Improving Efficiencies

A range of advanced coal combustion technologies have been developed to improve the efficiency of coal-fired power generation. New, more efficient coal-fired combustion technologies reduce emissions of CO_2, as well as pollutants such as NOx, SOx and particulates.

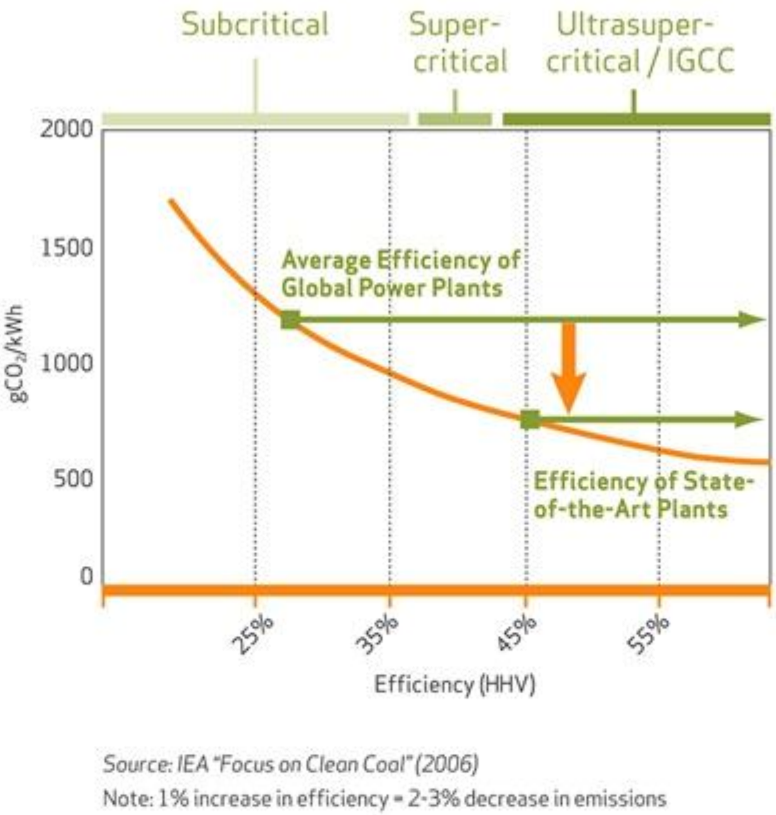
Improving Efficiency Levels

Improving efficiency levels increases the amount of energy that can be extracted from a single unit of coal. Increases in the efficiency of electricity generation are essential in tackling climate change. A one percentage point improvement in the efficiency of a conventional pulverised coal combustion plant results in a 2-3% reduction in CO_2 emissions. Highly efficient modern coal plants emit up to 40% less CO_2 than the average coal plant currently installed.

Efficiency improvements include the most cost-effective and shortest lead time actions for reducing emissions from coal-fired electricity. This is particularly the case in developing and transition countries where existing plant efficiencies are generally lower and coal use in electricity generation is increasing.

The average global efficiency of coal-fired plants is currently 33% compared to 45% for the most efficient plants (see graph). A programme of repowering existing coal-fired plants to improve their efficiency, coupled with the newer and more efficient plant being built, will generate significant CO_2reductions. Although the deployment of new, highly efficient plants is subject to local constraints, such as ambient environmental conditions and coal quality, deploying the most efficient plant possible is critical to enable these plants to be retrofitted with CCS in the future. Efficient plants are a prerequisite for retrofitting with CCS as capturing, transporting and storing the plant's CO_2 consumes significant quantities of energy. Highly inefficient plants will undermine capacity to deploy CCS technologies.

Improving the efficiency of the oldest and most inefficient coal-fired plants would reduce CO_2emissions from coal use by almost 27% representing nearly a 7% reduction in global CO_2emissions. These significant emissions reductions can be achieved by the replacement of plants < 300 MW capacity and older than 25 years, with larger and significantly more efficient plants and where technically and economically appropriate the replacement or repowering of larger inefficient plants with high-efficient plants of >40%.



