Project ThermH₂: Hydrogen Blending in Natural Gas Pipelines
Dominion Energy – At A Glance

*We are striving to be “the most sustainable energy company in the country”*

- **Fortune 200** company with 17,000 employees
- **$65 billion** market capitalization
- **7 million** electric and gas utility customers over 16 states
- **24 gigawatts** of zero-carbon power generation by 2036
- **$32 billion** of investments in clean energy over next 5 years
- Pursuing **Net Zero 2050** as an enterprise-wide goal
Dominion Energy Is Pursuing “Net Zero 2050”

**Capturing Methane Emissions**
- 65% reduction from existing gas infrastructure by 2030 vs 2010 levels
- 80% reduction from existing gas infrastructure by 2040 vs 2010 levels

**Developing Renewable Natural Gas Projects**
- Partnerships with Smithfield Foods & Vanguard Renewables
- Designing, building and operating RNG plants at swine and dairy farms

**Incorporating Hydrogen Into The System**
- Prepare gas system to receive 5% hydrogen by 2030
- ThermH₂ is a multi-phase leading hydrogen blending initiative in US
Why H2? “The ABCD’s of Hydrogen”

- **Abundant**: Hydrogen is the most abundant element in the universe, found in water and in all hydrocarbons.

- **Broad**: Hydrogen’s use is broad, serving the same markets as natural gas—heating, power generation, transportation.

- **Compatible**: Hydrogen is largely compatible with natural gas infrastructure – pipelines, valves, leak monitoring detection, combustion turbines.

- **Decarbonize**: Hydrogen helps decarbonize the global economy, especially hard-to-decarbonize sectors such as cement and steel.
# Comparing Natural Gas to Hydrogen

<table>
<thead>
<tr>
<th>Category</th>
<th>Natural Gas (methane)</th>
<th>Hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Symbol</td>
<td>CH4</td>
<td>H2</td>
</tr>
<tr>
<td>Molecular Weight (g/mol)</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Molecular Diameter (pm, 10-12m)</td>
<td>380</td>
<td>289</td>
</tr>
<tr>
<td>Heat Content (Btu/scf)</td>
<td>912</td>
<td>275</td>
</tr>
<tr>
<td>Heat Content (Btu/lb)</td>
<td>21,515</td>
<td>51,593</td>
</tr>
<tr>
<td>CO2 Intensity (g/Kwh)</td>
<td>198</td>
<td>0</td>
</tr>
<tr>
<td>Boiling Point (°F)</td>
<td>-306</td>
<td>-423</td>
</tr>
<tr>
<td>Flame Temperature (°F)</td>
<td>3586</td>
<td>3895</td>
</tr>
<tr>
<td>Flammability Range</td>
<td>5-15%</td>
<td>4-78%</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.55</td>
<td>0.069</td>
</tr>
<tr>
<td>Vapor Density (lb/ft³)</td>
<td>0.0406</td>
<td>0.0052</td>
</tr>
</tbody>
</table>

- Hydrogen is 8x lighter than methane and 14x lighter than air.
- Hydrogen has less than 1/3 the volumetric heat content of methane.
- Hydrogen burns hotter (i.e. higher flame temperature) than methane.
- Hydrogen has a wider flammability limit than methane.
Why Hydrogen Pilots?
“Hitting Singles”: Micro-Learn Now to Mass-Produce Later

Pilot projects enable technical, market, and organizational learning at small scale with less risk.

**Learn:**
Internal expertise, key relationships, analyzing market signposts

**Pilot:**
Do a small hydrogen project using existing infrastructure with off-takers in key “early adopter” regions

**Validate:**
Test assumptions surrounding cost, price, market readiness, potential partnerships

**Align:**
Build cross-functional teams to execute scalable projects

**Execute:**
Build larger projects “at scale” to capture greater market growth potential

**ENGAGE**

**LAUNCH**

**SCALE**

**EMBED**

**SUSTAIN**

“Hitting Singles”
Micro-Learn Now to Mass-Produce Later

Why Hydrogen Pilots?
Industry-Wide Hydrogen Pilots

- Gas and Electric Utilities in 17 states are in various stages of development of their hydrogen pilots in transportation, power generation, transportation and industrial feedstock sectors.

- 14 out of 36 (39%) of Dominion Energy’s gas & electric utility peer group have announced or active hydrogen pilots.

