

Thermal Power: Guidelines for New Plants

Industry Description and Practices

This document sets forth procedures for establishing maximum emissions levels for all fossil-fuel-based thermal power plants with a capacity of 50 or more megawatts of electricity (MWe) that use coal, fuel oil, or natural gas.¹

Conventional steam-producing thermal power plants generate electricity through a series of energy conversion stages: fuel is burned in boilers to convert water to high-pressure steam, which is then used to drive a turbine to generate electricity.

Combined-cycle units burn fuel in a combustion chamber, and the exhaust gases are used to drive a turbine. Waste heat boilers recover energy from the turbine exhaust gases for the production of steam, which is then used to drive another turbine. Generally, the total efficiency of a combined-cycle system in terms of the amount of electricity generated per unit of fuel is greater than for conventional thermal power systems, but the combined-cycle system may require fuels such as natural gas.

Advanced coal utilization technologies (e.g., fluidized-bed combustion and integrated gasification combined cycle) are becoming available, and other systems such as cogeneration offer improvements in thermal efficiency, environmental performance, or both, relative to conventional power plants. The economic and environmental costs and benefits of such advanced technologies need to be examined case by case, taking into account alternative fuel choices, demonstrated commercial viability, and plant location. The criteria spelled out in this document apply regardless of the particular technology chosen.

Engine-driven power plants are usually considered for power generation capacities of up to 150 MWe. They have the added advantages of shorter

building period, higher overall efficiency (low fuel consumption per unit of output), optimal matching of different load demands, and moderate investment costs, compared with conventional thermal power plants. Further information on engine-driven plants is given in Annex A.

Waste Characteristics

The wastes generated by thermal power plants are typical of those from combustion processes. The exhaust gases from burning coal and oil contain primarily particulates (including heavy metals, if they are present in significant concentrations in the fuel), sulfur and nitrogen oxides (SO_x and NO_x), and volatile organic compounds (VOCs). For example, a 500 MWe plant using coal with 2.5% sulfur (S), 16% ash, and 30,000 kilojoules per kilogram (kJ/kg) heat content will emit each day 200 metric tons of sulfur dioxide (SO₂), 70 tons of nitrogen dioxide (NO₂), and 500 tons of fly ash if no controls are present. In addition, the plant will generate about 500 tons of solid waste and about 17 gigawatt-hours (GWh) of thermal discharge.

This document focuses primarily on emissions of particulates less than 10 microns (μm) in size (PM₁₀, including sulfates), of sulfur dioxide, and of nitrogen oxides. Nitrogen oxides are of concern because of their direct effects and because they are precursors for the formation of ground-level ozone. Information concerning the health and other damage caused by these and other pollutants, as well as on alternative methods of emissions control, is provided in the relevant pollutant and pollutant control documents.

The concentrations of these pollutants in the exhaust gases are a function of firing configuration, operating practices, and fuel composition. Gas-fired plants generally produce negligible

panded or other pollution sources will increase significantly, the analysis should take account of the impact of the proposed plant design both immediately and after any probable expansion in capacity or in other sources of pollution. The EA should also include impacts from construction work and other activities that normally occur, such as migration of workers when large facilities are built. Plant design should allow for future installation of additional pollution control equipment, should this prove desirable or necessary.

The EA should also address other project-specific environmental concerns, such as emissions of cadmium, mercury, and other heavy metals resulting from burning certain types of coal or heavy fuel oil. If emissions of this kind are a concern, the government (or the project sponsor) and the World Bank Group will agree on specific measures for mitigating the impact of such emissions and on the associated emissions guidelines.

The quality of the EA (including systematic cost estimates) is likely to have a major influence on the ease and speed of project preparation. A good EA prepared early in the project cycle should make a significant contribution to keeping the overall costs of the project down.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the EA process on the basis of country legislation and the *Pollution Prevention and Abatement Handbook*, as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The following maximum emissions levels are normally acceptable to the World Bank Group in making decisions regarding the provision of World Bank Group assistance for new fossil-fuel-fired thermal power plants or units of 50 MWe or larger (using conventional fuels). The emissions levels have been set so they can be achieved by adopting a variety of cost-effective options or technologies, including the use of clean fuels or washed coal. For example, dust controls capable of over 99% removal efficiency, such as electrostatic precipitators (ESPs) or baghouses, should always be installed for coal-fired power plants. Similarly, the use of low-

NO_x burners with other combustion modifications such as low excess air (LEA) firing should be standard practice. The range of options for the control of sulfur oxides is greater because of large differences in the sulfur content of different fuels and in control costs. In general, for low-sulfur (less than 1% S), high-calorific-value fuels, specific controls may not be required, while coal cleaning, when feasible, or sorbent injection (in that order) may be adequate for medium-sulfur fuels (1–3% S). FGD may be considered for high-sulfur fuels (more than 3% S). Fluidized-bed combustion, when technically and economically feasible, has relatively low SO_x emissions. The choice of technology depends on a benefit-cost analysis of the environmental performance of different fuels and the cost of controls.

Any deviations from the following emissions levels must be described in the World Bank Group project documentation.