Improving the Efficiency of Coal-fired Power Plants Reduces CO_2 Emissions
Improvements in the efficiency of coal-fired power plants can be achieved with technologies

including:

- *Fluidised Bed Combustion*
- *Supercritical & Ultrasupercritical Boilers*
- *Integrated Gasification Combined Cycle*

Fluidised Bed Combustion

Fluidised Bed Combustion (FBC) is a very flexible method of electricity production – most combustible material can be burnt including coal, biomass and general waste. FBC systems improve the environmental impact of coal-based electricity, reducing SOx and NOx emissions by 90%.
In fluidised bed combustion, coal is burned in a reactor comprised of a bed through which gas is fed to keep the fuel in a turbulent state. This improves combustion, heat transfer and recovery of waste products. The higher heat exchanger efficiencies and better mixing of FBC systems allows them to operate at lower temperatures than conventional pulverised coal

combustion (PCC) systems. By elevating pressures within a bed, a high-pressure gas stream can be used to drive a gas turbine, generating electricity.

FBC systems fit into two groups, non-pressurised systems (FBC) and pressurised systems (PFBC), and two subgroups, circulating or bubbling fluidised bed.

- *Non-pressurised FBC systems operate at atmospheric pressure and are the most widely applied type of FBC. They have efficiencies similar to PCC – 30-40%*
- *Pressurised FBC systems operate at elevated pressures and produce a high-pressure gas stream that can drive a gas turbine, creating a more efficient combined cycle system – over 40%*
- *Bubbling uses a low fluidising velocity – so that the particles are held mainly in a bed – and is generally used with small plants offering a non-pressurised efficiency of around 30%*
- *Circulating uses a higher fluidising velocity – so the particles are constantly held in the flue gases – and are used for much larger plant offering efficiency of over 40%*

The flexibility of FBC systems allows them to utilise abandoned coal waste that previously would not be used due to its poor quality.

Supercritical & Ultrasupercritical Technology

New pulverised coal combustion systems – utilising supercritical and ultra-supercritical technology – operate at increasingly higher temperatures and pressures and therefore achieve higher efficiencies than conventional PCC units and significant CO_2 *reductions.*

Supercritical steam cycle technology has been used for decades and is becoming the system of choice for new commercial coal-fired plants in many countries.

Research and development is under way for ultra-supercritical units operating at even higher efficiencies, potentially up to around 50%. The introduction of ultra-supercritical technology has been driven over recent years in countries such as Denmark, Germany and Japan, in order to achieve improved plant efficiencies and reduce fuel costs. Research is focusing on the development of new steels for boiler tubes and on high alloy steels that minimise corrosion.

These developments are expected to result in a dramatic increase in the number of SC plants and USC units installed over coming years.

Integrated Gasification Combined Cycle (IGCC)

An alternative to achieving efficiency improvements in conventional pulverised coal-fired power stations is through the use of gasification technology. IGCC plants use a gasifier to convert coal (or other carbon-based materials) to syngas, which drives a combined cycle turbine.

Coal is combined with oxygen and steam in the gasifier to produce the syngas, which is mainly H_2*and carbon monoxide (CO). The gas is then cleaned to remove impurities, such as* *sulphur, and the syngas is used in a gas turbine to produce electricity. Waste heat from the gas turbine is recovered to create steam which drives a steam turbine, producing more electricity – hence a combined cycle system.*

By adding a 'shift' reaction, additional hydrogen can be produced and the CO can be converted to CO_2 which can then be captured and stored. IGCC efficiencies typically reach the mid-40s, although plant designs offering around 50% efficiencies are achievable.

Reliability and availability have been challenges facing IGCC development and commercialisation. Cost has also been an issue for the wider uptake of IGCC as they have been significantly more expensive than conventional coal-fired plant.

Gasification may also be one of the best ways to produce clean-burning hydrogen for tomorrow's cars and power-generating fuel cells. Hydrogen and other coal gases can be used to fuel power-generating turbines, or as the chemical building blocks for a wide range of commercial products, including diesel and other transport fuels.