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# What explains the renewable hydrogen deployment gap? Insights from plant-level modeling and expert interviews

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### Extended Abstract

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### Abstract Summary

Achieving net-zero emissions requires decarbonization solutions for hard-to-abate sectors where electrification is not viable, while escalating geopolitical tensions demand that these solutions also strengthen energy security. Domestically produced renewable hydrogen addresses both, offering a decarbonization pathway while reducing dependence on volatile fossil fuel imports. Despite its prominence in national energy strategies, deployment remains far below policy projections, risking continued fossil fuel dependence and jeopardizing climate targets.

Part of the explanation may lie in how Energy System Models (ESMs) represent hydrogen. ESMs rely on generalized cost assumptions and limited representations of operational constraints, simplifications that allow wide geographical scope but introduce systematic inaccuracies. Plant-level studies show that production costs are highly sensitive to system configuration, renewable availability, and demand proximity, dynamics that aggregate models cannot capture. Yet existing plant-level work rarely examines how economies of scale, minimum load constraints, and location-specific renewable profiles interact across plant sizes and supply configurations, leaving ESMs at risk of miscalculating the costs and designs that investment and policy decisions depend on.

This paper addresses this gap through plant-level techno-economic optimization combined with twelve stakeholder interviews, applied to renewable hydrogen projects in Switzerland. Results show that ignoring economies of scale leads to underestimating costs of small installations by over 20%, while large plants exhibit fundamentally different optimal configurations than pilot-scale designs suggest. Minimum load constraints only drive up costs where battery storage or stable renewable supply is absent, and renewable generation variability is a primary cost driver, with intermittent locations requiring substantially greater storage capacity.

Taken together, these findings demonstrate that realizing the potential of domestic renewable hydrogen as both a decarbonization tool and a strategic energy security asset

requires granular plant-level analysis, realistic investment frameworks, and policy mechanisms that support domestic hydrogen value chains.

**Presenting Author Biography**

Paula Baumann joined the Group for Sustainability and Technology at ETH Zürich as a PhD candidate in February 2025.
Before joining SusTec, Paula worked at the German Environment Agency on the implementation of the Carbon Border Adjustment Mechanism in Berlin. She holds a MSc and a BSc in Mechanical Engineering and Business Administration from RWTH Aachen University.