Quantifying hydrogen emissions

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Associate Chief Scientist

How much hydrogen is emitted today?

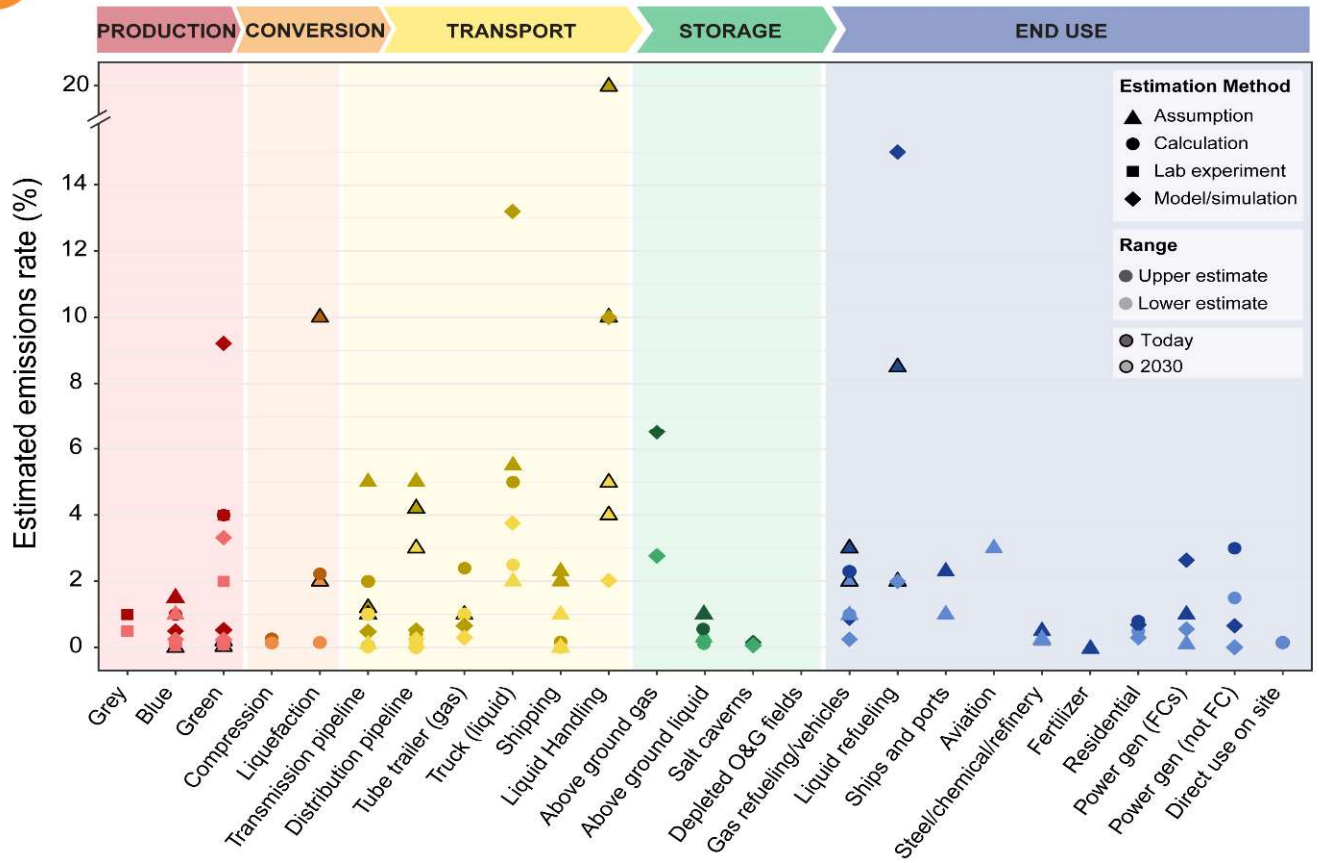
1 No data

Lack of in-field measurements from venting, purging, leakages

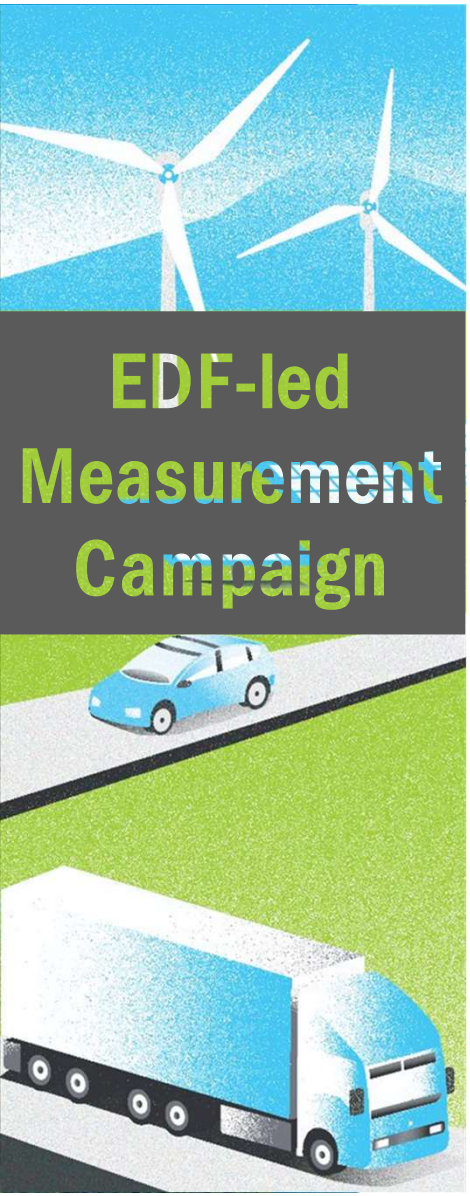
2 Instrumentation

capable of measuring small leaks and site-wide emissions (ppb level) is only now becoming available

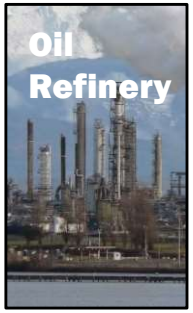
3 Wide range in published estimates (<1 to 20%)



