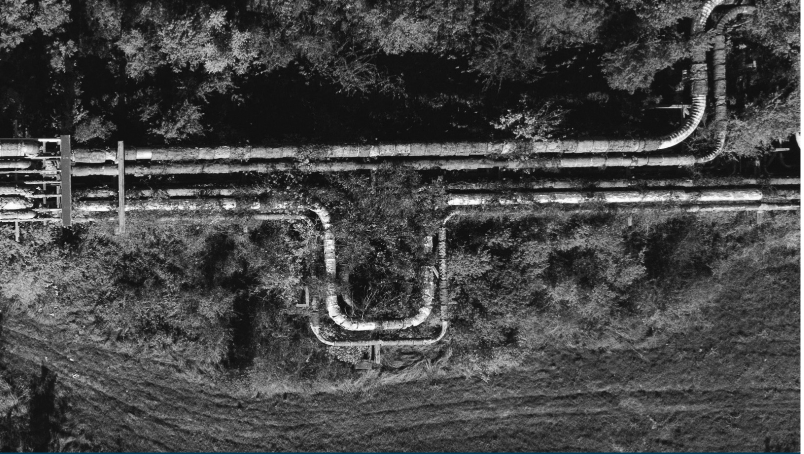
Summary for Policymakers
January 2023



HYDROGEN PIPELINE SAFETY

The Pipeline Safety Trust commissioned a report, titled "Safety of Hydrogen Transportation by Gas Pipelines," from Accufacts Inc.[1] This Summary for Policymakers presents the context and key findings of that report which assesses the risks associated with hydrogen pipeline transportation.

As government and the private sector seek to reduce greenhouse gas emissions that contribute to climate change, hydrogen is increasingly regarded as a critical tool for decarbonization. The 2021 Infrastructure Investment and Jobs Act appropriated $9.5 billion for clean hydrogen[2] and the 2022 Inflation Reduction Act (IRA) provided an even greater level of support for clean hydrogen through the hydrogen production tax credit.[3] Reliance on hydrogen as an energy source will require hydrogen transportation infrastructure, and some industry stakeholders are proposing that existing natural gas pipelines could be used to transport hydrogen.[4] **However, there are many outstanding questions on the impacts and risks of transporting hydrogen through pipelines—particularly with regard to the suitability of existing gas pipeline infrastructure.**

This Summary for Policymakers presents the context and key findings of the report commissioned by Pipeline Safety Trust to assess the risks associated with hydrogen pipeline transportation. **The report finds that transporting hydrogen by pipeline poses serious explosion risk due to hydrogen's flammability, propensity to leak, pipeline integrity issues, and other factors.** Furthermore, hydrogen is an indirect greenhouse gas, making its leak-prone nature **concerning from a safety and climate perspective.**[5] The report finds transportation of hydrogen blends in existing gas distribution systems particularly problematic; however, even pure hydrogen in gas transmission systems will require additional research and careful consideration. **This summary is intended to assist policymakers and other stakeholders to ensure that deployment of hydrogen does not increase community safety risks, while accomplishing climate objectives.** This summary and the underlying report build on, and identify additional issues that were not addressed by, a recent University of California, Riverside study commissioned by the California Public Utilities Commission on the safety implications and knowledge gaps of blending hydrogen into the natural gas system.[6]

SUMMARY OF CONCLUSIONS

Hydrogen blending into gas distribution systems
Should not be permitted at any level because of hydrogen's ability to explode, especially in buildings. Downstream gas pipeline systems within buildings are not designed for hydrogen.

Hydrogen blending into gas transmission systems that supply gas distribution systems
As most gas transmission pipelines feed into distribution systems—where blending is inappropriate—hydrogen blending should not be allowed in such existing gas transmission pipelines.

Hydrogen blending into limited gas transmission pipelines, not supplying gas distribution systems
May be suitable for hydrogen blends that only service major industrial gas users, if knowledge gaps can be resolved and pipeline integrity can be demonstrated for hydrogen service.

New gas transmission pipelines designed for exclusive hydrogen service
New smaller diameter gas transmission pipelines may be suitable for hydrogen service if knowledge gaps can be resolved, pipeline integrity can be demonstrated, and pipelines can be sited to ensure that failures will not result in deaths or injuries.

Policymakers should be diligent and cautious in considering projects involving hydrogen 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 hydrogen pipeline safety is critical to our organization.

Pipeline Safety TRUST

EXISTING HYDROGEN PIPELINES IN THE UNITED STATES

At present, there are only 1,500 miles of hydrogen transmission pipelines in operation throughout the country.[7] Hydrogen pipeline safety falls under the jurisdiction of the US DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA). Pipeline operators and regulators have little experience with hydrogen transportation and hydrogen pipelines currently face little hydrogen-specific regulation despite the unique safety and integrity issues hydrogen poses to pipelines. Furthermore, almost all current hydrogen mileage exists in rural areas and is exclusive to smaller diameter transmission lines.

