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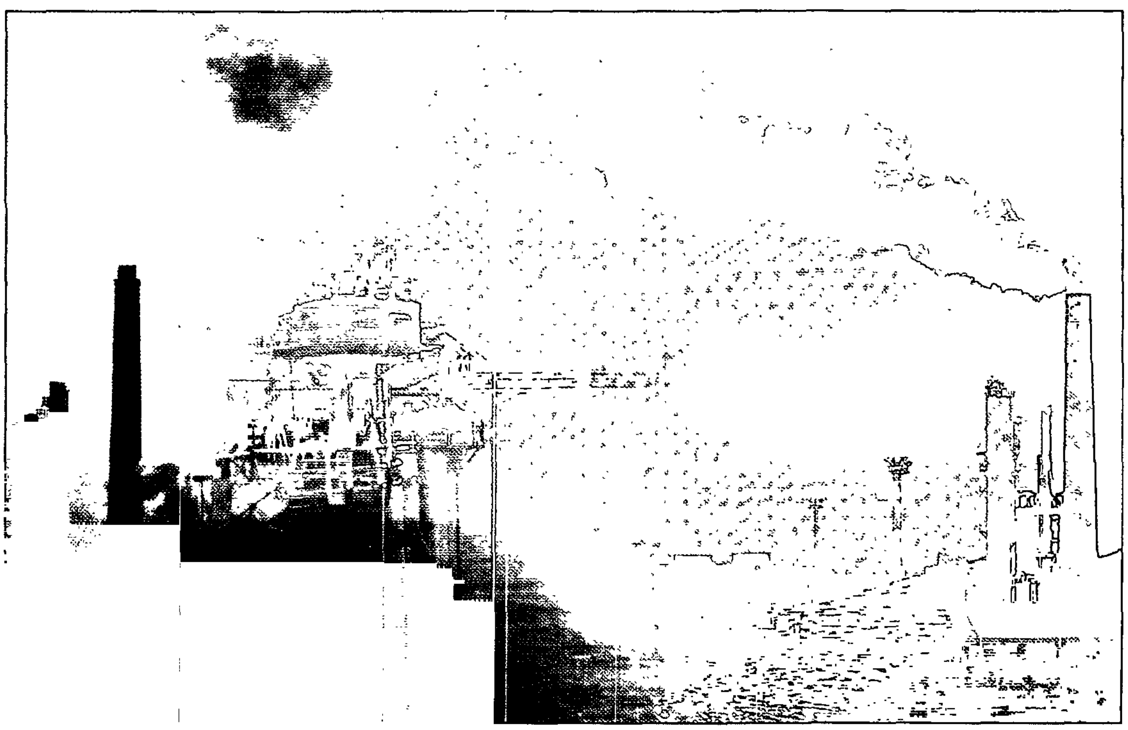
Protecting the Global Environment

Initiatives by Japanese Business

Edited by
Wilfrido Cruz, Koichiro Fukui, Jeremy Warford



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Foreword

Although countries' perspectives on climate change differ greatly, a prevailing perception in the developing world is that the developed countries are primarily responsible for climate change problems and that considerations of both equity and ability to pay require developed countries to absorb the costs of global environmental protection. Developing countries' reservations about taking remedial measures to address global environmental problems are reinforced by uncertainty concerning the physical and economic consequences of environmental degradation, and in particular the long time horizons involved. These uncertainties, and the difficulties inherent in economic valuation, have been illustrated by numerous studies on climate change.

However, developing countries are likely to suffer at least as much as developed countries from global environmental degradation in general, and the largest ones will be significant contributors to new growth in greenhouse gas (GHG) emissions. Thus, while physical and economic uncertainties abound, the potential for widespread impact on *all* countries is sufficiently large for developing countries to take global environmental problems seriously.

Developing countries are, of course, likely to be affected by global environmental problems in different ways. Vulnerability to environmental damage varies tremendously by country. Countries also differ in the extent to which their actions pose a global threat, and in the costs they would incur in taking remedial action. Consequently, it should not be expected that all countries (developing or developed) take a uniform response to global environmental concerns. Indeed, the quality of the global debate requires that the informed views of a wide range of affected groups be articulated with regard to policies and actions at the national level and also with regard to the role of the international and bilateral agencies that exist to assist the process of sustainable development. Significant differences in conditions and perspectives require the development of public and private sector institutions, nongovernmental organizations, and legal and informal systems on a country-by-country basis to address these issues effectively.

This volume is the result of a cooperative effort between the World Bank Institute (WBI) and the Development Bank of Japan (DBJ) to encourage policy discussion of the links between global environmental concerns and national development policies and programs. The book is based on the premise that policymakers traditionally have not viewed global environmental problems, such as climate change, as collateral outcomes of their national sustainable development agenda. Therefore, the objective of this book is to present case studies that demonstrate how policy reform and investments can together produce national economic benefits while mitigating carbon emissions associated with climate change. These examples from Japan, which highlight the "software" aspects of change instead of the technology (for example, the important role of public-private sector cooperation, pricing incentives, and community participation) will be relevant for developing countries where the potential for these sources of change have not been sufficiently exploited.

The WBI-DBJ program helps develop networks of policymakers (government officials, parliamentarians, advisers, planners, managers) and others who shape public opinion (civil society organizations, media communicators, academics), thereby expanding the constituencies for coordinated approaches to climate change actions and national sustainable development initiatives. WBI is pleased to collaborate with DBJ in this multiyear training and capacity-building program, which encourages national and regional policy discussions among key stakeholders and takes concrete steps to address the institutional and political constraints in dealing with global environmental concerns and national or local needs.

Frannie Leautier
Vice President
World Bank Institute

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Part I

The Relevance of Japanese Global Environmental Initiatives to Developing Countries—An Overview

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Global Benefits from Private Sector Initiatives: Lessons on the Environment from Japan

Koichiro Fukui

As the twenty-first century begins, environmental policies now being adopted and implemented by developed and developing countries are deciding the fate of the world environment. At the Fourth Conference of Parties (COP_4) of the International Framework Convention on Climate Change, held in Kyoto in 1997, developed countries made significant progress in agreeing to take measures to reduce greenhouse gases (GHGs), the principal gases linked to climate change. For developing countries and transition economies, however, specific responses to global environmental issues are constrained by immediate problems: the pressing need to reduce poverty and promote economic growth. Resolving national environmental issues is already difficult; addressing global concerns is more difficult still. Among developing countries there is also an underlying resentment that some industrial countries, which followed a "grow first and clean up later" approach in pursuing their own economic well-being, now appear to be preventing poor countries from concentrating their efforts on attainment of rapid economic growth.

This chapter analyzes Japan's experience with environmental and energy policies and summarizes the issues discussed in detail in the rest of the book. Examples show how environmental goals have been effectively combined with efficiency and growth-oriented concerns. The chapter begins with historical background and explains the integration of environmental policy into national development policy. Specific examples for three different sectors (steel, power, and forestry) are then presented to illustrate Japan's integrated approach and its implementation.

Japan's overall experience demonstrates how technology, government policy (both central and local), and private sector initiatives can be used to improve efficiency and overcome resource constraints. Two of the case studies deal with energy-intensive industries: steel and power generation. New production processes and replacement of outdated equipment with state-of-the-art equipment have improved production, resource, and energy efficiency in these sectors. The third sectoral case, on a tropical reforestation program, shows the potential for innovative international cooperation: the dissemination of green technologies contributed to the economic welfare of local communities.

Each country is unique in its background, stage of development, and surrounding international environment. However, this does not preclude the applicability of lessons derived from Japan's experience. Japan achieved remarkable environmental improvements during the 1970s and 1980s. Efforts in the 1990s achieved further efficiency gains and reduction of carbon dioxide (CO_2) emissions. Japan's experience offers valuable lessons that can be tailored to address the unique problems each country faces.

Integration of Environmental Policy into National Development Policy

In the early stages of Japan's modernization, some of the country's severe environmental problems were already apparent near copper mines and metal refineries. Further industrialization and urbanization accelerated the problems in the first half of the twentieth century. However, public awareness in Japan of environmental issues was then very low, and these problems did not become important social issues. During the period of high economic growth in the 1950s and 1960s, air pollution and water contamination greatly worsened due mainly to the rapid growth of heavy industries and petrochemical complexes. The government recognized the need to prevent pollution, but its response was slow. It can be said that the government at that time put a higher priority on growth than on environmental concerns. By the end of the 1960s, pollution had become visible everywhere near big cities and industrial sites in Japan.

As pollution increased, its victims multiplied. Those with pollution-related health problems filed lawsuits in the late 1960s, and the courts judged in favor of the victims. Under the new rule by the Supreme Court in 1970, the defendant (polluter) had the burden to prove that there was not a cause-and-effect relationship between its pollution and any adverse health outcome. Furthermore, a principle obligating polluters to pay for the damages they caused was established: the Polluters Pay Principle (PPP). The rulings in favor of plaintiffs successfully pressed government and industry to introduce pollution control measures. These trials, culminating in the cases of mercury poisoning and asthma patients, revealed to the public the extent of the pollution, thus exposing government measures to public scrutiny.

The government of Japan clearly set environmental protection above industrial development in the 1970s. The Diet in 1970, known as the "Pollution Diet," passed or amended fourteen pieces of regulatory legislation. In 1971 the Environment Agency was established to centralize the administration of environmental matters. In the same year a law was enacted that required factories over a certain size to be monitored by qualified pollution controllers. In 1973 a law on pollution-related health damage was enacted. In a short period Japan set up rigorous environmental parameters and business obligations that were very advanced by world standards at that time. Indeed, Japan became a leading country in dealing with pollution. Businesses made maximum efforts to meet the harsh standards, greatly reducing the level of pollution.

During the 1980s, lifestyle pollution (for example from household sewage and garbage) replaced industrial pollution as the primary pollution problem in Japan. Two issues gained attention: the need for new technologies to break down wastes and the need for greater consumer consciousness about recycling. Then, in the second half of the 1980s, the world began to witness a succession of abnormal weather patterns. This heightened the necessity of a worldwide consensus on global warming, and a number of summits were held in which some of the advanced countries pledged to stabilize or lower their emission levels of the greenhouse gases. The Japanese government decided to reduce these gases (such as CO_2 and methane) to 6 percent below their 1990 levels between the years 2008 and 2012.

Improvements in Air and Water Pollution

Countermeasures by both the central and local governments and strenuous efforts by private companies have improved Japan's environment substantially. Between 1971 and 1996 the average annual ambient concentrations of sulfur dioxide (SO_2) and carbon monoxide (CO) were reduced by 85 percent and 70 percent, respectively. Nippon Steel Corporation's steel factories decreased SO_2 emissions by 85 percent between 1973 and 1997. Levels of nitrous oxide (NO_x) also declined. The average NO_x emission intensity of thermal power plants in Tokyo Electric Power Company, for example, was reduced by 85 percent per kilowatt hour (kWh) between 1973 and 1997. Despite these strides, the ambient concentration of nitrous dioxide (NO_2) did not improve because of the rapid expansion of automobile traffic. Pollution from exhausts outweighed the decreases of the factories. However, the achievements can be judged to be remarkable.

The government and the private sector also tackled the problem of water pollution. Emissions of heavy metals and toxic chemicals, which caused the Minamata and *itai-itai* diseases, are almost nonexistent in Japan today. But organic pollution of water has not improved substantially. Polluted effluents from factories have declined, but this has been offset by decreased water flow in urban rivers from growing industrial use and delays in controlling domestic water discharge. Further efforts are required in this area.

Climate Change: The Energy-Environment Connection

Industrial pollution of the atmosphere and water is not the only problem. Concern has grown in recent years about the climatic change caused by increases in greenhouse gases. Among all GHGs, carbon dioxide is the largest contributor to global warming. At the same time, CO_2 emissions are directly related to energy consumption. Here "win-win" opportunities exist for developing countries to reduce CO_2 emissions while simultaneously controlling energy consumption. Bringing down energy costs thus would curtail the magnitude of global warming.

Between 1971 and 1995, CO_2 emissions in Japan increased by 1.8 percent per year compared with growth in the country's gross domestic product (GDP) of 3.6 percent. This means that although CO_2 emissions were still increasing, they increased at a much slower rate than industrial production. This decline was achieved through industrial structure change, more efficient energy use, and change in the fuel mix, especially in the power generation sector. Now Japan and France have the lowest CO_2 emissions per GDP among developed countries.

Japan also achieved the largest improvement in energy intensity among major industrialized countries between 1971 and 1995, and its energy use per GDP was by far the lowest. During this period, the share of energy-intensive industries declined in conjunction with the increase in high-tech industries. At the same time, energy-intensive industries achieved rapid improvements in energy usage. By the end of the 1970s various energy-saving investments had become economically viable due to the oil crises and resulting higher oil prices. In the iron and steel sector, for example, energy-saving investment in total investments increased from 15 percent in 1979 to 27 percent in 1980. The energy efficiency in this sector improved by 30 percent between 1971 and 1985. Other energy-intensive industries, such as chemicals, ceramics, and pulp, also achieved substantial gains in energy efficiency.

Improvement in energy efficiency began to stagnate in these industries following the collapse of oil prices in 1985. This trend was also observed in consumer goods. People began to demand more luxurious (and energy-consuming) home electric appliances and automobiles. This trend underscores the importance of energy price in promoting energy efficiency, although the great industrial achievements of Japan by the 1980s cannot be denied.

The government's energy conservation policy also helped industries to promote energy-saving investments. In 1979 the *Law Concerning the Rational Use of Energy* was enacted with detailed guidelines for energy-saving equipment and building standards. The government also provided long-term, low-interest loan programs through government financial institutions such as the Japan Development Bank. In addition, the government introduced tax exemptions and accelerated depreciation for energy-saving investment. Policy-based finance and preferential tax treatment were the methods typically observed in the industrial policy of Japan.

Contributing to the change in energy use during this period was the policy of fuel diversification away from oil, following the two oil crises in the 1970s. This policy had a particularly important impact on the fuel mix for power generation. Between 1980 and 1996 the shares of nuclear, liquefied natural gas (LNG), and coal power increased from 17 percent, 20 percent, and 3 percent to 38 percent, 29 percent, and 9 percent, respectively. The government also encouraged the development of "new energy," such as geothermal, wind, wave, and solar-generated electricity. In 1980 the New Energy Development Organization (NEDO) was established to support these activities. Despite these efforts, however, new energy accounted for only 1.3 percent of total energy supply in 1996 because of the cost disadvantage.

Antipollution investments in the 1970s were mainly end-of-pipe technologies such as flue gas desulfurization to meet legal and other regulatory requirements. In contrast, investment in the 1980s involved energy-saving and clean production technologies that contribute to firms' profits through reduction of energy consumption while at the same time reducing carbon dioxide, nitrous oxide, and sulfur oxide (SO_x). The bulk of Japan's reduction in SO_x emissions in the 1980s was attained through energy saving, an example of win-win opportunities for other countries.

The Role of Local Governments

One unique characteristic of Japan's pollution control strategy is the active role played by local governments. Local governments have initiated various measures such as pollution control ordinances, extensive monitoring networks, and environmental impact assessment. Since environmental degradation in many cases was site specific, it was natural that local governments became aware of pollution and took countermeasures. Their ordinances were often more stringent than the nationwide standards required by national laws.

Another unique approach to pollution control at the local level is the use of voluntary agreements between local governments and businesses. Factory-by-factory emission levels are decided in detailed written agreements after intensive discussions by businesses, local governments, and residents; the potential for enforcement is considered. Such agreements are nothing more than "gentlemen's agreements," but they function as though they are legally binding. Businesses must seek the approval and support of environmentally conscious local governments and communities for their activities.

Compliance with laws, regulations, ordinances, and voluntary agreements depends largely on their enforceability. Air and water quality is constantly monitored at monitoring stations set up by local governments, and emission levels of individual factories are periodically reported to local governments. Also important is the environmental impact assessment, which became mandatory for new projects after the cabinet decision in 1984 to establish nationwide procedures. The pattern of having environmental studies followed by voluntary pollution control agreements has become common practice in many local governments before projects are finalized. The ability, status, and moral standards of local bureaucrats also contribute to the success of these procedures.

Private Sector Initiatives

At the initial stages of environmental degradation, end-of-pipe solutions work effectively, but this type of policy eventually reaches a point of diminishing returns. In many cases the latest clean production technologies offer superior production efficiency, while contributing not only to pollution control but also to resource and energy conservation. Japan's environmental policy is distinguished by its emphasis on technological development. Japanese business strategies have evolved from the initial end-of-pipe solutions in the 1970s to clean production technologies, which provide new business potential and can enhance economic competitiveness. By 1978 the Japanese automobile industry, for example, had met strict standards through effective emission-control technologies. Secondary benefits, such as combustion control, resulted. These technologies allowed Japan to penetrate the U.S. market when there was high demand for fuel efficient and less polluting cars.

Another motivation for Japanese businesses to prevent pollution is the heavy legal liability borne by polluters. Under the Polluters Pay Principle established in the early 1970s, polluters bear the financial burden for restoring the environment and compensating those suffering from pollution. This rule has induced industries to reduce their environment-related risk through pollution prevention measures, which are more economical than symptomatic measures taken after the environmental damage has already been done.

Japanese businesses, through cooperation with existing business associations, have adopted voluntary action plans with numerical targets for the reduction and recycling of waste, as well as measures to counter global warming. These plans are not for manufacturers only but also affect distribution and construction. Even though these efforts are completely voluntary, there is neither opposition nor delay in action, because businesses pay serious attention to environmental issues, which have become an increasingly important part of a company's image and reputation.

Collaboration between the Public and Private Sectors

In spite of conflicts in the bargaining process during which environmental measures are formed, the public and private sectors have long collaborated in the setting of environmental standards. As a result, compliance is high. The step-by-step collaborative mechanism allows time for the private sector to anticipate the next stage of regulation and to develop efficient and affordable technologies. It also enables the public sector to reassess each new step for strengths and weaknesses based on actual pollution control.

Pollution control in Japan is also characterized by joint research initiatives by the government, businesses, and universities. One example is the New Energy Development Organization. In addition to its initial mandate to develop new energy technologies, NEDO has expanded its activities to include the development of technologies for global environmental protection. The government finances NEDO's operations, but scientists and engineers in private businesses participate in its activities. The private sector cannot be relied upon to fund all the necessary research and development, particularly at the ends of the research spectrum where the collaborative mechanism becomes important.

Public Awareness of Pollution Control Measures

In Japan, citizens' activism in the local community, supported by judicial decisions, became the driving force behind pollution control measures. Scientists and lawyers support the activism of ordinary citizens, making it difficult for government and industry to ignore their efforts. Although nongovernmental organizations (NGOs), a more sophisticated form of citizen activism, have been weak constituencies in Japan, public awareness about environmental issues has substantially increased in the past three decades. One reason is improved education at school. Progress can also be attributed to the mass media, which freely express critical views that pressure politicians, bureaucrats, and industry to take action to safeguard the environment.

Examples from Japanese Experience

This chapter presents three examples of how Japan has combined environmental goals and growth-oriented policies. Cases from the steel, power, and forestry sectors are examined. The first example is based on the experience of the Nippon Steel Corporation (NSC).

Toward Cleaner and More Efficient Steel Production: The Case of Nippon Steel Corporation

Japan's steel production peaked at 120 million tons in 1973. Production leveled off in the 1980s at around 100 million tons per year due to the shift in industrial structure toward a service-oriented economy. However, the iron and steel industry in Japan still accounted for 13 percent of world steel production in 1996, and it has kept a competitive edge in the world market. The Nippon

Steel Corporation, Japan's largest steel producer, had about a 25 percent share of Japan's steel production in the 1990s. Using NSC as an example, this case study examines Japan's environmental efforts in the steel sector and seeks lessons for developing countries.

The iron and steel industry is energy intensive. It accounts for 11.4 percent of total energy consumption in Japan; 78 percent of the iron and steel industry's energy use comes from coal. When coal is used to make steel, pollutants such as SO_x and NO_x are released. Japan's iron and steel industry has succeeded in drastically reducing these hazardous pollutants while maintaining high production levels. It has also succeeded in reducing CO_2 emissions through efficient energy use and the introduction of new technologies. Efforts to recycle by-product wastes have been remarkable as well. Although the current technologies are already state-of-the-art by world standards, the industry aims to reduce its energy use further through various means, including the utilization of waste plastics as a fuel source.

EFFORTS TO REDUCE HAZARDOUS POLLUTANTS. In the steel-making process, hazardous pollutants and by-product wastes are inevitably produced. Japan's iron and steel industry had to meet strict standards and regulations introduced in the early 1970s. In addition, most steel mills concluded more stringent agreements on pollution control to reflect the geographical and social conditions of each area. Examples of specific mills show that local agreements on air quality are substantially stricter than the level required by law. Moreover, the actual level of pollutant emissions that is attained is even lower, in some cases, than the level specified in the agreement with the local government, reflecting the efforts of the industry.

In order to reduce SO_x and NO_x, end-of-pipe and energy-saving technologies have been extensively used. Water pollutants (such as suspended solids, leaked oil, chemical oxygen demand, and acid and alkali) have been lowered to minimal levels by establishing a water recycling system. NSC's capital investment for pollution control totaled 400 billion yen between 1970 and 1997. The historical trend shows a concentration of investments in the first half of the 1970s, reflecting the massive investment for desulfurization and denitrification of flue gas. Pollution control investment accounted for 34 percent of total investment in the iron and steel industry in the peak year of 1976.

A law enacted in 1971 requires Japanese factories above a certain size to appoint a qualified pollution controller. In the 1990s NSC had about 1,030 authorized managers at various facilities who had passed a national examination. By carrying out measures and improving communications between factories, the local government, and the local community, the managers played an important role in establishing an organizational system for pollution control.

EFFORTS TO REDUCE ENERGY USE AND CO_2 EMISSIONS. The evolution of energy-saving measures has reflected changing energy prices. Between 1974 and 1978, the iron and steel industry became 10.4 percent more energy efficient than in 1973. After the second oil crisis, investment in large-scale new technologies—such as continuous casting (CC), coke dry quenching (CDQ), blast furnace top pressure recovery turbines (TRT), and sinter waste heat recovery equipment—became economically viable. A further gain of 8.6 percent was achieved between 1979 and 1983. After 1984 oil and coal prices stabilized, and new investment opportunities diminished. In addition, a product mix shift toward high-quality steel, which requires higher energy use per ton of steel, worked adversely. However, the industry achieved a 2.8 percent gain in energy efficiency by various measures between 1984 and 1988. These gains from 1974 to 1988 total about 20 percent. Because of these massive efforts, Japan's iron and steel industry has achieved the world's highest energy efficiency. In terms of energy consumption per unit, the United States, United Kingdom, Germany, and France are higher than Japan by 18 percent, 12 percent, 3 percent, and 11 percent, respectively. China has a very high unit consumption of energy: 50 percent higher than that of Japan.

In the 1990s the iron and steel industry further reduced energy use. The industry adopted a voluntary action program for global warming control measures and is making efforts to attain numerical targets to reduce energy consumption by 2010 to 10 percent below its 1990 level, thus reducing CO_2 emissions by 10.5 percent. The industry's efforts include the introduction of next generation technologies (such as a new coke oven under development through a national program since 1994), utilization of waste plastics as a fuel source, and recovery of medium- and low-temperature waste heat for the use of local communities.

INTERNATIONAL COOPERATION AND LESSONS FOR DEVELOPING COUNTRIES. The Nippon Steel Corporation has increased its international cooperation activities and plans to transfer energy-saving technologies to developing countries. A plant using coke dry quenching technology in China is an example of such activities. From this project, NSC has derived several valuable lessons: (a) procure parts locally wherever possible (self-help efforts should be encouraged); (b) ensure compatibility of interface between imported parts and locally procured parts, taking into consideration the other party's technological level; (c) include software in technology transfers (maintenance technology is important); and (d) provide training in operation and maintenance, preferably at facilities where similar equipment is in operation (technologies cannot be established without developing the requisite human resources).

Japan's initiatives for cleaner and more energy-efficient production of steel have rich lessons applicable to other countries. First, step-by-step, priority-based introduction of technologies is important. NSC first introduced simple and low-cost technologies; it did not rush to sophisticated, expensive technologies at the outset. Second, an important role can be played by an environment management organization within an industry. NSC established such an organization, and it also devised an operational management method for environmental measures. Third, the development of high-level environment-friendly technologies can heighten competitiveness. NSC aggressively tried to develop such technologies.

Toward Cleaner and More Efficient Thermal Power Plants: The Case of the Electric Power Development Company

Japan's electric power industry, with its 242 million kilowatt (kW) capacity, is by far the biggest primary user of energy in Japan, converting 40 percent of Japan's primary energy supply to electricity. During the period of strong economic growth, Japan constructed thermal power plants (both coal and oil) on a massive scale. By the early 1970s these plants had to meet strict regulation standards for air pollution. The industry drastically reduced SO_x and NO_x emissions at that time. The electric power industry is also the biggest emitter of carbon dioxide in Japan. It now produces 25 percent of industrial CO_2 emissions. To reduce this level, the industry has made tremendous efforts to use energy more efficiently and to diversify its fuel sources to nuclear power and liquefied natural gas. With heightened attention in the 1990s to the problem of global warming, the industry continued to try and reduce the level of CO_2 emissions.

The Electric Power Development Company (EPDC) was established in 1952 as a wholesaler of electric power to the nine integrated regional power companies in Japan. Two thirds of its capital is still owned by the government, but the company will be fully privatized by 2003. EPDC has the fifth biggest generating capacity (14 million kW) in Japan. It has played an important role in the development of hydroelectric, coal-fired, and geothermal power plants. Using EPDC as an example, this case study examines Japan's efforts to address environmental problems and offers lessons for other countries.

EFFORTS TO REDUCE HAZARDOUS POLLUTANTS. As a government-owned power company, EPDC has generated coal-fired power since the 1960s in accordance with the energy policy of the government. The company planned to construct a coal power plant at Isogo (near Yokohama) in the 1960s, but environmental pollution was already a local issue by that time. Responding to the opposition of residents and local communities to the expansion plans of factories and power plants, the Yokohama municipal government commissioned four local academics to examine pollution prevention measures. The agreement between the Yokohama government and EPDC reflected the academics' recommendations and provided the first example of a full-scale pollution prevention agreement. The Yokohama government enforced a similar series of pollution prevention measures and paved the way for voluntary agreement on pollution control between individual plants and local governments. This method, widely observed in the 1970s in Japan, became known as the Yokohama method.

Responding to the stricter standards of air pollution in the early 1970s, EPDC fit three coal power plants with five flue gas desulfurizers (FGD), a technology that it had been developing for some time. This drastically reduced the level of SO_2 emissions to less than 1 gram per kWh by 1976, although it pushed up the generation cost by 17 percent. EPDC's achievement is remarkable, since the overall average of the United States, United Kingdom, France, Germany, Italy, and Canada was more than 6 grams per kWh in 1993-94. The Isogo power plant exemplifies optimal use of space for large pollution-prevention equipment in an existing coal power plant.

EPDC is also the world pioneer in developing full-scale flue gas denitrification devices for coal power. This technology has gained acceptance not only throughout Japan but also in Europe and elsewhere. EPDC's level of nitrous oxide emissions was reduced to less than 1 gram per kWh in 1996, compared with 2.7 grams per kWh, the average of the countries mentioned above.

Efforts to Reduce Energy Use and CO_2 Emissions. Coal-fired power plants produce more carbon dioxide per unit of electricity generated than do other fuel sources. Switching to liquefied natural gas or nuclear power lowers CO_2 emissions. In many countries, however, coal is still an important energy source, and it is essential to find ways to minimize CO_2 emissions of coal-fired power plants.

After the oil crises in the 1970s and the greater need to save energy, EPDC reduced CO_2 emissions although CO_2 emissions had not been a specific target of reduction at that time. Since then EPDC has assiduously introduced the best available technologies and actively involved itself in R&D. The Matsuura plant of EPDC, which started operation in 1990, has a thermal efficiency of 38 percent compared with Isogo's 36 percent. Pressurized fluidized bed combustion (PFBC), a new technology with thermal efficiency reaching 42 percent, is currently in the demonstration stage at EPDC. Another method, integrated coal gasification combined cycle (IGCC), with thermal efficiency of 44 percent, is now being tested at a pilot plant. These thermal efficiency improvements reduce CO_2 emissions as well as fuel input.

There are many ways to improve the thermal efficiency of coal-fired power plants, such as plant replacement, rehabilitation of outdated equipment, introduction of auxiliary equipment, and proper operation. Replacing subcritical plants, which continue to be built in most non-OECD countries, with supercritical or ultra-super-critical plants improves thermal efficiency substantially, making SC and USC commercially feasible while reducing both CO_2 and air pollutant emissions. Commercial feasibility is site specific. For optimal modifications, financially and environmentally, to improve thermal efficiency, proper analysis of each power plant is needed. Another important factor for efficiency gains is proper operation.

Lessons for Other Countries. Pollution control measures at existing coal-fired power plants are mostly end-of-pipe technologies and bear additional cost for power producers. When EPDC had to introduce flue gas denitrification devices in the 1970s, the generation cost of the corresponding plant increased 17 percent. EPDC managed to limit its electricity price hike to 11 percent because of its own cost reduction efforts and government aid. Consensus building among stakeholders regarding the necessary investments, timing, and level of electricity price increases, and incentives, are essential. Consensus is achieved through discussions and information sharing within special committees (*shingikai*), which are established either by the national government or local governments. Stakeholders, including the concerned companies, industrial associations, the local community, and academia, are represented on these committees.

Enforcement of environmental standards is another indispensable factor in order to internalize the cost of pollution control. In the case of EPDC, a qualified environment controller in each power plant measures and reports the emission levels of various pollutants to the local environmental authority. Local governments then have abundant information for effective monitoring and enforcement of the agreement with EPDC.

Reduction of CO_2 emissions can be attained through more efficient use of energy, which simultaneously maximizes profits. The incentive for energy-saving investment increases when the price of energy increases. As a matter of fact, EPDC's efficiency enhancement efforts saw major progress after the oil crises. If the energy price is kept unreasonably low either by controls or subsidy, incentives to save energy will be weakened and the allocation of resources distorted.

The government's involvement in research and development is essential. Clean coal technology development plays an indispensable role in enabling the Electric Power Development Company to control pollution and reduce carbon dioxide without harming production. EPDC has been an active participant in projects sponsored by the government and the New Energy Development Organization. Cooperation between the government and power companies in R&D activities has mitigated the risk and financial constraints of pollution control.

Reforestation of the Indonesian Tropical Forest: The Case of the Sumitomo Forestry Corporation

In 1991 the Sumitomo Forestry Corporation, one of Japan's largest forestry and housing companies, initiated the Sebulu experimental forest. This project was undertaken for the reforestation of the Indonesian tropical forest. Its main objective is to restore areas destroyed by forest fires and slash-and-burn farming by replicating the conditions of the original forest as closely as possible and establishing sustainable forest utilization for the local people. If this project successfully restores the tropical forest, it will create a carbon sink and, at the same time, convince local people that the adjacent social forest brings them more products than slash-and-burn farming, thus providing a persuasive "win-win" example for similar areas in the world.

Historical Background. In the early 1970s Sumitomo acquired a concession right on the tropical forest in East Kalimantan Province and established a local joint venture, P.T. Kutai Timber Indonesia (KTI). Forest development began in the area around the current experimental forest. The main role of the forestry operation was to supply lumber for Sumitomo's plywood manufacturing in Java. KTI gained an excellent reputation for its sustainable forest management based on selective cutting. During 1982-83, however, forest fires swept through Kalimantan causing unprecedented damage. The fires destroyed 3.1 million hectares of forest and forced KTI to terminate its forestry operations and relinquish its concession right to the Indonesian government. After that, frequent forest fires and slash-and-burn farming practices turned the area into mostly wasteland by 1990.

Aware of worldwide deforestation and the increasing concern over global warming toward the end of the 1980s, Sumitomo focused its corporate social mission on the protection of the global environment through forestry-related activities. Sumitomo then began to commit itself to environmental issues on a large scale. It chose Sebulu as an experimental reforestation site after careful study of the area by three Sumitomo survey missions between 1989 and 1991. One important factor behind the choice of Sebulu was Sumitomo's business activities there beginning in the early 1970s and the considerable respect the company had among local people.

THE SEBULU EXPERIMENTAL FOREST PROJECT. A total area of 3,000 hectares was established as the Sebulu experimental forest in 1991 after an agreement between Sumitomo and the Indonesian government. The first stage of the project began in November 1991, managed by KTI, Sumitomo, and the Forest Research and Development Agency of the Indonesian Ministry of Forestry. The project targets reforestation and social forestry. A proper combination of the two concerns is expected to improve local people's income-earning opportunities while replicating the original forest as closely as possible.

This reforestation is done through artificial plantation of mainly dipterocarps, an indigenous Southeast Asian tree for which Sumitomo developed a tissue culture technique for mass propagation, and plantation of other fast-growing trees. The first stage of this experiment was 1991 to 1996; the second stage, 1997 to 2001. As of December 1998, the plantation covered an area of 405 hectares with more than 600,000 seedlings. This was achieved in spite of the damage caused by big fires in 1997.

As noted earlier, social forestry is another unique aspect of this project, which aims to improve the standard of living of former slash-and-burn farmers through their resettling and participation in artificial plantation. At present, the program is being implemented with the cooperation of thirteen families in four social forestry trial zones totaling forty-three hectares. Dipterocarp trees (50,000), fruit trees (such as durian and mango), fast-growing trees (such as sungkai, gmelina, and teak), and crops (peanuts, maize, dry-field rice) have been planted. KTI's role is to provide continuous technical guidance as well as the seedlings, fertilizer, and materials, which the farmers repay after the harvest. Social forestry is slowly but steadily drawing the attention of more slash-and-burn farmers, although this experiment is still new. Once its economic viability is clearly established, social forestry will accelerate the resettling and participation of slash-and-burn farmers.

SOCIAL FORESTRY AND SLASH-AND-BURN FARMING: AN ECONOMIC COMPARISON. The Sumitomo Forestry Corporation and the Development Bank of Japan intensively interviewed social forestry participants in 1998 and 1999. The results of these interviews and the outcome of a 1995 Sumitomo study of slash-and-burn farming are presented for economic comparisons. According to the analysis carried out, the average cash flow per hectare of rice with slash-and-burn farming is estimated to be US$89 (1998 price, US$1 = Rp8000), while the per hectare cash flow of a social forestry mix of maize, soybeans, green beans, peanuts, and onions is US$105. (The social forestry figure is somewhat conservative, since it excludes output of chili and sweet potatoes.) Cash flow takes into account the opportunity cost of family labor input. Substantial differences in families' incomes from social forestry reflect differences in product mix, timing of planting, and damages by wild boar and insects. It should be pointed out that weather conditions that affect agricultural output were better in 1995 than in 1998. Keeping these factors in mind, we can conclude that crop cultivation in Sebulu is economically more viable than the slash-and-burn farming on contiguous tracts of land.

Analysis is also being performed on the activities of one farmer who began planting fruit trees (durian, mango, rambutan, and magnets) a few years ago. Since little data are available, assumptions (growth of trees, productivity, and prices) were based on existing studies in Java and the actual situation of fruit near Sebulu. Multiyear simulation becomes necessary for such cash flow analysis, since it takes years for these trees to begin to bear fruit (three years for mango and four years for durian, for example), and the fruit yields increase over the years. According to the simulation on mango and durian, the cash flow reaches US$89 per hectare in the fourth year, when mango trees first bear fruit, on a par with slash-and-burn farming. Once durian begins to bear fruit, fruit tree planting generates much higher cash flow than does slash-and-burn farming. However, high cash flow in the future may not induce slash-and-burn farmers to begin fruit tree planting if their livelihood concerns are more immediate. Other crops must be promoted in combination with the fruit tree planting to compensate for the initial negative cash flow, and farmers' awareness has to be raised.

Implications and Lessons of the Sebulu Experimental Forest. The final outcome of the Sebulu experimental forest is yet to be seen, since it takes many years for the trees to grow and since social forestry was initiated not so long ago. Based on initial findings, however, the experimental forest appears to be on the right path to replicating the conditions of the original tropical forest as closely as possible and to increasing the standard of living of local farmers through social forestry. These two objectives are closely related: the original forest cannot be replicated if social concerns are not addressed because population growth is broadening the destruction from slash-and-burn farming.

The Sebulu experimental forest is a carbon sink. It is estimated that the area under reforestation by the year 2010 will absorb more than 146,000 tons of CO_2 between 1991 and 2010. Although many developing countries have not yet formally accepted the innovative international cooperation mechanisms proposed under the Kyoto Protocol and the Buenos Aires Action Plan, the experimental forest experience can serve as a detailed model for the future. The experimental forest also represents a first small step for biodiversity. As the tropical forest has been rehabilitated with indigenous trees, orangutans have come back to the Sebulu area as have wild boar, deer, and other animals.

Sebulu has also produced fruitful outcomes in research activities. The characteristics of the dipterocarps have been carefully studied, although many things are still to be learned. Effective planting methods have been easily understood and utilized by the local people, and all equipment and materials for the planting are procured locally. For one of the dipterocarps species, Sumitomo has established a first-in-the-world tissue culture technique that may be applied to other tropical rain forest trees. Although Sumitomo initiated this project as a purely social activity, the tissue culture technique, protected by patent, might involve Sumitomo in a "win-win" situation.

It is important to note that the project was begun by a company with rich forest management experience in many countries and that on-site research activities made it possible to restore not only the forest of the dipterocarps but also the original ecosystem in the region. The experience of this project, though still in process, suggests that other "win-win" reforestation cases may be possible if business entities with technique, technology, and experience take the initiative and commit to the long term.

One important part of project implementation is cooperation with the local community. Although slash-and-burn farming in the experimental forest is illegal, the company has never tried to expel slash-and-burn farmers out of the boundary. The legal basis may hold no meaning for those farmers, and enforced banishment would undermine the existence of the project. Sumitomo tries to communicate with the farmers and counts on dissemination of information by participating farmers to slash-and-burn farmers. The priority placed on the local community is also observed in human resource management in KTI, the actual implementing entity, whose staff consists of local people.

Strong ties between Sumitomo, KTI, and the local communities in the Sebulu area have contributed to the success of the project. Human resources and physical infrastructure such as roads, schools, and other public facilities provided by KTI have been maintained, and this has facilitated the cooperation of the local community. Such strong ties imply that the experience is applicable elsewhere. Other examples of North-South cooperation have been demonstrated by European firms having strong ties with African countries, and U.S. firms with Latin American countries.

Finally, the importance of support from the public sector and academia must be pointed out. Financial support by the Japanese government, through the Research Association for Reforestation of Tropical Forests, has enhanced the research activities and the cooperation between Sumitomo and Indonesia. The University of Tokyo's involvement has been mutually beneficial; the Sebulu experimental forest serves as a site of field research and experiment for faculty members and students, while Sumitomo can mobilize the university's resources for its research activities for propagating dipterocarps. This framework can be used as a model in other cases, too.

The Sebulu experimental forest is young, and there are still tasks for the future. But the rich experience thus far bodes well for "win-win" opportunities in other tropical areas of the world.

2

Expanding the Scope and Constituency for Global Environmental Initiatives in Developing Countries

Wilfrido Cruz and Jeremy Warford

Global environmental problems threaten the future of the entire planet. Climate change, pollution of international waters, declining biodiversity, ozone depletion, desertification, acid rain, and many other environmental issues have transboundary consequences. Although industrial countries bear much of the responsibility for these problems, both historically and at present, prospects for the global environment will be seriously affected by actions in the developing countries and transition economies. This is especially true for the largest ones (such as China, India, Brazil, the Russian Federation, Indonesia, and Nigeria), whose combined populations account for most of the world's population. Cooperation is urgently needed among all countries to arrest global environmental degradation.

Background of WBI-DBJ Cooperation

In response to this challenge, the World Bank Institute (WBI) and the Development Bank of Japan (DBJ) have held a series of consultation meetings and training workshops to identify strategic issues and options for learning activities and capacity building. This partnership is designed to encourage dialogue on environmental policies and to put global environmental concerns in the mainstream of national development decisionmaking.

The World Bank already is deeply involved in global environmental work and plays a significant role in implementing a portion of the Global Environment Facility (GEF) project portfolio. The Global Environment Facility provides incremental cost financing to developing countries to promote projects on biological diversity, climate change, international waters, and the ozone layer. The Montreal Protocol has the more focused goal of supporting projects to phase out the manufacture and use of ozone depleting substances (ODS). These projects are substantial, but global environmental issues are still a limited part of the Bank's mission. The expectation is that the involvement of the Bank will continue to grow. It has recognized the close link between the global environment and development issues. As a World Bank presentation in Kyoto made clear, "the global environment and climate change are development issues" (Koch-Weser, 1997). This view continues to be reflected in the Bank's periodic reports to the GEF Council (World Bank 1998, 1999).

This perspective motivates Bank efforts to expand the scope of global environmental initiatives to include the role of policy incentives and to expand the global environmental constituency beyond traditional environmental agencies and the foreign ministries that coordinate international conventions. For example, the World Bank's Global Overlays Program (GOP), launched in 1995, has as its goal to incorporate global environmental externalities in the discussion and reform of national and sectoral policies. In this regard some progress has been achieved in linking the area of climate change to energy sector planning (World Bank, 1997). However, much more needs to be done to promote better understanding of the linkages between broad policy reforms and global environmental impacts and to develop a wider constituency for this integration.

The Relevance of Japanese Case Studies

The WBI-DBJ partnership's main theme is to identify the policy and institutional constraints to expanded involvement of government agencies and the private sector in global environmental initiatives. In principle, the global concerns include the entire range of GEF/Montreal Protocol concerns (climate, biodiversity, international waters, and ozone), as well as other transboundary issues, such as acid rain. However, as a practical approach it was decided to focus on climate change issues and their linkages to national or local activities, to ensure a manageable scope for the partnership. This topic is of great political significance because of the Framework Convention on Climate Change (FCCC) negotiations and because of the central position of the energy sector in national economies. Tremendous win-win opportunities exist in the energy sector, with potential economic efficiency gains accompanied by environmental benefits at both the national and global levels. However, the costs and benefits of socially desirable policy reforms must be considered carefully.

Although global environmental issues are being recognized as increasingly important, many developing countries are reluctant to address these problems. Their reluctance stems largely from the perception that, while interventions impose a cost, developing countries do not stand to benefit directly from such interventions. In addition, industrial countries are viewed as the source of much of the problem. Thus, a widely stipulated condition for developing countries' active participation is that the developed countries be the first to take major steps toward tackling global environmental problems. Based on this view, current global environmental programs have emphasized funding from developed countries to support projects in developing countries. In the past several years there has been significant progress in these environmental projects through specialized funds, such as the Global Environment Facility and the Montreal Protocol fund for phasing out ozone depleting substances.

The scope of the challenge is great. Specific project-oriented interventions are not enough to arrest, much less reverse, the environmental decline that is taking place worldwide. Despite progress in biodiversity conservation projects, unsustainable land use and deforestation continue to threaten biodiversity in many countries. Similarly, rapid urbanization and industrial growth in many developing countries continue to contribute to excessive greenhouse gas (GHG) emissions. In virtually all countries there remains considerable scope for investments that pass social cost-benefit tests at the national level as well as contribute positively to environmental quality. In the climate area in particular, opportunities for such investment in energy efficiency and clean production technologies abound.

