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Techno-economic analysis of integrated onshore and offshore UCG-CCS systems to produce electricity, SNG and urea

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Underground coal gasification (UCG) enables the utilization of coal reserves that are economically not exploitable because of complex geological boundary conditions. In the present study, we investigate site-specific commercial-scale onshore and offshore UCG-systems combined with carbon capture and storage (CCS) in line with electricity, synthetic natural gas (SNG) and fertilizer (urea) production based on data of in-situ trail undertaken at the Wieczorek coal mine (Silesian Basin, Poland) [1] and ex-situ tests on different Polish coals. Hereby, techno-economic modeling approaches according to Kempka et al. [2] and Nakaten et al. [3] have been applied to determine onshore and offshore levelized end-use product costs as well as cost bandwidths resulting from economical, technical and geological uncertainties.

Our analysis results show that the investigated onshore UCG end-use options are by 3 % (SNG), 27 % (electricity) and 47 % (urea) lower than the according market prices, and thus competitive on the Polish energy market. However, due to high costs for the offshore platform and the related infrastructure, offshore UCG end-use products are not economic in view of the EU raw materials and energy market. For UCG-CCS systems, a relevant approach to decrease production costs is a precise management of the oxidizer composition: an oxygen ratio below 30 % by volume and a high UCG-to-syngas conversion efficiency favor the economics of electricity and SNG production, whereby cost-effective urea production under the given boundary conditions is characterized by high CO_2 and H2 ratios in the synthesis gas composition. As drilling costs have a limited share on total levelized production costs of 3 % in maximum, uncertainties related to model input parameters affected by drilling costs, e.g., UCG reactor width, are negligible.

From our techno-economic modeling results, we conclude that competitiveness of the investigated onshore UCG-CCS end-use options will be even more profitable in view of the expected future development of natural gas prices.

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