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Renewable Energy Webcast Series

Carbon Sequestration and Storage: An Overview

Presenters:

Bridget D. Furbee **Armando F. Benincasa** **David M. Flannery**

Challenges for Fossil Fuels in the US

- Concerns related to greenhouse gas emissions are requiring both the fossil fuel industry and users of fossil fuels to find ways to offset or lower emissions
- Obligations at both the national and state level, as well as in corporate board rooms, are pushing toward a carbon neutral position in the next 20-40 years
- It is imperative that the fossil fuel industry and those that rely on fossil fuels for energy and manufacturing production prepare to ensure that fossil fuels have a seat at the table as a viable source of energy into the future

A Carbon Neutral Future

- State Government Trends
  - At least 21 individual states now have some version of 100% clean energy goals into the future
  - Tax credits historically used to incentivize wind and solar projects are now being used to reduce the cost and risk to private capital when investing in carbon dioxide emissions capture and storage
- Build Back Better Act
  - The Clean Electricity Performance Program will make a $150 billion public investment to help utilities accelerate clean electricity development
  - Provides incentives and inflicts penalties on utilities that do not use clean electricity
  - Under the Act, clean electricity is generated with a carbon intensity of no more than 0.10 metric tons of CO_2 equivalent per megawatt-hour

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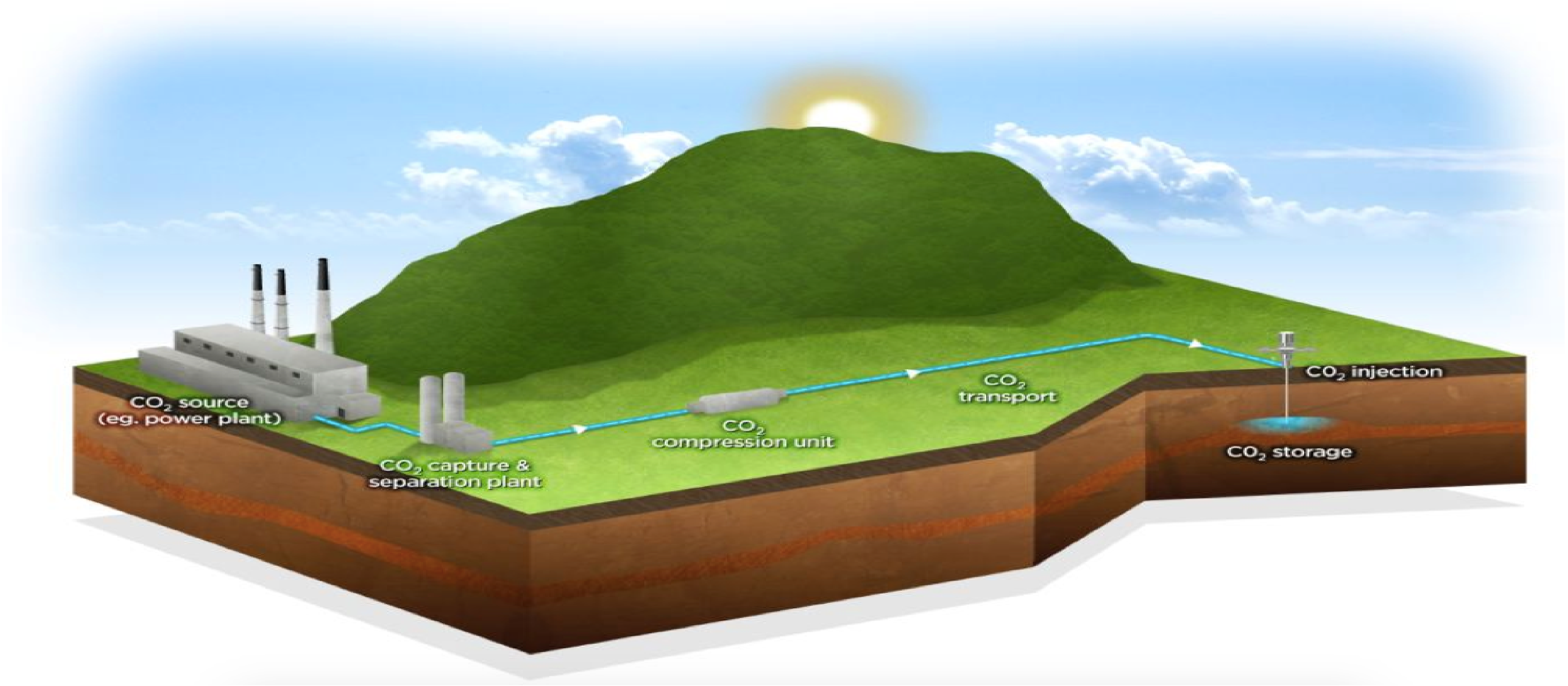
What is Carbon Capture Utilization and Sequestration?

