Part 1 of a Two-Part Series

Incorporating International Environmental Legislation Into Power Plant Development

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Editor's Note: **New power plant installations are shifting world-wide faster than anyone could have imagined, even two years ago. Acumen and experience developed laboriously in the U.S. is now in international demand. Dr. Cooper's two-part series explores the environmental legislation which is integral to this global development.**

Part 1 reviews "Economics, Energy and the Environment"... "Environmental Overview of Power Plant Projects"... "Environmental Impact Issues"... and concludes with "The Regulators."

Part 2, to appear in the Fall 1997 issue, carries on with "Environmental Standards"... "Meeting Environmental Requirements"... "Obtaining Environmental Permits"...and "Trends."

ECONOMICS, ENERGY AND THE ENVIRONMENT

There are tremendous disparities between the technologically and scientifically advanced countries of the world, the "Countries in Transition," and the truly underdeveloped countries. A majority of the latter are not able to offer adequate modern services, such as dependable electric power, due to their inadequate infrastructures. This, in turn, restrains their economic growth.

As countries compete for markets, many of their governments find they do not have the monetary resources to finance major infrastructure improvements. They frequently then privatize government monopolies such as those for gas and electric utilities, and welcome independent power producers. This has catapulted the power development sector into playing a major role in the globalization process of narrowing the gap between the energy-rich and energy-poor countries. Privatization of electric power is occurring in many countries.

The challenge for every country is to promote economic growth that is "sustainable." Although vast amounts have been written about "sustainable growth," it is not precisely clear what is being sustained. The phrase generally means

> *"meeting the needs of the present generation without jeopardizing the ability of future generations to meet their needs."*

This means the economic growth that can occur without drawing down natural capital such as forests, animal and marine life, or excessively polluting the immediate region, the country or indeed the rest of the world. The key elements of sustainability are economic, environmental and social, including property rights(11). The environmental issues vary depending on the type of project. Financial institutions as well as national governments realize the importance of policies to protect health and preserve natural resources such as forests, rivers and lakes. Donor agencies and international financial institutions are increasingly concerned with implementing policies which will lead to sustainable development.

It is important, but very difficult, to quantify the trade-offs between energy policy and environmental objectives. Increased economic activity requires additional energy. Energy resources are important not only for economic prosperity, but also for a desirable quality of life. There is a synergy between economic growth and environmental quality. Some environmental problems decline as incomes rise; some problems initially worsen, but then improve as the economy improves(12). Without consideration for the environment, long-term development will be undermined. But, conversely, without accelerated economic growth in developing nations, funds for environmental protection and remediation will not be available; environmental policies will fail.

A growing awareness of the potentially detrimental health and

environmental effects of power plant emissions has lead to increased environmental regulation and enforcement throughout the world. Electric system planners are thus increasingly faced with the problem of meeting the demand for more power in both an economically viable and environmentally acceptable manner. Fortunately, properly planned electric system development need not cause extensive or irreversible environmental damage; environmental protection can be achieved without thwarting economic development.

A thermal power plant can be a significant source of harmful emissions, depending on its capacity, its mix of fuels and their characteristics. The amount and quality of coal, lignite and heavy oils to be used are of particular concern. The economic reality is, of course, that the availability of natural resources is the determining factor in choice of fuel for the power plant, rather than seeking to use the cleanest possible fuel at any cost.

Hydroelectric power plants may lead to major losses of forests and wildlife habitat, massive resettlements of populations, silting and flooding problems. The results of low-probability events such as earthquakes can be devastating to large numbers of people.

Successful implementation of environmental programs requires regional cooperation. Key industries in many countries are often state-owned and, as a practical matter, not forced to comply with recommended practices or even regulations. Economic dependence on exports further minimizes the likelihood that facilities (especially if state-owned) would be shut down due to noncompliance. This situation is common.

The Ukrainian government, for example, depends on the Russian-built Chernobyl nuclear power plant. This 21-year-old plant produces 3,760 megawatts, which represents forty percent of Ukraine's demand. Twenty-three countries have expressed their opposition to its continued operation. The Ukrainian government has taken the position that the plant is safe, and if other countries wish it shut, they should make compensation payments.

