

ABSTRACT:

**Beyond Global Warming Potential:
A Sustainability Assessment of Green Hydrogen Technologies**

M. P. Maniscalco¹

¹National Research Council - Institute of Advanced Energy Technologies “Nicola Giordano”
(CNR – ITAE), Salita Santa Lucia Sopra Contesse, 5, 98126 Messina ME

Green hydrogen is increasingly positioned as a cornerstone of zero-net CO₂ emission strategies, particularly for hard-to-abate sectors. However, its sustainability is often discussed primarily in terms of climate change mitigation, with economic feasibility typically identified as the main barrier to large-scale deployment, while other environmental and social dimensions remain comparatively underexplored. Building on recent literature, this work provides a critical overview of green hydrogen technologies, highlighting that their sustainability cannot be assessed solely through global warming potential (GWP) or cost metrics. While renewable-based electrolysis can significantly reduce life-cycle greenhouse gas emissions, broader trade-offs emerge when additional environmental indicators are considered, including acidification, eutrophication, water scarcity and resource use. In parallel, techno-economic studies consistently identify electricity demand as the main driver of hydrogen production costs. However, focusing exclusively on cost risks overlooking other structural constraints, such as the dependence on critical raw materials (e.g. platinum group metals), the geographical mismatch between renewable resources and water availability, and the social dimension of the hydrogen value chain. Recent social life cycle assessment studies indicate that these stages may entail relevant risks related to labour conditions, inequality and geopolitical dependence, particularly when supply chains rely on vulnerable mining and processing regions. Overall, the talk proposes a shift from a climate- and cost-centric narrative towards an integrated sustainability perspective. Green hydrogen should not be assessed as inherently sustainable, but rather through an integrated perspective able to capture trade-offs across environmental, economic and social dimensions, in line with emerging Safe and Sustainable by Design (SSbD) principles.