More powerful than individual investments are policies that are typically required to induce such investments. Indeed, there is considerable scope for "win-win" policies of public agencies that at first sight may have limited involvement with the environment. For example, environmental benefits from energy price reform are a fortunate byproduct rather than the intended result of policies by the energy or finance ministries involved. In addition, there is a need to go beyond "win-win" approaches toward a more proactive sustainable development stance. External social benefits must be integrated into decisionmaking throughout the public administrative structure. This is particularly true of policies that are implemented at a high enough level in the economic system to have a countrywide impact.

Thus, the emphasis of the WBI program is to support policy reforms that promote both national benefits and global environmental benefits. In contrast to technology-oriented training activities, the program is designed for opinion leaders and senior decisionmakers at the policy level. Many training programs implemented under the auspices of bilateral development agencies, the United Nations Environment Program (UNEP), and GEF have addressed various aspects of the global environment (GEF, 1997). Most of these training programs have focused on improving technical awareness of environmental problems in areas such as biodiversity, climate change, international waters, and ozone layer protection; the programs also have discussed international conventions and project development. WBI-DBJ cooperation has a wider focus, however. In addition to information dissemination on the conventions and technical discussion, the partnership has emphasized the need to situate training and capacity building in the context of national development concerns in general and to link them to policy reforms in particular.

Practical examples and case studies are critical to progress in this area. The approach to policy reform must deal with all the complexities of legislative and institutional changes. At the same time, the process of building broad support for programs requires the involvement of a wide range of stakeholders from the private sector. Actual case studies have the advantage of identifying key lessons derived from a wide range of experiences. The Japanese examples presented here describe the complex involvement of the private sector and local communities and their differing sectoral interests and environmental concerns. However, cooperation between Japanese policymakers and the private sector has been extremely effective in harmonizing environmental initiatives and efficiency requirements. Many of these examples provide key lessons of value for multistakeholder initiatives in developing countries.

Constraints on Promoting Global Environmental Initiatives

Certainly, no substantive support for global environmental programs will be forthcoming unless it is linked to national priorities and multisectoral constituencies. A major concern related to economic constraints is fairness in allocation of responsibility for the source of global environmental problems and the needed financial resources to remedy the situation. Broad support for global environmental initiatives will depend, in the first instance, on the feasibility of integrating global environmental components into national priorities and, secondly, on developing countries' perception of developed countries' commitment to set their own house in order and to provide financial resources for these initiatives. As the case studies show, Japan succeeded in promoting domestic programs that also improved the global environment (for example, increasing energy efficiency reduced GHG emissions). The country's role as a leading donor to global environmental programs is particularly relevant in this regard.

The lack of a national policy on global environmental issues and weak constituencies for global environmental initiatives constitute major constraints. The lack of national policy must be distinguished from international policies or positions on global environmental conventions or processes. Developing countries, individually and as groups, have well-articulated positions in international meetings. However, such positions often are developed only within the confines of ministries of foreign affairs, and consultations usually include only national environmental officials.

Awareness of the relationship between global environmental issues and national economic and development policy is very limited. Since the national and sectoral economic and financial officials are not involved, global environmental policies and agreements can be implemented only through specific projects. They are not integrated into the economic and sectoral programs that can have the most impact on the global environment (for example, power generation and distribution, agricultural and forestry land use management). In addition, because other stakeholders in society are excluded, there is no broad constituency and therefore limited potential for generating multisectoral programs.

Opportunities for Expanding Global Environmental Initiatives

Despite these constraints on promoting global environmental initiatives in developing countries, opportunities abound for them to expand their initiatives in new directions. Several approaches are presented in this section.

Going Beyond Project-Oriented Responses

The preceding discussion highlights the need to go beyond project-oriented approaches to improving the global environment. As a first step, global environmental issues need to be linked to specific components of a nation's sustainable development program. In the Japanese cases discussed, national environmental priorities were identified, and the policy and programs that followed eventually contributed to global environmental goals. In developing countries there may be a strong national emphasis on urban and industrial pollution management. Global environmental initiatives to mitigate GHG emissions could be linked explicitly to this national program. Another approach would be to identify key investment sectors (such as land management in agriculture) and then integrate environmental issues with sectoral investment strategies. Because of the added global benefit that can arise from national sustainable development programs, additional resources might be made available to expand their scope.

"Win-Win" Actions at the National Level

As a next step, any significant effort to address global environmental issues, whether in developed or developing counties, has to include the search for "win-win" policies and investments. There appear to be many cases where domestic economic and environmental objectives coincide closely with global objectives. What prevents the implementation of these types of initiatives? In fact, major obstacles are to be observed in all countries. These include costs, lack of information, and jurisdiction constraints.

INCIDENCE OF BENEFITS AND COSTS. A project or policy that yields net social benefits may not be advantageous for those parties that control political decisionmaking. Relevant for all development objectives, this issue is particularly important when externalities and conflicts of interest cause those who are harmed by environmental degradation to have less say in the decisionmaking process than those who cause the damage.

Thus poor communities living downstream or downwind of industrial waste dischargers, indigenous people threatened by timber or mining interests, and, indeed, the well-being of future generations all tend to be under-represented in the decisionmaking process. Environmental degradation can be profitable, at least in the short run, and politically powerful vested interests create a formidable obstacle to change. However, wealthy interests are not always the obstacles: opposition to increasing energy or water prices, or to protection of natural habitats, may come from poor people as well. In practice, the incidence issue is a major reason why financial resources may not be made available for economically or environmentally justified actions.

LACK OF INFORMATION. Reinforcing the position of vested interests may be the public's lack of understanding of the environmental damage that is being created and the direct and underlying sources of that damage. Pseudo-scientific research or propaganda on the part of industrial lobbies and other forms of corruption may compound the problem. Awareness of the costs, sources, and incidence of environmental damage, requiring transparency and openness in public and private sector decisionmaking, is thus essential.

As the Japanese experience shows, an educated population and serious efforts by the local community to gather and disseminate environmental information can be important determinants of improved environmental policies. On the other hand, inadequate access to state-of-the-art technologies for energy efficiency or clean production often constrain progress. Formal educational establishments as well as nongovernmental organizations (NGOs) and religious and community leaders have vital roles to play in raising public awareness of environmental problems. This must be backed up not only by continued efforts to better understand the physical consequences and methods to combat global environmental degradation, but also by operationally oriented economic and social research.

JURISDICTION CONSTRAINTS. The issues of incidence and knowledge also arise with regard to public sector decisionmaking. First of all, different government agencies may have conflicting mandates, and internalizing external (environmental) effects may run into a knowledge barrier. Energy ministries may not have staff adequately trained in environmental impact assessment, and they may not be aware of the environmental consequences of their investment programs or individual projects. Administrative constraints also can hamper the mobilization of financial resources. For example, financing agencies have different time horizons and thus different institutional objectives than resource management agencies.

Even more complex are the linkages between sector, regional, and countrywide policies on the one hand and the environment on the other. Here considerable research is required, but the wide-ranging environmental impact of policies at the national level may justify the effort. Upgrading the environmental qualifications and understanding of staff would seem to be advisable. But while knowledge is necessary, it is not sufficient; systems of incentives need to be devised to induce government officials in a wide range of capacities to ensure that environmental factors are systematically taken into account in their day-to-day activities.

As noted earlier, developing countries, individually and as groups, may have well-articulated positions in international meetings, but these positions often are developed within the confines of ministries of foreign affairs, and consultations usually include only national environmental officials. Thus, awareness of the relationship between global environmental issues and national economic and development policy tends to be limited.

Beyond "Win-Win" Approaches

Taking advantage of "win-win" opportunities, while crucially important, is not a panacea. In many cases environmental improvement cannot be demonstrably justified in traditional economic terms. Indeed, valuation of the environment in economic terms is notoriously uncertain. This is especially a problem when costs are incurred now, but the benefits are realized a long way off, or when environmental improvement is clearly justifiable in commonsense or social terms but economic valuation is all but irrelevant for decisionmaking.

Beyond the win-win approaches discussed earlier, developing countries will find it difficult to promote approaches that are not amenable to "win-win" solutions at the national level. Developing countries' primary focus in such situations will be, by necessity, to obtain assistance from international or bilateral sources. For longer-term sustainability, however, it will be necessary to build constituencies for actions that do not fall within the "win-win" category in the major developing countries, as well as to continue efforts to strengthen such support in the industrial world. Whether because of the inadequacy of economic measurement or because impacts are felt outside their borders, developing countries, for the reasons mentioned earlier, rarely wish to absorb the net economic costs of global environmental protection measures. For this reason, international mechanisms, such as the Global Environment Facility, have evolved that address this issue.

The sustainability of dependence upon external funding is questionable. Therefore, developing countries should pursue two objectives: first, strengthening a constituency for environmental measures that are not easily justified in standard economic terms but would bring the country social and amenity benefits (these measures may not be "win-win" as conventionally defined); second, as a long-run goal, creating support for environmental protection measures, the benefits of which accrue to the world community as a whole and not just to the country concerned.

In practice, this latter objective would require a new way of thinking. Companies in many parts of the world are beginning to realize that although environmental measures are often unprofitable in the short term, it is in their own interest to adhere to internationally agreed environmental standards (for the reasons of image, marketing, recruitment, as well as avoidance of longer term resource degradation and depletion costs). This trend is discussed extensively in the Japanese case studies.

The Role of International and Bilateral Cooperation

The scope of international cooperation will need to support the expanded agenda for global environmental initiatives in developing countries described above. At the same time developing-country policymakers will have to be more involved in the development of new international mechanisms. They must better understand the cost-effectiveness of global environmental initiatives and the role of international initiatives, such as joint implementation (JI) or the Clean Development Mechanism (CDM)—innovations proposed during the 1997 Kyoto meeting on climate change to promote more international cooperation on carbon-reducing activities.

Supporting Cost-Effective Initiatives

Whatever the global environmental objective, it should be achieved at least cost. For any particular intervention, whether policy reform or investment program, actions should be ranked in order of their cost-effectiveness in achieving desired outcomes. This is an important practical policy issue: there remain many opportunities for "win-win" policy reforms that are politically difficult to introduce but would merit high priority if an overall social benefit–cost perspective was adopted. At the same time investments in actual projects with lower-order priority but beneficial to powerful vested interests could be implemented.

As shown in Figure 2-1, priority interventions would involve projects or policy changes along the axis between O and A. These items are economically and environmentally beneficial ("win-win") at the national level, and they should be financed by the country concerned, perhaps using World Bank or African Development Bank loans. Between A and B, actions are justified in the sense that they yield global benefits in excess of global costs but are not perceived as "win-win" at the national level; this is where GEF or another international subsidy mechanism comes in. However, GEF funding can make it easier for governments to avoid taking the hard decisions to carry out policy reforms in the region O-A. It can be argued that the presence of such mechanisms is at odds with the objective of achieving globally cost-effective solutions to environmental problems.

Creation of a constituency for global environmental protection in developing countries depends heavily upon the continued and increasing commitment of industrial countries in this regard. They should put their own houses in order as well as increase their financial and technical support for such initiatives in developing countries. It is essential that contributions to global environmental support be seen as additional to other aid commitments, not simply as a substitute for them.

Box 2-1. Financing Projects on the Basis of the Marginal Costs and Benefits of Reducing CO_2 Emissions

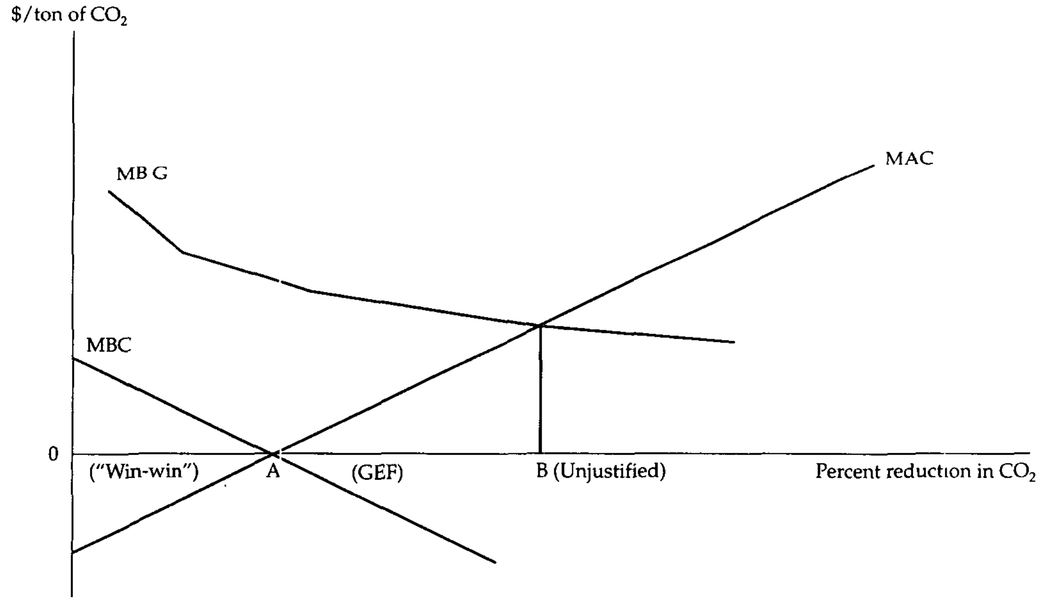
Figure 2-1 illustrates the situation facing a country considering greenhouse gas reduction projects. The MAC curve refers to the net marginal abatement cost to the country of each new method of reducing (or sequestering) greenhouse gases. MAC is the sum of the costs of introducing policy reform or emissions-reducing investments, minus any benefits that result from such expenditures. Therefore, it represents the net costs of alternative measures. (Up to point A, MAC could be mirrored by the curve MBC, the net marginal benefit to the country concerned.)

Countries intending to reduce GHG emissions should select the most efficient (that is, cost-effective) options first. Thus, MAC increases the greater the percentage reduction in carbon dioxide emissions. The portion of MAC lying in the negative range (O–A) represents opportunities for "win-win" actions by the country. These might include energy conservation measures, improved energy pricing policies, or clean production technologies that are justified in their own right at the national level and also benefit the global environment.

Point A represents the level at which it is no longer in the interest of the country to reduce greenhouse gases any further; at that point the costs exceed the benefits accruing to the country. However, there is a benefit to the world at large from such a reduction. The global optimum emissions level requires a greater emissions reduction than for the country alone. A global marginal benefit curve, MBG, intersects MAC to the right of level A at B. This represents the global optimum: the point where global marginal benefits equal global marginal costs.

Assuming that all "win-win" opportunities are taken by the countries concerned, using conventional financing sources, grant aid financing from the Global Environment Facility may be sought. In principle, such assistance should be restricted to the range A–B. Beyond that, further reduction in carbon dioxide emissions would not be justified, even when global considerations are included. In view of the massive costs involved in arriving at a global optimum, significant progress in this direction will depend heavily upon the implementation of sectoral policy reforms—justified in their own right—at the country level.

Figure 2-1. Marginal Costs and Benefits of Reducing CO_2 Emissions



New Mechanisms for Cooperation

In addition to one-way flows of resources and support from international donors to developing countries, new international mechanisms are being developed that can expand the scope and participation for global environmental initiatives and capacity building in developing countries. For example, joint implementation activities can have a positive influence by helping to build up local technical expertise in carbon emission reduction activities. Presumably, for an industrial country or company to obtain political or economic credit for investing in JI, there should be a strict requirement that its investment to achieve the environmental target is sustainable. In turn, this requires development of institutional capacity. Thus, if JI or other such measures are to work properly, they should build up environmental expertise and contribute to constituency building. Qualification for credit should be subject to strict monitoring and institution-building requirements to ensure that it is effective.

Similarly, developing-country policymakers need to consider how an emissions trading regime could be designed to most effectively promote global environmental awareness and capability within developing countries in a way that is consistent with cost-effective achievement of global targets. As in the case of joint implementation activities, emissions trading can be expected to generate more awareness of the issues, but whether or not the net impact is efficient in a global or indeed national sense may be open to debate.

Support for Capacity Building in Developing Countries

Improving developing countries' awareness of these issues and ability to take action on them is a pressing global concern. Many training programs have addressed global environmental issues under the auspices of the World Bank and other international and bilateral development agencies. Most of these training programs have focused on technical awareness in specific areas such as biodiversity, climate change, ozone layer protection, and international waters, and on discussion of international conventions and project development. These are important topics that require continuing support. However, the WBI-DBJ partnership has identified a critical need for training and capacity building that goes beyond this agenda. The challenge is to support initiatives that will enable the full integration of environmental policy into national policymaking.

References

GEF (Global Environment Facility). 1997. *Quarterly Operational Report.* Washington, D.C. March.

Koch-Weser, Caio. 1997. "The Global Climate for Sustainable Development." Presentation prepared for the Third Meeting of the Parties to the Framework Convention on Climate Change, Kyoto, Japan, December 8, 1997.

World Bank. 1997. *Report of the Global Overlays Program (GOP) Advisory Group Meeting, October 8.* Washington, D.C.

———. 1998. *Mainstreaming the Global Environment in World Bank Group Operations, Report to the GEF Council.* Global Environment Facility, Washington, D.C. October.

———. 1999. *World Bank Group Progress Report on the Preparation of an Environment Strategy.* Global Environment Facility, Washington, D.C. November.

3

Review of Environmental Policy and Energy Conservation Policy in Japan

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To protect the environment, Japan has adopted very strict environmental standards and used the best available technologies. Nationwide standards are often supplemented by stricter ordinances and guidelines from local governments as well as by voluntary agreements that help to adapt national efforts to local conditions. The emphasis on technology led the national government to offer considerable public support for environment-related R&D expenditure and investment in pollution control and prevention equipment.

Conventional wisdom is that strict environmental protection and energy conservation measures, and the concomitant spending, inevitably harm a country's economic growth. On the contrary, the Japanese experience demonstrates that technology, improvement of management efficiency in the private sector, and government policy can be used to overcome resource and regulatory constraints. As noted in Chapter 1, Japan made a national commitment in the mid-1970s to reduce pollution and increase efficiency of production (especially energy efficiency) through combined efforts in the public and private sectors.

Developing countries and transition economies face situations that are quite different from Japan's in two respects. First, economic development issues and environmental issues simultaneously confront them. Japan grew first and cleaned up later. In this sense the Japanese model may not be suitable for duplication by other countries. Second, developing countries and transition economies face an assemblage of environmental issues (pollution control, energy conservation, natural resource preservation, and global environmental issues) all at the same time, whereas Japan was able to face them one by one. Some of what has happened in Japan reflects that country's unique economy and society. However, these differences, as well as circumstances and backgrounds specific to Japan, do not preclude the applicability of its experience to other countries. Many aspects of Japan's experience are relevant and useful. For example, Japan institutionalized environmental policy at the national and local government levels. It persuaded industry of the self-interest aspects of environmental protection, and it created public awareness of environmental issues. All of these experiences provide helpful lessons as developing countries and transition economies implement their own policies to protect the environment and promote development.

The Appearance of Pollution Problems

In the early stages of Japan's modernization, some of the country's severe environmental problems were already apparent near copper mines and metal refineries. Further industrialization and urbanization accelerated the problems in pre-war Japan. The Japanese people, however, were not very aware of their environmental rights at that time, and these problems did not become important social issues right away. Environmental problems became socioeconomic problems during the rapid development of heavy and chemical industries after World War II. In the 1950s, paper mills discharged polluted water in many parts of Japan; in 1956 thousands of residents in the Kyushu area were poisoned by organic mercury that had leaked from a factory that used it in its manufacturing process. When Japan's growth took off in the 1960s, petrochemical complexes that had been built all over the country began emitting waste gases such as sulfur oxide (SO_x), nitrous oxide (NO_x), and carbon monoxide (CO), greatly aggravating air pollution.

Previously, most of the air pollution had been localized or purified naturally, but by the 1960s it exceeded the absorption capacity of natural processes, and many Japanese citizens suffered under its cloud. The Japanese government and some of its agencies, which should have protected public health by setting pollution standards and holding companies accountable to them, were slow to respond. Japanese law recognized the obligation of companies to prevent pollution (for example, the *Law Relating to Factory Effluents* enacted in the 1950s), but these standards were weak, and they were not designed to reduce water pollution substantially. The Japanese government at that time was more concerned with how pollution policies would affect production output than with how it could protect the health of Japanese citizens. It can be said that the government valued the right of companies to conduct business more than the right of the people to a safe environment. Pressure by citizens forced local governments to take action against pollution and set pollution standards. These measures, however, were not effective, and in the 1960s pollution began to spread widely.

Antipollution Actions

As pollution increased, its victims multiplied. Victims and other citizens who saw the damage jumped into action, forming grassroots movements around the country. Movements to oppose construction of petrochemical complexes sprang up, and suits claiming damage caused by pollution were prosecuted one after another. To the government's surprise, the courts judged in favor of the victims, ordering the defendants to pay damages to them and take steps to control their pollution. Companies from that time on were obliged to control pollution and were fined for damages when their operations breached this responsibility.

Those who suffered from pollution-related health problems filed lawsuits in the late 1960s, and a decision by the Supreme Court in 1970 helped citizens in the judicial process. Under the new rule, the defendant (polluter) had the burden to prove that there was no cause-and-effect relationship between its pollution and any adverse effect on health. Associations were organized around the pollution issues; some helped obtain compensation for those who suffered from illnesses such as the Minamata and Yokkaichi diseases, and others did the same for those whose livelihoods were affected by lost fisheries and other adversely affected industries. In every Minamata and Yokkaichi case in the 1970s, the ruling was in favor of the plaintiffs. The rulings successfully pressed government and industry to introduce effective pollution control measures. It is important to note that these trials revealed to the public the extent of the pollution, and, as a result, business management and government measures became exposed to public scrutiny.

Accordingly, in the 1970s the administration of antipollution measures changed greatly. The people's right to enjoy their environment gained far more safeguards. Furthermore, Japan along with other countries began applying the Polluter Pays Principle (PPP), obligating polluters to pay for the damages they caused. Polluters were financially liable for the treatment of the harmful waste materials they produced; in addition, they had to pay damages for their past activity. This clearly indicates that the government at that time set environmental protection above industrial development.

In fact, many laws were enacted reflecting the turnabout in policy. Laws set strict standards for seven environmental problems (air pollution, water pollution, soil contamination, noise pollution, vibrations, land subsidence, and noxious odors) to which businesses were held strictly accountable. The *Air Pollution Control Law* of 1968 tightly regulated the emission of sulfur oxide.

This influenced the structure of the energy demand in Japan. Industries changed their sources of energy from fuels with high sulfur content to those with low sulfur content. In addition, because of two oil crises in the 1970s, energy saving became a major policy issue. Industries rationalized their energy usage, which also contributed to lower air pollution.

The administration of environmental matters, a function previously handled by various ministries, was centralized in 1971 when the Environment Agency was established. Because it was taking too long for damage claims to work their way through the courts, an administrative framework for awarding judgments was also set up. In this milieu, a 1973 law on pollution-related health damage was enacted. It established a scheme whereby companies found guilty of polluting were charged according to the amount of harmful waste they produced; money was distributed to everyone suffering health problems, wherever they lived. These rigorous environmental parameters and the obligation of businesses to pay for damages from past pollution were very advanced by world standards at the time and helped place Japan as a leading country in fighting pollution. In addition, there is increasing recognition in government and industry that measures to control pollution before it leads to damages end up costing less than having to pay for damages afterward.

In the 1980s lifestyle pollution replaced industrial pollution as the primary pollution problem in Japan. Lifestyle pollution has multiple sources, but most of it comes from households. (Household sewage and garbage are two critical examples.) Households are seldom able or willing to pay for the environmental damage they cause. This has made it difficult to enact a law that holds the polluters accountable. The solution to this kind of pollution calls for lifestyle changes such as use of reusable resources that cause as little disturbance to the earth's ecosystem as possible. The environment is overburdened by the massive quantity of material that does not break down naturally in the environment. Examples are consumer goods produced by the petrochemical industry. New technology to break down those materials is needed, but so is a change in consumers' consciousness about recycling. Educating citizens to become enlightened problem solvers and nurturers of the earth becomes increasingly important.

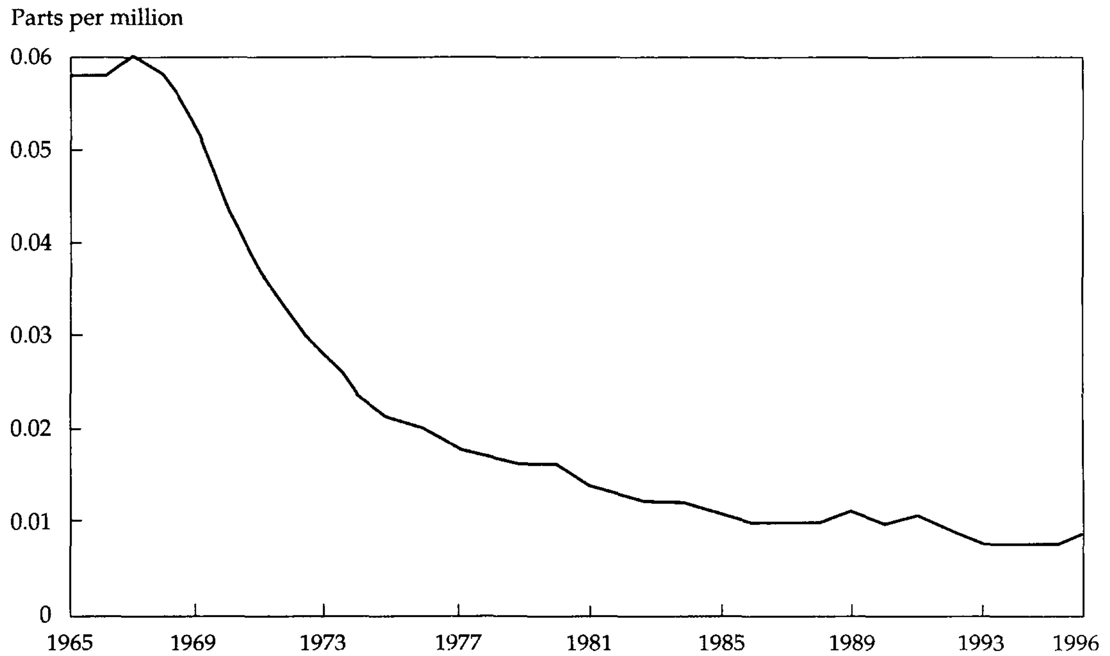
The second half of the 1980s witnessed a succession of abnormal weather patterns, and the global warming phenomenon became a worldwide concern. The urgency of concluding an international convention on global warming was heightened, and a number of summits were held. Some of the advanced countries pledged to stabilize or cut down the emission levels of the gases that cause the greenhouse effect. The Japanese government decided to require that emissions of greenhouse gases such as carbon dioxide and methane be reduced to 6 percent below their 1990 levels by some time between the years 2008 and 2012. In order to achieve this, the government further promoted energy conservation, in both industry and households.

Trend in Air Quality

As a result of the countermeasures employed by the central and local governments, and private companies' strenuous efforts to reduce pollutants, Japan's environment has improved substantially.[1] The average annual ambient concentrations of sulfur dioxide and carbon monoxide (observations from a sample of general stations) decreased from 0.06 parts per million (ppm) and 2.4 ppm respectively in 1971 to 0.009 ppm and 0.7 ppm in 1996. The SO_2 emissions from the steel factories of Nippon Steel Corporation decreased by around 85 percent between 1973 and 1996, while the amount of crude steel produced there decreased by 34 percent during this period (Figures 3-1 and 3-2). Other pollutants, such as dust, are important as well. Although there

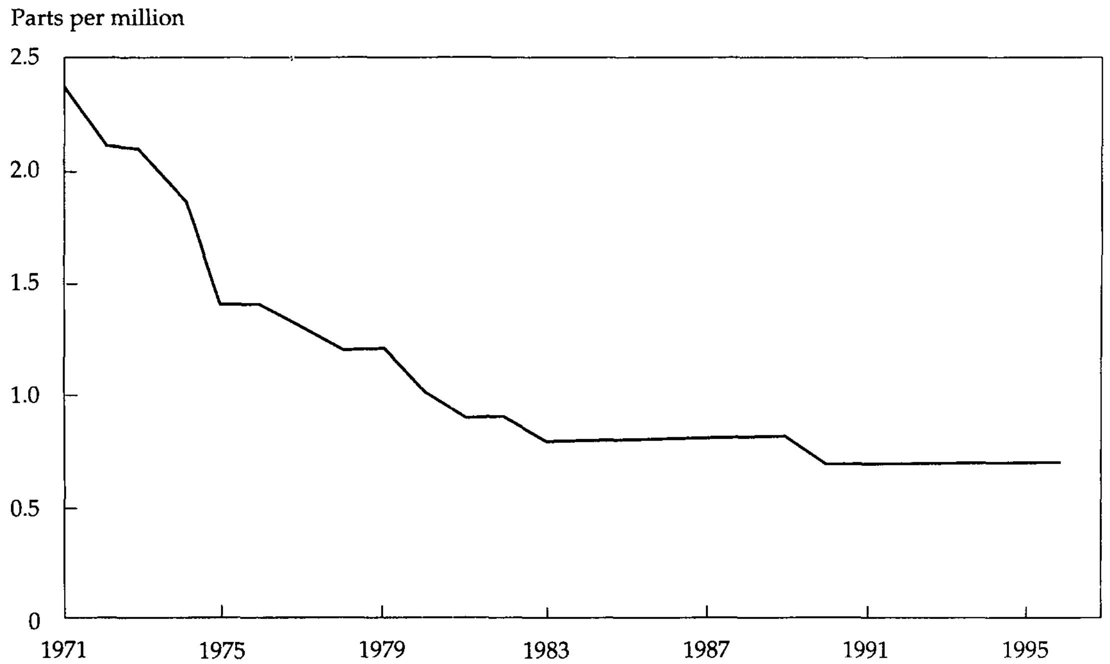
1. The rational usage of energy curbed the increase in carbon dioxide emissions in Japan. Details will be discussed in the following section.

Figure 3-1. *Average Annual Ambient Concentration of SO_2 in Japan, 1965–96*



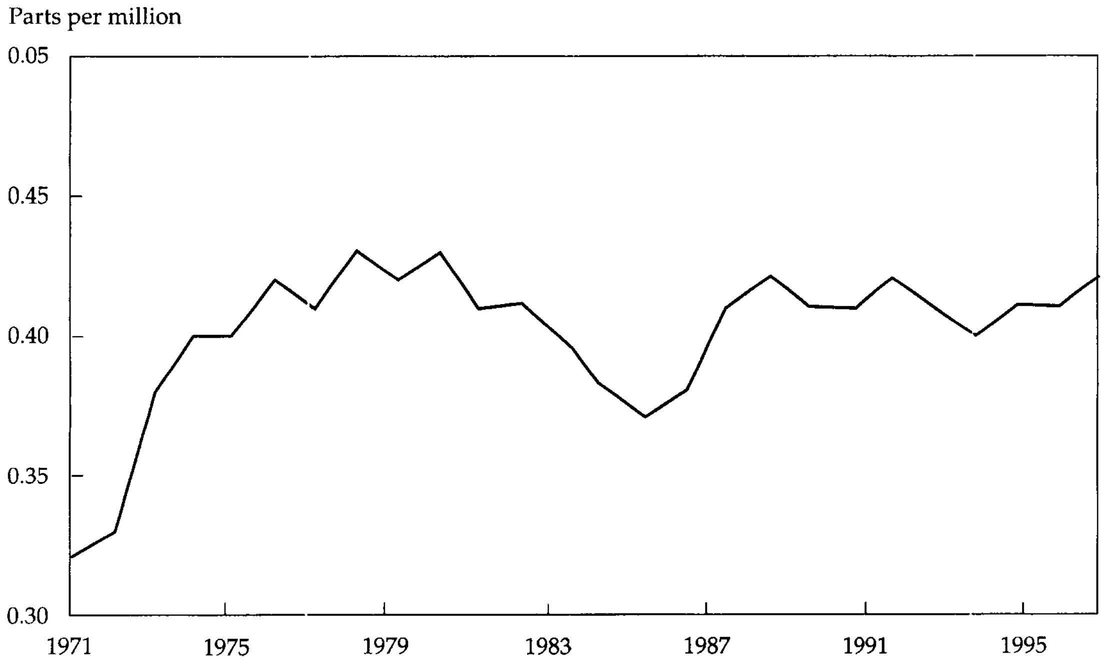
Note: Data are from continuous monitoring of general environmental monitoring stations.
Source: Environment Agency (1998).

Figure 3-2. *Average Annual Ambient Concentration of CO in Japan, 1971–96*



Note: Data are from continuous monitoring of general environmental monitoring stations.
Source: Environment Agency (1998).

Figure 3-3. Average Annual Ambient Concentration of NO_2 in Japan, 1971–96



Note: Data are from continuous monitoring of general environmental monitoring stations.
Source: Environment Agency (1998).

are important health implications from these pollutants, Japanese policy has concentrated on SO_x and NO_x.

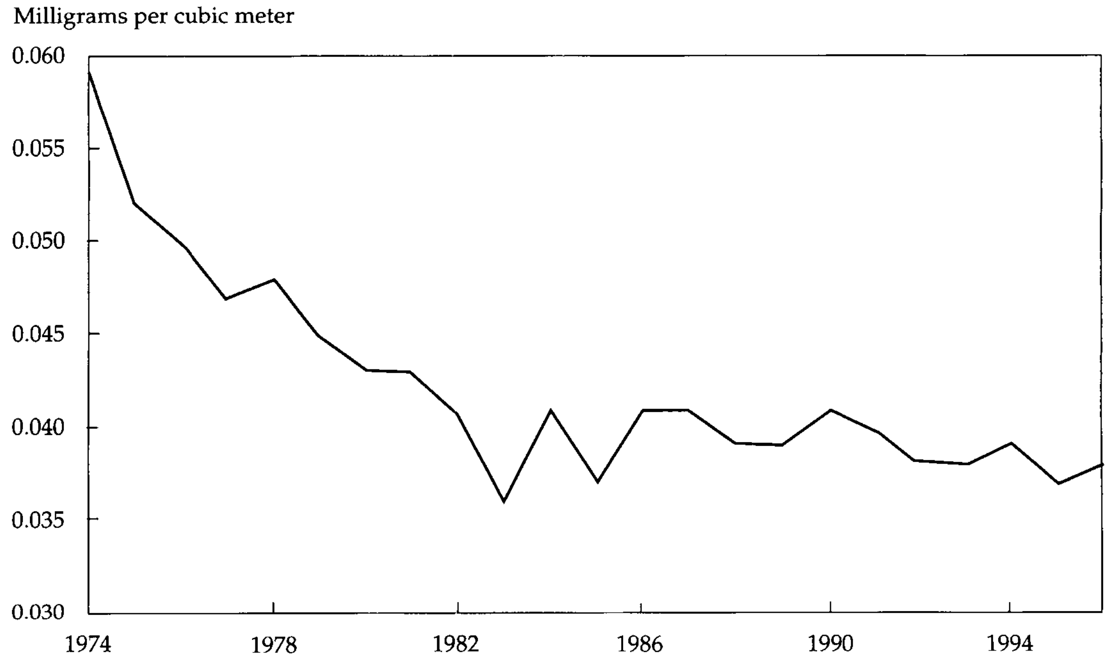
The ambient concentration of NO_2 did not improve between 1971 and 1996, and suspended particulate matter (SPM) remained relatively stable between 1981 and 1996 (Figures 3-3 and 3-4). Despite decreased emissions on a per-factory basis[2] and on a per-vehicle basis, the incremental amount of emissions caused by the growth in traffic volume outweighed these decreases. Air pollution control measures at stationary sources in the 1970s improved the ambient concentration of SPM, but it increased in the 1980s because of the greater number of diesel automobiles. As for nitrous oxide, emission from stationary sources was reduced. However, automobiles are the major sources of emission. Increases in driving distance, the average age of automobiles, road congestion, as well as the increasing share of diesel automobiles contributed to the relatively poor performance of NO_x emission control.

Trend in Water Quality

Japan's environmental conservation efforts led to an improvement in water quality as well as air quality; emissions of water pollutants such as heavy metals and toxic chemicals have been abated almost completely. Twenty-three toxic substances are regularly surveyed in Japan. By 1996, fifteen substances, such as total mercury, alkyl-mercury, and PCBs, met the standards and targets at

2. For example, the average NO_x emission intensity (NO_x emissions per unit of electricity generated) of thermal power plants owned by Tokyo Electric Power Company decreased from around 1.6 grams per kWh in 1973 to 0.25 grams per kWh in 1997.

Figure 3-4. *Average Annual Ambient Concentration of Suspended Particulate Matter in Japan, 1974–96*



Note: Data are from continuous monitoring of general environmental monitoring stations.
Source: Environment Agency (1998).

all measurement stations, and the remaining surveyed substances failed to meet them at only a very few stations. Overall, in only 42 of 5,471 observations were standards not met in 1996.

In contrast with the relatively good situation concerning heavy metals and toxic chemicals, organic pollution of water has not improved substantially. Compliance ratios for Biological Oxygen Demand (BOD) in rivers and for Chemical Oxygen Demand (COD) in coastal waters, lakes, and reservoirs have not improved much (Figure 3-5). Compliance on COD in lakes and reservoirs is especially substandard (42 percent in 1996) despite a decrease in polluted effluents from factories. The decreased water flow in urban rivers as a result of growing industrial use and delays in controlling domestic water discharge seems to have offset this decrease in polluted effluents from factories.

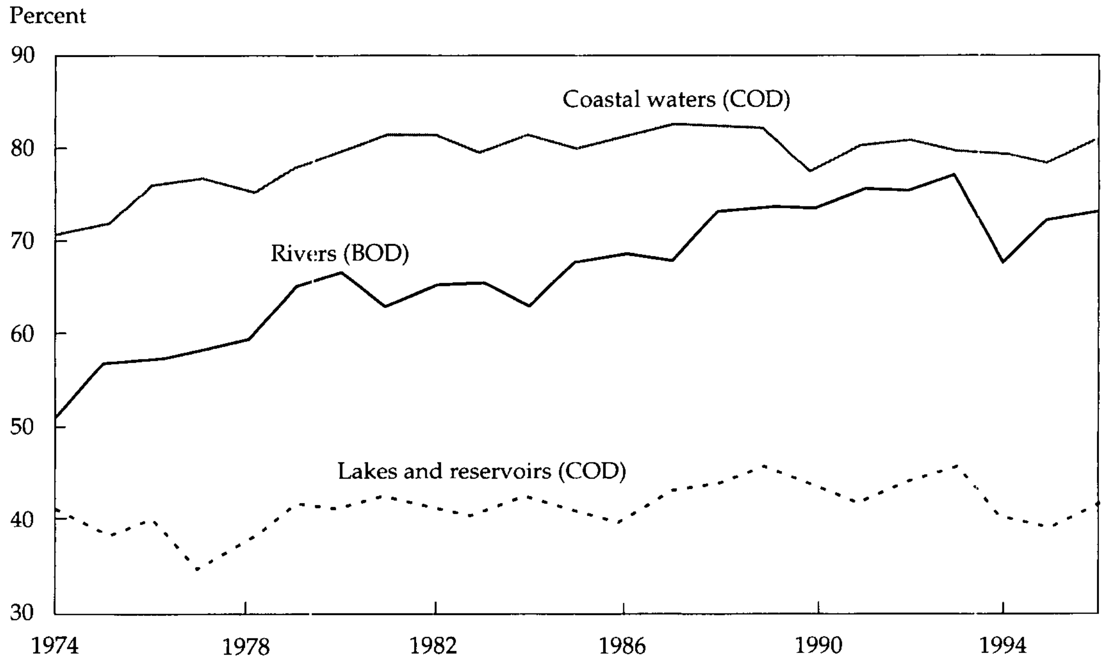
Climate Change: The Energy-Environment Connection

Industrial pollution, such as atmospheric pollution or water contamination, remains an important problem to be solved in many countries, especially in the developing world. These countries are still on the brink of industrialization, so full-scale industrial pollution is yet to come. Climate change, however, is already causing growing concern worldwide.

Current Situation and Trends in GHG Emissions

Scientists and policymakers around the globe are studying the amount of gas emissions that affect the absorption and emission of radiation in the atmosphere. These gases include carbon

Figure 3-5. *Chemical and Biological Oxygen Demand: Ratio of Compliance with Envrionmental Quality Standards in Japan, 1974–96*



Source: Environment Agency (1998).

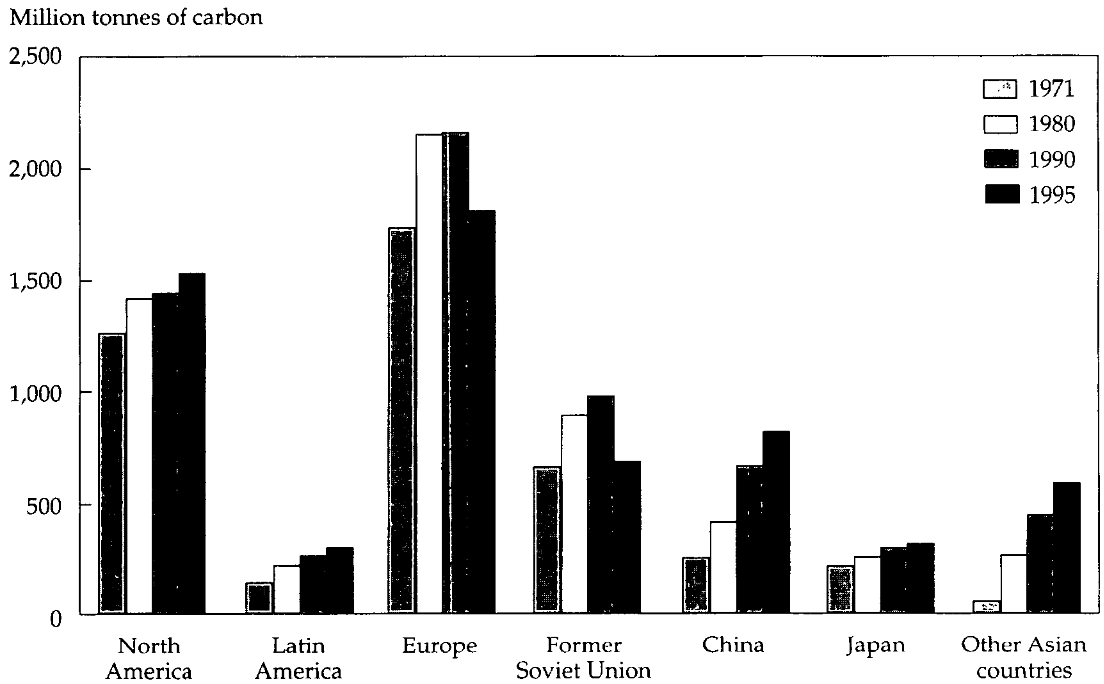
dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tropospheric ozone (O_3), and chlorofluorocarbons (CFCs), and they are collectively referred to as greenhouse gases (GHGs).[3] This section focuses on CO_2 emissions, since carbon dioxide is the most important greenhouse gas for industrial countries such as Japan and the relationship between the emissions and energy consumption is clearer for CO_2 than for the other gases.[4] In fact, according to research conducted by the Environment Agency in Japan, among all the greenhouse gases emitted in 1993, CO_2 was responsible for more than 90 percent of the global warming in the year.

