

Hydrogen Energy: A New Frontier for Gas Pipeline Infrastructure

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Gas Pipeline Infrastructure: Powering the U.S.

- Natural gas is mostly methane (~97%)
- 1,400+ gas utilities; 1.2 mil. miles distribution mains; 900,000 miles service lines
- 160,000 miles = cast iron & bare steel legacy pipelines; ~35% remain in service
- Gas is cheap, readily available energy source
- Considered a growing contributor of greenhouse carbon emissions



Current Gas Industry Issues

- Aging gas infrastructure
- Methane emissions & leakage
- Estimated 20% of greenhouse gas emissions attributed to natural gas usage; ~7.8 billion tons CO₂ (2020)
- Clean energy focus: reduce carbon footprint, develop renewable energy
- US Dept of Energy goals: increased energy efficiency, lower greenhouse gas emissions





Hydrogen: A New Horizon for Gas Pipeline Infrastructure

- Key focus of energy industry
- Gaining research funding, political attention
- Clean & renewable gas energy
- Convert methane-based gas pipeline systems to hydrogen (or blend)



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Potential Advantages of Hydrogen

- Lightest & simplest of Earth elements
- Renewable; plentiful in supply
- Can be produced locally using variety of sources
- Clean energy
- Non-toxic; can reduce pollution
- Can be more efficient than other energy sources



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Potential Challenges & Disadvantages...

- High flammability & volatility
- Hydrogen production takes a lot of effort
- Electrolysis, other production methods = expensive & energy-intensive
- More challenging to store and transport; requires high pressures



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What Does this Mean for Gas Pipeline Infrastructure?

- Significant “conversion” efforts
- Existing infrastructure leakage with hydrogen
- Hydrogen embrittlement issues
- More hydrogen by volume needed
- Hydrogen blend (~15%) most practical approach
- A big shift; extensive rehabilitation, replacement



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Challenges Present Unique Opportunities

Creating an abundant clean energy supply

Conversion of existing gas infrastructure

Solving leakage and hydrogen embrittlement

Safety, cost and reliability considerations

Funding, timing & implementation



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Under Pressure: Hydrogen Supply & Distribution Needs

- 3X the volume to produce equivalent energy
- Downstream systems not designed for it
- First step: on-site hydrogen energy generation
- Approximately 1,600 miles of hydrogen pipelines currently operating
- Long way to go for reliable, safe distribution on widespread basis



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Leakage is a Problem

- Existing gas pipelines prone to methane leakage
- Hydrogen will likely result in higher levels of leakage, permeation issues
- Leak reduction: Focus of gas industry, EPA, US DoE
- Methods to reduce leakage & seal gas distribution pipelines



Gas System Conversion Challenges

- Entire gas system includes
 - ✓ Distribution pipeline network
 - ✓ Gas storage facilities
 - ✓ Individual service connections
 - ✓ Gas powered industrial equipment
 - ✓ Gas appliances & furnaces
- Methane gas blends (up to 15% hydrogen) vs pure hydrogen
- Gas system functionality, pressure differences, volume requirements, BTU equivalence



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Hydrogen Embrittlement Considerations

- Hydrogen-induced cracking can cause degradation in steel, other metallic materials
- Hydrogen molecules can lower stress required initiate & propagate cracks
- Potential solutions include lining systems that prevent hydrogen embrittlement
- Materials less susceptible to embrittlement
- Additional research needed



Hydrogen Gas Presents Infrastructure Safety Challenges

- Safe and well-functioning gas infrastructure is critical
- Highly flammable, explosive
- Downstream gas pipelines not designed for hydrogen or blends
- High storage, distribution pressures
- PHMSA & Pipeline Safety Trust defining standards, requirements



Extensive New Infrastructure, Rehabilitation, Conversion

- Substantial investment interest, R&D focus
- Conversion: daunting task, but opportunity for construction industry
- Increased demand: compliant lining systems, new pipeline installations, leak prevention methods, materials that prevent hydrogen embrittlement
- Long-term, economical solutions



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The Path Forward for Hydrogen

- Europe is ahead of North America
- EU's Hydrogen Strategy vision: carbon neutrality by 2050
- 25% of European renewable energy derived from hydrogen by 2050
- At least 6 GW renewable hydrogen electrolyzers by end of 2024
- Significant technology gaps exist
- Projected EU investment up to \$550 billion



