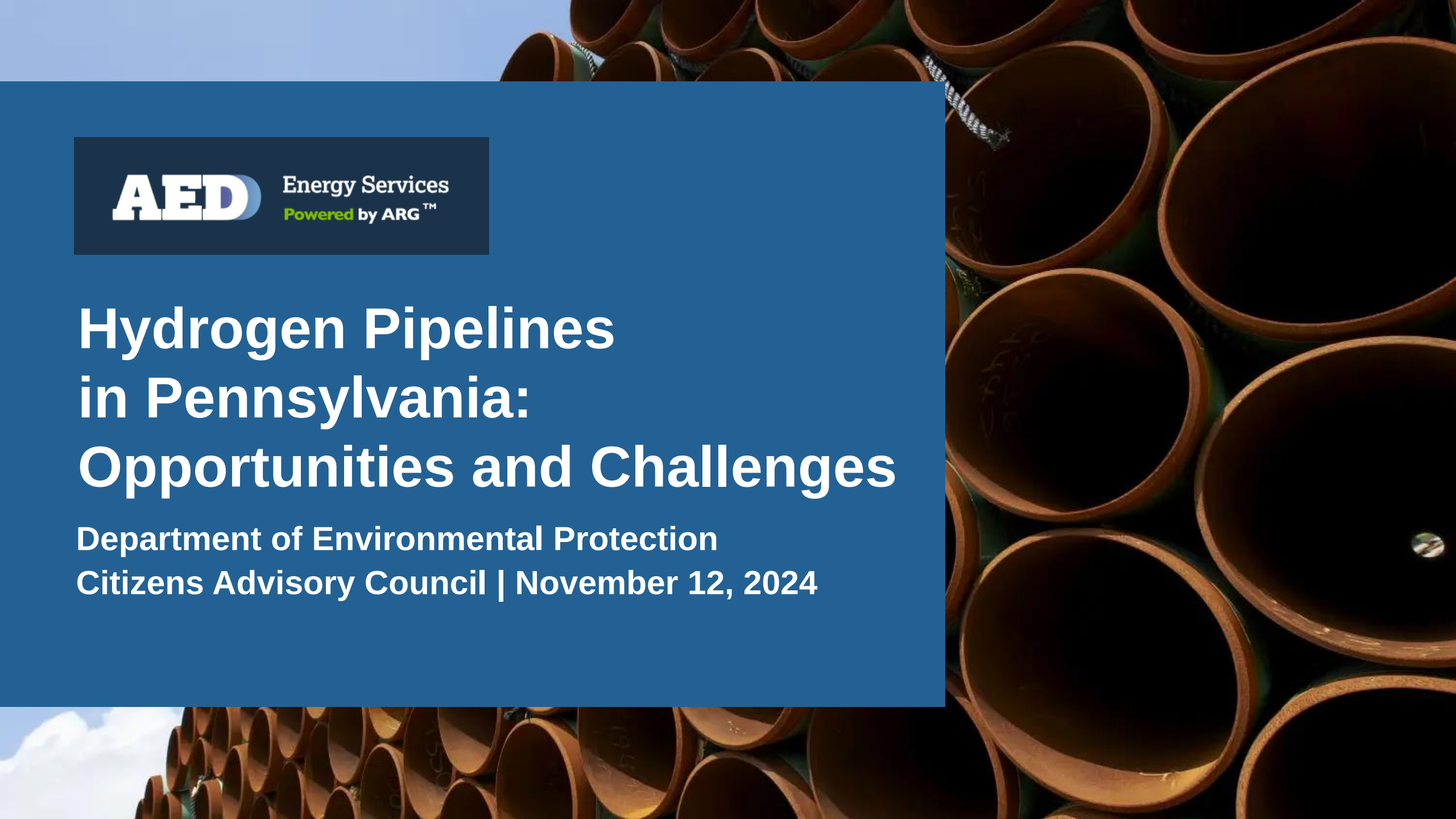
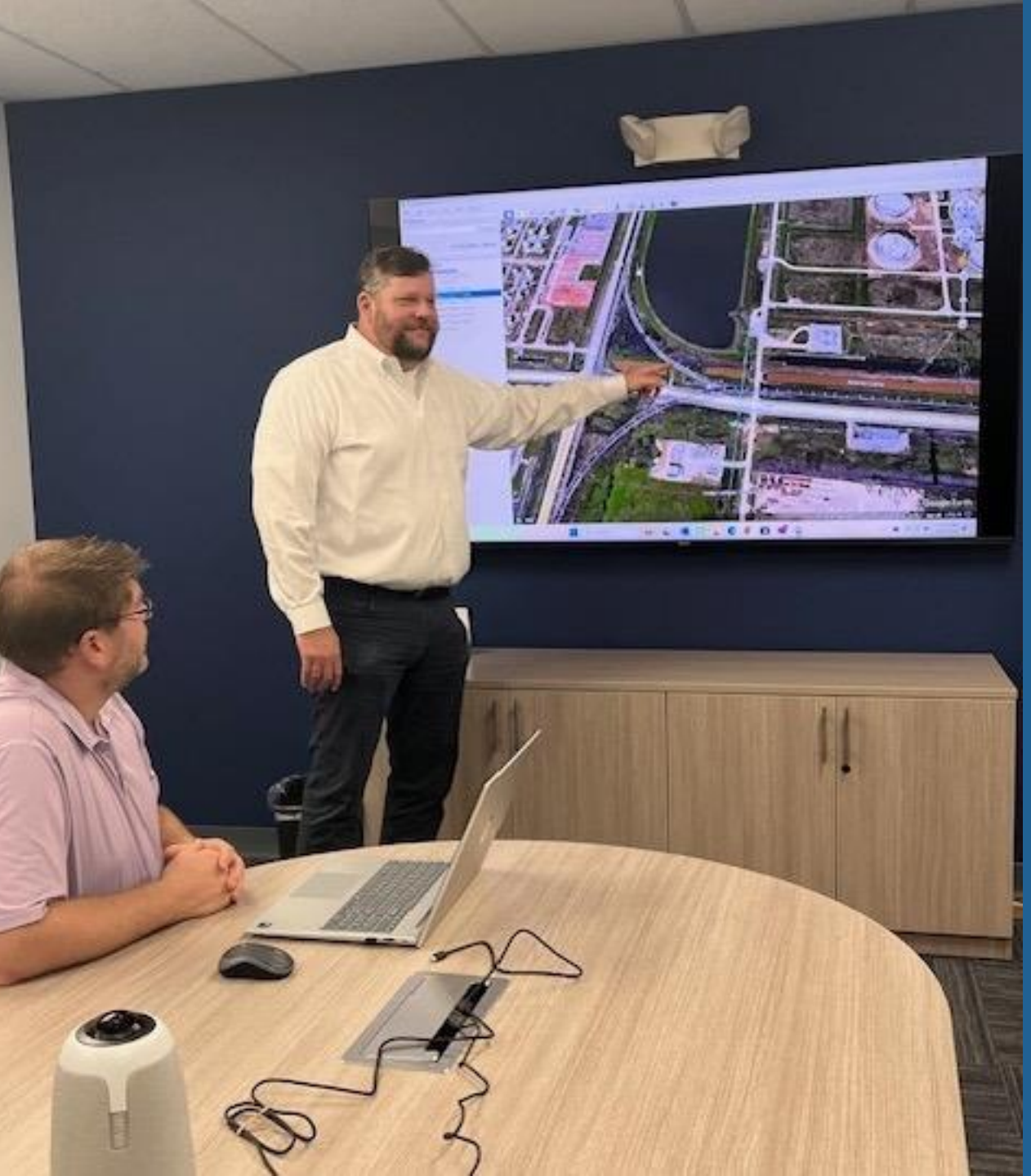


