Comparative techno-economic analysis of different methanol production through CCU electrified reforming and CCS pathways.

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Highlights

- Electrified methanol production achieves up to 8% lower selling prices, ensuring positive net present value, making it economically competitive.
- The electrified process demonstrates environmental benefits with net CO_2 utilization, aligning with sustainable practices in the chemical industry.
- Despite advantages, CCU pathways face financial competition; their minimum selling prices must align with conventional and CCS processes for broader adoption.

1. Introduction

As CO_2 is the primary contributor to greenhouse gas emissions, the industry has long emphasized developing carbon-free and reliable chemical processes to reduce these emissions [1]. Because methanol, a commodity chemical with high GHG emissions, is predominantly produced from syngas and generated through methane reforming reactions, it is essential to decarbonize its manufacturing process. A crucial aspect of implementing this strategy involves utilizing renewable energy sources and incorporating effective units for converting CO_2. Carbon capture and utilization (CCU) not only provides economic benefits by using captured CO_2 as a feedstock for valuable products and fuels but also stands as a promising approach [2]. However, CCU products are generally more expensive than those derived from fossil fuels. On the other hand, carbon capture and storage (CCS) become a practical and competitive way to reduce CO_2 emissions. The goal is to capture and store 5.1 gigatonnes of CO_2 annually by 2050, making up 14% of what is needed to stabilize global temperatures [3]. As green electricity generation advances and environmental concerns about industrial processes grow, there is an increasing need to move away from fossil fuel-based manufacturing [6]. Integrating electric energy as an alternative heat source for chemical reactions makes it feasible to effectively reduce or eliminate CO_2 emissions associated with various chemical processes. Therefore, the primary goal of this study is to have an innovative electrified reforming approach aligned with CCU technology and compare its techno-economic results to those of other methanol production pathways, specifically CCS technology.

2. Methods

Figure 1 shows the simplified body flow diagram of methanol production's electrified combined reforming and CCS process. A comprehensive cost analysis is performed to assess the economic feasibility of the electrified process. The economic analysis entails the capital cost investment and operating cost estimations, as well as the profitability evaluation of each pathway based on its net present value (NPV) calculation results. The equipment sizing and capital cost estimation of process units is performed in Aspen Capital Cost Estimator, using the simulation results of electrified combined reforming, tri-reforming (TRM), conventional, and CCS (based on ACTL project [4]) pathways for methanol production from syngas in ASPEN Plus [5].

3. Results and discussion

Techno-economic analysis (TEA) evaluates various economic metrics: capital costs, operating costs, profitability, minimum methanol selling price, and required financial support. The minimum methanol selling price, defined as the price at which the net present value is not negative, is a critical metric in the economic analysis of any process. The minimum selling price for each methanol production pathway is depicted in Figure 2. As can be seen under current market conditions, methanol production via the

electrified process yields a positive net present value (NPV). According to our results, the minimum selling price of methanol can be up to 8% lower than the current market price while having net CO_2 utilization. However, the conventional and CCS processes show lower selling prices compared to the electrified combined reforming and TRM as the reference process.

4. Conclusions

The findings highlight improved process parameters and the economic viability of the proposed electrified process. This research advances sustainable practices to facilitate a greener and more environmentally friendly future in the chemical industry. Also, considering the minimum selling price and equivalent CO_2 mitigation credit, the mentioned CCU pathways need to compete financially with conventional and CCS processes.

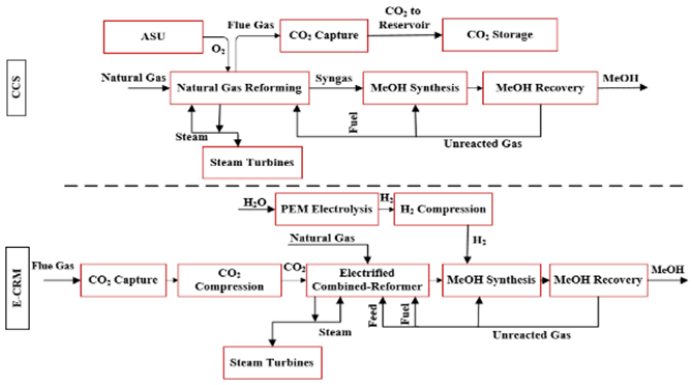

Figure 1. CCS and E-CRM body flow diagram.

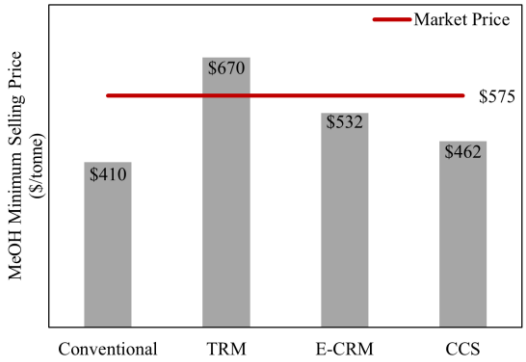

Figure 2**.** The minimum selling of each methanol production pathway.

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Keywords

Electrification, Carbon capture and storage, Carbon capture and utilization, Techno-economic analysis**.**