The bulk of this limited hydrogen transmission pipeline mileage, about 85%, exists in three major transmission pipelines. All three pipelines are located in the rural Gulf Coast region, with over 80% of their pipeline mileage in areas of lower building density.

In comparison, there are approximately 300,000 miles of onshore natural gas transmission pipelines and slightly over 2,300,000 miles of natural gas distribution pipelines.[8] **Industry and its regulators do not have the same kind of experience with hydrogen as they do in transporting natural gas.**

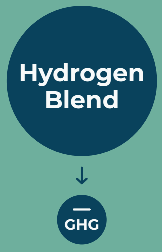
HYDROGEN VS. METHANE

Hydrogen's unique physical properties make its movement, whether via gas transmission or gas distribution pipeline or whether transported as pure hydrogen or blended with natural gas, substantially more dangerous than conventional natural gas pipelines. The physical characteristics of hydrogen that augment risks include:

Hydrogen is **much more prone to explode** than methane.[9]

Hydrogen **explosions are larger and burn hotter** than methane.[10]

While more research is needed, hydrogen can leak as fast or faster than methane leading to increased hydrogen emissions into the atmosphere, as well as migration and accumulation in confined places where the risk of explosion is increased.[12] The leak rate is also important to consider given hydrogen's role as a **potent indirect greenhouse gas.**[13]



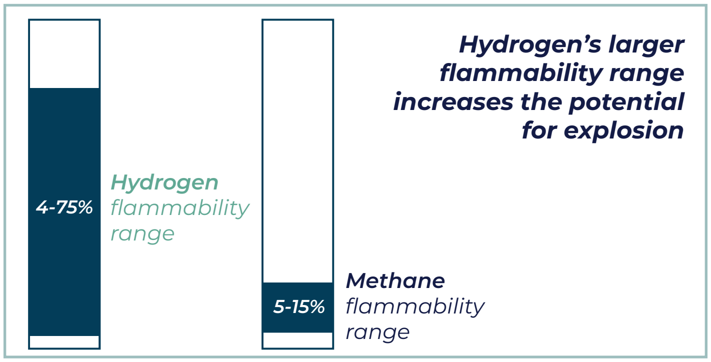
Hydrogen's **energy density by volume is much lower** than methane, which means that a larger volume of gas must be delivered to achieve the same energy output, if hydrogen is blended into natural gas. For instance, **blending 20%** green hydrogen into natural gas pipelines **would only reduce GHG emissions by less than 7%** (accounting for hydrogen and methane leaks would further diminish climate benefits).[11]

Many pipeline materials, such as certain steel and polyethylene, are inappropriate for transporting hydrogen due to issues such as **embrittlement and cracking**. Introduction of hydrogen in existing natural gas pipelines would cause such systems to fail at higher rates unless operators conducted extensive system upgrades.

Together, this suggests that the transportation of hydrogen by pipeline should be approached with caution and limited to facilities capable of transporting it without leaks or failures and at sufficient distance from buildings and people.

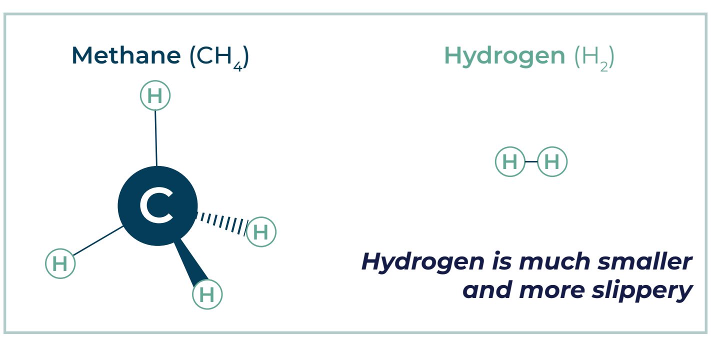
CURRENT PIPELINE INFRASTRUCTURE IS RARELY SUITABLE FOR HYDROGEN TRANSPORT

Hydrogen's unique physical properties increase the probability and intensity of explosions relative to methane natural gas



Hydrogen has a flammability range of 4% - 75%, meaning an explosion is possible when the concentration of hydrogen in the air is between 4% and 75%, compared to methane's flammability range of 5% - 15%.[14] Hydrogen also has a lower autoignition temperature,[a] burns faster, and has a higher combustion efficiency[b] compared to methane. These physical properties contribute to hydrogen's greater propensity to ignite as well as its ability to produce larger and hotter explosions and fires as compared to methane.