AED Energy Services Powered by ARG™

Hydrogen Pipelines in Pennsylvania: Opportunities and Challenges

Department of Environmental Protection
Citizens Advisory Council | November 12, 2024



Christopher D. Antoni,
P.E., P.Eng.

- 25+ Years as a Professional Engineer in Energy, Industrial, and Manufacturing Markets
- Expertise in Multidisciplinary Engineering Teams, Site Development, Environmental Permitting, Erosion & Sedimentation Controls, Stormwater Management, and Pipeline Design
- Bachelor’s Degree from
  The Pennsylvania State University
  - Minor in Environmental Engineering
  - Marshal of Civil Engineering
- Master of Science From Villanova University
- Professional Engineer in PA and 47 other states, DC and 3 Canadian Provinces

Designing America's Energy Lifelines

- **Proven Experience:** **Over** 30 years in Energy Processing and Transportation, with a Focus on Liquid Petroleum and Natural Gas Midstream Projects
- **Comprehensive Services:** From Feasibility Studies and Environmental Permitting to Full Design, Field Services, and Construction
- **National Presence:** Teams Positioned Across Key U.S. Regions (Mid-Atlantic, Gulf Coast, Midwest, Southeast, Northeast, and West)
- **Trusted Partnerships**: Long-term Relationships with Major Petroleum, Natural Gas, Specialty Gas, and Electric Utility Companies
- **Pennsylvania** based with hundreds of projects within the Commonwealth

