Eliminating Non-Cash Flow Risks to Full Scale-Up of Geologic Storage (GS) Once Commercial Deployment Has Been Achieved

Steven Carpenter
Managing Partner, Carpenter Global, LLC

July 2022

This research paper was commissioned by the Energy Futures Initiative (EFI) and represents the views and conclusions of the author(s). EFI has not endorsed or approved the statements and conclusions contained in these documents but will be sharing this work as part of the project process.

About the Author

Steven Carpenter

Dr. Carpenter is a seasoned executive with 30 years of experience in the energy, mining, international, and standards development industries. He is an internationally recognized Subject Matter Expert on Enhanced Oil Recovery (EOR), climate change, carbon, and risk management issues. His diverse work includes technical assessments, public policy, legal and regulatory issues, training and education. Dr. Carpenter is both an accomplished author and sought after public speaker. Dr. Carpenter holds degrees in Physics from Earlham College, Conflict Analysis and Engagement of Environmental Public Policy from Antioch University, and Transdisciplinary Approaches to Carbon Dioxide Capture, Utilization, and Storage from the California Institute of Integral Studies.

Abstract

This paper explores the non-cash flow risks uniquely inherent to the Geologic Storage (GS) portion of the overall CCS value chain. These non-cash flow risks include consideration of the adequacy of pore space volume; conversion of operating hydrocarbon fields to storage only; pore space acquisition; challenges in obtaining MRV plans; challenges in obtaining UIC Class VI permits; risks posed by orphan wells; post closure expenses; and long-tail risks.

Complex problems like climate change require a unique and specific approach to identify and implement the appropriate solutions requiring a transdisciplinary approach. In many cases geologists, engineers, and geoscientists either overlook or are not exposed to certain non-technical—and in the case of this paper, non-cash flow—considerations that are integral to full scale commercial deployment of CCUS. An analogy used internationally by the International Standards Organization (ISO) Technical Committee 265: CCUS is to consider a Geologic Storage project like building a barn. There are four major considerations to address that include 1) the size of barn (e.g., storage capacity and porosity); 2) the number and size of the doors in the barn (e.g., injectivity, permeability, number of wells); 3) how sturdy is the barn (e.g., caprock, basement, MVA); and 4) can you build the barn, and if so, where (e.g., Social License to Operate (SLO), Environmental Social Governance (ESG), Environmental Justice (EJ), permits).

This paper finds eight (8) key areas that must be addressed.

1. Identify pore space through pre-screening—which could be much improved and lower the cost of entry and development.
2. Orphan wells and uncertainty about plugging and abandonment—may increase development costs and slow deployment
3. More certainty about converting old wells to GS is needed—could speed up development
4. Unitization and eminent domain for pore space—some states have clear laws, but not all

5. Defining closure responsibility and then assigning post-closure liability—and the difficulty to insure—may require a Price-Anderson type approach
6. Is GS free from and exempt from RCRA?
7. Inadequate pace and resources at EPA for MRVs—ISO superiority to GHGRT
8. Whitehouse pronouncements conflict with respect to CCS—EJ requirements undefined and need clarification

Is GS possible? Certainly. Is it possible at the size and scale that is necessary, and can it be deployed as quickly as needed, as economically as desired, and are there real existential obstacles that exist? Absolutely—but these obstacles must be overcome.

Table of Contents

1. Introduction

In support of the first project of the EFI to explore the current state of commercial deployment of carbon capture and storage in the US, this whitepaper seeks to focus on non-cash flow risks uniquely inherent to the GS portion of the overall CCS value chain. Cash flow risks of GS Facilities are not considered in this white paper. Those risks not considered nor included in this whitepaper assume that a GS facility could be dedicated to a single capture project, or it might be part of a larger "hub" serving a diversified group of large capture projects. In either case, since current ($50/MT) and proposed ($85/MT) federal support levels are far higher than most estimates of GS costs in reasonably favorable geologies (i.e., costs <$20/MT), we take the practical approach that concerns regarding the sufficiency and volatility of cash flows are best discussed in the context of the capture units.

The Non-Cash Flow risks considered in the whitepaper include consideration of the adequacy of pore space volume; conversion of operating hydrocarbon fields to storage only; pore space acquisition; challenges in obtaining MVR plans; challenges in obtaining UIC Class VI permits; risks posed by orphan wells; post closure expenses; and long-tail risks.

Complex and wicked problems like climate change require a unique and specific approach to identify and implement the appropriate solutions. Climate change is a very complex issue that requires a transdisciplinary approach.[1] The need for this transdisciplinary approach is evident from the IPCC itself, when critical realist Roy Bhaskar stated in his edited book, *Interdisciplinarity and climate change: Transforming knowledge and practice for our global future*:

> Physical science has reached its explanatory limits in the climate context and now needs to be integrated with the human sciences, a project which it has been reluctant to undertake and for which a critical realist perspective is essential. Current divisions of climate issues (e.g., by the IPCC) into separate study areas continue to reflect and

reinforce traditional disciplinary (e.g., science/arts) cultural divides in climate research.[2]

Presented in a slightly different manner, in many cases geologists, engineers, and geoscientists either overlook or are not exposed to certain non-technical—and in the case of this paper, non-cash flow—considerations that are integral to full scale commercial deployment of CCUS. Another analogy used to describe this notion is that of a barn, used as part of the development of the of the International Standards Organization (ISO) Technical Committee 265: CCUS. Two working groups, WG3: Geologic Storage and WG6: CO_2 EOR, both included the discussion of the barn as the storage reservoir and what must be considered in order to construct the barn. There are four major considerations to address that include 1) the size of barn (e.g., storage capacity and porosity); 2) the number and size of the doors in the barn (e.g., injectivity, permeability, number of wells); 3) how sturdy is the barn (e.g., caprock, basement, MVA); and 4) can you build the barn, and if so, where (e.g., Social License to Operate (SLO), Environmental Social Governance (ESG), Environmental Justice (EJ), permits). In most cases, the technical experts consider, think about, and plan CCUS projects in this order, 1 – 4. However, when one considers eliminating non-cash flow risks to full scale-up of geologic storage, the technological order is not necessarily accurate. More directly, from a development standpoint, it is far more important to understand if one has a social license to operate in the area in which one desires to build. The issue of ESG, SLO, and other EJ considerations make the order of ‘barn construction tasks’ a process for consideration.

2. Identifying Pore Space through Pre-Screening

Despite much public funding and research that has created large amounts of data, there are no efficient tools to connect and access that data to aid in the screening process. There can and should be better ways to cross reference existing wells and subsurface data. Existing CO_2-EOR projects and data can screen for storage options, but much of the EOR data is private and understanding how to access, connect, and use the data is lacking. Assuming one can screen and connect EOR data, across the fee, state, and federal property landscape, assemblage of unified pore space is difficult.

Using the technologist perspective, the first thing to consider is whether there is adequate pore space proximal to the project site. There are a host of options, sources, and data that currently exist to adequately identify the pore space volumes and in many cases seals (e.g., cap rock), permeability, and injectivity of the pore space. These sources include many federally funded options, the most significant is the Department of Energy's National Energy Technology Laboratory's Energy Data eXchange (EDX).[3] Developed in 2011, EDX was initiated as an innovative solution to data challenges by offering a means for better preservation of DOE's research for future access and re-use, to provide efficient and easily discoverable access to authoritative, relevant, external data resources, and to meet DOE's mission and goals. These data repositories provide significant first-level screening for potential developers and provide for economic development agencies at the state or local level to 'encourage' developer's consideration of certain pore spaces.

EDX contains ten CCUS specific data sets that include:

- **Carbon Storage Open Database:** data resources related to all open carbon storage data on EDX
- **CarbonSAFE:** Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative projects focus on development of geologic storage sites for the storage of 50+ million metric tons (MMT) of carbon dioxide (CO_2) from industrial sources.

