Profiles

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Low water FGD technologies

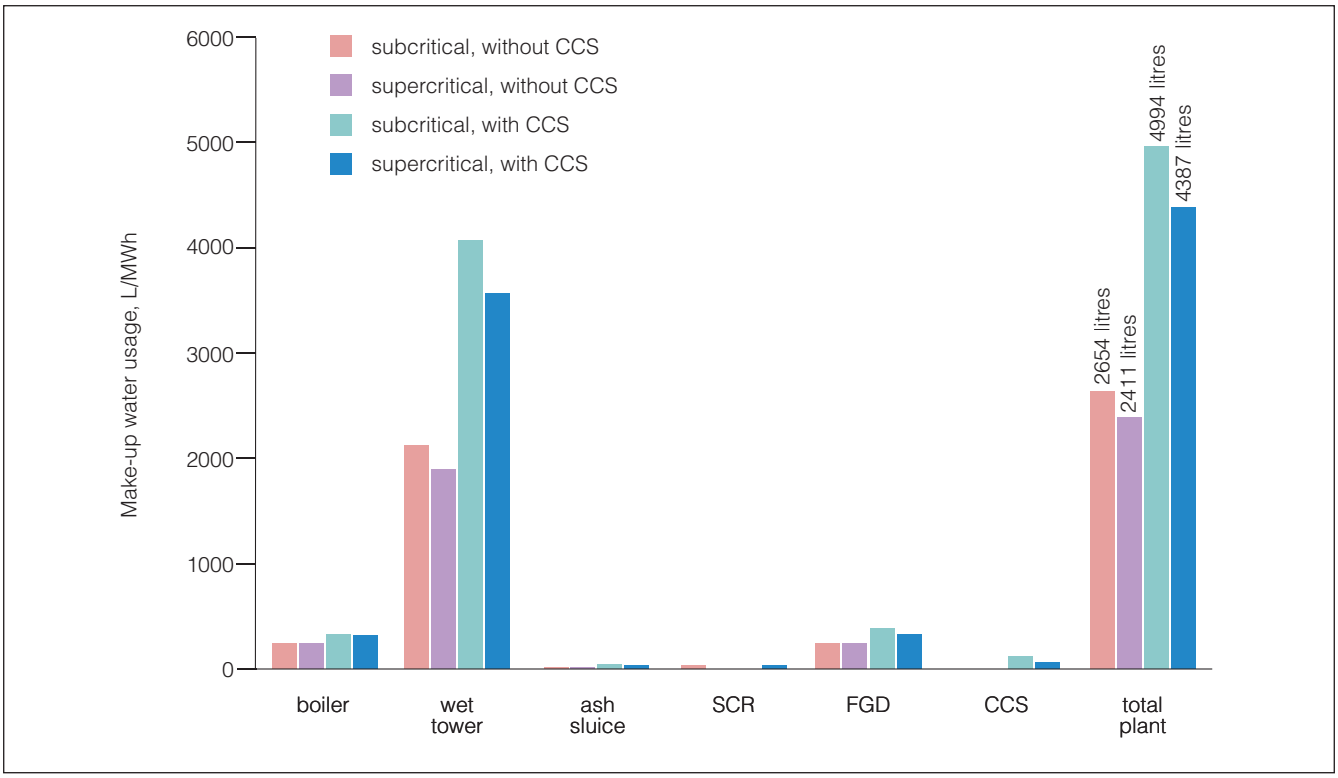
Large amounts of water are consumed within a coal-fired power plant for cooling purposes, flue gas desulphurisation (FGD) make-up, boiler make-up and other uses. The amount consumed varies depending on the type of plant (subcritical, supercritical or ultra-supercritical), the cooling system employed, the FGD system and other factors. Make-up water usage within a subcritical and a supercritical 550 MW coal-fired power plant is shown in the figure. The plant utilises a wet scrubber (limestone forced oxidation process) for FGD and a wet cooling tower (the most common type of cooling system). It can be seen that the FGD unit is the second largest consumer of water, closely followed by the boiler. Adding a CO_2 capture (amine-based) system increases the FGD make-up water consumption by around 45–50% for both the subcritical and supercritical plants. This is due to the low flue gas SOx level (<10 ppm) required for the amine unit. On a site which utilises dry/air cooling for the condenser, or once-through seawater cooling, then the wet FGD system can become the largest water consumer, reaching 40–70% of total site usage (without CO_2 capture). Technologies which reduce water usage are becoming more important with the large number of FGD systems being installed in response to ever tightening emission regulations. Reducing water loss is particularly important in arid regions of the world or in areas subject to drought.

