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Techno-economic analysis for the evaluation of three UCG synthesis gas end use approaches

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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 UCG as a potential economic approach for conversion of deep-seated coals into a synthesis gas and its application within three different utilization options.
Related to geological boundary conditions and the chosen gasification agent, UCG synthesis gas composes of varying methane, hydrogen, nitrogen, carbon monoxide and carbon dioxide amounts. In accordance to its calorific value, the processed UCG synthesis gas can be utilized in different manners, as for electricity generation in a combined cycle power plant or for feedstock production making use of its various chemical components. In the present study we analyze UCG synthesis gas utilization economics in the context of clean electricity generation with an integrated carbon capture and storage process (CCS) as well as synthetic fuel and fertilizer production (Kempka et al., 2010) based on a gas composition achieved during an in situ UCG trial in the Wieczorek Mine. Hereby, we also consider chemical feedstock production in order to mitigate CO_2 emissions.
Within a sensitivity analysis of UCG synthesis gas calorific value variations, we produce a range of capital and operational expenditure bandwidths that allow for an economic assessment of different synthesis gas end use approaches. To carry out the integrated techno-economic assessment of the coupled systems and the sensitivity analysis, we adapted the techno-economic UCG-CCS model developed by Nakaten et al. (2014).
Our techno-economic modeling results demonstrate that the calorific value has a high impact on the economics of UCG synthesis gas utilization. In the underlying study, the synthesis gas is not suitable for an economic competitive electricity generation, due to the relatively low calorific value of 4.5 MJ/Nm^3. To be a profitable option for electricity production, the UCG synthesis gas should have a calorific value of at least 7 MJ/Nm^3. However, UCG feedstock production in view of the underlying geological and chemical boundary conditions can compete on the market.

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