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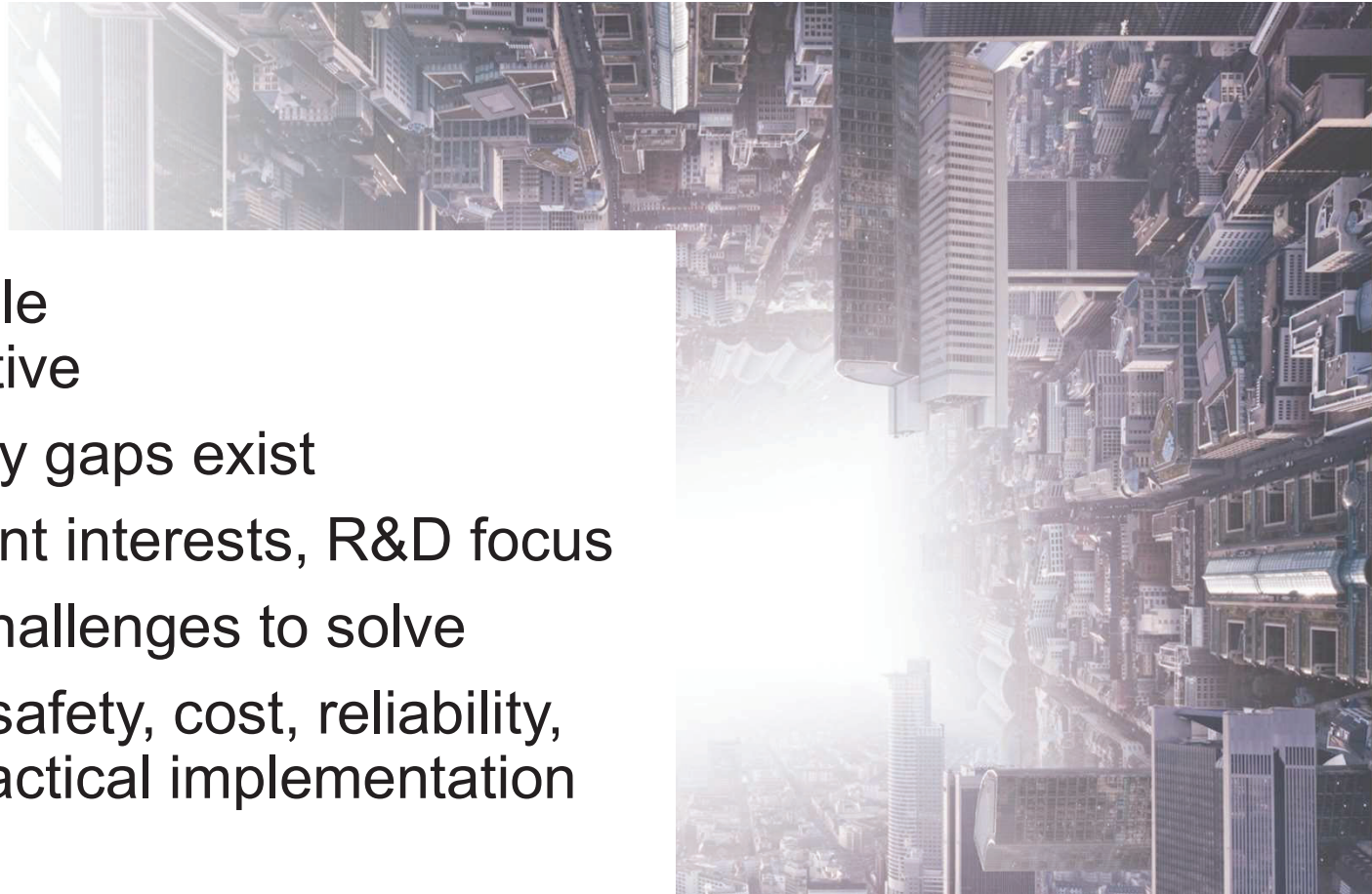
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Future outlook

- Promising, sustainable clean energy alternative
- Significant technology gaps exist
- Substantial investment interests, R&D focus
- North America: big challenges to solve
- Key considerations: safety, cost, reliability, technical hurdles, practical implementation



Questions?

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