Between 1971 and 1995, CO_2 emissions worldwide increased from a little less than 4 billion tons of carbon to about 5.9 billion tons (Energy Data and Modeling Center, 1998). Huge increases occurred not only in industrial countries but also in the developing world, particularly in China and East Asia (Figure 3-6). Among the total incremental CO_2 emissions during the period, about 30 percent came from China and another 7 percent from Hong Kong, Taiwan, the Republic of Korea, and Singapore. Huge increases in the emissions of developing countries are from the boosts in energy consumption that accompany periods of high economic growth. Economic growth and

3. In many developing countries, emissions of both CH_4 and N_2O are relatively important, because those emissions are related to enteric fermentation (cattle and rice paddies) and fertilizer application respectively.

4. According to the research conducted by Wuebbles and Edmonds (1988), the majority of man-made CO_2 emissions are related to energy use, while the emission of CH_4 and CFCs from human activities are less related to energy use.

Figure 3-6. *CO_2 Emissions by Region, Selected Years, 1971–95*



Source: Energy Data and Modeling Center (1998).

increasing energy consumption in these countries are expected in the future.[5] Hence, it is predicted that the bulk of incremental CO_2 emissions will again come from developing countries.

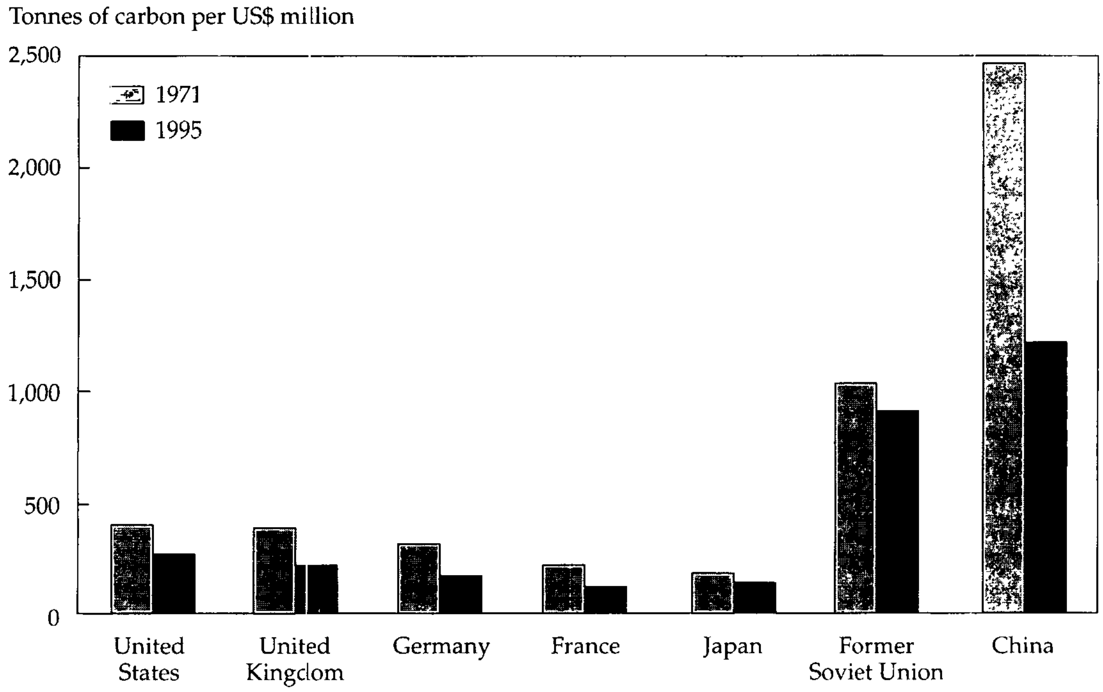
CO_2 emissions in Japan accounted for about 0.3 billion tons of carbon in 1995, 14 percent of the world total. Among the five major industrial countries, Japan had CO_2 emissions in 1995 that were second to those of the United States, which emitted more than four times the Japanese amount. CO_2 emissions per GDP (at 1987 prices and exchange rates) were lower in Japan than in the United States, Germany, and the United Kingdom, and they were almost comparable to those in France (Figure 3-7).

Figure 3-8 shows the trend in CO_2 emissions in Japan between 1971 and 1996. They increased from 0.2 billion tons of carbon to 0.3 billion tons, a 1.8 percent per year increase on average. This rate of increase was similar to that of the world (1.7 percent per year). During this period, real GDP in Japan grew on average by 3.6 percent per year; therefore, CO_2 emissions per GDP declined 1.8 percent per year. The relationship between GDP growth and CO_2 emissions growth is a function of industrial structure, the rationality of energy usage in the energy-consuming sector, and the fuel mixes in the sector. Japan's reduction in CO_2 emissions per unit of GDP is attributable to three factors:

- A decline in outputs from energy-intensive industries as a share of total GDP
- Improved usage of energy by Japanese industries

5. Some of the Asian economies are suffering negative growth due to the recent financial turmoil in the area, but these economies are expected to grow faster again, once the financial problems are settled.

Figure 3-7. CO_2 *Emissions per GDP by Region, 1971 and 1995*



Source: Energy Data and Modeling Center (1998).

- A change in the fuel mix, especially in the power generation sector. (Between 1970 and 1996, the share of electricity generated by nuclear power plants increased from 1.3 percent to 29.9 percent.)

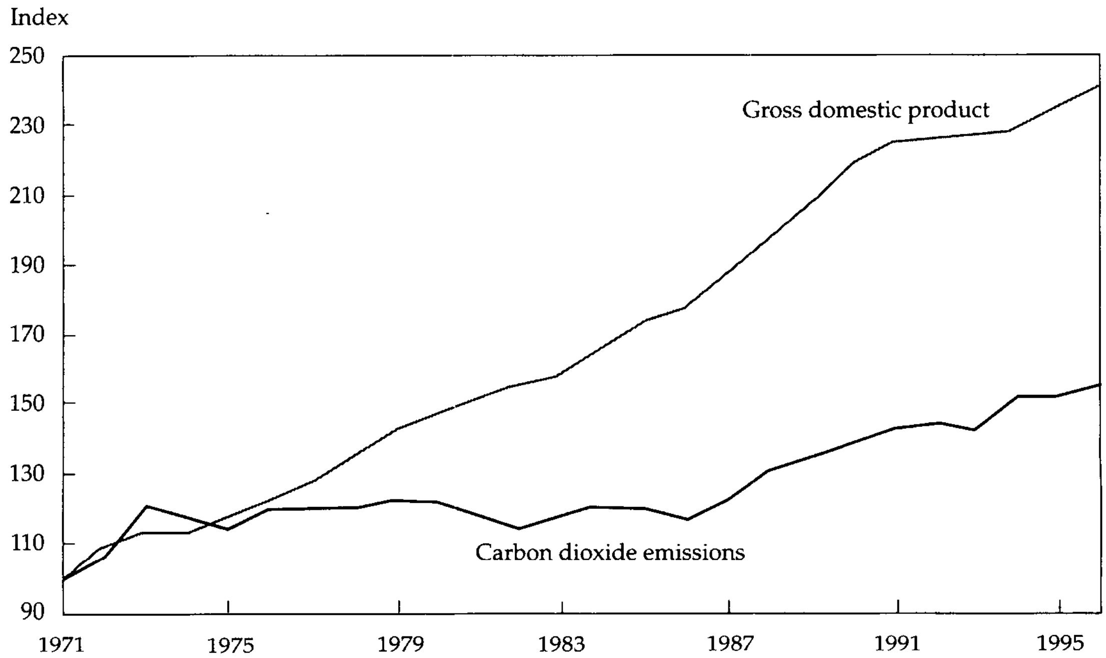
Energy Consumption and Energy Intensity

Total energy consumption in Japan increased from 270 million tons of oil equivalent (MTOE) to 510 MTOE between 1971 and 1996. During this period, Japan's real GDP (evaluated at the market exchange rate in 1990) increased by $1,358 billion to $3,316 billion. Figure 3-9 shows trends in energy intensity of the five major industrial countries. Energy intensity in Japan (measured in TOE per one thousand 1990 U.S. dollars of GDP) declined from 0.20 TOE in 1971 to 0.15 TOE in 1996, a 1.1 percent annual improvement on average and the lowest of the five.

The industrial sector is the largest end user of energy in Japan. In 1971 industrial energy demand accounted for about 60 percent of total energy demand, but by 1996 the share had fallen to 39 percent, which was still high compared with the OECD standard of 30 percent in 1996. The rapid improvement in energy intensity is largely the result of a shift in industrial production away from energy-intensive industries toward high-technology industries that are not energy intensive.

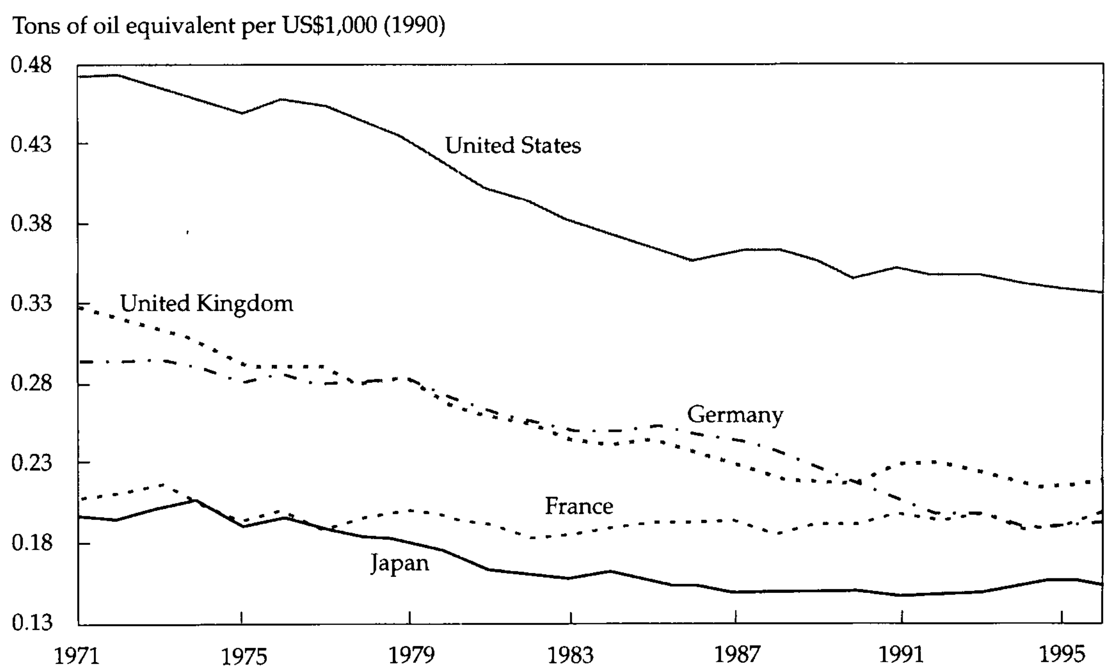
The share of gross domestic product held by energy-intensive industries declined during the 1980s and 1990s. For example, the share of the iron and steel industry declined from 2.6 percent to 1.6 percent, and the share of the nonmetallic mineral industry dropped from 1.6 percent to 1.0 percent. Meanwhile, the share held by high-tech industries increased. For example, the share of GDP of the electrical machinery industry increased from 0.5 percent to 2.0 percent during these two decades.

Figure 3-8. *GDP and CO_2 Emissions in Japan, 1971–96*



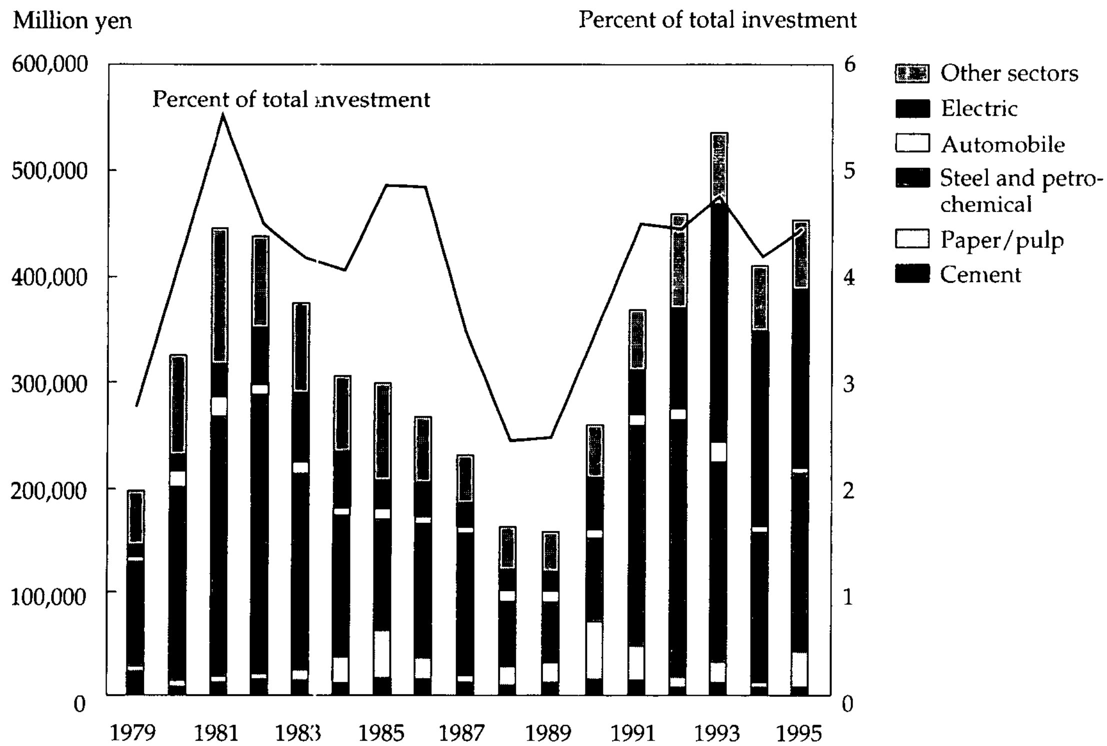
Note 1971 = 100.
Source: Energy Data and Modeling Center (1998).

Figure 3-9. *Energy Intensity of Major Industrial Countries, 1971–96*



Source: International Energy Agency (1997).

Figure 3-10. *Trends in Energy-Saving Investment by Energy-Intensive Industries, 1979–95*



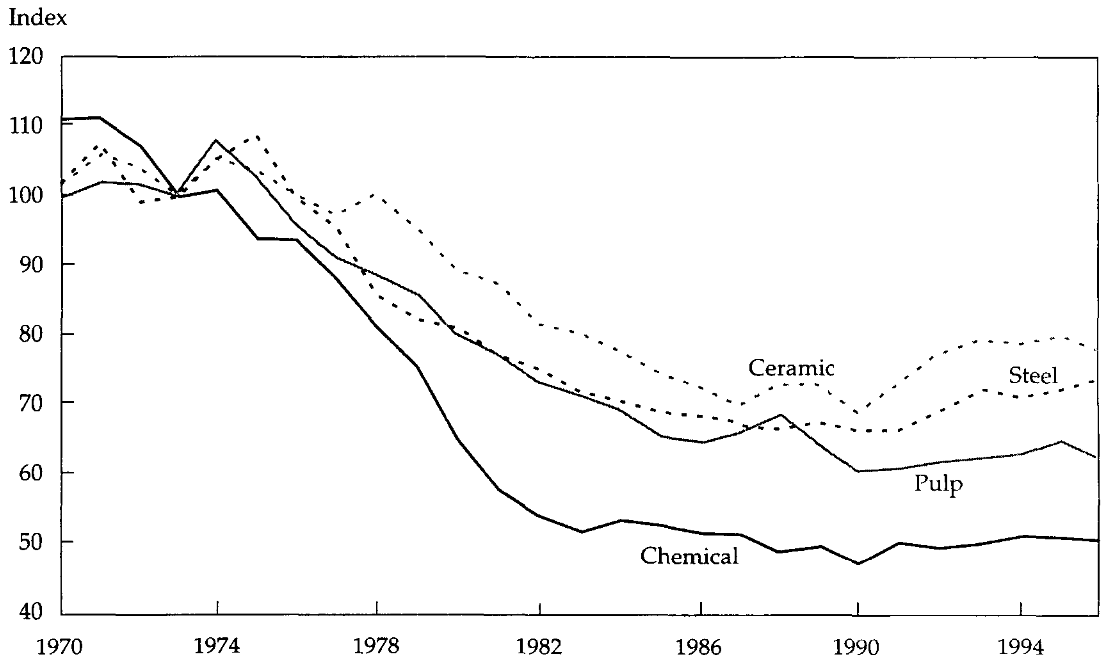
Source: Ministry of International Trade and Industry (1998).

During that period, energy-intensive industries also achieved rapid improvements in the usage of energy. Because of oil price shocks in the 1970s, the price for imported oil increased from US$2.57 per barrel to $4.85 per barrel between 1973 and 1974, and from $23.37 per barrel to $34.63 per barrel between 1979 and 1980. After both crises, major industries invested heavily in energy saving. According to the Ministry of International Trade and Industry's survey on capital spending (Figure 3-10), the share of energy-saving investment in total investment increased from 2.8 percent to 4.2 percent between 1979 and 1980. In the iron and steel sector, the share increased from 15 percent to 27 percent between those years.

As a result of those investments, Japanese manufacturers achieved substantial improvements in energy efficiency (Figure 3-11).[6] For example, the energy efficiency in the iron and steel sector improved by 31 percent between 1971 and 1996. The steel industry introduced energy-saving methods and equipment, such as coke dry quenching, continuous casting production, and blast furnace top-pressure recovery turbines. At the same time there were shifts in production techniques from basic oxygen furnaces to scrap-oriented electric arc furnaces (EAFs). EAFs avoid most energy-intensive processes, such as converting iron ore to iron. Furthermore, unlike the blast furnace, the EAF does not require an energy-intensive coke preparation stage.

6. Hereafter, improvement of energy efficiency implies a reduction in the amount of energy required to produce one unit of a certain product.

Figure 3-11. Industrial Energy Efficiency in Japan, 1970–96



Note: 1974 = 100.
Source: Energy Data and Modeling Center (1998).

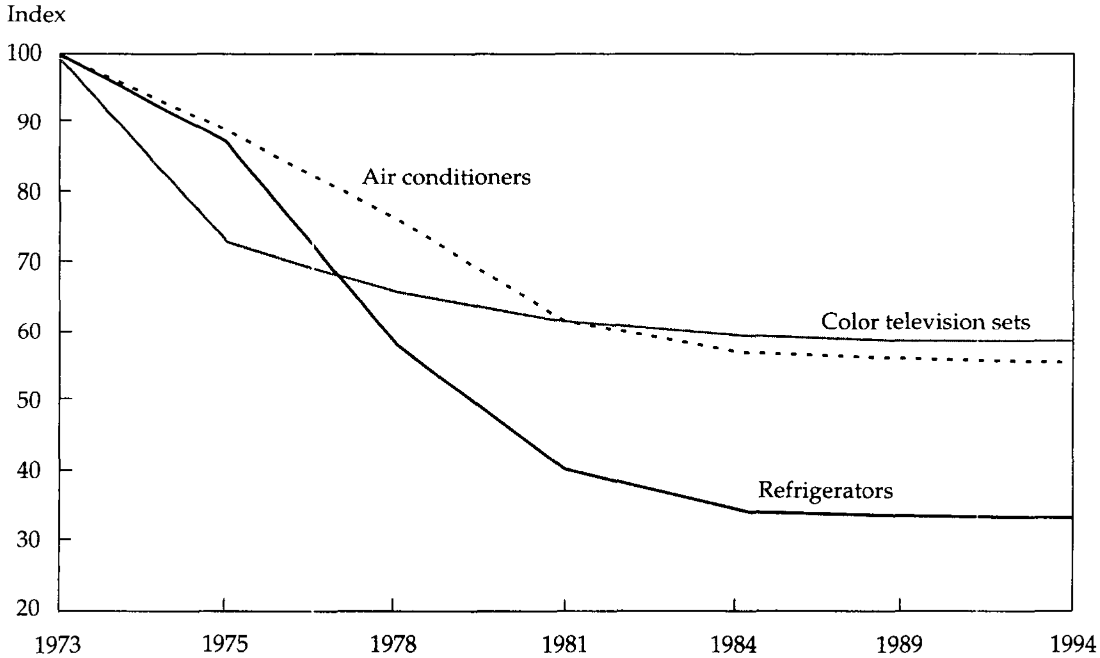
Energy Prices and Energy Conservation

Energy prices play an important role in achieving efficient energy usage. During the surge in oil prices between 1970 and 1980, the prices for nearly all forms of energy in Japan rose: imported oil rose from US$1.83 per barrel to $34.63 per barrel, imported liquid natural gas rose from US$27.34 per ton to $286.65 per ton, and imported coal rose from US$21.21 per ton to $67.11 per ton. Because of these rapid increases in energy prices, energy-saving investments were essential in manufacturing industries, especially energy-intensive industries, if they were going to keep their competitiveness in domestic and foreign markets.

Following the collapse in oil prices in 1985, the pace of improvement in efficiency stagnated. There was almost no improvement in energy efficiency between 1985 and 1996, after an average annual improvement of 3.9 percent between 1971 and 1985. This stagnation was partly attributable to low energy prices, which made additional energy-saving investments uneconomical. Some industries began to produce higher-value-added products, which require more processing and thus more energy inputs. A similar phenomenon can be found in the home electric appliance sector. The energy efficiency of refrigerators, color television sets, and air conditioners in Japan improved significantly between the early 1970s and the early 1980s (Figure 3-12). People then began to pay less attention to energy conservation. Since the early 1980s, large and high-speed cars, which are less efficient from a fuel economy point of view, have become more popular.

The International Energy Agency (IEA) in 1995 estimated the energy price elasticity of Japanese industrial energy demand and found that the long-run elasticity is -0.33. This implies that a 1 percent increase in energy price would lead to a 0.33 percent decrease in the Japanese industrial sector's energy consumption in the long run. This result also indicates the close connection between the price of energy and the energy efficiency of Japan's industrial sector.

Figure 3-12. Energy Efficiency Improvements in Japanese Home Appliances, 1973–94



Note: 1973 = 100.
Source: Energy Data and Modeling Center (1998).

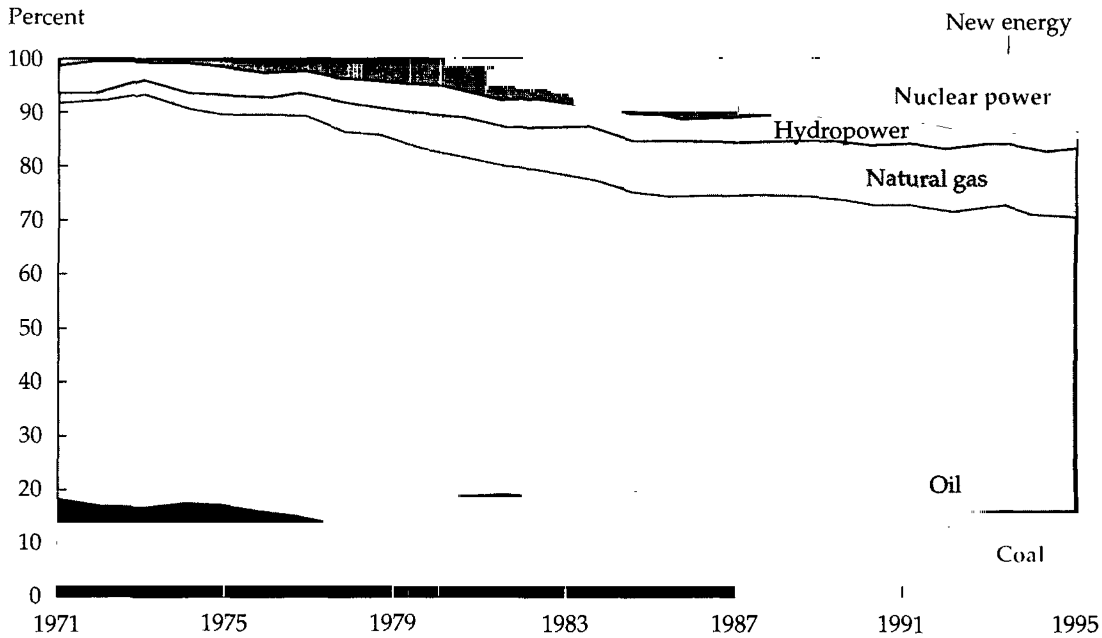
Government Policy and Energy Conservation

Energy policy has changed drastically since the first oil price shock in 1973. Before the oil shock, the Japanese government gave top priority to the development of heavy industries, such as coal and steel, and there were no important policy measures for energy conservation. In 1977, however, the Japanese government set up a committee on energy saving and began to discuss policy measures. In 1979 the *Law Concerning the Rational Use of Energy* was enacted with detailed guidelines for energy-saving equipment and building standards. This law required each factory within the industrial sector to nominate qualified persons to implement the guidelines for heat and/or electricity management. In order to support these policy ends, government provided long-term, low-interest loan programs for companies and households through governmental financial institutions such as the Japan Development Bank, Japan Finance Corporation for Small Business, and Housing Loan Corporation. The government also introduced tax exemptions and accelerated depreciation for energy-saving equipment. As a result, industries were able to invest heavily in energy-saving equipment and could achieve substantial reductions in energy consumption.

Fuel Diversification

Following the two oil crises in the 1970s, diversification of energy resources became an important issue for the Japanese government. Japan's dependence on oil from the Middle East was very high in the 1960s and 1970s; 78 percent of energy supply came from oil when the first oil crisis occurred in 1973. In order to secure a more stable supply of energy, the government decided to reduce the country's dependence on oil; it introduced measures that facilitated (1) conversions from oil to other energy sources and (2) development of alternative energy resources.

Figure 3-13. *Share of Japan's Primary Energy Supply, by Type, 1971–95*



Source: Energy Data and Modeling Center (1998).

This energy diversification policy had a particularly important impact on the fuel mix of the power generation sector. Power companies invested actively in plants powered by nuclear fission, coal, and liquefied natural gas. As a result of these investments, the ratio of oil-generated electricity to total electricity (at nine major electric power companies) declined substantially in the 1980s and 1990s. The ratio was 43 percent in 1980, 26 percent in 1990, and 15 percent in 1996. Concurrently, between 1980 and 1996, the ratios of other electricity sources increased: coal from 3 percent to 9 percent, liquefied natural gas from 20 percent to 29 percent, and nuclear power from 17 percent to 38 percent.

Figure 3-13 shows the trend of energy supply between 1971 and 1995. The share of oil substantially increased between 1965 and 1975, when it reached 73 percent of energy supply. The share of oil then declined by about 18 percent between 1975 and 1985. It became quite stable in 1985 at around 55 percent. Since 1975, the shares of nuclear generation and natural gas have increased at the expense of the share of oil.

The Japanese government encouraged research and development activities in so-called "new energy," such as geothermal, wind, wave, and solar-generated electricity. In 1980 the New Energy Development Organization (NEDO) was established to support these activities. Although tremendous efforts have been made to increase the share of energy supplied by "new energy," it is still negligible (1.3 percent in 1996). This is mainly because the cost of new energy is much higher than conventional forms of energy, such as oil, gas, and coal.

Japan's "Win-Win" Experience in Energy Conservation

Rationalization in energy usage reduces emissions of CO_2 and other pollutants such as SOx and NOx. These pollutants are emitted when fuels combust; therefore, less use of energy automatically means fewer emissions of pollutants. Antipollution investments usually involve end-of-pipe technologies, such as flue gas desulfurization. By themselves, these investments usually do not contribute to firms' profits. In contrast, the adoption of clean production technologies not only reduces the emission of pollutants but also contributes to profits. Energy-saving investments can be regarded as clean production technology investments; they reduce CO_2, NO_x, and SO_x emissions and contribute to the profits of firms through reduction in energy consumption.

In fact, the bulk of Japan's reductions in SO_x emissions in the 1980s materialized through energy saving. According to a study by Imai (1998, 24), "a steel company 'S Steel' in Kitakyushu City, Japan, attained more than 30 percent of its total SO_x reduction from 1970 to 1990 through energy and materials saving and over 40 per cent from the use of clean fuel (that is, converting from heavy oil to liquefied petroleum gas to liquid natural gas); end-of-pipe technologies accounted for 25 percent." Furthermore, simulation results from a macro energy demand model incorporating a pollution damage function show that the bulk of reduction of SO_2 emissions in Japan between 1975 and 1996 was achieved by switching from high sulfur content fuels to low sulfur content fuels, and by energy conservation (Committee on Japan's Experience, 1997).

Stakeholders' Varied Roles

The previous sections discussed the evolution of environmental policy and energy conservation policy in Japan and its applicability to developing countries and transition economies. In this section four of the most important aspects of the Japanese experience will be analyzed and evaluated.

Public Sector Divisions of Labor: National and Local Government

Traditionally, Japan's national government, on the one hand, establishes the framework for public policies through legislation and regulation and, on the other, provides local governments with financial and technical support. Local governments are entrusted with the implementation of public policies, and the fiscal system makes possible this role: the national government disburses necessary funds to local governments after collecting them through taxes and other methods. Under the constitution, local governments are authorized to enact ordinances as long as they are not in conflict with national laws. Those ordinances can be more stringent than the nationwide standards.

Japan's environmental policy reflects this relationship between national and local governments. Environmental degradation is usually regarded as a local problem at first. Because pollution is perceived in specific areas of the nation, local governments naturally are the first to become aware of it and take countermeasures. For example, the Minamata and Yokkaichi diseases first attracted local attention. To address current environmental problems, local governments have implemented pollution control ordinances, established extensive monitoring networks, and performed environmental impact assessment.

Antipollution ordinances by local governments first appeared around 1950 in the Tokyo and Osaka metropolitan areas, where industry is heavily concentrated. Now all prefectures and major municipalities have enacted them. National laws for pollution control introduced in the late 1960s and 1970s enabled local governments to invoke ordinances with more stringent emission standards if it was determined that public health and living conditions would not be adequately protected by the nationwide general standards. Reliance only on nationwide uniform standards is not sufficient since environmental problems differ from place to place, depending on natural, economic, and social circumstances. A majority of the local governments introduced emission standards that were stricter than the national standards.

Another unique characteristic of the Japanese approach to pollution control at the local government level is the use of voluntary agreements between local governments and businesses. Local governments negotiate with individual firms to reach detailed written agreements on pollution control measures. In such a "Pollution Control Agreement," quantitative emission levels are determined based on consideration of technological and technical issues and discussion among the stakeholders, including civil activists. Although such an agreement is nothing more than a "gentlemen's agreement," it, in effect, functions like a legally binding agreement. In order for businesses to operate smoothly, they must obtain the approval and cooperation of local governments and communities; the agreement is equivalent to local government approval and community support for activities in the area. Almost all businesses comply with these agreed emissions standards, and some accept spot inspections to ensure that they are in compliance with all regulations and to avoid problems in the future. From the perspective of local governments and residents, this system is quite favorable because the standards are tailored to local geographical, social, and economic conditions. Since details of an agreement are worked out through intensive discussions by businesses, local governments, and residents, this process enhances public awareness as well.

Compliance with laws, regulations, pollution control ordinances, and voluntary agreements depends largely on their enforceability. Major prefectures and municipalities in Japan have developed extensive and sophisticated monitoring systems. Air and water quality is constantly monitored at stations set up by local governments. Emission levels of factories are recorded by the firms according to national law, which requires them to have pollution control managers and controllers and to make periodic reports to the local government. Some factories over a certain scale are required to have automatic monitoring systems that are directly linked to local government agencies through telemetric systems.

The *Environmental Impact Assessment Law* was enacted in 1997. Before then Japan had no uniform legislation for this. The national government had only a cabinet decision, *Implementation of Environmental Impact Assessment*, which was introduced in 1984 to establish nationwide procedures. Environmental impact assessment was conducted in Japan as early as 1961 at the local government level. These were internal studies that lacked public involvement. However, environmental impact studies have become indispensable when making industrial development plan proposals to local communities. In general, the local government requires that environmental impact studies be open to the public for review before projects are finalized. Environmental impact studies are often followed by voluntary pollution control agreements. This has become a common practice in many local governments, making it a tool with which to provide a sound scientific basis for taking appropriate pollution control measures.

Under the Japanese approach, local governments undertake the implementation and enforcement of the framework through ordinances and other measures such as on-site inspections. Environmental issues are resolved through cooperation between local governments, industry, and citizens. Implementation of Japanese environmental policy owes its success to the usually excellent training of local civil servants and their strong desire to serve the public good. The fact that local legislatures, including their heads, are subject to elections contributes to environmental sensitivity and awareness.

Local governments differ from country to country, but they are the first to recognize environmental problems—problems that exhibit the specific characteristics of each region. Therefore, the environmental law and ordinance enforcement capacity of local governments in developing countries and transition economies needs to be developed. The political and social climate in each country will determine the effectiveness of pollution control agreements between businesses, local governments, and citizens. Raising public awareness, especially through information sharing and dissemination, can help make implementation feasible.

Private Sector Initiatives

The Polluter Pays Principle (PPP), which actually guarantees fair competition among polluters, forms the basis of Japanese environmental policy. Strict regulations on industrial activities, based on this principle, contribute to the introduction of equipment, technologies, and a management system for effective pollution control. In this way environmental protection measures are introduced into the market. The response to environmental problems is dependent on many factors: the legal system, technologies, and human and financial resources. Japanese businesses attach great importance to their resolution through technology development supplemented by innovative management and human resource development.

TECHNOLOGY DEVELOPMENT AND IMPROVED MANAGEMENT. While it is true that Japan's commitment to pollution control is centered on the development of sophisticated end-of-pipe technologies, it is only partially true. Japanese environmental policy is distinguished by its emphasis on technological and technical development. Its preferred course for reducing the burden on the environment has not been to take steps to reduce production but rather to rely on innovation to reduce environmental burdens and increase production at the same time. Development of this technology requires a viable market for environment-friendly equipment.

In the early days when environmental degradation was primarily caused by harmful effluents, all that was necessary was to regulate the discharge of those materials. Governments only had to regulate the businesses that were discharging pollutants. Businesses addressed the pollution problem almost entirely with end-of-pipe solutions (for example, by installing desulfurization equipment to remove SO_x from smoke, or purifiers to clean wastewater). This method was effective at the time in significantly reducing the number of polluters. However, the effects of urban waste disposal and climate change worsened. To cope with this problem, businesses had to address every activity of their operations, from R&D to the production process to sales; in fact, clean production technologies, namely green technologies, were developed alongside end-of-pipe technologies.

The Japanese private sector has learned not only that environmental protection and economic growth can coexist but that there is a large potential market for environmental technologies. The typical Japanese response to environmental issues has been to see them as part of a larger strategy of supplying goods and services. Responses to air and water pollution, energy crises, and global warming are much more than environmental policy: they become production standards. Adopting consistent domestic standards is essential to helping industry learn what is necessary to simultaneously achieve profits and meet environmental obligations. Environmental protection has evolved into a strategy for enhancing economic competitiveness.

Regulatory standards in Japan, compared with other developed countries, have been high and there was concern that the high cost would weaken industry's competitive edge. However, tightened regulation standards can serve as a business incentive and create competition in the marketplace. A good example is the Japanese automobile industry. To meet air pollution standards, the industry developed vehicles that emit less NO_x and SO_x. Emissions in the late 1970s were less than those specified in the 1978 emission control regulations of the United States. These regulations in Japan fostered the technological development of the Japanese automobile industry for effective emission control. They also brought secondary benefits such as combustion control and quality control.

Improvement in fuel efficiency positioned the industry to capitalize on the sudden worldwide demand for fuel-efficient automobiles when the oil crises struck. The Japanese automobile industry grew rapidly from the 1970s to the 1980s. Sales of cars with high fuel efficiency—and lower pollution levels than were mandated—soared in the U.S. market as well as the Japanese market.

Managerial capacity is needed as well as technological innovation in order to deal with environmental issues at the industry level. The effect of technological development can be very limited if top or middle-level management is not willing to take action to control pollution. Management, of course, needs to be supplemented by technical experts at the operation level. Human resource factors, namely management and technical experts, have played major roles in the introduction and improvement of pollution control equipment and green technologies in Japan.

A system of pollution control managers and controllers has contributed to businesses' technology development and capacity building. The *Law Concerning the Improvement of Pollution Prevention Systems in Specific Factories* (1971) requires that factories over a certain size appoint a pollution control manager and a controller who have passed a national examination. Industry is obliged to keep records of operational management and the effluents from specified facilities, while pollution control managers are required to check fuel and raw materials and to inspect and repair facilities. These personnel have a vested interest in complying with emission standards set by regulations and ordinances. In case of noncompliance, they can be relieved of their positions, and their employers may face fines. The technical expertise of pollution managers and controllers in this self-monitoring system supports generic changes in production processes that improve quality, reliability, and controllability, as well as cost factors (reducing material inputs and the need to clean up toxic wastes). In addition, strict record-keeping requirements on effluents enables local governments to understand the actual and potential sources of pollution in their areas, thereby providing the information necessary to conclude pollution control agreements and/or introduce ordinances.

Recently, new environmental criteria in the market such as International Standards Organization 14001 have helped establish and maintain environment-friendly management systems.[7] The public is increasingly putting strong emphasis on the environmental performance of enterprises, and large firms that have obtained ISO 14001 now request that their suppliers, most of which are small and medium-size enterprises, meet certain environmental criteria.

End-of-pipe solutions work effectively as initial fixes to environmental degradation, but this kind of environmental policy eventually reaches a point of diminishing returns—the stricter the regulations become, the more technology and technical innovations are needed. In many cases the latest green technologies and clean production innovations offer superior production efficiency while contributing to pollution control and resource and energy conservation. Thus technologies that optimize environmental and economic objectives in the production process create win-win opportunities. Replacing outdated equipment with state-of-the-art equipment is expected to have a huge impact on developing countries and transition economies.

LEGAL LIABILITY. Business activities are considered unlawful if they damage another party, and the aggrieved is entitled to compensation by the party responsible. This responsibility to compensate victims for damage arises only for unlawful acts that are done deliberately or knowingly. However, it was difficult for pollution victims, who are outsiders, to prove a causal relationship between the damage (probably arising from pollution) and the illegal activity.

Japanese courts have changed their way of adjudication in order to combat the proliferation of environmental destruction. Strict liability was introduced in 1972 by the *Air Pollution Control Law* and the *Water Pollution Control Law*. These laws required businesses to compensate victims of pollution, even when there was no evidence of direct fault, if it was found that considerable damage was possibly caused by the company. The *Pollution-Related Health Damage Compensation*

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7. The ISO is an organization that certifies compliance by firms with specific management and production standards. ISO 14001 is the set of standards that focuses on environmental improvement.

Law of 1973 responded to victims' need for a comprehensive system that provides them with support for living and medical expenses. All of these changes in the rules of compensation—by reducing the costs of filing for indemnity and increasing the costs for wrongdoing by businesses—have made it easier for victims to claim damages.

The new liability regime prompted enterprises to take severe measures to prevent pollution. Damage to health is often irreversible: once the damage has occurred, the compensation is expensive and must be paid for many years; therefore, company management treats it as a mid- or long-term risk. This has been inducing industry to prevent pollution and thereby reduce a financial burden on itself. The experiences of Japanese industry demonstrate that pollution prevention measures can proceed hand in hand with the pursuit of profits, or at least with the reduction of costs.

In Japan polluters bear the financial burden not only for pollution prevention measures but also for restoration of the environment and compensation to those suffering from pollution. Given the rapid speed of environmental degradation in developing countries and transition economies at the height of their economic growth, and the significant damage generated by delayed responses, these countries should incorporate legal liability into PPP as a preventive measure that is less costly than symptomatic measures. Indeed, according to a Japan Environment Agency study, if the timing of investment for flue gas desulfurization had been delayed six to ten years in Japan, damages would have peaked at two to three times their actual amounts (Committee on Japan's Experience, 1997).

VOLUNTARY COMMITMENT. In addition to setting up special units for dealing with global environmental issues, many enterprises and industries have adopted their own guidelines or action plans. The Keidanren (Federation of Economic Organizations) is Japan's top business association. It has published *Global Environmental Charter* (1991), *Keidanren Appeal on the Environment* (1996), and *Voluntary Action Plan on the Environment* (1997). The Voluntary Action Plan establishes numerical targets for reductions and recycling of waste and addresses the problem of global warming—not only for the manufacturing and energy industries, but also in distribution and construction.

Enterprises that do not comply with emission standards tend to be criticized by the public. In the Minamata disease and Yokkaichi asthma cases, a huge cost to the companies other than compensation for health damage was the lost public esteem, something that is very important in Japan. Japanese companies are very sensitive to the risk to their reputations, and they want to make sure that there are no boycotts or bad publicity regarding their products or practices. Therefore, a steady commitment to pollution control and dialogue about the environment with the local community help maintain an enterprise's good public image.

Interactions between the Public and Private Sectors

Checks on business, like the regulation of emissions standards and the requirement for compensation, do not constitute all of Japan's pollution control measures. Also beneficial are business-friendly policies like long-term low-interest loans and tax exemptions. In addition to using strict guidelines, the government has extended economic incentives for businesses to install pollution control equipment.

