Hydrogen Blending in Natural Gas Transmission

A summary presentation of an INGAA Foundation Study

Disclaimer

The information presented here is based on publicly disclosed statements and positions of INGAA and INGAA Foundation members. The statements are those of the presenter and do not necessarily represent the positions of INGAA, INGAA Foundation, or their member companies.

Who Are We?

Interstate Natural Gas Association of America

Trade association of natural gas transmission pipeline and storage owner/operators. Mission is to advocate on behalf of the operators.

INGAA FOUNDATION

Trade association of both natural gas transmission pipeline and storage owner/operators and the full value chain of the industry. Mission is to provide research to support advocacy and advance the industry.

Who is the INGAA Foundation?

As an Organization

Our primary activity is to sponsor research aimed at promoting natural gas use and safe, efficient pipeline construction and operation.

We have completed over 200 studies and workshops since 1990

Additional projects/workshops focus on key industry issues

- Environmental impacts of energy use
- Improved pipeline construction practices
- Pipeline safety procedures
- New technologies and market opportunities for natural gas

We are a 501(c)6 – not-for-profit – Member-driven organization

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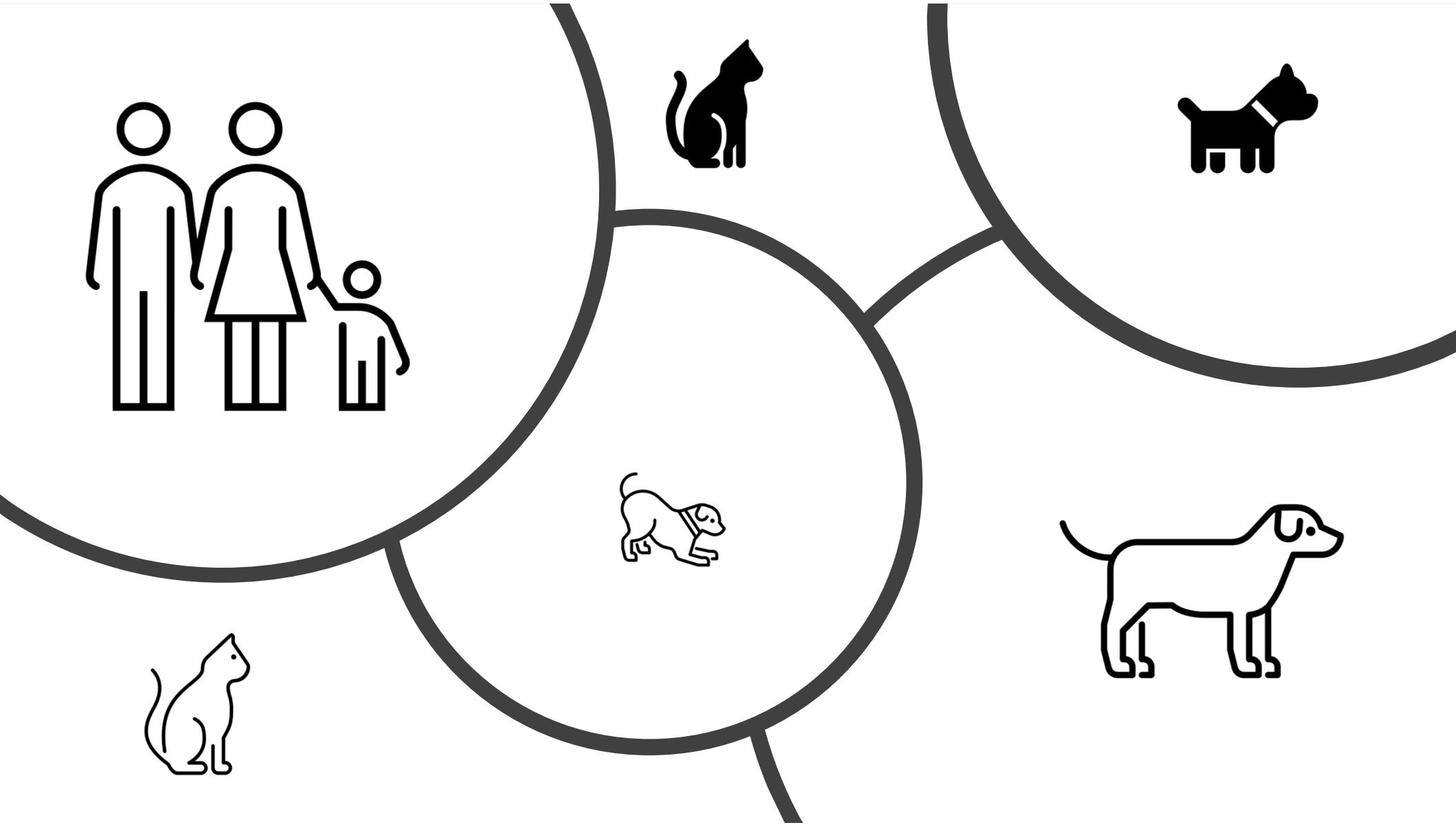