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Pipeline Types and Applications

- **Crude**: Transport Unrefined Crude Oil
- **Petroleum**: Carry Refined Petroleum Products like Gasoline, Diesel, and Jet Fuel
- **Natural Gas**: Transport Natural Gas from Production Sites to Processing Facilities and Consumers
- **N_2 (Nitrogen) and O_2 (Oxygen)**: Used for Industrial Gases, Often for Manufacturing and Medical Applications
- **H_2 (Hydrogen): I**ncreasingly Used for Energy, Industrial Processes, and Hydrogen Hubs
- **H_2O (Water)**: Serve Drinking Water, Industrial Cooling, or Process Water Needs
- **Sewer**: Transport Wastewater or Sewage to Treatment Facilities

Hydrogen Transportation

49 CFR 192:
Transportation of Natural and Other Gas by Pipeline

NFPA 2:
Hydrogen Technologies Code

Project Successes: Pipeline Development and Community Integration

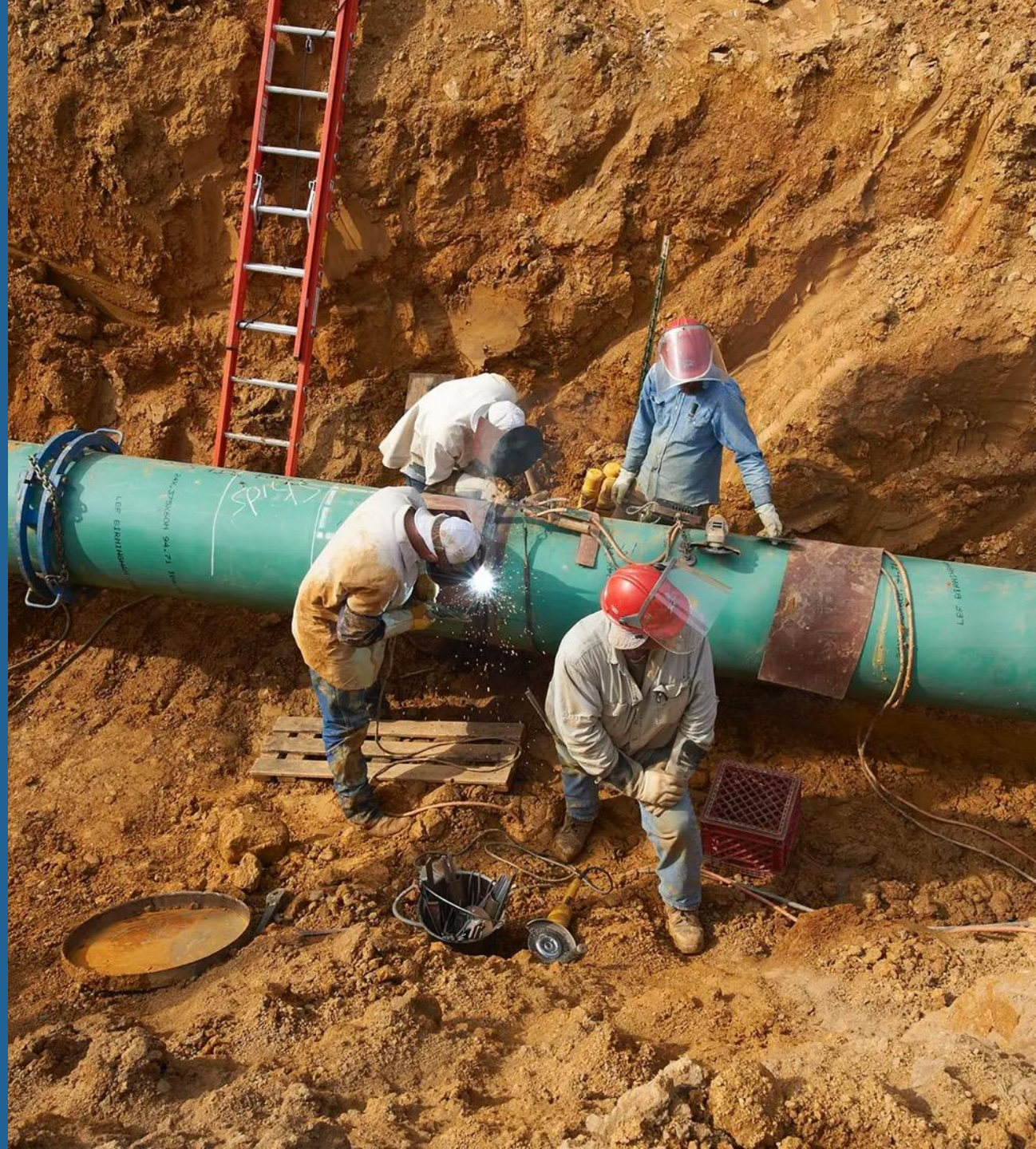
- **Safety-Driven Design**: Prioritized Pipeline Safety, Addressing Public Concerns About Explosion Risks
- **Public Trust Built Over Time**: Established Pipelines Operate Without Disrupting Communities, Minimizing Visibility and Interference
- **Seamless Integration**: Utilized Existing Routes Where Possible to Limit Public Disruption and Environmental Impact