- **NRAP:** NETL is leading a multi-laboratory effort that leverages broad technical capabilities across the DOE complex into a mission-focused platform that will develop the integrated science base that can be applied to risk assessment for long-term storage of CO_2. NRAP involves five DOE national laboratories: NETL, Los Alamos National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, and Pacific Northwest National Laboratory, with the motivating goal to evaluate risks at geologic carbon storage sites, in the context of system uncertainty, particularly those associated with potential release of CO_2 or brine from the storage reservoir, and potential ground-motion impacts due to large volume injection of CO_2.
- **RCSP - Big Sky:** includes carbon storage datasets from the Big Sky Regional Carbon Sequestration Partnership.
- **RCSP – MGSC:** includes carbon storage datasets from the Midwest Geological Sequestration Consortium: MGSC.
- **RCSP – MRCSP:** includes carbon storage datasets from the Midwest Regional Carbon Sequestration Partnership.
- **RCSP – PCOR:** includes carbon storage datasets from the Plains CO_2 Reduction Partnership: PCOR.
- **RCSP – SECARB:** includes carbon storage datasets from the Southeast Regional Carbon Sequestration Partnership: SECARB.
- **RCSP – SWP:** includes carbon storage datasets are from the Southwest Partnership: SWP.
- **RCSP – WESTCARB:** includes carbon storage datasets are from the WESTCARB Regional Carbon Sequestration Partnership.

In 2012, the US Geological Survey (USGS) completed the national assessment of geologic carbon dioxide storage resources.[4] Its data and results are reported in three publications: the assessment data publication, the assessment results publication, and the assessment summary publication.[5] This data publication contains (1) individual storage assessment unit (SAU) input data forms with all input parameters and details on the allocation of the SAU surface land area by State and general land-ownership category; (2) figures representing the distribution of all storage classes for each SAU; (3) a table containing most input data and assessment result values for each SAU; and (4) a pairwise correlation matrix specifying geological and methodological dependencies between SAUs that are needed for aggregation of results. Using the EDX data sets from the seven Regional Carbon Sequestration Partnerships (RCSP) noted above, the USGS then updated the Carbon Dioxide Storage Resources Assessment.

The Association of American State Geologists (AASG) is comprised of the state geological surveys in all 50 states and Puerto Rico. The organization provides a link to each of the surveys, many of which have data depicting the subsurface and many, especially those whose surveys also engage with or regulate the oil and gas industry, have additional data that details the subsurface.[6]

Many have argued that these data repositories lack the requisite or adequate data detail of the pore space volume required at a proposed location. The argument can, and should be made, that these data sources do not relieve the project developer or permit applicant from the required reservoir characterization, which includes understanding of the pore space. These data repositories do, however, provide significant first-level screening for potential developers and provide for economic development agencies at the state or local level to 'encourage' developer's consideration of certain pore spaces. Two examples of this effort are the States of Louisiana and Wyoming. The Louisiana Department of Natural Resources, State Energy Office has embarked on a program to determine pore space availability (e.g., porosity, permeability, etc.) on state lands in an effort to encourage economic development within the state. Wyoming's Energy Authority has initiated the Sequestration as a Service within Wyoming.[7] The WEA would permit and build commercial sequestration sites with wells for injecting CO_2 and the sites would then be offered as a service to any CO_2 emitter.

We must find better ways to use and connect existing data. What the paper suggests as a means to speed the commercial development of CCUS is to use these data repositories for their intended use—first level or high-level screening—and not for permit or economic decision making. If one makes the argument that these data repositories should exist with the permit level data regarding pore space, they would be in essence providing the first level of the permit application, especially in the UIC Class VI program that requires identification of ownership, appropriate stratigraphic testing, and unitization, where appropriate. These data lack the detail required for permit application. In most cases, those developers who are in the mode of decision-making to first secure pore space, would not be in any position to know these three things: who owns the pore space, what is the quality of the detailed data of the pore space from stratigraphic tests, and can the pore space be unitized? Again, these data repositories may increase the speed at which a number of developers can review multiple sites and help fast-track state or regional level economic decisions; but they have not been designed for, nor should they be assumed to be permit-level or project specific decision-making tools. With the aforementioned as background, the states of Wyoming, Louisiana, and Oklahoma are advancing these types of efforts and other states are in various phases of advancing efforts to digitize, advance, and openly share data for the purpose of supporting these development tools.

While this paper has been critical of the lack of usefulness and correlation of the data as exampled by the out of data Carbon Atlas (e.g., the most current publication is circa 2015), this data does have value for education and stakeholder engagement.[8] The Carbon Atlas is a wonder STEM took and has many useful graphics for stakeholder engagements such as townhall meetings, etc., but is not appropriate for any project level decision-making.

Having stated that the above should not be used for detailed decision-making and rather for high-level or first-level go-no-go decisions, there are some tools that exist that begin to drill down and increase the level of detail necessary to make some of these project level or permit level decisions. These include several standards, designed to address the pore space and detailed reservoir characteristics necessary to implement a CCUS storage project. Two international standards include ISO 27914:2017 Carbon dioxide capture, transportation, and geological storage — Geological storage and ISO 27916:2019 Carbon dioxide capture, transportation, and geological storage — Carbon dioxide storage using enhanced oil recovery (CO_2-EOR), both of which contain sections that address the issue of pore space applicability for storage. There are national and private standards designed to do the same. They include CSA Group's Z741-12 (R2018) Geological storage of carbon dioxide for North America, ANSI's CSA/ANSI ISO 27916:19 Carbon dioxide capture, transportation, and geological storage — Carbon dioxide storage using enhanced oil recovery (CO_2-EOR), which is a US approved, verbatim version of the ISO 27916:2019 standard. DNV-GL has a geologic service specification that also defines and requires the description of the pore space for storage in their DNVGL-SE-0473 Edition October 2017, Certification of sites and projects for geological storage of carbon dioxide. DNV has used their specification, coupled with the ISO 27914:2017 to independently review and certify international storage projects that include QUEST, CarbonNet, Gorgon, Project Greenland, Northern Endurance Partnership, and two projects in Russia. These tools however are driven by, or only have value if there is data to action them. These standards or tools depend on data and the more data that is available, and the more detailed the data, the more rapidly these tools will have value in driving commercial deployment of CCUS.

Beyond the “first-level” data discussed above, many developers will embark to collect the deepest and most detailed level of data by engaging in site-specific work by consultants like Advanced Resources International; Gaffney, Cline; Netherland and Sewell; and Ryder Scott. These consulting firms and many others use many guidelines or standards, or better stated, “tools”, to evaluate the subsurface to ascertain both reserve information (e.g., amount of the assets in place) as well as the characteristics of the reservoir. These tools include the Society for Petroleum Engineers (SPE) CO_2 Storage Resources Management System (SRMS), SPE’s Petroleum Resources Management System (PRMS). Those companies that are publicly traded and need to secure funding for operations are required to provide an assessment of their assets, and that assessment must be completed in an approved manner. In the US companies that have solid assets (e.g., coal, mineral ore) that may intend to store CO_2 can use the US Securities Exchange Commission’s (SEC) Industry Guide No. 7, Description of property by issuers engaged or to be engaged in significant mining operations. Similarly in Canada, the comparable process is known as a National Instrument 43-101, or NI43-101. Both the SEC Guide 7 and the NI43-101 are bound by financial trading schemes such as the NY Stock Exchange and the NASDAQ.

The large regional and continental pore space studies were conducted not to determine if one could inject in a particular place, but rather to ensure that there was sufficient pore space volume to allow for society (e.g., US, Canada, etc.) to store the whole of the emissions, therefore it was done to meet policy goals not project goals. One should not assume that we can convert this policy effort of regional and continental assessments into project level assessments. 3D seismic data is extremely valuable data, as is utility rights of way (ROW), and certainty of pore space ownership. The government can assist in assembling, supporting, and sharing project level data or project level assessments. Project level quality data need not differ from hydrocarbon production field data. Reusing or repurposing this data can minimize cost, reduce risk, and shorten project schedules. In other words, the real “project” or task here, relative to project level data and curation, for government to participate, lead, support, or otherwise engage in a typical “consultancy” project. Specifically, there will be a need for consultancy level—work for hire by the project developers—in order to complete permit application and financial viability. However, for every project, there will be new data created. An agency, pick your poison—DOI, DOE, DOC, EPA—someone should step forward and collect, curate, archive, and publish said data in an open and transparent manner, much like ESRI and ArcGIS. This then becomes not a policy issue, but simply a budget issue. So long as the regulations are clear, reducing costs and risks are appropriate roles for government engagement.