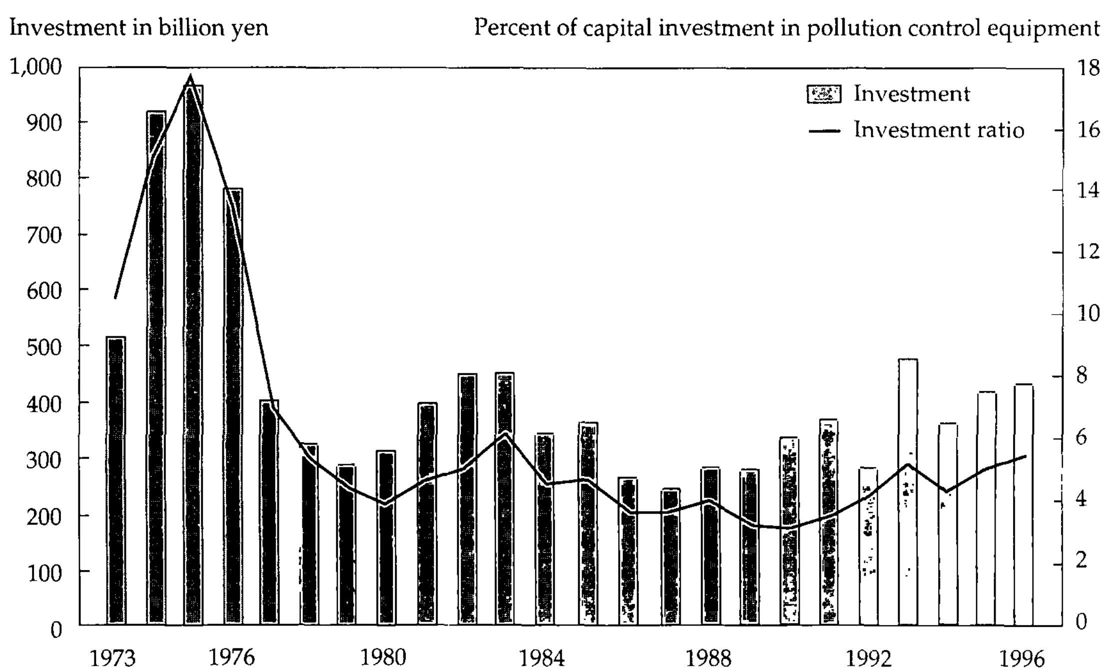
SUPPORT FOR POLLUTION COUNTERMEASURES. The government provided particular assistance to small and medium-size enterprises for taking pollution countermeasures. This policy was designed to reduce the damage from pollution without dampening the dynamism of these enterprise. The Japan Environment Corporation (established in 1965 as the Environmental Pollution

Control Corporation and renamed JEC in 1992) encourages small and medium-size businesses to move out of the cities to newly created industrial areas. The Japan Finance Corporation for Small Business and special funds operated by local governments also have low-interest loan programs for small enterprises

The market for manufacturers of pollution control equipment was ensured by tax exemptions and other incentives in the 1970s. Thereafter the market expanded rapidly. Accelerated depreciation for pollution control equipment or facilities is granted under the *Exceptions to the Tax Law Act*. It allows deferred payment of taxes, providing an effect similar to that of tax reduction. The share of capital investment that went to pollution control equipment approached 17.7 percent in 1975. The vast investment demands of large companies were realized partly because of loans from the Development Bank of Japan. Without DBJ's support, even large companies would have found it difficult to finance antipollution investments that did not contribute to their profits directly. DBJ loans for antipollution measures and other environmental provisions amounted to 205.5 billion yen in 1975 (26.8 percent of all loans for the period and the maximum proportional outlay for antipollution loans to date). There was a high concentration of loans in this sector from FY 1973 through FY 1976. After industries met the deadline for costly end-of pipe measures, this amount began to decline in the latter half of the 1970s (Figure 3-14). Annual totals for antipollution loans were around 30 to 40 billion yen, and despite slight fluctuations from varying interest rate levels, the capital requirement has been relatively stable.

Two immediate effects of DBJ loans are more available capital and investment incentives through loans at below-market interest rates. Capital availability arises directly through the allocation of DBJ loans and indirectly through DBJ loans inducing private-sector loans. In the 1970s many companies were not in a position to invest in non-profit-returning activities such as pollu-

Figure 3-14. *Antipollution Investment, 1973–96*



Source: Ministry of International Trade and Industry (1998).

tion prevention. This was partly due to an immature long-term financial market and partly due to the decline in economic growth after the booming 1960s. By supplying the necessary capital, governmental financial institutions made possible the installation of antipollution facilities.

Competition in the development of pollution control technology was spurred by the expansion of the market and gradual strengthening of regulations. The Science and Technology Agency, the Ministry of International Trade and Industry, and other agencies helped by subsidizing research and development.

STEP-BY-STEP APPROACH. Japan's step-by-step approach to setting of standards is a major reason for high compliance, although there was criticism that the country acted too late and too little in some areas. The incremental approach enabled both the public sector and the private sector to prioritize environmental problems and concentrate on the most serious and urgent ones. It allowed the private sector time to develop efficient, manageable, and affordable technologies in anticipation of the next regulatory step. In fact, technology development has been by way of incremental innovation rather than sudden breakthroughs. Furthermore, the step-by-step approach has enabled the public sector to assess the actual strengths and weaknesses of existing mechanisms to control pollution before considering new ones.

This kind of approach has succeeded in Japan because of collaboration between the public and private sectors. The legal and regulatory process has tended to be dominated by scientists, lawyers, and economists. If, however, the focus is to expand to technological and technical innovation, the process should include more engineers and industrial managers, providing for a mix of skills.

Often committees consisting of representatives from national and local governments, the private sector, academia, and civil activists are set up to coordinate the stakeholders' interests in the formation of environmental measures as well as the mid- and long-term national visions of economic development and environmental policy. In these committees industries often provide technical information to the public sector that is used to develop rational emission standards; otherwise the public sector does not have enough detailed information about technologies and techniques. Governments, in turn, inform the local community about the outcomes of R&D, while civil activists urge both governments and enterprises to take appropriate action. Those committees must reach and convey their consensus on when, to what extent, and how to make commitments to particular environmental issues. In such a manner Japan has been responding to new environmental realities in an organized fashion.

Such an approach often results in the formation of new joint research initiatives by the government, businesses, and universities. For example, with respect to energy conservation, most technology development policy has been overseen by the New Energy Development Organization. Its original mission was the commercial development of new energy technologies that would mitigate Japan's dependence on imported energies, but this was expanded in 1990 to include the development of technologies for global environmental protection. NEDO operates with government money and, in part, with participation by employees of private businesses. This type of collaborative mechanism is quite common in Japan and is not confined to environmental initiatives. NEDO's major projects are the Sunshine Project (to discover new and recyclable energy sources) and the Moonlight Project (to achieve greater energy efficiency). Solar cell systems and coal liquefaction and gasification technologies are successful outputs from these initiatives, subsidized through partnerships between the public and private sectors. For example, a part of taxes on oil and electricity sales is earmarked to go to a Special Account that subsidizes research and deployment of new and clean energy sources.

The private sector cannot raise all of the research and development funds it needs, let alone what the nation needs. Public support for research, particularly for the basic end of the research spectrum, should become a bedrock of environmental policy in developing countries and transition economies, where the overall R&D budget is badly skewed toward only a few objectives such as national defense. Serious consideration should be given to creating programs with many stakeholders in environmentally relevant industrial R&D. The guiding criterion should be to support critical technologies of general applicability in areas where private R&D cannot keep pace with national needs.

Role of Communities

During the Japan's rapid economic growth, air pollution and water contamination damaged the health of its citizens. The ensuing activism of victims and ordinary citizens began to make a difference.

ACTIVISM OF CITIZENS AND NONGOVERNMENTAL ORGANIZATIONS. Citizens' activism in the local community, supported by judicial decisions, became the driving force behind the pollution control measures taken by governments and industry in Japan. Scientists and lawyers supported the activism, making it difficult for governments and industry to ignore. Tragic incidents attracted public sympathy and gained coverage in the national press. However, environmental measures were taken only after the local people complained and only after the damages had become irreversible.

Nongovernmental organizations (NGOs), a more sophisticated form of citizens' activism, have been weak in Japan. After some of them joined the movement that opposed the construction of Narita Airport in the 1970s, NGOs expanded their activities to include natural conservation and recycling, for example. Though they are now focusing on global environmental issues such as tropical forests and biodiversity, when the pollution-related health damage appeared in the 1960s they usually lacked sufficient knowledge and financial resources. Even now they do not have a large membership and do not have legal standing in courts on environmental issues. Neither are they financially supported by public authorities: for example, few NGOs satisfy requirements for tax deductions on donations.

MASS MEDIA AND EDUCATION. Scientific and technical investigations of pollution and its effects on public health and natural resources need to be conducted to help with monitoring and preventive strategies. It is necessary to not only collect and assess information on the causes, effects, and current status of pollution but also to disseminate such information to the governments, industry, and citizens. In Japan the mass media have played a pivotal role in raising public awareness. The public's understanding of pollution has been heightened by broad media coverage of activism on behalf of pollution victims and by the lawsuits that have followed, which have pressured the government and industry to take appropriate measures. Pollution has long been taken up as an important political issue, and a national consensus regarding the importance of knowledge about pollution-related damages has been achieved.

Facing growing public concern about environmental degradation, Japan's Environment Agency, in cooperation with the Ministry of Education, has undertaken measures to improve education on environmental issues. At the forefront of civil activism opposing certain industrial complexes, schoolteachers were again among the first to recognize the importance of learning about pollution. Since the late 1960s they have incorporated information about the environment into school courses on history, natural science, and physical health. The guidelines for elementary and high school education were amended in 1989 to include a provision recommending instruction on the environment. Although such curricula remains voluntary, the sad stories of the Minamata, Itai-Itai, and Yokkaichi diseases have been deeply implanted in the minds of all Japanese citizens, at least in their compulsory social science classes.

Consumer education enables citizens to choose services and goods based on their effects on the environment. In other words, it develops the public's environmental consciousness. For this purpose, the Environment Agency and the Ministry of Education work closely together to produce television broadcasts and films on the environment, sponsor seminars, and distribute teaching materials. Most public education on the environment, however, is conducted by local governments. Their information dissemination networks utilize Local Environmental Conservation Funds to develop a database of information on environmental education activities.

With the rise in consumers' consciousness of the environmental impacts associated with the production of goods and services, the Ecomark Labeling System was introduced. For a product or service to be eligible for the label, its use and disposal should improve or conserve the environment by entailing minimum or no pollution.

During the past three decades, public awareness and concern about environmental issues in Japan have substantially increased. The fundamental reasons are the high levels of general education (the high literacy rate resulted in a well-informed population) and the mass media, which freely expressed critical views to put pressure on politicians, bureaucrats, and industry to take environmentally sound actions. Developing countries should establish a framework for releasing and sharing information, both by the media and in the education system, so that they can avoid bitter confrontation and, more importantly, irreversible environmental consequences.

Conclusion

Japanese environmental policy has been criticized for being too little too late. In fact, the government and the public did not know enough to recognize the nature and severity of damage when it occurred. As a result, environmental pollution rapidly worsened as the economy grew. Incidents of health damage would have been much fewer had Japan more quickly and appropriately responded to the issues. Because Japan successfully integrated environmental protection into its economic system after experiencing rampant pollution, other countries may think that dealing with economic development first and coping with environmental issues later is a plausible path. However, significant advancements in knowledge, information, and technologies have become widely available since the 1970s when Japan tackled the environmental problems created by development. For developing countries to adopt a strategy of "first develop, then clean up" might no longer be justifiable because the costs of environmental protection have been reduced substantially.

The speed of environmental degradation at the height of economic growth in developing countries and transition economies is rapid, and delays in response generate significant damage. It is now common knowledge that the use of preventive measures is a far more effective and less costly way to fight pollution than after-the-fact efforts. Once pollution has occurred, it is extremely difficult, and often impossible, to return to the status quo. Furthermore, because pollution affects human life and the ecosystem, the value of which is especially difficult to measure, the most practical policy is to insist that pollution prevention equipment be installed when factories are built.

It is sometimes said that Japan has emphasized pollution control and energy conservation and only recently addressed global environmental issues such as global warming and acid rain. Yet Japan's experience demonstrates that government policy and private sector initiatives in technology development and production process innovation for pollution control and energy conservation can positively affect the global environment. For example, air pollution control is linked to fossil fuel combustion, which has already been targeted by measures on energy conservation and reduction of CO_2 emissions. In turn, energy conservation has contributed to rises in productivity as well as air pollution control and global warming prevention. The Japanese experience shows that there are win-win opportunities for developing countries and transition economies.

References

Committee on Japan's Experience in the Battle against Air Pollution. 1997. *Japan's Experience in the Battle against Air Pollution: Working Towards Sustainable Development.* Tokyo: The Pollution-Related Health Damage Compensation and Prevention Association.

Energy Data and Modeling Center. 1998. *Energy and Economics Databook.* Tokyo: Energy Conservation Center.

Environment Agency. 1991. *Twenty-Year History of the Environment Agency* (in Japanese). Tokyo.

———. 1998. *The Japanese Government White Paper on the Environment* (in Japanese). Tokyo: Printing Bureau, Ministry of Finance.

Goodstein, Evan S. 1999. *Economics and the Environment.* Englewood Cliffs, N.J.: Prentice-Hall.

Hamamoto, Mitsutugu. 1998. *Environmental Regulations and Corporate Behavior: Essays on Environmental Policy Choice and Dynamic Adjustments of Firms in Japan* (in Japanese). Ph.D. diss., Kyoto University.

Imai, Senro 1998. "Role of Industry: Standards and Technology." In Wilfrido Cruz, Kazuhiko Takemoto, and Jeremy Warford, eds., *Urban and Industrial Management in Developing Countries: Lessons from the Japanese Experience.* EDI Learning Resource Series. Washington, D.C.: The World Bank.

International Energy Agency. 1991. *Greenhouse Gas Emissions: The Energy Dimension.* Paris: Organization for Economic Cooperation and Development.

———. various years. *World Energy Outlook.* Paris: Organization for Economic Cooperation and Development (published annually).

———. 1997. *Energy Balances of OECD Countries, 1995-96.*

Kazuhiro, Ueda, T. Oka, and H. Niizawa, eds. 1997. *Economics of Environmental Policy: Theory and Practice* (in Japanese). Tokyo: Nihon Hyoronsha.

Keidanren (Federation of Economic Organizations). 1991. *Global Environmental Charter.* Tokyo.

———. 1996. *Keidanren Appeal on the Environment.* Tokyo.

———. 1997. *Keidanren Voluntary Action Plan on the Environment* (Final Report). Tokyo.

Ministry of International Trade and Industry. 1998. *Business Investment Plans of Major Japanese Industries* (in Japanese). Tokyo: Government of Japan.

Moore, Curtis, and Alan Miller. 1995. *Green Gold: Japan, Germany, the United States, and the Race for Environmental Technology.* Boston: Beacon Press.

Nippon Steel Corporation. 1998. *Environment Report* (in Japanese). Tokyo.

OECD (Organization for Economic Cooperation and Development). 1994. *OECD Environmental Performance Reviews: Japan.* Paris.

Tokyo Electronic Power Company. 1988. *Environment Action Report: Action toward Energy and Environmental Problems* (in Japanese). Tokyo.

Wuebbles, D. J., and J. A. Edmonds. 1988. *A Primer on Greenhouse Gases.* TR040, DOE/NOB. Washington, D.C.: U.S. Department of Energy.

Part II

Case Studies

4

Environmental Conservation by Japan's Iron and Steel Industry: An Example of the Nippon Steel Corporation

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Akie Takeuchi

Reflecting the economy's rapid growth, iron and steel production in Japan increased significantly in the 1960s, expanding from 23 million tons in 1960 to a peak of almost 120 million tons in 1973. Since then production has leveled off at around 100 million tons. The slowdown in Japan's economic growth following the oil shocks and the shift in economic structure from manufacturing industry to services are contributing factors.

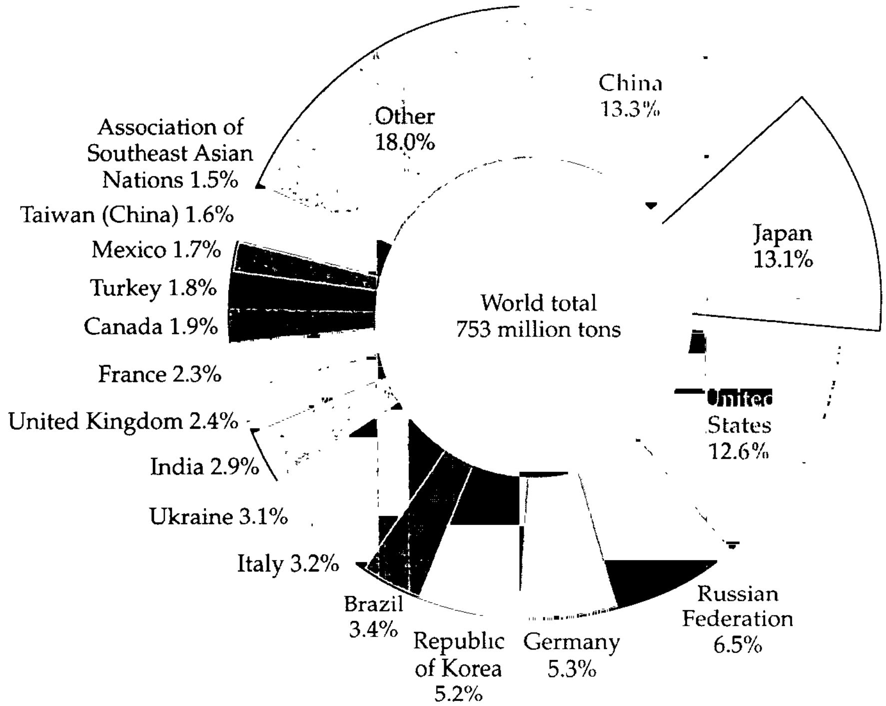
Although Japan exported more than 30 percent of its steel during the 1970s and early 1980s, the export ratio dropped to about 20 percent in the mid-1990s. Worldwide iron and steel production in 1996 was 750 million tons. Of that amount Japan accounted for about 13 percent, the second largest share following China. (Japan was the world's largest producer until 1995.) The United States accounted for 12.6 percent; the Russian Federation, 6.5 percent; Germany, 5.3 percent; the Republic of Korea, 5.2 percent; and Brazil, 3.4 percent (Figure 4-1). Nippon Steel Corporation, Japan's largest steel producer, contributes about 25 percent of domestic production.

Steel consumption and production are closely related to economic development. They rise in the early stages because huge amounts of iron and steel are required as roads, railways, and other infrastructure facilities are rapidly built. This is expected to be the case in many developing countries as they experience economic growth. With the expansion of production activities in these countries, environmental issues will become serious concerns. Steel making is an energy-intensive industry and uses large amounts of coal. When coal is used, pollutants such as sulfur oxide (SO_x) and nitrous oxide (NO_x) are released, as is carbon dioxide (CO_2), which causes global warming. Japan's iron and steel industry has succeeded in reducing such hazardous pollutants and CO_2 emissions significantly while sustaining high production levels. Japanese companies' efforts to address environmental problems provide valuable lessons for developing countries. Nippon Steel Corporation (NSC) is used as an example.

Environmental Regulations and Agreements

With the dramatic economic development that took off in the 1960s, Japan faced various environmental problems, such as air pollution and water contamination. At the same time rising living standards and population concentration in the cities led to urban pollution in the form of vehicular emissions and traffic noise. People began to focus more attention on environmental issues as pollution became more serious. In 1967 the *Basic Law for Environmental Pollution Control* was enacted. It formed a basis for promoting environmental policies. Then in 1970 specific laws concerning the environment were amended or enacted (Table 4-1).

Figure 4-1. *Production Share of Crude Steel by Country, 1996*



Source: Japan Steel Federation.

These new laws were different from the previous ones in the following respects: the target area became nationwide, penalties could immediately be imposed on organizations not complying with the standards, and stricter standards set by local government ordinances gained a legal basis. In 1971 the Environmental Agency was established to reinforce Japan's legal and constitutional foundations concerning the environment. On a global level, the first United Nations' Conference on the Human Environment was held in June 1972 in Stockholm. It paved the way for countries to initiate global activities for environmental conservation beyond the regional level.

Since environmental issues entail regional as well as global considerations, many local governments have fully committed themselves to addressing them. For example, they have issued ordinances that set stricter standards than those provided by law, and they have signed pollution control agreements with individual corporations to supplement the laws and ordinances. Businesses have worked hard to satisfy the stringent standards set by laws, ordinances, and agreements. In addition, they have taken voluntary measures to reduce pollution and to develop and disseminate pollution control technologies.

Regulation via the *Air Pollution Control Law* and *Water Pollution Control Law* has been reinforced numerous times. Many integrated steelworks in Japan are built in areas that are subject to *Air Pollution Control Law* limits on the total amounts of sulfur oxide (SO_x) and nitrous oxide (NO_x) and to *Water Pollution Control Law* restraints on the total amount of chemical oxygen demand (COD). Therefore, every piece of steelworks equipment in Japan is subject to at least one of these four types of regulation:

- Nationwide uniform emissions control
- Special emissions control by laws in designated areas

Table 4-1. Environmental Regulation Laws, 1970

Emissions control	*Environmental quality standards*	*Responsibility of individual companies*
• Air pollution control law • Law concerning prevention of marine pollution and marine disasters • Special measures for conservation of the environment of Seto Inland Sea • Agricultural land soil pollution prevention law • Noise regulation law and offensive odor control law • Waste disposal and public cleaning law	• Sulfur dioxide, nitrogen dioxide, particulates, water pollutants, and noise	• Law concerning improvement of pollution prevention systems in specific factories

Source: Japan Basic Law for Environmental Pollution Control, revision of 1970.

- Reinforcement of emissions control by local governments
- Restrictions on total volume (applicable only to those areas that do not satisfy environmental standards).

Agreements on Pollution Control

In addition to these laws and other regulations, most steelworks have concluded agreements on pollution control individually with local governments, thereby subjecting themselves to stringent environmental standards. An agreement on pollution control is an agreement between a company and a local government based on bilateral consensus about the measures that the company must take to prevent pollution, contamination, and destruction of the environment.

The *Memorandum on Pollution Control* that the Gotsu factory of Sanyo-Kokusaku Pulp Co., Ltd., and the Masuda factory of Daiwabo Co., Ltd., concluded with Shimane prefecture in March 1952 is generally regarded as Japan's first agreement on pollution control. (The name of Sanyo-Kokusaku Pulp Company was changed to Nippon Paper Industries in 1993.) However, the agreement that Electric Power Development Co., Ltd., and Tokyo Electric Power Co., Ltd., signed with Yokohama city in December 1964, covering planned facilities in the Negishi coastal industrial region, is the prototype of today's agreements. Since then this "Yokohama method" has rapidly spread to local governments and municipalities all over Japan. There have been about 40,000 such agreements.

A core difference distinguishes legislation and local ordinances from agreements: legislation and local ordinances apply to all operators, whereas agreements are restricted to relatively large-scale operators with high environmental loads. Furthermore, legislation and local ordinances legally bind operators to penalties in case of violation, but agreements are contract based, and they are not associated with binding powers of penalty.

The advantage in adopting agreements is that laws and local ordinances must be applied consistently to all operators in the interest of public fairness. Consequently, small- and medium-scale operators with limited investment capacity face unnecessarily strict regulation. Agreements, on the other hand, are, in essence, individualized contracts with operators. They make it possible to target high-emission operators, providing flexible response on a case-by-case basis, and they contribute to substantial reductions in environmental load. Authorities can set achievable but challenging targets for individual operators on the basis of specific considerations such as the individual company's technical capability and financial standing.

A disadvantage of agreements is that they often contain confidential terms, which cannot be disclosed to the public. This creates concerns about transparency. However, local authorities are required to publicly release data on emissions of different polluting substances and to monitor ongoing trends in emissions, so that it is possible to externally verify the effectiveness of agreements.

Pollution prevention agreements came into being in the 1970s in the context of worsening pollution and today are prevalent throughout Japan. Initially not all operators were eager to sign these agreements. In order to maintain friendly relations with local residents in the vicinity of factories, however, operators altered their course to favor environmental protection and agreed to enter into pollution prevention agreements. In response to scathing public criticism of pollution problems, these agreements stipulated stricter controls than did existing legislation and local ordinances. As local residents' concerns about the environment have grown, pollution prevention agreements have helped improve the public image of corporations and their relationships with local communities.

To illustrate how such agreements are constructed, we consider the agreements made by Nippon Steel Corporation (NSC) with two local governments, one a prefecture and the other a city government. (Table 4-2 presents the simplified components of the NSC agreements.) The *Agreement on Pollution Control* was concluded between the governor of the prefecture, the mayor of the city, and the head of two NSC steelworks in June 1970. In the agreement each piece of equipment in the steelworks was assigned an emissions standard for every pollutant. Note that in such agreements, the standards are stricter than those set by laws and ordinances, but the target figures can vary depending on the conditions of each area and particular pieces of equipment. Ever since the conclusion of the agreement, the steelworks have complied with all its requirements, and emissions levels have been maintained below the standards set by laws and ordinances.

Air Pollution Control Law

The *Air Pollution Control Law* stipulates separate regulations for "smoke- and soot-emitting facilities" and "dust-generating facilities." The smoke and soot emissions standard is set according to the kind and scale of each facility. For example, the method to determine the SO_x limit was changed from density control to k-value control (or touchdown density control, depending on the height of the chimney) in 1968 when the *Air Pollution Control Law* was enacted. This k-value control was made stricter on eight occasions. However, because it had a limited effect on SO_x reduction, a regulation on total emissions was introduced in 1974 (Table 4-3).

Table 4-2. *Pollution Control Agreements between Local Governments and Two NSC Steelworks*

		NO_x concentration standard (parts per million)			*Soot and dust (mg/Nm^3)*		
NSC steelworks	*Type of equipment*	*By law*	*By agreement*	*Actual Performance*	*By law*	*By agreement*	*Actual performance*
Steelworks A	Type a	260	165	162	200	150	20
	Type b	200	140	100	200	100	4
Steelworks B	Type a	260	260	250	200	80	40
	Type b	200	200	130	200	50	4

Source: Nippon Steel Corporation.

Table 4-3. Air Pollution Control Legislation

Year	Law	Regulation	Target area
1962	Law for Smoke and Soot Emission Restriction	Density control: SO_X, smoke and soot	Designated areas
1968	Air Pollution Control Act	Density control: NO_X, smoke and soot k-value control: SO_X (k-value: touch-down density control depends on the height of the chimney)	Designated areas Depends on areas
1970	Amendment of Air Pollution Control Act	Diffusion of emission control Smoke and soot: Standard value depends on kind of facilities NO_2: Standard value depends on kind of facilities SO_X: k-value control (The control was made stricter every year until 1976.)	Nationwide Depends on areas
1974 1981 1982	Amendment of Air Pollution Control Act	Controls on total amount of SO_X Controls on total amount of NO_X Stricter standards on smoke and soot emissions	Areas unsatisfied with environmental standards
1972	Amendment of Air Pollution Control Act	No-fault liability to compensate for damages in cases of injury to human health or body	
1993	Enactment of Special Law of Air Pollution Control Act	Reduced the total amount of NO_X emitted from cars in designated areas	
1998	Revision of the Cabinet order on Air Pollution Control Act	Environmental standards on benzene air pollution; control standards on dioxin emitted from electric furnaces for steel and waste incinerators	

Source: Japan Environment Agency.

In a similar manner the *Air Pollution Control Law* controls emissions of nitrogen oxide. (Density control was made stricter on five occasions between 1973 and 1983.) Since 1981 the law has regulated total emissions for every factory operating in highly contaminated areas. Dust—defined as "substances that are generated or scattered in the process of mechanical treatment such as crushing and separation, or during sedimentation"—is not suitable for control by uniform emission standards. Consequently, standards for structure, usage, and management are established separately by the type of the dust-generating facility.

Water Pollution Control Law

Though our focus is on air pollution, we mention water pollution regulations governing the iron and steel industry to complete our description of relevant environmental legislation. The *Water Pollution Control Law* applies to factories that discharge more than 50 cubic meters of effluent every day on average. It regulates the density of effluent discharged into public waters (Table 4-4). Effluent standards for toxic substances that are harmful to human health are set at levels ten times higher than environmental quality standards; the dilution effect after inflow into public

Table 4-4. Water Pollution Control Legislation

Year	Law	Regulation	Target area
1958	Law relating to factory effluent regulations	Density control of effluent (violators ordered to make improvements)	Limited to designated water areas
1970	Water Pollution Control Law	Penal provisions for noncompliance with standards; allows for severer standards by ordinance	All public waters
1972	Amendment of Water Pollution Control Law	No-fault liability to compensate for damages is introduced for cases of injury to human health or body	—
1978	Amendment of Water Pollution Control Law	Introduction of total effluent control system; restrictions on total volume of COD were made stricter for every target year (reinforcement of regulatory standard)	Tokyo Bay, Ise Bay, and Seto Inland Sea
1978	Amendment of Water Pollution Control Law	Prohibits infiltration into ground of effluent or waste liquid containing harmful substances	—
1993	Revision of the Cabinet order on Water Pollution Control Law	Reinforcement of harmful substance regulations; enlargement of scope of regulated items; standard reinforcement concerning lead and arsenic	—
1993	Revision of effluent standard	Effluent standards on nitrogen and phosphorus in sea as part of eutrophication control measures	Limited to inner bays

— No specific target area mentioned in legislation.
Source: Japan Environment Agency.

waters is taken into account. To control organic pollution, this law adopts biological oxygen demand (BOD) for effluent discharged into rivers and chemical oxygen demand (COD) for effluent discharged into lakes and sea areas. BOD is the amount of oxygen consumed by microorganisms in water; an index shows the amount of organic substances that can be decomposed by microorganisms in water. COD is the amount of oxygen consumed by certain oxidants; an index shows the amount of organic substances in water. COD control by the *Water Pollution Control Law* on effluents discharged from the steel industry has been made stricter on three occasions (1979, 1987, and 1991).

Japanese Steel Industry's Efforts to Protect the Environment

Before examining environmental protection initiatives by the Nippon Steel Corporation, we explain the harmful substances generated in the steel production process. Although it is important to keep such byproducts to a minimum, there is no way to eliminate them. They should be recycled as much as possible—for example, by utilizing collected dust as a material in the steelmaking process or by building a water recycling system. Byproducts include air pollutants, water pollutants, and wastes.

Air Pollutants

- SO_x: Generated by the combustion of the sulfur content in materials and fuels; the sintering process is a major source
- NO_x: Generated by combustion; the sintering process is a major source
- Smoke and soot: Generated by combustion
- Dust: Generated by transportation of fuels and materials, and scattered by wind from storage facilities such as yards.

Water Pollutants

- Suspended Solid (SS): Generated in the waste gas dust collection process and the hot materials direct cooling process
- Oil: Leakage of various oils used in machines, generated as rolling oil in the cold rolling process
- COD: Generated as ammonia water in coal coking, and as plating wastewater from cold rolling
- Acid and Alkali: Generated in the cold rolling process (acid cleaning) and the finished product acid cleaning process.

Wastes

- Slag: Generated in the refining processes for blast furnaces, basic oxygen furnaces, and electric furnaces
- Sludge: Byproduct processed by water treatment facilities
- Dust: Collected by dust collectors.

Development of Energy Conservation Technologies

Energy saving is the most efficient and effective way to prevent air pollution. It not only reduces pollutants but also entails the use of exhaust gas treatment equipment that is more compact, thereby reducing investment and running costs. Technology that tries to solve environmental problems by streamlining production and cutting production costs is called clean production technology. By contrast, technology that merely reduces emissions without streamlining production is called end-of-pipe technology. Both end-of-pipe technology and energy-saving technologies have been extensively used to reduce emissions of sulfur oxide and nitrogen oxide.

The major sources of SO_x are sintering machines, reheat furnaces, and boilers. Using low-sulfur fuels and materials can reduce SO_x. For example, low-sulfur iron ore may be used for sintering, or desulfurization methods may be applied to coke oven gas (COG) or flue gas. Although nitrogen oxide is generated by all combustion equipment, the sintering machines and coke ovens are two major sources. Combustion improvement from a low-NO_x burner and flue gas denitrification technology may be used to control nitrogen oxide.

For desulfurization of sintering flue gas, the Nippon Steel Corporation initially tried to adopt the lime-gypsum technology. Later, however, the company developed the magnesium hydroxide method after discovering its superior post-treatment efficiency. The greatest challenge was how to treat desulfurized water effectively. NSC has succeeded in developing a low-cost desulfurization process. Magnesium hydroxide has excellent load characteristics because of its high reaction rate, making it possible to achieve a high desulfurization rate by using a simple, compact absorption tower. Moreover, the tower's remarkable ability to remove dust helps reduce visible smoke density. Since the absorption tower is compact, it requires little space and can easily be combined with a chimney.

In this method the required absorption liquid has low adhesion because sintering dust slurry, which tends to stick and choke, is not present. Therefore, the maintenance efficiency of the magnesium hydroxide method is significantly better than the lime-gypsum method. Since little pressure is lost in the magnesium hydroxide method, the cost for related equipment can be reduced. Lastly, the absorbent magnesium hydroxide is a stable alkali material that can be easily handled, and the environmental load that this method places when discharged into the sea is very low because the salts it produces (magnesium chloride and magnesium sulfate) are the main components of seawater.

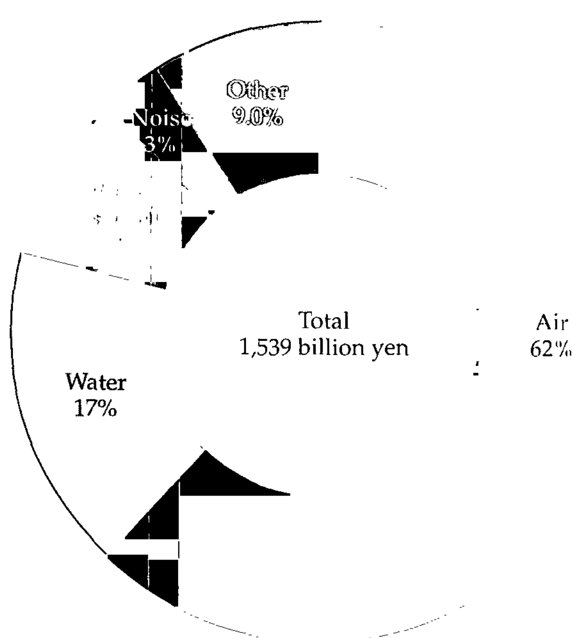
The Nippon Steel Corporation improved the so-called "Takahax" method of desulfurizing coke oven gas. It also developed its own method, called "Hirohax," for treating byproduct liquid waste. The combined "Takahax-Hirohax" method has numerous advantages. First, byproducts pose no environmental problems because nitrogen and sulfur in the coke oven gas are removed to form ammonium sulfate. Second, the method needs no external fuels because it uses stored reaction heat. Finally, operational efficiency is high because of the short treatment process and the compactness of the equipment.

Investment in Environmental Pollution Control Measures

Environmental investment (about 1,500 billion yen) accounts for about 10 percent of the iron and steel industry's total investment from 1971 to 1994. About 62 percent of this amount was devoted to air pollution control (Figure 4-2). Reflecting stricter standards, capital investment in pollution control increased particularly rapidly between 1974 and 1976. The iron and steel industry's investment in environmental pollution control measures peaked in 1976 at more than 250 billion, about 34 percent of total investment in such technologies by all industries (Figure 4-3).

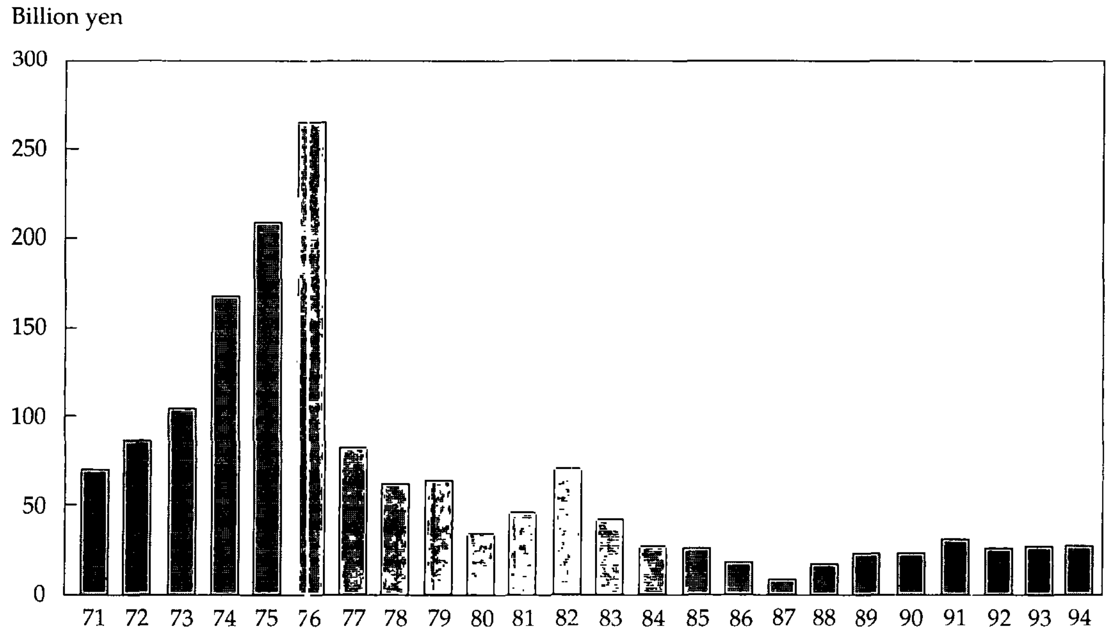
NSC invested almost 400 billion yen in pollution control measures from 1970 to 1997 (Figure 4-4). The huge investments in the first half of the 1970s reflected the availability of new technologies. For example, the iron and steel industry established the Flue Gas Desulfurization Test

Figure 4-2. *Investment in Environmental Protection by Japan's Iron and Steel Industry, by Area of Investment, 1974–94*



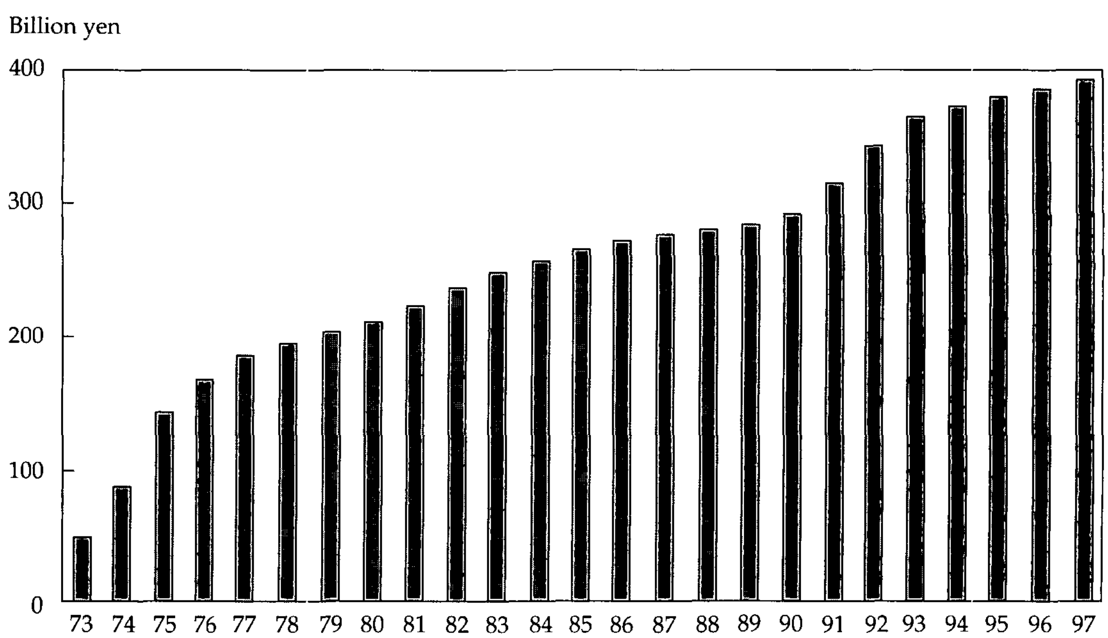
Source: Japan Steel Federation (1997)

Figure 4-3. *Investment in Environmental Protection by Japan's Iron and Steel Industry, by Year, 1971–94*



Source Japan Steel Federation (1997).

Figure 4-4. *Accumulated Investment in Pollution Control Measures by Nippon Steel Corporation, 1973–97*



Source. Nippon Steel Corporation (1998a).

Committee and the Iron and Steel Industry Research Association on NO_x Removal Technology. Joint research on pollution control equipment was conducted. Technology for the unique procedures to make steel was developed intensively at these institutions. Due to such environmental conservation measures, NSC's 1997 emissions of sulfur oxide and nitrogen oxide were 13 percent and 58 percent of their 1973 levels, respectively (Figures 4-5 and 4-6).

Organizational Approach to Environmental Conservation

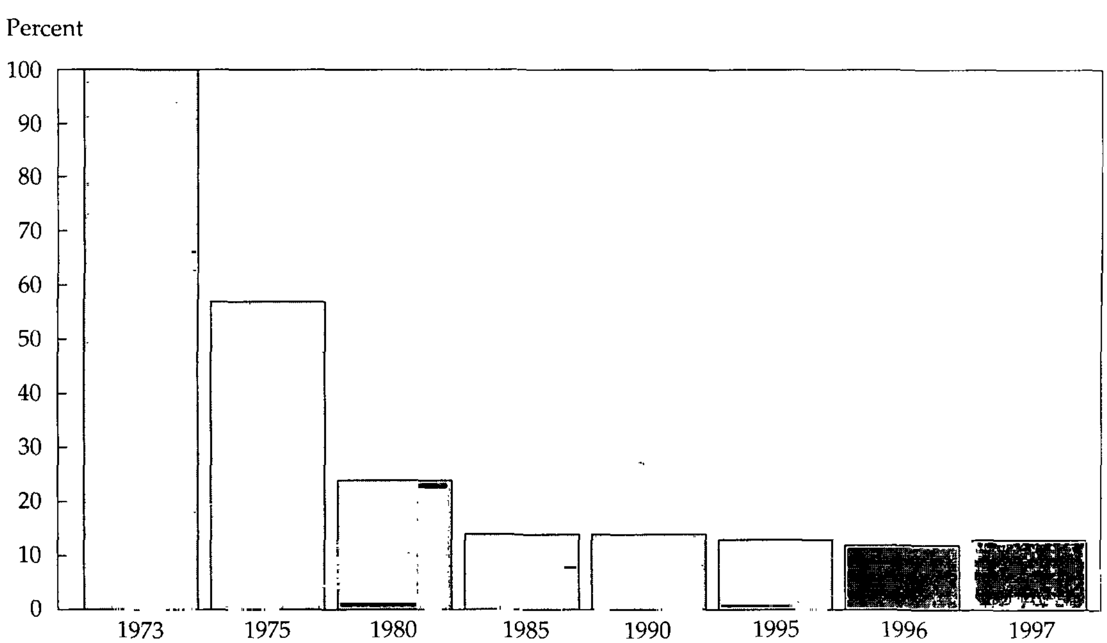
The *Law Concerning the Improvement of Pollution Prevention Systems in Specific Factories* enacted in June 1971 requires the appointment of a supervisor for pollution control and a pollution control manager, and it stipulates those persons' responsibilities and authority. The manager in charge of pollution control, an authorized person who has passed the national examination, must assist the supervisor on technical matters. In order to meet this legislative requirement, businesses have trained many pollution control managers who have national qualifications. In 1999 there were about 250,000 authorized pollution control managers in Japan. NSC had about 1,030 authorized managers at various facilities. This legislation was instrumental in

- establishing an organizational system for pollution control;
- carrying out pollution control measures and preventing pollution; and
- improving communication between factories, local government, and the local community.

After environmental standards are set, company compliance is monitored, an important and very time-consuming task. Because the regulating authorities receive reliable reports on emissions levels from the authorized managers at each factory, regulation is efficient as well as effective.