Source: Esquivel Elizondo et al. 2023

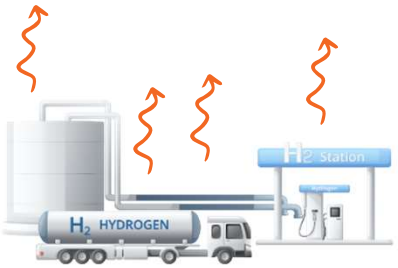


Collaborative H_2 Emissions Measurement Campaign



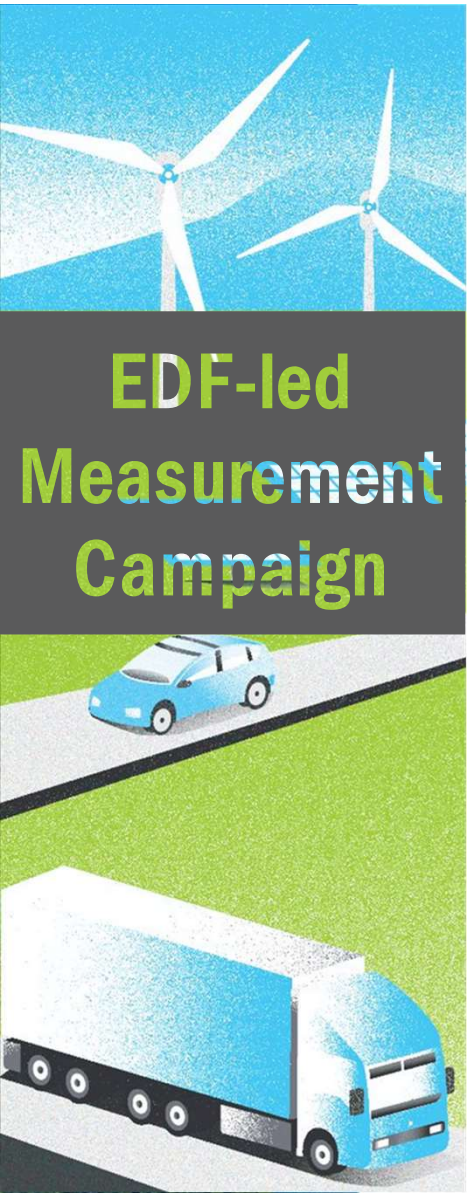
PRODUCTION

CONVERSION & STORAGE



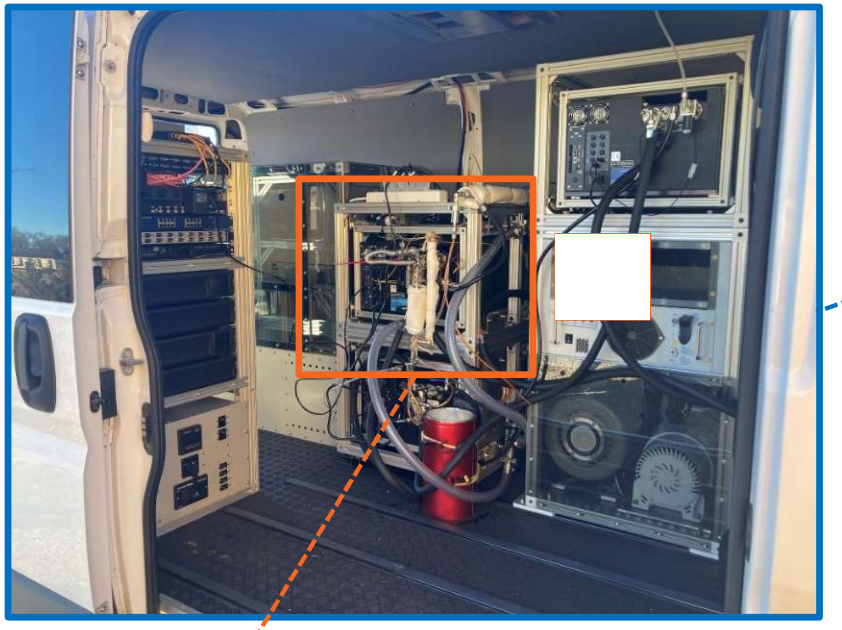
DISTRIBUTION

APPLICATION



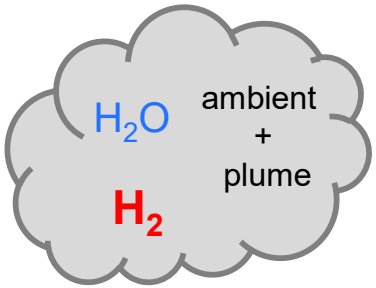
New technology capable of site-level emissions measurement

Aerodyne Research's ultra-sensitive hydrogen analyzer.

