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

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1. Energy Penalty associated with carbon capture

the energy penalty and it was assumed to be made up of three contributions (Lin et al., 2012). The first was the heat required to raise the temperature of the solvent stream to the stripper temperature and the second was the heat required to balance the enthalpy of reaction associated with regenerating the solvent and releasing the CO_2 in the stripper. The total heat required per mole of CO_2, Q, was given by

$$Q = \frac{m_{\text{solvent}}\left(C_p \Delta T + \Delta q_{CO_2} \Delta h_{CO_2}\right)}{m_{CO_2}}$$ 1

where C_p is the heat capacity of the solvent, m_{solvent} is the molar flowrate of solvent, Δq_{CO_2} is the change in CO_2 loading of the solvent between its rich and lean states, Δh_{CO_2} is the heat of absorption of CO_2 and m_{CO_2} is the molar flow rate of CO_2. ΔT is the change in temperature required, assumed to be 10 K, accounting for the fact that there is heat exchange between the rich and lean solvent streams. This thermal energy was supplied by diverting steam from the power cycle. The resulting decrease in electrical output is taken to be:

$$E = 0.75 \eta Q$$ 2

where the factor of 0.75 is the efficiency of the turbine (Freeman et al., 2009) and η is the Carnot efficiency of extracted steam, given by:

$$\eta = 1 - \frac{T_C}{T_H}$$ 3

where T_C and T_H are the temperatures of the environment (298 K) and of extracted steam (623 K) respectively. The final contribution was the electrical energy required to compress the CO_2 to 150 bar, assumed to be 15 kJ/mol CO_2 (House et al., 2009). The contribution of electrical energy required to pump the solvent between the absorber and the stripper was found to be negligible.

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