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Techno-economic evaluation of electrochemically-driven CO_2 capture using alkali solutions in magnesia plants

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Abstract

This submission presents the updated techno-economic analysis (TEA) results of the ConsenCUS CO_2 capture technology at Grecian Magnesite magnesia production plant.

The European Commission has set the ambitious goal of reaching net zero by 2050. Although this target is at the epicentre of EU climate policy, it puts much pressure to decarbonise on energy intensive industries such as magnesia plants. During the calcination process in magnesia plants, CO_2 emissions from fuel combustion and $MgCO_3$ decomposition are generated with the latter being process-inherent. In this context, Carbon Capture and Storage (CCS) technologies could be considered as a viable alternative.

To this day, amine-based solvents have been extensively studied with the non-proprietary second generation CESAR1 solvent, an aqueous blend made of 26.7%wt. AMP and 12.9%wt. PZ, being widely considered as the new benchmark technology. Extensive tests at RWE's Innovation Centre facilities at Niederaussem also showcased its long-term stability[1,2]. However, the generation of volatile AMP emissions and the formation of PZ-related degradation products such as nitrosamines make the deployment of more severe emission mitigation measures necessary[1,3].

Alkaline solvents have recently regained prominence due to their fast reaction kinetics and their inorganic degradation-resistant nature. Meanwhile, in line with reaching the net-zero targets, electrically-driven regeneration technologies have been getting steam. In the ConsenCUS project (consencus.eu), an international effort has been made to develop and pilot a modular post-combustion CO_2 capture unit operating with aqueous KOH/K_2CO_3 solvent.

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In this study, we evaluate the potential of deploying the ConsenCUS CO_2 technology for capturing the CO_2 emissions from the plant's rotary kilns, each one operating with a distinct fuel mix resulting in varying CO_2 concentrations in the flue gas. For acquiring the mass and energy balances, here we employ the recently developed integrated Aspen Plus/ACM model [4] while for providing reliable cost estimates for each of the scenarios under investigation, we make use of the hybrid costing method [5]. The main goal of this study is to identify trade-offs between capture efficiency and energy consumption and to quantify the impact that varying CO_2 gas concentrations have on TEA metrics.

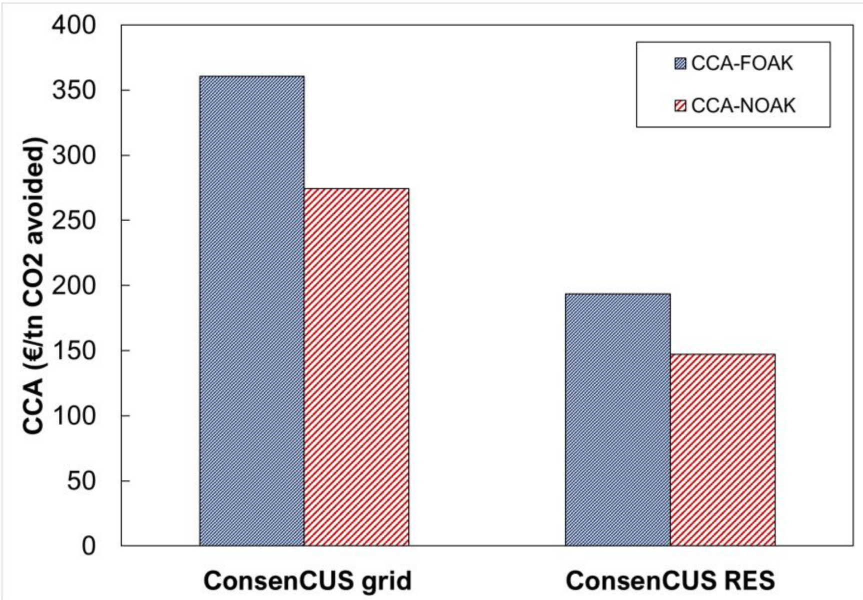

Figure 1: Cost of CO_2 avoided (CCA) for the First-of-a-kind (FOAK) and N^{th}-of-a-kind (NOAK) ConsenCUS CO_2 capture plants over a 25-year project lifetime. The CCA values are calculated considering the carbon intensity of the Greek electricity grid (ConsenCUS grid) and the carbon intensity of renewables (ConsenCUS RES). The values correspond to a flue gas with a CO_2 concentration of 9.1%vol.

Keywords: CO_2 capture, process modelling, techno-economics, alkali absorption

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