U.S. DEPARTMENT OF ENERGY | Fossil Energy and Carbon Management

NATIONAL ENERGY TECHNOLOGY LABORATORY

WORKSHOP

CARBON TRANSPORT & STORAGE R&D PRIORITIES FOR REPURPOSING INFRASTRUCTURE

February 23 and 24, 2022

DOE/NETL-2022/3789

Disclaimer

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ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization, and storage
CEQ	Council on Environment Quality
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CTS	Conversion to service
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
EIS	Environmental impact statement
EOR	Enhanced oil recovery
EPA	Environmental Protection Agency
FECM	Office of Fossil Energy and Carbon Management
FERC	Federal Energy Regulatory Commission
ft	Foot
H_2	Hydrogen
H_2S	Hydrogen sulfide
lb	Pound
LCA	Life cycle analysis
LiDAR	Light detection and ranging
N_2	Nitrogen
N_2O	Nitrous oxide
NEMS	National Energy Modeling System
NETL	National Energy Technology Laboratory
P&A	Plugging and abandonment
PHMSA	Pipeline and Hazardous Materials Safety Administration
R&D	Research and development
RD&D	Research, development, and deployment
RDD&D	Research, development, demonstration, and deployment
ROW	Right of way
UIC	Underground Injection Control (EPA)

1 OVERVIEW

1.1 INTRODUCTION

The U.S. Department of Energy (DOE) sponsored the Carbon Transport and Storage R&D Priorities for Repurposing Infrastructure Workshop in response to widespread stakeholder interest. Repurposing pipelines for use in transporting carbon dioxide (CO_2) and the conversion of existing wells (natural CO_2 accumulations, saltwater disposal, acid gas injection, enhanced oil recovery [EOR]) may be viable, at pace with, or faster than, construction of new infrastructure to support meeting future carbon transport and storage goals. The aim of this workshop was to make a concerted effort with industry, professional associations, and other government stakeholders to address technical and regulatory challenges associated with repurposing infrastructure.

The workshop was held via webinar on February 23 and 24, 2022 (about four hours each day). On the first day, the workshop focused on converting existing wells for CO_2 injection or monitoring and defining plugging standards for future carbon storage settings. On the second day, the workshop focused on repurposing existing pipelines in the offshore and on onshore regions.

1.2 INTENDED WORKSHOP OUTPUT

The primary objective of the two-day workshop was to determine the most critical research and development (R&D) needs for repurposing pipeline infrastructure and existing wells for the carbon transport and storage. Other objectives included:

- Connecting industry, professional associations, and other government stakeholders active in repurposing pipeline and wells infrastructure for carbon transport and storage research, development, demonstration, and deployment (RDD&D) projects.
- Improving understanding about the challenges and opportunities in meeting future carbon transport and storage goals.
- Exploring technical advancements, operational considerations, RDD&D gaps, and regulatory considerations for conversion of use of pipeline and well infrastructure for carbon transport.

Some of the input received at the workshop will feed directly into R&D priorities in the multi-year program plan.

The workshop was by invitation only and included more than 170 participants, including members from other U.S. government agencies such as the U.S. Environmental Protection Agency (EPA), the U.S. Department of Interior (DOI), and the Department of Transportation (DOT) Pipeline and the Hazardous Materials Safety Administration (PHMSA). In addition, DOE invited stakeholders involved in existing or emerging carbon storage facilities, carbon transport projects, and R&D studies.

The workshop format was comprised of expert panel presentations followed by breakout sessions. A total of 12 presentations were given by expert panelists to share the current state of understanding for repurposing existing wells and pipelines. These presentations occurred during two theme sessions followed by breakout sessions. The moderators for each breakout session focused discussion around a set of questions (Appendix C and Appendix D), which were not circulated among the participants prior to the workshop. During the breakout sessions, the moderators provided a short introduction to each question and then facilitated dialogue, including a Q&A with attendees. Workshop participants were also provided with four poll questions. From poll responses, participants strongly agreed it would be useful to have a matchmaker service to connect with technical providers (e.g., industry, national labs, academia, etc.) and to document existing infrastructure via a digital map/platform. In addition, some participants responded that some infrastructure assets in their organizations can be repurposed—well infrastructure from seven respondents could be converted for CO_2 injection, well infrastructure from eight respondents could be converted for monitoring purposes, and pipeline infrastructure from five respondents could be repurposed for CO_2 transport (Appendix E and Appendix F).

Key takeaways and R&D recommendations from the workshop are summarized in Sections 1.3 and 1.4. Some of the statements below are listed as an action item (A) or an observation (O). Furthermore, each action item is classified as Technical R&D (i.e., A – R&D), Policy (i.e., A – P), or Regulatory (i.e., A – R). For purposes of this report, day one of the workshop is referred to as the Existing Wells Workshop and day two is referred to as the Pipelines Workshop. Subsequent sections provide more detailed summaries of the breakout discussion. Note that the topics discussed in the breakout sessions for existing wells have been separated into two categories: technical considerations and regulatory considerations for repurposing existing wells for carbon storage.

