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A TECHNOLOGY ROADMAP FOR HIGH EFFICIENCY, LOW EMISSIONS COAL POWER PLANT

HELE COAL IS ESSENTIAL FOR A SUSTAINABLE GLOBAL POWER SECTOR

Coal power is the world's single largest source of electricity and has remained at around 37% of global generation since 1990, even as total demand has more than doubled. With the strengthening of international efforts to reduce carbon dioxide (CO_2) emissions, coal's dominance over power generation is expected to gradually decline, but it will retain a major role in the sector for the coming decades – particularly for emerging economies with growing demand. However, coal power contributes around a third of global energy-related CO_2 emissions and is also a major source of harmful atmospheric pollutants including particulates, sulphur dioxide (SO_2), nitrogen oxides (NOx), and heavy metals. High efficiency, low emissions (HELE) technologies describe the suite of state-of-the-art and emerging solutions for generating power at lower carbon intensity and effectively removing pollutants from flue gas. As long as coal continues to be present in the power sector, it is vital to maximise the uptake and development of these technologies, which can also pave the way for the more cost-effective application of carbon capture.

RAISING EFFICIENCY TO REDUCE CO_2

State-of-the-art 'ultrasupercritical' (USC) coal power plants currently achieve up to around 47% efficiency (LHV, net), equivalent to around 720g CO_2/kWh. As this performance limit is largely set by the steam temperatures achievable with advanced steels, efforts to go beyond have centred on developing an 'advanced USC' plant based on nickel alloys. This technology could see demonstration in the next decade, but more incremental technology development may have more impact in a risk-averse power sector. Smaller increases in steam temperature using new steels, together with advanced steam cycle designs, have the potential to raise efficiencies to approach 50% (around 680 gCO_2/kWh). Several alternative high-efficiency pathways are based on gasified coal, offering potential additional benefits of fuel flexibility, generation of high-value products, and good compatibility with carbon capture.

While less efficient 'subcritical' coal units will be progressively phased out and replaced, several options must be considered for the >240 GW capacity with significant remaining lifetime. Existing upgrading technologies can raise efficiency by up to 5 percentage points, or they may be converted to biomass cofiring, cogeneration units, or highly flexible plant with limited operation. As coal plant increasingly plays a role as dispatchable backup to variable renewables, smaller, flexible USC units (≤300 MW) must also see greater development and deployment.

A PATHWAY TO ULTRA-LOW EMISSIONS

State-of-the-art combustion optimisation and flue gas treatment technologies are capable of almost eliminating SO_2, NOx, particulates, and mercury from coal plant flue gas, with near-zero levels of these species demonstrated at benchmark power plants. Driving the uptake of these solutions is therefore primarily a matter for cost optimisation and policy – particularly in the form of national or local emissions

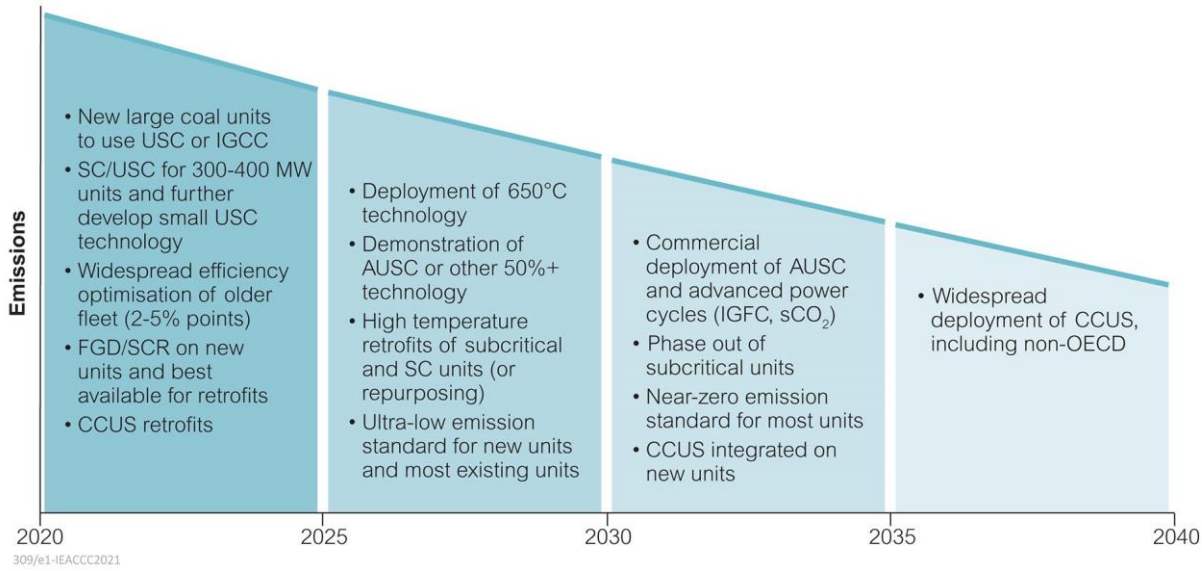
standards. The last decade has seen significant tightening of such legislation beyond the high-income economies, notably including the stringent 'ultra-low emission' standard in China, and requirements for flue gas desulphurisation in India, Indonesia, and South Africa. Innovation in this sector must help ease the financial burden on struggling power sectors by providing technologies with lower capital cost, reduced water consumption, and waste reduction in favour of saleable by-products. A more integrated approach to multipollutant control should be pursued, including anticipation of the future tightening of standards and greater inclusion of trace species such as mercury.

DRIVING HELE DEPLOYMENT

There has been a marked global trend towards adoption of higher efficiency plant designs over the past decade, with USC technology accounting for 47% of capacity installed in 2019, and the proportion of subcritical plants falling to 14%. This trend has been driven partly by the more competitive economics of more efficient plant, but increasingly by climate policy. Countries which have successfully maximised HELE deployment have introduced minimum efficiency standards for new and existing plants, in addition to encouraging attainment of strict emission standards. More competitive power markets can promote efficient operation, but complementary market mechanisms or regulatory intervention may be required to avoid lower-cost, but more polluting units being favoured in merit order dispatch.

All new, large coal units can adopt USC conditions and best-available pollutant controls, while the next decade should see a trend towards 50%+ efficiency plant and widespread attainment of 'ultra-low' levels (<50 mg/m^3) of key pollutants.

As investment and policy in power sector transformation focuses on renewable energy, there is a risk of allowing existing and future coal capacity to operate well below its environmental potential. This is exacerbated by the current flight of international finance and technology providers from the coal sector, as well as the financial and technical challenges of more intermittent operation. While coal remains fundamental to many of the world's grids, the sector should be made viable and supported in a rapid transition to HELE technologies through adequate valuation of dispatchable capacity, continued support for research and development, and greater international collaboration. This roadmap aims to accelerate the transition by setting clear milestones and identifying leading technologies and research priorities.



Roadmap targets for the deployment of high efficiency, low emissions technologies

Each executive summary is based on a detailed study which is available separately from www.iea-coal.org. This is a summary of the report: A technology roadmap for high efficiency, low emissions coal power plant by Toby Lockwood, CCC/309, ISBN 978-92-9029-632-4, 92 pp, February 2021.

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