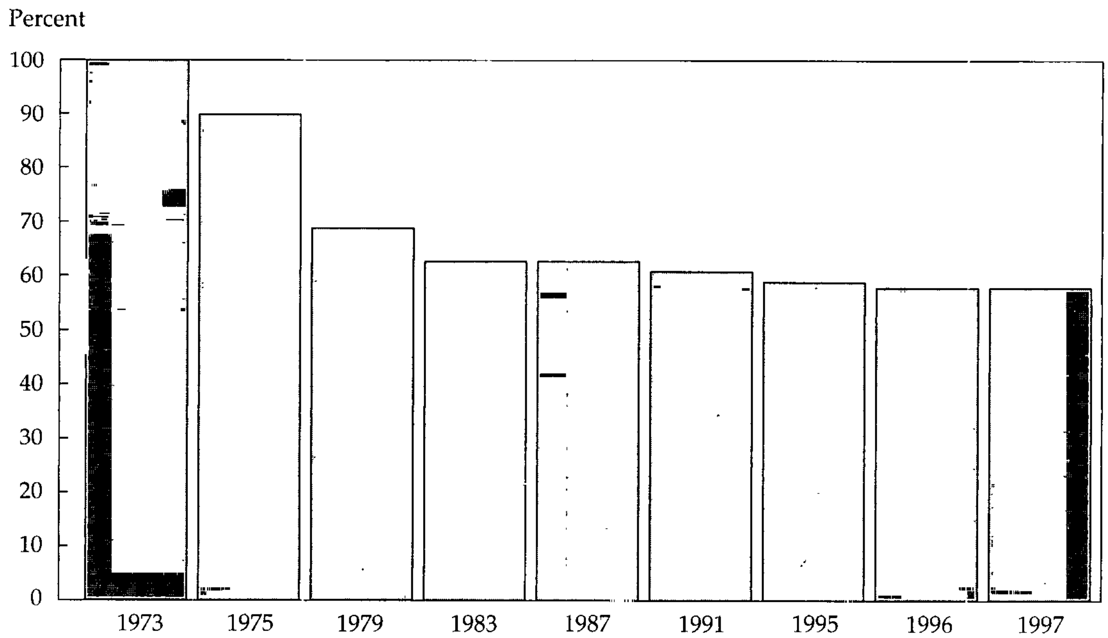
The Nippon Steel Corporation has set up an organized system of monitoring that enables the company to determine what the problems are, identify the sources of pollution that have an effect

Figure 4-5. *SO_x Emission Reduction by Nippon Steel Corporation, 1973–97*



Source: Nippon Steel Corporation (1998a).

Figure 4-6. NO_x Emission Reduction by Nippon Steel Corporation, 1973–97



Source: Nippon Steel Corporation (1998a).

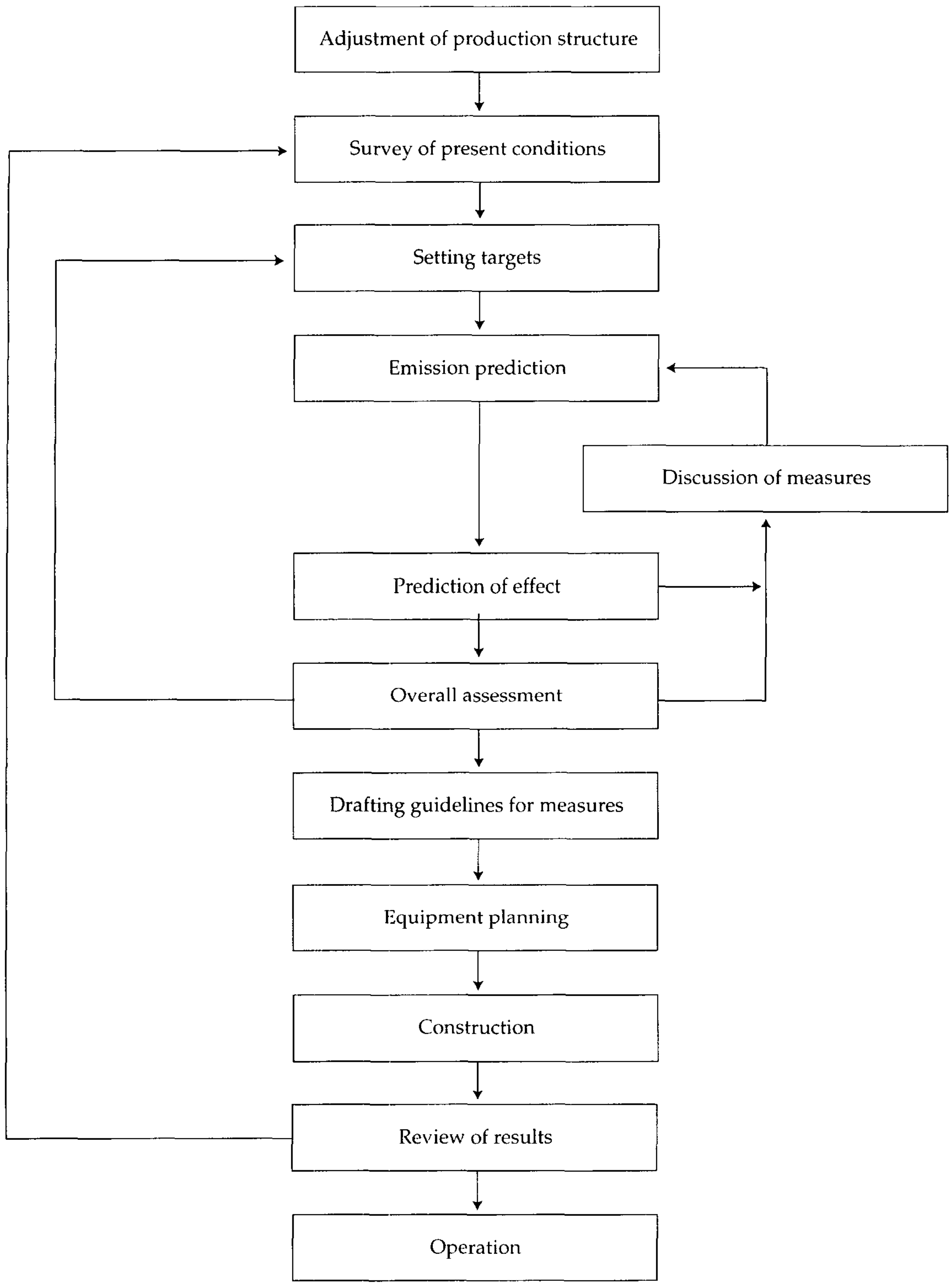
and to what extent, and implement appropriate measures. NSC has developed and followed such a systematic method to monitor environmental measures based on its experience (Figure 4-7). Its step-by-step approach is summarized here:

- *Understand the production structure.* In order to promote carefully planned environmental measures, a company must understand the current condition of production equipment.
- *Analyze environmental conditions.* After ascertaining current pollution levels as quantitatively as possible, a company should research the relationship between the environmental density levels and regulations set by the national government and local governments; repetitive sources contributing to pollution; and target levels of environmental standards.
- *Research the effects of each source of pollution.* Effects on the environment are predicted by conducting model simulations.
- *Prepare guidelines for environmental control measures.* Pollution control measures are set and prioritized for implementation.

Energy Consumption and Savings by the Japanese Steel Industry

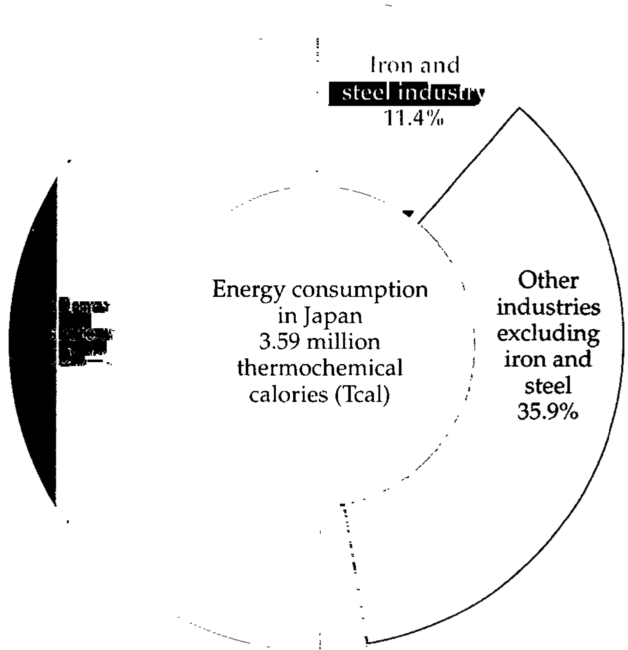
In 1995 the iron and steel industry accounted for 11.4 percent of total final energy consumption in Japan (Figure 4-8). The source of 78 percent of energy consumed by the Japanese steel industry is coal, which is used as the raw material reducing agent (Figure 4-9). It has properties for reducing iron ore that cannot be duplicated by other fuels. The Japanese steel industry's energy-saving measures have focused on the reduction of oil consumption, thus conforming to the government's energy policy (since the oil shocks) of reducing oil dependency.

Figure 4-7. *Nippon Steel Corporation's Environmental Monitoring System*



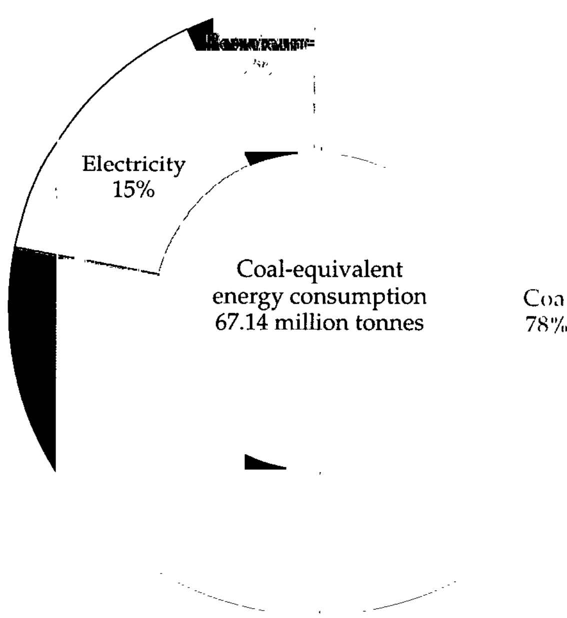
Source: Nippon Steel Corporation (1998a).

Figure 4-8. *Iron and Steel Industry's Energy Consumption Share in Total Final Energy Consumption, 1995*



Source: Japan Steel Federation (1997).

Figure 4-9. *Energy Consumption of Japan's Iron and Steel Industry, by Energy Type, 1995*



Source: Japan Steel Federation (1997)

Energy-saving measures by the industry have changed over time as energy prices have changed (Table 4-5). Responding to the first oil shock, energy-saving measures during the 1974–78 period focused on relatively small-scale capital investment such as operational improvement and small-scale waste heat recovery. Dependent on petroleum fuels for 20 percent of its energy consumption in the late 1970s, the Japanese steel industry realized the importance of significantly reducing its dependence on oil. A shift from heavy oil to coke was achieved by replacing the heavy oil used in reheat furnaces by coke oven gas. By 1982 there was a shift to 100 percent use of coke.

After the second oil shock in 1979, continuous casting was implemented and large-scale capital investment in process development, such as introduction of large-scale waste heat recovery equipment, was undertaken. Examples are the coke dry quenching (CDQ) system, blast furnace top pressure recovery turbines (TRT), and sinter waste heat recovery equipment.

As oil and coal prices stabilized in the mid-1980s, the steel industry made an effort to reduce its purchases of electricity, which had become a relatively expensive form of energy. Companies built power generation facilities that made use of the waste energy that was generated in the steel-making process. Consequently, the electricity purchase ratio declined from 31 percent in 1980 to 13 percent in 1995.

Global warming has become a serious concern for all people. Energy-saving must be considered not only from the traditional viewpoint, to save costs, but also from the global viewpoint, to preserve the world's environment. The steel industry has drawn up a voluntary action program to control the global warming effect, reduce waste, and promote recycling (Box 4-1).

Energy-Saving Technologies in the Steel Industry

Technological changes created the improvements in energy consumption in the steel industry. The three most important technologies for saving energy were the coke dry quenching system, the top pressure recovery turbine, and the continuous casting process.

Table 4-5. *Energy-Saving Activities and Achievements of the Japanese Iron and Steel Industry*

Time period	*Energy-saving activity*	*Achievement*
1974–78	Operational improvements such as reduction of blast furnace fuel cost; implementation of measures using relatively small-scale energy-saving equipment	10.4% reduction in energy use (compared with the first half of 1973)
1979–83	Implementation of measures using large-scale energy-saving equipment mainly for waste heat recovery; development of non-oil-using processes (blast furnaces using only coke, increased use of byproduct gas, gas-using reheat furnaces)	8.6% (compared with the first half of 1978)
1984–88	Promotion of waste heat recovery and introduction of energy management systems; introduction of continuous casting systems in all processes, hot charge rolling, and pulverized coal injection; drastic change in production structure and shift to high-quality steel products	2.8% (compared with the second half of 1983)
1989–98	Dissemination of information on the problem of global warming; voluntary action program to reduce carbon dioxide emissions, reduce waste, and promote recycling	

Source: Japan Steel Federation.

Box 4-1. *Japanese Industry's Initiative: The Role of Keidanren*

The foundation of the Japanese industry's involvement in environmental issues is found in the *Keidanren Global Environmental Charter,* announced in 1991. The charter stated explicitly that "endeavoring to deal with environmental problems is an essential condition of corporate existence and activities." It also declared the organization's intentions to pursue voluntary and active efforts to preserve the environment. This concept is translated into more concrete language in the *Keidanren Appeal on the Environment,* published in 1996. A number of goals are affirmed: dealing with global warming, building a society oriented toward recycling, establishing environmental management and auditing systems, and incorporating environmental concerns in overseas business activities.

With the public's growing awareness of pollution, pressure for environmental reforms mounted. The Japanese government chaired the Third Conference of Parties in Kyoto. Private industry took the initiative in 1997 and announced the *Keidanren Voluntary Action Plan on the Environment.* It was a significant step. The plan provided a framework for the steady implementation of environmental measures at all levels of Japanese industry. By declaring specific objectives and conducting follow-up surveys each year, the plan promoted accountability for environmental measures. This created "incentives in the form of public promises" and brought to bear the maximum amount of voluntary effort.

The industry-wide framework was then broken down by particular industries. Responsibility for policy formulation was assigned to a specific organization in each industry—in the case of the iron and steel industry, to the Iron and Steel Federation. These designated organizations are also responsible for the follow-up system and for publication of results. Forty-one industries and 142 industrial organizations participated in the plan.

As for global warming, the 1997 action plan states that the goal is "to reduce CO2 emissions from the industrial and energy-conversion sectors to below 1990 levels by 2010." To ensure transparency, each industry's action plan and findings of the follow-up surveys must be reported to the Industrial Structure Council and other bodies for third-party review. In *Basic Principles for the Promotion of Measures Dealing with Global Warming,* adopted by the Japanese government in June 1998, the policies spelled out in the *Keidanren Voluntary Action Plan* are identified.

Source: Keidanren (1991, 1996, 1997).

Coke Dry Quenching (CDQ) System. In the traditional process used before the 1980s, hot coke had to be taken out of the coke oven and cooled directly with water, causing valuable energy to dissipate into the atmosphere. The coke dry quenching system, however, cools hot coke with inert gas instead of water and recovers the heat from coke (in the form of steam through a waste heat boiler) for use in power generation. About 200 to 300 million calories per ton (Mcal/t) are saved.

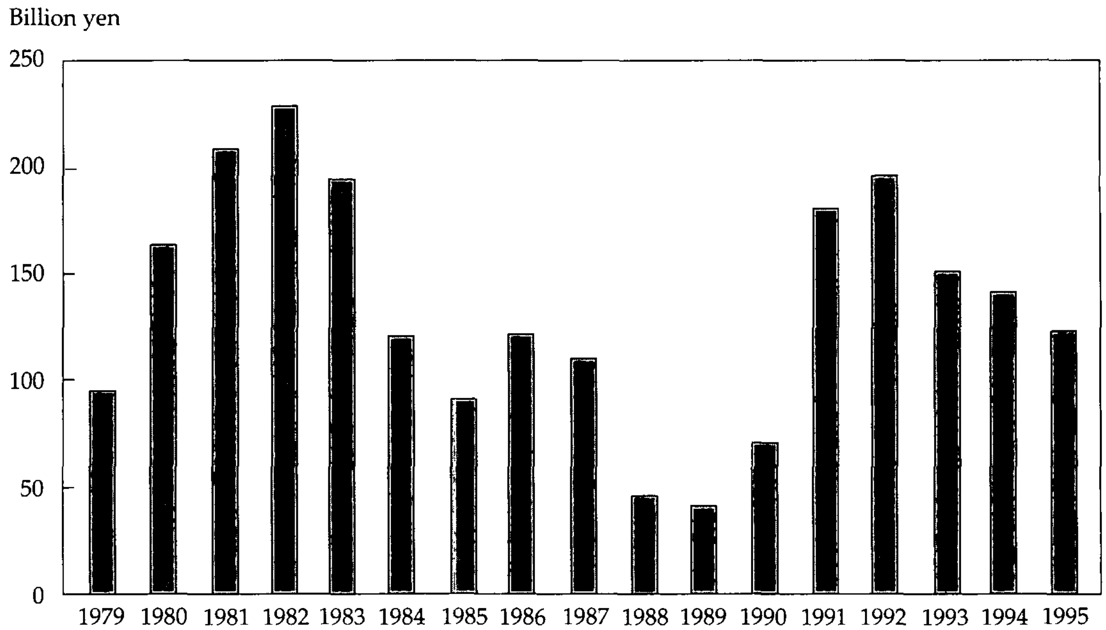
Top Pressure Recovery Turbine (TRT). Top pressure of the blast furnace gas is recovered for electric power by an expansion turbine. Shifting the dust collection method from the wet type to the dry type can further improve efficiency. Approximately 90 to 120 Mcal/t are saved.

Continuous Casting (CC) Process. While the previous production process contained three steps (ingot making, soaking pit, and dividing/rolling), continuous casting shortens these processes into one, thus saving energy and improving the yield rate. About 150 to 200 Mcal/t are saved.

Energy-Saving Investment and Economic Efficiency in the Steel Industry

At the time of the second oil shock in 1979, energy-saving investment by the steel industry as a whole was a little less than 100 billion yen. Investment peaked in 1982, decreased temporarily,

Figure 4-10. *Energy Saving Investment by Japan's Iron and Steel Industry, 1979–95*



Source: Japan Steel Federation (1997).

and then recovered to reach a second peak in 1992 that was partly caused by the need to replace or upgrade the 1982 investment (Figure 4-10).

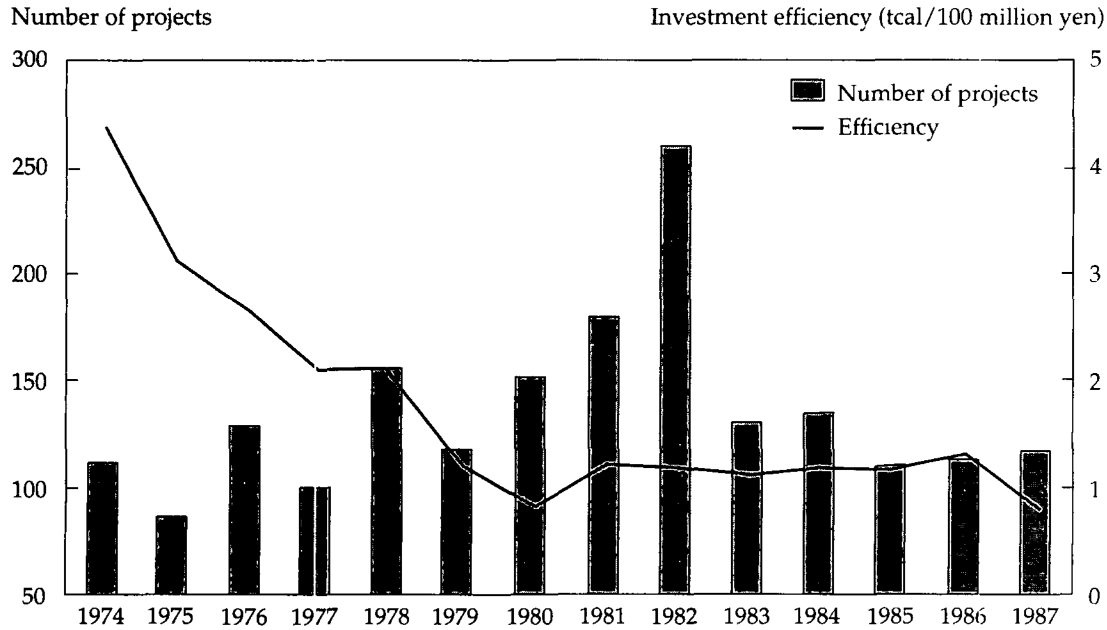
The efficiency of energy-saving investment in Japan has changed over time as the example of one company, referred to as Company A, shows (Figure 4-11). In 1974 the energy saved was 40 Tcal per 100 million yen of investment by Company A. In 1987, however, investment efficiency plunged to 10 Tcal per 100 million yen of investment. This shows that during the first half of the 1970s, when energy efficiency was significantly improved, the reduction rate of energy consumption based on one investment unit was very high, thereby substantially reducing the cost of fuels and materials.

Following the oil crises, the Nippon Steel Corporation successfully reduced energy consumption by improving energy efficiency and introducing new waste heat recovery systems. However, measures for energy efficiency improvement at NSC reached their limits in the 1990s and investment in waste heat recovery and operational improvement diminished. To further reduce energy consumption in the future and control the global warming effect, next-generation technologies and highly energy efficient equipment such as efficient industry-owned power generators are needed.

Energy-Saving Achievements by the Steel Industry

The steel industry's massive efforts to save energy include operational improvements, production process reduction, and waste energy recovery. The energy needed to produce one unit of steel in Japan declined by 20 percent after 1973. Consequently, the Japanese steel industry has achieved the highest energy efficiency and the least environmental load in the world, due not only to advanced technologies in production and operation, but also to a high dissemination rate of waste energy recovery equipment.

Figure 4-11. *Energy-Saving Investment Efficiency: The Example of Company A, 1974–87*



Source: Nippon Steel Corporation, internal reports.

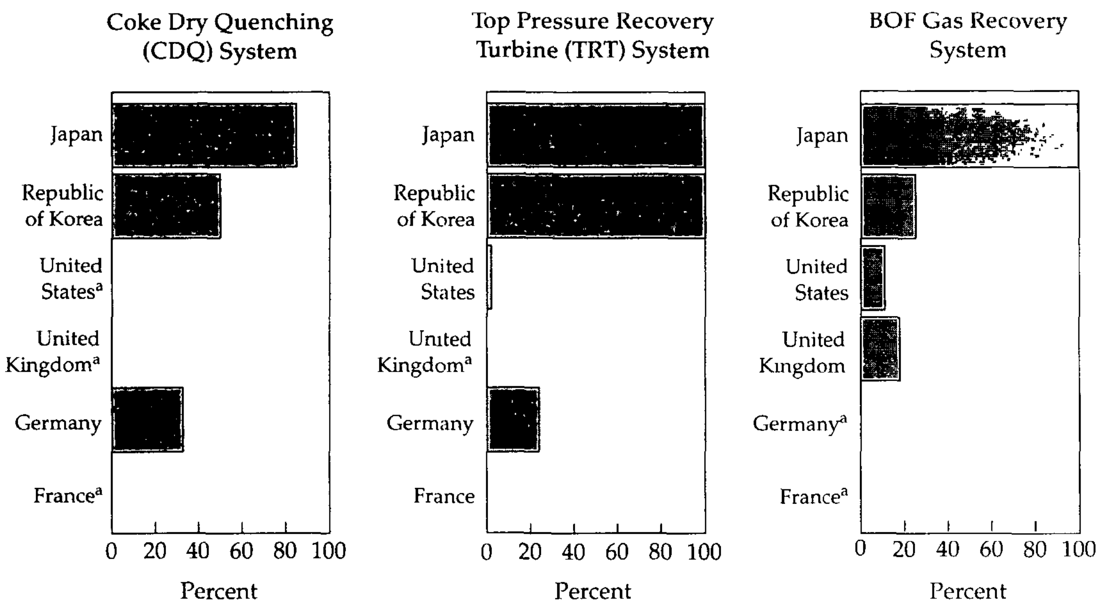
The dissemination rate of the three major types of waste energy recovery equipment (CDQ, TRT, and BOF gas recovery equipment) is remarkably high in Japan compared to other steel-producing countries in the Organization for Economic Cooperation and Development (OECD). A survey by the Iron and Steel Institute of Japan in 1996 indicated that while the dissemination rate of the coke dry quenching system in Japan is 85 percent, it is zero in the United States, United Kingdom, and France. In stark contrast to the 100 percent dissemination of the top pressure recovery turbine in Japan, in the United States it is only 2 percent and in the United Kingdom and France it is zero. Moreover, Japan has achieved 100 percent dissemination of BOF gas recovery equipment compared with 11 percent by the United States and 18 percent by the United Kingdom (Figure 4-12).

Continuous casting is a typical production-bypassing and concatenation process that saves energy. More than 90 percent of Japan's steel-making facilities introduced this process in the second half of the 1980s, before all other industrial countries. These efforts have helped Japan's steel industry achieve the world's highest energy efficiency. Japan compares well to the other major steel-producing countries. The energy unit cost (energy consumption required for one unit production of steel) is lower in Japan than in the United States, United Kingdom, Germany, and France by 18 percent, 12 percent, 3 percent, and 11 percent respectively. To present a broader perspective, we note that China, a major steel producer among developing countries, has an energy unit cost that is about 50 percent higher than that of Japan (Figure 4-13).

Global Warming and the Steel Industry's Voluntary Action Program

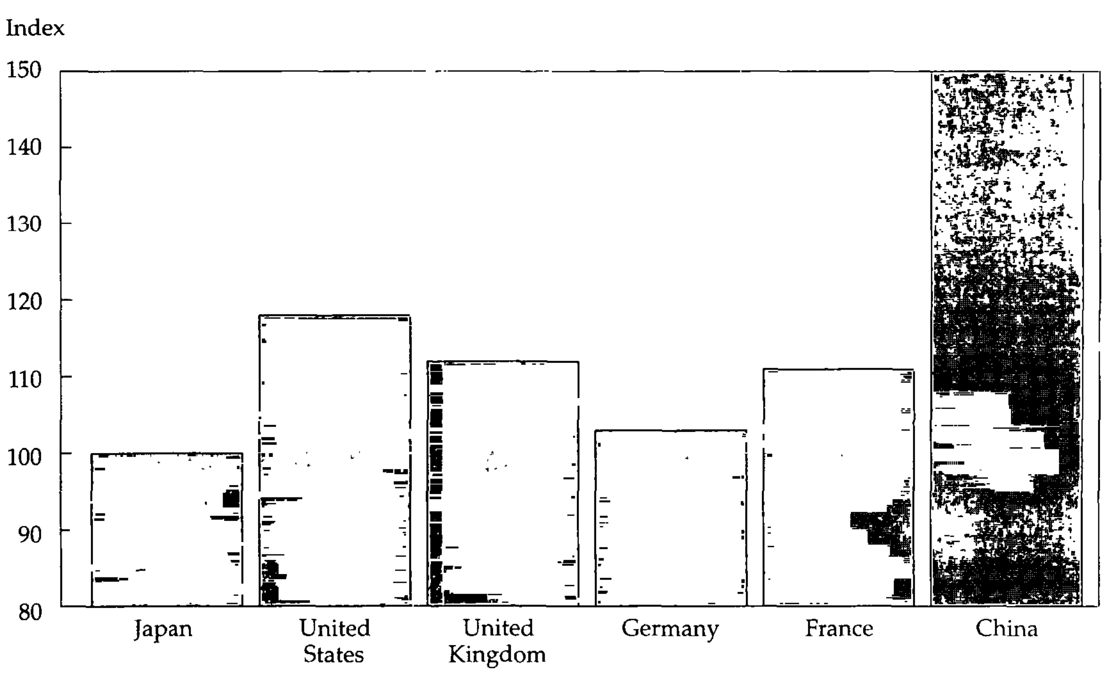
In preparing a voluntary action program for global warming control measures, the steel industry did not limit itself to energy-saving production processes but rather took into account the industry's

Figure 4-12. Diffusion Rate of Energy-saving System



a Zero percent.

Figure 4-13. Energy Efficiency of Iron and Steel Industry in Major Steel-Producing Countries, 1994



Source: Japan Steel Federation (1997).

potential and its advanced technologies. The voluntary action program includes the following five measures:

- Energy-saving efforts in steel-making processes;
- Effective utilization of waste plastics;
- Distribution of unused energy to surrounding areas;
- Contribution to energy-saving in society, with steel products and byproducts;
- Contribution to overseas energy-saving through technical assistance.

ENERGY-SAVING INITIATIVES. The steel industry intends to reduce its energy consumption in 2010 to 90 percent of the 1990 level. In addition, by establishing an effective logistics system, it plans to reduce energy consumption by a further 1.5 percent, for example through utilizing waste plastics in blast furnaces.

The industry will accelerate the introduction of energy-saving measures that have already been developed as well as promote next-generation steel-making technologies. In the past, energy-saving measures were carried out on the basis of economic rationalization. The voluntary action program, however, should be implemented according to a carefully prepared timetable that takes into account the replacement timing for existing equipment and the program's goals, since the program includes energy-saving measures that have low investment efficiency.

The implementation rate of measures for which technology development has been completed[1] is as high as 83 percent. The action program will attempt to increase this rate to 91 percent. A next-generation coke oven has been under development since 1994 as part of an eight-year national project. Coal is rapidly heated before being placed in the coke oven, and this enables dry distillation at a lower temperature. The energy consumption expected from this new coke oven is approximately 20 percent lower than from existing coke ovens.

The utilization of waste plastics in blast furnaces is another measure included in the action plan. One million tons of waste plastics are expected to be utilized, which is equivalent to 11 percent of all waste plastics in Japan. In order to achieve this goal, two problems must be solved. First, conditions required for implementation must be established (for example, a product collection system). Second, technical issues must be addressed. Examples of these issues are separate recovery of foreign matter (matter other than general plastics) and dechlorination technology for PVC waste plastics.

OTHER GLOBAL WARMING COUNTERMEASURES. Most of the waste heat generated at steelworks is recovered by the coke dry quenching system and used wherever possible for power generation and preheating within the facilities. The remaining medium- and low-temperature waste heat, such as sensible heat, cannot be used at the works, even if recovered. However, the waste heat that cannot be utilized at the works can be used efficiently, if it can be supplied to the local community. In fact, the local community's consumption of this otherwise wasted heat can be as high as 1 percent of the total energy consumed by the steelworks.

Although the steel industry is determined to promote the use of such waste heat, national and local government initiatives are necessary because infrastructure and systems must be established to transport waste heat to the user, and huge investment sums are involved.

The steel industry has moved ahead not only by developing steel-making processes that save energy but also by providing society with energy-saving products (such as lighter cars, thinner

1. Implementation rate = energy-saving effect by measures already implemented / energy-saving effect by measures for which technology development has been completed.

steel cans, and lighter steel materials for construction). In addition, the industry is developing and disseminating products that shorten the process times at users' facilities.

The steel products provided by NSC also help reduce environmental load when they are used in society. Cars built of high-strength steel are lighter because less steel is used, and they consume less gasoline. In addition, more corrosion-resistant steel makes cars more durable. An energy assessment of these effects is based on life cycle assessment (LCA). Although high-performance steel takes more energy to produce due to the increase in the number of processes, it saves energy in the long run by improving the products' energy efficiency and shortening the production processes for users.

Japan's steel industry has actively provided technical assistance to overseas steel producers by disseminating advanced energy-saving technologies. With highly cost-effective countermeasures against global warming, these technologies can contribute to joint implementation and Clean Development Mechanisms (CDM) promoted by the government. The steel industry is committed to participating in global projects to reduce CO_2 emissions.

NSC's Actions on Environmental Issues

The Nippon Steel Corporation's recent environmental conservation activities are summarized in this section. To reduce environmental load at every stage of business activity, the Nagoya steelworks acquired (in March 1996) ISO14001 certification (an international standard for environmental management systems). It was the first steelworks to do so in the steel industry worldwide, followed by the Kimitsu steelworks in March 1998. Every steelworks in Japan plans to acquire this certification in due course.

NSC has steadily developed new technologies for energy saving to help control global warming. One example is completion of the continuous hot rolling process at the Oita steelworks in 1998. In addition, to reduce hazardous air pollutants, the company started voluntary management activities. By preventing leakage from the coke oven and improving dust collection, NSC controlled benzene generated in the coke dry distillation process.

Based on the *Water Pollution Control Law*, a new effluent standard for nitrogen was instituted in October 1998. At the Hikari steelworks, a high-efficiency biological nitrogen removal technology has been developed and implemented. The company also has stepped up the recycling of byproducts such as slag, dust, and sludge generated in production processes. In 1997 it achieved a recycling rate of more than 98 percent. As a step towards building a recycling society and in accordance with the voluntary action program by steel-makers, NSC has set the following goal: reducing its final disposal amount by 2010 to 25 percent of the 1990 level. The whole steel industry has been promoting the recycling of steel cans. (The rate of the recycling improved from 43.6 percent in 1990 to 79.6 percent in 1997.)

Environmental Management Policy

Nippon Steel as a whole has been tackling environmental issues for the purpose of making society more conservation oriented. In addition, Nippon Steel now aims to conduct business activities in harmony with the total ecological system, to enhance the maintenance and improvement of the living environment, to prevent obstacles to environmental conservation such as hazardous air pollutants, and to promote global environmental conservation measures including those for the protection of the ozone layer and prevention of the greenhouse effect.

Nippon Steel conducts its business activities with the goal in mind of reducing environmental load at all stages, including acquisition of raw materials and supplies, production, product transport, product use, and scrap disposal. To promote these ends, Nippon Steel collaborates with other industries, including its users.

Japan's international technical assistance is cost effective in addressing global environmental issues. Nippon Steel has developed environmental conservation and energy-saving technologies, and it is experienced in transferring them overseas with the support of the Japanese government. In starting new business activities in overseas countries, Nippon Steel fully considers their natural and societal environments to ensure environmental conservation.

Environmental Management Committee

As concerns about global warming increase, businesses must meet ever-stricter requirements to reduce carbon dioxide, recycle resources, and safely handle hazardous materials. Companies must also satisfy the demands of the marketplace and the needs of consumers by developing products with low environmental loads. In response, the Nippon Steel Corporation established an Environmental Management Committee on April 1, 1998. The objectives of this committee are to enhance environmental efforts in general business management including production, sales, creation of new businesses, and technology development to support these activities. The committee informs all members about relevant facts, issues, or problems regarding the environment. It then discusses and adjusts the policies in response.

Efforts to Control Global Warming

The steel industry's voluntary action plan achieved a 6 percent energy reduction during the period from 1990 to 1995. Companies are now required to achieve another 4 percent energy reduction by 2010. In NSC's plan, goals for energy reduction are set at 2.0 percent in 2005 (middle year) and at 4.4 percent in 2010 (final year). NSC has redoubled its efforts to achieve these goals, implementing measures that are more economically challenging than previous ones. One example is the accelerated introduction of established technologies into production processes.

Efforts to Create a Socioeconomic System with Environmentally Sound Material Cycle

The accumulated volume of steel products in Japan is estimated at 1.2 billion tons. Ferrous scrap, after its service life, is recovered and recycled as a material, amounting to 32 million tons a year. The steel-making process generates about 40 million tons of byproduct a year. Its main components are slag and dust sludge. Blast furnace slag is utilized almost entirely for cement and road-bed materials; about 93 percent of steel-making slag is recycled mainly for use in civil engineering, soil improvement, and road-bed materials. The dust sludge recycling rate is almost 90 percent.

Announcing a target of reducing final disposal by 75 percent by 2010 (compared with 1990), NSC has been engaged in research and development of recycling, such as improving the quality of stainless slag and dezincification of dust sludge. Furthermore, the company has contributed to recycling and waste reduction by effectively utilizing byproducts generated in the production processes of other industries. The sludge from paper manufacturing as well as chemical substances generated in the aluminum production process can be used as heat insulators or auxiliary substances for steel-making; a nickel catalyst in oil and food refining can be used as a stainless material; and iron powder generated in the recycling of waste acid from semiconductor production can be used as a steel-making material. The company thus has promoted recycling and waste reduction not only in the steel industry but also in society as a whole.

International Cooperation

As noted earlier, with the advanced energy-saving technologies it has developed, NSC has actively provided technical assistance to foreign countries. The company will further contribute to international society and preservation of the global environment through projects to reduce CO_2 emissions in developing countries and by transferring environmental conservation technologies to these countries. NSC has participated in the green helmet project, a model project set up by the New Energy Development Organization. In this project, NSC is transferring to China energy-saving technologies such as those for blast furnaces and hot stove waste heat recovery, coal humidification, and coke oven dry quenching. NSC also is assisting East European countries, Brazil, and Mongolia by sending experts, accepting trainees, conducting field surveys, and holding seminars, in accordance with each country's needs.

Contribution to Communities

NSC has steelworks all over Japan, from Muroran in Hokkaido to Oita in Kyushu. Each of the steelworks has signed the Environmental Protection Agreement (agreement on environmental control) and the Industrial Landscaping Agreement with the local government that administers its facilities. These agreements cover air, water, waste, noise, vibration, and offensive odor types of pollution. They also include standards for sulfur content in fuels and materials that are not prescribed in national laws. Some of the agreements stipulate standards that are severer than those in the national laws, reflecting local characteristics. While complying with laws for environmental conservation, NSC also abides by its agreements with local governments, thus protecting the local environment and reducing the environmental load.

In an effort to protect the environment, NSC launched its "native woods" project in 1971, using a close planting of seedlings method and a direct planting of acorns method. After twenty years, woods as high as 10 meters have grown into habitats for birds such as pheasants and thrushes and for animals such as raccoons, dogs, and hares.

Suggestions for Addressing Environmental Issues in Developing Countries

There are many reasons for developing countries' slow progress introducing environmental conservation technologies. Here we discuss some of the technological, financial, economic, administrative, and social barriers these countries face.

Barriers to Progress

Technological barriers present a formidable obstacle. Since most environmental conservation technologies lack universal applicability, generalization and standardization of the technologies are difficult. Software technologies, know-how that is a particularly important part of technology, tend to be kept within companies. Insufficient monitoring of contamination and operational conditions also impedes developing countries' ability to decide what measures to take.

Other barriers are financial. It is difficult to raise funds for projects that do not produce short-term economic benefits. Investment decisions are hard to make because of the difficulty in calculating environmental values and other cost-benefit values. In developing countries, interest rates tend to be high, so small- and medium-size companies cannot raise funds easily. Moreover, in developing countries, energy prices tend to be set artificially low. The medium- to long-term energy price trend is unclear, which also makes cost-benefit calculations difficult.

Insufficient environmental administration in developing countries dampens investment sentiment. Governments of these countries do not have adequate policies and measures for the commercialization, application, and standardization of environmental conservation technologies. Because of institutional barriers, companies lack incentives to adopt these technologies. Those that do, receive insufficient financial and institutional support from government.

Finally, there are social barriers. Developing countries have limited human resources for adopting environmental conservation technologies. There is also a serious concern that stricter environmental standards may damage economic vitality.

NSC's Technology Transfer to China

The transfer of coke oven dry quenching equipment to China exemplifies the potential for Activities Implemented Jointly (AIJ) between Japan and that country. Numerous valuable lessons for developing countries were learned from this experience.

First, parts should be procured locally wherever possible. This will make future dissemination of the technology easier. It is necessary, however, to recognize whether a part's quality is uneven and to adjust for such unevenness in the design. Self-help efforts should be encouraged.

Second, to avoid interfacing problems, existing equipment or locally procured equipment should be compatible with new equipment. In addition, specifications should be commensurate with the technological level of the other party. In the CDQ project, generated steam is led to a turbine procured in China for power generation. While a high-pressure turbine is used in Japan, the turbine procured in China is low pressure.

Third, the technologies that are transferred should be maintainable by the other party, or the transfer should contain both hardware and software, including maintenance technology.

Fourth, training, including practice in operation and maintenance, is needed after the technology is transferred. Advance practice at facilities where similar equipment is in operation is effective. Through experience at the donor countries' facilities, trainees can acquire knowledge and learn the details of operational management. Trainees should learn how to encourage improvements and how to do the work. Technologies cannot be established unless the developing country has the requisite human resources.

Lessons from NSC's Experience

Barriers to the introduction of environmental conservation technologies in developing countries can be surmounted. The solutions will depend on each country's economic and social conditions. Those in charge of environmental policy and economic development in developing countries must search for the most efficient solutions by studying measures taken by industrial countries such as Japan. From NSC's environmental efforts discussed in this report, the following conclusions can be drawn.

ECONOMIC EFFICIENCY. The maintenance of a sound business structure requires economic efficiency. Before developing countries introduce costly leading-edge technology, they should consider a combination of energy-saving technology and high-cost performance and end-of-pipe technology that directly controls emissions.

ENVIRONMENTAL MANAGEMENT. It is important that the managers of industries in developing countries understand the significance of environmental conservation and construct an internal management system that institutes proper environmental controls.

TECHNOLOGICAL CAPACITY DEVELOPMENT. In the case of Japan, private firms were enthusiastic about environmental technology R&D. Behind their eagerness was a perception that a high level of environmental technology would increase their competitiveness. In the case of developing countries, it would be more reasonable to introduce technologies already developed in industrial countries. But they still must acquire the technological capacity to operate and maintain the equipment, not just install it.

Environmental Policy Choice. In most countries environmental policies accompany legal obligations such as emissions regulations. But Japan often set emissions targets and published performance data without legal recourse in order to promote private initiatives by industry. In this way Japan avoided a situation where strict environmental regulations become nothing more that scraps of paper because companies cannot observe them. Japan's approach motivates private firms to actively engage in environmental conservation because their actions are always watched by the community through a published track record of emissions indicators. It should be noted that in tackling environmental problems, countries need to achieve balance between the ideal and what is feasible in reality. Lastly, providing economic incentives, such as preferential tax treatment for companies that quickly achieve the emissions target, would be worth considering, although this practice was not common in Japan.

References

Committee of Kitakyushu for Cleaner Production and Technology. 1998. *Environment-Protection-Type Production Technology.* Tokyo: Nikkan Kogyo Shinbun.

Imura, Hidefumi. 1995. *Environmental Problems in China.* Tokyo: Toyo Keizai, Inc.

———. 1998. *Cases of Technology Transfer (Intergovernmental Panel on Climate Change).* Tokyo: Toyo Keizai, Inc.

Institute of Developing Economics. 1996. *Environmental Laws in the Developing Countries: Southeast Asia and South Asia.* Tokyo.

Japan Institute of Energy Economics. 1992. *Japanese Energy Industry's Research Report on International Cooperation in Tackling Air Pollution Problems in China.* Tokyo.

Japan Steel Federation. 1989. *Research Report on Energy Use by Honkei Steel Company and the Feasibility of Energy -Saving.* Tokyo.

———. 1990. *Earth-Friendly Steel Manufacturing.* Tokyo.

———. 1996. *Report on Total Measures Concerning Generated Objects from an Integrated Steel Mill (Shougang Corp.) in China.* Tokyo.

———. 1997. *Steel and Green Earth.* Tokyo.