Hydrogen Project Successes: Feasibility Studies

- Delaware to Southeastern PA
- Poconos to Southeastern PA
- NJ to Southeastern PA

Hydrogen Project Challenges:

- Projects are still in Feasibility Phase
- Presidential Election
- Lack of Familiarity with Federal Funding Processes
- Complexities in Navigating Federal Regulatory Requirements
- Community Opposition (NIMBY) and the Need for Stakeholder Engagement
- Fear of Hydrogen (Hindenburg)

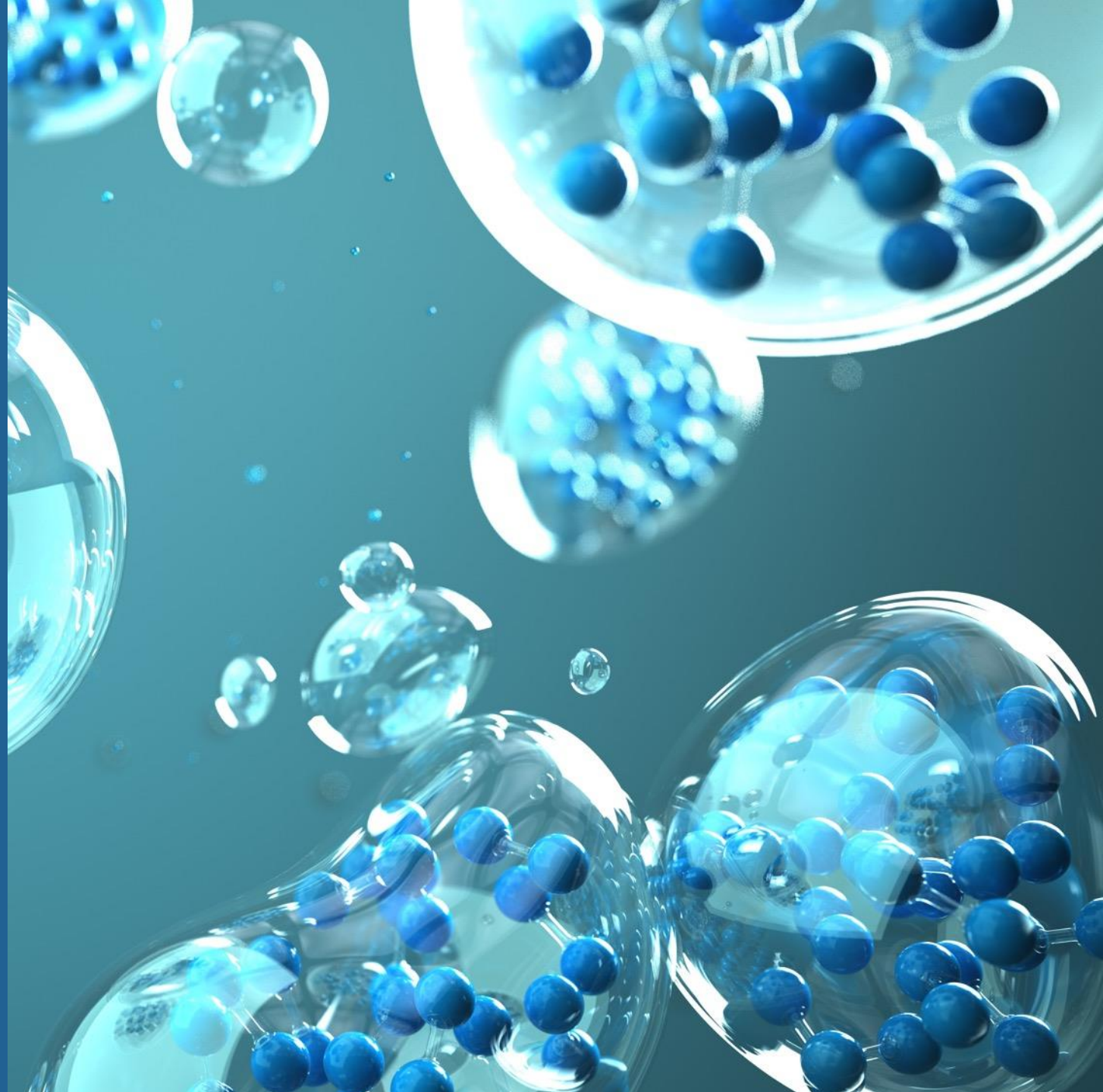


Why is Hydrogen Difficult to Transport?

The Size of Hydrogen is the Source of Many Issues

Hydrogen Gas

- Smallest Molecule – 0.120 nm vs. 0.68 for Methane—5.67 Times Smaller
- 1/8th Molecular Weight of Methane
- 1/3 Energy Density as Methane



Hydrogen Embrittlement

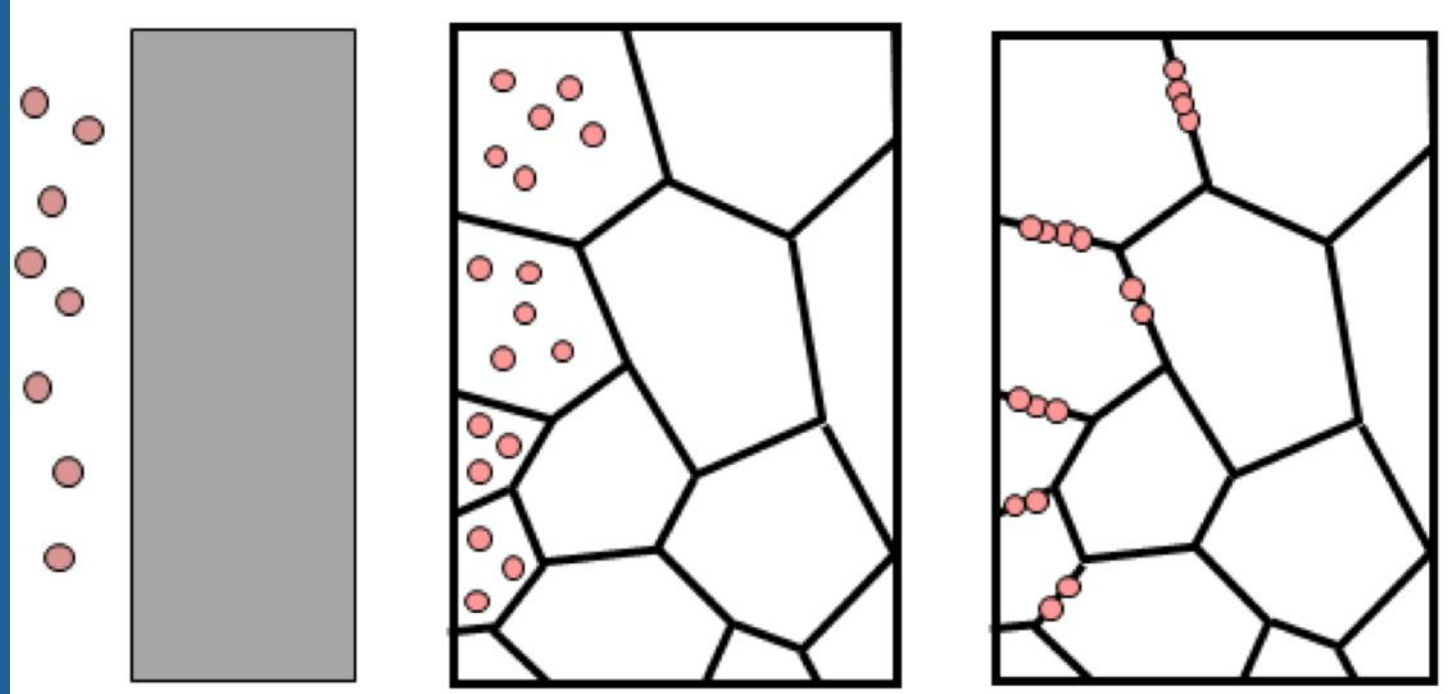
- Hydrogen Atom Infiltration
- Atomic Bond Disruption
- Pressure Buildup

