clean Energy Survey*.

[353] Texas Commission on Environmental Quality, "Greenhouse Gas Permitting"; Texas Commission on Environmental Quality, "Fact Sheet - Air Permitting," June 2021.

[354] Texas Commission on Environmental Quality, "Public Participation in TCEQ Decision-Making."

public notices related to CO_2 storage projects.[355] The agency maintains a frequently asked questions page to help the public understand the Class VI well process, safety protocols for pipelines, and opportunities for input.[356]

Academic institutions in Texas have also played important roles in expanding outreach and educational efforts. The University of Texas at Austin, through its Bureau of Economic Geology, the Gulf Coast Carbon Center, and the Lyndon B. Johnson School of Public Affairs, has published fact sheets, technical briefs, and videos explaining the science of CO_2 storage. It has also hosted community programs and conferences to share insights with researchers, regulators, and the public.[357]

The Gulf Coast Carbon Center launched the Texas-Louisiana Carbon Management Community, a consortium of several universities that delivers CCS information via newsletters, workshops, and community programs, and Texas A&M University is researching direct air capture.[358] Rice University has also been active, partnering with Climate Now and the City of Houston in November 2023 to host a Carbon Management Dialogue, featuring listening sessions, workshops, and stakeholder discussions on CCS in the Greater Houston region.[359] Nonprofits have worked to engage community members on both the benefits and potential risk of CCS project expansion."[360]

Despite these efforts, stakeholder input during the development of the Texas Roadmap and state-wide studies indicate that many Texans remain unaware of how to access or navigate these resources. As the state's role expands, particularly with Texas obtaining Class VI primacy, these information needs are likely to grow. Preparing communities and local decision makers with clear, consistent information about carbon management technologies and the state's regulatory role will improve transparency, reduce opposition, and support responsible deployment.

Recommendation: Increase public communication on carbon management permitting

The RRC and TCEQ, which regulate different portions of the carbon management process, should collaborate to develop a plain-language overview of how various carbon management projects are regulated in the state. This resource should:

- Describe the types of permits that projects may require (e.g., air, water, waste, injection)

[355] The Railroad Commission of Texas, "Injection-Storage Permits"; The Railroad Commission of Texas, "Notices for CO2 Geologic Storage"; The Railroad Commission of Texas, "Geologic Storage of Carbon Dioxide."

[356] The Railroad Commission of Texas, "Geologic Sequestration of CO2 and Class VI Wells in Texas."

[357] The University of Texas at Austin - Lyndon B. Johnson School of Public Affairs, "University of Texas at Austin & Lamar University Workshop on Carbon Management and Community Impacts in the Gulf Region"; Gulf Coast Carbon Center, "UTCCS Showcase and Conferences"; Gulf Coast Carbon Center, "Put It Back"; Gulf Coast Carbon Center, "Research, Technology, and Education for the Geological Storage of Carbon Dioxide (CO_2)."

[358] Gulf Coast Carbon Center, "Texas-Louisiana Carbon Management Community (TXLA CMC)"; Texas A&M Energy Institute, "Carbon Capture, Utilization, and Storage (CCUS) and the Hydrogen Economy."

[359] US Department of Energy, "Carbon Management Dialogue."

[360] Pohjankoski, "Carbon Capture in Houston."

- Clarify the roles of state versus federal regulators for each part of the process
- Include best practices for developer engagement with local governments, communities, and state agencies.

Making this guide publicly available would improve regulatory transparency, help local officials prepare for project proposals, and build public trust, as carbon management deployment grows in Texas.