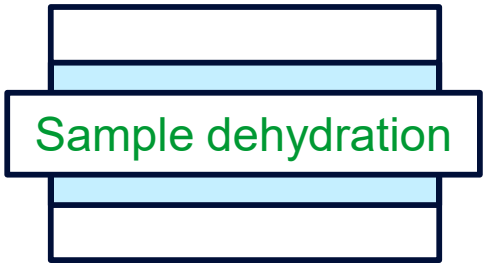


Aerodyne Research

H_2 quantification system using chemical oxidation pretreatment

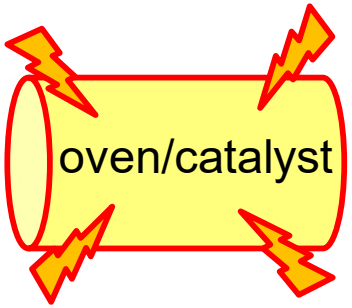


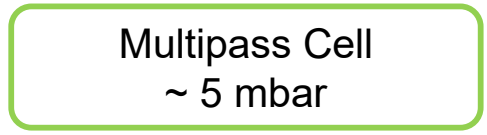
1 lpm



- Molecular sieves
- Condensation/trapping
- Filtration

- Catalytic H_2 oxidation to generate H_2O in high yield





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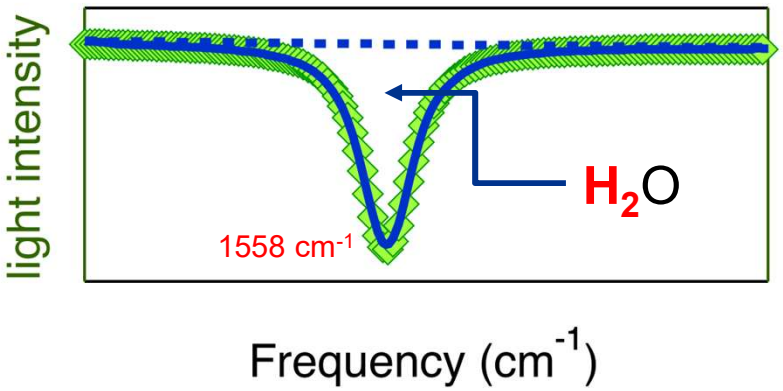
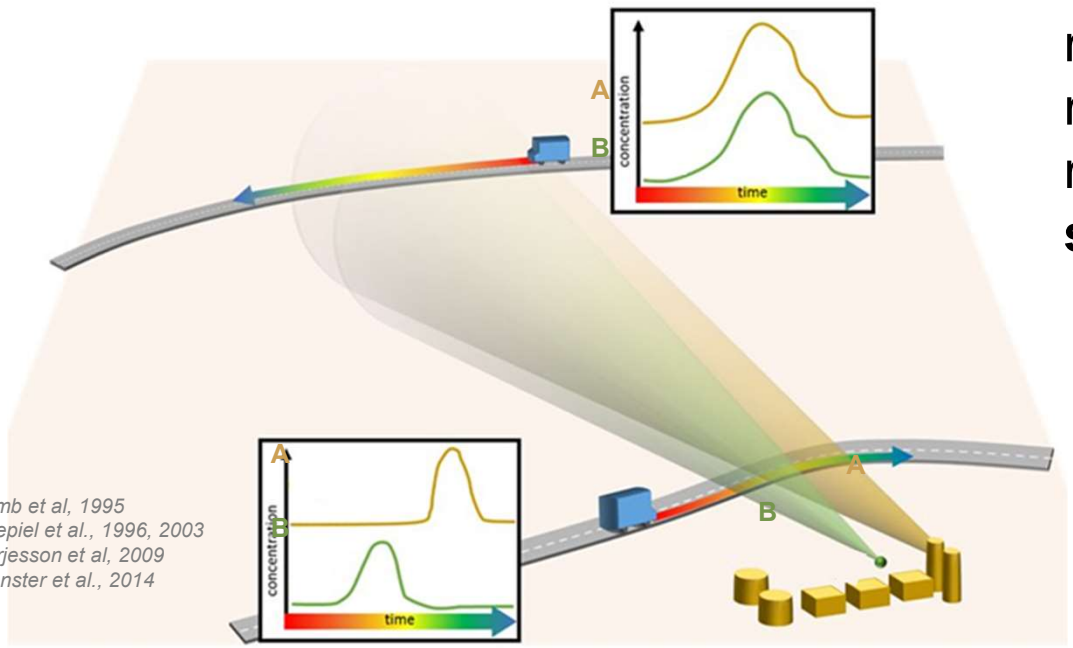
Instrument Performance

H_2 precision : ~5 ppb
time response :~5 s
accuracy : 5%



Quantifying H_2 emissions using tracer release



Lamb et al, 1995
Czepiel et al., 1996, 2003
Börjesson et al, 2009
Mønster et al., 2014

Quantification of hydrogen leaks using reliable, established plume and tracer release measurement techniques requires a **field-deployable**, **fast** and **sensitive** sensor technology

Low limit of detection

Fast time response

High precision

Field-deployable

Demonstration of tech and quantification methods

Field testing at Methane Emissions Technology Evaluation Center, Colorado State University