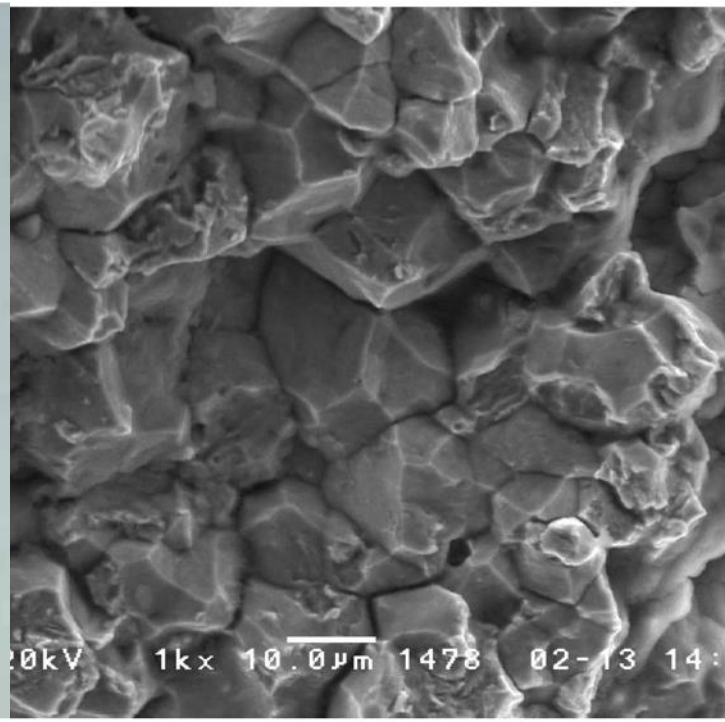
Hydrogen Embrittlement leads to:

- Hydrogen Cracking
- Hydrogen Stress Cracking
- Loss overall Ductility

Best Design Practices:

- Austenitic Stainless Steel – Above Grade
- Carbon Steel - Underground
  - Lower Yield Strength
  - Thicker Wall Thickness

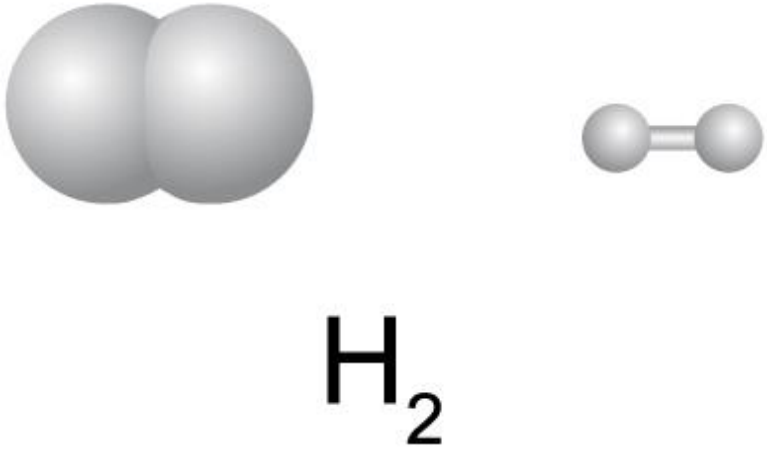




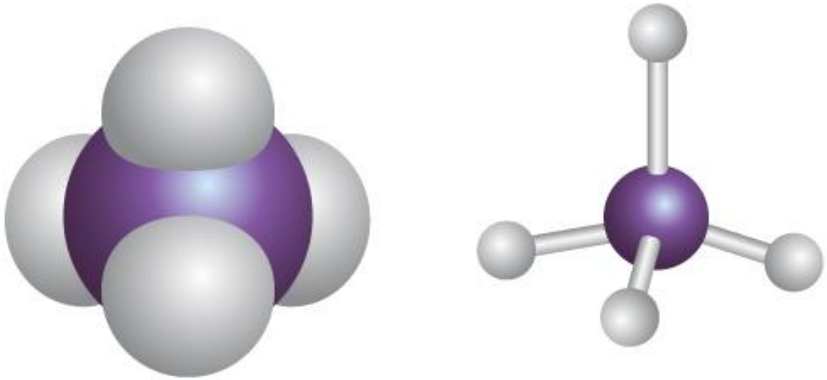
Hydrogen Escape

Escape

- Lighter than Air – Rises
- Because of the Size of H2, Different Seals, Gaskets, and Sealants are Needed
  - Valves
  - Flanges
  - Compressors
  - Instruments
  - All Joints and Connections



