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. 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
- 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.

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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).