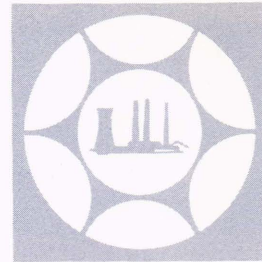


POWER PLANT



SITE EVALUATION PROGRAM

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I. GENERATION AND SITING

Rapid expansion of electric power generation, in response to rapidly increased electric power demand, is in confrontation with public demand for environmental protection. The Johns Hopkins University is conducting comprehensive power plant site evaluations for the State of Maryland in response to these demands as embodied in the Maryland Power Plant Siting Law.

Historical Trends

AMERICANS ARE PRODIGIOUS USERS OF ENERGY. With 6% of the world's population, the U.S. has been consuming approximately one-third of the world's energy production; and the use of energy continues to grow. These facts are compatible with, and in fact largely responsible for, the high gross national product, the high individual incomes, and the general high level of material wealth which we enjoy.

Electrical energy is the most rapidly growing form of energy utilization today with an annual growth rate of some 7% to 10% up to the time of the recent energy crisis in 1973. Electricity production now constitutes about 25% of the energy fuel utilization in the United States.

As the demand for electricity has increased, the basic energy forms used in its production have also changed. Whereas 25 years ago, nearly 50% of the electrical power was derived from coal, today oil and gas combined account for approximately three-fourths of the total fuel requirements with the major burden being placed on the oil supply. While this change came about naturally as the result of a search for cleaner, more economical, and more convenient fuel, and has been

reinforced by the environmental considerations embodied in the National Environmental Policy Act (NEPA), it is now becoming clear that expanded usage of these cleaner, more convenient fuels may no longer be possible.¹ Pressures are developing for reserving these fuels for use in the transportation and petrochemical sectors of the economy, and alternate sources may well be required for the electrical industry.

Forecasts

Faced with this past history, public utilities have initiated planning for increasing the electrical supply at rates varying from 5 to 10% per year over the next decade. Many expert opinions anticipate a decrease in the rate of growth beyond that time due to factors such as price increase, conservation measures, and decreased population growth rate. Nevertheless, significant amounts of new electrical power will be required, and its generation must be accommodated (or limited) by the available fuel supplies and accomplished within the environmental constraints that are imposed.

¹ Report of the Cornell Workshops on the Major Issues of a National Energy Research and Development Program, Chapter I, Cornell University, Dec. 1973.

Present indications are that the next 30 years will see nuclear energy used to produce 50% of the generated electricity; hydroelectric and fossil fuel will account for 12% and 38% respectively in the United States. This anticipates a dramatic increase in the generation of power from nuclear fuel, a significant increase in the generation of power from fossil fuel, and a significant increase in the percentage use of coal; but the fossil fuel mix ultimately achievable is critically dependent on developments in mining, liquefaction, or gasification, and the availability and costs of imported oil.²

Site Evaluation Environmental Considerations

Concurrently with these developments in power generation technology, a public awareness of possible adverse environmental effects of industrial development arose. In Maryland, public opposition to the Calvert Cliffs nuclear plant centered on the facts that construction work had been initiated prior to approval by the Public Service Commission and the granting of required water use permits. State legislation was enacted to require such approvals in the future. Nevertheless, opponents of Calvert Cliffs continued to raise the issue that no adequate scientific basis for predicting the long-term environmental effects of the plant existed. Ultimately this matter was litigated in the Federal Courts resulting in the "Calvert Cliffs Decision" requiring the U. S. Atomic Energy Commission to conduct a full environmental impact study for all nuclear plants. Approval was to be dependent on environmental acceptability as well as the other issues considered by regulatory agencies.

General public concern and the legal requirements embodied in NEPA now require that each new nuclear power plant site proposed be subjected to various levels of environmental impact evaluations prior to the approval of construction and/or operation. In the State of Maryland, Power Plant Siting Legislation now requires such an evaluation of all power plants. The responsibility for conducting these evaluations resides in the Maryland Power Plant Siting Program, an interdepartmental program which involves the State Departments of Planning, Economic, and Community

Development; Transportation; Health and Mental Hygiene; and Natural Resources; the staff is housed in the Department of Natural Resources. The Johns Hopkins University, specifically the Department of Geography and Environmental Engineering (DOGEE), the Chesapeake Bay Institute (CBI), and the Applied Physics Laboratory conduct the experimental and analytical studies and prepare a detailed environmental impact evaluation report for each proposed power plant site. The study is initiated after a site has been identified to the Maryland Public Service Commission by a utility company. Such evaluations have now been completed for two fossil fuel plants; the first, an oil-burning plant at Brandon Shores on the Patapsco River, and the second, a coal-burning plant at Dickerson on the Potomac. Work is currently underway on the environmental impact studies of the Douglas Point, Perryman, and Chesapeake City sites, all of which are proposed nuclear power generation stations, and at a diesel electric plant site at Easton. All currently planned large electric power plants utilize steam electric generation systems with the fossil fuel or nuclear energy providing the source of heat for steam generation. Current trends favor the construction of large power plants at locations remote from the load centers.