- Carbon Capture Utilization and Sequestration, generally known as CCS, is an anthropogenic carbon emission reducing technology that can help lower greenhouse gas emissions created when burning fossil fuels
- Generally, CCS is a three-step process:
  1. Capture – carbon dioxide is separated from other gases at its emitting source, like coal and natural-gas-fired electric generation facilities
  2. Transport – the captured carbon dioxide is compressed and transported by pipelines, road, or ship to storage sites

  3a. Utilization – oil and gas production

  3b. Sequestration – the captured carbon dioxide is injected into underground geologic formations for permanent storage
- While not widely used in a commercial setting yet, it is a well-known technology

CCS



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Challenges for CCS

- Cost
  - CCS technology of the scale needed to sequester large amounts of CO_2 has not been readily available
  - Cost associated with removing CO_2 and delivering and sequestering the gas has meant that most projects need significant public dollars
    - The Illinois Basin – Decatur Project, primarily funded through the Midwest Geological Sequestration Consortium by the DOE announced in May the successful capture and storage of one million metric tons of CO_2
  - CCS technology is being refined with the hopes of moving toward economic viability
  - Not all Fossil Fuels are Equal. The differences in levelized costs per ton of CO_2 avoided are estimated by some:
    - Natural Gas - $21.5/ton
    - Coal-fired - $78/ton

Challenges for CCS

- Environmental Concerns
  - Model regulations have been developed and regulatory programs exist for CO_2 capture and injection, but issues related to environmental safety persist
- Transportation
  - Pipeline capacity
- Property Rights and Operational Liabilities
  - Pore space, use of eminent domain, and long-term liability

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Making CCS Affordable – the Cost Issue

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Refining CCS Technology is Necessary to Control Future Costs

- Federal Research and Development
  - Beginning in 1997, the DOE's Office of Fossil Energy and Carbon Management's Carbon Storage program has advanced the CCS knowledge base through diverse and applied research projects in hopes of making CCS an alternative and affordable technology
  - The primary focus is on early-stage R&D to develop coupled simulation tools, characterization methods, and monitoring technologies. This focus is intended to improve storage efficiency, reduce overall cost and project risk, decrease subsurface uncertainties, and identify ways to ensure that operations are safe, economically viable, and environmentally benign.

Federal Research and Development

- The key Carbon Storage Program goals include:
  - Determining the CO_2 storage resource potential of on and offshore oil, gas, and saline bearing formations
  - Improving carbon storage efficiency and security by advancing new and early-stage monitoring tools and models
  - Improving capabilities to evaluate and manage environmental risks and uncertainty through integrated risk-based strategic monitoring and mitigation protocols
  - Disseminating findings and lessons learned to the broader community and key stakeholders

With Technology Moving Forward, Making Money Available for CCS Project Development is Key

- U.S. Department of Energy
  - The Energy Act of 2020 authorized an expanded scope for DOE carbon capture and carbon removal research programs
  - The President's FY2022 Budget also proposes expanding DOE's CCS activities compared to previous years

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Tax Credits to Encourage CCS Project Development