Recommendation: Develop a centralized, user-friendly online carbon management hub

To build on existing agency efforts and reinforce transparency, the RRC and TCEQ could develop a centralized, user-friendly, accessible online carbon management hub that compiles these resources in one place, and:

- Directs users to relevant permitting resources, including the resources mentioned in the "Increase public communication on carbon management permitting" recommendation
- Clarifies which agency handles which components
- Outlines opportunities for public engagement
- Provides plain-language summaries of key processes
- Offers an online mapping tool to better allow Texans to find and engage with permitting requests near where they live
- Lists instances of permitting violations relevant to the project
- Displays results of relevant environmental and community studies conducted by the state

Such a hub could serve both community members and project developers, helping to build trust and facilitate informed participation in the development of carbon capture, DAC, and CO_2 storage projects.

Public notice and engagement in Texas's environmental permitting process

Texas employs various permitting methods to help ensure the safety and efficacy of carbon capture and storage projects across the state. The state has received Class VI primacy for underground injection and storage of CO_2, and subsequently, most of Texas's policies around engagement follow standard guidelines set forth by the EPA's rules for Class VI. For any components of a CCS project that pertain to carbon capture, the state requires developers to procure air quality permits through TCEQ. Guidance around standards for public participation and engagement in the air quality permitting process are set by the state. This section seeks to outline the current procedure for engaging members of the public in key components of the permitting process for carbon capture projects, while highlighting areas where that engagement can be expanded.

CAPTURE

Currently, TCEQ requires developers of carbon capture projects to apply for and obtain an air quality permit. This process includes publishing a Notice of Receipt of Application and Intent to Obtain Permit in a local newspaper where any project will be sited and on the TCEQ state website. This publication must occur within 30 days of TCEQ declaring the application administratively complete. These notices must inform residents about how to submit comments, request public meetings, and more, while typically allowing at least 30 days for public comment.[361] In some instances, residents can contest a public comment period and request an extension, which is approved at TCEQ's discretion.[362]

While TCEQ does offer an avenue for individuals to request a public meeting on a certain application or project if they are defined as "affected persons" (i.e., Texans who can demonstrate they are personally affected by a permit application), that request must be deemed to have "significant public interest" for a public meeting to be called.[363] Likewise, current state practice tends to limit the ability to challenge permits to individuals living within one mile of a proposed project, even though there is no official guidance reinforcing that limit.[364]

Setting clear benchmarks for what qualifies as "significant public interest," including clearly designating a qualifying impact area for each project, would increase transparency and provide enhanced avenues for citizens to engage with project development early on.

Recommendation: Establish a clear definition of "significant public interest" in air permitting

To give residents meaningful opportunities to participate in the air permitting process for carbon capture projects, TCEQ should establish guidance to clearly define "significant public interest" in a project in greater detail for hearing requests. For example, the state could set an equitable threshold for the number of meaningful non-duplicative requests that would qualify significant public interest that is relative to the total population within a set radius of the project.

Current law requires public notice at the outset of the air permitting process, but there is no obligation to provide ongoing information if a project remains unchanged. Many projects may operate for decades, during which time new property owners and residents may move into the impact area. Without regular updates, communities may be unaware of the project's presence, which could undermine transparency, limit property owners' ability to make informed decisions, and reduce confidence in the safety of nearby operations.

Recommendation: Establish regular communication requirements for carbon capture projects within the designated impact area

At minimum, TCEQ should ensure that residents receive one mailed notice per year, including a reminder of the project's existence and location, relevant CO_2 safety information, information on opportunities for community engagement, and clear directions on how and where to access state information about carbon management projects across Texas (e.g., an online carbon management hub). These mailed notices should be in languages relevant to communities in the impact area and written accessibly.

TRANSPORT

The state of Texas does not have a siting authority for the development of pipelines, with siting largely completed by operators engaging directly with landowners.[365] As such, there is no formal pathway for community engagement regarding the siting and construction of a CO_2 pipeline.

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[361] Texas Commission on Environmental Quality, "Overview: Public Participation in Environmental Permitting."

[362] Public Notice of Air Quality Permit Applications.

[363] Determination of Affected Person, Title 30 Part 1 Chapter 55.

[364] Baddour, "The '1-Mile Rule.'"