It is characteristic that the steam electric plant rejects more than 60% of the available heat energy in the fuel as low-temperature waste heat. Figure 1 presents the input/output flows of a typical coal-fired plant and illustrates some of the numerous environmental impacts that must be considered. In addition, the questions of aesthetics and visual intrusion are of great concern to many of the nearby neighbors of such generating stations. Because of the very large size of the plants currently being proposed (characteristically 1500 Megawatt Electric (MWe) to 2500 MWe), the condenser cooling system for these plants constitutes a prime source of possible environmental impact. In the past, condenser cooling has been accomplished by a once-through system which takes water directly from a stream or reservoir, passes it through the system, and releases it back into a receiving water supply. Such systems require large quantities of water and entail the risk of entrainment or entrapment of aquatic life and the return of potentially harmful heated water and toxic chemicals into the receiving waters. Because

² See p. 31 of Ref. 1.

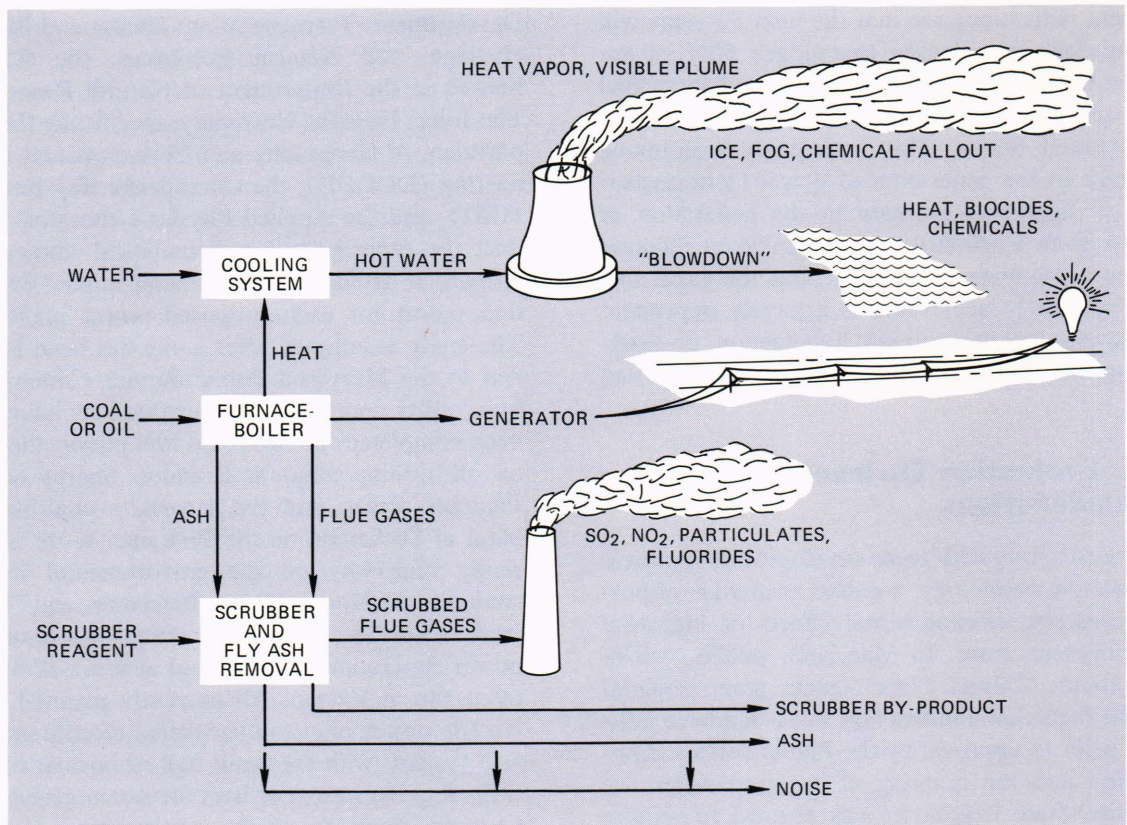


Fig. 1—Interactions between power plant and environment.