Similar situations exist in The Slovak Republic (Bohunice Plant), Bulgaria (Kozloduy Plant) and Lithuania (Ignalina Plant). In each of these, international pressure is being exerted to modify nuclear plants to conform to world standards, and in each of these the governments have demanded payments to comply.

ENVIRONMENTAL OVERVIEW OF POWER PLANT PROJECTS

Two types of electric power generation will be discussed herein: thermal and hydroelectric. Nuclear, solar, fuel cells, geothermal, biomass and wind, though used to generate electricity,will not be included.

Thermal Power Plants

All thermal power plants generate electricity through a series of energy conversion stages that start with a fuel and produce electric energy. These include boiler plants, combustion turbines and internal combustion engines. These may also be configured to operate as cogeneration plants.

Thermal power plant wastes are typical of those from the combustion process. Exhaust gases from burning coal and oil contain particulates (including any heavy metals present in the fuels), sulfur oxides, nitrogen oxides and volatile organic compounds. The concentrations of these exhaust gas pollutants are a complex function of the firing configuration, operating practices and fuel composition. In general, gas-fired plants produce negligible quantities of particulates and sulfur oxides. Their exhaust gases do contain nitrogen oxides, but at much lower concentrations than from coal or oil-fired units.

Ash residues and the dust removed from exhaust gases may contain significant levels of sulfates, heavy metals and organic compounds as well as inert materials. Fly ash removed from exhaust gases make up 60-85 percent of the coal ash residue in pulverized coal boilers. Bottom ash includes slag and coarser, heavier particles than fly ash. The volume of such solid wastes may be substantially increased if certain pollution control methods are used such as flue gas desulfurization, or fluidized bed combustion. Conversely, good mining (or coal purchasing) practices may significantly reduce the volume of solid wastes.

Steam turbines, if used, require a way to condense and/or cool the exiting steam. Although it is not very unusual to use air cooling, it is far more common to use large quantities of water for this purpose. Water is also necessary for auxiliary station equipment, ash handling and flue-gas desulfurization systems. The characteristics of the waste water will depend on the way the water was used. Contamination by wastes from demineralizers, lubricating and auxiliary fuel oils and chlorine, biocides and other chemicals used to manage the quality of

water in recirculating systems is common in different types of thermal power plants.

Hydroelectric Power Plants

Hydroelectric projects include dams, reservoirs, canals, penstocks, powerhouses and switchyards for the generation and transmission of electricity. Among the benefits of hydroelectric power are elimination of air emissions and ash from burning fossil fuels and the problems of disposing of radioactive wastes from nuclear plants. Construction of hydroelectric power plants is labor intensive, creating many jobs during construction.

Hydroelectric projects, however, have a disruptive effect to both people and the ecological environment if permanent flooding is required for dam construction. These often require large numbers of people to be relocated, involving human rights issues in addition to the technological challenges. The controversial 1,800 megawatt Bakun dam project in Malaysia, for example will lead to the disappearance of homes and villages of 9,400 people. The Eltran II hydroelectric project on the Yalong River in China will displace 35,000 people, and the huge Three Gorges project on the Yangtse River will require resettlement of 1,000,000 people. Payment to uprooted peoples for their land, farms and businesses, as well as prompt disbursement thereof have been major factors leading to dissatisfaction by affected people. Additionally, careful consideration must be given to education, health care, and the entire range of social factors that constitute fair and dignified treatment of all affected people.

Construction of a power plant can impact rural to urban migration or change the character of a community that can now accommodate a more technical or manufacturing economy, and ultimately lead to a loss of cultural identity. Location of the facility could also increase the affluent/poor income gap.

ENVIRONMENTAL IMPACT ISSUES

Air Issues

Various pollutants, described below, can have adverse effects on the life and health of humans, animals, trees and flora, fish and other marine life. The severity of the effect depends on the specific pollutant,

its concentration and the duration of exposure. Assessing the impacts of air pollution involves five considerations:

- Which pollutants will the plant emit?
- At what rates will they be emitted?
- What will the resulting ground-level concentrations be?
- What maximum allowable values should be imposed?
- How can the maximum allowable values be reached?

