Dr. Chris Moore
Director, Center for Methane Research
Director, HyRes
GTI Energy

Dr. Chris Moore is a member of the Zero Emissions Systems Team at GTI Energy where for the last 8 years he has led the Center for Methane Research. He has recently transitioned to the study of hydrogen emissions via establishing HyRes, a GTI Energy Hydrogen Emissions Research Consortium. Dr Moore's work has been published in Nature, PNAS, Environmental Science and Technology, and others. He holds a B.S. in Chemistry from WVU Tech, an M.S. in Environmental Science from the University of Virginia, and a PhD in Environmental Science from the University of Maryland.

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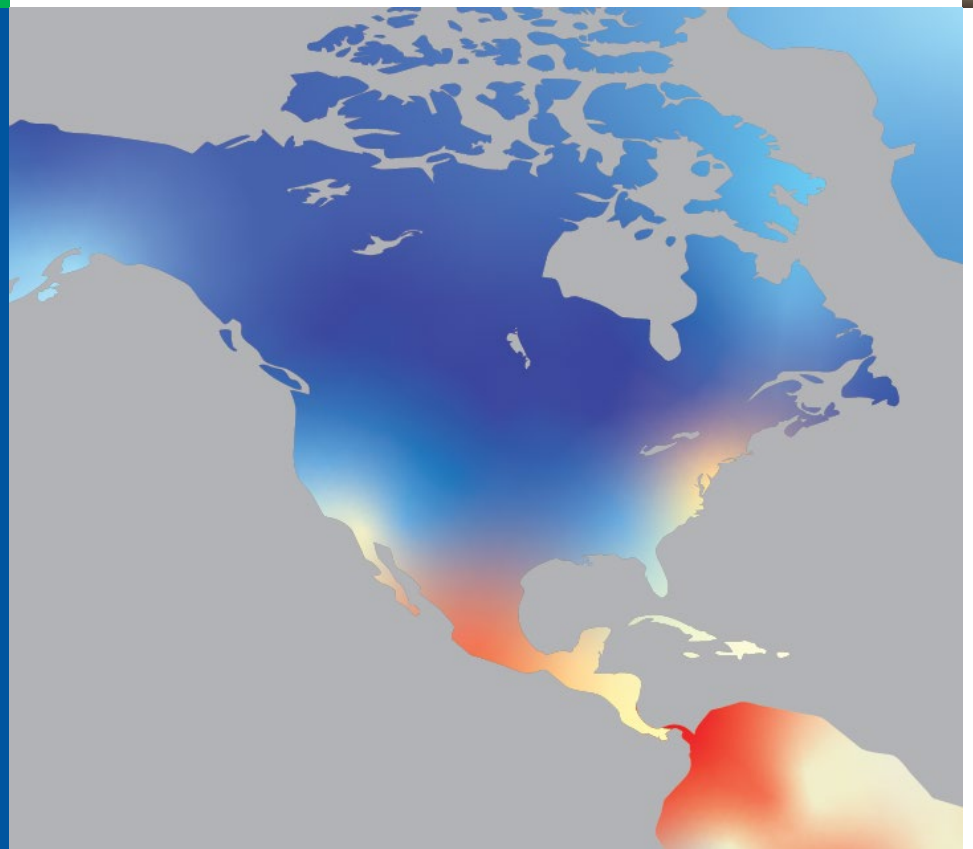
Hydrogen Emissions Research Consortium



Hydrogen Detection Efforts

Chris Moore, PhD *Director - HyRes*

UPISC Collaboration Workshop | November 2023

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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 - 34
- 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 15+ years

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 detect and quantify 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

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

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

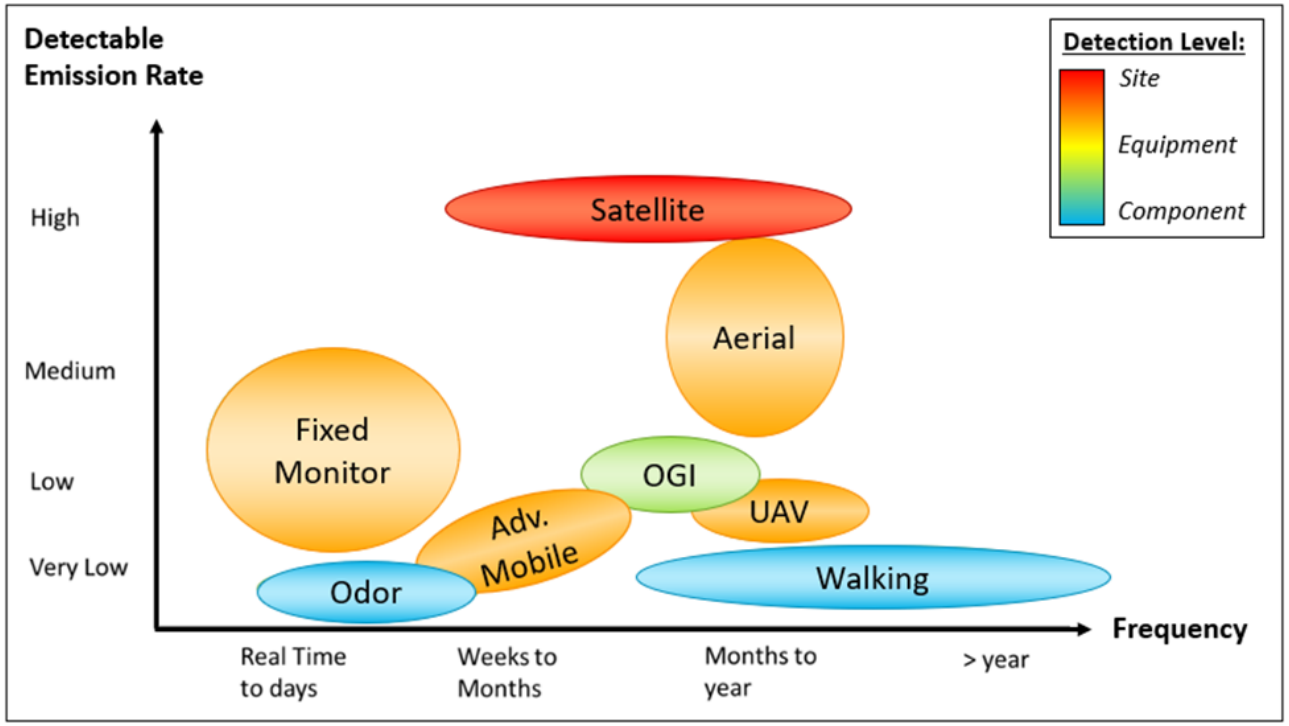

Table Notes:

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

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

Currently Soliciting Foundational Sponsors and Members

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Hydrogen Emissions
Research Consortium

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