———. 1998. *Japanese Steel Industry's Outlines of the Challenges of Global Warming.* Tokyo.

Keidanren (Federation of Economic Organizations). 1991. *Global Environment Charter.* Tokyo.

———. 1996. Keidanren Appeal on the Environment.

———. 1997. *Keidanren Voluntary Action Plan on the Environment* (Final Report). Tokyo.

Kitakyushu Environment Bureau. 1991. *International Environmental Cooperation in Kitakyushu.* Kitakyushu-city, Japan.

NEDO (New Energy Development Organization). Japan Steel Federation and Metallurgy Industry Department of the National Planning Committee of China. 1997. *Meeting of Chinese and Japanese Steel Industries on Energy Saving.*

Nippon Steel Corporation. 1990a. *Environmentally Friendly Antidotes by Nippon Steel Corporation: Targeting the Realization of a Comfortable Environment.* Tokyo.

———. 1990b. *From Seven Seas to Seven Seas: A Thirty-Year History of Nagoya Steelworks.* Tokyo.

———. 1990c. *Nippon Steel Corporation's List of Measures to Tackle Environmental Problems.*Tokyo.

———. 1996. *Environmental Management Policy.* Tokyo.

———. 1997. *Engineering Enterprises of Nippon Steel Corporation.* Tokyo.

———. 1998a. *Environmental Report.* Tokyo.

———. 1998b. *Guidebook of Nippon Steel Corporation.* Tokyo.

Research Institute of Global Industrial Culture. 1997. *Research Report on Technology Transfer in the Asian Region*. Tokyo.

———. 1998. *Research Report on Technology Transfer in Asia Region*. Tokyo.

Research Institute of International Trade and Industry. 1996. *Energy Consumption and Environmental Problems in China*. Tokyo.

Takahashi, Makoto. 1999. *Environmental Governance and the Steel Industry: Air Quality*. Tokyo: Institute for Global Environmental Strategies.

5

Environmental Conservation by Japan's Electric Power Industry: An Example of the Electric Power Development Company

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Japan's electric power industry, after successfully controlling domestic pollution problems, has turned to the emerging global issues associated with climate change. To achieve the world's highest efficiency power generation, the industry is focusing on technology development as well as operation and management. Motivation for these efforts comes from a combination of factors: Japan's strict environmental regulations, the general public's awareness of the dangers of global warming, high energy prices, and the notion of social responsibility of quasi-public corporations. Thanks to these factors, Japan's sulfur oxide (SO_x) emissions have drastically decreased, increases in nitrogen oxide (NO_x) emissions remain low, and Japan's rate of emissions of carbon dioxide (CO_2) per unit of GDP is one of the world's lowest.

Although Japan's industries are highly energy efficient already, the government has pledged to further reduce CO_2 emissions to help combat global environmental problems. In 1996 the power generation industry accounted for about a quarter of all CO_2 emissions in Japan. Clearly, the industry plays a leading role in reducing CO_2 emissions, and it is striving to attain an even higher level of efficiency in energy use.

Worldwide emissions of carbon dioxide are expected to continue to increase, mainly in developing countries. According to a 1998 estimation by the International Energy Agency (IEA), global CO_2 emissions will rise, from 1990 to 2020, by around 9,800 million tons; in the "business as usual" scenario, more than 70 percent of this amount will be from developing countries. One reason for this is that coal-fired power generation, which emits more CO_2 per unit of electricity generated than most other fossil fuels, will increase to satisfy the rapidly growing power demand in developing countries. The increase in coal-fired power generation will also lead to increases in SO_x and NO_x emissions, which are already causing regional pollution problems and contributing to global warming. One solution is to shift from coal to other energy sources that have a less harmful impact on the environment. This option, however, is not feasible in countries such as China and India, where there are large coal reserves, and it is economical to use coal. Therefore, environmental safeguards in coal-fired power plants are critically important in these countries. Japan's experience addressing environmental problems in coal power generation can be a useful point of reference.

This chapter presents the case of the Electric Power Development Company. It has been operating coal-fired power plants in response to government requests to convert from oil to coal to reduce Japan's dependence on imported oil. The company has successfully resolved regional environmental problems in cooperation with the government and local communities, and it has made great strides in reducing the greenhouse gases (GHGs) associated with global warming.

Since coal-fired power plants are expected to play an important role in Japan's power generation in the future, the company will continue to conduct research and development (R&D) and technological development activities for further improvement of energy efficiency. Although it may be difficult to replicate these measures in developing countries, the experiences fully described here could contribute to the creation of sound environmental policy in such countries.

Japan's Electric Power Industry

Japan's electric power businesses are classified into two categories under the *Electricity Utilities Industry Law*: the vertically integrated power supply industry that supplies electric power to meet general demand in particular areas and the wholesale power industry that mainly supplies electric power to power companies irrespective of area. The first type consists of ten regional electric power companies, such as Tokyo Electric Power Company for the Tokyo metropolitan area. The second type includes the Electric Power Development Company (EPDC). Apart from their self-generated power, public power companies purchase power from the wholesalers to distribute to consumers.

Structure of the Industry

The present structure of electric power companies started in 1951, one year after the government issued the *Ordinance on Public Utilities* and the *Ordinance on Reorganization of Electric Utilities* in response to the demand of the American occupation army. In accordance with the ordinances, a private, integrated company for the generation, transmission, and distribution of electric power was founded for each of the nine regions in Japan. A structure of nine electric power companies, each of which had an exclusive supply privilege for its region, was thus started. Basically, the same organization has continued ever since (although it expanded to a structure of ten electric power companies after Okinawa Electric Power Company was founded following the reversion of Okinawa to Japan). In 1952 the Electric Power Development Company, Ltd. was founded based on the newly established *Electric Power Development Promotion Law*.

Industry Trends in Energy and Environmental Measures

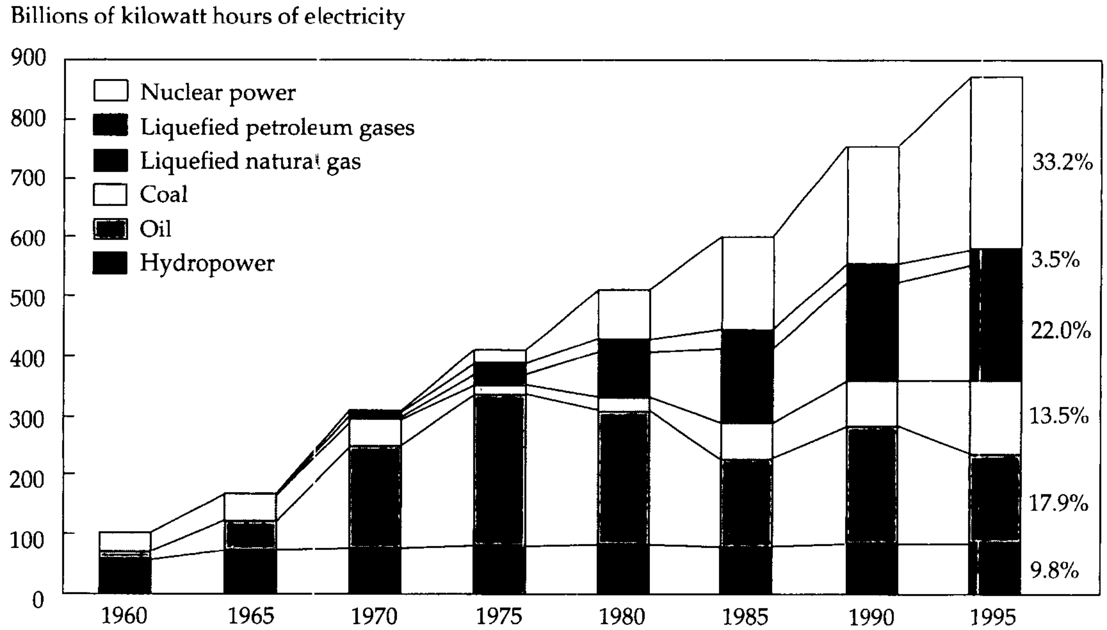
Since the two oil shocks, diversification of energy sources and energy saving have strongly been promoted in Japan. Coal-fired power generation was dominant until the 1960s, when there was a progressive shift from coal to oil, which became the leading fuel for power generation to meet the rapidly increasing power demand from economic growth. Thermal generation from oil steadily increased, but with the first oil crisis in 1973 and the International Energy Agency's 1979 prohibition on construction of new oil-burning thermal generation plants to reduce dependency on oil, a shift to liquefied natural gas (LNG) or coal began in the early 1980s (Figure 5-1). Dependent on imported resources for most of its energy supply, Japan has examined all alternative sources of energy including nuclear power and has continually pursued the best energy mix among them.

The scarcity of its natural resources has made Japan an energy-saving society since the oil crises. As consumers and industry became more keen on energy saving, electric utility companies improved energy efficiency and thus succeeded in cutting down CO_2 emissions per kilowatt hour (Figure 5-2).

While there was just under a threefold increase in power generation from 1970 to 1995 (from 304 billion kWh to 878 billion kWh), CO_2 emission increases were just under twofold (from 48 million tons to 84 million tons carbon equivalent) during the same period.[1] CO_2 emissions per

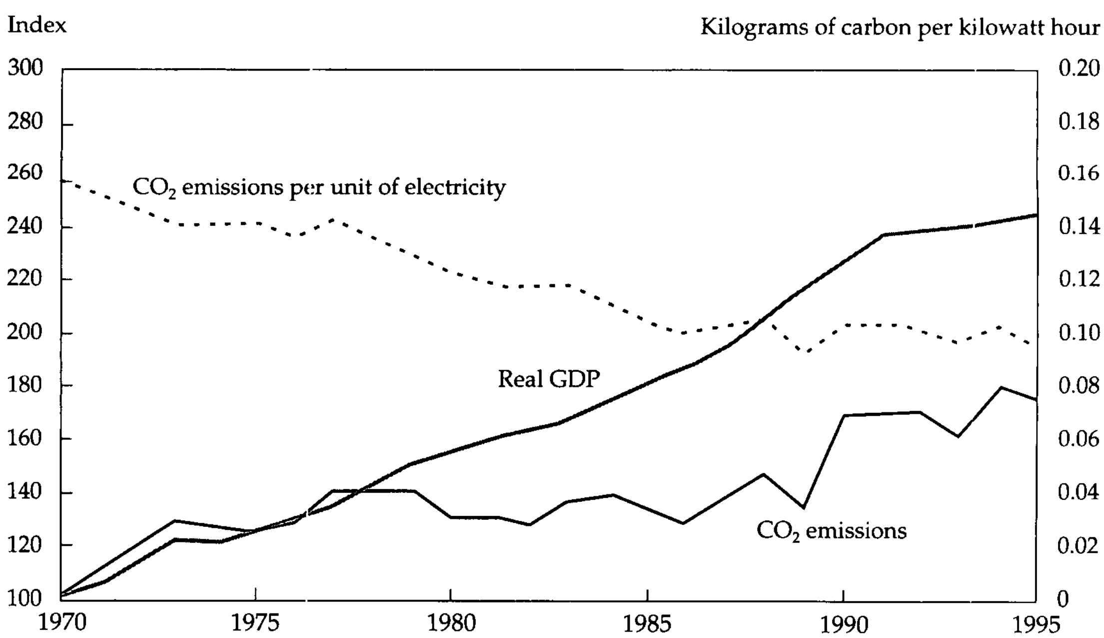
1. Estimated by the Institute of Energy Economics, Japan.

Figure 5-1. *Japan's Energy Sources, 1960–95*



Note: LPG includes other gases and geothermal and bituminous material
Source: Ministry of International Trade and Industry of Japan, Agency of Natural Resources and Energy.

Figure 5-2. *CO_2 Emissions from Power Generation*



Note: 1970 = 100.
Source: Japan Federation of Electric Power Companies (1997).

unit of power generated continued to decrease. They declined from 158 grams of carbon per kilowatt hour (g-C/kWh) in 1970 to about 96g-C/kWh in 1996.

Japan compares favorably to other developed countries. While Japan's CO_2 emissions rate is higher than the rate in Canada, where the ratio of hydroelectric plants is relatively high, and in France, where the ratio of nuclear power plants is relatively high, it is lower than the figures in the United States, United Kingdom, Germany, and Italy.[2] When the comparison is limited to thermal power plants, Japan's figure shows relatively high energy efficiency (Tables 5-1 and 5-2). As a result, the CO_2 emissions rate from Japan's thermal power plants is the lowest among developed countries.

As for the local environmental problems, the Japanese electric power industry successfully overcame pollution concerns that had become serious social issues in the rapid economic growth phase in the 1960s and 1970s. Each electric power company drew up its own action plan to address environmental problems and has carried out full environmental measures by strictly subscribing to the plan. Specifically, by introducing nuclear energy and new energy sources ("clean energy"), high-quality fuel at thermal power plants, and flue gas desulfurization and denitrification equipment, the industry reduced NO_x to about one twentieth and one third their levels of 20 years ago, respectively. The levels are now among the lowest in the world.

Electricity Pricing

Electricity rates in Japan are based on the average cost of supplying electricity. This method, the Total Cost of Service Method, is stipulated in Article 19 of the *Electricity Utilities Industry Law.* The article provides that general power utilities draw up a supply contract, including electricity rates, and obtain authorization of the Minister of International Trade and Industry. The contract will be authorized if the Minister thinks it reflects "proper costs, based on efficient business management, plus fair return." "Proper costs" are calculated by adding up expenses for personnel, fuel, maintenance, and depreciation, as well as costs for wastewater treatment, exhaust gas treatment, and other environmental measures. "Fair return" is calculated on the Rate Base Method by multiplying business assets invested (including facilities for generation, transmission, and distribution) by a certain rate of return (4.4 percent in 1998). Adding up the above-mentioned costs and remuneration and deducting the target figure for managerial effort (to encourage better management) gives the total cost, which is used as the basis for calculating electricity rates.

Table 5-1. *Net Thermal Efficiency and Transmission/Distribution Loss Factor, 1995*
(Percent)

Item	*Japan*	*United States*	*Canada*	*United Kingdom*	*France*	*Germany*	*Italy*
Net thermal efficiency	37.5	33.5	30.8	36.3	34.5	34.7	38.6
Transmission/distribution loss factor	5.5	5.6	8.0	7.6	7.3	5.0	6.7

Note: Net thermal efficiency value for Canada and Germany are for 1994.
Source: Japan Federation of Electric Power Companies (1996a, b).

2. Survey by the Japan Federation of Electric Power Companies.

Table 5-2. Carbon Dioxide Emissions per Unit of Electricity Generated, 1996
(Kilograms of carbon per kilowatt hour)

Average emissions	*Japan*	*United States*	*Canada*	*United Kingdom*	*France*	*Germany*	*Italy*
For thermal power plants	0.16	0.23	0.22	0.19	0.21	0.25	0.17
For all power plants	0.10	0.16	0.05	0.13	0.02	0.16	0.14

Source. OECD (1998).

This cost calculation method allows electric power companies to take necessary measures to protect the environment and pass on the costs to consumers, thus recovering the environmental cost of power generation. Although this system tends to drive up the electricity price in Japan (it is higher than in other countries), it was Japan's choice to spend more on environmental protection and energy security. But there was no explicit cost and benefit analysis in this decision. Whether the level of spending was the best allocation of resources remains to be answered.

Thermal Power Generation and Atmospheric Pollution

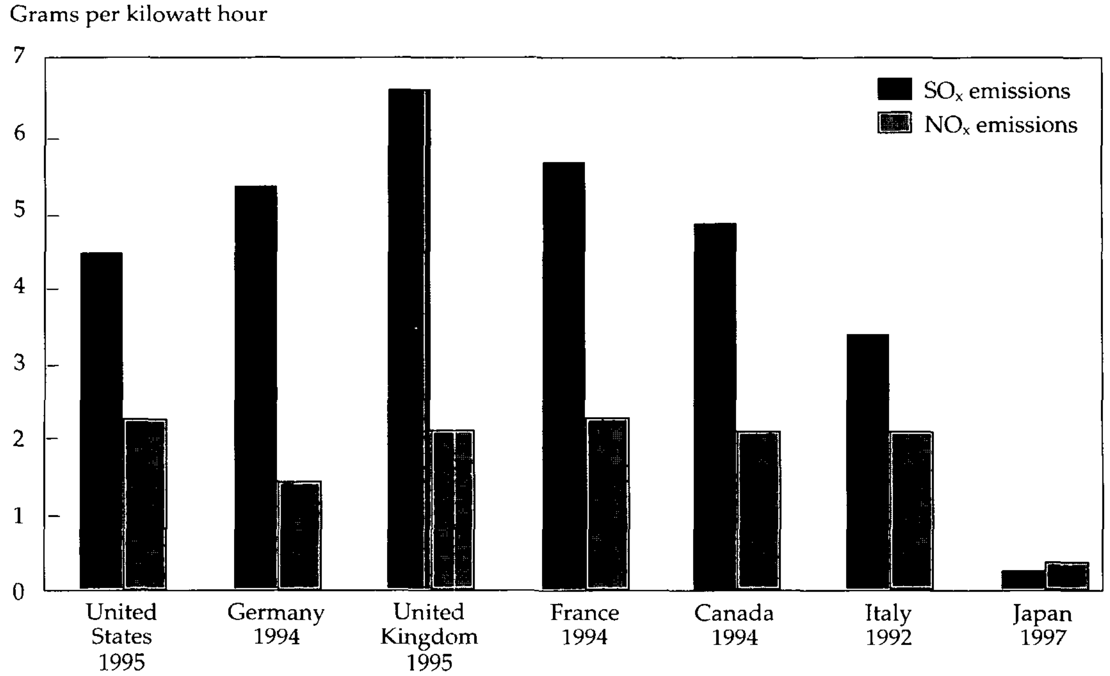
In the thermal power generation process, fossil fuel is burned in a boiler, and substances such as soot, particulates, SO_x, and NO_x are discharged into the atmosphere. The sulfur oxide that is generated during the combustion process as a result of the reaction between the fuel's sulfur component and oxygen in the air is thought to cause acid rain. Most of the NO_x is produced by combustion in a boiler. It, too, is considered to cause acid rain. The industry is actively taking measures to control these emissions. Japan compares favorably with other industrial countries in emissions of sulfur oxide and nitrogen oxide (Figure 5-3).

Reduction of SO_x, NO_x, and particulate emissions can be achieved through the use of high-quality fuels such as heavy/crude oil and coal with low sulfur and nitrogen, and liquefied natural gas that contains no sulfur or particulate matter. Adoption of LNG for energy generation substantially reduces emissions. However, there are huge requirements for initial investment for generating facilities and for ensuring availability of long-term supply. In the case of the Tokyo Metropolitan Area, which faced significant and increasing air pollution problems, Tokyo Electric Power Company received financial assistance from the government, including loans from the Development Bank of Japan (with concessionary terms) to support the adoption of LNG energy sources.

SO_x, NO_x, and particulates can be removed through the installation of flue gas desulfurizers (FGDs), selective catalytic reduction (SCR) equipment, and electrostatic precipitators. NO_x reduction can also be achieved through improved combustion methods such as two-stage combustion or through low-NO_x burners. In addition, complete combustion management and monitoring of the emission source should be undertaken.

Since coal contains large quantities of sulfur, nitrogen, and ash compared with other fossil fuels used for thermal power generation, combustion improvements and flue gas treatment should be combined to reduce the environmental load. Coal also produces more soot and particulate matter in flue gas than heavy oil because there is more ash. So most coal-fired power plants are equipped with highly efficient precipitators, which remove more than 99 percent of the particulate.

Figure 5-3. SO_x and NO_x Emissions per Unit of Electricity Generated



Note: The figures for Germany and France include private power generation in industries. Those for other countries are for the power utility industry.
Source: Japan Federation of Electric Power Companies (1997).

Global Warming and the Industry's Voluntary Action Plan

Fossil fuel combustion also emits carbon dioxide, which is the principal cause of global warming. Emitting nearly a quarter of the total emissions of carbon dioxide, the electric power industry is fully committed to achieving reductions in many aspects of its business. Preceding the Third Conference of Parties (COP3) to the International Framework Convention on Climate Change in Kyoto in 1997, many private Japanese companies voluntarily drew up action plans to address overall environmental problems. Electric power companies have been taking the lead in making various efforts to protect the global environment (Box 5-1).

In its "Environmental Action Plan" in 1996, the Federation of Electric Power Companies declared its aim to counter global warming by limiting increases in the overall emissions of the electric power industry. Even though electric power generation in 2010 is forecasted to be 1.5 times the 1990 level, the increase in CO_2 emissions is targeted to be only 1.2 times that level.

On the demand side, it is important to promote energy saving and load leveling. Electric power companies are developing and promoting highly energy efficient electric devices and disseminating useful information on energy saving and the environment. The industry's efforts on the energy supply side are concentrated in three categories.

First, the electric power industry is seeking a balanced composition of power sources. It is expanding the use of clean energy, mainly by establishing nuclear power plants and managing the nuclear fuel cycle, increasing the use of natural gas, and developing and promoting clean coal technologies. Renewable energy and new energy sources also are being developed.

Second, the industry is trying to use energy more efficiently. Generators have been improved year by year, and now thermal power plants with plant thermal efficiency exceeding 50 percent are being constructed. Transmission loss is now less than 10 percent. The electric power industry will construct even more highly efficient power generation and transmission equipment, and it is focusing efforts on the effective use of unused energy such as heat from waste incineration facilities.

Third, environmental protection technologies are being introduced. The industry will develop CO_2 collection and treatment technologies for thermal power plants. Techniques to reduce the energy consumed when collecting CO_2, and research regarding this application to thermal power plants, are both needed before these technologies can come into practical use. The industry is also involved in international efforts to promote environmental protection technologies. As part of the Kyoto initiatives, joint country efforts to reduce carbon emissions (Activities Implemented Jointly or AIJ) were instituted.

Government Subsidies for Environmental Measures

The biggest problem implementing environmental measures is economic. Environmental equipment requires large amounts of initial investment and funding, and operating the equipment

Box 5-1. *Environmental Action Plan of the Electric Power Industry*

This plan was issued in 1996 and published the following year. It includes the following measures against global warming.

1. Promotion of the optimum combination of power sources, centering on nuclear power generation for which CO_2 emissions are extremely low.
2. Upgrading energy utilization efficiency, including continued improvement of thermal efficiency at thermal power plants, adoption of combined cycle power generation systems, and a reduction in transmission and distribution loss factors.
3. Introduction and promotion of renewable energy sources, such as solar and wind power generation systems.
4. Further energy-conservation in electricity usage, including the development and installation of such equipment as regenerative heat pumps and utilization of untapped energy sources.
5. Development of technologies related to CO_2 recovery, disposal and fixation.

To supply the primary energy requirements for early next century, the Federation of Electric Power Companies believes that it is necessary to expand nuclear power generation by approximately 70,000 megawatts by 2010. Within fifteen years, the industry intends to aggressively tackle new energy development of about 30,000 megawatts. Furthermore, the industry wants to increase the rate of nuclear power generation by reducing the time required for regular inspections without sacrificing safety.

With the continued development of nuclear energy, the entire power industry should strive to reduce CO_2 emissions per unit of electricity by about 20 percent in 2010 relative to 1990. If this measure is achieved, total CO_2 emission levels in 2010 should be restricted to below 1.2 times the 1990 levels, whereas the growth rate of power generation is forecast to reach about 1.5 times those levels. To further reduce total CO_2 emissions, energy conservation must occur in electricity usage through the introduction of highly efficient equipment and the adoption of untapped energy sources. The electric power industry actively supports these industrial trends.

Source: Japan Federation of Electric Power Companies (1997).

requires power to run the devices and expendable supplies like treatment chemicals. Power generation itself requires large amounts of capital investment, and additional investment significantly burdens companies. Electric power companies must be socially responsible and take environmental measures while meeting their responsibility to provide a steady supply of energy at an affordable price. Electric companies need to improve business efficiency to moderate the increase in costs.

The government has introduced assistance programs to relieve the financial burden and to give business the incentive to protect the environment. Following are the main efforts by the government to support environmental measures in the electric power industry: (1) a low-interest-rate loan program through the Japan Development Bank for pollution control facilities, energy efficiency enhancement facilities, and recycling facilities; (2) preferential tax treatment through accelerated depreciation of equipment for environmental measures, reduction or exemption of fixed property taxes related to environmental facilities, and tax deductions on energy-saving technology R&D; and (3) subsidy for R&D of environment-friendly technology.

Profile of the Electric Power Development Company

Electric Power Development Company, Ltd., a wholesaler of electricity, operates hydroelectric, coal-fired, and geothermal power plants that it has constructed at sixty-five sites in Japan (Table 5-3). They have an installment capacity of about 14,000 megawatts (MW). It has also constructed extra-high-voltage transmission lines that form a connection between the business areas of the electric power companies. These lines enable the companies to efficiently trade electricity among themselves depending on their supply capacity, and they give flexibility and efficiency to the Japanese power supply system. There are plans to construct three more coal-fired power plants and a nuclear power plant.

History

EPDC was founded in 1952 when the Japanese economy was recovering from the devastation of war. The supply of electric power, so essential for production, lagged far behind demand and

Table 5-3. *Facilities and Capacity of EPDC, 2000*

Generating facilities (authorized maximum output)	58 hydroelectric plants: 8,260,800 kW 7 thermal power plants: 5,654,500 kW All 65 plants: 13,915,300 kW
Transmission facilities (length spanned)	2,422.7 km ultra-high voltage transmission lines: 2,088.3 km DC transmission lines: 167.4 km
Transforming stations	4 stations: 4,791,000 kVA
Frequency modulation stations	1 station: 300,000 kVA
AC/DC conversion stations	2 stations: 600,000 kVA
Wireless communication facilities	560, 908ch-km
Power sales (FY1997)	Hydroelectric: 13,728,721 MWh Thermal power: 34,024,362 MWh Total: 47,753,083 MWh

Source: Electric Power Development Company.

was a serious obstacle to economic development. Developing new power sources required huge funds and materials. Since the newly established electric power companies could not procure the necessary long-term funds, injections of government funds into the industry were necessary. The *Power Development Promotion Law* was enacted to alleviate the extreme imbalance between electric power supply and demand and to support a project that was a national priority. Under the law, EPDC was founded with 100 percent capital from the Japanese government as a special public corporation that had direct access to public funds.

In the early years of EPDC (the 1950s), large-scale, storage-type hydroelectric power plants were developed throughout Japan and helped satisfy the rapidly growing demand for power through their wholesale operations to the nine electric power companies. Following this period came the construction of coal-fired power plants, which used domestic coal as fuel. Converting coal-fired power plants into large-scale heavy/crude oil thermal power plants satisfied the rising demand for electric power. The conversion led to unemployment problems in the coal industry, and the government requested EPDC to construct coal-fired power plants to increase the demand for coal. Several thermal power plants were completed and were commissioned into service, starting with Isogo Plant No.1 (265 MW) and Takehara Plant No.1 (250 MW) in 1967.

After the oil shock in 1973, diversification of fuel sources was strongly requested to ensure the long-term stable supply of energy in Japan, which has few domestic resources. To shift away from oil, rapid development of hydroelectric plants, coal-fired power plants, and nuclear power plants was encouraged. EPDC cooperated with the government's energy policy by developing large-scale coal-fired power plants, which mainly used imported coal. Through the years EPDC has implemented national power source development policies such as fuel diversification, green technology, and efficiency enhancement technology development. With good results the company has attained its original objective to advance government policy.

Recently, lively discussion on across-the-board reform of Japan's social system and its high-cost and over-regulated economic system has been gathering momentum. Deregulation and administrative reform of public-private role sharing is now under way. The streamlining of public corporations is one such development. The electric power industry is no exception. A 1995 amendment to the *Electric Utility Industry Law* introduced a bid system to the electricity wholesale market to encourage competition. As a result, some independent power producers (IPPs) entered the power generation market. Under these circumstances, the Japanese government has decided that it will sell off its shares in EPDC in FY 2003 and that EPDC, as a completely private company, will serve as a major player in the new competitive market of the electric power industry.

Stockholders and Fundraising

EPDC was founded as a corporation with special status to implement Japan's energy policy. Originally the Japanese government owned 100 percent of its stock, but currently about one-third of ownership is held by nine electric power companies. EPDC is different from a private company and has a special privilege to borrow loans directly from the Fiscal Investment and Loan Program (FILP) operated by the Ministry of Finance. This pool of funds is collected from the public (through postal savings, for example), and it is backed by the government's credibility. The money is used to directly finance special status corporations such as EPDC, and it indirectly finances the private sector through governmental financial institutions such as the Japan Development Bank. FILP has effectively provided funds to critical industrial sectors to boost economic development, especially in the years after the war when there was a shortage of savings.

Since the supply of electric power was a national priority in the rebuilding of Japan's economy, EPDC was able to secure FILP loans for building large-scale power sources. Energy policies in every period have provided for funding on more favorable terms than have been available commercially.

EPDC and Environmental Protection

During nearly fifty years of dam and generation plant construction and operation, EPDC has faced conflicts between environmental conservation and energy source development. Villages were submerged, uprooting the people who had been living there, and the shapes of mountains and rivers were changed for the construction of dams. Reclamation of land for constructing power plants changed the coasts, and smoke from thermal power plants polluted the surrounding air.

As this destruction of nature and the dark sides of economic development came into the spotlight, and as society's consciousness of the environment grew, EPDC recognized the need to balance the three Es (environmental protection, energy security, and economic growth). It then began to take action to minimize the impact of its operations on the environment. EPDC planted trees to restore mountains. It learned techniques to eliminate soot, smoke, sulfur oxide, and nitrogen oxide from the smoke stacks of thermal power plants. The company thus found that business could be compatible with protecting the environment if environmental dangers were faced squarely. In 1993 EPDC drew up the following environmental action guidelines as its basic principles on the environment (Box 5-2).

Efforts to Counter Local Environmental Problems

The rapid pace of economic growth in the 1960s increased industrial production and energy consumption and led to the formation of large-scale petrochemical industrial complexes. The scaling up of dedicated oil-burning power plants produced massive quantities of pollutants. In Yokkaichi City the effects of "Yokkaichi asthma" and "stinking fish" began to be felt around 1961, instantly casting the area into the public limelight as a polluted city.

In this period when the public was becoming aware of environmental problems and was demanding heavy-handed controls on the electric power industry, the EPDC was planning to construct the Isogo coal-fired power plant. This was in response to the government's request in the *Basic Program for Coal Industry* for increases in coal demand. The EPDC's reaction to this environmental challenge became a model case for thermal power plant construction in Japan.

Box 5-2. *EPDC's Action Guidelines on Environmental Protection, 1993*

1. We will make efforts to protect the global-scale environment as well as local environment by cleaner and more highly efficient thermal power plants, greater utilization of water resources in hydroelectric power plants, and safe development of nuclear power plants. We will also develop new technologies to utilize renewable and other unutilized energy sources.
2. We will respect natural environments and local communities, and build and operate power plants in harmony with surrounding natural environments and local communities.
3. We will make efforts not only in power generation and transmission but also in every business field to eliminate all possible waste, and to achieve effective use and recycling of natural resources.
4. Every employee in the company will be aware of environmental concerns of everyday work, and will act as a local citizen and a global citizen, coping with everyday-life environmental concerns.
5. We will cooperate with every country in the world to develop new technologies for effective energy utilization and environmental protection.
6. We will team with local citizens to consider energy and environmental problems.

Source: Electric Power Development Company (1993).

Following is a description of the process leading up to the construction of the Isogo thermal power plant; the focus is on environmental concerns. As noted earlier, environmental problems had become by this stage a significant social issue with residents and local communities staunchly opposing expansion plans for factories and power plants. In this social context, the Yokohama municipal government commissioned four local academics to examine pollution prevention measures for the nearly completed Negishi Bay coastal industrial zone. They made the following nine recommendations to the Yokohama government:

- That the municipal authorities should review their industrial location and town planning schemes;
- That it would be desirable to have the Isogo power plant site relocated;
- That it would be desirable to reinforce the pollution supervisory network;
- That the health care system for residents should be intensified and additional emergency facilities established;
- That the municipal government should establish its own set of pollution prevention standards and intensify government guidance;
- That the organization of the Yokohama pollution control administration should be reinforced;
- That it would be desirable for pollution research centers to be established to enhance basic and applied research on pollution control;
- That the municipal authorities should actively speak out against the pollution responses of the national government; and
- That the municipal authorities should adhere to a set of "open information principles" relating to pollution problems.

These recommendations were later included in the pollution policy of the Yokohama municipal government. Consequently, EPDC's Isogo thermal power plant provided the first example in Japan of a full-scale pollution prevention agreement. The Yokohama municipal government demanded that EPDC conform with its pollution prevention measures. EPDC tried to reassure the municipal government, municipal assembly, and local residents' groups of the ecological soundness of the power plant. It documented the Wakamatsu thermal power plant's realization of a 98 percent particulate extraction rate in actual operation and the results of wind tunnel experiments at the Mitsubishi Heavy Industries Nagasaki shipyard. Despite these efforts by EPDC to alleviate concerns, the municipal government maintained its cautious stance and brought the matter up for deliberation with the Anti-pollution Measure Council. The Yokohama government went on to lobby the Ministry of International Trade and Industry (MITI) to have stringent national-level guidance and supervision of the pollution prevention measures imposed on the Isogo thermal power plant, and to make budgetary provisions for investment in antipollution facilities. The MITI responded by saying that it would take steps to comply with the basic demands of the Yokohama government.

The Yokohama government later presented EPDC with a fourteen-point set of antipollution measures, including requirements that the smoke stacks be 120 meters tall, that a high-grade dust catcher of at least 98 percent efficiency be used to keep ash and soot below $0.6g/Nm^3$, and that low-sulfur coal be used at all times and the output concentration of sulfurous gas be no greater than 500 parts per million. EPDC immediately indicated that it would comply with these measures and committed itself to the construction of the Isogo power plant.

The company's full acceptance of the Yokohama municipal government's demands was significant in two respects. First, it made the Yokohama government the pioneer of antipollution policy. Following this success, the Yokohama government enforced a series of similar pollution prevention provisions for companies setting up operations in the Negishi Bay industrial zone.

This style of administration came to be known as the "Yokohama method" and was propagated throughout Japan to all local governments. It later contributed to the national government's *Basic Law for Environmental Pollution Control*.

Second, EPDC gained self-assurance in the application of measures to fight pollution. Although the antipollution movement would not gain national momentum until later, EPDC's ability to comply with what were at the time inconceivably strict provisions gave it confidence to go on and gain a solid local reputation for antipollution measures.

THE ADVANTAGES OF VOLUNTARY AGREEMENTS. Voluntary agreements on pollution control between individual plants and local governments have numerous advantages. First, the local government can set standards that are severer than laws based on consensus among related parties. Second, unlike nationwide laws that are uniform, voluntary agreements can reflect the geographical and social conditions of a particular area. In the Yokohama case, Yokohama City belongs to the Tokyo metropolitan area; it serves as a major residential as well as commercial area. The industrial zone is nearby. Therefore, the concentration of factories in a small area, combined with other sources of urban pollution such as exhausted gas from automobiles, necessitates stricter environmental controls than the national standard in order to protect the health of citizens. Third, voluntary agreements are a very effective means of controlling and supervising pollution sources. The targeted level of each pollutant can vary from plant to plant depending on technical conditions and the nature of facilities. The company and the local government negotiate a target that is technically feasible. In this case, a study was carried out by a group of academics, and the agreement was made based on the results of the study. Fourth, as local residents' concerns about the environment have grown, voluntary agreements can improve corporate images and relationships with local communities.

TIGHTER GOVERNMENT STANDARDS. In 1971 the Environment Agency was formed, signifying tighter government control over environmental protection. The agency's aim was to accelerate antipollution measures centering around fourteen pollution-related statutes. This policy was aided by the ruling in the 1972 Yokkaichi pollution case. The health risks associated with sulfur oxides (SO_x) were recognized, giving a considerable boost to public support for strict regulation of air pollutants.

Within this social context, the Environment Agency revised the emissions standards for sulfur oxides in 1973, from the original maximum daily average of 0.05 parts per million to a maximum daily average of 0.04 ppm. It incrementally imposed k-value regulations, which set output values based on the height of stacks and other parameters of factories and power plants. There was a gradual tightening of the standards to achieve the mandated level of air quality. During this process, it became apparent that imposing emissions regulations on individual polluting sources would not adequately maintain environmental quality in areas with concentrated industry. This led to the introduction of an areawide pollutant load control system as part of the 1974 amendment of the Clean Air Act.

EPDC'S FLUE GAS DESULFURIZATION UNITS. In 1973 EPDC decided to fit three thermal power plants with five flue gas desulfurization units (FGDs), a technology it had been developing for some time. It then petitioned the government for aid, arguing that in an industry that already required high levels of capital investment, the installation of such devices pushed electric utility companies beyond workable economic bounds. The government responded with three alternative financial aid plans for the installation of FGDs: capital subscription for the construction of desulfurization units; lump-sum subsidies for desulfurization unit construction; and annual subsidies for the operation of desulfurization units. The latter was adopted as the main aid type. It was also decided that operating costs for desulfurization units should be incorporated into electricity charges, thus providing electricity utility companies with an avenue to recompense their additional outlays. The advent of FGDs inflated the cost of power generation an estimated 17 percent, but government subsidy receipts kept the final increase to the power companies down to 11 percent, which was directly recouped through an increase in electricity tariffs.

The subsidy for this expensive pollution control equipment was introduced at a very early stage. As a large consumer of domestic coal, EPDC had been encouraged to use coal even though it contains a higher percentage of sulfur than does other fossil fuels. EPDC was obliged to install desulfurization units before its competitors, who were shifting to oil, did. A new technology is usually expensive in terms of investment and operational costs, and initial government support is needed to develop know-how and demonstrate success before the technology, which does not contribute to profit, can become widely used. Having recognized its necessity, the government decided to support EPDC's introduction of the FGD technology from the United States as a test case. Once a technology becomes well established, the subsidy is abolished based on the polluter pays principle (PPP), and the cost of such equipment is born partly by the company and partly by consumers of electricity.

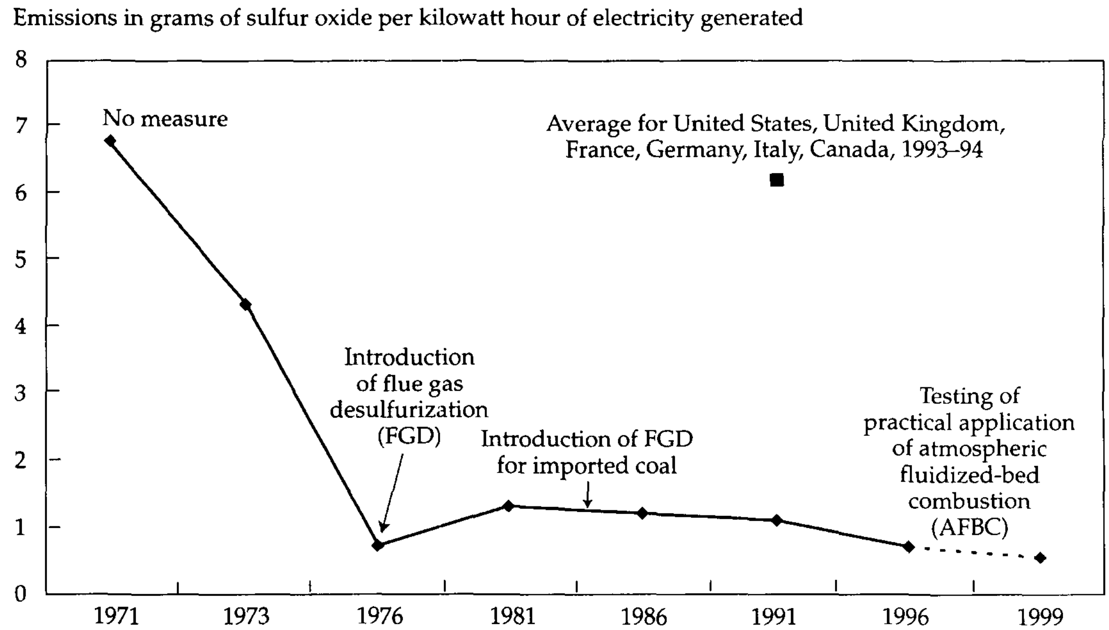
EPDC utilized a full-flow FGD method known as the "wet lime-gypsum process." Positioning the desulfurization units within the confined surroundings of the power plants presented considerable difficulties, since coal-fired power generation, by nature, involves large-scale facilities. In the Isogo power plant, part of the coal yard was given up to house the desulfurization unit common to turbines 1 and 2; for optimal use of the space, the gas ducts were vertically separated into three levels. The construction of the absorption tower was so complicated and elaborate that the president of a U.S.-based chemical company is said to have commented, "this is a jigsaw puzzle, magic, the hand of god!" Later, on an inspection tour in 1981, an executive of the U.S. Environmental Protection Agency (EPA) praised the desulfurization technology in the highest terms, describing the Isogo plant as "the world's best anti-pollution facility."

Figures 5-4 and 5-5 indicate changes in outputs of SO_x and NO_x from EPDC power plants per unit of power generated. The effectiveness of the environmental provisions adopted by EPDC, even when compared with those used in other developed nations, is clearly superior.

OTHER ENVIRONMENT-FRIENDLY TECHNOLOGIES. Without EPDC's longstanding efforts to develop new technology, the construction of coal-fired power plants compatible with stricter environmental control standards would have been difficult. The company, with government financial aid, has been developing full-scale flue gas denitrification facilities for coal-fired power plants at Takehara Plant No. 1 since the 1970s. EPDC was one of the pioneers in this development field, and its first flue gas denitrification facilities were installed in a commercial plant in 1982. The technique spread not only in Japan but to Europe and to other countries. EPDC's overseas technical cooperation projects flourished. Use of flue gas denitrification facilities by Power Plant Dürunrohr in Austria in 1983 was particularly noteworthy because EPDC's environmental measures received high acclaim from the developed world. Denitrification and desulfurization facilities now have become standard for coal-fired power plants in many countries.