These will be considered in turn.

Emissions and Discharges—Health Related

The "Criteria Pollutants" normally considered for electric generating projects are those that, above threshold concentrations, lead to adverse health effects. They are:

- oxides of nitrogen — NO_x
- sulfur oxides — SO_x
- particulate matter (less than 10 micron diameter) — PM_{10}
- volatile organic compounds — VOCs
- carbon monoxide — CO
- lead — Pb

Emissions and Discharges—Greenhouse Gases

Certain compounds, including the following, absorb infrared radiation from the earth, thus acting as an insulating blanket, preventing heat from escaping from the atmosphere. These pollutants, termed *greenhouse gases,* have regional and global effects, causing elevated ambient temperature levels which may cause a rise in sea level as the glacial ice caps melt.

- carbon dioxide — CO_2
- nitrous oxide — N_20
- methane — CH_4
- ground-level ozone — 0_3
- chlorofluorocarbons — CFCs

Emissions and Discharges—Other

Besides gaseous emissions, issues related to power facilities may include the impacts of cooling tower plumes on visibility, salt deposition, fogging and icing. Mathematical models have been developed to predict the geographical extent and severity of these impacts.

Ground Level Concentrations

The exhaust gases leaving a power plant stack tend to behave in a very complex way. They are buoyant because of their high temperature and thus tend to rise. Simultaneously, they cool as they mix with the ambient air. The mixing also dilutes the stack gases, reducing pollutant concentrations. Additionally, they are transported by the wind, which frequently changes direction and interacts with buildings and hilly terrain.

The dispersion of exhaust gases can be analyzed, with varying degrees of accuracy, by numerous mathematical models that have been developed during the last thirty years. Many of the models have been vetted by the scientific establishment, and are now accepted as "standards" to be used in environmental analysis.

The models require data about the emission rate, composition and temperature of the stack gases, the stack height and diameter, dimensions of nearby structures, and the elevation contours of the terrain. Additionally, they require much meteorological data, including hourly wind speed, direction and temperature. These requirements can cause serious delays since some models require a full year's site-specific weather data.

The models predict the increase in concentrations of pollutants from the stack as a function of distance from the stack, and time. These increases must then be added to the existing pollutant concentrations, to produce a total ground-level concentrations that would be breathed by those at various locations for various durations. The existing pollutant concentrations usually vary on a seasonal and weekly basis. This is the reason for studying a full year of actual air quality data. There is thus often a need for two different kinds of data: meteorological and existing air quality data.

Developing countries have recently begun to establish programs to collect accurate air quality data, determine current levels of pollutants, establish standards, project future emissions levels, and model projected emissions. Their data gathering, analysis and reporting sys-

tem are, however, most often poorly funded. The data are frequently weak, not in a scientific format, and inadequate for drawing meaningful environmental conclusions. Many air pollution studies are therefore based on surrogate data from industrialized countries.

Opacity

By definition opacity means to cause to become opaque; impervious to light. Opacity problems can impact street and road traffic, shipping operations, or aircraft operations. They, moreover, can impact the aesthetics of the plant. Power plant opacity issues arise from two different sources.

The first relates to the emissions leaving the stack tip. Depending on the conditions of combustion, the types of post-combustion pollution controls used and the ambient weather conditions, the opacity of the emissions can vary from clear to totally obscured. Problems are usually caused by particulate matter in the emission stream, or by water particles in the exhaust condensing in the cooler ambient atmosphere causing a fogging effect. In most cases, the particulate matter can be controlled by using either cleaner fuels such as natural gas, or pollution control devices such as a baghouse or electrostatic precipitator.

The second item for opacity concern is the cooling tower. Part of the hot water entering the cooling tower evaporates into an air stream. As the air leaves and slowly drifts away from the cooling tower, the stream cools to the ambient air temperature and, under certain conditions of as cold weather and/or high humidity, the water vapor recondenses to fine liquid droplets. This situation can cause heavy, dense fog to form in the area of, or just downwind of, the cooling tower.

In order to mitigate this impact either an alternative facility cooling system could be selected or a partial/full system shutdown might become necessary when visibility becomes poor.