H_2



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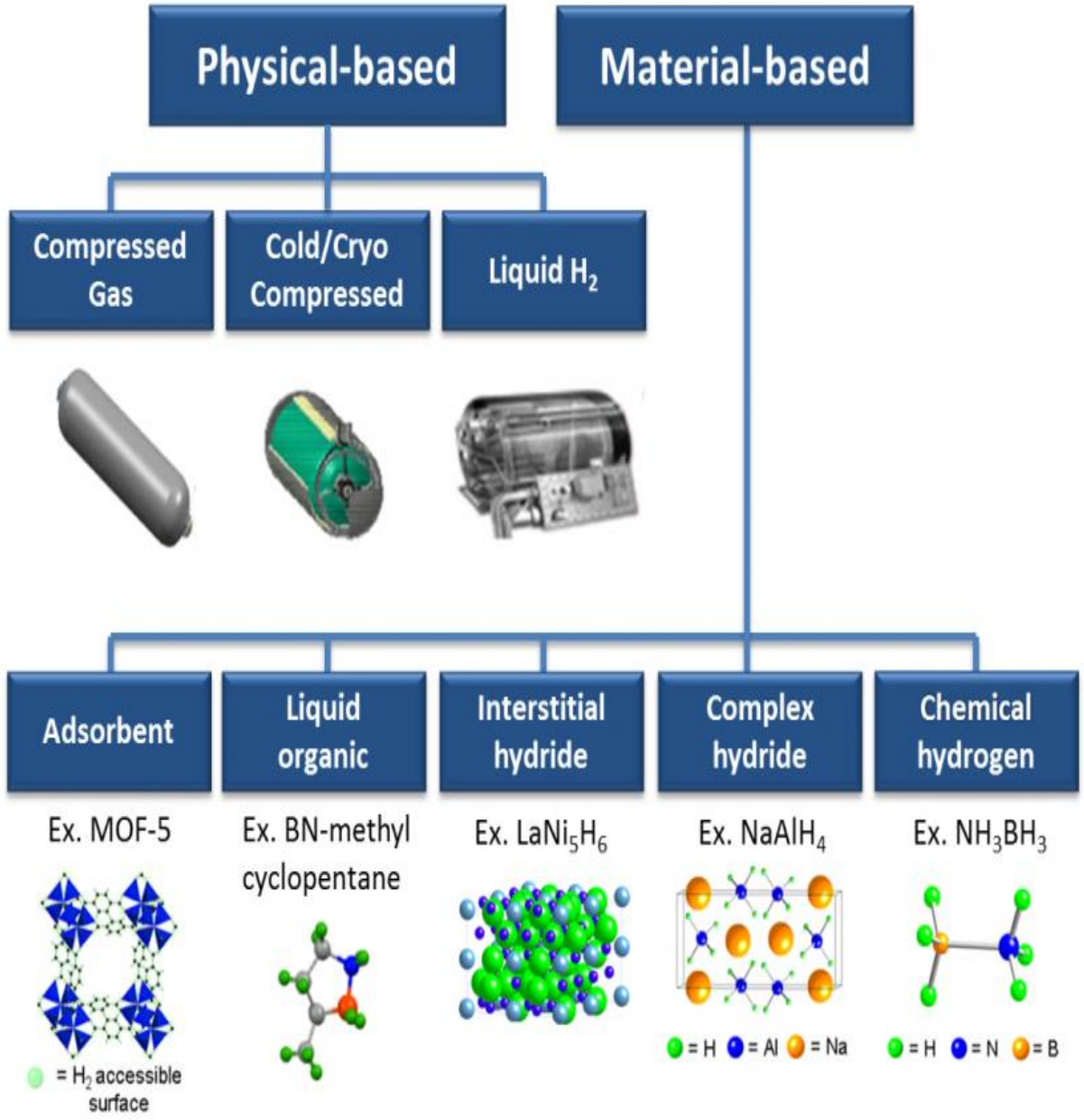
Hydrogen Containment/Storage

- Hydrogen May Be Stored in a Solid, Liquid or Gaseous State
- Hydrogen Storage Tanks
  - Types I-IV: Depending on Material and Wrap and Pressure



