Deploying gas power with CCS: The role of operational flexibility, merit order and the future energy system

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Combined cycle gas turbine (CCGT) power plants are an important part of many electricity systems. With the growing penetration of intermittent renewables they will be expected to adjust their power output more frequently and over greater ranges. By fitting these plants with carbon capture and storage (CCS), the CO_2 emissions associated with the generation of electricity could be virtually eliminated.

We evaluate CCGT power plants with different variations of post combustion capture of CO_2 using amine solvents, looking particularly at the impact on the rate of CO_2 capture. The variations cover the full range of technological options, including solvent storage, partial capture and shifting the energy penalty associated with carbon capture in time. The analysis is based on the most recent Future Energy Scenarios from National Grid for the electricity system of the UK in 2025. The modelling was conducted by interfacing the Energy Policy Research Group electricity system model for the UK with a general model of a CCGT power plant fitted with CCS in a unique way. The combination is powerful, making it possible to evaluate different capture options for any named CCGT plant in the UK and to determine important trade-offs, *e.g.* operational flexibility *vs.* level of CO_2 capture. This distinctive capability is valuable for power plant operators and organisations such as National Grid as they plan for the future.

The behaviour of individual CCGT plants is mainly governed by the plant's location in the merit order and to a lesser extent on the CO_2 reduction targets for the electricity system. Plants low in the merit order ramp frequently between peak power output and minimum stable generation, while at the other extreme, plants high in the merit order operate as peaking plants, only a few times per year. In the UK CCGT plants built from 2016 onwards will emit ~ 90% of the CO_2 emissions of the whole CCGT fleet in 2025. From a system perspective, these plants should therefore be addressed first.

The typical 'base case' CCGT plant with post combustion using amine solvents is designed to capture 90% of the CO_2 emissions and to operate dynamically with the power plant. Downsizing the capture facility could be attractive for plants at high and intermediate points in the merit order. Solvent storage is also an option. Beyond a few minutes of storage, substantial storage tanks for rich and lean solvent would be needed. Altering the size of the regenerator and compressor is another design option. Ensuring that tanks are sized so that they can be utilized well is important and this is governed by the typical power output profile and the rate at which rich solvent can be regenerated. If solvent storage is to play an important role, it will require definitions of 'capture ready' to be expanded to ensure sufficient land will be available to accommodate the storage tanks.

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