Profiles

IEA CLEAN COAL CENTRE

Techno-economic analysis of PC versus CFB combustion technology

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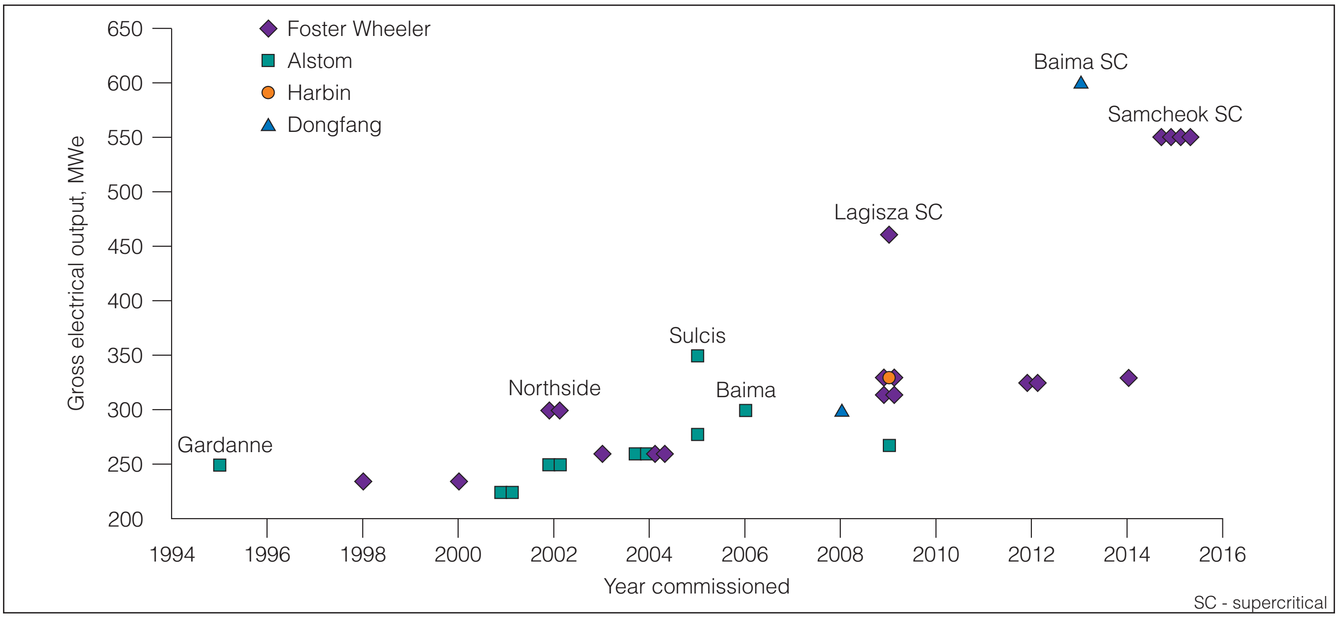
Since its first use in the early twentieth century, pulverised coal combustion (PCC) has maintained a dominant role in power generation from coal, and currently represents over 90% of global capacity. Circulating fluidised bed combustion (CFBC) is a more recent boiler technology whose higher tolerance to fuel quality has favoured niche application in small-scale and industrial power generation, often firing unconventional fuels such as waste coal and biomass. Despite also attaining status as a 'cleaner' coal technology due to more easily controllable NOx and SOx emissions, use of CFBC at the utility scale has long been restricted by smaller boiler sizes and lower efficiencies than PCC. However, scale-up and optimisation over the last ten years have allowed CFB boilers to benefit from economies of scale and begin to provide a viable alternative to PCC for utility power generation. Crucial to this progress has been the successful operation of the first supercritical CFB boiler at Lagisza power plant in Poland. In China, even 300 MW subcritical CFB boilers have managed to capture around 10% of the country's rapidly growing coal capacity, and the recent commissioning of the world's largest supercritical CFBC unit at 600 MW may mark the beginning of similar growth at this scale. Elsewhere, ongoing construction of a multiple unit 4400 MW CFBC plant in South Korea is further evidence that this technology may be in the process of acquiring a more prominent share of global coal power.

