

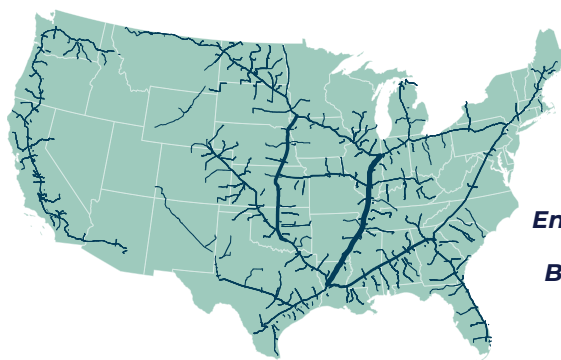
CARBON DIOXIDE PIPELINE SAFETY

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 CO₂ 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 CCUS² 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 **CO₂ 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 CO₂ transported as a supercritical fluid consisting of over 90% carbon dioxide molecules.⁴ This narrow definition has the potential to exclude new CO₂ pipelines built for CCUS from federal regulatory oversight.

With the potential for a massive buildout of CO₂ 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
CO₂ Pipeline
Buildout by 2050
6, 7, 8

SUMMARY OF CONCLUSIONS



Regulatory Oversight

Supercritical CO₂ — Regulated by the Pipeline and Hazardous Materials Safety Administration (PHMSA)
Liquid CO₂ — Not regulated
Gaseous CO₂ — 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 CO₂ can dramatically increase the size and scope of the impacted area of a rupture. Weather, terrain, and atmospheric pressure affect how quickly CO₂ 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 CO₂ and have the potential to impact the integrity of the pipeline.



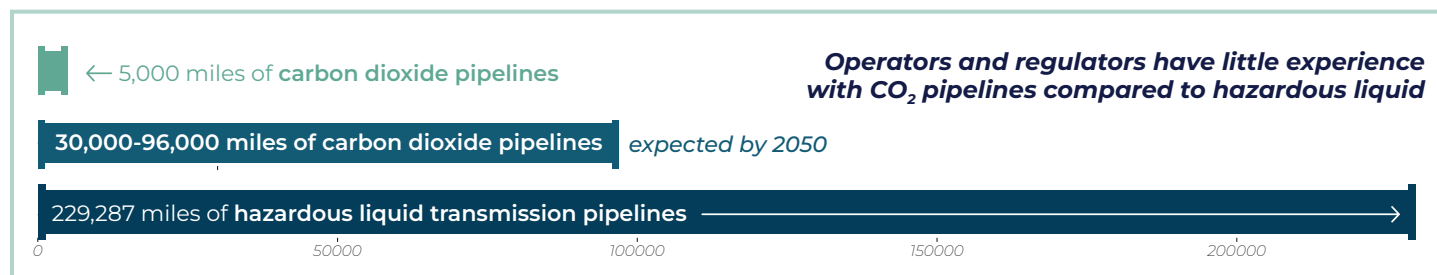
Existing Pipeline Conversion

More research and consideration are needed to assess whether the conversion of existing pipelines to CO₂ 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.

CO₂ PIPELINE MILEAGE AND REGULATIONS



Operators and regulators have little experience with CO₂ pipelines compared to hazardous liquid

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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ pipelines at the time, regulators opted not to issue more specific standards for supercritical CO₂ 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 CO₂ 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, CO₂ can migrate far away from the rupture site and settle in low lying areas before detection or dispersion.

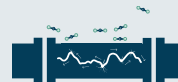


Carbon dioxide is an asphyxiant. The displacement of oxygen in the air by CO₂ has the potential to cause long-term health effects and casualties for both humans and animals.

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



Supercritical CO₂ 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.



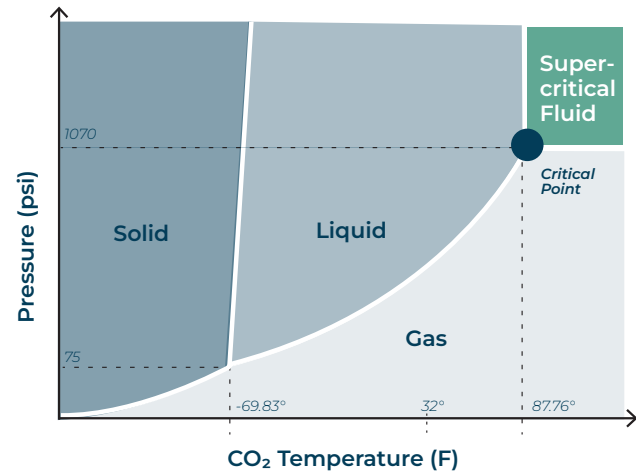
Carbon dioxide's interaction with impurities, such as water and hydrogen sulfide, can compromise pipe integrity and increase the risk of corrosion and failure.



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 CO₂ strictly as a gas.¹¹ Communities need assurances that safety regulations apply to all CO₂ pipelines.



SITING OF NEW CO₂ PIPELINES

In addition to all the technical and regulatory challenges surrounding a safe buildout of CO₂ pipelines, there are also concerns with permitting and siting authority. Currently, there is no federal oversight for the siting and permitting of CO₂ pipelines. Hazardous liquid pipelines, including CO₂ 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 CO₂ pipelines.¹¹ All too often pipelines are routed through underserved communities, targeting “the point of least resistance” along the proposed route.¹² Whether a CO₂ 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 CO₂ pipelines.

WATER IN CO₂ PIPELINES: POTENTIAL FOR CORROSION



Historically, CO₂ pipelines have transported relatively dry and pure CO₂. However, the expansion in different sources of CO₂ 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 CO₂ 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 CO₂ pipeline operation.
- C** Further research should address odorization strategies to ensure safe and effective interaction with CO₂ transport.
- D** There is currently no defined safe distance or plume dispersion model for developing a potential impact area along CO₂ 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 CO₂ pipeline ruptures.
- 3** PHMSA should identify how to incorporate fracture propagation protection on CO₂ transmission pipelines.
- 4** PHMSA should mandate the use of odorant injection into CO₂ transmission pipelines.
- 5** PHMSA should establish regulations setting specific maximum contaminant levels for CO₂ pipelines.
- 6** PHMSA should strengthen federal regulations for conversion of existing pipelines to CO₂ pipeline service.

Endnotes

1. <https://pstrust.org/wp-content/uploads/2022/03/3-23-22-Final-Accufacts-CO2-Pipeline-Report2.pdf>
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