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- Tax Credits
  - Internal Revenue Code Section 45Q offers tax credits that vary between $12 to $50 per metric ton of carbon captured and sequestered depending on timing and type of project
  - American Jobs Act
    - Creates a dedicated research agency – the Advanced Research Projects Agency – Climate (ARPA-C) within the DOE for climate research and advanced technologies
    - In line with the SCALE Act and the House Select Committee on the Climate Crisis's recommendation, supports large-scale carbon sequestration efforts to capture CO_2 directly from emission sources and from ambient air
    - Reforms the 45Q tax credit to make it direct pay and easier to use for hard-to-decarbonize industrial applications, direct air capture, and power plant retrofits

Providing an Environment to Encourage CCS - SCALE Act

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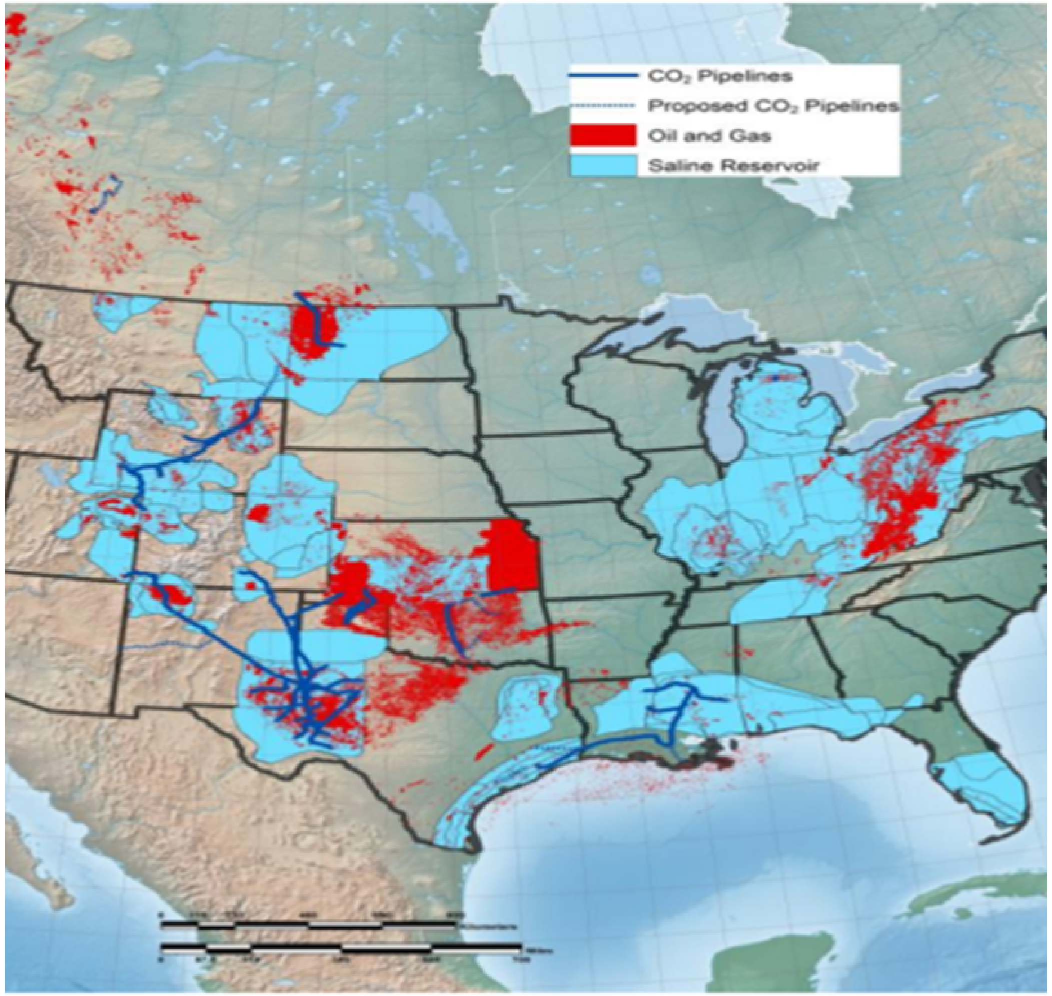
- The Storing CO_2 and Lowering Emissions Act (SCALE Act)
  - Bipartisan legislation would enable CO_2 transport and storage infrastructure required to scale up carbon capture, removal, use, and storage across domestic industries
  - The SCALE Act focuses on three key areas:
    - A federal financing mechanism for CO_2 transport and storage infrastructure and leveraging economies of scale by reducing the overall costs associated with interconnected systems buildout
    - Supports development of saline geologic storage resources and implementation of the EPA permitting program on CO_2 injection for secure geologic storage
    - Grants for states and municipalities to acquire low- and zero-carbon products derived from CO_2 and carbon oxides

