Yazoo County Emergency Management Agency

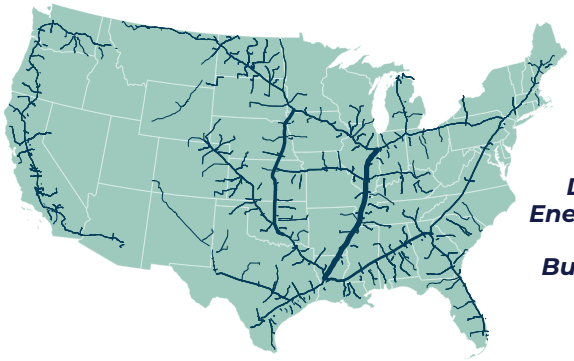
CARBON DIOXIDE PIPELINE SAFETY

In 2022, the Pipeline Safety Trust (PST) commissioned a report from an independent pipeline safety expert on the unique aspects of carbon dioxide pipelines.[1] This Summary for Policymakers presents the current state of safety risks and knowledge gaps associated with CO_2 pipeline transportation.

As government and the private sector seek to reduce greenhouse gas emissions that contribute to climate change, lawmakers have increasingly incentivized carbon capture utilization and storage (CCUS or CCS), as a tool for decarbonization. The 2021 Infrastructure Investment and Jobs Act appropriated $12.2 billion for CCUS[2] and the 2022 Inflation Reduction Act (IRA) provided an even greater level of support for CCUS through the extension and expansion of the 45Q tax credit for carbon capture, utilization, and sequestration.[3]

Transporting carbon dioxide by pipeline poses serious public safety risks due to the fact that **CO_2 is odorless, colorless, heavier than air, and is an asphyxiant and intoxicant**. Furthermore, carbon dioxide has a narrow definition within the federal regulations, only encompassing CO_2 transported as a supercritical fluid consisting of over 90% carbon dioxide molecules.[4] This narrow definition has the potential to exclude new CO_2 pipelines built for CCUS from federal regulatory oversight.

With the potential for a massive buildout of CO_2 pipelines in the next decade,[5] the report highlights the regulatory challenges and remaining knowledge gaps which need to be addressed to ensure public safety. **This summary is intended to assist policymakers and other stakeholders to ensure that pipelines associated with the deployment of CCUS projects minimize community safety risks while accomplishing climate objectives.**



Department of Energy Estimated CO_2 Pipeline Buildout by 2050
6, 7, 8

SUMMARY OF CONCLUSIONS

Regulatory Oversight
Supercritical CO_2 — Regulated by the Pipeline and Hazardous Materials Safety Administration (PHMSA)
Liquid CO_2 — Not regulated
Gaseous CO_2 — Not regulated

Public Safety Concerns
Carbon dioxide is odorless, colorless, does not burn, is heavier than air, and is an asphyxiant and intoxicant. These factors increase the need for public awareness and emergency response training.

Dispersion Modeling
The unique physical properties of CO_2 can dramatically increase the size and scope of the impacted area of a rupture. Weather, terrain, and atmospheric pressure affect how quickly CO_2 will dissipate and how far the product will migrate away from the failure site.

Pipeline Integrity
Hydrogen sulfide, methane, carbon monoxide, oxygen, nitrogen oxides, sulfur oxides, hydrogen, and water are all impurities which can occur depending on the source of the CO_2 and have the potential to impact the integrity of the pipeline.

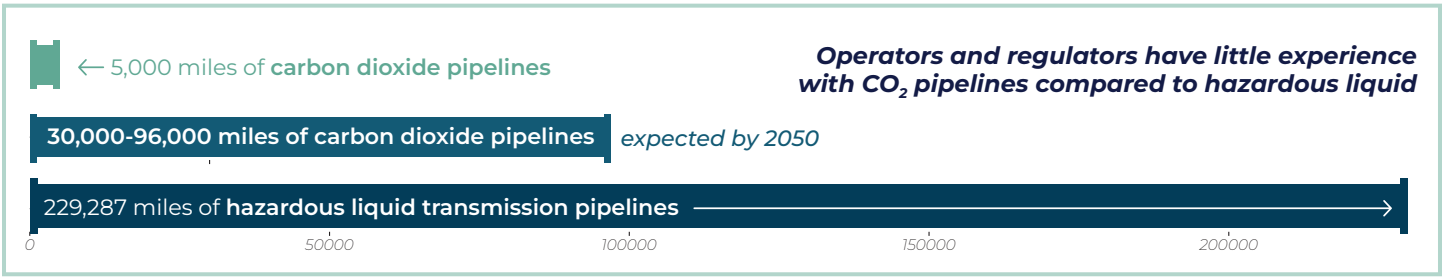
Existing Pipeline Conversion
More research and consideration are needed to assess whether the conversion of existing pipelines to CO_2 service will impact public safety.