[365] The Railroad Commission of Texas, "Pipeline Eminent Domain and Condemnation."

Portions of operational pipelines that could impact regulatory-defined, high consequence areas must follow the regulatory requirements for public engagement, as established by PHMSA.[366]

While the RRC has some information available on CO_2 pipelines, there are opportunities for the state to make this information more accessible for the public, who may be interested in proposed CO_2 pipelines but are not directly involved in landowner negotiations.

Recommendation: Expand public access to information on proposed CO_2 pipeline projects

The RRC can make CO_2 pipeline information more accessible on its website to improve transparency and ensure that Texas residents can stay informed about CO_2 pipeline development. The RRC could also include publishing a regularly updated list of proposed CO_2 pipeline projects, with details such as developer names and permitting status. The RRC could also provide plain language summaries of the permitting process and the RRC's role, along with links to relevant federal oversight, such as PHMSA guidance. In addition, the RRC's website could host interactive maps showing proposed and existing CO_2 pipeline infrastructure across the state.

STORAGE

There are existing federal community engagement and public notice guidelines tied to permitting for Class VI injection wells, which are used for long-term CO_2 storage, which the RRC had to meet to receive primacy. Now that the state has received primacy, the Commission can establish their own engagement standards that either meet or exceed those of the EPA.[367]

Requirements for Class VI permits include:

- Publication of a public notice in a newspaper of general circulation and on the permitting agency's website.
- A minimum 30-day public comment period following notice publication.
- Availability of permit applications and supporting materials for public inspection.
- Opportunity to request a public hearing, which are typically granted if there is significant public interest.

During a Class VI primacy public meeting, some community members and environmental advocacy groups requested to extend the public comment period from 30 days to 60 days. The RRC maintained the 30-day period, noting that it meets the minimum requirements for Class VI permitting. These requests from community members specific to the Class VI permitting process also reflected comments made during virtual roundtable conversations with community stakeholders earlier this year. During those roundtables, participants expressed, among other things, a desire for a more robust and accessible public engagement process around the development of CCS projects.

Best practices for public comment around general complex government regulations and rulemaking suggests that a 60-day window can enhance the number and quality of comments received.[368] In 2023, the Texas Legislature

[366] Public Awareness.

[367] US Environmental Protection Agency, *Geologic Sequestration of Carbon Dioxide: Guidelines on Community Engagement for Geologic Sequestration Project Developers and Class VI Permit Applicants*.

[368] SIFMA, "Importance of Appropriate Length of Comment Periods."

passed C.S.S.B. 1397, which expanded some requirements to make the opportunity for public comment more accessible to individuals without reliable access to internet. [369] However, the updated guidance, which is in effect until 2035, does not include broad requirements for project developers to initiate public outreach, education, or meetings.

Recommendation: Increase public engagement opportunities during Class VI processes for carbon storage projects

The RRC should ensure that applications for the development of injection wells require community engagement efforts, including:

- Ample public comment periods of 60 days following notice publication
- Public meeting opportunities, both as a requirement prior to application submission and prior to development beginning
- Additional regular methods of community outreach and engagement aligned with federal requirements and best practices

Policy pathways to enable quality community engagement

Early and transparent engagement is essential to build trust with communities. Clear communication about how community members can share input and participate in decision-making ensures that their voices are heard and valued from the start. This involves multiple strategies, including door-knocking, easy-to-understand digital resources in multiple languages, tabling at community events, and offering clear timelines. Communities understand that context is often changing, and that developers may need to make decisions they did not expect. As long as this is communicated earnestly and often, developers and community members can build trust.

State agencies play an important role in reinforcing this trust. Their efforts should focus on providing consistent, accessible information that explains how permitting and oversight decisions are made, what protections exist for public health and safety, and how residents can raise concerns. Agencies can strengthen legitimacy by ensuring that public meetings are well-advertised, held at accessible times and locations, and supported with interpretation services, when needed.

