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POTENTIAL FOR SYNERGY BETWEEN RENEWABLES AND CARBON CAPTURE AND STORAGE

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Overview

Throughout the world, industrialised countries have interconnected electricity systems, often known as grids, which connect a range of power generators to electricity users through a transmission system. All grids exploit the inherent strengths of the various technologies operating in them to provide the lowest possible cost of generation whilst ensuring response and reserve capacity are available to maintain the quantity and quality of supply. Fossil-fired power plants often play an important role in these systems since they are inherently flexible so can be used to balance changing demand and provide back-up capacity for intermittent renewable generation.

Increasing concern over the impact of carbon dioxide (CO2) emissions on the atmosphere has led to the development of carbon capture and storage (CCS) technology that could allow continued use of fossil fuels but with significantly reduced emissions. Such technology could be important in the short to medium term since the availability of flexible fossil-fired plants could become increasingly important as many countries look to increase the proportion of electricity generated by renewable sources, often focussing on intermittent sources such as wind.

This paper discusses preliminary work to establish important technical and economic issues related to the flexibility offered by fossil-fired power stations and some potential changes as a result of adding carbon capture. Understanding these technical characteristics is crucial in determining what roles power plant with CCS could play on the grid. In particular, the potential for fossil-fired power plants to support increased penetration of electricity generation using renewable sources in the short to medium term is examined. Flexible plants may be required to maintain quality and security of supply with increasing penetration of intermittent renewables such as wind. There are also specific opportunities to use carbon capture on biomass combustion for power generation, particularly at plants where biomass is co-fired with pulverised coal. Initial conclusions suggest that some fossil-fired plants with carbon capture could have economically viable synergies with renewables so it is important that these unique potential advantages for fossil-fired power plant with CCS are not overlooked in comparisons between low-emission generation options.

Methods

Carbon capture at fossil-fired plants can be undertaken using a range of different processes. Of particular interest is the additional plant flexibility that could be associated with the addition of an amine scrubbing plant for post-combustion capture such as that shown in Figure 1.

