Blue hydrogen production via Steam Methane Reforming with CO_2 capture and Sorption-Enhanced SMR: a techno-economic analysis

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While hydrogen (H_2) is increasingly recognized as a promising alternative to fossil fuels across various industrial applications, the demand for low-carbon H_2 production has been rising significantly [1]. One of the most appealing pathways to meet this demand is blue H_2, which involves producing H_2 from fossil fuels while coupling the process with carbon capture, utilization, and storage (CCUS) technologies to substantially reduce carbon emissions.

Within this framework, two blue H_2 production technologies are explored: traditional Steam Methane Reforming (SMR) combined with CCUS via amine-based solvent scrubbing, and an innovative process known as Sorption-Enhanced Steam Methane Reforming (SE-SMR), which integrates in-situ CO_2 capture using a solid sorbent like CaO directly into the SMR process [2,3]. Both technologies are designed the same H_2 production capacity and are compared in terms of technical performance and economic feasibility.

The integration of the CO_2 sequestration within the reforming reactor enhances H_2 yield by shifting the reactions equilibrium according to Le Chatelier's principle and simultaneously reduces the overall capital cost (CAPEX) thanks to the use of a more compact process configuration. The economic assessment incorporates uncertainties in future costs to estimate the potential range of blue H_2 production costs, in comparison with the state-of-the-art in H_2 production technologies. Electricity price, natural gas price, and CAPEX overrun risks are identified as primary factors influencing the economic viability of blue H_2 under volatile market conditions. Both technologies exhibit a levelized cost of H_2 that is competitive with conventional grey H_2 production processes, including conventional SMR, partial oxidation, and autothermal reforming [4]. Furthermore, the increase in Emission Trading System credit prices observed since 2019 and expected to continue rising has increasingly promoted the deployment of low-carbon over grey H_2 production, thereby consolidating blue H_2 technologies as both environmentally sustainable and economically viable solutions.

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