Repurposing Existing Pipeline Infrastructure

Positives

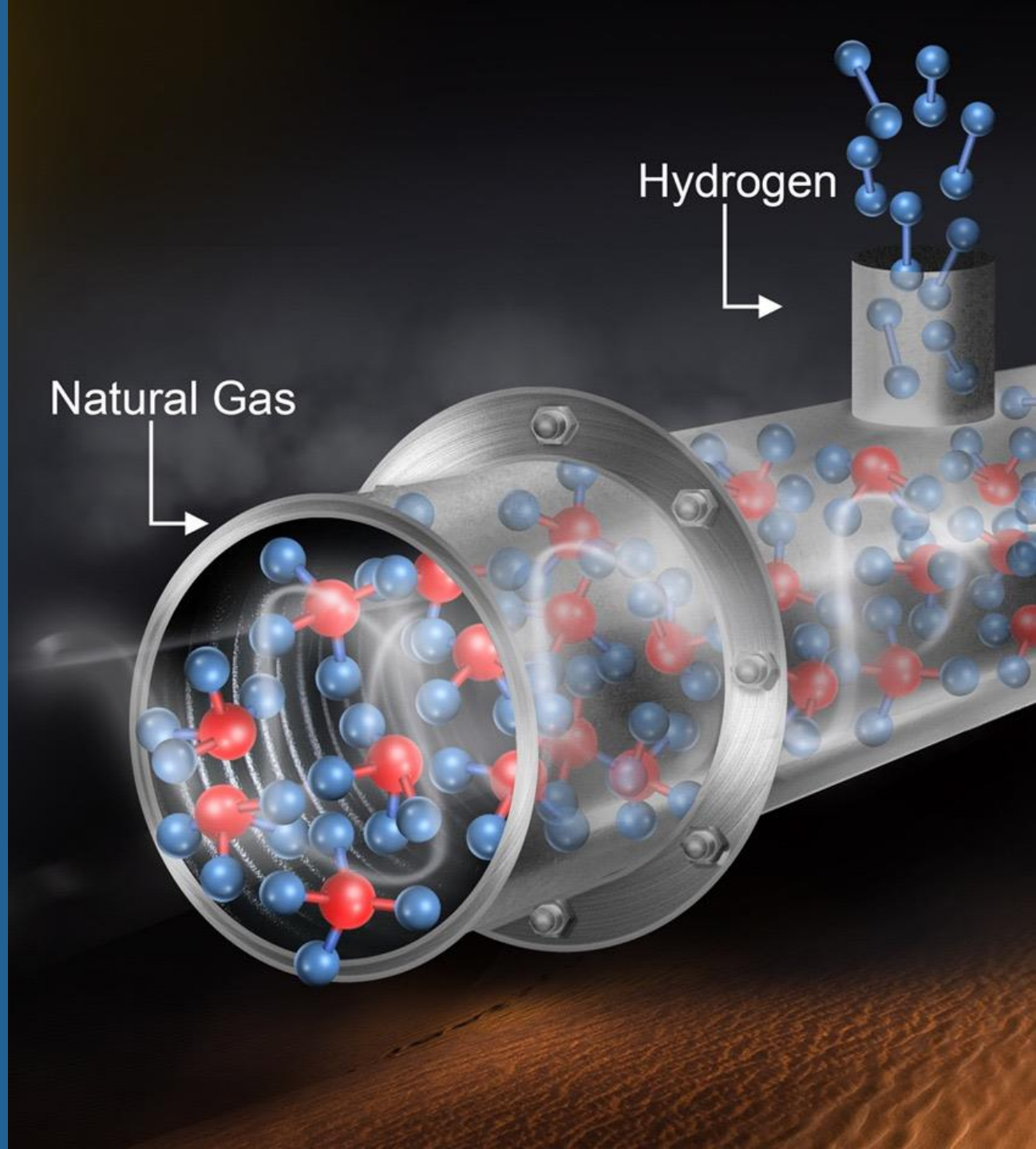
- Minimal Public Disruption
- Reduced Environmental Impact

Negatives

- Varying Pipeline Characteristics
- Older Welding Procedures
- Newer Pipelines High Strength Steels
- Thinner Wall Thicknesses
- More Throughput for Same Energy Value

Mixing in Natural Gas Lines

- 1%-30% Hydrogen by Volume
- Metallurgic Evaluations Required
- Seals/Flanges/ Gaskets and Instruments Must be Evaluated
- Hydrogen has 1/3 of Energy Density per Standard Cubic Foot of Gas. This Requires Operators to Increase the Pipeline Flow and Pressure to Meet Energy Value



Q&A