1.3 KEY TAKEAWAYS FROM EXISTING WELLS WORKSHOP

1.3.1 Overall Summary Points from Expert Panel Presentations

- A significant issue with well reuse is the completeness and clarity of records. (O)
- In an EOR flood operation, it is typically less costly to reuse a well than to drill a new well. (O)
- Well integrity is the biggest risk, usually from fluids moving “around” the cement, not through it. (A – R&D)
- Well corrosion is not regularly monitored in oil wells, but must be an integral part of monitoring carbon capture and storage (CCS) wells. (A – R&D)
- EPA Class VI permit is at the “director’s discretion.” (O)
- Choosing to repurpose wellbores requires conducting comprehensive characterization and analysis to ensure that the opportunities and the challenges are in alignment with project goals. (A – R, R&D)

- EPA Class VI regulations are performance-based; the same performance objectives must be met for both repurposed and new wells. (A – R)
- Requirements for maintaining mechanical integrity and protecting ground water extend to monitoring wells. (A – R&D)
- Challenges in repurposing include operational, regulatory, and financial concerns related to repair, replacement, or additional monitoring needs. (A – R&D)
- Multiple logging technologies are available (and needed) to analyze the integrity of wells. (A – R&D)
- Research has shown airborne (mounted on drones or helicopters) magnetometers and light detection and ranging (LiDAR) to be very promising for locating legacy wells. (A – R&D)

1.3.2 Technical Considerations from Breakout Sessions

- Determining optimal infrastructure: repurposing wells for CO_2 injection versus repurposing for monitoring versus developing new wells. (O)
- Participants expressed strong reservations about repurposing wells for CO_2 injection; multiple technical considerations were identified. (A – R&D)
- Participants expressed strong support for repurposing wells as monitoring wells. (O)
- Data is limited and scattered for old wells; an online database should be developed for well data. (O)
- Data recovered may need to be re-tested with modern advanced technology. (A – R&D)
- Assessing reservoir and caprock stability for CO_2 injection versus original intended use. (A – R&D)
- There are no standards across industries for proper well plugging and well integrity. (O)
- Studies are needed on how well integrity changes over decade-long time scales. (A – R&D)
- Create well life cycle analysis (LCA) from primary construction to plugging and abandonment (P&A). (A – R&D)
- Offshore wells present unique challenges for locating legacy wells and assessing wellbore integrity. (O)
- Field laboratories should be developed to allow access for researchers to test new monitoring technologies, validate simulation tools, and demonstrate approaches for improving monitoring costs and accuracy. (A – R&D)

1.3.3 Regulatory Considerations from Breakout Sessions

- Participants expressed the need for more time efficiency in the EPA Class VI permitting process. (O)

- Participants expressed the need for more clarity on several issues in EPA Class VI regulations. (O)
- Participants expressed support for uniform pore space unitization standards for all states, but did not discuss the difficulties in achieving this due to each state having statutory authority over this issue. (A – P)
- Pressure plumes create pore space, and this is not addressed in regulations. (A – R)
- Newer wells may meet current regulatory criteria better than old wells. Acid gas injection and unconventional wells are considered by some as ready candidates for Class VI reuse. (O)
- Education and outreach are needed among regulators, between states, and for well operators in the P&A process and those looking to repurpose wells. (O)

1.4 KEY TAKEAWAYS FROM THE PIPELINES WORKSHOP

1.4.1 Overall Summary Points from Expert Panel Presentations

- Key considerations of repurposing pipelines to supercritical phase transport are project-specific regarding size and pressure rating. (A – R&D)
- External and internal corrosion are core concerns for reusing older pipelines. (O)
- In an offshore environment, pipeline burial depth can be challenging in terms of overpressure due to hydraulic head. (O)
- Converting pipelines to CO_2 service requires review of materials and methods of construction, impurities in CO_2 stream, and consequence of failures, which are very different from natural gas due to risk of asphyxiation and impact radius. (A – R, A – R&D)
- Gaps in knowledge exist in corrosion validation, failure risk, nondestructive examination methods, and effects of impurities. (A – R&D)
- Gas-phase CO_2 transport is only efficient for short distance and small volumes; at long distance, its disadvantages are emphasized due to requiring more intermediate equipment and energy input. (A – R&D)
- Carbon dioxide treatment should consider moisture levels, dew point profile, temperature, and pressure range under transport conditions. (A – R&D)
- Gas-fired pipeline equipment will need to be replaced by commercial power, which affects project lead time, cost, and dependency on the grid. (A – R&D)
- PHMSA enforces CO_2 pipeline safety via 49 CFR Part 195 regulations, which exclude underground storage, injection wells, and production facilities. (A – R)
- PHMSA regulates CO_2 pipelines transporting greater than 90% supercritical CO_2 made of steel (with exception); chemical compatibility, low temperatures, and fracture propagation must be considered. (A – R)