3. Orphan Wells and Uncertainty of Plugging and Abandonment

It is obvious through federal and state legislation that significant funds have been put in place to address the issue of orphan wells, plugging and abandonment (P&A). Much work has been accomplished with respect to the identification, cataloging, assessment, and plugging and abandonment (P&A) of wellbores, with focus on orphaned, unknown, or newly discovered wellbore penetrations through the caprock seal of the storage reservoir. A question to consider is how many of the hundred thousand plus Class II wells in the US should be considered for CCUS projects and in that identification process, how much public funding should be used to ensure that the former hydrocarbon producing field is now up to current standards to be considered for carbon storage. In response to this risk issue, the federal government has invested in research to address the issue. Given the need to focus on identifying orphan wells as well as plugging them, a policy recommendation should be to take the next step and marry orphan well characterization with wellhead location, combining it as a well-defined opportunity for GS.

CCUS programs at the federal level require some form of risk assessment, which in turn helps to ensure that orphan wellbores are considered with each and every CCUS project. One such program is the Department of Energy's Systematic Assessment of Wellbore Integrity for Carbon Storage Projects Using Regulatory and Industry Information, DE-FE0009367. This work is led by Battelle and has several industrial and research partners that include BP Alternative Energy and Columbia Pipeline. The project objectives were to identify the existing, plugged, and abandoned wellbores as one of the greatest risks for CO_2 migration pathways. The project designed a methodology to identify risks and recommend mitigation procedures, develop, and validate technologies to ensure 99% storage permanence, and to develop technologies to improve storage efficiency while ensuring containment effectiveness (goals). The project considered wellbore integrity issues such as cement degradation, cement type, cement age, additives, hydrogeologic conditions, cracks and micro annuli, acid gas zones, geologic logs, drilling logs, and casing corrosion. Much of this work has been incorporated into current best practices both within the Department of

Energy's CCUS program and by outside organizations that include the two ISO standards for GS and CO_2-EOR. All of DOE's Regional Carbon Sequestration Partnerships as well as the CarbonSAFE programs must address abandoned and orphaned wells. As these projects and programs implement the risk management plans, more and more orphaned and abandoned wells are identified, plugged, and abandoned. What remains are the fewer and fewer elusive, old wells, which were never placed on maps, never recorded, that may be open holed (e.g., no metal casing), or plugged with wood—often in the "old days" with railroad ties—both of which make it extremely difficult to locate, especially with a magnetometer.

Included in the Infrastructure Investment and Jobs Act (IIJA), in Title—Methane Reduction Infrastructure SEC. 40601, Orphaned Well Site Plugging, Remediation, and Restoration, Section 349 of the Energy Policy Act of 2005 (42 U.S.C. 15907), The Secretary of Transportation is charged with working cooperatively with the Secretary of Agriculture; affected Indian Tribes; and each State within which Federal land is located; and to consult with the Secretary of Energy; the Administrator of the EPA; and the Interstate Oil and Gas Compact Commission. The required consultation and cooperative work encompass the following tasks: plug, remediate, and reclaim orphaned wells; identify and characterize undocumented orphaned wells; rank orphaned wells based on factors; make information regarding the use of funds received under this subsection available on a public website; measure and track emissions of methane and other gases—one could argue that CO_2 should be included; remediate soil and restore native species habitat; and to address the Administration's Justice40 requirements by identifying and addressing any disproportionate burden of adverse human health or environmental effects of orphaned wells on communities of color, low-income communities, and Tribal and indigenous communities. In order to accomplish the work prescribed by Congress, funding is provided to multiple agencies. The funding falls into several buckets identified as: $25 million for each State as initial grants to identify abandoned or orphaned wells; $20 million for each State to make regulatory improvements; $30 million for each State as matching grants to plug, remediate, and reclaim orphaned wells; $30 million to the Secretary of Energy in cooperation with the Interstate Oil and Gas Compact Commission to conduct research and assist the Federal land management agencies, States, and Indian Tribes to identify, characterize, and mitigate orphaned wells; and an additional $2 million to the Interstate Oil and Gas Compact Commission to carry out this work.

It is obvious through federal and state legislation that significant funds have been put in place to address this issue, making it a public concern, and therefore a public solution or mandate. A question to consider is how many of the hundred thousand plus Class II wells in the US should be considered for CCUS projects and in that identification process, how much public funding should be used to ensure that the former hydrocarbon producing field is now up to current standards to be considered for carbon storage. There is significant sunk capital already spent to create the hydrocarbon producing field. It is also true that EOR projects typically have significantly more information about the characterization of the reservoir and have decades of production history to know what and how the reservoir responds. Given the need for vast amounts of storage capacity expected and given the vast amount of existing infrastructure in these EOR fields (e.g., Class II wells and pipelines), so long as the technical aspects for GS can be met, why would these assets not be considered for retrofit, repurpose, and reuse.

4. More Certainty about Converting Old Wells

If one looks at the reservoir from a geologic and engineering perspective, the notion of repurpose, conversion, and transition from EOR to GS seems clear and concise. This is a matter of heterogeneity versus homogeneity. Public policy wants to make decisions based on cookie cutter, one size fits all perspectives. Virtually all CCUS storage technical discussions are based on the reservoir specific notion that no reservoir is the same and every reservoir must be evaluated on the specific data and merits of the formation. Thus, the conflict between policy's homogenetic desires and the reservoir's heterogenetic mandates.

Hydrocarbon field conversion of existing infrastructure that can be repurposed from the declining hydrocarbon production at oil fields (e.g., water floods or enhanced oil recovery (EOR)), has been considered for possible reuse in carbon dioxide disposal or geologic storage only. One of the reasons for this consideration is the sheer volume of options. Consider that there are some 140,000 operating Class II EOR wells in the US, injecting approximately 70 million tonnes of CO_2 per year.[9] Compare that to the two (2) Class VI currently permitted wells that inject slightly more than 1 million tonnes per year of CO_2. The sheer number of options that the sunk capital of the Class II EOR industry offers should not be overlooked. To that end, the Department of Energy and the EPA recently conducted interviews of Class II well operators to understand from their perspectives the issues that may exist in converting this vast resource of Class II wells by considering their repurpose to geological storage (GS) only.

Through the United States Energy Association's (USEA) Consensus Program with DOE, more than 70 participants engaged in an interactive roundtable discussion entitled *"Roundtable on Carbon Storage R&D Priorities for Existing Wells"* via Zoom on February 23, 2022. The several hour interaction provided some valuable data and insight from industry regarding the questions of "if and how" can Class II injection wells can be repurposed for GS only. Industry overwhelming believes that they have the technical capability to repurpose wells, but it is unclear if they have the authority to do so nor clear guidance on how to accomplish the transition. The concern expressed by industry lies in the fact that even though EPA has provided “guidance”, the guidance lacks certainty because the “guidance” for well conversion requirements is at the “discretion” of EPA Director which does not provide enough clarity to move industry forward. In other words, there was significant business risk, not technical risk, that industry could complete the transition.

The discussions at the roundtable identified additional confusion regarding the conversion of Class II to Class VI wells, with some participants asking why Class VI well specifications are needed at all if a Class II well could be converted to a Class VI well. It is obvious that many technical considerations must be addressed with converting a well, beginning with the most significant consideration being the materials of construction and the wells operating history. The participants concurred that repurposing of Class II wells to Class VI may be more appropriate for monitoring compared to injection purposes. Less than one quarter of the roundtable participants believed it was likely that their wells would be converted for Class VI use due to the "uncertainties” of guidance as compared to regulations and “discretion” versus certainty from the Administrator. Conversely, the participants overwhelmingly agreed that a digital map documenting existing infrastructure, say marrying orphaned well locations to GIS maps for repurposing would be useful if available.

The topic of infrastructure and wellbore reuse or repurpose is also a topic of interest to the International Standards Organization (ISO). ISO’s Technical Committee 265: CCUS has embarked on an effort to prepare a Technical Report ISO/AWI 27926 entitled Carbon dioxide capture, transportation, and geological storage - Carbon dioxide enhanced oil recovery (CO_2-EOR) - transitioning from EOR to storage (CO_2-EOR).[10] The draft report explores the potential technical, policy, and regulatory hurdles that could complicate transitions between oil and gas production and geological storage of carbon dioxide in hydrocarbon bearing reservoirs. Scenarios are considered to identify potentially complicating issues and approaches that have been offered to resolve the often-unanticipated complications. The report is expected to be published later in 2022.