Announced US hydrogen pilot projects

As of May 9, 2023.
Map credit: Cat VanVliet.
Source: S&P Global Commodity Insights.
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Not shown: Hawaii Gas, standard operations.
### Ohio: Hydrogen Heights – Phase 1

**Hydrogen Provider:** Linde Gas  
**End user appliances:**  
- 14 Houses  
- 9 Types of appliances  
  - Example: Dryer, Furnace  
- 26 Total Quantity of appliances  
- 40,558 Btu/Hr Average Energy  
**Technical Components:**  
- 12 cylinders storage (7.35 kg)  
- In-line static mixer  
- Chromatograph system  
- Hydrogen storage tanks  
**Facility Specifications:**  
- 6” gas main HD plastic (MP – 99 lb)  
- No blast wall  
**Testing Scope:**  
- Gas Control  
- Gas Planning  
- Field maintenance  
- Field operations

### Utah: ThermH2 – Phase 1

**Hydrogen Provider:** Airgas  
**End user appliances:**  
- 16 Houses  
- 11 Types of appliances (Ex. Oven, Range)  
- 73 Total Quantity of appliances  
- 46,476 Btu/Hr Average Energy  
**Technical Components:**  
- 16 cylinders storage (7.24 kg)  
- No mixer  
- Welker “odor-eyes” system  
- Alicat flowmeter  
**Facility Specifications:**  
- 2” gas main MDPE plastic (MP – 45 lb)  
- Blast wall  
**Testing Scope:**  
- Odorization  
- NOx Emissions  
- Material Compatibility  
- End-user appliances

### Similarities

**Hydrogen Capacity:**  
- Ohio 3,120 scf (7.35 kg)  
- Utah 3,000 scf (7.24kg)  
**Technical Component:**  
- GC system to confirm blending of hydrogen and fuel gas.  
**Testing Scope:**  
- Leak Survey  
- Safety  
- Gas Quality  
- Heat Content
Project ThermH$_2$ Scope – Phased Approach, Incremental Learning

### Phase 1
- 5% blend at DEU Training Academy confirms existing research
- Status: Completed December 2021.

### Phase 2
- 5% H$_2$ blending in Delta, UT's IHP system, started 3/23/23
- Status: In Process - PEM electrolyzer expected in Q4 2023

### Phase 3
- 5% H$_2$ blending in rural HP system: 2028 timeframe
- Status: indicative budget and schedule created

### Phase 4
- Produce synthetic natural gas (biomethane) from industrial CO$_2$ and green H$_2$ via biomethanation in HP system: 2030 timeframe
- Status: indicative budget and schedule created

Phases 3-4: Included in Western Interstate Hydrogen Hub (WISHH) application for ~50% funding match from DOE.
Phase 1: Test Findings

**TEST RESULTS**

- Appliance Safety: PASSED
- Leak Detection: PASSED
- Pipeline Material: PASSED
- Gas Quality: PASSED

Extensive testing and analysis of 5% hydrogen blending over a variety of applications confirmed our top research priority:

**Hydrogen Blending Is Safe and Reliable**
Phase 2: Why Delta?

Delta, Utah will be a leader in this emerging area of energy innovation

- Customer base and system size allows for a controlled environment
- Modern infrastructure system
- Proximity to a variety of renewable and traditional energy sources
- Proximity to massive amounts of potential storage – Salt Caverns

- Nearly 2,000 customers in the Delta area will receive a blend of up to 5% hydrogen
- All hydrogen will eventually be created on-site using a process called electrolysis
- Community will continue to enjoy the safe, affordable and reliable natural gas service they receive today with added sustainability
- As we blend hydrogen and natural gas, safety and reliability will continue to be our first priority
Phase 2: Delta, UT Regulator Station Site Overview

- Project will be built at the Delta Regulator Station, Dominion Energy-owned property
- Adequate space for hydrogen production, storage, blending, and construction laydown
- Access to water
  - Expected water consumption is 270 gallons per day or 100,000 gallons per year
- Access to renewable electricity for green hydrogen production
- Will remove 110 tons of CO2 from the atmosphere per year, the equivalent of planting 5000 trees or removing 25 cars from the roads
# Project ThermH₂: Phase 1-2 Test Protocols

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Procedures</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak Detection</td>
<td>Use handheld devices</td>
<td>Already identified in Phase 1</td>
</tr>
<tr>
<td>Appliance Compatibility</td>
<td>Use different appliances: stoves, dryers, furnaces, water heaters, fireplaces</td>
<td>Consider business district or school district; utilized GTI support.</td>
</tr>
<tr>
<td>Materials</td>
<td>Embrittlement tests</td>
<td>Utilized GTI support</td>
</tr>
<tr>
<td>Electrolyzer Performance</td>
<td>Conversion ratio tested</td>
<td>Conversion ratio = proxy for efficiency</td>
</tr>
<tr>
<td>Odorant</td>
<td>Sniff test</td>
<td>Mercaptan detection</td>
</tr>
<tr>
<td>Gas Homogeneity Tests</td>
<td>Ensure 5% at start and end of tested area</td>
<td>Consider business district or school district</td>
</tr>
</tbody>
</table>
What can Delta customers expect from 5% hydrogen blending during Phase 2?

**NO CHANGE** to existing residential natural gas appliance performance and no residential appliance adjustments needed

**NO CHANGE** to bills or rates

**NO CHANGE** to system safety

**NO CHANGE** to carbon footprint increases – it actually decreases!
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- **Corporate Website**: Hydrogen: The Next Frontier of Clean Energy | Dominion Energy
OPEN DISCUSSION

THANK YOU FOR YOUR TIME!