the requirements for cooling water are very great, there is increasing impetus to place power plants on sites that are biologically sensitive in that they may be adjacent to spawning grounds, fish nurseries, or shellfish beds. In addition, large quantities of cooling water are sometimes not readily available. At such sites, waste heat is rejected by evaporative cooling towers because they require significantly less water than a once-through system. Such towers have possible environmental impacts in their own right. While the impact on receiving waters can be very greatly reduced, the waste heat must be dispersed into the air, carrying with it large quantities of water vapor and mist which provide a potential for icing, clouds, and chemical fallout on the land.

A second major source of environmental insult associated with fossil fuel plants is that produced by the combustion products in the forms of gaseous and particulate emission from stacks and solid waste which results from furnace ash and the stack gas cleaning processes. Allowable limits to air pollution from such combustors are specified by both Federal and State standards. It is

necessary to ensure that a power plant proposed for any particular site will conform to these ambient air quality specifications in the neighborhood around the plant. The achievement of the air quality criteria is greatly complicated by the use of coal as a fuel. For large coal-fired plants, particulate removal of greater than 99% effectiveness is required; and the use of the more abundant, higher sulfur coals, e.g., 2 to 5% sulfur, requires highly efficient scrubbers for the removal of the gaseous sulfur dioxide formed during combustion. Low sulfur coal, e.g., less than 1% sulfur content, is not sufficiently available to satisfy the need.

Analytical techniques have been devised to allow prediction of the spatial and temporal distribution of air pollution from these plants and, thus far, have confirmed that, for the two plants studied, the ambient air quality standards can be met. For the Dickerson plant,³ where coal is to be used as fuel, high efficiency particulate pre-

³ *Power Plant Site Evaluation Report—Dickerson Site*, PPSE 3-1, The Johns Hopkins University, Applied Physics Laboratory, Apr. 30, 1973.

cipitators, 90% effective sulfur dioxide scrubber systems, and tall stacks are required. At the present time, however, many scrubbing systems are only in the pilot plant or prototype stage. Furthermore, the by-products of limestone scrubbers have very undesirable properties for use as landfill. Alternative scrubber processes, under development, provide for chemical regeneration of the scrubber material and the production of elemental sulfur or sulfuric acid as a by-product. Such products are marketable in modest quantities; but the amount produced by the electrical power generation system could far surpass the currently projected demand so that a disposal problem could arise with these products as well. It is fortunate, however, that elemental sulfur is a relatively inactive, relatively insoluble, easily storable material; and it appears that systems producing elemental sulfur as the final product are currently to be preferred.

Many coals contain about 15% ash, and this material appears as solid waste (mostly fly ash) which must be disposed of after the combustion process. Consideration of the many millions of tons of coal that will be required for the electric utility system and the many millions of tons of ash that must be disposed of, gives some indication of the ash disposal problem which arises from the use of coal as fuel. Current discussions relative to this problem lead to the desire to return the ash to the coal mines for disposal.

Nuclear power plants present the problem of the control of radioactive releases, both to water and air. This problem has been under very close scrutiny by the U. S. Atomic Energy Commission throughout the development of reactor systems. For each such plant site, the impact study requires careful tracing of the pathways of all aqueous and airborne radioactive materials which might impact on people or biota and calculations of associated dose rates (dosages) under a variety of operating conditions. For normal radiological releases it is only necessary to verify that the radiation waste treatment facilities are adequate to assure that the radiation exposure from those releases will be small compared to the exposure a person receives from natural sources. Other concerns about nuclear power relate to the possibility of a severe accident, safeguarding weapons grade fissionable material, ultimate disposal of radioactive wastes, and the prevention of sabotage

which could precipitate a serious radioactive release.

All power plants offer the potential of noise impact upon the surrounding community. This can be treated analytically and it appears that by proper precaution in the design of the plant, noise can be kept to acceptable levels at the plant boundary in most instances. In addition, there are problems of aesthetics and community acceptability which must be treated in considering each plant. Power plants have the potential of placing a substantial burden on groundwater availability in the vicinity of the site. Field tests and modeling are used to evaluate this potential. As with all large construction projects, sediment runoff and erosion must be controlled; after dredging, dredge spoil disposal must be controlled.