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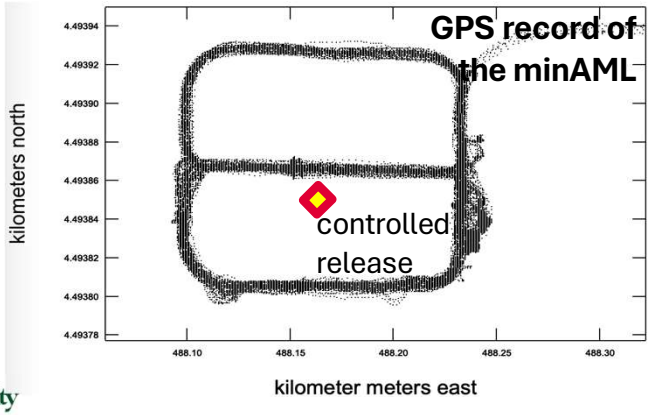
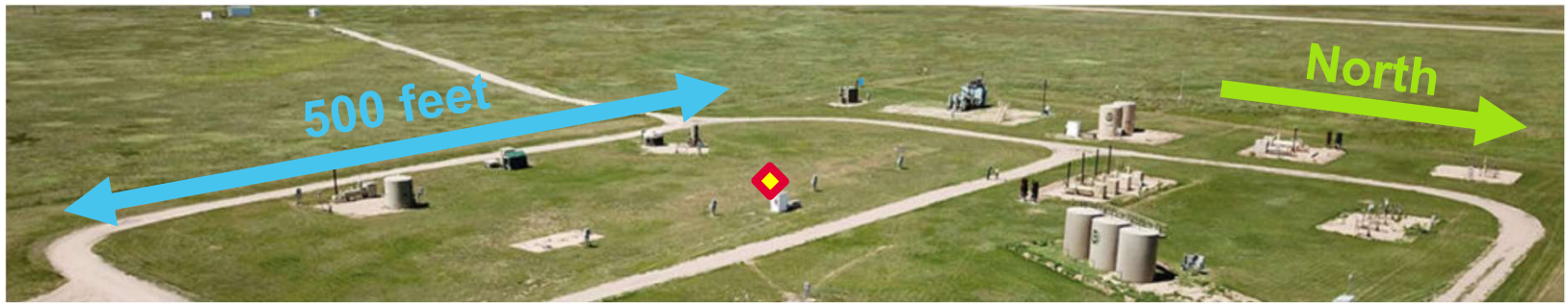
