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# Modelling green hydrogen for a fairer, cleaner Australia: The role of digital twins and circular economy

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**Abstract:** Australia is accelerating the development of a green hydrogen industry as a key enabler of its net-zero emissions target. Despite abundant renewable resources, green hydrogen production remains economically and environmentally challenging due to high capital costs, water and energy demands, and underutilised by-products. This study addresses these barriers by developing a system dynamics-based digital twin model to simulate the green hydrogen supply chain in Australia. The model incorporates circular economy strategies, including the valorisation of by-products such as oxygen and waste heat, optimisation of solar-dominant energy inputs, recovery of process water, and efficient ammonia export logistics. Four scenarios are assessed from 2025 to 2050. The results indicate that integrating by-product reuse can increase hydrogen output by over 2 Mt and reduce the Levelised Cost of Hydrogen (LCOH) to below $3.20/kg. Water recovery strategies yield savings of over 600 GL, and solar-based input optimisation contributes to improved emissions outcomes. These findings demonstrate how digital twin models and circular strategies can guide infrastructure planning, enhance supply chain resilience, and inform Australia's policy ambitions. This work is aligned with MODSIM2025's theme of 'Modelling for Positive Change', providing a science-based tool to support sustainable energy transitions and bridge research, policy, and practice.

***Keywords:*** *green hydrogen, circular economy, digital twin, system dynamics, Australia*

 