Air Emissions

The maximum emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems. In contrast, poor operating or maintenance procedures affect actual pollutant removal efficiency and may reduce it to well below the design specification. The maximum emissions levels are expressed as concentrations to facilitate monitoring. Dilution of air emissions to achieve these guidelines is unacceptable. Compliance with ambient air quality guidelines should be assessed on the basis of good engineering practice (GEP) recommendations. See Annex C for ambient air quality guidelines to be applied if local standards have not been set.³ Plants should not use stack heights less than the GEP recommended values unless the air quality impact analysis has taken into account building downwash effects. All of the maximum emissions levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.⁴ The remaining 5% of annual operating hours is assumed to be for start-up, shutdown, emergency fuel use, and unexpected incidents. For peaking units where the start-up mode is expected to be longer than 5% of the annual operating hours,

exceedance should be justified by the EA with regard to air quality impacts.

Power plants in degraded airsheds. The following definitions apply in airsheds where there already exists a significant level of pollution.

An airshed will be classified as having *moderate air quality* with respect to particulates, sulfur dioxide, or nitrogen dioxide if either 1 or 2 applies:

1. (a) The annual mean value of PM_{10} exceeds 50 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) for the airshed ($80 \mu\text{g}/\text{m}^3$ for total suspended particulates, TSP); (b) the annual mean value of sulfur dioxide exceeds $50 \mu\text{g}/\text{m}^3$; or (c) the annual mean value of nitrogen dioxide exceeds $100 \mu\text{g}/\text{m}^3$ for the airshed.

2. The 98th percentile of 24-hour mean values of PM_{10} , sulfur dioxide, or nitrogen dioxide for the airshed over a period of a year exceeds $150 \mu\text{g}/\text{m}^3$ ($230 \mu\text{g}/\text{m}^3$ for TSP).

An airshed will be classified as having *poor air quality* with respect to particulates, sulfur dioxide, or nitrogen dioxide if either 1 or 2 applies:

1. (a) The annual mean of PM_{10} exceeds $100 \mu\text{g}/\text{m}^3$ for the airshed ($160 \mu\text{g}/\text{m}^3$ for TSP); (b) the annual mean of sulfur dioxide exceeds $100 \mu\text{g}/\text{m}^3$ for the airshed; or (c) the annual mean of nitrogen dioxide exceeds $200 \mu\text{g}/\text{m}^3$ for the airshed.

2. The 95th percentile of 24-hour mean values of PM_{10} , sulfur dioxide, or nitrogen dioxide for the airshed over a period of a year exceeds $150 \mu\text{g}/\text{m}^3$ ($230 \mu\text{g}/\text{m}^3$ for TSP).

Plants smaller than 500 MWe in airsheds with moderate air quality are subject to the maximum emissions levels indicated below, provided that the EA shows that the plan will not lead *either* to the airshed dropping into the “poor air quality” category *or* to an increase of more than $5 \mu\text{g}/\text{m}^3$ in the annual mean level of particulates (PM_{10} or TSP), sulfur dioxide, or nitrogen dioxide for the entire airshed. If either of these conditions is not satisfied, lower site-specific emissions levels should be established that would ensure that the conditions can be satisfied. The limit of a $5 \mu\text{g}/\text{m}^3$ increase in the annual mean will apply to the cumulative total impact of all power plants built in the airshed within any 10-year period beginning on or after the date at which the guidelines come into effect.

Plants larger than or equal to 500 MWe in airsheds with moderate air quality and all plants in airsheds with poor air quality are subject to site-specific requirements that include offset provisions to ensure that (a) there is no net increase in the total emissions of particulates or sulfur dioxide within the airshed and (b) the resultant ambient levels of nitrogen dioxide do not exceed the levels specified for moderately degraded airsheds.⁵ The measures agreed under the offset provisions must be implemented before the power plant comes fully on stream. Suitable offset measures could include reductions in emissions of particulates, sulfur dioxide, or nitrogen dioxide as a result of (a) the installation of new or more effective controls at other units within the same power plant or at other power plants in the same airshed, (b) the installation of new or more effective controls at other large sources, such as district heating plants or industrial plants, in the same airshed, or (c) investments in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boilers.⁶ The monitoring and enforcement of the offset provisions would be the responsibility of the local or national agency responsible for granting and supervising environmental permits. Such offset provisions would normally be described in detail in a specific covenant in the project loan agreement.

Project sponsors who do not wish to engage in the negotiations necessary to put together an offset agreement would have the option of relying on an appropriate combination of clean fuels, controls, or both.

Particulate matter. For all plants or units, PM emissions (all sizes) should not exceed $50 \text{ mg}/\text{Nm}^3$.⁷ The EA should pay specific attention to particulates smaller than $10 \mu\text{m}$ in aerodynamic diameter (PM_{10}) in the airshed, since these are inhaled into the lungs and are associated with the most serious effects on human health. Where possible, ambient levels of fine particulates (less than $2.5 \mu\text{m}$ in diameter) should be measured. Recent epidemiologic evidence suggests that much of the health damage caused by exposure to particulates is associated with these fine particles, which penetrate most deeply into the lungs. Emissions of PM_{10} and fine particulates include ash, soot, and carbon compounds (often