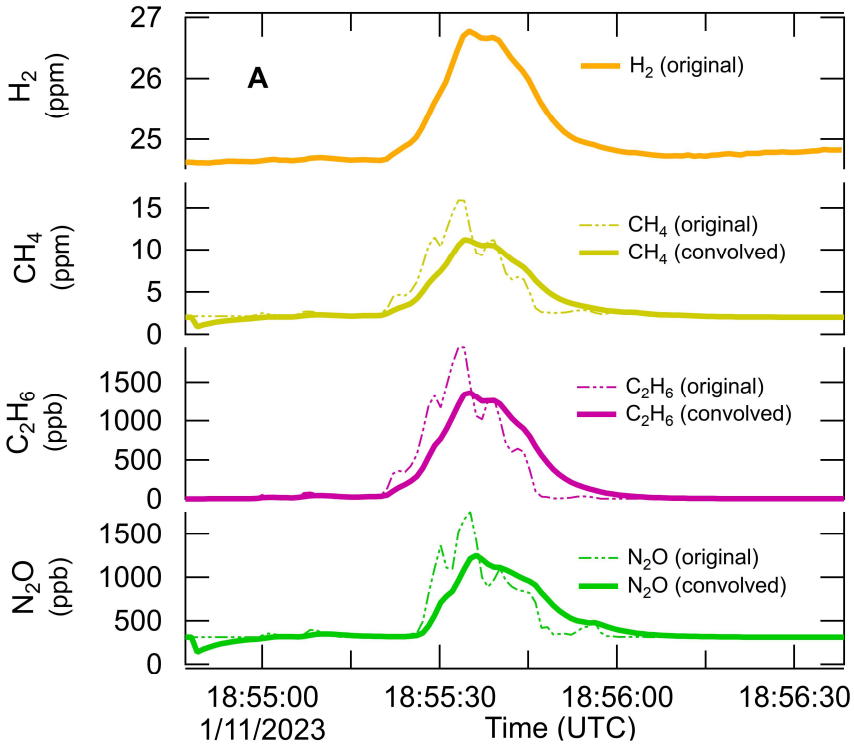
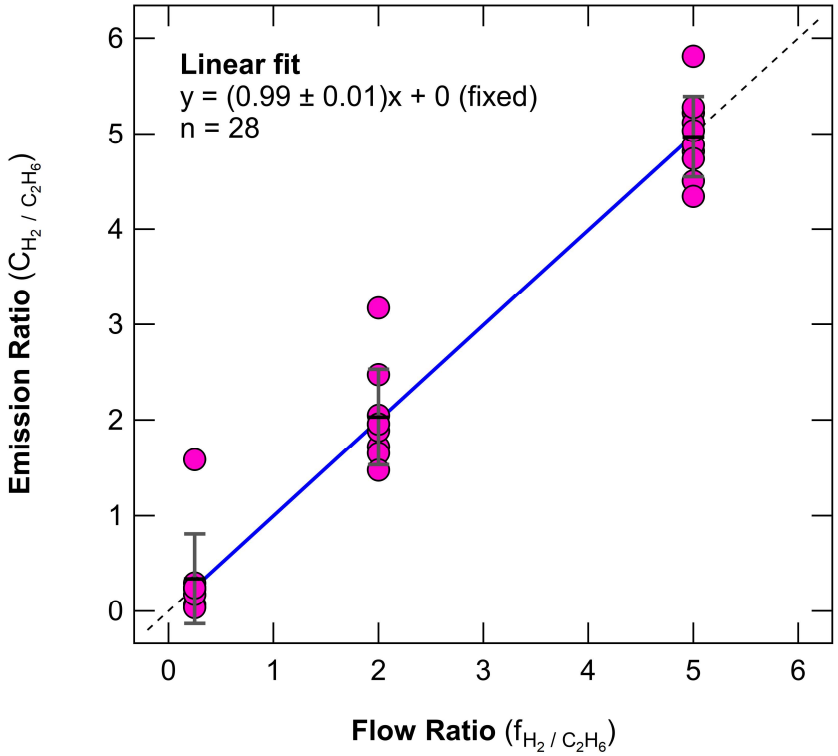
Colorado State University