The second roundtable discussion facilitated by USEA focused on the Carbon Transport R&D Priorities for Existing Pipelines and was held virtually on February 24, 2022. This discussion focused on oil and gas pipeline and infrastructure instead of wells. This group of some forty industry participants arrived at an almost antithetical position than that of their contemporaries on the well side. Industry believes that the vast value of the pipeline repurposing is in the value of the right of way (ROW) and not in the actual reuse or repurpose of the pipeline itself. Participants felt that the technical conversion was too risky for repurposing, citing conflicts with materials of construction (e.g., embrittlement) and significant pressure differences between NG, CO_2, or hydrogen transportation. A second consideration dubbed the “elephant in the room” is the fact that pipelines are full, currently in use and likely to remain in use and would not be vacant or available for repurpose.

5. Unitization and Eminent Domain for Pore Space

Pore space ownership, i.e., who owns or otherwise controls and therefore has the authority to place CO_2 in the pore space is the best place to start. State law, usually state common law but sometimes expressed statutes, provides that the surface owner owns the pore space unless it has been conveyed or transferred (e.g., split estate). The states also provide that a mineral estate, whether created by lease or severance, does not "own" the pore space but nevertheless has the right to use the pore space as reasonably necessary to produce the minerals beneath a particular tract. Much of this jurisprudence is implied from state statutes that define the subsurface space that is devoid of minerals as pore space. Many state statutes do not explicitly discuss pore space ownership, nor do they discuss implied rights of the mineral or surface estate owner to that space. Some exceptions to this standard exist. In Kentucky, pore space ownership is only defined within the context of CO_2 storage. Mississippi requires CO_2 geologic sequestration facility operators to obtain approval from the majority interest of surface and subsurface owners. In Nebraska, the title to any subsurface reservoir is owned by the surface owner, unless it was previously severed.

Having defined who owns the pore space, the next consideration, similar to any oil and gas venture, is to consider the assemblage of enough lease acreage for unitization, assuming that the project is large enough to be economical. As has been the case for decades, there are mechanisms for creating unitized fields, each defined by state statues and oil and gas commissions. Similar to oil and gas operations, there are risks of "holdouts" in states where forced unitization is not allowed. These risks appear to be no more daunting than those encountered today in the oil and gas industry. While Texas does not have a regulatory framework for compulsory oil and gas unitization, all other states provide for oil and gas reservoirs to be unitized for economic development.

The vast majority of states have not yet, however, applied this oil and gas production unitization concept to address pore space unitization for purposes of CO_2 sequestration. Kentucky, Louisiana, Montana, North Dakota, and Wyoming have statutes in place permitting pore space unitization. Where state legislatures have not enacted rules for forced unitization, a storage operator will need to reach voluntary agreements with each surface owner whose pore space is part of the storage reservoir. In the absence of agreement from an owner, it is possible that the owner can sue the injector of CO_2 for trespass. It is likely that these regulatory gaps can be addressed by state legislatures as the development potential in each state increases and the needs are better defined, especially in terms of economic development. The opposite is true for the federal government. While no clear laws and regulations regarding federal pore space utilization for geologic storage exist, this lack of clarity may pose significant risk for projects of mixed private or fee land and federal land, especially in the West where the total CO_2 storage capacity within federal lands is estimated to be substantial.

The federal government has extensive eminent domain power, however, currently, no specific federal statutory authorization exists for condemnation of land for CO_2 pipelines or CO_2 storage on private land. From the state perspective, many legislatures consider CCUS-related activities, especially those related to EOR, to be a public use for the common good, and therefore allow the taking of private property if proper procedures are followed and fair compensation provided. The general use of this eminent domain has occurred for pipeline rights-of-way (ROW), underground storage, and surface operations. Some states have begun to expand their eminent domain authorities to CO_2 storage operations, which largely emulate those of the oil and gas industry. While Kentucky and Ohio are silent on the issue, Indiana, Louisiana, Michigan, Mississippi, and West Virginia have regulatory language that speaks to eminent domain as it relates to transporting CO_2 to storage reservoirs via pipelines. Colorado and Montana have explicitly enumerated underground natural gas storage reservoirs as public use for eminent domain purposes. Conversely, Wyoming has expressly prohibited the use of eminent domain for the purpose of condemning pore space rights. As discussed previously regarding the federal government's options with respect to DOI/BLM land, the states certainly have the authority to correct or create statues should they deem the economic development and deployment of CCUS of merit in their state provided that they do not take private property without just compensation.

When considering pore space ownership, acquisition, eminent domain, unitization, and liability, there are two recent works by USEA that summarize much of the U.S. mineral producing states.[11,12] These works collectively cover the states of Alabama, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Montana, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Tennessee, Utah, West Virginia, and Wyoming.

6. Defining Closure Responsibility and Post-Closure Liability

Throughout the life of a GS project, from site selection through project closure, managing risks of liability are a concern for storage operators. Many argue that because the storage of CO_2 is a public good—absorbing an otherwise terrible externality—that the liability for the stored CO_2 should ultimately fall to the government in the long term. Implied in this argument is the assumption that unless the government expressly assumes the liability the CO_2 injector or operator will remain responsible for the operational liability and the post-injection liabilities, and therefore may not initiate the project.[13]

A major precursor to long-term liability is to define the time at which, or conditions under which, the long-term responsibility of the operator might be terminated, even if the government were to assume the liability. In some cases, the current concept is to set a specific time frame post-closure that must expire prior to the releasing of the injector from post-closure liability (e.g., 100 years post closure in California under the GS provisions of the LCFS program). Another approach is to allow a transfer of liability only if the operator has demonstrated that the plume of injected CO_2 has stabilized, with the operator retaining residual responsibility in the case of fraud or malfeasance in such demonstration of stability. Absence fraud and negligence, the government should take on post-closure liability.

Damages that manifest post-injection and can give rise to liability may be cast into several buckets which include toxicological effects, environmental effects, induced seismicity, subsurface trespass, climate change effects, and liability to pay carbon emissions fees at prevailing rates (if any) on CO_2 released in the future. Each of these aspects of liability can be separately addressed with a variety of methods that include contractual, insurance, existing, and newly proposed legislation. When one considers the whole of a carbon storage program, say in the United States, the sheer size prohibits the use of insurance alone. Anecdotally, when the CCUS industry began, the focus was on the capture and storage aspects of the value chain. The “understanding” by the industry was that we know how to transport products by pipeline as evidenced by the natural gas infrastructure in the US.

There, the transportation piece is not something that we need to consider, at least not now. The time has come to address the transportation issue and even though the US has a vibrant natural gas transportation and storage industry, there are still issues to address such as materials of construction, rights of way, and re-use or re-purpose of natural gas pipelines for other (e.g., CO_2) purposes. Similarly, the CCUS industry has done the same thing with respect to insurance and liability. We assumed since we have a robust insurance industry, we'll just create what we need when we need it. In reality, that is not possible. Insurance is based on an evaluation of risk as measured by data from actuarial tables. If data doesn't exist, then neither do actuarial tables. If claims to insurance policies have not been made, no one knows if, when, or how a risk (e.g., claim) will happen, and therefore how much it will cost to address. Stated more technically, the insurance industry is unable to even write a policy because there has been no measurable event – there has been no useful data to create statistics to base a policy, and it is not possible to write a policy to insure for a speculative risk. In short, we need CCUS failures in order to write CCUS insurance.

Another aspect to consider is the long-term nature of CO_2 storage. Many storage regimes require the post-injection or post-closure considerations to last for years and decades beyond the completion of the injection. These post-injection and post-closure requirements may contain active monitoring and passible assumption of liability. This "event horizon" creates issues of risk transfer as one asks the real questions like will the injection company or the insurance company remain solvent and viable for the next fifty years or one hundred years? It is impossible to answer those questions and therefore difficult to plan for, manage, nor grow the CCUS commercial sector knowing this unknown liability exists.

Two suggested solutions to this long-term issue are for the government, either the state or federal, to assume the long-term liability for the stored CO_2. This would provide a reliable assurance that damages will be addressed by assuming that the state and federal government will be in existence some fifty and one hundred years hence. This obviously occurs outside of the US as all the subsurface is owned by the Crown and therefore the long-term stewardship remains with the Crown once she allowed leaseholds to extract certain minerals. Transfers of liability for GS operations have been legislated only in several states. North Dakota has a state statute providing for liability transfer, although it is unclear to what extent that statute would apply to a multi-state project. Other states like Louisiana and Wyoming are considering legislation to address this issue. The DOI/BLM could provide significant advancement by issuing guidance and rulemaking specific to the processes, terms, and conditions for obtaining rights to use federal land for geologic storage.