Cost Recovery in Electric Generation for CCS Projects?

- CCS Retrofits
  - The Electricity Market Module (EMM) in the U.S. Energy Information Administration's National Energy Modeling System includes the option of retrofitting existing coal plants for CCS
  - The cost modeling structure for CCS retrofits within the EMM was developed by the National Energy Technology Laboratory and uses a generic model of retrofit costs as a function of basic plant characteristics. Those costs have been adjusted to be consistent with the costs of new CCS technologies.
    - Generally, capital costs average $1,819 per kW and range from $1,326 to $2,557 per kW assuming plants greater than 500 MW and heat rates lower than 12,000 Btu per kWh
    - While the project was not constructed, the WVPSC did approve a proposal for rate recovery to recover costs for a proposed CCS project

Transportation of CO_2



- If not utilized at source site, CO_2 must be compressed, transported for utilization/injection downstream
- ~ 5,200 miles of liquid CO_2 pipelines (mostly for EOR)
- Map shows pipelines in relation to OG and saline reservoirs
- Massive expansion of CO_2 pipeline network needed to transport for significant commercial CCS
- DOE estimates ~50,000 miles of new CO_2, lines needed in next 20 years to implement CCS "at scale"

Transportation of CO_2 (Regulatory Issues)

- **Federal** - No current federal economic regulatory scheme for CO_2 pipelines; thus, no access to federal eminent domain powers to secure easements (exception - pipelines on federal lands subject to BLM oversight)
  - FERC has declined to regulate:
    - *Cortez Pipeline Co.*, 7 F.E.R.C. ¶ 61,024 (1979) (CO_2 not "natural gas" under NGA due to traces of methane); *Southern Gas Co.*, 115 F.E.R.C. ¶ 62,266 (2006) (natural gas pipeline abandonment in conversion to CO_2 pipeline non-jurisdictional)
  - ICC declined to regulate:
    - *Cortez Pipeline Co.*, 46 Fed. Reg. 18805 (Mar. 26, 1981) (jurisdiction only covers lines moving commodities other than "water, gas, or oil")
- **State** - CO_2 pipelines subject to state-by-state regulation with minority granting condemnation rights to carrier

Transportation of CO_2 (Commercial Issues)

- 45Q tax credits available to entity that captures CO_2 (could be emitter, midstream company, or separate sequestration/storage operator)
- Title/ownership of CO_2
- Question of UCC application – is the CO_2 a "good" or a "service"?
- Liability issues (custody, environmental, loss of tax credits)
- Volumetric commitment
- Rates

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CO_2 Sequestration – Permanent Carbon Storage

- CO_2 injected, flows through/fills pore spaces (empty space between grains of rock, fractures, and voids) in permeable layers of rock matrix
- Potential targets: depleted oil/gas fields; shale formations; coal/CBM; deep saline formations
- Variables include:
  - Physical space of reservoir
  - Structural integrity of formation
  - Amount of CO_2 to be injected
  - Areal footprint over which injected CO_2 will migrate (plume)

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Property Rights – Key Issues

- Property rights issues related to sequestration include:
  - Ownership of pore space
  - Statutory framework
  - Common law
  - Correlative rights
  - Liability issues