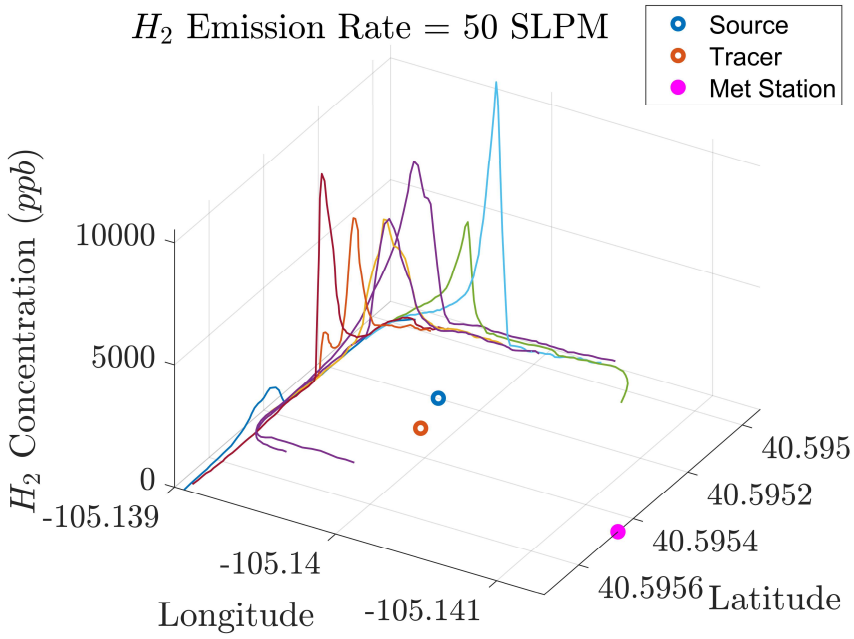
Quantifying H_2 emissions using tracer release