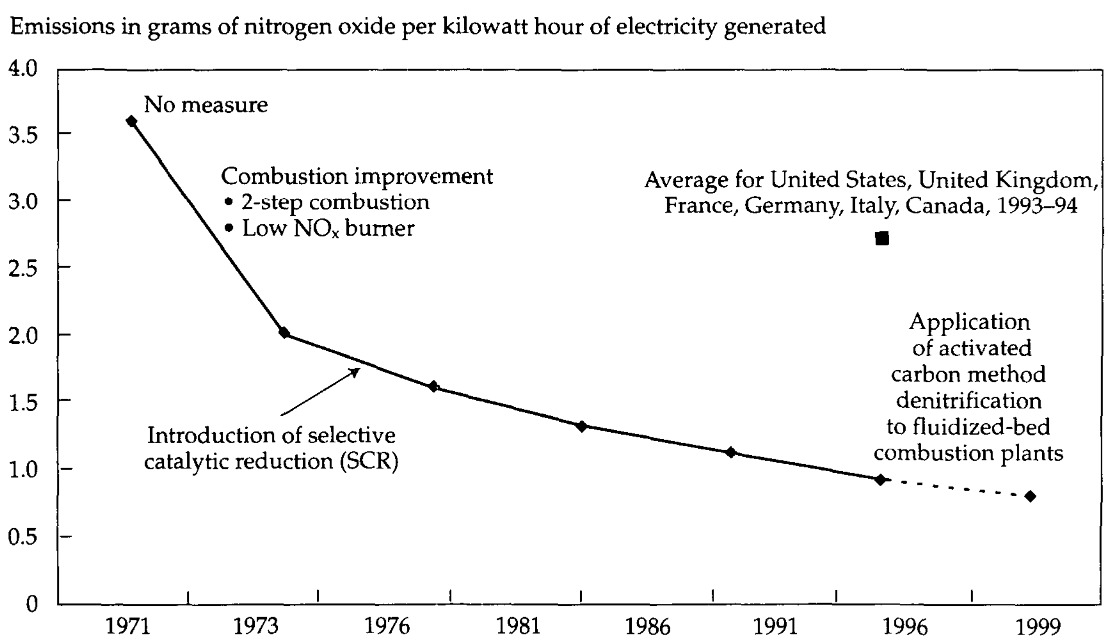
The company also has been developing new problem-solving techniques that respond to modern needs. One of these is the dry activated carbon method, a simultaneous desulfurization and denitrification technology that EPDC has been developing for more than twenty years with financial aid from the government. The technique not only offers advanced desulfurization and denitrification, but also effectively treats trace substances for which tougher controls are expected to be enacted in the future. The technique has been demonstrated and adopted in EPDC's Takehara Plant No. 2 for desulfurization. It has several advantages: it requires only small amounts of water; it requires less energy to operate because large auxiliary machines such as slurry pumps are

Figure 5-4. *SO_x Reductions by the Electric Power Development Company, 1971–99*



Source: Electric Power Development Company (1998a).

Figure 5-5. *NO_x Reductions by the Electric Power Development Company, 1971–99*



Source: Electric Power Development Company (1998a) not needed; and denitrification performance is more stable because the technique reuses activated carbon in cycles. The technique is attracting the attention of many urban area plants as an advanced environmental measure, and it may also be applied to emissions treatment for refuse derived fuel (RDF) thermal power plants where proper treatment for heavy metals, dioxins, and other substances is needed.

As mentioned earlier, many of the environment-friendly R&D activities of EPDC have received government support. The government has established two special accounts to provide funding for the power utility industry: the Special Account for Coal, Oil and Energy Demand Structure Adjustment Measures and the Special Account for Electric Power Development Promotion Measures. The sources of funds for the former are energy taxes and taxes on various fossil fuels such as coal, crude oil, gasoline, LPG, and LNG. The revenue for the latter comes from an electricity tax, which is explicitly included in electricity prices. Neither account is dedicated exclusively to environmental measures as their names might imply: however, considerable amounts are allocated to R&D for pollution control technology, energy-saving technology, and new energy development. Indeed, new initiatives on clean energy development have been implemented under partnerships between the public and private sectors. In order to provide stable financial resources for these programs, a part of the taxes on oil and electricity sales is earmarked for the Special Accounts.

The support for R&D projects can take these forms: direct subsidy for the R&D project of an individual company; contract research from the Ministry of International Trade and Industry and the New Energy Development Organization, a government-funded research organization; joint research with NEDO; and government participation in power companies' joint research projects.

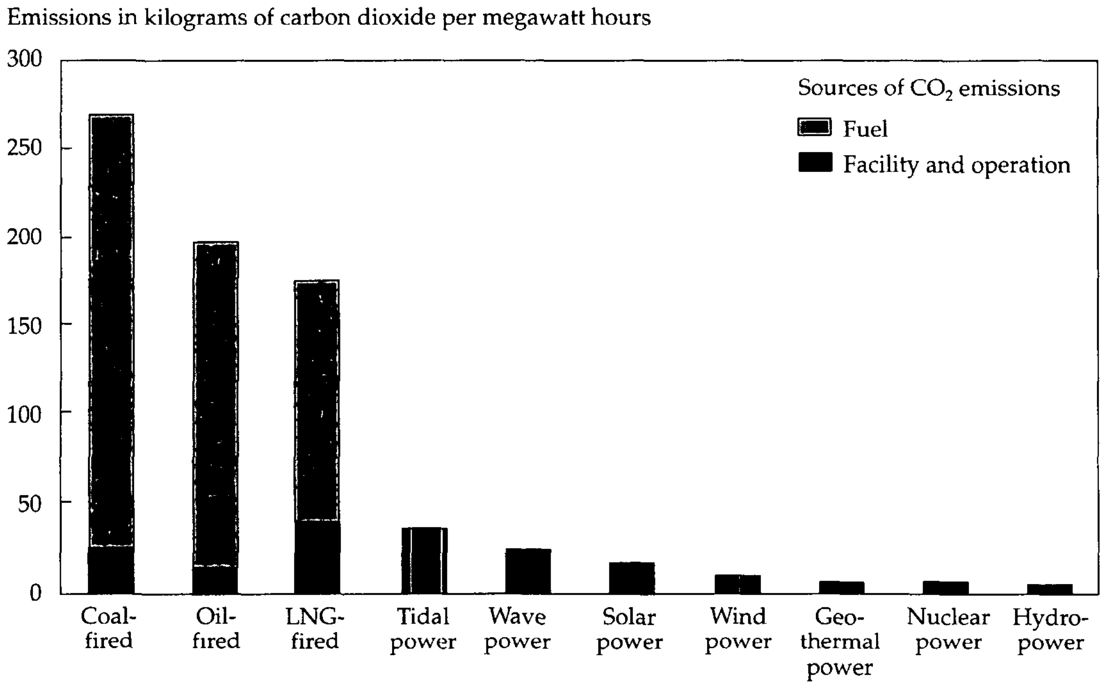
Efforts to Reduce CO_2 Emissions

Carbon dioxide emissions involved in power generation come from many sources. In addition to fuel combustion in thermal power plants, sources include (i) construction of mining and transportation equipment, fuel refining facilities, and power plants; and (ii) operation of equipment and facilities. Figure 5-6 shows that the emissions of coal-fired power plants (270 kilograms of carbon per megawatt hour) are remarkably high compared to other power sources. However, coal supply and price are stable, thanks to immense deposits and widespread distribution. Therefore, coal is still an important energy source for the world, especially for developing countries such as China with large domestic reserves of coal.

IMPROVEMENT IN EFFICIENCY IN THERMAL POWER PLANTS. In Japan, CO_2 emissions reductions by the Electric Power Development Company were an unintentional result of its attempts to save energy. CO_2 emissions levels are directly correlated with the consumption of fossil fuels. Efforts to improve thermal efficiency during the oil crises of the 1970s resulted in a large reduction in the CO_2 emissions rate. Initially, the motivation for thermal efficiency improvement was provided by the hike in energy prices, but even after the prices stabilized, the importance of thermal efficiency improvement technology was recognized because of the global warming issue and the growing awareness of the need to reduce CO_2 emissions. CO_2 reduction through improved plant efficiency can be economically beneficial and thus compatible with economic growth; therefore, it is a realistic and effective way of coping with the global warming problem because it can be carried out in developed and developing countries.

The EPDC diligently introduced the best available technologies and actively involved itself in R&D for thermal efficiency improvement. These efforts have placed its achievement at the forefront of the world. Improved plant efficiency reduces CO_2 emissions per unit of energy by using less fuel. EPDC is promoting the pressurized fluidized-bed boiler combustion (PFBC) method;

Figure 5-6. *CO_2 Emissions by Power Sources in Japan*



Source: Central Research Institute of the Electric Power Industry.

the target is a plant efficiency of 42 percent (Table 5-4). If this efficiency is realized, the company's CO_2 emissions per one kilowatt hour will be reduced by about 10 percent.

The pulverized coal-fired generation system prevails in Japan as the established method of coal-fired generation. In this system steam generated by the burning of pulverized coal in a boiler drives a turbine. Higher pressure and temperature increase the thermal efficiency and therefore reduce fuel consumption. The history of coal-fired power generation has been a history of efforts to increase the scale of the boiler and turbine in order to raise the thermal efficiency by attaining higher steam pressure and temperature. A supercritical unit of 24 Mpa (Mega pascals) in pressure and 538/566 in temperature was introduced in the 1960s. After the oil crisis, development started on an ultrasupercritical unit with higher thermal efficiency. Currently, R&D is being conducted for the purpose of achieving a steam temperature of 630 degrees C.

As a new approach, EPDC is developing a power generation system that combines steam and gas turbines. Current mainstream technologies in combined power generation use liquefied natural gas as fuel. To diversify power sources, EPDC is developing coal-using combined power generation forms such as the pressurized fluidized-bed combustion (Box 5-3) and integrated coal gasification combined cycle (Box 5-4). Compared with the traditional pulverized coal thermal generation, PFBC will improve relative efficiency by about 10 percent. It performs desulfurization inside the boiler and restrains NO_x emissions, thus helping protect the surrounding environment. PFBC, in the demonstration stage at the Wakamatsu Power Plant, is being commercialized in other plants in Japan. IGCC is being tested at a pilot plant, and if the system is put into practice, thermal efficiency is expected to be even higher. EPDC has pioneered these technologies with financial assistance from the government.

Table 5-4. Thermal Efficiency and CO_2 Emissions of Coal-fired Power Generation

Power generation system	*Net thermal efficiency (%)*	*CO_2 emissions (kg-C/kWh)*
Pulverized coal-fired (China)	28	0.4
Pulverized coal-fired (EPDC, Isogo plant)	36	0.31
Pulverized coal-fired (EPDC, Matsuura plant)	38	0.28
Pressurized fluidized-bed combustion combined cycle	42	0.25
Integrated coal gasification combined cycle	44	0.23
Molten carbonate fuel cells	50	0.20

Source: Electric Power Development Company (1998a).

IMPROVEMENT IN OPERATIONS AND MAINTENANCE. Introduction of efficient plants will improve thermal efficiency drastically but large amounts of investment are required. It is probably easier to wait to introduce new technology at times of new construction or major expansion, while in the meantime improving the operational or management aspects of the existing plants.

In operating power facilities, efficiency varies with the operator. In coal-fired power plants, differences in the skills of the operator lead to (small) differences in combustion efficiency, steam volume, and power used in the plant, thus affecting the efficiency of the whole plant. EPDC, which strives "never to waste even one grain of coal," is raising the efficiency of each plant to the limit. It has been trying to improve the skills of its operators so that they can always achieve optimum operation. The company also has been improving peripheral equipment such as measuring and data processing devices so that operators can make the best decisions by grasping the current operating status (such as the numbers of mills, pumps, and fans used; the condition of the

Box 5-3. *Pressurized Fluidized-bed Boiler Combined Cycle*

The Electric Power Development Company began to develop atmospheric fluidized-bed combustion (AFBC) technology in 1981 using a national government grant. Fluidized-bed combustion technology burns pulverized coal on a fluidized bed. Since limestone is used as the fluidized bed material, the AFBC system removes SO_x within the combustion process and thus does not require a flue gas desulfurization unit. Other major strengths of AFBC are more adaptability to different kinds of coal, occupation of less space because the FGD unit is not needed, and generation of less NO_x since the combustion temperature is lower.

EPDC has built on the technological base developed in Sweden and other countries with new, home-grown Japanese technologies (for example, ceramic filters that improve the reliability of the gas turbine, and use of the PFBC system in combination with ultra-high-temperature steam turbines (USC-T) to improve efficiency. The results were first embodied in the Wakamatsu 50 megawatt AFBC/USC-T demonstration plant. With the conclusion of demonstration testing at Wakamatsu, work began on a 70 megawatt PFBC combined-cycle power plant in April 1992.

PFBC enhances the basic strengths of AFBC. Pressurized combustion is more economic on the whole, since facilities can be more compact and construction periods shorter. It is also more efficient since it is suitable for combined-cycle power generation, in which gas turbines powered by high-temperature, high-pressure combustion exhaust gas are used in conjunction with steam turbines to generate electricity. PFBC technology is one of the most promising means of reducing carbon dioxide emissions, a significant cause of global warming.

Source: Electric Power Development Company (1998b).

Box 5-4. *Integrated Coal Gasification Combined Cycle*

The idea behind integrated coal gasification combined-cycle (IGCC) power generation is to create fuel gas from coal that can be burned to turn gas turbines. It offers vast improvements over the heat efficiency limitations of conventional coal-fired power plants. Indeed, the system promises high efficiency even with small-capacity units. As gas turbines achieve higher temperatures and better performance in the future, further gains in heat efficiency can be expected. Coal gasification also has the advantage of limiting the output of carbon dioxide gas.

When coal is gasified, either in the air or in a combination of oxygen-based oxidants and steam, it generates a gas composed primarily of flammable hydrogen and carbon monoxide. In a combined-cycle generation system, this gas is fed into the combustor of the gas turbine, where it is burned, generating heat to drive the turbine and produce electricity. The heat of the turbine's exhaust gases can also be used by heat recovery boilers to turn water into steam that will drive a turbine, generating more electricity.

The Electric Power Development Company has been an active participant in projects sponsored by the national government and the New Energy Development Organization. The development of practical IGCC technology will be a priority.

Source: Electric Power Development Company (1998b).

burning coal; and the adherence of ash to coal) more quickly, precisely, and easily. EPDC also periodically overhauls and repairs its facilities to maintain optimal conditions.

Other Efforts

EPDC is also seriously engaged in the development of renewable energy and unused energy; this includes more effective use of water resources in hydroelectric plants, development of safer nuclear power plants (in Aomori prefecture a nuclear plant is being constructed), and use of natural energy. Geothermal power generation is now economically feasible, and power generation using refuse derived fuel (RDF) technology is being applied in commercial endeavors.

An alternative solution to the global warming problem would be to collect and treat the CO_2 in flue gas rather than restraining overall emissions levels. The huge amounts of energy required to do this have made implementation of this alternative infeasible. Some technological breakthroughs are needed. EPDC has already started research on development of a CO_2 solidification technique.

Coal ash generated by coal-fired power plants has been used in cement and fertilizers. Usage for ground reinforcement material, fly ash cement, and building materials is promoted. By 1996 more than 60 percent of the coal ash being generated at EPDC plants was recycled.

International Cooperation

As one of the most technologically advanced countries in the world, Japan has an obligation to provide technical assistance to developing countries. EPDC has, at the request of central and local governments, cooperated on generation and transmission projects around the world, earning in the process a reputation for reliability and excellence. The company had completed 150 projects in 45 countries around the world as of March 1998. These projects include hydroelectric and thermal power development and related research, and environment-related technology transfer in areas such as SO_x and NO_x reduction. It has sent 174 experts to 29 countries and accepted 1,775 trainees from foreign governments and electric power companies.

As China and Southeast Asia industrialize, their energy consumption will increase rapidly. Because the ratio of coal consumption to primary energy consumption is relatively high and their coal contains a relatively high percentage of sulfur (2 to 3 percent compared with 1 percent in Japan), the environment is likely to deteriorate rapidly. MITI drew up a "Green Aid Program" to encourage the use of low-cost, simple desulfurization systems based on Japan's advanced techniques for protecting the environment. In this program EPDC is sharing its technical development expertise.

In the future EPDC plans to provide a more comprehensive international cooperation program that uses its experiences in hydroelectric, coal-fired, and geothermal power development and transmission projects. It wishes to make such projects more sound by providing assistance in project management know-how, engineering, and operational maintenance.

Cost and Effectiveness of Thermal Efficiency Technology

There are many ways to improve the thermal efficiency of coal-fired power plants. Plants can be replaced, depleted equipment can be rehabilitated, auxiliary equipment can be introduced, and operation and management can be improved.

Plant Replacement

Replacing subcritical coal-fired power plants, which continue to be built in most non-OECD countries, with supercritical (SC) or ultrasupercritical (USC) plants will improve thermal efficiency substantially. According to the study by the Coal Industry Advisory Board of the International Energy Agency, SC plant efficiency is about 3 percentage points higher than subcritical plants, and USC plant efficiency is about 7 percentage points higher (Figure 5-7).

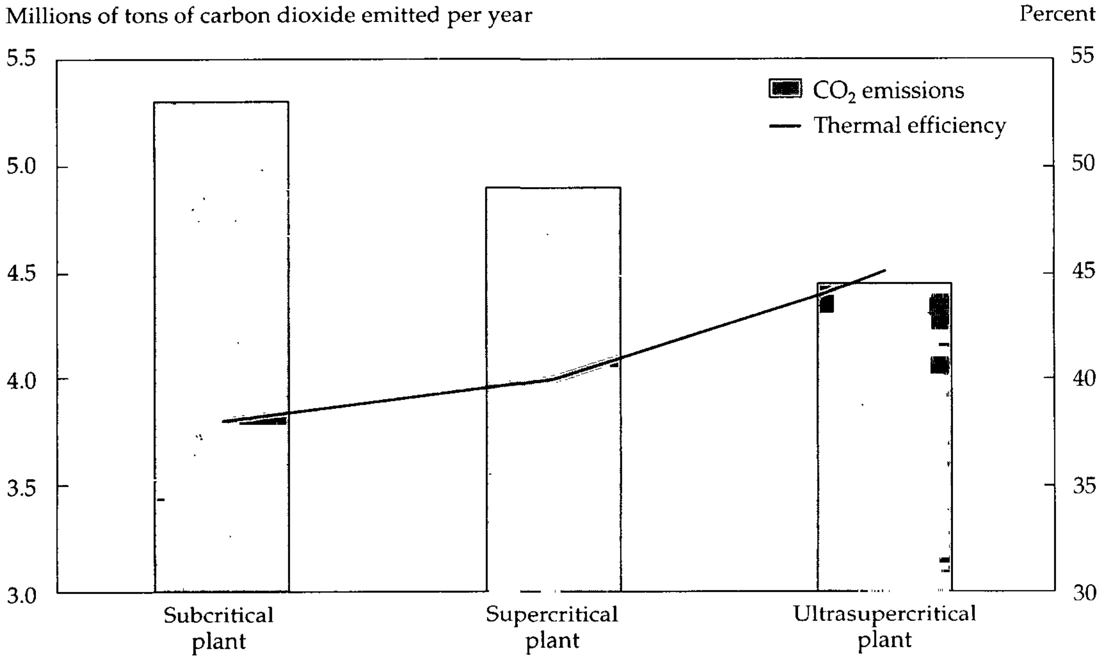
Supercritical and ultrasupercritical plants cost just as much as subcritical plants, but their lower fuel costs will result in total cost reduction per kilowatt hour of electricity generation compared with subcritical plants. Thus, investment in SC or USC plants is commercially feasible and profitable, while reducing emissions of both CO_2 and air pollutants. SC plants have been built and operated in hundreds of places, and this technology has already been proven.

Maintenance

Table 5-5 describes thermal efficiency enhancements and reductions in CO_2 emissions through power plant retrofitting. We assume a 300 megawatt subcritical plant with steam pressure of $169 kg/cm^2$ and main and reheated steam temperature of 566 degrees C, which is widely used in developing countries. Because the initial condition of the equipment, installation costs, and the prices and quality of fuel differ from country to country, it is difficult to directly apply these calculations to a specific plant. Proper consideration of target efficiency enhancement figures based on a study of the actual status of the plant would make it possible to propose the optimal set of modifications, both in terms of cost and environment, and produce a plan many times more attractive to the power plant owner. Generally speaking, these plant modifications are one of the possible options for plants already in operation, for they require less initial investment, and if the current design and status of the plant are properly diagnosed and an optimal plan is implemented, they could be very cost effective.

Since the calculations in Table 5-5 are based on Australian coal, the calorific value and carbon content per unit will differ greatly from those of lower grade coals. Assuming that average grade

Figure 5-7. Thermal Efficiency of Subcritical, Supercritical, and Ultrasupercritical Coal-Fired Power Plants



Source: IEA Coal Industry Advisory Board.

bituminous coal is used, an increase in relative plant efficiency of 1 percent or more should facilitate a 8.5g/kW reduction in CO_2 output for a 300MW-class coal-fired power plant. Assuming that the power plant runs at an average annual capacity of 70 percent, this correlates to an annual reduction in CO_2 emissions of 15,640 tons, and a 5,700 ton per year reduction in coal consumption. Given that the coal price in Japan is about 5,000 yen per ton at CIF prices, the annual savings in fuel cost works out at 28.5 million yen.

If a power plant were retrofitted as detailed in Table 5-5, it would take almost twenty years to recover the cost of facility modifications through savings in fuel costs, making the modifications somewhat less than economical. However, in terms of the effectiveness of the modifications in reducing CO_2, NO_x, and SO_x emissions, while it is not possible to perform a cost conversion, the cost outlay would generate a more significant benefit than the figures suggest, and on a national level, investment effectiveness would certainly be achieved.

Note that since the modification costs have been calculated based on Japanese prices, they are slightly inflated compared with what they would be if the same investment took place in a developing country. It should be possible to implement the same modifications at lower cost in a developing country because of cheaper local labor costs and other factors.

Cost and Effectiveness of Pollution Control Equipment

Examples of air pollution control equipment are selective catalytic reduction (SCR) systems, flue gas desulfurization (FGD) units, and electrostatic precipitators (ESP). Table 5-6 shows the relative cost of pollution control devices to total plant cost at a coal-fired power plant in Japan. The

Table 5-5. Thermal Efficiency Enhancements and the Associated Cost

Equipment	Retrofitting activity	Relative increase in thermal efficiency (%)	Cost[a] (yen/kW)
Boiler	Modify boiler structure & burner	0.2 to 0.4	4,100
	Increase the number of soot blowers	0.1 (approx.)	200
Turbine	Replace the steam passage parts	3 to 4	3,000
Auxiliary equipment	Install gas recirculating fan	0.1 to 0.3	150
	Recovery in degree of vacuum	0.7 to 1.3	400
	Axial flow FDF	—[b]	600[c]
Combined effect		4.1 to 6.1	8,450[d]

a. Prices in Japan.
b. Effective for partial load. The power required for medium loads is half that of centrifugal FDF.
c Includes installation cost.
d. Combined installation cost is 5000 yen/kW.
Source: Electric Power Development Company.

emissions level at the flue top, with only a dust precipitator, would be 1,000 parts per million for sulfur oxide, 300 to 600 ppm for nitrogen oxide, and 10 to 30g/m^{3}N for soot and dust. Dust is reduced to 300 milligrams per cubic meter of nitrogen (mg/m^{3}N) by an electrostatic precipitator with a removal rate of 99 percent, and to 30mg/m^{3}N through the dust removal effect of a wet-type flue gas desulfurization unit. With a wet-type FGD unit, SO_x emission will be reduced by as much as 90 percent to 100 ppm. With some additional improvement of peripheral equipment, it could be reduced to 50 ppm for SO_x and 10mg/m^{3}N for soot and dust. As for NO_x emission, it can reduce to 150 to 200 ppm through combustion improvement provided by low NO_x burners and two-step combustion. Selective catalytic reduction is used in combination with this equipment. NO_x emissions would be reduced to 45 to 60 ppm with the combination.

Table 5-6. Cost Composition of Pollution Control Environmental Equipment at a Coal-Fired Power Plant

Equipment	Effect of equipment before/after use	Cost composition of equipment as a percentage of the total plant cost
Wet-type limestone-gypsum desulfurization unit	1,000/50ppm	10.5
Denitrification device (dry-type ammonia selective catalytic reducer method)	300–600/45ppm	3.0
Combustion improvement (Low-NO_x burner)	300–600/150–200ppm	0.6
Wastewater treatment equipment		2.2
Electric dust precipitator	10,000–30,000/300mg/m^{3}N	3.1
Major equipment of plant		80.6

Implications for Developing Countries' Energy and Environmental Policies

Most of the measures to control pollution that can be taken at power plants are end-of-pipe technologies, and they bear certain additional costs for the power producer. In principle, the pollution control cost should be reflected in higher electricity rates because environmental pollution is a negative externality of power generation operations that needs to be internalized. However, since electricity is essential in industry and people's daily lives, too steep a rise in price might result in adjustment costs that are unacceptably high, both politically and socially. In Japan's case, government subsidy was introduced to mitigate the sudden hike in the price of electricity.

Despite strict environmental standards, the Electric Power Development Company managed to limit the electricity price hike to only 11 percent due to its own cost reduction efforts and government aid. Note that the government measures were just for a smooth transition and were gradually abolished. The ultimate goal of optimal resource use requires that power producers and consumers eventually bear the entire environmental cost of electricity.

In order to internalize the cost of environmental conservation, it is necessary to set environmental standards and effectively enforce them. But in many developing countries, monitoring and enforcement of the standards are reported to be problematic. In EPDC's case, the local community had become more conscious of the environment and was demanding strict environmental standards. Strong pressure from local government and the support of the residents greatly influenced the setting of standards and their enforcement. Considering the importance of community relations to EPDC, voluntary agreement was as important as legal requirements. Pressure from local government and the residents was effective not only initially but also at the monitoring stage. Since the local community had strong interests and relatively abundant information on technology and on the company's environmental data, it could effectively monitor EPDC.

The Japanese government is extensively involved in environment-friendly technology development. Clean coal technology plays an indispensable role in EPDC's ability to control pollution and reduce CO_2 emissions without harming production. But commitment to cutting-edge technology development is very costly and risky for a private company. The Japanese Ministry of International Trade and Industry conducted large-scale research on these technologies and acted as a sponsor and coordinator of research among private companies in order to mitigate the risk and financial constraints. The basic idea of Japan's environmental standard setting is that it should be based on the "best available technology." At the same time the government is investing heavily in raising the level of "the best available technology" to achieve desirable environmental standards. EPDC has developed pollution control technology and improved efficiency while funding R&D. Joint research among companies in the power utility sector or with the government is cost effective and becoming more common.

CO_2 emissions cannot be avoided in the coal-fired power generation process, but by correlating it to fuel cost, it is possible to simultaneously pursue profit maximization and CO_2 reduction. For this incentive to be effective, fuel price must be above a certain level. The EPDC's efficiency enhancement efforts saw major progress after the oil crisis. The fuel price hike and the fear of continuous price increases provided strong incentive for active involvement in R&D, and the company achieved the world's highest level of clean coal technology in the process of pursuing thermal efficiency.

It is important to note that in Japan, while government regulates electricity and gas rates for consumers (based on the cost of generation or supply, plus a fair return to suppliers), there is no intervention on oil input prices, except for the taxes earmarking funds for the special energy accounts. By contrast, in many developing countries, energy price is kept unreasonably low under some form of government intervention either by direct control or subsidy provision. As a result, an electric power company is not likely to recover any investment in energy-saving equipment through fuel cost reduction. Supporting the introduction of proven efficiency enhancing technology such as supercritical plants, along with changes in energy pricing policy, will be beneficial for both CO_2 reduction and long-run national economic development.

References

Electric Power Development Company. 1993. *EPDC's Environmental Measures: In Pursuit of Energy Security and Environmental Conservation* (in Japanese). Tokyo.

———. 1998a. *EPDC Environmental Action Report* (in Japanese). Tokyo.

———. 1998b. "Thermal Power Generation Technology." *Research Report,* vol. 100 (in Japanese). Tokyo.

International Energy Agency. 1998. *World Energy Outlook.* Paris: OECD.

———. Coal Industry Advisory Board. 1998. *Regional Trends in Energy-Efficient, Coal-Fired, Power Generation Technologies.* Paris: OECD.

Japan Federation of Electric Power Companies. 1996a. *Electricity Industry Handbook for Japan.* Tokyo.

———. 1996b. *Overseas Electricity Industry Statistics.* Tokyo.

———. 1997. *Energy and the Environment.* Tokyo.

OECD. 1998. *Energy Balances, 1995–96.* Paris.

Takagi, Shintaro, and Toshinori Kojima. 1998. *Energy and the Environment* (in Japanese). Tokyo: Federation of Electric Power Companies.

Takahashi, Masaki. 1998. "Technologies for Reducing Emissions in Coal-Fired Power Plants." *Energy Issues,* no. 14. Washington, D.C.: World Bank.

6

Reforestation of an Indonesian Tropical Forest: The Win-Win Approach of a Private Japanese Firm

Noriyuki Kobayashi
Hiroyuki Kato

Forests provide a variety of products and services. The raw materials for housing and many products made out of wood are extracted from the forest. In many parts of the world, wood is an important fuel. Paper products are derived from wood fiber. Trees cleanse the air by absorbing carbon dioxide and adding oxygen. Forests provide shelter and sanctuary for wildlife, and play an important role in the ecology of watersheds that supply much of our drinking water.

The dramatic growth in the world's population, from 3 billion in 1960 to around 6 billion today, has greatly affected forestry, particularly in developing countries. The growing population's need for greater food supply has led to a massive increase in cropland. By the early 1990s, almost 40 percent of the earth's land surface had been converted to cropland and permanent pasture, largely at the expense of forests and grassland (World Resources Institute, 1997, p. 201). Furthermore, since per capita consumption of industrial forest products is responsive to income change at low levels of income, the economic growth in developing countries and transition economies intensifies the competitive situation between demand for commercial logging and that for agricultural use. Poor enforcement of property rights and frequent forest fires are other factors that exacerbate the situation.

Due to these pressures from population and economic growth, deforestation is proceeding at an unprecedented rate. Since a large proportion of the poor in developing countries live near forests and are dependent on their resources, deforestation makes it difficult for them to obtain food and fuel. In the western part of Africa, female family members have to commute on foot for several hours to obtain wood for fuel every day. Furthermore, deforestation undermines the environmental functions of forests and intensifies global warming, decreases biodiversity, causes decline in agricultural productivity, and increases soil erosion and desertification.

The challenge is to meet the growing demand for agricultural production and forest products while safeguarding the environmental functions of forests. In this effort we should not and cannot stop commercial logging, conversions of land for agricultural purposes, and the use of wood as fuel wood per se. Rather, appropriate forest management, namely sustainable forest management, which incorporates biological as well as social functions of forests, needs to be considered in addition to the purely economic functions.

Forest conservation requires us to confront intractable problems such as overpopulation, economic stagnation, uneven allocation of resources, and poverty. While we are unable to solve all of these problems, pragmatic changes in technology, management, and attitudes will make progress possible. One promising avenue is to help communities in and around the forests develop alternatives to current destructive practices by cultivating extractive products that can be harvested without long-term damage to forest ecosystems. This approach depends on working with and supporting the people who live in the forest and know it best.

The Sumitomo Forestry Company., Ltd., one of Japan's largest forestry firms, operates the Sebulu experimental forest project in the eastern part of Kalimantan, Indonesia. This project's unique approach to reforestation involves not only artificial plantation but also social forestry—resettling of the local people who practice slash-and-burn farming and involving them in reforestation. The goal is to provide income opportunities for local people while replicating the original ecosystem as closely as possible.

Before discussing the Sebulu experimental forest, we explain the functions of tropical forests and current causes of deforestation in Indonesia. The chapter also assesses social forestry, including its economic viability compared with slash-and-burn farming. The required input/output and cost/price data for this analysis were gathered from the existing survey and on-site interviews with farmers. Carbon sequestration from reforestation and research activities in the experimental forest that complement reforestation efforts also are discussed. We conclude this case study by drawing lessons from the Sebulu experimental forest that are applicable to other developing countries.

Forests and the Environment

Forests provide a variety of products and services, only some of which can be expressed in monetary terms. Forests mitigate global warming, conserve the biodiversity of the planet, and protect soil and water resources. These are the most significant benefits of forests, but the environmental functions are also the most difficult to quantify. In this section we discuss the commercial and social functions of forests as well as their environmental benefits.

Commercial Functions

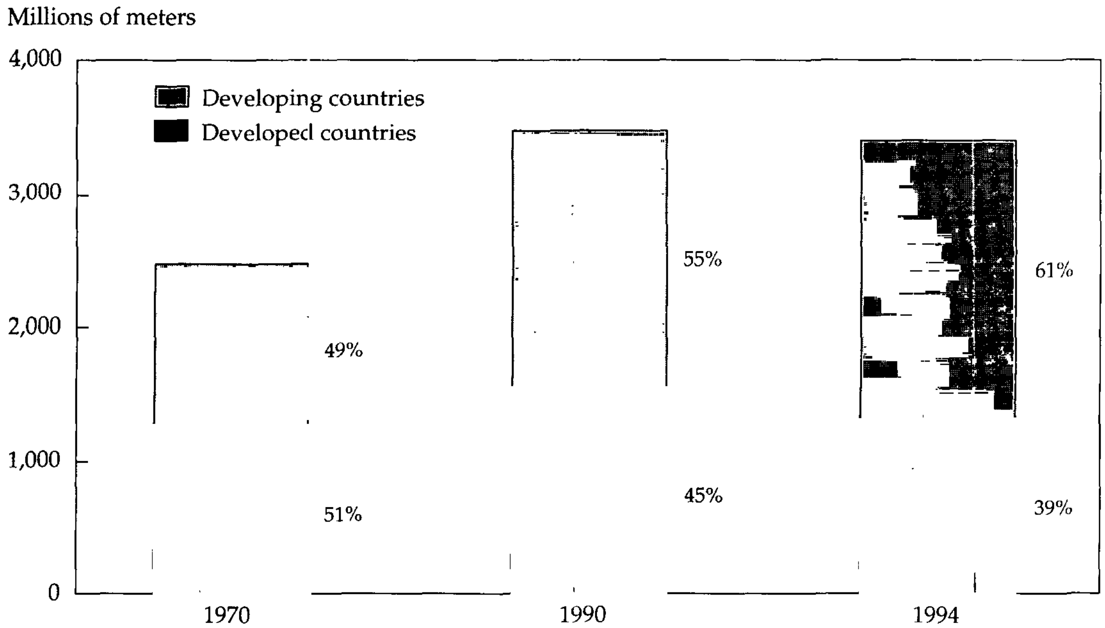
Forest products are major sources of income, foreign exchange, and employment. The Food and Agriculture Organization (1998, p. 35) estimated that in 1997 forestry contributed to 2 percent of GNP and 3 percent of merchandise trade at a global level. Although developed countries contribute more than 80 percent of the world's industrial forest production, it represents only 1 percent of their GNP compared with 4 percent in developing countries. The actual economic value of forests is larger than those numbers imply, since forestry in this context includes only processed products and excludes nonwooden products as well as nonmarketed and intangible functions.

The commercial functions of forests differ from region to region, especially between tropical and nontropical regions. Comparing production and consumption patterns in tropical (mainly developing) countries and nontropical (mainly developed) countries, we find that the nontropical regions accounted for 83 percent of production and consumption of industrial round wood in 1994, and the tropical regions accounted for three-quarters of production and consumption of fuelwood and charcoal. Contrary to the general perception, developed countries are the dominant traders of forest products: 81 percent of total exports and 29 percent of total imports in 1994 (World Resources Institute, 1997).

Yet the share of developing countries in the production of roundwood products increased rapidly between 1970 and 1994 (Figure 6-1), and the relative importance of developed and developing countries in production and consumption of wood forest products is expected to change. For example, two in five people in the world, mostly in developing countries, rely on fuelwood and charcoal as their main sources of domestic energy for cooking and heating. The rapid population increase in developing countries in the 1970s and 1980s raised environmental concerns about the consequences of demand for fuelwood and charcoal: deforestation and desertification.

Forests also provide nonwood forest products. These products include a vast array of animal and plant resources: food such as meats, fruits, nuts, and spices; fibers used in furniture and construction; and plant or animal products for medical and cosmetic uses. They are distinguished from cash crops such as cocoa and rubber, because they are wild or semidomesticated and are

Figure 6-1. Word Production of Roundwood



Source: FAO (1998).

important to the subsistence of the indigenous people living in and around forests. An estimated 80 percent of the population in developing countries depend on nonwood forest products to meet their health and nutritional needs (FAO, 1998, p. 35). In some cases families engage in small-size processing to produce craft goods such as rattan work.

Environmental Functions

As noted earlier, one of the most significant benefits of forests is their ability to mitigate global warming. The earth's mean temperature has increased 0.3 to 0.6 degrees Celsius over the past 100 years. Much of this global warming is believed to be from the increased concentrations of greenhouse gases in the atmosphere. Combustion of fossil fuels by the industrial sector is a major factor in the level of greenhouse gases, followed by deforestation and degradation of forests.[1] In a matter of a few decades, industrialization actually puts back into the atmosphere the equivalent of the carbon that nature had fixed into fossil fuels over the course of millions of years. Climate models project that, if current trends in greenhouse gas emissions continue through 2030, the earth could experience between a 1.5 and 4.5 degree Celsius rise in temperature, which would be comparable to the total warming since the last ice age, 18,000 years ago.

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1. The Food and Agriculture Organization's definition of *deforestation* is depletion of tree crown cover to less than 20 percent for developed countries and 10 percent for developing countries (FAO, 1998, p. 174). Deforestation also includes the conversion of forests to other uses such as cropland and shifting cultivation; forests that have been logged and left to regenerate are not included (World Resources Institute, 1997, p. 203). *Degradation* refers to changes within the forest class that negatively affect the stand or site, lowering the production capacity.

The effects of a rise in global temperature would include a decline in nontropical forests, increases in air pollution, tropical diseases, species extinction, a northward movement of agricultural production, and a rise in sea level by as much as 1.5 meters. Although the best way to reduce greenhouse gas emissions is by controlling the combustion of fossil fuels, forests can mitigate global warming as well.

One hectare of forest can absorb several hundreds of tons of carbon dioxide.[2] Forests also contribute to the purification of the air by acting as a filter of compounds. The surface area of leaves reach 5 to 15 times the land surface area of forests and absorb compounds floating in the air. Carbon dioxide is released into the atmosphere when forests are cleared or degraded or when trees die. If trees are burned, other greenhouse gases, including nitrogen oxide and carbon monoxide, are added to the air as well. Thus deforestation, especially in the tropical regions, eliminates a potentially significant means of ameliorating the rise in carbon dioxide emissions. Tropical forests have the greatest potential for sequestering carbon. It is estimated that through regeneration and reduced deforestation, they could increase the carbon storage capacity in the world's forests by 80 percent (FAO, 1998, p. 42).

The diversity of the forms of life on the planet is diminishing at an unprecedented rate. This extinction of species is an irreversible process, and deforestation is a major source of the extinction, because it destroys the most biologically active habitats. Scientists began warning in the 1980s that one-quarter or even a half of the earth's species could be lost over a few decades, largely from the destruction of tropical forests, which are estimated to host more than 50 percent (at most 90 percent) of the "existing" species. The quantities of bird, fish, plants, and insects that are endemic to the tropical forests are unmatched anywhere else on the planet. Furthermore, tropical forests contribute genetic material that increases the disease resistance of agricultural crops such as coffee and that provide some entirely new foods. However, this genetic diversity in agricultural crops eroded rapidly during the twentieth century because wild strains were lost in the conversion of forest to land. It is also important to note that approximately one-quarter of all prescription drugs include the extract of substances found in tropical plants. Thus deforestation leads to the extinction of some species, the reduction of genetic variation, and lessens the ability of humans to respond to diseases and keep the world's food supply secure from pests and climate change.

Forests protect the productivity of soil. Trees are part of the nitrogen chain, enriching the soil when their residues decompose. Roots of trees absorb nonorganic compounds from the deep soil and release nutrients and improve the soil structure when they decompose into organic compounds that are necessary for plants. Deforestation and overexploitation of forests are major causes of soil degradation and, ultimately, desertification.[3] The impact of deforestation on soil productivity is especially high in the tropical regions; once trees are cut down, the topsoil can easily be washed away during rainy seasons because it is thinner than that of nontropical forests. Strong sunlight accelerates the soil degradation.

Forests serve as watersheds that feed hydroelectric projects and supply water, not only for the communities located around the forests but also for those downstream. Forests are adjustable bulbs for balancing the earth's water table (for example, by reducing floodwater in rainy seasons and by raising the water level of rivers in dry seasons). Maintaining a good forest cover is essential for safeguarding a reliable and clean water supply for downstream agricultural lands. The

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2. Trees release some carbon dioxide as a byproduct of respiration. The extent of net absorption depends on the age and species of the trees: the younger the trees, the larger the net absorption.

3. *Desertification* is defined as land degradation in arid, semi-arid, and dry subhumid areas resulting from various factors including climatic variations and human activities (FAO, 1998, p. 39).

loss of forests not only increases the surface water flows that erode soil and its nutrients, but also changes the amount of water evaporation and rainfall.

Social Functions

The value of forests' social functions, although large, is difficult to estimate. Forests are used for recreational activities such as hunting and bird-watching and sports activities such as hiking and mountain climbing. Their scenery provides immeasurable pleasure. In some cultures forests have spiritual and religious meanings that are specific to the community. Therefore, the degree to which a community is socially attached to the forest will determine the quality-of-life benefits that can be derived. Since these benefits vary between communities, an economic value is difficult to assign to them.

Changes in Forest Cover in Indonesia

The FAO defines developed-country forest area as "land with tree crown cover of more than 20 percent of the area," while for developing countries, it refers to an "ecosystem with a minimum of 10 percent crown cover of trees and/or bamboo, generally associated with wild flora, fauna and natural soil condition, and not subject to agricultural practice." By that definition 3,454 million hectares, which correspond to 26.6 percent of the world's terrestrial surface, were covered by forests in 1995. Developing countries account for 56.8 percent of the world's forests, and tropical forests, nearly all of which are located in developing countries, occupied 1,760 million hectares (FAO, 1998).[4]

Indonesia is a leading country in terms of forested land mass and second only to Brazil in tropical forest area. The total forested land area is 144 million hectares according to government proclamations (110 million according to the FAO). The average annual loss is said to be in the range of 0.9 to 1.3 million hectares. The average annual rate of loss was 1.0 percent during the first half of the 1990s.

The forestry and forest product industries are both key industries in Indonesia with an annual turnover of 13.5 billion U.S. dollars, accounting for 2 percent of Indonesia's GDP. They employ 1.5 million people, which corresponds to 7.5 percent of the total population.

Full-scale development in natural forests on islands such as Kalimantan and Sumatra only began in the 1960s. The history of this development can be divided into three main periods. The first period of natural forest development extended from the 1970s to the early 1980s and was characterized by raw wood exports. A system of forest harvesting concessions was established, and development rights were granted for a series of forest plots. Foreign investment in forest area development was subsequently allowed, leading to involvement by companies from around the world in what came to be known as the "Green Olympics," signifying the commencement of full-scale forest area development.

In the second period of development, from the late 1980s to 1990, domestic industrialization based on plywood production was promoted in Indonesia. An industrialization policy in effect since the beginning of the 1980s required companies possessing development rights to supply logs domestically. This led to year-to-year drops in raw wood exports. The major export item shifted to plywood, making Indonesia the world's leading plywood manufacturer, with more than 120 factories.

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4. All data in this section are derived from FAO (1998).

The third period of development, beginning in the 1990s and continuing to the present day, has concentrated on sustainable forestry management. With the ever-growing prominence of environmental issues, the depletion of the world's tropical forests has become a global concern and has shifted the spotlight to Indonesian forestry policy. In the 1990s, what had been a production-oriented forestry policy shifted towards sustainability through such measures as the reduction of logging output and a drive for plantation development, for which the Indonesian government has been commended by international organizations such as FAO. The forest industry policy, administered as part of the 1995–2000 five-year plan for national development, calls for forest product production to be 15 percent lower than that for the preceding stage.

