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HyRes
Hydrogen Emissions Research Consortium

Hydrogen Emissions and Detection Efforts

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Why Focus on Hydrogen Emissions?

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CLIMATE IMPACTS

- H_2 emissions can indirectly affect global warming
  - More O_3, Strat. H_2O
  - Longer CH_4 life
- GWP_{100} of 11.6 ± 2.8
  - ~12 times that of CO_2
  - GWP100 of CH_4 is 28
- Differing perspectives on the net impacts of H_2 emissions
  - H_2 emission rates
  - Upstream CH_4 leakage

EMISSIONS DATA

- Very little data exists on H_2 leakage and/or venting rates
  - Estimates, simulations & assumptions put it at 0.2-20%
  - No empirical data
- Lack of clarity of emissions along the future H_2 value chain

TECHNOLOGIES

- H_2 detection technologies are in their infancy
- Existing tech is focused on safety
- H_2 is hard to detect through conventional spectroscopy
- Low-level detection and quantification critical to developing emissions estimates

Parallel issues have surrounded methane and the use of natural gas for the last 10+ years

Climate Impacts of Hydrogen Emissions

Key Research Question

What are the net climate impacts of a hydrogen economy when accounting for methane and hydrogen leakage?

Research Overview

Objectives

- Evaluate warming impacts of fugitive H_2 emissions in decarbonized energy systems relative to CO_2 & CH_4
- Study decarbonization scenarios to illuminate conditions under which H_2 exacerbates or mitigates warming

Tasks

1. Define H_2 and CH_4 emissions rate cases
2. Develop H_2 and CH_4 throughput cases
3. Impact analysis for relative H_2, CH_4, and CO_2 emissions across cases
4. Project management and reporting

Updates

- Reviewed the literature on hydrogen emissions and climate impacts
- Obtained data for tasks 1 & 2
- Using ecoinvent database and OpenLCA software to conduct LCAs of hydrogen pathways with and without H_2 and CH_4 leakage

Key Findings

Will be summarized in a report in Q1 2024

Why This Matters

- Hydrogen is crucial to the energy transition, but fugitive emissions indirectly cause global warming
- Need to better understand leakage and its impacts to evaluate the overall impact of transitioning

What do we not know?

- Uncertainties around natural H_2 fluxes, such as amount of H_2 sinking naturally in the soil
- Amount of H_2 leaking or venting from the value chain today or in the future
- How to go about detecting and measuring H_2 emissions
  - Ongoing discussions with instrument developers
  - Several groups are testing measurement technology options for H_2
- How could hydrogen blending be implemented through existing infrastructure

Critical need to qualify and quantify these unknowns

Operational Impacts of Hydrogen Blending

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- Leak detection
- Operating pressure
- Compression, flow, and capacity
- Metering
- Gas quality
- Welding, joining, hot tapping, stopping, squeeze-off, and purging
- Education and training of workforce, contractors, and first responders

DOT PHMSA Project on Detection

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- Title: "Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends"
- Objective: Advance leak detection as hydrogen is introduced into natural gas infrastructure which will be realized through five different areas of effort
  1. Evaluate leak detection equipment currently used by natural gas pipeline operators
  2. Provide guidance on new/altered usage protocols
  3. Map out any threshold of hydrogen blending above which these devices become ineffective
  4. Map out the impact of varying amounts of hydrogen on the calibration and analytics of currently used leak detection equipment
  5. Develop a proof-of-concept hydrogen detection scheme to fill any gaps identified by the project team

Existing Leak Detection Methodologies and Equipment

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Sensor Type	Range	H_2 Effect on Calibration	H_2 Damage to Sensor	Gas	Primary Mode of Use
Thermal Conductivity	%Gas	1	No effect	H_2 CH_4	Walking
Catalytic	LEL ppm	1, 3	Damage possible at high levels	H_2 CH_4	Walking, Fixed
MOS	ppm	1, 3	Damage possible at high levels	H_2 CH_4	Walking
Flame Ionization (FID)	ppm	1	No effect	H_2 CH_4	Walking, Mobile
Electrochemical	ppm	2, 3	Damage possible at high levels	CO O_2 H_2S	Confined space
Mass Flow	LPM	1	Not evaluated	CH_4	Odor Concentration
Laser Infrared	ppm.m	0	No effect	CH_4	Walking, fixed, mobile
NDIR	LEL %Gas	0	No effect	CH_4	Walking, fixed
Etalon	ppm %Gas	0	No effect	CH_4	Walking, mobile