Water Issues

Three broad issues arise:

- the physical *availability* of water to the plant for cooling/condensing and steam generation purposes, and the legal right to use it

- the technically, economically and legally acceptable methods of *discharging* and disposing of waste-water

- the *water quality* will determine the type of water treatment necessary, and chemicals which must be used, stored and disposed of

Water Availability

The source of water is important since, in addition to legal and commercial considerations, it may be associated with disruption of hydrology or prolonged periods of reduced rainfall which could affect its availability. Water rights or impairment of other beneficial uses of the water, particularly for irrigation, may also be a major issue. It is possible to reduce the amount of water necessary for operation of cooling systems by installing air (fin/fan) coolers or evaporative recirculating cooling systems which use as little as five percent of the water volume required for once-through cooling systems. However, such systems will be more costly and require careful maintenance to minimize biofouling and the resultant discharge of biocides in water vapors or droplet drifts.

Water Discharge

Water discharges include those from coal pile runoff, boiler blowdown, SO_2 and particulate scrubber water, cooling water and sanitary wastes. These can be lead to serious issues if they might affect the chemistry and temperature of surface or subsurface water, or a marine habitat. Details of oil spill control and countermeasures must be considered. Another impact of the discharge of water may be erosion or silt runoff, especially during construction, deposit of sludges or regional flooding. Where once-through cooling systems are used, the impact of its discharge can be reduced by careful siting of intakes and outfalls, minimizing the use of biocides and anti-corrosion chemicals.

Controlling the discharge temperatures and extent of thermal plumes may be necessary to protect marine life.

Solid Waste Issues

Thermal plants can create solid waste residues including fly ash, flue gas desulfurization sludge and water treatment resins. Problems with air-borne dusts are minor; problems with sludge and wastes from scrubber systems used to control particulates, NO_x and SO_2 are often difficult and expensive to solve.

Fly ash handling systems are generally wet or dry, even though

the dry handling involves wetting the ash to ten to twenty percent moisture to improve handling characteristics and mitigate dust created during disposal.

Using a wet system, the ash is mixed with water to produce a liquid effluent with five to ten percent solids by weight. This is discharged to settling ponds, often with bottom ash and flue gas desulfurization sludges included. These ponds may be used as the final disposal site, or the settled solids may be dredged and removed for final disposal in a landfill.

Problems arise because the water will most often contain dissolved contaminants such as chlorides, sulfates and heavy metals such as lead, cadmium, vanadium and mercury.

Infrastructure Issues

Roads are often inadequate and hard to improve in developing countries because of the way urban areas have evolved. Even if technically feasible, necessary improvements are often costly both in terms of capital requirements and implementation time. These issues, together with environmental protection, are magnified if forests need to be cleared. Road conditions are particularly important if frequent fuel deliveries are by truck or during construction when heavy equipment is moved to and from the site.

Ecologically Sensitive Areas

Loss of flora or fauna or endangered species is becoming a major issue when projects are located on wetlands, destroy forests or cause acid rain which may damage nearby sensitive areas. There is much concern about the future of the rain forests of Latin and South America, Southeast Asia and parts of Africa. Loss of prime farmland can also be a negative impact of facility development, offsetting the potential for economic growth it creates. Negative impacts, such as silting and runoff or traffic through ecologically sensitive areas, are often more severe during plant construction than during normal plant operation.

Electromagnetic Fields

Studies have been done to evaluate the health risks from proximity to the fields which surround electric wiring and appliances. To date no conclusive evidence has been found to correlate adverse health

effects and certain types of cancers with exposure to electric magnetic fields, but it is an issue often connected with power plant development and electric transmission.

