Hydrogen Emissions and Associated Warming Effects During Production and Across Hydrogen Supply Chains

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Abstract:

In the effort to alleviate climate change, hydrogen has gained considerable interest as an alternative energy source to reduce greenhouse gas emissions. When consumed either in fuel cells or via combustion, hydrogen does not emit other greenhouse gases; thus, it is a key decarbonization option for otherwise hard-to-abate sectors. Recent energy policies, such hydrogen production tax credits, and support for regional hydrogen hubs are set to dramatically increase the production and use of clean hydrogen. However, hydrogen can act as an indirect greenhouse gas by extending the lifetime of atmospheric methane. Thus, there are concerns that the indirect warming impacts of hydrogen could outweigh the climate benefits of its use.

In this project, the indirect warming effects of hydrogen emissions are examined through a life-cycle assessment approach from upstream production to end use to better understand the use cases of hydrogen that meaningfully reduce emissions and to help inform future policy decision-making. The proposed framework and analysis consider hydrogen production through steam methane reforming (SMR) with and without carbon capture and storage (CCS), and electrolysis using wind and solar energy coupled with pipeline distribution and steel production, heavy-duty transport, and electricity end use. The analysis was conducted using open LCA software and the Ecoinvent database. The IPCC 2021 impact assessment method with the addition of global warming potential (GWP) and global temperature potential (GTP) values for hydrogen is used. Furthermore, the uncertainties associated with leakage rates and the global warming potential of hydrogen are explored to identify gaps in hydrogen impact assessments to construct a framework that can be used for evaluating hydrogen supply chains.

The results indicate that the primary factors influencing the overall climate impact of hydrogen production are the chosen production method and related elements rather than the rates of hydrogen leakage and the indirect warming potential of hydrogen. Additionally, a comparison of traditional fossil fuel and hydrogen-based steel production and heavy-duty transport pathways demonstrated a decrease in overall regardless of accompanying fugitive or intentional emissions and hydrogen indirect warming effect. However, using hydrogen to produce electricity had similar life cycle emissions to current grid mix electricity production and thus might not offer climate benefits.