At the same time, state-led efforts can be viewed with skepticism, especially in communities that have experienced environmental harm in the past. Education should be developed in collaboration with independent, trusted actors to ensure communities have a full understanding of the benefits and potential harms of a project near their homes. These actors can include businesses, schools, and community-based organizations. For the purposes of state engagement on carbon management, a community-based organization should be considered a non-profit of demonstrated effectiveness that is representative of a community and provides resources or services to individuals in the community. [370] This type of collaboration helps residents make informed contributions to discussions and decisions.

It's important to recognize that educational efforts will not be successful in one or two short sessions. Instead, project developers will find the

[369] Schwertner, "Bill Analysis - C.S.S.B. 1397."

[370] PublicInput, *What Is a Community Based Organization (CBO)?*

greatest returns when they take the time to inventory community members' existing knowledge of carbon management and work to create tailored resources to address questions and concerns. Greater knowledge of a project and the broader context for why a project is valuable can decrease fear and uncertainty.

Collaboration with community leaders and local non-profits is critical to determining how economic benefits can be directed in innovative ways that address disparities and enable strong communities, ensuring that resources are invested where they are most needed. [371] It is important to ensure community leaders and community-based organizations in Texas are informed early about plans and consulted to foster a positive. [372]

In November 2022, TCEQ began requiring the completion of Public Involvement Plan for certain projects, as a component of the permitting process. The plan is meant to help project developers advance community engagement, especially in areas where projects may raise public interest or impact historically underserved communities. A Public Involvement Plan outlines how the applicant will provide clear, accessible information about the project, assess community demographics and language needs, and plan outreach activities, such as public notices, plain-language summaries, meetings, or interpretation services. This structure can be leveraged and enhanced to help project developers leverage best practices to deepen their outreach throughout Texas communities.

Recommendation: Establish and promote best practices for meaningful community engagement in air permitting

TCEQ should expand the requirements for submitting a Public Involvement Plan to include any new permit application activity that either requires public notice, has significant public interest, or is in a key geographic region within the state.

TCEQ should also develop clear, accessible best practices to guide developers in conducting meaningful community engagement for carbon capture projects. These best practices would be integrated into the existing Public Involvement Plan structure and would provide a consistent standard that communities can reference, and developers can follow—ensuring transparency, accountability, and a stronger foundation of trust.

TCEQ should provide resources, templates, and technical guidance to developers to support robust engagement. By offering standardized tools and clear expectations, the agency can help developers better align outreach with community needs and ensure feedback is meaningfully incorporated into project planning.

Elements of these best practices should include: [373]

- Guidance on early and intentional engagement. Developers of new carbon capture projects should be encouraged to undertake intentional outreach, including hosting at least two public meetings (one in person and one virtual or an equivalent level of engagement).

[371] Wilburn et al., "Cultivating Community Resilience Through Nonprofit Connections."

[372] Rabinowitz, "Chapter 18, Section 4. Using Community Sectors to Reach Targets and Agents of Change"; Texas Health and Human Services, "Texas Community Partner Program."

[373] Penn State College of Agricultural Sciences, "Guiding Principles of Effective Community Engagement."

These meetings should both educate the community about carbon management and provide an open forum to discuss the economic, social, and safety issues most important to residents.
- Meetings and educational efforts should be conducted, when possible, in partnership with local third-party organizations, such as community-based organizations or research institutions.
- Outreach should be in languages relevant to the engaged community, clear, and tailored for a range of technical backgrounds, to ensure all residents can meaningfully participate. Materials should be accessible both digitally and in print, recognizing differences in technology accessibility across communities.

Challenges to successful community engagement

Community engagement in carbon management faces a range of challenges, including mistrust of regulators, unenforceable promises, skepticism of technologies, and the complexity of working with diverse stakeholders.