Updated Vision & Mission (Pending Vote)

Vision:

Develop and deliver safe, affordable, reliable, clean energy solutions for the people of North America and the World.

Mission:

Convene industry leaders from natural gas and complementary clean energy solutions to identify and address critical matters related to the development, construction, operation, and maintenance of the gas infrastructure value chain through research, engagement, and outreach.

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Background

The INGAA Foundation and INGAA's IMCI 2.0 Hydrogen Subgroup engaged Mott MacDonald to produce a study focused on preparing the natural gas transmission infrastructure for transporting hydrogen blends.

The study draws upon selected public domain work that has been completed or currently underway.

For this study, the relevant key findings are limited to transmission pipelines defined as operating above 50% SMYS (hoop stress).

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Why Hydrogen?

- It is an energy carrier – providing power and heat
- It can be produced from multiple energy sources
- It can serve as a chemical feedstock
- It can be converted to electricity using fuel cells

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Hydrogen Pipelines and Storage in the US

According to PHMSA annual report for both transmission and distribution for 2020:

- 700 BSCF was transported across 1,560 miles of pipeline that year (avg. 1.9 BSCFD)
- Approximately 200 miles are considered “transmission pipeline”
- 99.6% of the pipelines were steel
- 99.8% were 20” OD and smaller

There are three operating underground hydrogen storage facilities in the US:

- Beaumont, TX operated by Air Liquide
- Moss Bluff, LA operated by Praxair
- Clemens Dome, TX operated by ConocoPhillips

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What are the drivers for the rise of hydrogen?

- Clean hydrogen supports the US goal to achieve a net zero emissions economy by 2050 through decarbonizing multiple sectors.
- Clean hydrogen can support the US commitment to meeting greenhouse gas (GHG) reduction and nationally determined contributions by 2030
- Incentives at the Federal, state and city levels, including renewable energy tax credits and 45Q CO_2 tax credits for carbon capture and storage, and other proposed hydrogen incentives.
- The anticipated lower levelized cost of renewable energy (LCOE) and green hydrogen (LCOH), due to lower capital and operating costs (higher learning rates for renewable energy and electrolyzers).

