



executive summary

Operating ratio and cost of coal power generation

Coal has been the cornerstone fuel of the global energy system since the industrial revolution. Today, projections, estimates and forecasts indicate that the future of coal is uncertain and its utilisation will continue to decline. This is attributed to market sources, regulations and environmental pressures. However, in 2016, global data show that coal remains the second source of primary energy and continues to be the first source of energy for power generation. The review presents the concept of operating ratio in coal power generation but focuses on the costs, especially operating and maintenance (O&M) of pulverised coal power generation at the plant.

Operating ratio

Operating ratios are a representation of revenue and expense categories found on a typical company's financial (profit and loss) statement. The revenue ratios are a per cent of total revenue and the expense ratios are also a per cent of total revenue. As such, revenue ratios total 100%; expense ratios may or may not. Expense ratios totalling less than 100% denote an operating surplus. Those totalling more than 100% denote an operating deficit. In the case of deficits, a power company would either draw on reserves or carry the deficit as debt into the next fiscal year. In the context of the review, in simple terms, the operating ratio is power generation operating expenses to revenue. An operating ratio is usually given in percentage terms. The formula used in the review for calculating operating ratios is: $\text{Operating ratio} = \text{Operating expenses} / \text{revenue or sales} * 100$.

The operating ratios were calculated for the companies listed below from their 2015 annual reports (available in the public domain). The exercise was undertaken simply to indicate the year-on-year operational efficiency of these major power generating companies and, to show where the operating ratio improved and/or deteriorated. ***The operating ratios must not be compared between the different companies as the information provided in the consolidated financial statements differs from one power supplier to another in that there is no detailed/exact breakdown of all operating costs.***

- EDF (France)
- Enel (Italy)
- E.ON/Uniper (Germany)
- Iberdrola (Spain)
- Duke Energy (USA)
- Exelon (USA)
- Southern Company (USA)
- NextEra Energy (USA)
- Dominion Resources (USA)
- SSE (UK)
- China Datang Corporation (China)
- NTPIC (India)

Coal power plant generating cost parameters

Power generation entails fixed and variable costs. Fixed costs are essentially capital and land costs. Operating costs include fuel, labour and maintenance. Most existing coal-fired plants were designed to operate at full or baseload to maximise efficiency, reliability, and

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revenue. The increased utilisation of intermittent renewable energy has necessitated the flexible operation of these plants, which means more frequent start-ups/shut-downs and more aggressive ramp rate, which can result in increased component failure, unplanned/forced outages, increased heat rate and decreased revenue.

Typical capital and operating costs for selected power plants		
Technology	Capital cost, US\$/kW	Operating cost, US\$/kWh
Pulverised-coal combustion	500–1000	0.02–0.04
Natural gas combustion	400–800	0.04–0.10
Wind turbine (including offshore)	1200–5000	<0.01
Nuclear	1200–5000	0.02–0.05
Photovoltaic solar	≥4500	<0.01

Profitable, long-term operation of a power plant involves providing maximum availability by optimising equipment life. This can be achieved by developing and implementing effective maintenance, environmental, and safety management programmes. Preventative, predictive and scheduled maintenance procedures would result in achieving maximum plant availability, equipment reliability and minimise forced outages. Generation cost parameters include:

- Start-up (non-fuel) (US\$/MW) is the starting of a unit that is offline. Starts are described as hot, warm, or cold, depending on the temperatures of the metal in the turbine. Start-ups impact costs as the fuel consumption and manpower requirements are higher than when the plant operates at generation capacity, which is the maximum output it can produce under specific conditions.
- Cycling, which is a range of operations in which a plant’s output changes, including start-up and shut-down, ramping up and down, and operating at part-load (less than full output). Ramping results in output that varies between full and minimum levels in order to follow changes in generation demand.
- Ramping penalty. Significant ramping (up and down) of baseload coal-fired plant results in increases in maintenance cost and decreased time between maintenance work. The ramping rate, up or down defines the unit capability to move within the hour; ramping penalty, however, controls the unit ability to respond to changes. A question arises: whether the penalty cost is reported as part of O&M costs or not. Either way, a ramping penalty can impact on the operating cost.
- Forced Outage is an unplanned component failure (immediate, delayed, start-up failure) or other condition that requires the unit to be removed from service immediately or within a specific time. Equivalent forced outage rate (EFOR) is a measure of the probability that a generating unit will not be available due to forced outages or forced deratings. The lower the EFOR, the better the performance of the unit. EFOR is also considered a measure of reliability.
- Variable operation and maintenance (VOM) includes wear and tear. Wear means the component reaches the end of its natural life through ordinary causes (such as corrosion or thermal fatigue), but can be accelerated by cycling. Tear refers to an abnormal event that accelerates the end of life, such as that which occurs during poor control of operating conditions. Tear can occur during baseload operations, but abnormal events are more likely during some cycling modes.

The likelihood of significant new coal generation coming online in Europe, the USA and Australia is low. However, coal power generation continues to grow in other parts of the world, mainly China, India and Southeast Asia. Many conventional, existing coal-fired plants were built prior to the expansion targets for and adoption of intermittent wind and solar power. In many of these plants, measures to allow greater flexibility have been implemented subsequently, so that power plants can meet increased requirements for market load adjustments. As a result, many baseload power plants have been modified or are taking the necessary steps to allow for flexible operation at reasonable cost.