HYDROGEN EMISSIONS MEASUREMENT STUDY

A Collaborative Research Initiative of Environmental Defense Fund and Partners

Zero and low carbon hydrogen holds great promise as a decarbonization strategy. But to maximize its climate benefits, it is critical that it be produced, managed, and used in a way that minimizes emissions.

Background

The universe's smallest molecule, hydrogen, is a leak-prone gas that causes climate warming. When released through venting, purging, or unintended leaks, it increases the concentrations of other greenhouses in the atmosphere (i.e. methane, tropospheric ozone and stratospheric water vapor). Like methane, hydrogen's warming effects are short lived, but potent: more than 35 times more powerful than carbon dioxide pound for pound over the first 20 years after its release. Recent studies indicate that if hydrogen emission rate ranges from less than 1% to 20% for various components and can severely undermine the intended benefits of hydrogen deployment, particularly over the near term. The international hydrogen community, including the US Department of Energy, EU Joint Undertaking, UK Department for Business Energy & Industrial Strategy, and the International Energy Agency have highlighted the importance of understanding hydrogen emissions, underscoring the need to monitor, measure, and mitigate leaks and releases.

What is not well understood is how much hydrogen is released from various processes and infrastructure types. Studies over the last 20 years suggest emission rate ranges from less than 1% to 20% for various components of the value chain, but this range is highly theoretical, because there are few empirical data on hydrogen emissions from real-world infrastructure. Current commercial technologies are designed to detect relatively high concentrations (at the parts-per-million level) as those can pose a safety risk. They do not detect the smaller "climate relevant" emissions – at the parts-per-billion level – and they lack the fast response necessary to enable quantification of hydrogen plumes released from various infrastructure.

To responsibly deploy hydrogen at scale, across major industries, we need better understanding of hydrogen emission rates from representative facilities and equipment types. With the help of new hydrogen measurement technology and experts in making trace gas measurements, EDF is launching the first comprehensive Hydrogen Emissions Measurement Study in North America and Europe in 2024.

Benefits of the Hydrogen Emissions Measurement Study

The study will quantify current emissions and improve hydrogen infrastructure development by:

- Establishing a baseline understanding of how much hydrogen is released and from where, thereby laying the foundation for best practices and mitigation strategies;
- Understanding emissions from existing infrastructure will aid demonstration projects, such as the Hydrogen Hubs, in the development of infrastructure with high environmental integrity;
- Offering insights into the effectiveness of current safety leak repair programs to minimize emissions, thereby supporting companies to establish operational excellence;

- Offering transparency and assurance of safety to local communities;
- Offering assurance to governments and private sector actors that investments in hydrogen will generate the promised climate benefits, backed by high-quality, directly measured data; and
- Saving valuable product by minimizing unintended hydrogen losses.

The study

EDF and partners seek industry leaders to join a collaborative study to quantify the hydrogen emission rate of various hydrogen infrastructure. The goal is to create a foundation of empirical data and knowledge that will inform management and decision making in hydrogen systems.

This study will involve making measurements at new and existing hydrogen infrastructure, using a prototype technology and scientifically rigorous methods designed by scientists who have decades of experience in emission measurements across sectors and geographies. Hydrogen facility types to be studied include fertilizer production, oil refining, methanol production, electrolysis, refueling, pipeline distribution, on-road transportation, storage, and others. The study aims to collect several data points for each facility type across multiple companies to get representative hydrogen emission rates.

Industry partners will have the opportunity to provide input into the measurement plan and help contextualize the findings, and participate in post-study communications. To ensure that companies have the freedom to fully participate, data will not be attributed to specific companies or locations, but instead will be aggregated and generalized. Results will be released as peer-reviewed scientific publications.

The detection technology

With Department of Energy funding, Aerodyne Research developed a prototype instrument capable of measuring hydrogen at a level of sensitivity and speed necessary to measure climate-relevant emission rates. The technology is based on optical principles and demonstrates a few seconds measurement precision of 10 ppb in situ. Researchers from EDF worked with Aerodyne Research and Cornell University to conduct the first field testing of this prototype in January 2023 at Colorado State University's METEC facility. Controlled-release experiments were carried out, including above- and under-ground releases of pure hydrogen gas and hydrogen/methane blended gas at various flow rates. The hydrogen sensor successfully detected small enhancement of hydrogen concentration downwind of the release point.

The emission quantification approaches

Multiple approaches will be used to quantify hydrogen emissions from concentration measurement: dual-tracer release and dispersion modeling were tested using data collected at METEC. The dual-tracer approach involves releasing two trace gases at known rates at a facility that's emitting an unknown amount of hydrogen. Both tracers will be measured downwind along with hydrogen concentration, and then used as references to quantify hydrogen emission rate. Common tracer gases include nitrous oxide and industrial acetylene, and can be adjusted based on the safety protocol onsite. The dispersion modeling approach will utilize wind and temperature measurements and an inversion model developed by scientists at Cornell University. Both approaches are scientifically robust and proven to quantify emissions with a high level of accuracy.

Timing

The study timeline is currently in development, with a start date in early 2024.

In-kind contributions

The study is funded by philanthropic contributions to EDF. Companies will be asked to provide necessary staff time to ensure safe operations and facility access as in-kind contributions.

Research Teams

Aerodyne Research, Inc.
Dr. David Nelson
Dr. Scott Herndon
Conner Daube

Cornell University
Dr. John Albertson
Dr. Ahmad Momeni

Environmental Defense Fund
Dr. Steven Hamburg
Dr. Ramón Alvarez
Dr. Tianyi Sun
Carly Pleines

SLR International
Matthew Harrison
Kenneth Malmquist

Netherlands Organisation for Applied Scientific Research
Amsterdam Free University
Dr. Arjan Hensen

Transport Energy Strategies
Dr. Nigel Clark
David McKain

University of Rhode Island
Dr. Anthony Marchese

Utrecht University
Dr. Thomas Röckmann

West Virginia University
Dr. Derek Johnson
Dr. Scott Wayne

Environmental Defense Fund
For more information, contact:
Dr. Tianyi Sun, tsun@edf.org

T 212 505 2100
F 212 505 2375
EDF.org