- Part 195.5 requires a conversion to service (CTS) plan that outlines requirements on pipeline integrity, inspection, training, and oftentimes a pressure test before repurposing pipelines. (O)
- EPA has extended regulations protecting drinking water to address CO_2 storage; the U.S. Department of Interior (DOI) is developing regulations for safe offshore geologic storage. (O)
- Some existing regulations address installation, testing, repair, and inspection, but lack specifics on offshore CO_2 pipelines. (A – R)
- Harmonization of federal and state laws, as well as agency coordination, are helpful to resolve issues around pore space ownership, unitization, pipeline siting, eminent domain, subsurface trespass, mineral rights, and liability transfer. (A – P)
- Current Council on Environment Quality (CEQ) guidelines for federal agencies emphasizes transparency, stakeholder consultation, and environmental justice. (O)
- Existing environmental impact statements (EISs) may need revision/supplement for environmental risk due to change of pipeline use. (A – P)

1.4.2 Technical Considerations from Breakout Sessions

- Development in both laboratory- and field-scale studies of pipeline materials and corrosion analysis (new and repurposed). (A – R&D)
- Participants indicated a desire for systematic analysis of pipelines from national labs and government financial assistance in development. (A – R&D)
- Participants emphasized a need for studies on corrosion and potential contaminants based on the specifications of CO_2 being transported. Additionally, analysis of effects of CO_2 streams on both metal and non-metallics, especially for repurposing pipelines, is also important to understand. (A – R&D)
- Field laboratories should be developed to allow access for researchers to test various pipeline materials and technologies. (A – R&D)

1.4.3 Regulatory Considerations from Breakout Sessions

- Participants would like to see unified federal regulations rather than individual state regulations for interstate pipelines. (A – P)
- Financial incentives would be required from the government to build-out pipelines for wide-scale deployment of carbon capture, utilization, and storage (CCUS). (O)
- Regulations are needed for supercritical/dense-phase transport. PHMSA has existing safety regulations for liquid/supercritical-phase transport, but not gaseous phase. (A – R)

- Regulations are needed for siting and route approval of carbon pipelines at the Federal level rather than state-by-state or county-by-county; similar to the Federal Energy Regulatory Commission's (FERC) jurisdiction on natural gas pipelines. (A – R)
- Right of eminent domain can be utilized in an effective way for pipeline build-out. It allows projects to move forward and not be held up. (O)
- Open access pipelines would be better for CO_2 than common carrier which the operator would have to legally make room for new shippers either by adding capacity (pump stations, line looping, etc.) or venting of CO_2. (O)
- Joint government-industry partnership is needed to build hubs and engage the public. (O)

2 SUMMARY OF THE EXISTING WELLS BREAKOUT SESSION

The topics discussed in the breakout sessions for existing wells have been separated into two categories: technical considerations and regulatory considerations for repurposing existing wells for carbon storage. The responses from workshop participants are further described in the following sections.

2.1 TECHNICAL CONSIDERATIONS

The discussion surrounding technical considerations focused on reservations toward repurposing wells, with an emphasis on lacking important information in addition to seeking technological advances to consider repurposing. Participants emphasized topic areas, including repurposing for injection of CO_2, repurposing for monitoring, creation of an online well database and existing infrastructure, reservoir and caprock analysis, cement and wellbore analysis (pre- and post-injection), and creation of a field test site to test different technologies.

2.1.1 Repurpose for Injection

There were strong reservations among the participants with repurposing wells for CO_2 injection. Participants highlighted key considerations for repurposing a well, including age of the well, well history, existing infrastructure, materials used in initial construction/design and purpose, method for plugging the well and remediation, risk associated with repurposing and maintenance costs versus developing a new well, and other unknowns. Another concern is the lack of clarity and data on existing wells, and another point made is that most wells are not of sufficient diameter to allow anything but the lowest of injection rates. Additional research into understanding potential root causes of blowout during a CO_2 injection operation and mitigation would be beneficial.

2.1.2 Repurpose for Monitoring

There was a strong support for repurposing wells as monitoring wells. Participants emphasized lesser risk associated with repurposing wells for monitoring wells versus repurposing wells for CO_2 injection and storage. A participant highlighted that a well that does not qualify for CO_2 injection could qualify as a monitoring well. Participants pointed out a need for improving monitoring technologies while reducing costs associated.