The Johns Hopkins University, in conducting these impact studies, attempts to be objective, quantitative, and whenever possible, to relate directly to the standards which have been established by regulatory agencies. In many instances, standards are nonexistent or subject to various interpretations. In such instances, quantitative answers are given, if at all possible, with a further requirement that the studies be done in sufficient

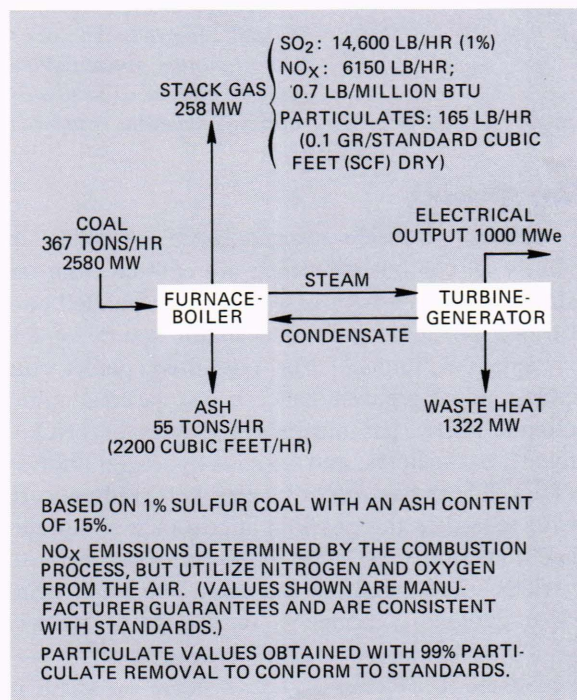


Fig. 2—Power generation flow chart using coal.

depth, that the conclusions derived therefrom can be defended under the questioning of knowledgeable intervenors and withstand the scrutiny of competent scientific review.

The Representative Electric Generating Plant (1000 MWe)

Modern steam-electric generating plants utilize generating modules of approximately 500 to 1000 megawatt electric output (MWe) and are typically being proposed as multiple units with total capacities up to 2500 MWe. For purposes of quantification, the following analysis relates to a "typical" 1000 MWe installation. This is convenient because most of the input-output relationships scale linearly; however, in predicting environmental impact, such linear scaling is not always possible or

appropriate. The representative plant discussed here is a coal-fired unit similar to that proposed for the plant expansion at Dickerson, Maryland. Nuclear power generation is not treated in detail in this review.

Figure 2 sets forth the basic operating parameters used in the evaluation of aquatic and air impact of this representative plant. Various scrubber configurations influence the total solid waste residuals. The methods by which these various factors are considered in the detailed site evaluation are treated.

The discussion emphasizes those areas of evaluation accomplished by APL. The areas of marine biology and hydrology are principally responsibilities of the Department of Geography and Environmental Engineering and the Chesapeake Bay Institute.

II. THE IMPACT OF COMBUSTION PRODUCTS*

The gaseous and solid products of fossil fuel combustion provide a major source of atmospheric pollution. Large fossil fueled electric generating plants are major sources of such emissions. Accurate prediction of the dispersion of pollutants and an evaluation of the efficacy of the best available technology for air pollution reduction are vital elements in impact prediction. Unfortunately, those pollutants removed from the flue gases usually appear as solid waste. Disposal to protect the land and groundwater resources is required.

Air Quality

General Considerations—Those products of fossil fuel combustion which are emitted from the stacks, including both gaseous and suspended particulate portions, provide a major source of environmental impact. For coal-fired plants, the emissions of greatest concern are gaseous sulfur dioxide (SO₂), gaseous oxides of nitrogen (NO_x), fly ash particulates, and gaseous hydrogen fluoride (HF). There has recently been increased concern with regard to the possible importance of sulfates and the submicron sized particles of the salts of various trace metals in the coal. The other principal gaseous components of flue gases, namely

carbon dioxide (CO₂) and unreacted nitrogen are not ordinarily treated as pollutants.

In various concentrations, these combustion products could produce effects which vary from serious damage to the health of people, domestic animals, and plants, to less serious conditions of discomfort, odor, and soiling. The effects are highly variable from species to species, and individual to individual, and in addition, many types of plant life appear to be more sensitive to these pollutants than are animals. Work under way in other laboratories is directed toward further refinement of our knowledge in these areas; however, conclusive evidence is not easily obtained and often relies on tedious, time-consuming, and expensive epidemiological studies.

As a practical working tool for the pollution control engineer, both the Federal government

* In addition to the authors, Mr. J. A. Kagan and Mr. J. H. Meyer of the Power Plant Site Evaluation Staff made substantive contributions to Chapter II through the conduct of experiments, the analysis of data and the conduct of topical studies.