Property Rights – Pore Space

- **Ownership**
  - Issues arise when fee simple interest severed into surface and mineral estate(s)
  - Injector must either own pore space, have permission from owner, or have a statutory or common-law right to use to avoid potential claims (e.g., trespass, conversion, nuisance)
  - Generally, mineral owner holds ownership interest in physical molecules of mineral (oil, gas, salt, etc.) either in place or right to recover/produce; but mineral ownership does not extend to geological structures that contain minerals beneath surface

Property Rights – Pore Space

- **Statutory Framework**
  - Federal law grants broad rights to DOI authorizing geologic storage, surface and subsurface storage leases, easements
  - Small number of jurisdictions statutorily determined pore space is owned by surface owner
  - Some states have addressed carbon sequestration and granted regulatory authority to specified agencies
  - Proposed IOGCC model statute/recommendations (but leaves to states how to address pore space ownership)

Property Rights – Pore Space

- **Common Law**

  Unless otherwise established by federal or state law, or express right addressed in title documents, ownership of pore space is determined by state common law

  – A few cases have determined that surface owner owns pore space; based on retention of all rights except those expressly granted to others, e.g., oil, gas, other minerals (not everything below surface/certain depths):

    - (WV) *Tate v. United Fuel Gas Co*., 71 S.E.2d 65 (1952) (*as long as no longer any recoverable minerals in stratum*, surface owner holds title to subsurface space for natural gas storage)
    - (TX) *Humble Oil & Refining Co. v. West,* 508 S.W.2d 812 (1974) (surface owner retained geological structures beneath surface and any structure suitable for storage of gas produced elsewhere)

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Property Rights – Correlative Rights

- Rights between surface owners/mineral owners "reciprocal and distinct"; no unreasonable interference between two
- Possible effect of injection/storage on minerals (native mineral substances affected by injected substances as well as minerals displaced by injection)
- Surface use agreements may be obtained from surface owner (granting right to inject and store), as well as subsurface easements from mineral owners, or lessors/lessees if subject to lease (to extent injection affects minerals)

Property Rights – Correlative Rights

- Storage of CO_2 has potential implication on following:
  - Natural Gas
    - Potential interference between projects in event of migration
  - Oil
    - Particularly EOR fields as to remaining oil and CO_2
  - Coal
  - Gas Storage Fields
    - Potential effect on gas storage zones in close proximity
  - Wastewater Injection Wells
    - Some in oil production zones (EOR), some in non-producing zones (above/below)
  - Compressed Air Storage

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Property Rights – Liability Issues

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Liability Rule, Not Property Rule

- Potential liability of CO_2 well operations for claims of trespass/subsurface injury to injection tracts/migration to other tracts
- However, subsurface intrusions generally treated differently than surface trespass claims and frequently require actual and substantial damages
- While comparisons have been made to gas storage, imperfect analogy to CO_2 sequestration
- Better analogy is to underground waste-injection cases
- Underground waste-injection operations conducted under federal/state authorization (UIC) *that do not cause actual harm to adjacent properties* may be carried out without compensation to surrounding landowners due to public interest/necessity

Property Rights – Liability Issues

- When injection of fluid wastes conducted under regulatory approval, courts have modified common law relating to subsurface property by rejecting notion that property owners entitled to compensation for use of their pore space, or that they have absolute right to prevent underground migration of fluid waste into their pore space, e.g.:

  – *Chance v. BP, Inc.*, 670 N.E.2d 985 (Oh. 1996) (Chemical plant operator not required to acquire pore space rights for permitted disposal wells; subsurface property rights not absolute; no trespass absent physical damage/interference with pore space)

  – *Crawford v. Hrabe*, 44 P.3d 442 (Kan. 2002) (lessee not prohibited from injecting off-site wastewater into lessor's subsurface for secondary recovery of oil and not liable for trespass; finding orthodox rules of surface trespass not applicable to subsurface, and that injecting wastewater for EOR operations was practical/efficient use of a potentially hazardous waste product)