2.1.3 Well Data

When seeking to repurpose a well, an important step is gathering data regarding well construction and any P&A efforts. Participants pointed out that there is limited data for old wells and the information and analysis of old well reports might not be accurate due to the limitation of the tools and techniques used at the time. Another concern was the time and resources it takes to locate well information, as most fields have been sold multiple times and records are usually lost in the process of transferring. Well data is scattered, and participants largely agreed that an online database of well data should be created, potentially by DOE, as a resource for those seeking well data and existing injection permits.

2.1.4 Reservoir and Caprock Analysis

Repurposing a well requires understanding of the surrounding geology. Depending on the age of the well, the previous data has potential to be out of date compared to current technological advances made since the previous well analysis. This is less of a concern for more modern wells but needs to be considered with older wells. Caprocks are almost never evaluated for oil and gas fields since the hydrocarbon accumulation proves caprock integrity.

2.1.5 Cement and Wellbore Analysis

Participants emphasized the importance of cements and wellbore analysis. R&D needs included developing techniques and tools that improve cement jobs for slimmer monitoring wells, developing materials that have self-healing properties in cement, and cement and wellbore integrity studies during the lifespan of the well. More data is needed to understand how well construction efforts can change over time. Participants also mentioned a need to study how well integrity changes over decade-long time scales. Plugged legacy wells could very easily have long intervals between cement plugs, or no plug at the storage reservoir caprock, allowing for large dump floods to occur.

2.1.6 Field Test Site

Participants expressed a desire for a field test site to test both monitoring and storage technologies. A field test site would allow for standardization of approaches for improving monitoring costs and accuracy, validating simulation tools, and analyzing development of storage sites and CO_2 migration.

2.2 REGULATORY CONSIDERATIONS

The discussion surrounding regulatory considerations focused largely on the lack of clarity in regulations, wells that meet current regulations, and additional regulatory needs. Participants indicated that more clarity was needed regarding EPA's Underground Injection Control (UIC) Class VI regulations and pore space access. Additionally, guidance on the P&A process, the creation of an online well database, and education and outreach regarding regulatory issues were identified as needs for the progression of carbon storage projects using existing wells.

2.2.1 EPA Regulations

Participants largely expressed the need for improved efficiency and clarity in the current EPA UIC Class VI permitting process. There was a perceived lack of clarity in the following areas:

- Well conversion.
- The is no clear definition on what proper plugging elements are.
- Likewise, no definition of low-risk well integrity standards.
- Trespass of the pressure plume is not addressed.

- Dual-type regimes (one company indicated they are currently injecting wastewater and would like to inject CO_2 as well).

Many existing wells do not meet current EPA Class VI requirements for conversion to CO_2 injection or monitoring wells. In addition, the required documentation analysis for well conversion is not clear to operators; participants identified this as an area DOE could step in and provide guidance. Early guidance from EPA was also mentioned as a crucial step to helping operators move forward with permits and avoid expending resources in the wrong areas.

Offshore wells will have their own unique issues. Access to the wellhead is much more difficult, high deviations make them harder to evaluate, the annuli between strings are much tighter, and many wells have liner hangers with non-compliant elastomers.

2.2.2 Pore Space

Participants perceived pore space access as one of the largest regulatory concerns in utilizing existing wells for carbon storage operations. The lack of a direct framework for pore space access on federal lands and variance of state laws regarding pore space ownership from state-to-state cause uncertainty in carbon storage projects. Unitization of pore space was identified as a path forward to create uniformity across state boundaries.

2.2.3 Candidates for Repurposing

There was an agreed-upon perception that repurposing old wells comes with much uncertainty and therefore great risk. Instead, participants suggested other types of wells that would be ready candidates for repurposing from a regulatory standpoint. Acid gas injection wells located in New Mexico, Texas, and Canada, designed to inject hydrogen sulfide (H_2S) and CO_2 into the ground, meet or exceed Class VI requirements. These are generally newer wells, which make them a better conversion target than other Class II wells. Other relatively new wells to consider for conversion to CO_2 injection are wells in unconventional reservoirs. These wells comply with current EPA regulations, thus reduces the costs of updating.

While older wells may not be ideal for repurposing, some participants provided suggestions to help operators determine if an existing well could be safely repurposed. Suggestions provided included:

- Integrate orphan well program and CO_2 storage program.
- Best practices for regulatory considerations in preparing wells for future use as an injection well.
- Tuning the P&A process to make newly P&A wells storage-ready.
- Looking at older wells not for injection but for monitoring or pressure management.

The final over-arching point was that operators should be diligent in accounting for all potential risks to show how good they are, not focus on what they can get by with.