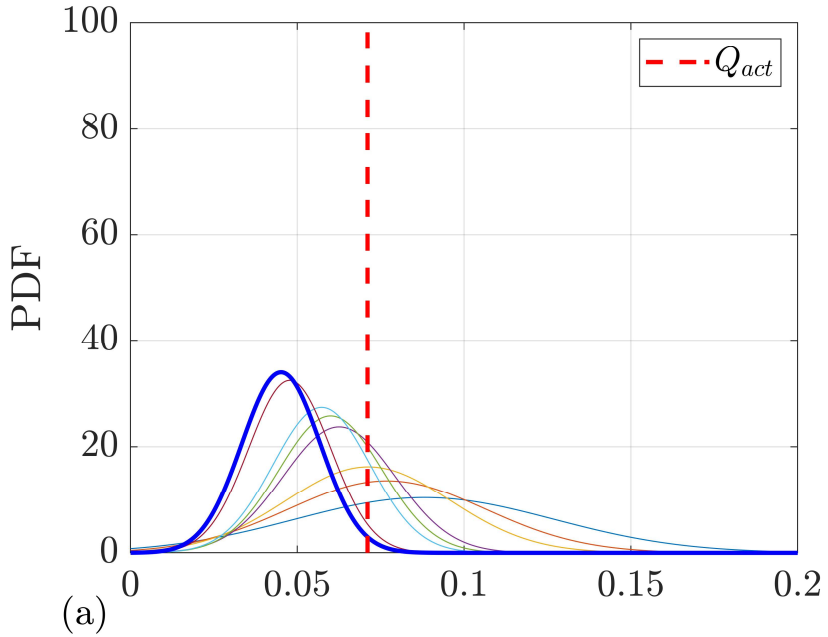




Source: Cornell, Aerodyne, CSU, in prep

Quantifying H_2 emissions using plume inversion

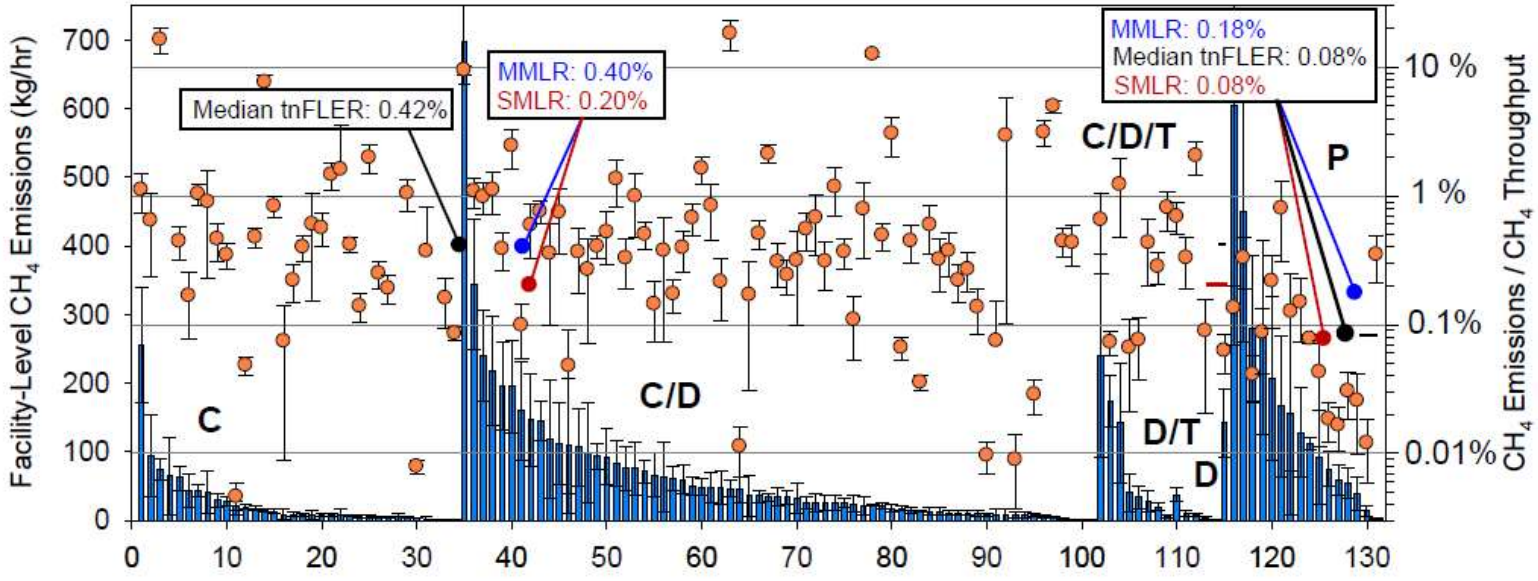




Yacovitch et al., 2015
Lan et al., 2015
Rella et al., 2015
Albertson et al., 2015
Foster-Wittig, 2015
Zhou et al, 2019a and 2019b

Source: Cornell, Aerodyne, CSU, in prep

Sample Dataset (US Gathering and Processing)



Marchese et al., *Environ. Sci. Technol.* 49, 10718 (2015)

Methods for direct measurement: fueling stations & vehicles

Full-Flow Sampling System
(Leaks, venting, purging, etc.)