A second method, which should be considered in conjunction with the government assuming the long-term liability is to create a funded mechanism to address any remedial activities. Again, due to the sheer size of the projected industry and the insurance markets limited fiscal ability to respond to a large catastrophic event, consider a Price-Anderson Act like mechanism. The Price-Anderson Act and Amendment was created for the nuclear power generation industry as it considered the same two CCUS long-term liability issues—is the industry big enough to handle a large catastrophic event and will the entities be in existence to settle their liabilities decades later. As such, the Price-Anderson Act was created to protect the environment, health, and safety of the public and workers. It provided indemnification for operators against public liability for a nuclear incident, established quality and safety requirements, and provided authority to DOE for enforcement. Why wouldn't and why couldn't DOE implement a similar program applied to CCUS?

National Petroleum Council. Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage provided another perspective on this issue of long-term risk, liability, and indemnification.[14] They suggested a layered approach that applies layers of risk management obligations across all phases of geologic sequestration (operation, post-injection site care, and post-closure). During in immature time of early CCUS deployment, it is difficult for mature industry risk management approaches to be applied and both developers and government will need incentives to get the CCUS industry to full commercial scale, to a place where normal industrial risk processes apply. The prevailing notion that government must be responsible for all risks and therefore establish a liability fund, e.g., Price-Anderson, does two incongruent things. First it assumes that government has the technical expertise to determine the size of the liability pool and second, that if damages arise—later in the lifespan of the industry when much of the risk has been removed—it is at time when the risks are expected to be the lowest. Neither of these two are economically efficient.

The project has been designed, permitted, operational, now full of CO_2, and will move into closure and post-closure activities. It is in this aspect of the CCUS value chain where it is difficult to merge the technical aspects with the social aspects and the philosophical aspects of the perpetual event horizon. It is clear that industry can design and build a CCUS project. It is also clear that social science can participate and ensure that stakeholders issues are addressed and to ensure the project as a Social License to Operate (SLO).[15] Having those two items does not address the notion of whether we, as an operator, as a regulator, as a society can dictate, manage, and ensure that post closure activities continue for five years, for twenty years, but we all must agree that no one as the ability to ensure today that the operator, the regulatory structure, the insurance methods (e.g., insurance policy, letter of credit, bond, etc.) will be in existence nor have any value a century from now.

States have the sovereignty to determine what is best for their population and their subsurface. To that end, any governmental entity, albeit the states or the federal government who determine that post closure requirements are needed and therefore define the specific parameters of their jurisdiction, it must follow that the same government will likely be responsible via public policy to find ways to accomplish their stated goals. Another way to state this would be to say that if governments decide that post closure activities, and therefore expenses and liabilities associated with the same, will likely have to be driven by, augmented by, and subsidized by the same government. This must be the case when the requirements for such responsibility exceed the lifetime of many of the entities, in the case of 100 years of monitoring.

What is needed is for the CCUS industry and its opponents to view the industry much like other heavy industries—steel, automotive, cement, chemical, bridge building—and let the regulators and the market drive innovation and market stabilization. As an example, in great part due to the inconsistencies in post closure time frames—or better stated—due to lack of certainties, the industry lacks the ancillary tools the other primary industries benefit from. It is also possible that the CCUS industry's lack of experience and therefore its inability to estimate the size of a loss may cause increased insurance costs or account for a lack of insurance vehicles. Insurance and risk are huge issues; issues that only a select few insurers or re-insurers will discuss relative to CCUS. The likes of Allianz Global, Zurich, Swiss RE, Marsh McLennan, and a few specialty boutique firms like Cobbs-Allan, will even discuss the possibility of risk management and CCUS. As more CCUS projects advance, any notion to provide traditional insurance for the construction and operational aspects of the project have the potential to create more education and understanding as well as literally more insurance available in the CCUS industry. This provides more time in grade, thereby creating more and better actuarial data, more bonding available, all of which would spur economic deployment of CCUS. The technical issues are not the impediment to CCUS commercial deployment. The perceived risk, lack of certainty, the inconsistency in post closure, the lack of certainty in converting Class II to Class VI, the lack of EPA ability to quickly permit Class VI wells, all contribute to holding back commercial deployment of CCUS. This is also driven by a lack of federal policy. There are no federal mandates for CCUS deployment. Even when there is a policy for carbon reduction, industry responds by building new wind and solar and is significantly reluctant to invest in CCUS for much of the coal and natural gas fired electric generation.

7. CO_2, GS, and RCRA

A long-standing question by many stakeholders has been whether CCUS regulations adequately address hazardous waste issues and whether CCUS regulations were inconsistent as compared to the Resource Conservation and Recovery Act (RCRA). The recently issued report from the Council on Environmental Quality Report to Congress on Carbon Capture, Utilization, and Sequestration, addressed this stakeholder concern.[16] RCRA Subtitle C authorizes EPA to regulate the management of hazardous wastes in a cradle-to-grave regulatory program. The question at issue is whether CO_2 is or is not a hazardous waste. To reduce potential uncertainty regarding the regulatory status of CO_2 streams and to facilitate the deployment of geologic sequestration, EPA finalized a rulemaking to exclude certain CO_2 streams from the RCRA definition of hazardous waste. EPA determined that even if any such CO_2 streams would otherwise be a hazardous waste, further RCRA regulation is unnecessary to protect human health and the environment provided certain conditions are met.

The rule conditionally excludes CO_2 streams as hazardous waste if the CO_2 is transported in compliance with US Department of Transportation or state requirements; if the CO_2 is injected in compliance with UIC Class VI requirements; if the CO_2 has no other hazardous wastes mixed or co-injected with the CO_2 stream; and if the CO_2 generators and Class VI well owners or operators sign certification statements. These rule exclusions leave open for interpretation the application of RCRA to a Class II EOR operation that is converting from CO_2-EOR to GS, based solely on the language of the exclusion. The policy correct should be to close this interpretation and be explicit with the application of RCRA exclusion to both Class VI and Class II wells.

8. Inadequate EPA Resources for MRV and Primacy

Our discussion thus far has considered whether we have access to pore space, have assessed the data, assembled a lease, and possibly unitized the storage field. The next step is to focus on the storage system itself. The wells, permits, Monitoring, Reporting, and Verification (MRV) plan, and closure of the project when completed. There are two options with respect to wells that can inject CO_2 which are controlled by the EPA's Underground Injection Control (UIC) program. The two well classes are Class II, which is an oil and gas injection well which can inject CO_2, and Class VI, which is solely a CO_2 injection well for GS. There are nearly two hundred thousand Class II wells in the US which can typically cost several hundred thousand dollars each compared to the several million-dollar price tag for a Class VI well. Currently there exist two (2) permitted Class VI wells in the US and the EPA reports that there are currently nine (9) Class VI permits under application review.[17] There is no controversy that there is a stark difference between the number, cost, and permitability of Class II wells as compared to Class VI wells. Now consider the timing to get a permit, that is how long does it take for the jurisdiction to issue a Class II versus a Class VI well. On average, a Class II well takes several months to secure, and the permit can be issued by the EPA or by one of 25 states that have primacy for Class II Permitting. Conversely, a Class VI well may take one to three years to permit, and currently only North Dakota and Wyoming have received primacy from the EPA to manage the Class VI program at the state level. It is not surprising given the time constraints and the desire by states to implement CCUS at commercial scale, that many states desire to control their own destiny by securing primacy. North Dakota was the first state to secure UIC Class VI primacy and their process took almost four years.[18] Wyoming followed suit as the second in the nation to secure state primacy and cut the application process by more than half. Now comes Louisiana, which has applied for Class VI Primacy and their process should half again the turnaround time to approximately one year. Oklahoma, Pennsylvania, and other states have indicated that they are in the process of or considering applying for Class VI primacy from the EPA. Under the Biden Administration's Justice40 initiative, the expected Class VI primacy may be delayed due to unresolved EJ issues.