2.2.4 Education

Participants expressed a lack of clarity in many regulatory areas surrounding reuse of existing wells for carbon storage and, therefore, would like to see more education and outreach focused on this topic. It was proposed that regulators should be educated on long-term liability, pore space, and activation. There is a lack of knowledgeable on Class VI requirements. Promoting interaction between regulatory agencies and states would help inform regulatory guidelines and aid in the permitting processes. For well owners and operators, a workshop on the issue of plugging wells was suggested to help ensure wells with potential for reuse can be repurposed after the P&A process. Participants would also like to see DOE and national labs become more involved in hosting outreach sessions and providing support in navigating the issues brought up in this workshop. For example, what is the possibility of a Class II well being repurposed as a Class VI well based on DOE/national lab experience?

3 SUMMARY OF THE PIPELINES BREAKOUT SESSION

The topics discussed in the breakout sessions for existing pipelines have been separated into two categories of considerations for repurposing existing pipelines for CO_2 transport: technical and regulatory. The responses from workshop participants are further described in the following sections.

3.1 TECHNICAL CONSIDERATIONS

The discussion surrounding technical considerations focused on pipeline material analysis, mode of transportation of CO_2 and pressure considerations, economic analysis, and a field test site for pipelines. Participants indicated a desire for systematic analysis of pipelines from national labs and government financial assistance. Additionally, the need for government de-risking of pipelines and development of various models was voiced.

3.1.1 Pipeline Material Analysis

Participants emphasized R&D needs in both laboratory- and field-scale studies. The most prominent topic was pipeline corrosion. Specifically highlighted was the effects of CO_2 impurities and contaminants originating from diverse CO_2 source (coal or natural gas) and corrosion mechanisms once water is removed. Alternative considerations included different materials, pipeline coatings, valves (material and spacing), compressors, pump capacities, and efficiency changes.

3.1.2 Mode of Transportation of CO_2 and Pressure (Gas or Supercritical Fluid)

Participants emphasized concerns on the transportation specifics of the CO_2. They understood the hydraulic efficiency (i.e., pressure drop due to higher density and lower viscosity) of transporting supercritical CO_2. The discussion of supercritical CO_2 transport was limited to new pipelines whereas gas-phase CO_2 transport was limited to existing repurposed pipelines. One potential solution dealing with repurposed pipelines' insufficient fracture toughness is crack arrestors; this would need to be further studied and be utilized on a site-by-site basis. The operability of the pipelines and associated risk mitigation based on the phase diagram effects needs to be fully understood.

3.1.3 Economic Analysis

An attractive option is to repurpose existing infrastructure or build new CO_2 pipelines. Participants stressed several considerations, such as diameter and length of pipeline, rights of way (ROWs), pipeline history, age of the existing infrastructure, and change in operating conditions (if repurposing). Ultimately, the participants concluded that a risk and economic analysis of the asset need to be considered and is to be determined on a site-by-site basis. Participants also noted higher offshore costs compared to onshore.

3.1.4 Field Test Site for Pipelines

There was overwhelming support for a location to test various pipeline materials and technologies. Participants noted literature results showing effects of impurities, but not a systematic method to understand limits and define specifications. A field test site could test various characteristic, including but not limited to corrosion, pressure, materials, feasibility, and effects of impurities within CO_2 and other blends (future potential for hydrogen [H_2] studies). A field test site could also offer a well-defined site for gathering data, modeling, reducing risks/failures, and standardizing results.

3.2 REGULATORY CONSIDERATIONS

The discussion surrounding regulatory considerations focused largely on the lack of federal regulations, additional regulatory needs, pipeline operations experience, and government-industry partnership. Participants indicated a desire for federal regulations rather than inconsistent state regulations and government financial assistance. They asked for guidance regarding taking existing pipelines out of service for repurposing, supercritical/dense-phase transport, and right of eminent domain. Additionally, government-industry partnership and the need for these pipelines to be open access rather than common carrier were identified as needs for the progression of pipeline repurposing for CO_2 transport. . Being a common carrier, the operator would have to legally make room for new shippers either by adding capacity (pump stations, line looping etc.) or venting. Lacking a fee-for-service tariff structure from an authority like FERC, the operator may be forced to take additional volume at a financial loss after the pipeline is fully subscribed.

3.2.1 Federal Regulations

Participants perceived a gap in federal regulations regarding CO_2 transport. Individual states are responsible for covering the gaps in the federal regulations, but participants were concerned that pipelines that cross state boundaries will have to contend with varying regulations from state to state. Instead, participants would like to see more federal regulations to make interstate pipelines easier to handle. There was also concern regarding the timeline of projects in states with long lists of regulations. In some states that require long lead times, federal policy could reduce cost and time of the regulatory process for operators.