Of the two advantages associated with CFBC, fuel flexibility has become the principal impetus for recent utility projects, as increasingly deregulated markets have encouraged utilities to seek cheaper fuel sources and the ability to easily change supply has become more attractive. Several recent power plants in the USA have employed CFBC as a means of cofiring locally available 'opportunity fuels' such as petcoke and waste coal, whilst in China the technology is seen as ideal for firing high-ash anthracite and lignite, as well as waste coal. In Poland, two major CFBC utility projects have been aimed at firing lignite and bituminous coals with variable properties or a tendency for slagging. Conversely, South Korea's dependency on imported coal has made CFBC an attractive option for acquiring flexibility in the global coal market and avoiding dependence on a single supply chain. Aside from being the sole means of firing some challenging fuels, CFBC can therefore also provide a significant financial saving on fuel costs for plants which are in a position to switch or supplement supply with a cheaper alternative when necessary.

On the other hand, the low NOx emissions and in situ desulphurisation capability of CFBC primarily represent a means of reducing plant capital expenditure by avoiding the costly installation of selective catalytic reduction (SCR) and wet flue gas desulphurisation (FGD). Estimation of PCC and CFBC plant costs for general, equivalent cases is challenging, but assessments from the past few years clearly indicate a closing of the financial gap between the two technologies as larger and more optimised CFB boilers have become available. Nevertheless, CFB boiler costs have remained higher, and the substantial savings derived from avoiding SCR and wet FGD installations are therefore significant in staying economically competitive with PCC plant. For this reason, future growth of the CFBC market share could be hindered by increasingly strict emissions limits which challenge the levels of desulphurisation practically achievable by addition of limestone to the furnace. All large CFB boilers in the USA have been obliged to add a form of downstream FGD, and it is likely that the recently introduced limit of 100 mg/m^3 in China will require similar investment. Whilst SNCR has proved sufficient NOx control for existing CFBC plant in regulated regions, the incorporation of SCR with four 550 MW boilers in South Korea suggest that this saving may also be lost for larger boilers and very low NOx limits.

Operational cost savings associated with flue gas treatment in CFBC plant are small due to the less efficient use of reagents compared to SCR and wet FGD processes. However, addition of limestone to the CFB boiler also has the undesirable side effect of producing a much larger quantity of solid waste which has unsuitable chemistry for use as a cement substitute. This is in contrast with the separate streams of relatively saleable fly ash and gypsum produced by a PCC boiler with wet FGD. CFBC ash has instead been widely used for mine reclamation activity, but has also proved suitable for lower value construction applications such as as flowable fill and road base, or as a



The scale-up of CFB boiler capacity in the last twenty years, with significant plants labelled

lime substitute in waste stabilisation and soil amendment.

High efficiency and reliability are also important criteria which must be met by CFBC for its widespread adoption for utility power plant. The move to supercritical steam conditions first implemented at Lagisza represents the most significant advance in increasing CFBC thermal efficiencies, with the 43.3% (LHV) efficiency reached by this plant competitive with equivalent PCC boilers. Relatively high auxiliary power consumption associated with fluidisation air fans remains the principal barrier to raising CFB efficiencies, but research in China has shown that reductions can be achieved by minimising the bed material whilst optimising the fluidisation state. This technique has also proved useful for reducing erosion damage which can afflict CFB boilers with some fuels. Although generally regarded as highly tolerant to high ash loadings, many early utility CFBC units have suffered severely reduced availability as a result of both ash erosion and agglomeration. As experience with the technology at large scales has grown, many of these problems appear to have been resolved by improved design and operational practice, and highly reliable operation has been achieved by boilers firing conventional fuels. However, maintaining such optimum levels of reliability and efficiency for large units is likely to require the sacrifice of some degree of fuel flexibility.

As international policy moves towards mitigating the CO_2 emissions from power generation, biomass cofiring and carbon capture technologies are two developments which will have an increasing impact on coal plants and in which CFBC could play an important role. In contrast to its role in coal-firing, CFBC is an established technology for biomass-firing, and many of the recent utility CFB boilers have incorporated the capability of burning up to 20% biomass with little design alteration required. On the other hand, as the practice of co-firing biomass in PCC rapidly grows and experience is gained, it appears that the more established boiler technology will become equally competitive for cofiring wood wastes for which relatively standard PCC equipment can be used. CFBC is nevertheless likely to retain an advantage for difficult high slagging biomass types such as agricultural wastes.

Oxyfuel combustion, in which elimination of nitrogen from the furnace produces a more easily captured stream of relatively pure CO_2, is emerging as one of the most viable carbon capture technologies. Both oxyfuel PCC and CFBC have been successfully tested at the pilot scale, but it is thought that CFBC may have greater potential for combustion at higher oxygen concentrations, thus economising on boiler size. Research into the viability of this idea is in its early stages, and both boiler technologies await scaling up to the demonstration plant scale.

Each issue of *Profiles* is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of *Profiles* is based on the report:

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