Because of these distinct characteristics and heightened safety risks compared to methane, hydrogen transportation will require the development of carefully planned and engineered infrastructure that is specifically designed for hydrogen and sited to ensure that failures will not lead to deaths and injuries. Reliance on existing natural gas infrastructure creates significant additional risks.



a. Autoignition temperature is the lowest temperature at which it spontaneously ignites in a normal atmosphere without an external source of ignition

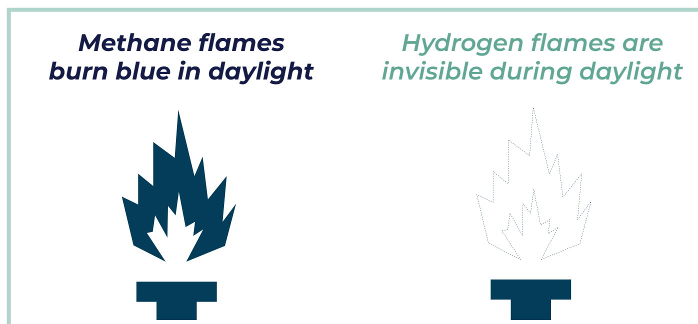
b. Combustion efficiency is a measure of how effectively the heat content of fuel is transferred into useable heat, meaning hydrogen events could have higher heat intensity

Gas distribution systems are inappropriate for hydrogen blending

Gas distribution networks move gas through densely populated areas, often relying on older, leak-prone pipe infrastructure. Research has also observed heightened urban methane levels[15] and gas appliance leakage,[16] indicating that pipes and appliances in buildings (behind-the-meter) are also quite leaky. Due to proximity to people and buildings, aging and leaky infrastructure, and the condition of internal piping in buildings, hydrogen transport, including blends, is inappropriate in gas distribution systems that serve homes and commercial buildings.

Few existing gas transmission systems are likely to be suitable for conversion to hydrogen service

Gas transmission systems tend to be larger diameter, higher pressure pipelines whose primary capacity mainly serves electric power plants, large industrial facility fuel consumers, and distribution utility systems.[17] Co-mingling gas and hydrogen in transmission pipeline systems would make it impossible to selectively target power plants and large industrial consumers with hydrogen without imposing blended hydrogen streams on the distribution systems they also serve.



In addition, many gas transmission pipelines contain manufacturing cracking threats, potentially making them unsuitable for conversion to 100% hydrogen service. Thus, hydrogen applications should be more targeted, rather than pursuing wholesale blending into gas transmission pipelines.

Hydrogen blending for natural gas distribution systems will not meet climate change emission reduction goals

It is easy to overstate the climate benefits of hydrogen, while understating the very real dangers to the public. Because existing pipeline infrastructure is leaky and the proposed level of blending is so low, emissions goals are not likely to be met by blending hydrogen into natural gas pipelines. When possible, electrification with renewable energy sources would often achieve a much greater emissions reduction,[18] and do so more efficiently,[19] without imposing the danger of hydrogen on communities.

CONCLUSION

Policymakers should be diligent and cautious in considering projects that involve moving hydrogen by pipeline. Decisionmakers must ensure that the pipelines will be a sufficient distance from people and communities, that the integrity of the pipelines will not be compromised by the presence of hydrogen, and that the project will indeed reduce greenhouse gas emissions.

KNOWLEDGE GAP RECOMMENDATIONS

A The knowledge gaps identified in the recent University of California Riverside Hydrogen Blending Report[20] should be addressed and the results made public.

B The report, focused on hydrogen blending, identifies knowledge gaps with blending rates as low as 2% in areas such as inspection and maintenance and underground gas storage. Beyond 10%, the knowledge gaps extend to network management and compression. Further knowledge gaps exist for blending hydrogen up to 30% in distribution, safety, and end-use equipment. The amount of knowledge gaps beyond 50% blends becomes very significant.

C Further research should be pursued to assess hydrogen compatibility of steel transmission pipelines and their components.

D Further research should fully explore and confirm the heat release capability and combustion dynamics from pipelines containing hydrogen, both as leaks and ruptures.

RECOMMENDATIONS FOR ADVANCING SAFETY IN FEDERAL REGULATION OF HYDROGEN PIPELINES

1. Gas utilities should not pursue hydrogen blending into their systems, and regulators should prohibit the blending of hydrogen in gas distribution systems that serve homes and commercial buildings.
2. PHMSA should update reporting requirements to include documentation of any percentage of hydrogen blended into a transportation pipeline.
3. Existing transmission pipelines that should not be candidates for hydrogen transportation should be clearly identified.
4. PHMSA should require gas transmission pipelines converting to transport hydrogen, either blends or higher purity, to conduct spike hydrotests.
5. Pipeline safety leakage survey regulations should be developed for pipelines transporting hydrogen.

Endnotes

1. https://pstrust.org/wp-content/uploads/2022/11/11-28-22-Final-Accufacts-Hydrogen-Pipeline-Report.pdf
2. https://www.energy.gov/articles/doe-establishes-bipartisan-infrastructure-laws-95-billion-clean-hydrogen-initiatives
3. https://www.atlanticcouncil.org/blogs/energysource/the-inflation-reduction-act-will-accelerate-clean-hydrogen-adoption/
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