LACK OF TRUST

While speaking to community organizations across Texas as part of the roadmap development process, many organizations expressed a distrust in the regulatory fidelity of state enforcement bodies. This mistrust, regardless of where it stems from, is likely to hinder the overall success of potential projects. [374] If communities do not believe project developers will act in the community's best interest, or if they believe the state will not provide adequate oversight, project developers will not gain the trust of their neighbors. Building trust is a critical step for companies to receive a social license to operate in both the short and long term. Connecting with trusted community leaders early, outlining a clear practice of transparency, soliciting and utilizing community feedback, and humanizing a project are important first steps in rebuilding long-lost trust.

UNENFORCEABLE AGREEMENTS

Community stakeholders expressed skepticism of promises made by developers that cannot be enforced. As developers navigate evolving economic or political conditions that require changes to plans, they can engage in iterative processes with community actors to create Community Benefits Plans or enforceable Community Benefit Agreements. This way, communities are secure in the knowledge that developers will meet priority needs. Likewise, developers can work with communities and deliver high-value certainties. An iterative process allows both companies and communities to familiarize one another with the constraints each experience. By working alongside communities, companies can proactively develop Community Benefits Plans or enforceable Community Benefits Agreements to help ensure projects bring tangible positive outcomes to nearby residents. One of the strongest and most well-recognized examples of a Community Benefits Agreement related to a carbon management project can be found in Nebraska, forged between Tallgrass, Bold Alliance, and numerous community organizations across the state. The agreement ensured protections and royalty payments for

[374] University of Minnesota Extension, "Building Trust in Communities."

landowners, as well as funding for local non-profits and emergency response personnel.[375]

Recommendation: Encourage work with developers and communities to develop Community Benefits Agreements and Plans

The state should encourage and provide guidance and resources for developers and communities looking to create Community Benefits Agreements and Plans. This guidance on community benefits agreements should be aimed at ensuring that communities where projects will be sited receive subsequent social, economic, and public health and safety benefits. These plans should be developed in conjunction with community members and groups and should leverage the support of local non-profits and NGOs.

TECHNOLOGY SKEPTICISM

Some community stakeholders during the Texas Roadmap development process expressed skepticism in the efficacy of carbon management technologies, voicing concerns about the possibilities of drinking water contamination, air pollution, and pipeline leaks. Developers, the state, trusted third parties, and research institutions should have a clear role in collaborating and demonstrating the safety mechanisms built into carbon management technologies. Interactive projects, classroom demonstrations, and hands-on activities can help communities visualize the role, understand the benefits, and assess and address the potential risks of carbon management. As an example, faculty members at the Tapia Center at Rice University prepare middle and high school students for careers in science, technology, engineering, and math, through hands-on projects. One project involves teaching students how to create carbon storage reservoirs with playdough, water, and rocks. Hands-on activities allow people to better understand how carbon management technologies operate. Moving beyond dense fact sheets and industrial jargon to intentional and inclusive education techniques can reduce skepticism and increase opportunities for support and collaboration of CCS projects.[376]

COMMUNITIES ARE VAST AND DIVERSE

Given the vast diversity that exists within any community, it's important for the state and project developers to work with as many stakeholders as possible.[377] Cultivating strong community buy-in can happen through diligent canvassing, building diverse coalitions, conducting community studies, and incorporating community concerns into a plan of action.

Ensuring safety and improved health outcomes for communities

Safety is often the primary concern for communities living near carbon management projects. Community members are familiar with the negative health impacts of industrial activity by their homes. Carbon management's strong record on safety and health outcomes presents project developers and the state with an opportunity to emphasize how carbon management projects can spur economic development while improving health outcomes.

[375] Tallgrass, "Community Benefits Agreement."

[376] Harvard Catalyst, *Plain Language*.

[377] Collinsworth, "Rural America Is Not a Monolith."