Policymakers should be diligent and cautious in considering projects involving carbon dioxide pipelines, ensuring that pipelines will be a sufficient distance from people, that the pipelines will maintain their integrity, and that the project will indeed reduce greenhouse gas emissions.

The Pipeline Safety Trust (PST) is the only national, public-interest nonprofit organization dedicated to pipeline safety and was founded in the aftermath of a pipeline tragedy in Bellingham, WA in 1999 that took the lives of three boys. The mission of the PST is to promote pipeline safety through education and advocacy; thus, the subject of carbon dioxide pipeline safety is critical to our organization.

Pipeline Safety TRUST

CO_2 **PIPELINE** MILEAGE AND REGULATIONS



At present, there are just over 5,000 miles of carbon dioxide pipelines in the United States, compared to 229,287 miles of hazardous liquid transmission pipelines carrying products such as crude oil, gasoline, jet fuel, and other liquid commodities.[9] The majority of CO_2 pipelines are currently used for enhanced oil recovery (EOR) where supercritical carbon dioxide is pumped into existing oil wells to extract more product. Most of the CO_2 being transported through these existing pipelines comes from high pressure, higher purity, natural underground sources.

Regulation of carbon dioxide pipelines began in 1988, primarily driven by a natural CO_2 release in Lake Nyos, Cameroon which killed more than 1,700 people. The final rule issued by the federal regulator, the Pipeline and Hazardous Materials Safety Administration (PHMSA), simply added the words "and carbon dioxide" to existing regulations developed for Hazardous Liquid pipelines. Due to the small number of existing and anticipated CO_2 pipelines at the time, regulators opted not to issue more specific standards for supercritical CO_2 pipelines.

As stated previously, carbon dioxide is currently defined by PHMSA as "a fluid consisting of more than 90 percent carbon dioxide molecules compressed to a supercritical state."[10] With the uncertainty surrounding the physical state and concentrations of CO_2 being transported to support new CCUS projects, this definition, along with the federal standards written for hazardous liquid pipelines, is not appropriate to ensure proper federal oversight and public safety in the coming years.

CARBON DIOXIDE: AN **INVISIBLE THREAT**

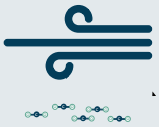
Carbon dioxide has unique physical properties which can make transporting it via pipeline extremely dangerous in the event of a rupture. The physical characteristics of carbon dioxide which augment risks include:

Carbon dioxide is odorless and colorless, making detection by first responders and the public difficult.

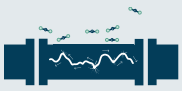
Unlike other hydrocarbon pipelines, **carbon dioxide does not ignite or dissipate quickly** in the event of a release. Depending on topography and weather, CO_2 can migrate far away from the rupture site and settle in low lying areas before detection or dispersion.

Carbon dioxide is an asphyxiant. The displacement of oxygen in the air by CO_2 has the potential to cause long-term health effects and casualties for both humans and animals.

Carbon dioxide is heavier than air, allowing the contents of a rupture to move along the ground and settle in low-lying areas.



Supercritical CO_2 undergoes rapid phase changes upon a pipeline rupture. These phase changes can exacerbate ruptures due to fracture propagation and cause large amounts of product to rapidly release into the environment.

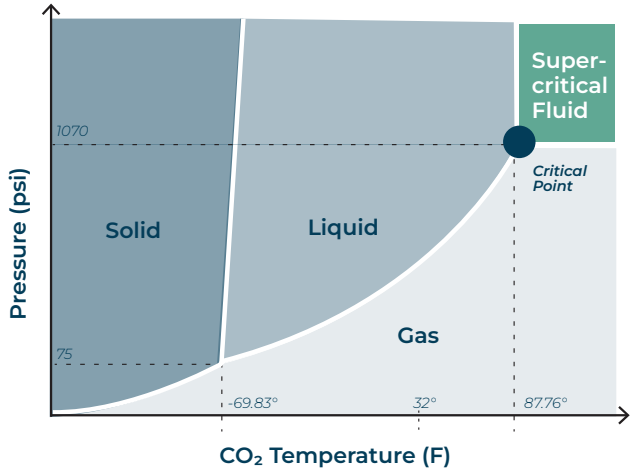


Carbon dioxide's interaction with impurities, such as water and hydrogen sulfide, can compromise pipe integrity and increase the risk of corrosion and failure.

