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The economic value of flexible CCS in net-zero electricity systems: The case of the UK

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Abstract

We build a unit-commitment optimisation model of a flexible combined-cycle gas turbine (CCGT) with solvent-based post-combustion carbon capture and storage (CCS). We derive the economic benefits of CCS with solvent storage for a 20-year investment (2030-2050) based on the expected long-term increase in carbon prices and the volatility of electricity prices. Drawing on National Grid's Future Energy Scenarios for the UK, our model shows that the CCGT-CCS plant profit is, on average, higher with solvent storage because of intertemporal arbitrage opportunities created by having this storage solution available. We find that the economic value of this intertemporal flexibility increases with greater electricity price volatility. Under high price volatility, the total return on investment (ROI) could reach 81-246%. In relative terms, this is much higher than the total ROI of the CCGT-CCS plant itself (7-64%). While there is an economic case for investing in flexible CCS with solvent storage, there are wider system benefits too. A flexible solvent storage solution should be seen in the context of the overall system 'flexibility' requirements of a low-carbon power system. On a cost basis, solvent storage represents just a fraction of the capital costs of more "mainstream" energy storage technologies, such as lithium-ion batteries or hydro pumped storage, while CCGT-CCS offers *firm* power. Overall, while seen as a rather technical solution, if abated fossil fuel generation is to be part of a future low-carbon power system having this flexibility adds economic benefits not just to operators but also improves overall system security and complements high shares of variable renewables on the grid.

Keywords Combined-cycle gas turbines, Carbon capture and storage, unit-commitment models, optimisation, flexible carbon capture, solvent storage

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