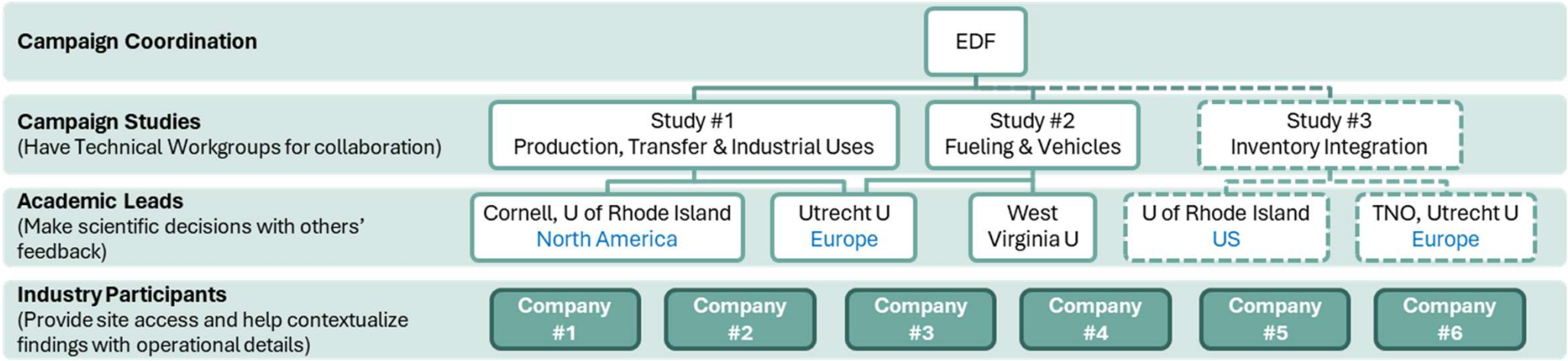
J. Vis. Exp. DOI :10.3791/54179-v

Portable Emissions
Measurement System (PEMS)

West Virginia University will adapt working versions (for CH_4 and exhaust gases, respectively) with ppm level H2 sensors or Aerodyne analyzer

Collaborative H_2 Emissions Measurement Campaign

Campaign studies structure



Thank you!

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Collaborative hydrogen emissions measurement campaign design

Studies	**Production, Transfer & Industrial Uses** (Downwind measurements of facility level emissions w/wo tracer release)			**Fueling & Vehicles** (Direct measurements of component level emissions)	**Emissions Inventory Integration**	
Potential facility type/ value chain segment targets	Site-level quantification: • SMR • Electrolysis • Oil refining • Ammonia production • Methanol production • Compression stations • Other pipeline components *Processes that may be covered but may not be quantified at process level:* • *Pipelines (underground portion)* • *Liquefaction* • *Storage* • *Loading/unloading*			Fueling stations: • Onsite production if applicable • Compression • Gaseous/Liquid storage • Gaseous/Liquid delivery • Fueling terminal/process Vehicles: • Fuel cell exhaust • Tank and plumbing	Full value chain (Not an official part of the campaign but highly relevant)	
Principal Investigator	**Cornell U**	**U of Rhode Island**	**Utrecht U** (Note that Utrecht U plans to measure fueling stations in Europe with downwind measurement techniques)	**West Virginia U**	U of Rhode Island	TNO
Method & Geography focus	**Inverse modeling – North America**	**Tracer release – North America** (a subset of facilities)	**Tracer release & Inverse modeling – Europe** (tracer for a subset of facilities)	**Full flow sampling – US** **Portable emissions measurement system – US vehicles**	US	Europe
Research team	Cornell, Aerodyne (H2 data only)	URI, Aerodyne, SLR	UU, TNO	WVU, TES	URI, SLR	UU, TNO