Wet scrubbers, the most widely deployed FGD technology, can remove over 98% of SO_2, have a high reliability and produce saleable gypsum. However, they require large supplies of water (as shown in the figure) and increase a plant's CO_2 emissions (CO_2 is a by-product of the desulphurisation process). Wet scrubbers account for around 10–15% of the evaporative water losses in coal-fired power plants equipped with water cooling systems. Evaporative water losses can be reduced by some 40–50% when the flue gas is cooled to 90–100ºC before it enters the wet scrubber. This is commonly carried out in Japan and Europe using regenerative heat exchangers. Technologies are under development to capture over 20% of the water in the flue gas exiting the wet scrubber, enabling the power plant to become a water supplier instead of a consumer. The technologies include condensing heat exchangers, membranes and liquid desiccant systems.

The semi-dry spray dry scrubbers (SDS) and circulating dry scrubbers (CDS) consume some 60% less water than conventional wet scrubbers. Furthermore, they have the advantages of lower investment costs (than a similar sized wet scrubber), no production of wastewater, dry by-products, lower parasitic power consumption, a smaller footprint (which may be easier for retrofit applications), and additionally capture over 95% of the SO_3, HCl, HF and oxidised mercury. The main drawback of SDS compared to wet scrubbers is their lower SO_2 removal efficiency (90–97%). State-of-the-art CDS can remove over 98%, approaching the efficiency of wet scrubbers. Operating costs are generally higher than those for wet scrubbers mainly due to the higher sorbent costs.

SDS are typically used at power plants burning low to medium sulphur coals, whilst CDS can be applied to units burning low to high sulphur coals. Both systems have a good turndown capability, and similar water usage, power consumption and capital costs. CDS systems consume some 20% more reagents than SDS. Although CO_2 is not generated in the desulphurisation process, it is emitted from on-site lime kilns (if present).

The commercial dry sorbent injection processes (where the sorbent is injected into the furnace or duct) have the lowest water consumption, consuming no water, or a minimal amount if the sorbent needs hydrating or the flue gas is humidified to improve performance. They are simple to install and operate, easy to retrofit with their small space requirements, have a low power consumption (~0.2% of electric capacity) and produce no wastewater. A co-benefit is the capture of some of the HCl, HF and mercury in the flue gas. The by-products are dry, and so are easier to handle and manage than the wet by-products from wet scrubbers. As a consequence, the capital costs of sorbent injection systems are considerably lower than the semi-dry and wet scrubber processes. Nevertheless, operating costs are generally higher mainly due to the high consumption of the sorbent. The bulk of the operating cost is the price of the sorbent. In general, calcium-based sorbents are cheaper than the sodium-based ones. The sorbent injection systems are best suited for use in small (<300 MWe) power plants



Make-up water usage in subcritical and supercritical plants

that utilise low to medium sulphur coals, and where only a moderate SO_2 removal efficiency is required. The main drawback of injection systems is the poor utilisation and SO_2 removal efficiency of the sorbents. In addition, the injection of carbonate-based sorbents can increase CO_2 emissions.

Multi-pollutant processes that remove several regulated pollutants in one system may be more cost-effective than separate components. Commercial systems are available that consume little or no water. ReACT™, for example, is a regenerable system that uses only 1% of the water required by conventional wet scrubbers. Over 99% of SO_2 and SO_3, 20–80% NOx, >90% of mercury (both elemental and oxidised) and around 50% of the particulates are removed in the process when burning low to medium sulphur coals. Parasitic power consumption is low (~0.7%) and saleable by-products are produced. SNOX™, a regenerable catalytic process, consumes no water and removes up to 99% of SO_2 and SO_3, up to 96% of NOx and essentially all of the particulates. It produces saleable sulphuric acid and fly ash. There is no parasitic power consumption because of the heat recovery features and, on larger plants, a potential net power gain. SNOX™ has lower capital, operating, and maintenance costs than a plant with a wet scrubber and selective catalytic reduction unit burning high sulphur coals, but will cost more than a wet scrubber when combusting low and medium sulphur coals (it was designed for high sulphur fuels).

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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