3.2.2 Financial Incentives

Participants mentioned the tremendous capital cost of the required pipeline build-out for wide-scale deployment of CCUS. One participant estimates that 88,000 miles of new pipeline potentially required to connect carbon sources to sinks in the United States. Participants suggested that financial assistance from the government would be required to complete this scale of pipeline build-out. Participants noted a lack of clarity among industrial emitters regarding financial modeling, because navigating 45Q tax credits slowed projects down, and emitters were not sure if they needed tax equity.

3.2.3 Additional Regulations

In repurposing underutilized natural gas pipelines, participants questioned whether the pipeline would have to be released from agreements with natural gas producers in order to be taken out of service before being repurposed for CO_2. If so, participants were interested in the steps that would have to be taken in such a process.

Participants perceived a lack in regulations for CO_2 in the gas phase, as the existing regulations appeared to be for supercritical/dense phase. Participants were uncertain whether newly issued guidance is applicable for gas-phase CO_2.

Participants discussed right of eminent domain as an aspect for pipeline build-out and routing. Iowa was mentioned as a state to watch regarding eminent domain and new pipeline build-out.

3.2.4 Common Carrier versus Open Access

One participant provided an opinion that open access is better for CO_2 pipelines than common carrier. Open access would allow someone to reserve capacity in a pipeline for a contracted amount of time; with common carriage, venting may be required to make room for someone new to come in and use the pipeline. This participant suggested expanding the system in such a way that when one pipeline reaches capacity, another pipeline is built to accommodate additional capacity; selling capacity in these pipelines would help to fund pipeline construction.

3.2.5 Government-Industry Partnership

Participants would like to see government-industry partnership regarding pipelines because pipelines are a privately held asset that is regulated by the government. Partnership would help effectively build hubs. Participants also saw this partnership as a way to engage with the public to tackle topics such as eminent domain before they become problematic. Participants wanted to understand the public perspective and similarly increase public knowledge of pipelines.

APPENDIX A: AGENDA—WORKSHOP FOR EXISTING WELLS

12:00 – 12:05 PM **Welcome**
Sheila Hollis, Acting Executive Director, U.S. Energy Association

12:05 – 12:10 PM **Introductory Remarks**
Dr. Jennifer Wilcox, Principal Deputy Assistant Secretary, U.S. Department of Energy – Office of Fossil Energy and Carbon Management

12:10 – 12:15 PM **Federal Investments in the Energy Transition**
Kate Gordon, Senior Advisor to U.S. Department of Energy Secretary Jennifer Granholm

12:15 – 12:30 PM **Context Setting: Department of Energy**
Sarah Leung, Carbon Transport and Storage Engineer, U.S. Department of Energy – Office of Fossil Energy and Carbon Management

12:30 – 1:00 PM **Session 1: R&D Priorities of Converting Existing Wells for CO_2 Injection: Technical and Regulatory Considerations**

1. **Performance-Based Standards and Class VI Regulations**
   Molly McEvoy, Environmental Engineer, U.S. Environmental Protection Agency
   Bruce Kobelski, Geologist/UIC Program Senior Advisor, U.S. Environmental Protection Agency

2. **Technical Conversion of Well Archetypes for CO_2 Injection**
   Scott Eberhardt, Business Development Manager – Carbon, Water, and Geothermal, Schlumberger

3. **Technical Considerations for Repurposing Wells for Class VI Permit Submission**
   Will Chessum, Technical Manager for the Carbon Management Team, California Resources Corporation

1:00 – 2:00 PM **Breakout Session 1:**
Facilitators:
Dr. Steven Carpenter, Managing Partner, Carpenter Global
Dr. Sallie Greenberg, Consultant, Carpenter Global

2:00 – 2:10 PM **Break**

2:10 – 2:40 PM **Session 2: R&D Priorities of Converting Existing Wells for Monitoring and Defining Plugging Standards for Future Carbon Storage Siting: Technical and Regulatory Considerations**

1. **Assessment of Wells for Repurposing: Characterization of Legacy Wells through Cement and Casing Integrity**
   Andrew Duguid, Vice President, Advanced Resources International

2. **Overview of Converting Legacy Fields: Hastings Oil Field**
   Kris Roberson, Director – CCUS Operations, Denbury

3. **Location of Wells: Advancing R&D for Determining Legacy Wells**
   Rick Hammack, Research Group Leader, National Energy Technology Laboratory

2:40 – 3:40 PM **Breakout Session:**
Facilitators:
Dr. Steven Carpenter, Managing Partner, Carpenter Global
Dr. Sallie Greenberg, Consultant, Carpenter Global

3:40 – 4:00 PM **Wrap-Up, Summary, Adjourn**

APPENDIX B: AGENDA—WORKSHOP FOR PIPELINES

12:00 – 12:05 PM **Welcome**
Sheila Hollis, Acting Executive Director, U.S. Energy Association

