Environmental Defense Fund

The science of hydrogen's warming effects

How does hydrogen warm the climate?

Around 30% of molecular hydrogen (H_2) emitted into the atmosphere chemically reacts with the naturally-occurring hydroxyl radical after a few years. This reaction ultimately increases the amounts of short-lived greenhouse gases including methane, tropospheric ozone, and stratospheric water vapor.[1]

What is hydrogen's warming potency?

Recent advancements in chemistry-climate modeling have led to quantification of hydrogen's full atmospheric warming effects using multiple models—leading to a doubling of earlier warming potency estimates. The latest science suggests that hydrogen emissions are 30-40 times more powerful at trapping heat over the following 20 years than carbon dioxide for equal mass, and 8-12 times more powerful over a 100-year period.[1]

How robust is the science?

Scientists from multiple academic and research institutions across the world are confident that hydrogen emissions warm the climate.[1] At least 15 scientific publications over the past two decades, including four IPCC assessment reports, have communicated this issue to varying degrees.[2]

How is hydrogen emitted?

Hydrogen (as H_2) is emitted from natural and human systems. A current concern is that hydrogen emissions may considerably increase as the hydrogen energy industry is scaled up. Hydrogen is notoriously hard to hold onto and emitted throughout the value chain from operational releases and leakage.[3] We need to start measuring emissions which will help us prevent and mitigate emissions through smarter designs and choices.

History of the science

2023 The first multi-model assessment of hydrogen's total warming potency is published. Sand et al.

2022 Several studies are published that show the climate risks of hydrogen emissions in the near- and long-term and The IPCC Sixth Assessment Report identifies hydrogen leakage as a challenge. Hauglustaine et al.; Bertagni et al.; Ocko and Hamburg; IPCC AR6 WGIII 6.4.5

2021 The first assessment of hydrogen's full atmospheric warming potency is published. Paulot et al.

2013 The IPCC Fifth Assessment Report includes hydrogen's GWP. IPCC AR5 WGI 8.SM.14

2007 The IPCC Fourth Assessment Report includes hydrogen's GWP. IPCC AR4 WGI 2.10.3.6

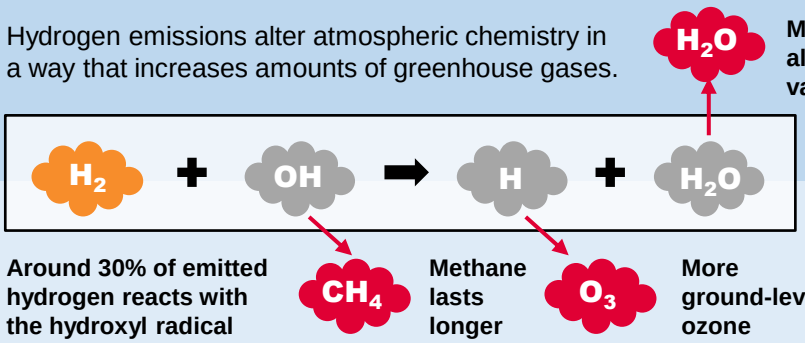
2003 Several studies warn about the climate risks of a potential hydrogen economy. Prather; Schultz et al.

2001 The first quantification of hydrogen's lower-atmosphere warming potency is published and is reported in the IPCC's Third Assessment Report along with a note of caution about the warming effects from a potential hydrogen economy. Derwent et al.; IPCC TAR 4.2.3 pg. 256

1972 The first description of hydrogen's atmospheric chemistry is published. Levy

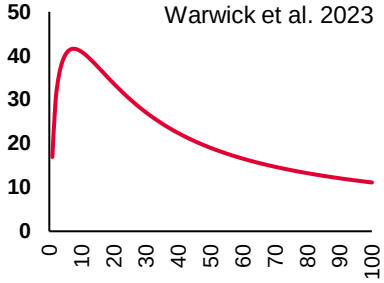
Hydrogen's chemistry and indirect warming effects

Hydrogen emissions alter atmospheric chemistry in a way that increases amounts of greenhouse gases.



Hydrogen's warming potency over time (years)

(Global Warming Potential)



[1] Warwick et al. (2023); Sand et al. (2023); Derwent et al. (2023); Hauglustaine et al. (2022)
[2] Ibid; Bertagni et al. (2022); Ocko and Hamburg (2022); European Commission JRC (2022); IPCC AR6 (2022); Paulot et al. (2021); Field and Derwent (2021); Derwent et al. (2020); IPCC AR5 (2007); Wuebbles et al. (2010); IPCC AR4 (2007); Derwent et al. (2006); Colella et al. (2005); Warwick et al. (2004); Prather (2003); Schultz et al. (2003); IPCC TAR (2001), Derwent et al. (2001)
[3] Esquivel-Elizondo et al. (2023)