# Coal-Fired Power

## HIGHLIGHTS

**PROCESS AND TECHNOLOGY STATUS –** Some 42% of the world's electricity production is based on coal combustion. The world's coal-fired capacity is 1440 $GW_e$ out of a global capacity of 4509 $GW_e$ (2007). In China, around 71% of the total installed capacity (502 $GW_e$ out of 706 $GW_e$, 2007) is based on coal-fired power plants. Currently, super-critical pulverised coal (**SCPC**) power - a mature technology - is the dominant option for new coal-fired power plants. In a SCPC power plant, pulverised coal combustion generates heat that is transferred to the boiler to generate supercritical steam. The steam is then used to drive a steam turbine and an electricity generator. Pulverised coal-fired power plants produce a considerable amount of airborne emissions. A 1,000 $MW_e$ supercritical plant emits about 5.2 million tonnes (Mt) of $CO_2$ per year, in addition to smaller but significant amounts of $SO_2$, $NO_x$, particulate matter (PM), and minor amounts of mercury. An alternative to the SCPC technology is the integrated gasification combined cycle (**IGCC**). In the IGCC plants, a thermo-chemical reaction with oxygen and steam is used to convert liquid or solid fossil fuels (e.g. hard coal) into a gas mixture of carbon monoxide (CO), hydrogen ($H_2$), and carbon dioxide ($CO_2$), along with small amounts of hydrogen sulphide ($H_2S$). After cleaning, the gas is fired in a gas turbine to generate electricity. The exhaust gas is used to produce superheated steam (in the heat recovery steam generator, HRSG) that drives a steam turbine and generates further electricity. The IGCC technology is less mature than SCPC technology. Several IGCC plants have been built in the US and in Europe. They have efficiency similar to that of SCPC plants, but lower non-greenhouse gas (GHG) emissions.

**PERFORMANCE AND COSTS –** Technological development aims to increase the efficiency and decrease the investment cost and the emissions of coal-fired power. The generating efficiency of SCPC plants is expected to increase from the current (2010) maximum value of 46% (lower heating value, LHV) to some 50% for 'ultra-supercritical' technology in 2020. Efficiency and reliability improvements are also expected for the IGCC technology. Its efficiency is estimated to grow from 46% in 2010 to 52% in 2020. In the IGCC plants, the production of $CO_2$ during the gasification process offers the opportunity for relatively low-cost $CO_2$ capture and storage (CCS), which may give the future IGCC plants some competitive and environmental advantages over SCPC. As far as costs are concerned, due to the increasing prices of materials, steel and equipment, the investment cost of a pulverised coal-fired power plant increased from \$1500/$kW_e$ in 2000 to approximately \$2200/$kW_e$ in 2008 (costs are quoted in US\$ 2008). Since the 2008 peak, investment costs have been slightly declining because of the reduction of the material cost induced by the economic crisis and the lower demand for new capacity. The IGCC investment cost is relatively high. It may be up to almost twice the cost of SCPC plants. The operation and maintenance cost (O&M cost, expressed in \$/$kW_e$ per year) is estimated at 4% of the investment cost per year for both SCPC and IGCC, but the IGCC plants may face higher O&M costs because of a lower technology maturity. Average costs of electricity today from SCPC are \$60–70/MWh (typically \$65/MWh), of which \$15–25/MWh is for the fuel. For IGCC plants, corresponding figures are \$90–100 (typically \$95/MWh), with \$15–25/MWh for the fuel. In terms of cost projections, technology learning is not expected to dramatically reduce the SCPC investment costs as the technology is mature. Therefore, the costs of supercritical and ultra-supercritical pulverised coal power plants are expected to decline from \$2200/$kW_e$ in 2010, to \$2000/$kW_e$ in 2020, and to \$1800/$kW_e$ in 2030. On the other hand, technology learning may significantly reduce the IGCC investment cost from \$3700/$kW_e$ in 2010 (70% more than PC) to \$2800/$kW_e$ in 2020, and to \$2200/$kW_e$ in 2030 (20-25% more than PC).

**POTENTIAL & BARRIERS –** Numerous coal-fired power plants are under construction or being planned in many countries. In the US, some 16 $GW_e$ were under construction in January 2009 and a further 10 $GW_e$ were approved for construction, some of which are to replace retired capacity. Coal-fired power offers advantages over gas-fired power if the natural gas price is high and/or volatile, or in light of supply security issues. New coal-fired power plants have higher efficiency and lower emission of $CO_2$ per kWh than existing plants. Emissions of airborne pollutants may be lower as well. A disadvantage is the high investment cost (compared to gas-fired power) that is compensated for by the lower fuel cost. The price of $CO_2$ may also be a barrier for new coal-fired capacity. The current price in the European emission trading system (some €13-14/$tCO_2$,) is not high enough to discourage the construction of new coal-fired capacity. However, uncertainties about future $CO_2$ prices can make it difficult to adopt new investment strategies. In the near future, the utilities that have to comply with emissions trading systems may consider implementing $CO_2$ capture and storage technologies (CCS). This may significantly increase the investment cost and reduce the efficiency of coal-fired power. Therefore, long-term emission reduction policies and high $CO_2$ prices are needed for CCS to become commercially available. Coal-fired power not only competes with gas-fired power, but also with nuclear and renewable power. While some renewable technologies are growing fast and will have an increasing impact on the electricity market, the competition with nuclear power will largely depend on licensing and regulatory aspects, environmental issues, social acceptance, and long-term $CO_2$ policies.



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