12:05 – 12:10 PM **Introductory Remarks**
Dr. Emily Grubert, Deputy Assistant Secretary, U.S. Department of Energy – Office of Fossil Energy and Carbon Management

12:10 – 12:15 PM **Federal Investments in the Energy Transition**
Kate Gordon, Senior Advisor to U.S. Department of Energy Secretary Jennifer Granholm

12:15 – 12:30 PM **Context Setting: Department of Energy**
Sarah Leung, Carbon Transport and Storage Engineer, U.S. Department of Energy – Office of Fossil Energy and Carbon Management

12:30 – 1:00 PM **Session #1: Carbon Transport R&D Priorities for Existing Pipelines: Technical Considerations**

1. **Technical Assessment of Repurposing Pipelines Offshore**
   Darshan Sachde, Senior Process Engineer, Trimeric

2. **Technical Considerations for Converting Pipelines for Carbon Transport**
   Tony Lindsay, Managing Director, Gas Technology Institute

3. **Considerations for Converting a Legacy Natural Gas Pipeline to CO_2 Service**
   Thomas Burgett, Vice President – Midstream, Kinder Morgan

1:00 – 2:00 PM **Breakout Session #1**
Facilitators:
Dr. Steven Carpenter, Managing Partner, Carpenter Global
Dr. Sallie Greenberg, Consultant, Carpenter Global

2:00 – 2:10 PM **Break**

2:10 – 2:40 PM **Session #2: Carbon Transport R&D Priorities for Existing Pipelines: Regulatory Considerations**

1. **Regulatory considerations for Dual-Use and Conversion of Use of Natural Gas Pipelines**

Vincent Holohan, Engineer, Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation

2. **Regulatory Considerations for Offshore Pipeline Reuse and Conversion**
   Robert Van Voorhees, Of Counsel, Bryan Cave Leighton Paisner

3. **Leasing and Pore Space Considerations: Carbon Storage on Public Lands**
   Tara Righetti, Professor of Law, University of Wyoming – College of Law

2:40 – 3:40 PM **Breakout Session #2:**
Facilitators:
Dr. Steven Carpenter, Managing Partner, Carpenter Global
Dr. Sallie Greenberg, Consultant, Carpenter Global

3:40 – 4:00 PM **Wrap-Up, Summary, Adjourn**

APPENDIX C: QUESTIONS FOR EXISTING WELLS WORKSHOP

Breakout Session 1—Converting Existing Wells for CO_2 Injection

1. What are your thoughts on the viability of conversion or repurposing wells for carbon dioxide (CO_2) injection?
2. Where and what do you see as the opportunities for repurposing existing wells for CO_2 injection?
3. What do you see as the technical and regulatory challenges in repurposing existing wells? What policy drivers, if any, are needed? (e.g., pore space issues, permitting, regulatory challenges, and opportunities for rulemaking updates.) What performance-based standards should be developed or implemented?
4. What do you see as the most critical research needs for repurposing existing wells? Of the ideas discussed, what would you prioritize as the top three?
5. What role to you see the U.S. Department of Energy (DOE) playing in accelerating activity in this area (some examples are: research, development, and deployment [RD&D]; technical assistance; and/or financing)? Do you see a role for the national laboratories, and if so, what role and which labs?
6. What unique challenges, if any, are present for repurposing offshore existing wells for CO_2 injection? Would current performance-based standards should be applicable for offshore?

Breakout Session 2—Converting Existing Wells for Monitoring and Defining Plugging Standards for Future Carbon Storage Siting

1. Where and what do you see as the opportunities for repurposing existing wells for monitoring or other needs?
2. What do you see as the technical and regulatory challenges in repurposing these wells? What policy drivers, if any, are needed? (e.g., pore space issues, permitting, regulatory challenges, and opportunities for rulemaking updates.)
3. What do you see as the most critical research needs for these wells? Of the ideas discussed, what would you prioritize as the top three?
4. What role to you see DOE playing in accelerating activity in this area (some examples are: RD&D, technical assistance, and/or financing)? Do you see a role for the national laboratories, and if so, what role and which labs?
5. What unique challenges are present for repurposing offshore existing wells for CO_2 injection? Would current performance-based standards should be applicable for offshore?
6. Is there anything different with monitoring well standard needs than previously asked with injection and storage wells? Is there anything different needed based on locations?