Anecdotally, the EPA has shared with many states discussing Class VI primacy, that the EPA is shorthanded. They have acknowledged a lack of qualified technical staff as well as losses based on retirements. This has left EPA with some 16 qualified technologists to address what is perceived to be an influx of Class VI applications with the passage of the IRS 45Q tax credit and additional research funding from the IIJA. The EPA resource constraint is further exacerbated when one considers the location of the remaining 16 UIC Class VI specialists, specifically that they do not reside in, therefore do not have access/authorization to work in the regions that are likely to see an influx of Class VI permits. This issue has been raised to EPA and some states are suggesting a labor sharing agreement with EPA to ensure that submitted permits from the given state do not languish in the permit process. Further, EPA has discussed the possibility of creating an internal center of excellence, which would allow EPA staff with appropriate expertise to respond to permit applications, regardless of EPA staff location. This would help ensure that the appropriate EPA application review staff can address UIC Class VI permits when they arrive, from any region.

Monitoring, Reporting, and Verification (MRV) plans are the next step in the progression of project completion. GS of CO_2 requires a mechanism to monitor the injection of CO_2 and the storage facilities ability to provide reporting data to EPA. The MRV plan formalizes the data and format required to be submitted that includes the amount of CO_2 received for injection, data related to the amounts of CO_2 sequestered, and monitoring device quality control. This allows for a mass-balance to be completed to analyze the disposition of the CO_2 and to be able to determine if any CO_2 has been released, emitted, sold, transferred, or otherwise no longer stored in the system. In the US there are two systems that are approved for use and applicable for permitting and submission to EPA and IRS for 45Q tax credit. The first is the EPAs Greenhouse Gas Reporting Program (GHGRP) Subpart RR – Geologic Sequestration of Carbon Dioxide.[19] Based on data from EPAs website, the Agency has issued 16 approvals for MRV plans. These 16 approved MRV plans comprise six separate facilities. The ADM facility in Decatur, Illinois is a DOE research site. The other five are commercial applications and include Core Energy’s Michigan facility, Oxy’s Denver Unit and Hobbs Field, Perdue’s North Burbank Unit, and XOM’s Shute Creek facility in Wyoming.

Oxy's Denver Unit was the first approved MRV plan under EPA's Subpart RR. Anecdotally, the process was not as smooth nor as short as those that followed. As is usually the case with first-of-a-kind, the lessons learned and time invested by Oxy have paid dividends to industry and EPA in creating a working trust between regulator and regulated, thereby making the subsequent applicants and processes shorter, smoother, and more widely accepted. Traditional business mechanisms like non-disclosure agreements, legal teams, go-no-go decisions, and the ability to cease a conversation with a regulator are always part of any first-of-a-kind process. Durations for MRV plan submittal to approval are not widely known but anecdotally there seems to be a consensus that short of the first-of-a-kind, the process is a 9-to-18-month process.

A second option for providing an MRV plan, at least for 45Q purposes, is through the use of CSA/ANSI ISO 27916:19 Carbon dioxide capture, transportation, and geological storage — Carbon dioxide storage using enhanced oil recovery (CO_2-EOR). The ANSI EOR standard has been approved by the IRS in consultation with EPA and DOE as an acceptable alternative to EPA's GHGRT Subpart RR MRV plans. On January 15, 2021, the Federal Register published a new rule, Credit for Carbon Oxide Sequestration, specifying that, "[t]he Treasury Department and the IRS, in consultation with the DOE, the EPA and the Interior Department, agreed that, in the case of tertiary injection and disposal through secure geological storage, allowing the use of subpart RR or CSA/ANSI ISO 27916:19 would sufficiently demonstrate secure geological storage for purposes of the statutory requirement, without creating or imposing undue burdens on taxpayers." [20] This alternative provided relief to many in the tertiary production or EOR industry that raised concerns with EPAs Subpart RR regarding post-closure access (e.g., trespass) as well as reducing a perceived burden for regulatory review and litigation, and finally to address a potential lease issue with "intent" of CO_2 storage versus hydrocarbon production.

In a side-by-side comparison of EPAs GHGRT Subpart RR and CSA/ANSI ISO 27916:19, there are two significant differences, and in both instances, the CSA/ANSI ISO 27916:19 is more stringent than EPAs Subpart RR.

- The first difference occurs in the calculation of the mass balance of CO_2. Specifically, the ISO document contains four (4) additional criteria or variables that must be addressed. These four include CO_2 mass loss due to venting or flaring, mass lost in CO_2 transfer, mass lost from the EOR complex, and the inclusion of any native, non-anthropogenic CO_2 in the storage project. These four additional mass balance calculations are not required as part of EPA GHGRT Subpart RR, § 98.443 Calculating CO_2 geologic sequestration, and therefore make ISO 27916:19 more stringent. More directly, Subpart RR only identifies a loss of CO_2 when the loss reaches the atmosphere in contrast to ISO which identifies and addresses any loss from the EOR complex, while still underground, prior to reaching the atmosphere.

- The second difference is in the Project Termination aspect of the MRV plan. The ISO standard requires the operator, in addition to all the requirement of EPA Subpart RR, to also be in compliance with all plugging, abandonment, and decommissioning of wells; provide sufficient documentation that the CO_2 is safely contained, that the characteristics of the reservoir will support, and that long-term demonstration can affirm the stability and predictability of the stored CO_2; that risks and uncertainties relating to the storage were managed throughout the life of the project; and facilities and ancillary equipment have been removed and the site reclaimed. These additional ISO requirements are not contained in EPA GHRT Subpart RR Cease operations section. Additionally, once the requirements are met to discontinue reporting, the operator will have an obligation under RR to revert back to or begin reporting CO_2 injection under Subpart UU. The ISO reporting provides certainty to the operator as to exactly when and how the project will be closed.

9. Existential Uncertainties of EJ, IRPs, and Climate Disclosures Generated by Conflicting Political Signaling and Regulatory Conflict

9.1 Federal

President Bidens' White House Environmental Justice Advisory Council's Justice40: Climate and Economic Justice Screening Tool & Executive Order 12898 Revisions: Interim Final Recommendations provides open and candid dissent for CCUS.[21] The Interim Final Recommendations provide specific examples of the types of projects that will ***not*** benefit the EJ identified communities. Three specific listed projects include:

1) Fossil fuel procurement, development, infrastructure repair that would in any way extend lifespan or production capacity, transmission system investments to facilitate fossil-fired generation or any related subsidy. This would exclude well and pipeline conversion.
2) Carbon capture and storage (CCS) or carbon capture, utilization, and storage (CCUS). This would exclude the entirety of the CCS program.
3) Direct air capture (DAC). This would exclude DAC from any CCUS project.

9.2 State Level

Public Utility Commissions and many Investor-Owned Utilities (IOU) are now also under additional constraints. As stated above, the White House Council's report openly criticizes the existence of carbon capture, while local rate payers and eNGOs seek to use the Integrated Resource Planning (IRP) process to force regulated IOUs to simply eliminate fossil fuel use. A compromise, realizing there are no silver bullets, one size fits all, single solution to the climate crisis; is to allow State Corporation Commissions or Public Utility Commissions to consider the capital expense of adding CCUS as a rate recoverable cost.

To date, the IRP by the IOUs are required to examine both their energy demand and supply and identify any risks that could prevent them from meeting their customers' long-term energy needs at reasonable costs. These IRPs have morphed into forcing coal and natural gas base-load generation into a load following mode and pushed the renewables of wind and solar into the base load side. Like with any research, the research question, the methodology, and the analysis are all dependent upon how they are designed. Better said, not all IRPs are created equal.

One example of an unequal IRP is the case of PacifiCorp's 2020 Wyoming Public Service Commission IRP. There were several non-PacifiCorp studies done in anticipation of the IRP that were intended to evaluate the economics of CCUS on specific power plants in Wyoming. The studies included Wyoming Carbon Capture, Utilization, and Storage (CCUS) Study and CCUS Tax Revenue Impacts in Converse, Sweetwater, Lincoln, and Campbell Counties, Wyoming.[22,23] These studies were compared to PacifiCorp's publicly submitted IRP. The University of Wyoming's Enhanced Oil Recovery Institute provided comments to the PSC that stated, "[t]he differences between the various documents and studies is difficult to immediately grasp. Our big picture summary is that RMP and LTI/NETL took two radically different approaches to analyzing the future of RMP, Wyoming's energy economy, and by extension, the Western region." [24] This radically divergent approach led Rocky Mountain Power (RMP) to, "…[n]evertheless exclude CCUS [o]ptions from [c]onsideration" …in the IRP.[25] How is it possible that an IOU will consider CCUS by excluding it from their analysis?

