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Development of a technical-economic model for dynamic calculation of COE, energy demand and CO_2 emissions of an integrated UCG-CCS process

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World-wide coal reserves can provide energy supply for several hundred years. Underground coal gasification (UCG) offers an economic and sustainable approach to convert these coal reserves into syngas. As combustion of fossil fuels releases CO_2 emissions into the atmosphere, the present study considers a coupling of UCG with CO_2 capture and its subsequent storage (CCS) in the previously converted seams, thereby offering a low carbon solution to coal fired power generation.

The aim of the present study is to develop a technical-economic model in order to evaluate costeffectiveness, energy demand and CO_2 emissions for a coupled UCG-CCS process. The model consists of five dynamic submodels which take into account the processes of air separation (ASU), UCG, syngas processing, electricity production and CCS. Capital (CAPEX) and operational expenditure (OPEX) of these process stages are combined to establish the overall levelised costs of electricity generation (COE). Therefore, the modeling approach developed within the present study allows for a comparison of the COE of the coupled processes with different technologies for electricity production. The influence of parameters relevant for COE (e.g. seam thickness and depth as well as syngas quality) and CO_2 emissions (e.g. quality of coal, plant efficiency) were analysed in the context of a sensitivity analysis.

Within the UCG&CO_2STORAGE project, funded by the EU Research Fund for Coal and Steel (RFCS), a theoretical UCG-CCS feasibility study is being performed for the Dobrudzha coal basin, the selected study area in northeast of Bulgaria. The concealed coalfield is of carboniferous age with high rank bituminous coals. The tectonic conditions in the area are complicated and some of the faults determine coal formation distribution. Explored are four coal formations, but only three of them (Krupen, Gurkovo, Makedonka) are of interest for the project. Investigated for the Dobrudzha coal deposit were 120 geological sections of deep coal wells (average depth 2,000m), 100 geological sections of shallow wells (average depth 500m), and well log data for 120 deep wells. The geological surveys show that the research area actually provides seven coal seams suitable for UCG. Their average seam depth counts 1,656 meters and the average thickness four meters. The perspective carboniferous section is covered by thick aquifer of mesozoic age.

As the costs and energy demand of the coupled UCG-CCS processes can be strongly influenced by geological, technical and infrastructural boundary conditions, the developed model considers detailed data on the study area (seam thickness and depth, calorific value of coal). The results of the calculation show a possible technical and economical start-up scenario for a UCG-CCS pilot in the study area.