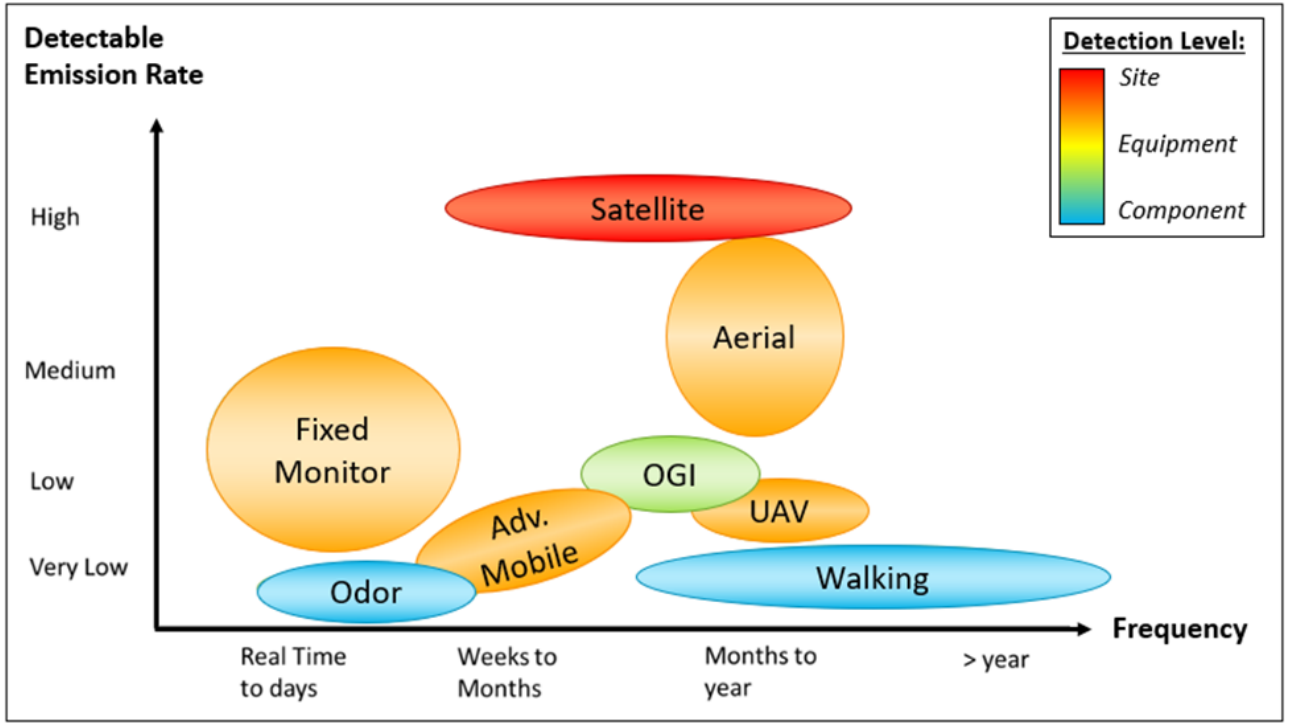

Table Notes:

0: Calibration specific to methane, not affected by other gas types. Will underreport flammable gas levels with hydrogen blends.

1: Calibration accuracy specific to gas ratio of calibration gas. If calibration gas is methane, then blended gas will read higher/lower, error increasing with percent of blend

2: Large cross sensitivity possible. Will produce false positive or false negative reading

3: Significant effects if exposed to high concentrations, may cause permanent damage

Leak Detection Impacts – Existing Methods & Equipment

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- **Odorization**
  - Studies suggest some odorants can continue to be effective when H_2 is present
  - Need to validate if a person can continue to readily smell a gas blend at one-fifth LEL
- **Electrochemical sensors (CO, O_2, H_2S)**
  - Cross-sensitivity can lead to false positives or negatives
- **Thermal conductivity, catalytic, MOS, flame ionization, and mass flow sensors**
  - If calibration gas is methane, then blended gas will read higher, increasing blend%
- **Infrared and etalon sensors**
  - Calibration specific to methane and not affected by other gas types; will underreport flammable gas levels with H_2 blends

DOT PHMSA Agreement 693JK32210004POTA

Equipment Technical Specifications and Requirements for Hydrogen Blends

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Parameter	Notes
Accurate/Repeatable	Is the technology accurate in general or for methane, hydrogen, or blends? What change in accuracy will hydrogen induce?
Cross Sensitivity/Selectivity	Can distinguish between chemical species? What change in sensitivity will hydrogen induce?
Detection Range	What change in detection range will hydrogen induce
Minimum Detection Limit (MDL)	Does the introduction of hydrogen impact the minimum level of gas that the technology measures
Response/Recovery Time (T90/T10)	Will hydrogen reduce the response rate of the sensor?
Robustness/Reliability	Is the sensor robust to be used for leak detection in the field?
Hazardous Location Certification	Can the technology be potentially made “intrinsically safe”
Power Consumption	How much power does the technology need? Could this be prohibitive for leak detection?

Newly Formed Collaborative Program - HyRes

HyRes is a GTI Energy-led research collaboration that will address important research questions on hydrogen emissions by:

RESEARCH & EDUCATION

- Clarify, harmonize, and educate on the foundational science of hydrogen's atmospheric climate impacts
- Develop R&D roadmap on hydrogen emissions and its atmospheric/climate impacts

EMISSIONS QUANTIFICATION

- Develop hydrogen emission inventories
- Create a rigorous set of measurement and reconciliation tools
- Perform real-world hydrogen emissions measurements

HyRes Program

- HyRes will leverage GTI Energy's time-tested expertise in emissions research reduction, reduction, and impact abatement.
- The Consortium is collaborative, building on the knowledge and capabilities of the entire hydrogen & energy community
- Potential sponsors and interested parties
  - Natural Gas Local Distribution Companies (Hydrogen blend projects)
  - Hydrogen Production Industry (e.g., Air Liquide, H2 Hubs collaborators)
  - Hydrogen Producers (e.g., integrated majors)
  - Hydrogen Transporters
  - Hydrogen End Users
  - Transportation Markets

HyRes Timeline

Work to Date	Q4 2023	Q1 2024	Q2 2024	Beyond

Technical Development

- CMR Workshop on Hydrogen

- CH4 Connections
- Summary paper on key research questions
- Program Launch

- H_2 Industry Map Development
- Information Library Assembly
- Hard Launch

- Release Industry Map
- Release H_2 Library
- Begin H_2 Emissions R&D Roadmap

- Integrate with Hydrogen Hubs

Thank you

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