Class VI UIC Program 40 CFR Part 146 Subpart H

https://bit.ly/3ArbguF

- Goals
  - Protect underground sources of drinking water
  - No requirement to capture/sequester CO_2
- Safe Drinking Water Act does not provide authority to address:
  - Capture and transport of CO_2
  - Property rights
  - Liability transfer
  - Accounting for GHG reductions

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IOGCC Guidelines for States

Guidance for States & Provinces on Operational & Post-operational Liability of Carbon Geologic Storage, **(September 2014 https://bit.ly/3Dx2j4I)**

- States should seek primacy of the USEPA Class VI UIC program
- State programs should embrace two basic principals:
  1. It is in the public interest to promote geologic storage of CO_2 in order to reduce CO_2 emissions
  2. Pore space should be managed as a resource
- States should develop their own programs to address matters not addressed under the Class 6 program, such as:
  - Pore space ownership
  - Surface facilities
  - Pipelines

National Coal Council

*"Expedited CCS Development: Challenges and Opportunities",
https://www.nationalcoalcouncil.org/reports/03_29_11_Final_NCC_Report.pdf (March 2011)

- CCS has not progressed fast enough due to technical issues, funding incentives and regulatory and permitting issues (including pore-space ownership and liability)
- Use of coal with CCS provides opportunity to significantly reduce GHG emissions
- Recommendations:
  - Accelerate near term development of CCS for coal-based generation
  - Promote CO_2 storage opportunities for EOR
  - Reduce regulatory barriers with PSD and NEPA
  - Allow use of pore space which is not being used
  - Limit an operator's legal liability

National Coal Council

Fossil Forward, Revitalizing CCS, Bringing Scale and Speed to CCS Deployment, National Coal Council, https://www.nationalcoalcouncil.org/studies/2015/Fossil-Forward-Revitalizing-CCS-NCC-Approved-Study.pdf (February 2015)

- USEPA Class VI program addresses many, but not all, aspects of CCS
- USEPA program addresses only the underground sources of drinking water
- USEPA program does not address pore space, surface facilities, pipelines
- CCS/CCUS Deployment Challenges
  - Infrastructure for transportation and storage of massive quantities of captured CO_2 does not exist.
  - Financing power plants with CCS is a major issue.
  - Legal and regulatory issues still remain unresolved.
  - Public acceptance is still an issue. There is a parallel public perception association between fracking and CCS that should be more closely observed. Some regions have banned fracking. They might also ban injection and storage of CO_2.

Council of Environmental Quality Report to Congress on Carbon Capture, Utilization, and Sequestration, June 30, 2021

https://www.whitehouse.gov/wp-content/uploads/2021/06/CEQ-CCUS-Permitting-Report.pdf

"To avoid the worst impacts of climate change and reach President Biden's goal of net-zero emissions by 2050, we need to safely develop and deploy technologies that keep carbon pollution from entering the air and remove pollution from the air."

"The report we are releasing today outlines a framework for how the U.S. can accelerate carbon capture technologies and projects in a way that benefits all communities."

State Delegation of Class VI Program

- **Approved delegation:**
  - North Dakota: 83 Fed. Reg. 17758 (April 24, 2018)
  - Wyoming: 85 Fed. Reg. 64053 (October 9, 2020)

- **Primacy applications pending:**
  - Arizona
  - Louisiana
  - West Virginia

States With CCS Legislation

- Illinois – ownership of CO_2; permitting; indemnification for certain liabilities, eminent domain
- Indiana – eminent domain; ownership of stored CO_2
- Kansas – exempts state from liability
- Louisiana – eminent domain; permitting; liability transfer; ownership of CO_2;
- Montana – pore space ownership; unitization; liability; ownership of CO_2
- Nebraska – pore space ownership; permitting; pooling; CO_2 ownership by state upon completion
- North Dakota – pore space ownership; liability; ownership of CO_2; unitization
- Oklahoma – ownership of CO_2
- Texas – pore space ownership; permitting; tax credits; ownership of CO_2
- West Virginia – permitting; property rights; interstate cooperation
- Wyoming – pore space ownership; permitting; ownership of CO_2; unitization

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