

Techno-economic analysis of biohydrogen production from lignocelluloses biomass via co-pyrolysis and gasification process

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Abstract

Hydrogen production from renewable biomass offers a pathway toward low-carbon energy systems. This study presents a techno-economic assessment of hydrogen generation from lignocellulosic biomass through an integrated pyrolysis, gasification, and reforming process modeled in Aspen Plus V10. The process design applies the Peng-Robinson equation of state for thermodynamic predictions and integrates methane steam reforming and water gas shift reactions to enhance hydrogen yield. Simulation results show a hydrogen yield of 0.0742 kg H₂ per kg biomass with a purity of 99.91%, representing a 40.5% improvement over standalone gasification. Pinch analysis demonstrates a 20% reduction in energy consumption through heat recovery. Economic evaluation estimates a capital cost of USD 14.8 million and an operating cost of USD 5.9 million per year, yielding a payback period of 5.52 years, an internal rate of return of 39.16%, and a net present value of USD 166.31 million. Integration of CO₂ capture reduces emissions by approximately 50% compared to conventional steam methane reforming. These results confirm the technical and economic feasibility of the process and its relevance for sustainable hydrogen production.

Keywords

Biohydrogen; Co-pyrolysis; Gasification; Techno-economic analysis; Carbon reduction; Biomass valorization