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Decarbonising grey hydrogen via bio-hydrogen and carbon capture and storage: a case study in Spain

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Abstract-

This study assesses the techno-economic feasibility of deploying biohydrogen with carbon capture and storage (HyBECCS) to decarbonise Spain's hydrogen production. The proposed framework replaces natural gas with biomethane while integrating CO2 capture and storage. Fifteen steam methane reforming (SMR) facilities, representing 90% of national hydrogen production, are characterised. A geospatial analysis matches each facility with the nearest CO2 storage site, estimating transport and storage costs as functions of distance and capacity. Full substitution of natural gas with biomethane across all facilities requires 28.7 TWh/yr of biomethane and yields up to 4.6 Mt CO2/yr of negative emissions. Partial substitution across five SMR plants reduces demand to 14.6 TWh/yr of biomethane, achieving net-zero operation. The levelised cost of hydrogen for HyBECCS averages 3.56 €/kg H2, compared with 2.61 €/kg H2 under current production conditions. These results confirm HyBECCS as a technically viable and infrastructure-compatible pathway to achieve large-scale hydrogen decarbonisation in Spain.

Index Terms- Biohydrogen; CCS; Grey hydrogen; Net-zero

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