There are several long-tail risks of note and worth discussing. The first is how does CCUS fit into any other ancillary industry, specifically the new hydrogen economy? Decarbonizing the industrial processes and increasing fuel use will require new or alternative forms of low-carbon fuels, advanced technologies, and modified equipment or production configurations. It is also clear that in order to achieve global emission goals will require significant amounts of negative emissions through carbon capture, biomass-based energy, and carbon removal via direct air capture. As the federal government encourages advanced, efficient, and cost-effective production of hydrogen from diverse domestic sources, including renewable, fossil, and nuclear energy resources, these processes will generate CO_2 that can and should be managed in the same manner as CCUS, or better said, CCUS can be a supportive industry to the hydrogen industry. Throughout the US there are areas of concentrated industrial activity within the vicinity of geologic storage formations that are also coupled with existing commodity transport infrastructure and therefore have been called potential carbon and hydrogen hubs.[26] These hubs would act as early launching points for investment in carbon removal and hydrogen production that can minimize financial and logistical barriers to market development. The regional clustering of industrial activity within these hubs would enable decarbonization solutions to achieve commercial demonstration and economywide deployment at the scale needed to achieve climate goals.

The Securities and Exchange Commission (SEC) has announced their plans for new rule making that proposes expansive mandatory climate disclosures with audit and attestation requirements. SEC Release Nos. 33-11042; 34-94478, The Enhancement and Standardization of Climate-Related Disclosures for Investors Registrants with Exchange Act reporting obligations pursuant to Exchange Act Section 13(a) or Section 15(d), and companies filing a Securities Act or Exchange Act registration statement would require financial disclosure statements to include climate related matters. These would include Scope 1 and 2 Greenhouse Gas (GHG) emissions, Scope 3 emissions if material, climate targets, goals, internal carbon pricing, scenario analysis, and carbon offsets. The intent of the proposed rule is to establish a common thread between the climate-related risks identified in the annual report (Form 10-K or 20-F) and any related financial impact in the financial statements.

While the proposal may sound reasonable in the current climate mitigation context that we find ourselves, it does raise a significant question. Is the SEC in the financial or environmental business? This exact question was recently posed by one of SEC's own. Commissioner Hester M. Peirce penned a statement on March 21, 2022, on the SEC's website entitled, "We are Not the Securities and Environment Commission - At Least Not Yet."[27] The commissioner crafted a lengthy piece that expressed her concern for SEC overreach. She suggests that the proposal would turn the disclosure regime on its head. Further she argues that the proposal will tell corporate managers how regulators should run and not how the executives should be expected to run their companies. The proposal will create a disclosure framework based, in large part, on the Task Force on Climate-Related Financial Disclosures (TCFD) Framework and the Greenhouse Gas Protocol. Her evaluation of the proposal suggests that there are existing rules that already cover material climate risks, that the proposal dispenses with materiality some places and distorts it in others, that the proposal will not lead to comparable, consistent, and reliable disclosures, that the proposed rule would hurt investors, the economy, and the SEC, that the Commission underestimates the costs of the proposal, and most importantly, that the Commission lacks the authority to enact this new rule.

The discussion of the SEC views of ESG and more importantly how the markets view ESG is very important. One aspect that needs attention, education, and engagement ought to be the international rating agencies. As financing remains a significant aspect of project development, the same international credit and rating agencies will play a larger and larger role in the cost of financing. Knowing that financing is discussed in another paper, it is noted that ESG understanding, industrial risk, albeit it mature or immature, and the technical aspects of CCUS should be considered by the likes of Moody's and S&P Global, AM Best, Fitch.

9.3 Environmental Justice

The final topic for discussion is Environmental Justice (EJ). President Biden issued Executive Order (EO) 14008 on January 27, 2021, and that EO the administration to integrate environmental justice in "all of government." The most significant issue with the EO and EJ is that the Biden Administration has not defined nor provided any guidance as to how they expect EJ to be implemented. As stated previously, the White House Environmental Justice Advisory Council has specifically denounced CCUS and any continued use of fossil fuel as a nonstarter with respect to EJ. In a recent letter from the Carbon Utilization Research Council to Energy Secretary Granholm on February 1, 2022, CURC points out that the Biden Administration has not been clear on what they expect relative to EJ.[28] Specifically, they ask the Administration to provide clear guidance in its funding opportunity announcements and to define how EJ will be evaluated into award selections and by what criteria and metrics will the Administration made judgments. To date, this is unclear, in some cases contradictory (e.g., WHEJAC) as many Agencies including the EPA and DOE are currently in the process of trying to understand, define, and create KPIs for such application. This same lack of clarity and uncertainty discussed earlier within the CCUS industry may haunt the application of EJ to CCUS as unintended—or possibly intended—consequence, by either dismissal or lack of consideration. Consider the title and subtitle of a recent article by Colorado Politics, “Colorado regulators face new challenge: cost of environmental justice in energy rates. The Colorado Public Utilities Commission is facing a sea-change in its traditional mandate to regulate utilities, so Coloradans receive safe, reliable, and reasonably-priced services.”[29]

A Colorado law now imposes a host of new duties on the Public Utilities Commission (PUC) that now mandate that they consider how to provide equity, minimize impacts, and prioritize benefits to disproportionately impacted communities and address historical inequalities, in other words, EJ. The PUC acknowledged that they are working through and trying to understand what EJ means to the PUC. The real issue for the PUC historically has been to ensure the lowest cost of electric generation for the customer. Under this new law, the PUC is in an environment where costs are important, but they are no longer the only, nor the most important consideration. The PUC is working with the newly formed Colorado Department of Public Health and Environment’s Environmental Justice Unit to understand how to meet the state mandate to decarbonize more than 90,000 retail customers to meet a mandated clean heat plan, thereby meeting the state’s Greenhouse Gas Roadmap. Couple these challenges with AARP Colorado criticizing the Colorado General Assembly for deciding to fund the state's transition to renewable on the backs of Coloradans. AARP believes that the Colorado legislature sent two messages to Coloradans. First, consumers will have to pay more for electricity and second, the PUC must ensure disadvantaged communities don’t absorb the cost. These two issues are likely to result in Xcel Energy’s rates increasing by nearly $200 million and some customers may pay as much as 50% more compared to last winter.[30]

10. Appendix

Pipelines

The participants at DOE's roundtable raised the issue of socialization of CO_2 pipelines as compared to natural gas pipelines. Even though gas pipelines are objectively more dangerous, since they can explode and CO_2 pipelines cannot, the public is more accepting of the gas pipelines. Consider the public perception and willingness to accept transportation of natural gas in pipelines in the US. According to fractracker.org, in 2018 some three million miles of natural gas pipelines transported almost 28 trillion cubic feet (Tcf) of gas.31 Combine these data with the transportation of natural gas liquids which adds more than 4.5 billion barrels transported through 295,000 miles of pipelines and gathering lines. In 2018, this industrial activity resulted in 228 incidents which caused eight fatalities and more than $900 million in damages. To date, there have been no deaths associated with carbon dioxide in the US. While there are reports of CO_2 pipeline ruptures, there are no explosions and no reported deaths. Why then would society accept deaths and millions of dollars in damages from natural gas/liquids transportation, but are seemingly so unwilling to accept any risk with the transportation of carbon dioxide?

Some argue that the notion of carbon dioxide risk aversion is based on the proverbial "red herring."32 From a purely legal perspective, virtually all activities contained in the value chain of CCUS and the resulting liabilities that can result, currently occur in other forms and in other applications, e.g., natural gas; and are acceptable by society. From both a property rights as well as a liability standpoint there is nothing new under the sun when looking at CCUS. While catastrophes can occur from the release of carbon dioxide, the actual instances are exceptionally rare, making the potential liability real, but in no way should be seen as a significant impediment, therefore a red herring. According to the Wyoming Energy Authority, the EIA, and the National Petroleum Council, there are only some 4,500 miles of CO_2 pipelines in the US yet these menial 4,500 miles of pipelines with no fatalities are met with significant social resistance when compared to the over 2 million miles of natural gas pipelines. This issue must be discussed as CCUS commercial deployment advances and the “menial” 4,500 miles becomes something substantive, in the hundred thousand or millions of miles.

