Preventing and mitigating hydrogen emissions from infrastructure

Maximizing hydrogen's decarbonization benefits requires minimizing hydrogen emissions throughout the value chain. Hydrogen is a leak-prone gas that can indirectly warm the climate.[1] While preventing and mitigating hydrogen emissions involves identifying/quantifying emissions from infrastructure—which will require new technologies/methods that are currently underway but not yet available—there are actions that can be taken now to help reduce future emissions.

IMMEDIATE ACTIONS TO REDUCE EMISSIONS

Minimize leakage

- Tighten valves and seals
- Use laminated gaskets and welded joints
- Avoid flanged and threaded joints
- Adequately insulate pipes and storage tanks minimize number of pipeline segments/seams
- Reduce operating pressure and/or minimize points of pressurization and depressurization

Mitigate operational emissions

- Recover vented, purged, and residual hydrogen and use it to produce process heat/electricity
- Incorporate technology to recombine vented, purged, and residual hydrogen with oxygen back into water
- Implement the latest technology to maximize the hydrogen recovery rate from purification
- Maximize combustion efficiency if flaring is necessary
- Install control devices to minimize emissions from storage tanks
- Install vapor recovery units to capture gas and boil-off and compress it into the gas line (via automatic gauging, vapor-balance systems, and tank-pressure monitors to tanks)

Mitigate operational repair emissions

- Immediately repair leaks and fix/replace malfunctioning equipment
- Minimize the volume that must be depressurized in a pipeline or vessel (use temporary line stops to isolate the section where repairs are needed)
- Verify repairs are successful through follow-up leak monitoring surveys
- Replace or eliminate components that leak
- Replace or retrofit high-leakage devices
- Reduce the number of blowdowns by coordinating repairs and maintenance events into a single downtime

WHY DO WE NEED TO REDUCE EMISSIONS?

Hydrogen indirectly warms the climate, especially in the near term, by triggering chemical reactions in the atmosphere that increase the amounts of greenhouse gases. This undermines hydrogen's climate benefits.[1]

WHERE ARE EMISSIONS COMING FROM?

Intentional emission sources:[2]

- Venting/purging pipelines/equipment during startup, maintenance, purification, shutdown, from boil-off.

Unintentional emission sources:[2]

- Leakage from pipework, equipment, storage sites through all materials; particularly valves, joints, seals.
- Residual hydrogen in exhaust streams (such as cross-over hydrogen in electrolyzers) and natural evaporation of liquefied hydrogen (boil-off).

HOW MUCH HYDROGEN IS EMITTED?

Total and by-component emissions have not been empirically quantified in part because current commercial sensor technologies are not sufficient and new technologies are needed.[3]

Several studies have estimated hydrogen emissions magnitudes with various assumptions/ methodologies, leading to a wide range in emissions rates anywhere from <1% to 20% depending on factors such as the type of equipment, segment of the value chain, and production-to-consumption pathway.[2]

Emissions can be very high because hydrogen is a tiny molecule that is hard to contain, similar to, but even more leak-prone than, natural gas.[2]

The first-ever high-precision hydrogen emissions sensor was recently developed and tested,[4] paving the way to begin identifying major emission sources and mitigation opportunities as systems are scaled up.

[1] Paulot et al. (2021); Hauglustaine et al. (2022); Ocko and Hamburg (2022); Warwick et al. (2022).
[2] Arrigoni and Bravo Diaz (2022); Cooper et al. (2022); Fan et al. (2022); Frazer-Nash Consultancy (2022).
[3] Najjar (2019); Mejia et al. (2020).
[4] www.edf.org/media/climate-concerns-about-hydrogen-energy-grow-new-tech-unveiled-ceraweek-delivers-unprecedented

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