As discussed in the Carbon capture section, carbon management technologies utilizing amine-based capture systems can have positive health benefits to communities—though it is important to mitigate potential for other pollutants that could arise from the process. It is important that project developers have honest conversations about the technologies being deployed, how they can improve air quality, and what is being done to mitigate any potential harm that could arise from the project. There is precedent in Texas for community engagement, both on behalf of project developers and the state. The Texas Department of Housing and Urban Development has clear guidelines and requirements for organizations seeking access to agency funding. [378] One requirement is the completion of a Community Needs Assessment to understand the makeup of the community, the issues it faces, and necessary areas of intervention.

Other state agencies have expanded their support for broader community engagement. Some agencies, including the Department of Family and Protective Services, work to partner with networks of faith-based institutions to expand their public reach. [379] The state's Health and Human Services department developed the Community Partner Program, which partners with local NGOs to amplify community outreach efforts. [380]

Ensuring local economic opportunities and prosperity

Public, enforceable agreements between project developers and community organizations can establish trust and ensure people living near carbon management projects benefit from local investment. Clear commitments to local hiring, workforce development, and mentorship opportunities for workers can increase buy-in from local communities. [381]

The economic benefits from the deployment of carbon management technology in Texas are vast. Communities across Texas would benefit from expanded employment opportunities. Workforce development areas throughout Texas with higher-than-average unemployment rates (including East Texas, North Central Texas, Alamo, Gulf Coast, and the Capital Area) also tend to contain the highest number of sites suitable for CCS project development. [382] Through intentional deployment and targeted workforce development programming, CCS could have a significant impact on the economic well-being of workforce development areas statewide. For a more detailed analysis of potential benefits, see the Workforce development section.

[378] Texas Department of Housing and Community Affairs, "Checklist of State Requirements for Community Needs Assessments."

[379] Texas Department of Family and Protective Services, "Faith-Based and Community Engagement Regional Coordinators."

[380] Texas Health and Human Services, "Texas Community Partner Program."

[381] LMW HR Group, *When Is Hiring Local Talent Preferred?*

[382] Great Plains Institute, "Texas Carbon Capture Opportunities"; Texas Workforce Commission, "Labor Market and Career Information."

APPENDIX: STAKEHOLDER ENGAGEMENT

As part of the *Texas Carbon Management Roadmap* development process, the project team conducted extensive stakeholder engagement to ensure that the roadmap reflects a diversity of perspectives and is informed by those with relevant expertise and local knowledge. Outreach efforts targeted a broad range of participants, including:

- Industry representatives
- State agency staff
- Community-based organizations
- Academic and legal experts
- Non-governmental organizations
- Workforce expertise

Engagement activities

The engagement process included a combination of direct outreach, virtual roundtables, and one-on-one meetings. In total, over 100 organizations were contacted, resulting in participation from 50 organizations in virtual roundtables, around 20 organizations in in-person meetings, and 15 organizations in individual meetings. Across all engagement activities, nearly 60 unique organizations and 100 stakeholders provided input. This mix of formats allowed the team to reach a wide range of stakeholders, accommodate different availability and preferences, and create opportunities for in-depth conversations.

Approach and principles

The engagement process was guided by principles of inclusivity, transparency, and respect for participants' time and expertise. Participants were encouraged to share their insights openly and candidly, with the assurance that their comments would be incorporated into the roadmap without attribution. This approach created a safe environment for constructive dialogue and allowed stakeholders to speak freely about challenges, opportunities, and potential solutions.

By combining structured discussions with targeted outreach, the team gathered a wide range of perspectives on technical, policy, community, and environmental considerations for carbon management in Texas. These insights directly informed the recommendations in the roadmap, ensuring that they reflect on-the-ground realities and align with the needs of Texas communities, industries, and policymakers.

Attribution and independence

Participation in the roadmap's engagement process does not imply endorsement of the roadmap by any participant or organization. No recommendation is attributable to any specific stakeholder. The project team synthesized all input and developed the analysis and recommendations independently.

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