Master Thesis

Techno-economic modeling and optimization of a CO_2 based geothermal system combined with Direct Air Carbon Capture Sequestration (DACCS)

Abstract: Direct Air Carbon Capture and Sequestration (DACCS) presents a viable method for reducing atmospheric CO_2 concentrations. DACCS involves drawing ambient air through fans and passing it over a sorbent material that captures CO_2, effectively filtering it from the air. The captured CO_2 is then released from the sorbent using pressure or temperature changes, resulting in highly concentrated CO_2. Due to the low concentration of CO_2 in the atmosphere, the DACCS process is energy-intensive and currently costs approximately €500 per ton of CO_2. Despite these challenges, various studies and forecasts consider DACCS a necessary component for achieving climate goals. [1]

In parallel, research over the past few years has explored a geothermal concept that utilizes supercritical CO_2 as the primary working fluid. This concept offers advantages such as lower viscosity and a strong thermosiphon effect of CO_2. [2]

Combining CO_2-based geothermal energy with DACCS presents several techno-economic benefits. The temperature levels required for DACCS align closely with those found in CO_2-based geothermal systems. Additionally, geothermal energy provides a baseload power source, ensuring high utilization rates for DACCS facilities, which in turn reduces specific capture costs. Further synergies arise from the potential co-location of DACCS and CO_2-based geothermal systems.

Objective: The objective of this thesis is to analyze the combination of CO_2-based geothermal energy and DACCS from a techno-economic perspective. Using a specific use case, the study will explore the potential benefits of this combination. This involves modeling both the geothermal and DACCS cycles, estimating the capital expenditure (CAPEX) based on cost functions, and calculating the Levelized Cost of Capturing (LCC).

Methodology:

1. Conduct a literature review on Direct Air Capture and CO_2-based geothermal energy.
2. Perform thermodynamic modeling of the combined Direct Air Capture and CO_2-based geothermal system.
3. Optimize the system for thermodynamic synergies.

4. Determine the CAPEX requirements using cost functions.
5. Calculate the Levelized Cost of Capture (LCC).
6. Conduct a sensitivity analysis to identify the main cost drivers.
7. Document the findings.

Literature:

[1] Breitschopf, B., Dütschke, E., Duscha, V., Haendel, M., Hirzel, S., Kantel, A., ... & Wietschel, M. (2023). *Direct Air Carbon Capture and Storage: Ein Gamechanger in der Klimapolitik?* (No. 01/2023 (DE)). Perspektiven-Policy Brief.

[2] Adams, B. M., Kuehn, T. H., Bielicki, J. M., Randolph, J. B., & Saar, M. O. (2014). On the importance of the thermosiphon effect in CPG (CO2 plume geothermal) power systems. *Energy*, *69*, 409-418.

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