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Scope of Work
Six Themes Identified

1. Impact of Hydrogen's Properties
2. Gas Quality, Heat Content, Volume, Compression, and De-blending
3. Pipeline Material and Integrity
4. Safety
5. Underground Hydrogen Storage (UHS)
6. Operations and Maintenance

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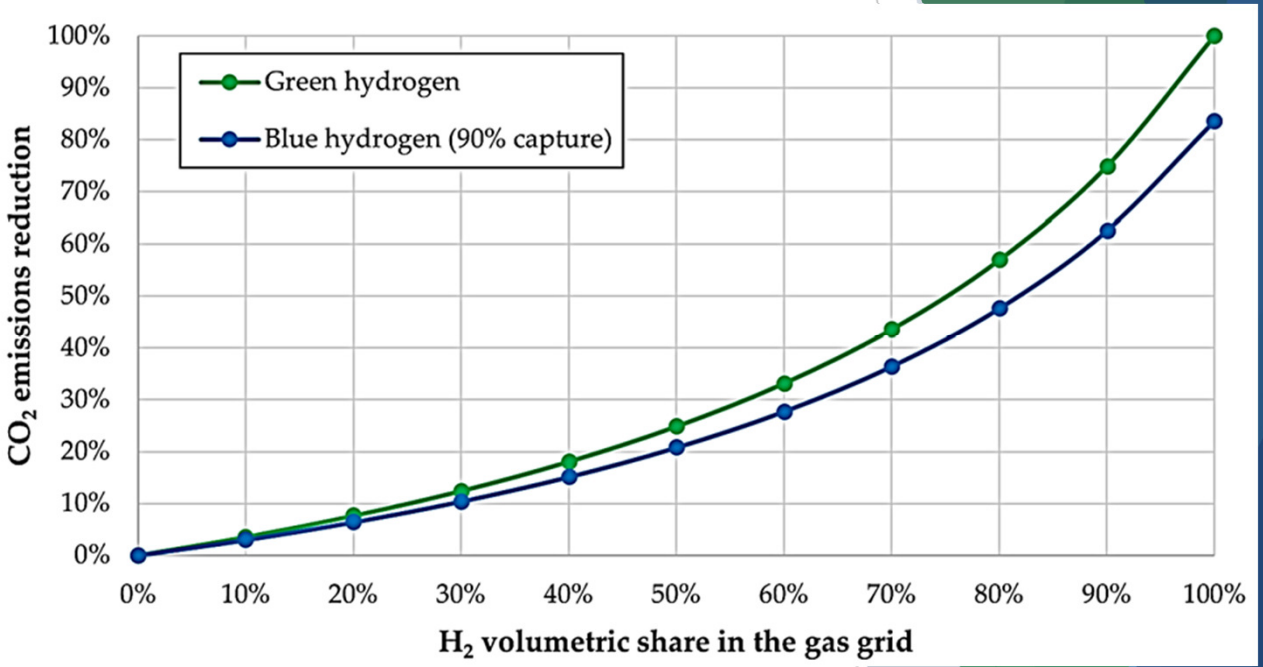
Key Findings from the Study

The elephant in the room…Carbon Emissions Reduction

Noussan et al. (2021) undertook an analysis of the reduction in carbon emissions associated with hydrogen blending for blue and green hydrogen.

- At 10% (v/v) blend, CO_2 emissions reduce by 3.5%
- At 20% (v/v) blend, CO_2 emissions reduce by 7.6%



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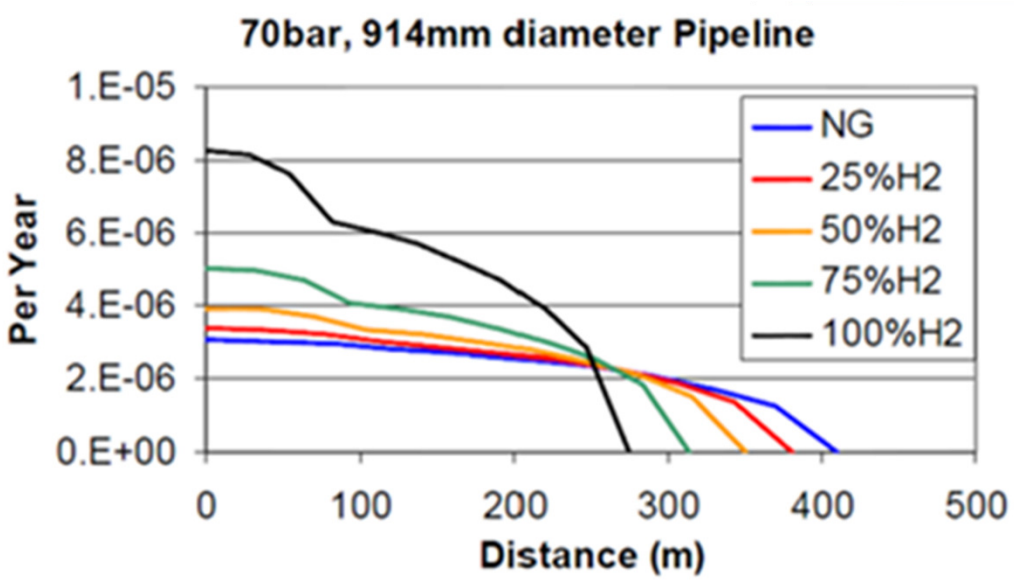
Safety