Notes

[1] Steve Carpenter, "Transdisciplinarity within the North American Climate Change Mitigation Research Community, specifically the Carbon Dioxide Capture, Transportation, Unitization, and Storage Community, PhD diss., California Institute of Integral Studies, 2017, https://www.proquest.com/openview/6cb245bec3eef5e0f12447d5842941be/1?pq-origsite=gscholar&cbl=18750.

[2] Roy Bhaskar et al., *Interdisciplinarity and climate change: Transforming knowledge and practice for our global future*, New York, NY: Routledge, 2010.

[3] Energy Data eXchange, "Reference Shelf," United States Department of Energy, 2022, https://edx.netl.doe.gov/about.

[4] U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment team, "National assessment of geologic carbon dioxide storage resources: data," United States Geological Survey, https://doi.org/10.3133/ds774.

[5] U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment team, "National assessment of geologic carbon dioxide storage resources: data," United States Geological Survey, https://doi.org/10.3133/ds774.

[6] Association of American State Geologists, "State Geological Surveys," https://www.stategeologists.org/surveys.

[7] Wyoming Energy Authority, "Active Initiatives," https://wyoenergy.org/wp-content/uploads/2022/11/WEA-Active-Initiatives.pdf.

[8] National Energy Technology Laboratory, *Carbon Storage Atlas: Fifth Edition,* September 2015, https://www.netl.doe.gov/sites/default/files/2018-10/ATLAS-V-2015.pdf.

[9] Michael Godec, Legal and Regulatory Frameworks and Incentives: *A Pre-Feasibility Assessment of Carbon Dioxide, Utilization, and Storage (CCUS) Opportunities to Spur Economic Development*, Advanced Resources International, June 23, 2021.

[10] International Organization for Standardization, "ISO/AWI TR 27926 Carbon dioxide enhanced oil recovery (CO2-EOR) - Transitioning from EOR to storage," https://www.iso.org/standard/67278.html?browse=tc.

[11] Kris Koski et al., *Study on States' Policies and Regulations per CO2-EOR Storage Conventional, ROZ and EOR in Shale: Permitting, Infrastructure, Incentives, Royalty Owners, Eminent Domain, Mineral-Pore Space, and Storage Lease Issues*, United States Energy Association, September 2020, https://usea.org/sites/default/files/Study%20on%20States'%20Policies%20and%20Regulations%20per%20CO2-EOR-Storage%20%281%29_0.pdf.

[12] Shari ring et al., *Carbon Capture, Utilization, and Sequestration: A State Comparison of Technical and Policy Issues*, United States Energy Association, October 2021, https://usea.org/event/ccus-state-comparison-technical-and-policy-issues.

[13] Mark Anthony de Figueiredo, "The Liability of Carbon Dioxide Storage," PhD. Diss., Massachusetts Institute of Technology, January 12, 2007, https://sequestration.mit.edu/pdf/Mark_de_Figueiredo_PhD_Dissertation.pdf.

[14] National Petroleum Council, "Topic Paper #4: The Layered Approach to Liability for Geologic Sequestration of CO_2," *Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage,* December 2019, https://dualchallenge.npc.org/downloads.php.

[15] Jessica Western and Selena Gerace, *Social License for Wyoming's Energy Future: What Do Residents Want?* University of Wyoming School of Energy Resources and Ruckelshaus Institute of Environment and Natural Resources, November 2020, https://www.uwyo.edu/haub/_files/_docs/ruckelshaus/pubs/2020-wyomings-energy-social-license-report.pdf.

[16] Council on Environmental Quality, *Council on Environmental Quality* Report *to Congress on Carbon Capture, Utilization, and Sequestration*: *delivered to the Committee on Environment and Public Works of the Senate and the Committee on Energy and Commerce, the Committee on Natural Resources, and the Committee on Transportation and Infrastructure of the House of Representatives, as directed in Section 102 of Division S of the Consolidated Appropriations Act, 2021,* White House, June 30, 2021, https://www.whitehouse.gov/ceq/news-updates/2021/06/30/council-on-environmental-quality-delivers-report-to-congress-on-steps-to-advance-responsible-orderly-and-efficient-development-of-carbon-capture-utilization-and-sequestration/.

[17] Environmental Protection Agency, "Class VI Wells Permitted by EPA," https://www.epa.gov/uic/class-vi-wells-permitted-epa.

[18] Eric Martin, "North Dakota's UIC Class VI Primacy Wait is Almost Over," Stoel Rives LLP, May 23, 2017, https://www.jdsupra.com/legalnews/north-dakota-s-uic-class-vi-primacy-31153/.

[19] Environmental Protection Agency, "Subpart RR- Geologic Sequestration of Carbon Dioxide," Greenhouse Gas Reporting Program (GHGRP), https://www.epa.gov/ghgreporting/subpart-rr-geologic-sequestration-carbon-dioxide.

[20] Department of the Treasury, "Credit for Carbon Oxide Sequestration," Federal Register Vol.86, no. 10, Jan 15, 2021, https://www.govinfo.gov/content/pkg/FR-2021-01-15/pdf/2021-00302.pdf, p. 4759.

[21] White House Environmental Justice Advisory Council, *Justice40 Climate and Economic Justice Screening Tool & Executive Order 12898 Revisions, Interim Final Recommendations*, May 13, 2021, https://www.epa.gov/sites/default/files/2021-05/documents/whejac_interim_final_recommendations_0.pdf.

[22] Leonardo Technologies, Inc., *Wyoming Carbon Capture, Utilization, and Storage (CCUS) Study*, August 2020,https://www.researchgate.net/publication/344256917_Wyoming_Carbon_Capture_Utilization_and_Storage_CCUS_Study/link/5f610fad92851c07896a0185/download.

[23] Management Information Services, Inc., *CCUS TAX REVENUE IMPACTS INCONVERSE, SWEETWATER, LINCOLN, AND CAMPBELL COUNTIES, WYOMING*, October 2020, https://docplayer.net/215454656-Ccus-tax-revenue-impacts-in-converse-sweetwater-lincoln-and-campbell-counties-wyoming.html.

[24] Jeffrey Brown, "Comments of University of Wyoming Enhanced Oil Recovery Institute," Wyoming Public Service Commission, September 25, 2020

[25] Jeffrey Brown, "Comments of University of Wyoming Enhanced Oil Recovery Institute," Wyoming Public Service Commission, September 25, 2020.

[26] Great Plains Institute, *Carbon and Hydrogen Hubs Atlas for US Decarbonization,* February 2022, https://betterenergy.org/blog/gpi-carbon-and-hydrogen-hubs-atlas/.

[27] Hester Peirce, "We are Not the Securities and Environment Commission- At Least Not Yet," U.S. Securities and Exchange Commission, March 21, 2022, https://www.sec.gov/news/statement/peirce-climate-disclosure-20220321.

[28] Carbon Utilization Research Council to Department of Energy Secretary Elizabeth Granholm, February 16, 2022, https://www.eqt.com/wp-content/uploads/2022/02/Letter-to-Secretary-Granholm-vF2-2.16.22-1.pdf.

[29] Colorado Politics. (2022). Colorado regulators face new challenge: cost of environmental justice in energy rates. Scot Weiser. February 6, 2022. https://www.coloradopolitics.com/energy-and-environment/aarp-colorado-urges-energy-regulators-to-reject-xcels-rate-hike-criticizes-legislature/article_76431ac0-7945-11ec-9f54-871a45f60f37.html

[30] Scot Weiser, "Colorado regulators face new challenge: cost of environmental justice in energy rates," Colorado Politics, February 6, 2022, https://www.coloradopolitics.com/energy-and-environment/aarp-colorado-urges-energy-regulators-to-reject-xcels-rate-hike-criticizes-legislature/article_76431ac0-7945-11ec-9f54-871a45f60f37.html.

[31] Matt Kelso, "Pipelines Continue to Catch Fire and Explode," Fractracker Alliance, February 21, 2020, https://www.fractracker.org/2020/02/pipelines-continue-to-catch-fire-and-explode/.

[32] Thomas J. Lane et al., "Carbon Sequestration: Critical property rights and legal liabilities— real impediments or red herrings?" *Proceedings of the Thirty-Second Annual Energy & Mineral Law Institute* 1-2, Lexington, KY: Energy Mineral Law Institute, 2022, https://emlf.org/product/carbon-sequestration-critical-property-rights-and-legal-liabilities-real-impediments-or-red-herrings/.