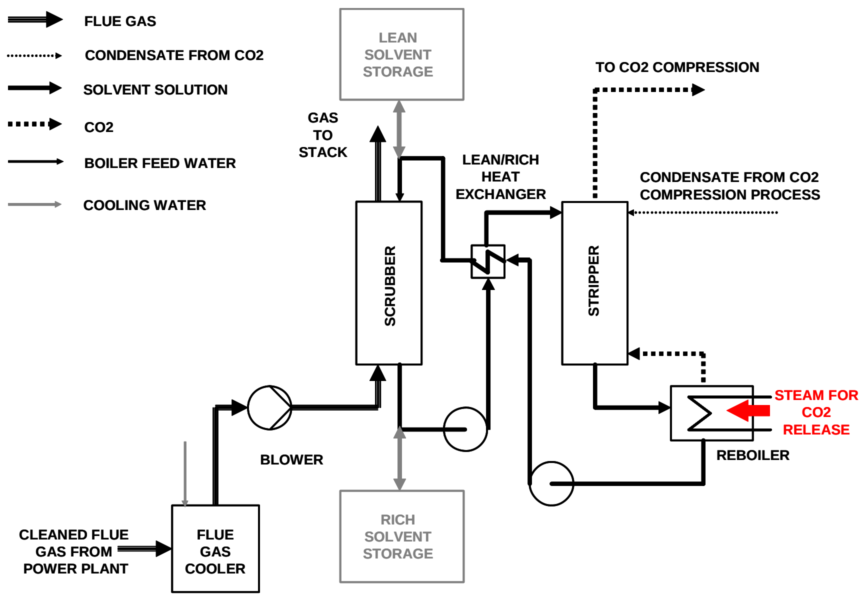

Fig. 1: Flow Diagram for Post Combustion Capture Using Amine Scrubbing

In post combustion capture plants, CO2 is removed from the waste (flue) gas by a solvent, in this case amine, in a scrubber column. The solvent is then moved to a stripper column where the CO2 is removed from the solvent. The solvent can then be re-used and the CO2 is sent for compression and eventual transport to safe geological storage. The CO2 capture process requires energy resulting in an associated reduction in power plant electricity output. This is mostly required for removing CO2 from the solvent in the stripper column and, to a lesser extent, for CO2 compression. Plant operators can alter the volume of steam used for CO2 release very quickly with an associated change in plant electricity output (and CO2 capture level) since steam used for releasing CO2 can be used to generate electricity instead. If solvent storage tanks are included, an increased electricity output could be obtained without releasing CO2 to the atmosphere in the flue gas since the CO2 could still be removed from the flue gas by the solvent, but with the CO2 release process left until that increased output is no longer required. It is also technically possible to operate the power plant without CO2 capture at all if required. Although this has obvious environmental impacts, it could be a valuable facility for providing additional capacity under extreme conditions.

It seems likely that other established capture technologies (e.g. oxyfuel and pre-combustion methods such as IGCC) will be significantly less flexible than post-combustion plant. However, pre-combustion capture plants that produce hydrogen which is used for electricity generation could also participate in a local hydrogen network, supplying the network at times of low electricity demand and, potentially, receiving hydrogen from that network to make up any shortage in hydrogen supply from on-site production facilities. This could help to support the development of a wider hydrogen economy for longer term use.

It is also worth noting some potential benefits associated with exploiting the potential for switching some fuel supply at a pulverised coal-fired power plant to biomass. Since the typical efficiencies of biomass-only and coal-fired plant are approximately 35% and 45%

respectively (based on LHV using best available technology) co-fired biomass can provide up to an additional 30% electricity output per unit of biomass input compared to biomass-only plant. Also, plants that co-combust biomass with coal can be much more flexible in accommodating any variations in supply by changing the volume of coal combusted thus helping to stabilise biomass prices, independent of supply fluctuations.

Preliminary technical and economic analysis has focused on identifying the key functions and roles of the different options outlined here and appropriate criteria for assessing their potential worth, both as a technical solution and a commercial operation. In particular, much of the literature applies only steady-state economics to analysis of power plants (i.e. one price for electricity throughout the day). This approach seems likely to undervalue flexible plant which can be operated to take advantage of peak electricity prices during the day and avoid losses when prices fall as a result of lower demand overnight. This paper presents a provisional economic analysis which attempts to identify more appropriate measures for valuing flexible power plant operations.

Results

Based on this work, it is clear that some fossil-fired power plants with carbon capture could be able to provide response and reserve capacity to the electricity grid. This could be an important element in allowing the grid to handle increased challenges in maintaining the balance between supply and demand with increased penetration of intermittent renewables. In addition, solvent storage could provide a similar service to pumped storage offered in hydro schemes so it is important to consider the relative costs of these alternative methods. It seems likely that appropriate implementation of carbon capture at fossil-fired plants could provide a reasonable technical solution that could support the increased penetration of renewable energy technologies and is also good value for money.

Biomass co-combustion is also potentially important, both in its own right and as a potential method for developing the infrastructure required for biomass-only plants. In the UK, biomass co-combustion occurs at most, if not all, coal-fired power plant whereas biomass-only plants are struggling to become economically viable. It is also important to note that where biomass plants operate with carbon capture there can be a net removal of CO2 from the atmosphere (since biomass removes CO2 from the atmosphere when it is grown which does not return to the atmosphere if carbon capture is used to capture CO2 at the power plant where it is burned).

Conclusions

This paper focuses on technical and economic aspects of adding carbon capture to power plants for electricity generation and discusses potential synergy between these plants and increased use of renewables. In particular, it analyses the value of flexibility offered by fossil-fired plants that could be vital to allow the volume of electricity from intermittent renewable sources to increase without damaging security and quality of supply. Also, the development of biomass combustion for electricity generation is important. Pulverised coal plants that use biomass co-combustion provide an effective use of biomass energy and may provide a route to support the development of biomass-only plants as a commercial operation.