APPENDIX D: QUESTIONS FOR PIPELINE WORKSHOP

Breakout Session 1—Technical Considerations

1. What are your thoughts on the viability of conversion or repurposing pipelines for carbon transport?
2. Where and what do you see as the opportunities for repurposing pipeline infrastructure? (e.g., intrinsic value to repurpose [right of way (ROW)] – different interstate versus intrastate considerations.)
3. What do you see as the existing practices and technical challenges in repurposing pipeline infrastructure?
4. What do you see as the most critical research needs for repurposing pipelines? Of the ideas discussed, what would you prioritize as the top three?
5. What role to you see the U.S. Department of Energy (DOE) playing in accelerating activity in this area (some examples are: research, development, and deployment [RD&D]; technical assistance; and/or financing)? Do you see a role for the national laboratories, and if so, what role and which labs?
6. What, if any, do you see as the relationship between planned carbon capture, utilization, and storage (CCUS) pipeline deployment with future hydrogen (H_2) pipeline deployment? (i.e., co-location, dual-use, carbon dioxide [CO_2] first followed by H_2 use.)

Breakout Session 2—Regulatory Considerations

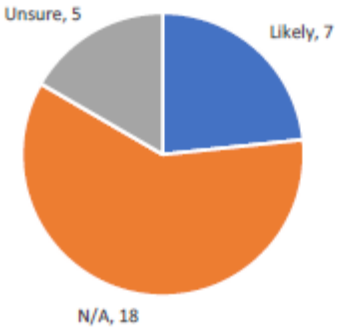
1. What regulatory needs are required for repurposing of infrastructure (i.e., testing protocols)? Are there any regulatory considerations or concerns when repurposing pipelines? (e.g., financing, needed steps to decommission, ROW changes with landowners.)
2. What policy drivers, if any, are needed?
3. Do you see the need for standards (e.g., existing, updated, or newly created?) If so, in what areas?
4. In your opinion, what is the federal role to support deployment? Could there be partnerships with industry at their sites?
5. What unique challenges, if any, are present for repurposing offshore existing pipelines for CO_2? Would current performance-based standards be applicable for offshore?

APPENDIX E: WELL REPURPOSING POLL RESULTS

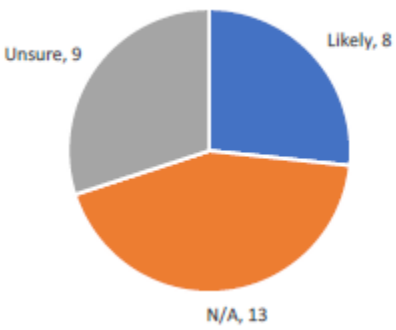
1. Would a matchmaker service to connect technical providers with need be beneficial (e.g., industry, national labs, academia, etc.)?
2. How likely is it that your organization's infrastructure assets may be converted for carbon dioxide (CO_2) injection?
3. How likely is it that your organization's infrastructure assets may be converted for CO_2 monitoring purposes?
4. Would a digital map documenting existing infrastructure for repurposing be useful?

Question 1

Question 2



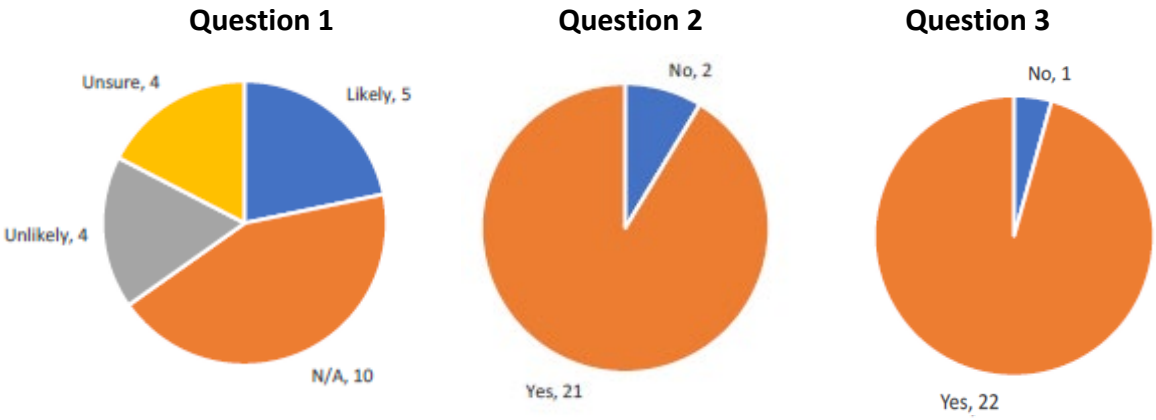
Question 3



Question 4

APPENDIX F: PIPELINE POLL RESULTS

1. How likely is it that your organization infrastructure pipeline assets may be converted to carbon dioxide (CO_2) transportation for future carbon storage sites?
2. Would a matchmaker service to connect technical provider with need be beneficial (e.g., industry, national labs, academia, etc.)? An example is the hydrogen (H_2) matchmaker.
3. Would a digital map documenting existing infrastructure for repurposing be useful?



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