THE "REGULATORS"

International Treaties

Globally, the country in which the project is proposed might be a signatory to treaties or agreements such as the:

• 1985 Vienna Convention	provides for monitoring research and information exchange for international ozone protection
• 1987 Montreal Protocol on Substances that Deplete the Ozone Layer	phases out consumption and trade of ozone-depleting substances
• 1992 Rio Treaty	The United Nations Conference on Environment and Development (UNCED) to set principles for global sustainability
• Berlin Mandate 1995	to control greenhouse gas emissions
• Basel Convention	to reduce transboundary movement of wastes
• Biodiversity Convention	to take action to preserve global species diversity
• Climate Change Convention	encourages all parties to stabilize greenhouse gas emissions
• London Convention	regulates at-sea dumping of hazardous wastes

The Intergovernmental Panel on Climate Change, sponsored by the United Nations, has now concluded that the first signs of global warming are appearing. Carbon dioxide emissions are likely to be

taxed and/or regulated within the next few years, and an international carbon dioxide emissions trading program has been proposed to add incentives for reductions.

Any of these Conventions may play a role in project design and review by governmental agencies and the financial community.

The European Union

Fifteen West European countries have joined together into a European Union, binding themselves to accept *"Common Positions"* with respect to many activities, including environmental protection. *Common Positions* have now been adopted by the Council of The European Union setting forth a broad framework for *integrated pollution prevention and control* and *ambient air quality assessment and management(7, 8).*

Directives will apply to *"Combustion installations with a rated thermal input exceeding 50 MW. "* Although the fine details are not yet available, it is clear that use of *"Best Available Techniques,"* and *"Access to information and public participation in the permit procedure"* will be mandated.

Importantly, *"Member States shall take the necessary measures to ensure that competent authorities periodically reconsider and, where necessary, update permit conditions."(8)*

This will require project sponsors to devote additional efforts to insuring that costs associated with complying with changes in regulations be passed on to electric and thermal purchasers.

"Limit Values" and *"Alert Thresholds"* of ambient concentrations of criteria pollutants were established 31 December 1996, and for other pollutants by 31 December 1999. It appears that more post-construction operational monitoring will be required by European Union directives than heretofore encountered by individual countries.

National Governmental Agencies

National environmental protection agencies of developing countries have a difficult task of balancing competing environmental and economic goals. They must:

- Establish standards officially through legislation and promulgation

- Monitor operating facilities to see that the standards are being complied with

- Take enforcement action if facilities are out of compliance

The difficulty arises in establishing appropriate standards. This involves not just the basic principles of environmental protection, but balancing these with the national economic situation. Regulations must incorporate what is affordable and enforceable, considering the government's relationship to society and its socioeconomic priorities.

A common approach is to review the latest standards used by industrialized countries and international assistance agencies. The United States Environmental Protection Agency (USEPA) standards are the most frequently used because the USEPA has done extensive work on the subject and its studies and conclusions are widely disseminated. Unfortunately this can result in a government adopting stringent standards whose attainment is financially unaffordable within the prevailing economic situation.

The Asian Development Bank believes that a more appropriate method for setting standards is to review the history of the evolution of standards in the industrialized countries. Then consider these in the context of the country's economic situation (except for some critical health-related standards such as those addressing the very low human tolerance for mercury.)

> *Importantly, the strictest standards imposed on any specific project may or may not be those of the government of the project's host country; they may be those of the financial community.*

The Financial Community

The financial community consists of equity investors, guarantors and lending institutions. Financing new electric generating capacity requires cooperation among these entities.

Multilateral lending institutions have realized that in order to increase the effectiveness of monetary assistance they must include strategic objectives such as economic growth, poverty reduction, women in development, population planning and environmental protection. There is now a strong emphasis on the latter factor; virtually

all loan applications now require environmental review procedures related to the size of the project and the severity of its environmental impacts.

Most banks now provide their staffs with environmental guidelines, technical papers, tools and techniques and staff training programs to increase the level of their institutional awareness and understanding of environmental issues.

Multilateral lending institutions today strive to be sure that all relevant environmental impacts have been taken into account before they will finance a project. Their procedures are intended to avoid environmental liabilities that could affect the implementation of projects, and ensure that capital and operating cost estimates include items related to environmental protection. This is often done in stages beginning with an environmental screening or categorization, which determines if an environmental assessment, impact statement or audit are necessary depending on the size and scope of the project.

In the process of increasing environmental awareness, banks are creating stronger local institutions by promoting development of skilled human resources, forcing consideration of policy and market reforms, using uniform standards and enabling technology transfer from developed countries. They are also promoting regional and international cooperation.

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