PHASES OF CARBON DIOXIDE

Depending on temperature and pressure, carbon dioxide can be transported by pipeline in three phases; liquid, gas, or supercritical fluid. **Supercritical fluid carbon dioxide has properties of both gas and liquid and is the only phase currently regulated by PHMSA.**

Carbon dioxide pipelines often operate outside the pressure and temperature necessary to maintain supercritical fluid state. Some proposed projects are designed to transport CO_2 strictly as a gas.[11] Communities need assurances that safety regulations apply to all CO_2 pipelines.



SITING OF **NEW CO_2 PIPELINES**

In addition to all the technical and regulatory challenges surrounding a safe buildout of CO_2 pipelines, there are also concerns with permitting and siting authority. Currently, there is no federal oversight for the siting and permitting of CO_2 pipelines. Hazardous liquid pipelines, including CO_2 pipelines, are permitted by either the state or local authorities tasked with this responsibility. Interstate natural gas pipeline projects are approved by the Federal Energy Regulatory Commission (FERC).

Because permitting and routing authority differ depending on the local or state jurisdiction, it is not uncommon to see differing standards of review, policies, and safety or other concerns among different jurisdictions. In addition, the ways in which these issues are addressed can be drastically different depending on the jurisdiction. This may result in an inconsistent level of safety along the route of a pipeline and communities facing differing levels of risk from one jurisdiction to the next.

Environmental justice and equity concerns should also play a role in the permitting and routing process of CO_2 pipelines.[12] All too often pipelines are routed through underserved communities, targeting "the point of least resistance" along the proposed route.[13] Whether a CO_2 pipeline is permitted, and how the route is chosen, can have significant impacts on the surrounding community, and therefore all state and local agencies holding this authority should ensure they are well versed in the technical and safety risks posed by CO_2 pipelines.

WATER IN CO_2 PIPELINES: POTENTIAL FOR CORROSION

Historically, CO_2 pipelines have transported relatively dry and pure CO_2. However, the expansion in different sources of CO_2 has the potential to lead to higher water content and more impurities introduced into pipelines. In addition, carbon dioxide mixed with water can form carbonic acid which is extremely corrosive to the internal surface of the pipe.

CONCLUSION

Policymakers should be diligent and cautious in considering projects that involve moving carbon dioxide by pipeline. Decisionmakers must ensure the pipelines will be fully regulated by an appropriate authority and constructed and operated in a way that does not compromise pipe integrity or public safety. Carbon Dioxide pipelines should only be part of CCUS projects that will truly help the country decarbonize and reach our shared greenhouse gas reduction goals. Decisionmakers must also ensure that the risks placed on communities from these pipelines will be borne in a just and equitable manner.

KNOWLEDGE GAP RECOMMENDATIONS

- **A** The appropriate fracture toughness and steel pipe quality is currently unknown to prevent CO_2 pipeline leaks or ruptures. More research is needed to develop pipe quality standards and strategies for the correct placement of fracture mitigation measures along these pipelines.
- **B** Further research is needed to explore the effects of corrosion, dents, cracks, or gouges on a wide range of steel grades for CO_2 pipeline operation.
- **C** Further research should address odorization strategies to ensure safe and effective interaction with CO_2 transport.
- **D** There is currently no defined safe distance or plume dispersion model for developing a potential impact area along CO_2 pipelines.

RECOMMENDATIONS FOR ADVANCING SAFETY IN FEDERAL REGULATION OF CARBON DIOXIDE PIPELINES

1. PHMSA should update the definition of carbon dioxide in current regulation to include all phases.
2. PHMSA needs to identify in regulation the potential impact areas for CO_2 pipeline ruptures.
3. PHMSA should identify how to incorporate fracture propagation protection on CO_2 transmission pipelines.
4. PHMSA should mandate the use of odorant injection into CO_2 transmission pipelines.
5. PHMSA should establish regulations setting specific maximum contaminant levels for CO_2 pipelines.
6. PHMSA should strengthen federal regulations for conversion of existing pipelines to CO_2 pipeline service.

Endnotes

1. https://pstrust.org/wp-content/uploads/2022/03/3-23-22-Final-Accufacts-CO2-Pipeline-Report2.pdf
2. https://crsreports.congress.gov/product/pdf/R/R47034
3. https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf
4. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-D/part-195/subpart-A/section-195.2#p-195.2(Carbon%20dioxide)
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