- The primary threat associated with hydrogen blends is jet fire or plume emerging from a line rupture.
- Hydrogen has been used for decades in the chemical, petrochemical, and space industries. These sectors have a high level of familiarity and experience in handling hydrogen. There has been a general trend of reduction in hydrogen safety incidents, with peaks in the 1990s to 2000s as observed in the Hydrogen Incident and Analysis Database (HIAD 2.0), due to improved safety design and operation.

Risk to an Individual per year as a function of distance from the pipeline.



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Hydrogen Properties and Impact

- Pure hydrogen's physical properties include being odorless, colorless, burning with a nearly invisible pale blue flame in air.
- Pure hydrogen burns with low radiant heat emissions and there is a danger that personnel can approach too close to a hydrogen flame.
- Hydrogen is around 14 times lighter than air, resulting in the potential to accumulate in confined spaces, which can potentially create a hazardous combustible zone.
- The higher adiabatic flame temperature of hydrogen compared to most other fuels can potentially promote NOx formation
- As hydrogen is introduced into natural gas, the blend density, specific gravity, and viscosity decrease; the blend's flammability range and detonatable range gets wider; and the blend's minimum ignition energy is lower. Thus, increasing hydrogen content, in general increases the potential for ignition.

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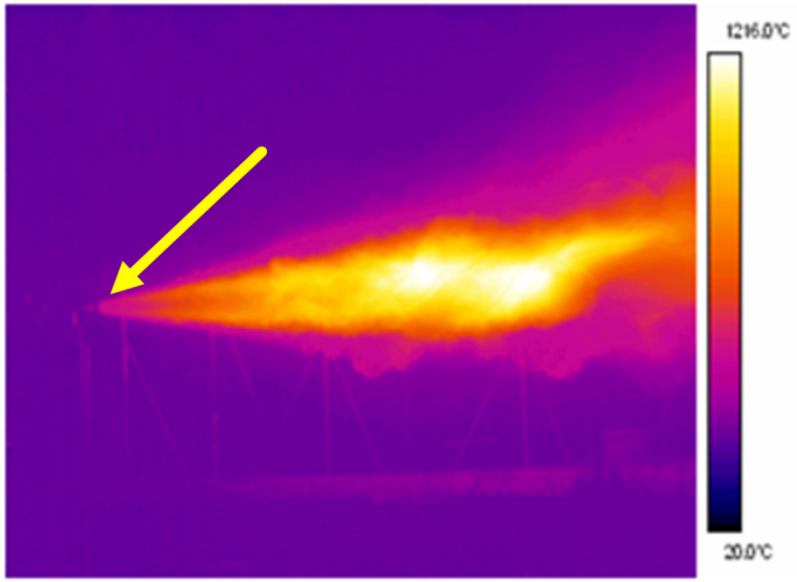
Hydrogen Properties and Impact

Image from video camera

Image from thermal imaging camera



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Quality, Heat Content, Volume, Compression, and De-Blending

- The injection of hydrogen may require additional compressor stations to maintain the gas pressure in long pipelines to compensate for pressure losses, resulting from a higher gas velocity due to a lower blend density.
- There is no clear consensus on the level of compressor modifications required with different percentages of hydrogen in natural gas (v/v) and a project specific analysis must be undertaken.
- Several groups are working to define quality standards for hydrogen and hydrogen blends for various end-use application, such as in electric vehicles for transport, gas turbines for power generation and heat generation in the built environment
- Downstream quality requirements will influence the level of blending and/or deblending that will be required.

