Profiles

Upgrading and efficiency improvement in coal-fired power plants

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Improving the efficiencies of the large number of older coal-fired power plants operating around the world would give major savings in CO_2 emissions together with significant other benefits. This could be achieved by improvements to operating and maintenance practices and through more major activities (retrofits). Earlier IEA Clean Coal Centre reports have described the issues and principles associated with efficiency losses and means that are available for correcting them at coal power plants. This report focuses more on example projects, especially retrofits.

The efficiencies of coal-fired plants decrease over time as components suffer deterioration with age and use. The losses that develop in the earlier part of the life of a plant are generally containable by employing good operating and maintenance practices. However, after about 25–30 years of operation, performance and reliability will usually have decreased to the extent that substantial works may be merited, in order that the unit may be restored to operating efficiently and economically. The lower performance of older plants also stems from the limitations of the prevailing technology at the time of plant design. Retrofitting offers the opportunity to incorporate technology advances made in the period since the unit was built.

Retrofits will increase efficiency significantly, by up to as much as 2–3 percentage points, and may compensate completely for loss of performance from addition of environmental control equipment after a plant was first commissioned. As an example of the latter, the annual average efficiency in 1982-83 of the first three units of Drax power station in the UK with no FGD was 39% LHV. Recent turbine retrofit work has now increased the efficiency to almost 40% LHV even with FGD. Major plant upgrading involving conversion of subcritical to supercritical or ultra-supercritical (USC) could raise efficiencies more substantially, but has seldom progressed beyond studies because of the high cost.

The impact of plant ageing on efficiency tends to be most significant in countries where financial resources for maintenance are limited, such as in the non-OECD countries of southeast Asia. Unfortunately, a warmer climate and, sometimes, higher ash coals also restrict the efficiencies of coal-fired units in parts of the latter region (even for new plants). These influences combine to make it particularly important to maximise efficiency of old units as much as possible by carrying out retrofitting works. This often needs to be conducted on all main areas of the plant, not just the turbine area, as will frequently largely suffice on many units in OECD countries.

Major boiler and turbine retrofits are the main subject of this report, but optimisation of the combustion process can give valuable benefits in efficiency and costs. The gain may typically be about 0.1–0.15% in fuel cost saving, efficiency and CO_2 emissions. Improvements in combustion efficiency can be achieved in parallel with other improvements, for example, reductions in primary NOx production from replacement burners and new air supply arrangements. Intelligent sootblowing systems can improve boiler efficiency by 1% or more and reduce the incidence of outages from fouling.

Lignites with inherent moisture contents as high as 50–65% are used for power generation in some countries. The conventional systems that use these coals restrict generation efficiency. Lignite pre-drying would give a potential efficiency advantage of about four percentage points if a boiler designed for the dryer feed were used. Retrofitting a pre-dryer to treat a maximum of about 25–30% of the fuel feed to an existing boiler would be possible, and would give a worthwhile one percentage point efficiency gain. Such dryers are at the point of commercial availability.

Programmes to drive efficiency improvements of coal fleets are important and some are described in the report (for example, Australia's Energy efficiency Opportunities Program and the USAID CenPEEP programme in India and India's Partnership in Excellence (PIE) Programme). Notably, China has recently set up a major programme providing incentives for plant owners to carry out upgrading and efficiency improvements through retrofits, with a total capacity of over 350 GW expected to have been improved or to be undergoing improvements by 2015.

Many companies provide efficiency improvement and upgrading services. A substantial chapter of the report contains a number of case studies in various countries. Most are major retrofits, but the last case study, from

Potential efficiencies from plant improvements in APEC countries		
Category	Area of improvement	Net efficiency gain (percentage points)
Combustion system	Pulveriser and feeder upgrades	0.3
	Air heater repair or upgrade	0.25
	Sootblower improvements	0.35
	Excess air instrumentation and control	0.2
Steam cycle	Feedwater heater repairs	0.4
	Heat transfer tube upgrades	0.6
	Steam turbine blades	0.5
	Cycle isolation	0.5
	Condenser repairs	0.4
O&M	O&M training	
	Computerised maintenance and management systems and reliability centred maintenance	Included in combustion and steam cycle gains. Efficient operation realised over the long term
	Distributed control systems	
Combined total		3.5

China, is an interesting example of relentlessly pursuing all the smaller potential losses in a new USC plant, to push efficiencies higher, by focusing on detailed areas, including areas not previously recognised as worthy of attention. A conclusion from that is that there may be other unrecognised losses capable of being reduced.

The report also summarises best practice in plant upgrading and improvement. The first requirement is to reduce losses through better operational practices, including monitoring of important plant parameters. A unit identified for retrofitting should have potential for long life, secure fuel availability and high future capacity factor. It should have a good track record of competent management, and the recent history of plant faults must indicate good prospects of achieving sustainable improvements. The improved plant must have a future-proof environmental control strategy with secure outlets for waste streams as by-products. A thorough plant examination should follow, including current performance measurements. In planning the upgrading and refurbishment activities, the components that require replacement or renovation have to be identified. The proposed work then needs to be analysed in detail in order to provide estimates of performance and reliability improvements, CO_2 savings and costs.

The example projects in the report show that there is extensive expertise and experience available among the major suppliers of new plants and other companies involved in retrofit work. Projects have been realised on schedule or ahead of time and gains in efficiency and output have been substantial.

Overall, this report shows that environmental and economic benefits are routinely achievable from plant modernisations and that the potential gains are now very considerable. Expertise is widely available, and progress is being made to realise these gains through projects at increasing numbers of plants. Technology sharing between all countries will be valuable in increasing the benefits.

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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£100 to organisations in non-member countries for six months after publication, and free thereafter.

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