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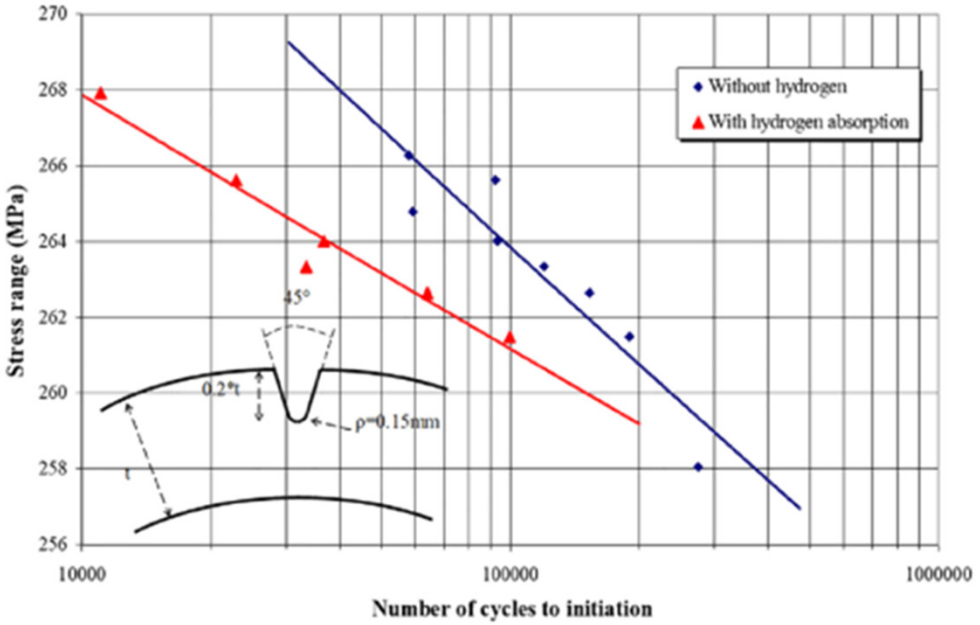
Pipeline Material and Integrity

- Crack initiation and propagation are accelerated when exposed to hydrogen.
- Characterization of an existing natural gas pipeline is a key step for any entity considering repurposing such a pipeline for hydrogen blending
- Yield and tensile strength were not significantly influenced by hydrogen. Ductility and uniform elongation, however, decreases as hydrogen is introduced into the system, and the magnitude of this effect is amplified at higher yield strengths (Guy et al., 2021)



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Summary of Key Findings

- **There is no clear consensus on the level of hydrogen content at which minimal, moderate, or significant modification of natural gas pipeline infrastructure is required.**
- To determine the suitability of reuse for an existing natural gas pipeline for hydrogen injection, an energy analysis is an important first step for technical feasibility.
- CO_2 emission reduction are expected to reduce around 3.5% and 7.6% at the commonly considered volumetric hydrogen blending ratios of 10% and 20% (v/v) respectively.
- Due to the US pipelines age, over time defects can accumulate and characterization of an existing natural gas pipeline, which is to be repurposed for hydrogen blending, is essential as it provides baseline information and identifies potential hazards.

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Thank you

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For more information on INGAA policies: www.ingaa.org

For information on joining INGAA Foundation contact Faith Brown (fbrown@ingaa.org)

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