Causes of Deforestation

Why is deforestation occurring so rapidly when the benefits from forests are so significant? A study of forest land cover changes in the tropics between 1980 and 1990 carried out through *Forest Resource Assessment 1990* indicates the nature of changes in forest area. For Asian forests, gradual changes as a result of rural population pressure and abrupt changes due to government policy for resettlement and commercialization of agriculture are responsible. However, other economic, social, and legal factors are also critical.

COMMERCIAL LOGGING. Commercial logging is one cause of forest loss. Loggers bulldoze roads deep into the forests to log the most valuable trees. Logs are then dragged out of the forest, leaving behind a trail of ecological havoc. Some of the current tree-cutting methods are inappropriate. So, too, are the roads that knife into the forest, allowing for the removal of trees and the entry of settlers. These roads provide access to remote forest areas for farmers, miners, land speculators, and ranchers who value the forest only for the land beneath it. This phenomenon has been well documented in parts of the Amazon and Indonesia.

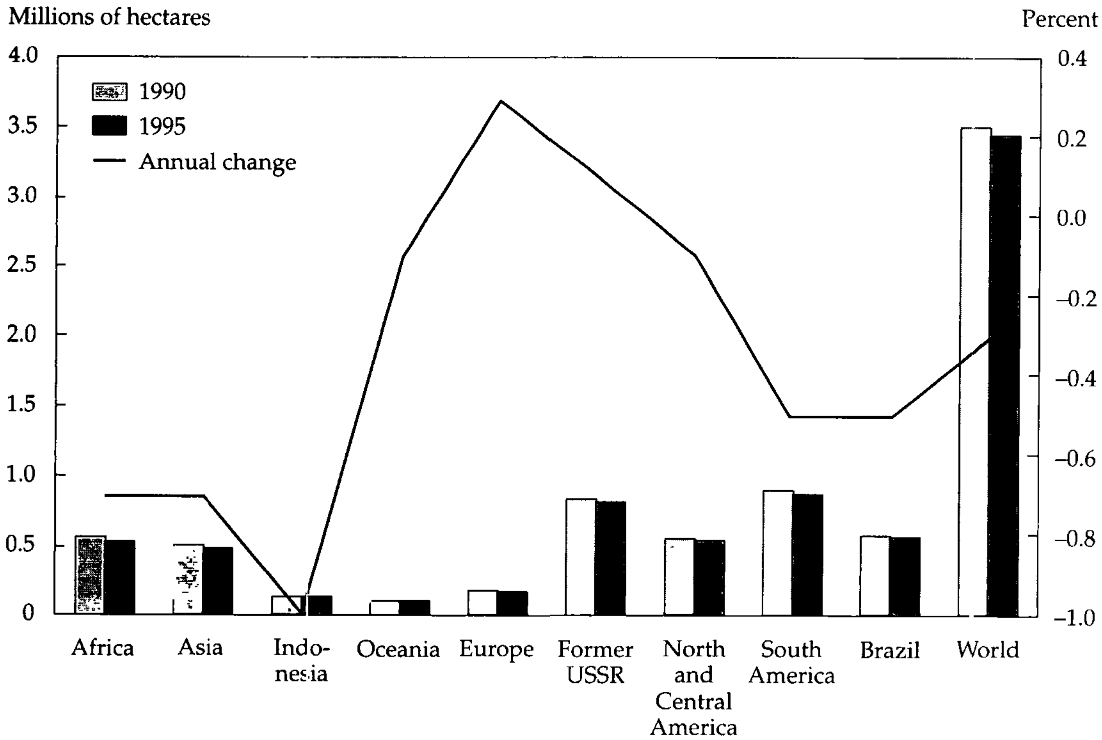
Commercial logging is usually associated with economic rent. Although governments have a variety of policy instruments to extract this rent from the logging companies, they typically give concessions for forest harvesting and do not capture all of the rent. As a result, the cost of harvesting is artificially reduced, and loggers can afford to harvest much more forest land than would otherwise be economically efficient.

CONVERSION TO AGRICULTURAL LAND. Forests generate income and employment; therefore, population growth and poverty put pressures on forests. It is important to note that there is an interwoven relationship among population growth, poverty, and government incentives behind the conversion of forests to agricultural land.

Since many of the world's poor live near forests and are dependent on forest land and resources for their livelihood, and since nearly all of the increase in population by the year 2010 is expected to occur in developing countries, forests will continue to play a particularly important role in providing products and income for those people. In fact, rural population growth, coupled with agricultural expansion, especially in Africa and Asia, is a major cause of changes in forest cover (Figure 6-2).

The poverty of rural farmers results in the conversion of forests to agricultural lands. They see unclaimed forest land as an opportunity to own land. Antipoverty policy by governments actually exacerbates the situation. Nations confronted with masses of farmers see unowned or publicly owned forests as a politically more viable source of land for the landless. Without land, those farmers are forced to migrate into the urban areas, causing a rise in unemployment and crime. Since it is politically difficult for the government to take land from the rich and distribute it to the poor, the government is forced to open up forests to the farmers.

Figure 6-2. *Changes in Forest Cover, 1990–95*



Source: FAO (1998).

For example, in Brazil, acquiring land by squatting has been formally recognized since 1850. A squatter acquires the right to continue using the land by living on a plot of unclaimed public land and using it effectively for at least a year and a day. If these conditions are met for five years, the squatter acquires ownership of the land, including the right to transfer it to others. A claimant gets land title for an amount up to three times the amount cleared of forest. The more deforestation the squatter engages in, the larger the amount of land he acquires. Deforestation is a necessary step for landless farmers to acquire land. In Indonesia the transmigration policy that encourages farmers to migrate from heavily concentrated Java to other islands has contributed to the opening up of forests owned by the national government. Both examples imply that the systems of land rights under antipoverty policy are faulty.

EXTERNALITY. Forests have no clear owner, even though they physically belong to countries. They are slow to grow and expensive to protect. Once gone, they appear to be irreplaceable. Their trees may yield long-term benefits to local people and countries in which they stand; however, once they are chopped down, they only yield quick profits to a lucky or ruthless few.

Sustainable management of forests is likely to be less profitable than clearing them and growing trees for commercial uses. Externality provides the key to resolving this paradox. The economic benefits from forests come at the expense of environmental benefits. For example, for countries with the forests, effects such as global warming and biodiversity loss are largely external, whereas the costs of preventing deforestation are internal. The loss of biodiversity is a deeper concern of developed countries; the technologies to exploit the forest gene pool for pharmaceutical products are in use in developed countries. Similarly, most of the damage from global warming would be felt outside the borders of the countries being deforested. The fact that the strongest opposition to the loss of biodiversity comes from developed countries, not from the countries that are home to the tropical forests (a typical example of so-called international externality), is indicative of why deforestation continues and developing-country governments themselves solve the problem on their own.

In sum, the pressures from poor farmers seeking more land, timber companies in pursuit of wood products, miners seeking to tap precious metals, and hunters seeking game are very real in the countries with tropical forests. At a time when they are saddled with huge external debts, those countries are encouraging overexploitation of their resource endowments in order to generate foreign exchange earnings. Numerous perverse incentives offered by government have long encouraged deforestation by local people and migrants: for example, tax credits that allow land speculators to offset the costs of clearing forest land for cattle ranching; and subsidies for crops, livestock, and the building of access roads. Poorly defined ownership adds to the pressures for clearance. Establishing legal title to land is often cumbersome.

The list of losers from deforestation includes local people who have lived in and derived their livelihood from these forests for a very long time. As the loggers and squatters push deeper and deeper into forests, the local people are forced to relocate farther and farther away from their traditional lands. Understanding and cooperation from the local community are indispensable for long-term forest management. It is clear that attempts to exclude from forest management those who are dependent on forests for their food, fuel, and other products result in failure. The local community should be managerially involved at the beginning stage and needs to benefit from its participation in forest management.

Overview of the Sebulu Experimental Forest

Sumitomo Forestry initiated the Sebulu experimental forest to address deforestation concerns in the Indonesian tropical forest. It has restored areas damaged or destroyed by forest fires and slash-and-burn farming. The goal is to replicate the conditions of the original forest as closely as possible and to establish sustainable forest utilization for the local people. The project includes natural reforestation of waste land, artificial plantation of dipterocarps and other trees, and implementation of social forestry with local farmers who have been practicing slash-and-burn farming.

Characteristics of the Site

The experimental forest is located at Sebulu in Kutai District, East Kalimantan Province, Indonesia (S 0°16′13″; E 116°59′15″). It is about 60 kilometers northwest of the province capital, Samarinda.

In the 1970s, P.T. Kutai Timber Indonesia (KTI, a joint venture of Sumitomo Forestry and local interests) began forest development in the area around the current experimental forest. The main role of the forestry operation was to supply lumber to the company's plywood operation in Java. KTI gained an excellent reputation for its sustainable forest management, which was based on selective cutting with the silvicultural technique called TPTI, stipulated by the Indonesian government. During 1982–83, Kalimantan was swept by forest fires on an unprecedented scale. Damage from the fires, which, according to one estimate, destroyed 3.1 million hectares of forest, forced KTI to terminate its forestry operations and to relinquish its concession right to the government.

Since then, local people have been practicing slash-and-burn farming and illegal logging. An aerial survey in July 1995 indicated that a quarter of the area had undergone repeated slash-and-burn farming after the forest fires of thirteen years earlier. Sparse forest cover had survived along the mountain ridges, but most of it was lost in the fires that raged between February and May of 1998. As a result, the area is now mainly wasteland.

Average annual precipitation within the experimental forest is 1,850 millimeters (mm), and the average temperature is around 28 degrees Celsius. The period between April and October is normally the dry season, but in recent years abnormal weather patterns have been frequent. Rainfall was extremely low in the second half of 1997 and the first half of 1998, and conditions remained abnormally dry between February and April. The severity of this dry period is apparent from the rainfall figures for 1998, which show that rainfall amounted to 81.5 mm in the January to March period, compared with 631.5 mm in the April to June period, 576.5 mm in the July to September period, and 513.5 mm in the October to November period (Ministry of Forestry, 1998). The likelihood of frequent climatic abnormalities in the future means that forest fire prevention and measures to halt slash-and-burn farming are extremely important.

The topography of the experimental forest area consists of rolling hills with numerous high and low areas. Elevation varies between 100 and 300 meters. While soil characteristics do not present a hurdle to the growth of vegetation, the area as a whole is not especially fertile. The geological structure consists of alternating layers of sandstone and shale, and there are scattered areas of highly acidic sulfate soil that are unsuitable for the growth of vegetation.

Even today the experimental forest area and the surrounding areas are still affected by large-scale slash-and-burn farming and illegal logging. The residential section of Sebulu Ule village (population 6,000) lies on the southern side of the experimental forest and extends along the Mahakam River. A settlement of about 1,500 migrant families from Java lies on the northern boundary of the experimental forest, as does P.T. Suruya Hutani Jaya's (SHJ) industrial forest plantation, which extends for 200,000 hectares into the hinterland. A medium-density fiberboard plant owned by SHJ and an open-cast coal mine are located on the western side of the experimental forest. Partly because of those industrial activities, the area around the experimental forest has developed rapidly during the past ten years. There is considerable traffic along an asphalt road linking the area to Samarinda. The area is typical of a region in which tropical forests are threatened with deforestation.

Main Activities

A total area of 3,000 hectares was established as the Sebulu experimental forest in 1991. As stated earlier, the experimental forest is intended to replicate the conditions of the original forest as closely as possible, and therefore Sumitomo Forestry decided to base the project on the planting of dipterocarp trees, which are indigenous to tropical Southeast Asia.

The project consists of three main activities: natural reforestation of wasteland (promoting the growth of natural saplings); artificial plantation of dipterocarps and fast-growing trees and fruit trees; and social forestry to improve the standard of living of the local people. The proper mix of these three is expected to establish a model for sustainable tropical forest management in harmony with the local environment. The cultivation of fruit trees and crops contributes to the livelihoods of local residents. In addition, commercialization is being investigated for fast-growing species such as sungkai.

In order to replicate the original forest, the stakeholders need to know the characteristics of dipterocarps and the natural conditions of the site. In this respect, research on soil conditions, as well as physiological and ecological characteristics of dipterocarps, has been completed to support the development of the experimental forest. The results are then utilized systematically in applied research (nursery and planting), which is seen as a way of creating sustainable forest management systems.

During the first stage of the project, which began in November 1991, a wide range of technologies suitable for local conditions was developed and implemented. The five-year second stage of the project began in April 1996. By December 1998 the company had established about 405 hectares of artificial plantation. Seventy percent are dipterocarps trees, and the others are fast-growing trees such as sungkai and fruit trees including papaya and mango. Since the experimental forest was damaged by the forest fires that swept through the whole of East Kalimantan Province in March 1998, replacement planting has been under way.

Management System and Policy

The Sebulu experimental forest is managed by KTI, a joint venture between Sumitomo Forestry and the Forest Research and Development Agency (FORDA) of the Indonesian Ministry of Forestry. Sumitomo Forestry provides financial, technical, and technological assistance and conducts research activities in conjunction with the Laboratory of Silviculture of the University of Tokyo's Department of Agriculture. Moreover, Sumitomo Forestry is also carrying out tasks assigned to it as a member of the Research Association for Reforestation of Tropical Forests (RETROF), which is affiliated with the Forestry Agency of Japan. The experimental forest is eligible for government research funding from RETROF.

A steering committee with members from the Indonesian Ministry of Forestry, KTI, Sumitomo Forestry, and the University of Tokyo is held once a year in order to decide the research topics and evaluate the outcomes of the experimental forest. Major activities in the experimental forest are supervised by a working committee (with members from the ministry and KTI). There are some blocks where technicians from FORDA conduct on-site research.

Many divisions of Sumitomo Forestry are cooperating in the implementation of the Sebulu experimental forest under the leadership of the Green Environmental R&D Division. The Tsukuba Research Institute is playing an important role in research and technological development activities, and three researchers are involved in developing the experimental forest. The first is responsible for seedling growing, planting, silviculture, and social forestry; the second for cuttings and tissue culture; and the third for forest product utilization. In addition to their research work at the institute, the researchers travel to Sebulu four or five times each year for three to four weeks to participate in joint research with KTI and FORDA's technicians. In the Green Environmental R&D Division, most of the project-related work is handled by two staff members. One is permanently stationed at the Sebulu experimental forest to supervise research and manage the experimental forest in cooperation with KTI staff.

The basic issues considered in relation to the tropical forest reforestation project are continuity, public benefit, and international significance. It was decided that the experimental forest should contribute to cooperation in the field of environmental technology and that it should involve research and technological development at the highest level. The public importance and public benefit are ensured through the joint management of the experimental forest by KTI and the Indonesian Ministry of Forestry. This arrangement also facilitates technology transfers and ensures that the project is firmly based in the Sebulu region.

Joint implementation by Sumitomo Forestry and KTI ensures that the project has international significance. Researchers from Sumitomo Forestry and the University of Tokyo and technicians from KTI and FORDA spend extended periods of time at the site. Their participation in joint research activities turns the experimental forest into a forum for international technological cooperation.

The involvement of the Laboratory of Silviculture of the University of Tokyo in joint research activities maintains high scientific standards. The project is expected to yield major public benefits through its contribution to tropical forest research. Experts' guidance throughout the project has laid the foundations for research activities with excellent results. The experimental forest can be an example of cooperation between the industrial and academic sectors.

The Research Association for Reforestation of Tropical Forests

For years Japan participated in international cooperation in the forestry sector primarily at the governmental level. Evidence that much could be gained through private sector participation in tropical forest conservation and the development of reforestation technology led to the decision to create a research association involving industry, academia, and government. The Research Association for Reforestation of Tropical Forests, established in July 1991 by the Industrial Technology Research Association Law, has ten corporate members and is under the jurisdiction of the Forestry Agency. The research association's operations are modeled on a system first introduced in the United Kingdom in 1917. Japan is the only country in the world to apply this system to the restoration of tropical forests.

The creation of RETROF gave impetus to Sumitomo Forestry's efforts to establish the Sebulu experimental forest. The organization has also played an important role in subsequent research activities in the experimental forest. RETROF has established four research themes, the most important of which is the development of a social forestry system.[5]

A Comparison of the Sebulu and Wanariset Forest Projects

Different from other reforestation projects in the region, the Sebulu experimental forest is a platform for industry, government, and academia to come together to achieve tropical forest regeneration. Sumitomo Forestry and KTI use the Sebulu plot not as just another industrial plantation but to carry out genuine research without direct profit to themselves.

Based in Samboja, nestled between Balikpapan and Samarinda in East Kalimantan, the Wanariset forest research station is owned by the Indonesian Ministry of Forestry and run through funding and technical support from a Dutch foundation. Wanariset has established enrichment planting techniques for forest production based on selective felling (that is, techniques for shaded areas), whereas at Sebulu, planting techniques suited to both shaded and open areas have been developed. With regard to propagation methods, Wanariset has developed dipterocarps cutting techniques, whereas Sebulu has been successful in developing both tissue culture and cutting techniques. Tissue culture makes it possible to produce seedlings from superior trees. When combined with cutting techniques, it makes the mass production of seedlings feasible. The Wanariset cutting technique is based on hydroponic cultivation, while the Sebulu method uses sand as the cutting medium, making it technically simpler and giving it the potential for wider acceptance.

For mass production of grafted seedlings, a spear plot from which spears can be cultivated in large quantities is required. Wanariset has successfully applied tea cultivation methods to the development of cutting stock nurturing techniques to be able to produce spears efficiently.

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5. In 1996 RETROF began the second phase of its research activities. Research themes of the second phase are development of nursing techniques for fast-growing tropical tree species, development of silvicultural techniques for tropical forests, development of a social forestry system, and development of utilization techniques for forest products. A total of eight companies, including Sumitomo Forestry, Oji Paper, and Toyota Motor, are actively engaged in this research. The budget for RETROF in 1997 was 151 million yen, out of which 78 million was subsidy.

Driving Forces behind the Experimental Forest

Sumitomo Forestry identified the experimental forest as a part of the answer to global environmental issues. It was initiated as a purely social activity, and no commercial returns were expected. Forests play a vital role in protecting the global environment, and the most crucial issue affecting the world's forests is deforestation of tropical forests. Among the factors contributing to the reduction of forest areas are the conversion of forest to agricultural land, excessive grazing by cattle, and inappropriate commercial logging. It is preferable to find a solution that takes into account economic as well as environmental factors. The Sebulu experimental forest targets the problems of tropical forests and contributes to the solution of global environmental issues.

Second, the reforestation of tropical forests is a field in which Sumitomo Forestry can use its unique skills and technology. The experimental forest provides an ideal opportunity to utilize experience and expertise accumulated through its many years of forest management in Japan and overseas.

Third, Sumitomo Forestry regards its reforestation of tropical forests as a way of repaying a debt: Japan imports timber and plywood from Southeast Asian countries. In this sense, Sebulu embodies the corporate philosophy of a "Spirit of Appreciation of Nature."

Fourth, the Sebulu experimental forest enables Japan and Sumitomo Forestry to make a visible contribution. It is often said that Japanese official development assistance and private-sector foreign aid projects consist of financial assistance or the mere construction of facilities, with the result that Japanese involvement is invisible. Business corporations commonly contribute to society or the international community by funding nongovernmental organizations or making donations to universities and research institutes. Rarely do they undertake projects that involve direct participation by their employees. The experimental forest is a project where the company, and Japan, can play a visible role. The company wanted a project through which its employees could work with local people to overcome difficulties.

Fifth, the experimental forest forms part of Japan's technical assistance in environmental technology, a field where Japan has a competitive advantage. There are various efforts to overcome the problems affecting tropical forests, and reforestation is seen as an area of environmental technology in which Japan's private sector can make an important contribution through international cooperation.

Why in Sebulu?

Tropical forest research requires an appropriate site, suitable researchers, and facilities where the researchers can reside for long periods. Indonesia, Malaysia, the Philippines, and Papua New Guinea were among the countries considered during the planning stage of this experimental forest. Sebulu, Indonesia, was eventually selected as the research site for the following reasons.

First, there is a long history of ties between Japan and Indonesia. From the Japanese perspective, tropical forests have long been regarded as part of the region known as the South Seas. Java and Borneo are prominent among the place names that the Japanese associate with that part of the world. Moreover, many Japanese view the South Seas with a kind of longing. In Japan tropical timber has always been called "South Seas timber," and Japan's traditional source for such timber was Indonesia.

Second, Sumitomo Forestry has operated for many years in Indonesia. It has been involved in Sebulu for more than twenty-five years through its links with KTI, which has built a relationship of trust with the local communities. In the prewar era the Forestry Division of Sumitomo Holding Company, the forerunner of Sumitomo Forestry, developed a pine plantation near Lake Toba in Sumatra. The plantation served as a watershed forest for the lake. The company also operated rubber plantations in West Kalimantan and Java. In 1970 it established KTI and began forest development activities in Sebulu. KTI maintained the production potential of its forests through sustainable forest management based on selective cutting. KTI also played an active role in human resource development and provided community infrastructure such as schools, mosques, and sports grounds in the Sebulu region. Despite the tragic forest fires of historic severity in 1982 and 1983, which forced KTI to close down its operations, KTI and Sumitomo Forestry left the area an important legacy in the form of a labor force with large numbers of highly skilled people.

Social Forestry in the Sebulu Experimental Forest

The key facet of the Sebulu experimental forest is social forestry. Its goal is to develop alternatives to slash-and-burn farming that provide more stable income opportunities for local people. This section discusses social forestry methodology employed in the experimental forest, and then, by estimating cash flows, it tries to assess the economic viability of social forestry relative to slash-and-burn farming. The required input/output and cost/price data for this analysis were gathered from the existing survey and on-site interviews with farmers.

Slash-and-burn farming accounts for 60 percent of the loss of forests in Indonesia. The "sustainability" of slash-and-burn farming is ruptured when pressures from population growth intensify. To increase output, farmers are induced to either shorten fallow periods or convert more forest to agricultural land. In Indonesia transmigration policy has been encouraging farmers in heavily concentrated Java to migrate to other islands, including Kalimantan. However, the fertility of the land where these migrants settle is often poorer than that of the land cultivated by the indigenous people, and they have been forced to perpetuate the slash-and-burn process. The increasing number of new migrants and the appearance of the second generation intensify the demand for land.

In preparation for the establishment of the Sebulu experimental forest, Sumitomo Forestry dispatched survey teams three times between 1989 and 1991. A report by Professor Satohiko Sasaki of the University of Tokyo, the leader of the third team, stated that the area around Sebulu has been affected by forest fires, secondary logging, human settlement, slash-and-burn farming and other factors. Little of the forest remains. In view of the customs and practices of local people, it will be necessary to take steps to protect the experimental area from slash-and-burn farming. We would need to devise a unique solution to this problem through dialogue with residents and research into their way of life."

Professor Sasaki's team decided that the basic concept for the Sebulu experimental forest should be reforestation and technological development that would contribute to the living standards of the local people. It is hoped that the introduction of social forestry will improve the potential for successful reforestation by reducing dependence on slash-and-burn farming. Article 2-(2) of the agreement between the Indonesian Ministry of Forestry and KTI regarding the joint management of the Sebulu experimental forest defines the scope of activities for the project, and social forestry activities are identified as key facets.

In 1995 Sumitomo Forestry conducted an economic survey in the Sebulu region in order to understand the local economy. The KTI staff surveyed 756 households to obtain data such as occupation, income, and number of family members.[6] Approximately 46 percent of the households had come from other parts of East Kalimantan, and more than 80 percent of those households had migrated in the past fifteen years. The major occupations reported were in forestry,

6. For the summary of the survey, see Ministry of Forestry (1996, pp. 73–77).

manufacturing at sawmills, transportation, and trading, most of which have ties to illegal logging. Slash-and-burn farmers engaged in illegal logging during slack seasons. Thus the survey confirmed that the Sebulu forest area was threatened by population growth and was a practical site for social forestry.

Experimentation and Implementation

Local participation is critical to social forestry, and the range of categories of local participants is broad: communities, villages, cooperatives, schools, and individual farmers. The Sebulu experimental forest focused on individual farmers and family units as the social nucleus, mainly because communities and cooperatives in the region were not well organized as joint producers. This strategy can vest management over a certain area in a specific person and thus makes the correlation between the inputs and outputs direct. Since farmers do not join unless they can perceive benefits from their participation, this strategy has been one of the most successful approaches used in other projects.

Slash-and-burn farmers are being encouraged to switch to settled farming as a way of reducing dependence on their destructive methods. This is being achieved through the creation of areas with mixed plantings of dipterocarps trees, fruit trees and crops, and through the development of fruit trees. At present, four social forestry trial zones with an area of approximately forty-three hectares have been established in the Sebulu experimental forest. As is shown in Table 6-1, the program is being implemented with the cooperation of thirteen families. The plantings in the social forestry trial zones include dipterocarps trees (50,000 seedlings), fruit trees (durian, mango), fast-growing trees (sungkai, gmelina, teak), and crops (peanuts, maize, dry-field rice).

KTI's role is to provide farmers with technical guidance as well as seedlings, fertilizer, and materials. The seeds and fertilizers are given in advance so that the farmers can start cultivation even if they do not have enough cash to purchase such inputs. Farmers repay those expenses later, once they have harvested their crops or fruits. The farmers constantly consult KTI about the implementation of social forestry.

Initially, social forestry in the Sebulu experimental forest was characterized by trial and error. However, after two stages were completed, the most suitable methods were standardized.

FIRST STAGE. Trial planting of fruit trees started in early 1992, as soon as development of the experimental forest began. Initially, seventy-five mango trees were planted around the base camp and another seventy-two in the fruit-tree trial zone. The trees fruited three years after planting. In addition, 120 enhanced durian trees were planted near the seedling nursery to produce seeds. Mixed plantings were also undertaken. In Block 1 and other first-year planting areas, mangoes and durians were planted in the dipterocarps planting zones; cotton plants were used in mixed plantings in Blocks 5 and 8. The fruit trees grew slowly and failed to fruit because of factors that included poor soil conditions and damage caused by an insect attack. The fruit trees were all enhanced varieties, not available locally, and the seedlings were transplanted from Java by KTI.

A family of slash-and-burn farmers settled in Block 7, where mixed plantings of dipterocarps trees, fast-growing trees, and crops were undertaken. The crops included maize, cassava, and pepper. The family was paid to prune and perform other management tasks in Blocks 1 to 7. This continued for approximately thirty months, after which the farmer concerned was made manager of the No. 2 Nursery of the dipterocarps seedlings at his own request.

SECOND STAGE. In June 1994 two families of slash-and-burn farmers (migrants from Java) settled in Block 56, and a four-hectare social forestry zone was established. The area was used for

Table 6-1. Families Participating in Social Forestry

Location	Site number and family name	Method
Block 56	1 *Eri*	Mixed planting of fruit trees and crops
	2 *Paimin*	Mixed planting of fruit trees and crops
Block 88	1 *Namon*	Development of fruit trees
Block 104	1 *Mashudi*	Mixed planting of fruit trees and crops
Location 31	1 *Alusius (Aluh)*	Mixed planting of dipterocarps, fruit trees, and crops
	2 *Dasto*	Mixed planting of dipterocarps, fruit trees, and crops
	3 *Gendut and Tepung*	Mixed planting of dipterocarps, fruit trees, and crops
	4 *Gupon*	Mixed planting of dipterocarps, fruit trees, and crops
	5 *Halimah/Zuki*	Mixed planting of dipterocarps, fruit trees, and crops
	6 *Markum*	Mixed planting of dipterocarps, furit trees, and crops
	7 *Naryo*	Mixed planting of dipterocarps, fruit trees, and crops
	8 *Rubadi*	Mixed planting of dipterocarps, fruit trees and crops

Source: Internal project documents.

mixed planting, including 426 durians, together with trees and crops. Their harvest began to decline in the second year, and crops (pumpkins, eggplants, and so on) were eaten by monkeys, wild boar, and other animals. The farmers became unwilling to continue with the activities and withdrew from the project. Those families had lived before in the Sebulu Ule village. It is difficult for people who had not settled in the area to come and live away from the village.

Yet subsequently Block 56 was successfully settled by the *Eri* and *Paimin* families, who are expected to manage the entire block—not only to produce crops and fruits, but also to maintain dipterocarps trees within and around the block. For this responsibility, KTI pays each family Rp155,000 every month.

In December 1995 work began on the development of an orchard in Block 88 with a shifting cultivation farmer named *Namon*. A total of 766 trees were planted on a 1.95-hectare area. The trees included 250 mangoes and durians, 216 rambutans, and 50 mangosteen. The mangoes and rambutans have started to fruit.

THIRD STAGE. In 1997 plans were drawn up for a large-scale social forestry area along Gang Kerbau Road. The start of this project was delayed because of forest fires. Trials of social forestry finally began in May 1998 and are now proceeding steadily. KTI consigned basic soil preparation and planting of dipterocarps seedlings to farmers. Then the farmers initiated the crop cultivation under the same scheme used in Block 56, although they do not receive salary from KTI. Maintenance, such as weeding and manuring, benefit not only the cultivated crops but also dipterocarps. In April 1999 the planting of fruit trees began.

Definition and Interpretation of Social Forestry

Theories about social forestry vary, and it appears that the concept has not yet been clearly defined in Japan. The World Bank defines *social forestry*, based on FAO's definition, as a broad range of tree- or forest-related activities that rural landowners and community groups undertake to provide products for their own use and to generate local income (Gregersen, Draper, and Elz, 1989, p. 3). It distinguishes social forestry from the conventional production forestry. The primary focus of social forestry is on people, on community involvement, and on those trees that offer direct and indirect benefits. Local participation and technological innovation to generate and sustain increases in land productivity are listed as common elements in social forestry. Agroforesty is regarded as a main tool in social forestry involving farmers.

The Japan International Cooperation Agency (1991) defines social forestry as the use of forestry to improve and stabilize the living standards and welfare of local residents. The Research Association for the Reforestation of Tropical Forests refers to sales of forest products to local residents and systems that enable forestry to become a basis for livelihoods (Sasaki, 1997, p. 25). RETROF also states that social forestry can help to improve the well-being of local residents while contributing to the conservation and regeneration of forests. It describes agroforestry "as a valuable tool for the implementation of social forestry" (Sasaki, 1997, pp. 357–58).

Jack Westoby (1989) has offered a very interesting definition. He describes social forestry as tree planting and management, at the farm, village or community level, by or for small farmers and the landless. In his view there can be no acceptable delimitation of social forestry as a particular area of forestry science and practice. All forestry should be social. In terms of Westoby's definition, social forestry activities in the Sebulu experimental forest include the planting and management of trees, fruit trees, and crops at the level of farming households with small holdings and those without land. The experimental forest implements social forestry in its broadest sense.

Economic Analysis of Social Forestry

Social forestry in the Sebulu experimental forest is expected to stabilize and improve the living standard of slash-and-burn farmers through their involvement in settled cultivation and reforestation. Therefore, successful promotion of social forestry depends on whether farmers perceive that they will actually receive benefits from it. Unless the benefits from social forestry are at least comparable with those from slash-and-burn farming, farmers will not be motivated to change their practices.

This section assesses the economic viability of social forestry, especially crop cultivation, relative to slash-and-burn farming. The cash flow, obtained by calculating a gross margin that takes into account the opportunity cost of family labor as well as the variable costs of input, is used as the indicator of economic viability. In cases where fruit trees are planted in social forestry, a spreadsheet is used for calculating multi-year cash flow; then the present value is derived. Costs and benefits are valued at the prices the farmers actually face with no adjustment for economic distortions.

The required input/output and cost/price data were gathered from the existing survey and interviews with farmers: for slash-and-burn farming, we extended the results from the *Economic Survey in the Sebulu Region* in 1995; for farmers participating in social forestry, intensive interviews were conducted by KTI and Japan Development Bank from August 1998 to February 1999.

Cash Flow of Slash-and-Burn Farming. Eight sites of slash-and-burn farming were surveyed through interviews with the farmers (Table 6-2). The *Economic Survey* produced data on cultivated area, labor input, and yields of rice. The average area was 1.85 hectares, and income per hectare ranged from Rp92,000 at Site 2 to Rp1,260,000 at Site 8; the average income per hectare was approximately Rp449,429, which corresponded to US$204 at the exchange rate at that time (US$1 = Rp2,200).

This "income," however, is not correct for two reasons. First, the cost of family labor is excluded from the calculation. In the assessment of economic viability, we should be sure to include all of the factors of production. This requires us to value family labor, which does not have an

Table 6-2. *Income from Slash-and-Burn Farming, 1995 Prices*

Site	1	2	3	4	5	6	7	8
No. of working persons	2	4	2	2	2	4	2	10
Total no. of person work days[a]	140	280	140	140	140	280	140	700
Area (ha)	0.8	2.55	0.85	1.01	2.67	3.04	0.64	3.25
Yield (Rp): (a)	693,000	735,000	525,000	490,000	980,000	840,000	140,000	4,200,000
Labor cost (Rp): (b)	118,000	500,000	145,000	110,000	300,000	100,000	10,000	105,000
Cutting & burning	30,000	150,000	60,000	50,000	300,000	0	6,000	0
Sowing	0	175,000	60,000	60,000	0	100,000	4,000	0
Weeding	88,000	175,000	25,000	0	0	0	0	0
Harvesting	0	0	0	0	0	0	0	105,000
Income (Rp): (a) – (b)	575,000	235,000	380,000	380,000	680,000	740,000	130,000	4,095,000
Income (Rp)/ha	718,750	92,157	447,059	376,238	254,682	243,421	203,125	1,260,000

a. The number of person work days equals 3.5 days per week times 20 weeks.
Note: The unit price of rice is 7,000Rp per can (7 kg). The labor cost does not include family labor.
Source: Internal project documents.

explicit cost but involves an opportunity cost.[7] Second, the price of rice and the cost of labor increased dramatically after the Asian currency turmoil and the subsequent political upheaval in Indonesia. An adjustment is needed to make slash-and-burn farming indicators consistent with the post-August 1998 interview-derived indicators of social forestry participants.

As a proxy of the opportunity cost of family labor, the payment for carrying out any agricultural activity such as working as a laborer in fellow farmers' fields can be used. From 1995 to 1998, a nonfamily laborer's daily payment increased by 30 percent from Rp6,000 to Rp7,500. Therefore, the opportunity cost of family labor, represented here by payment for daily labor in rice fields in 1998, is Rp7,500. On the other hand, the price of rice increased from Rp7,000 per can to Rp24,500 per can. The results of these adjustments are shown in Table 6-3.

The average cash flow is Rp708,850, which corresponds to US$89 at the exchange rate of US$1 = Rp8,000.[8] Negative cash flow at Sites 2 and 7 does not mean that they are losing cash in a physical sense but that they should cease the slash-and-burn farming and seek another job opportunity with positive cash flow. The large disparity in cash flow across the sites is probably due to land fertility, damages by wild boar, the working discipline of farmers, and the nature of the data collection method.

The amount of Rp708,850 can be regarded as the standard slash-and-burn cash flow in the Sebulu region. If social forestry can consistently generate at least this amount, farmers will be induced to participate in social forestry instead of depending on slash-and-burn farming.

7. Opportunity cost is a familiar term in economics. If an individual works in his own firm, his labor is an input and should be counted as part of costs. His wage rate is the market price of his labor: what he would get if he sold his labor on the open market. However, the opportunity cost of land is excluded here. Our concern is relative (not absolute) cash flow per hectare. As long as the unit price of land is the same for slash-and-burn farming and social forestry, a reasonable assumption in the Sebulu region, whether the opportunity cost of land is included or not does not affect the result.

8. Although the Indonesian rupiah depreciated dramatically against the U.S. dollar after 1997, it became relatively stable at this level after the resignation of President Suharto.

Table 6-3. Cash Flow of Slash-and-Burn Farming, 1998 Prices

Site	1	2	3	4	5	6	7	8
No. of working persons	2	4	2	2	2	4	2	10
Total no. of person work days	140	280	140	140	140	280	140	700
Area (ha)	0.8	2.55	0.85	1.01	2.67	3.04	0.64	3.25
Yield (Rp): (a)	2,425,500	2,572,500	1,837,500	1,715,000	3,430,000	2,940,000	490,000	14,700,000
Labor cost (Rp): (b)	153,400	650,000	188,500	143,000	390,000	130,000	13,000	136,500
Cutting & burning	39,000	195,000	78,000	65,000	390,000	0	7,800	0
Sowing	0	227,500	78,000	78,000	0	130,000	5,200	0
Weeding	114,400	227,500	32,500	0	0	0	0	0
Harvesting	0	0	0	0	0	0	0	136,500
Family labor (Rp): (c)	1,050,000	2,100,000	1,050,000	1,050,000	1,050,000	2,100,000	1,050,000	5,250,000
Cash flow (Rp): (a) – (b) – (c)	1,222,100	–177,500	599,000	522,000	1,990,000	710,000	–573,000	9,450,000
Cash flow (Rp)/ha	1,527,625	–69,608	704,706	516,832	745,318	233,553	–895,313	2,907,692

Note: The unit price of rice is 24,500 Rp per can. The labor cost is in 1995 prices times 1.3. Family labor equals the total number of person work days times Rp7,500.

Source: Internal project documents.

It should be noted that average cash flow is lower than Rp708,850, if we regard fallow fields as parts of the cultivation area. Slash-and-burn farming in the Sebulu region rotates among three places every three years on average. Therefore, farmers use three times as much land as the area indicated in the table, and the average cash flow is reduced to Rp236,283, or US$30.

Cash Flow of Social Forestry. Although yields from crops are occasionally monitored by Sumitomo Forestry, data which are equivalent to that of the *Economic Survey,*" and are necessary for estimating cash flow from social forestry, are not available. Therefore, we conducted a series of interviews with all farmers listed in Table 6-1 from August 1998 to February 1999 in order to gather input/output and cost/price data.

KTI gathered data on yields of various crops in the Sebulu experimental forest. Many sample plots (5 meters by 5) are established in each block, and KTI staff closely monitored them from planting to harvesting. In deriving the cash flow of Location 31, KTI predicted the total yields for each family based on these sample data and adjusted them to the actual yields based on interviews with farmers.

Our data collection in Blocks 56 and 104 (Table 6-4), and in Location 31 (Table 6-5), focused on crops, since mixed planting had just started, and even the farmers did not have full and actual records of input/output for fruit trees.

The coverage of crop variety depends on the farmers' input/output records; the crops listed in the tables make up the main portion of the input/output in each block but do not cover all of the crops. Labor includes family labor, and opportunity cost is set at Rp7,500, which reflects the daily payment to a laborer in fellow farmers' crop fields.[9]

9. The daily payment to a laborer for crop cultivation differs from location to location, while that for rice cultivation is constantly around Rp7,500. (In some cases the payment takes the form of crops that the laborers harvest.) Based on the interviews, we assume that Rp7,500 is the upper range of the payment, and the lower range is Rp6,200 (equivalent to the salary for daily workers at KTI).

Table 6-4. *Cash Flow of Social Forestry in Blocks 56 and 104*

Location (block)	56	56	104
Family	*Eri*	*Paimin*	*Mashudi*
Area for crop cultivation (ha)	0.68	0.55	1.4
Maize	186,000	680,000	2,700,000
Soybeans	175,000	45,500	700,000
Green beans	185,000	62,500	252,500
Peanuts	220,000	46,000	106,500
Onion	288,000	0	450,000
Total output (a)	1,054,000	834,000	4,209,000
Soil preparation	127,500	420,000	367,500
Planting	232,500	105,000	697,500
Manuring	30,000	30,000	105,000
Maintenance	232,500	232,500	892,500
Harvesting	135,000	232,500	712,500
Labor cost (b)	757,500	1,020,000	2,775,000
Seeds	162,000	192,500	354,500
Fertilizer	75,000	75,000	134,100
Insecticide	30,000	30,000	60,000
Equipment	1,000	1,000	1,000
Purchasing cost (c)	268,000	298,500	549,600
Total input: (d) = (b) + (c)	1,025,500	1,318,500	3,324,600
Cash flow: (a) – (d)	159,800	–484,500	884,400
Cash flow/ha (e)	28,500	–880,909	631,714
Salary from KTI /ha (f)	465,000	465,000	—
Cash flow/ha with salary: (e) + (f)	506,912	–415,909	631,714

Note: One term of cultivation is six months, and salary from KTI is for six months Salary/ha = (Rp155,000/month * 6 months) / 2 ha.

Source: Internal project documents.

The cash flow derived here is relatively conservative. We excluded output of other vegetables such as chili, peppers, and sweet potatoes since we could not collect labor input data for planting and harvesting them, whereas a portion of labor input for soil preparation, maintenance, and manuring, which are kinds of overhead cost, may have been related to those other vegetables.

In Block 56, the cash flow of *Eri* is Rp506,912, which corresponds to US$63 at the exchange rate of US$1 = Rp8,000, while that of *Paimin* is negative. The cultivated lands of these two families in Block 56 are located next to each other, and there seems to be little difference in land fertility. According to the KTI staff who had daily contact with the two families, the lower cash flow of *Paimin* was partly because his cultivation strategy, such as choice of crops, and the timing of planting were weaker and partly because of larger damages by wild boar and insects in the 1997 and 1998 seasons. The cash flow of Block 104 is estimated to be Rp631,714.

Crops are raised twice a year in each block; therefore, the annual cash flow is double what is shown in Table 6-4 (Rp1,013,824 for *Eri* and Rp1,263,428 for *Mashudi*). These are the figures that should be compared with annual cash flow from slash-and-burn farming (Rp708,850).

Table 6-5. Cash Flow of Social Forestry in Location 31

Family	*Aluh*	*Dasto*	*Tepung*	*Gupon*	*Halimah*	*Markum*	*Naryo*	*Rubadi*
Area for crop cultivation (ha)	1.14	2.05	3 7	1.15	2.2	3 21	3.2	1.26
Maize	72,699	840,719	698,669	335,978	708,888	646,408	857,504	464,720
Soybeans	0	0	122,444	26,096	0	0	0	0
Green beans	0	0	592,500	239,500	226,250	829,500	1,019,750	0
Peanuts	5,064,568	0	8,069,232	0	0	4,878,720	1,074,868	0
Total output (a)	5,137,267	840,719	9,482,844	601,573	935,138	6,354,628	2,952,122	464,720
Soil preparation	210,000	360,000	675,000	135,000	262,500	450,000	472,500	262,500
Planting	112,500	285,000	405,000	75,000	180,000	495,000	187,500	307,500
Manuring	7,500	30,000	60,000	15,000	15,000	30,000	22,500	22,500
Maintenance	750,000	240,000	2,677,500	82,500	120,000	1,935,000	862,500	180,000
Harvesting	270,000	135,000	405,000	236,250	247,500	675,000	465,000	7,500
Labor cost (b)	1,350,000	1,050,500	4,222,500	543,750	825,000	3,585,000	2,010,000	780,000
Seeds	293,750	157,500	652,500	150,750	150,000	515,000	282,500	146,250
Fertilizer	10,500	105,000	150,000	75,000	93,750	150,000	75,000	75,000
Herbicide	0	0	0	0	0	0	0	0
Insecticide	60,000	90,000	105,000	45,000	75,000	75,000	90,000	90,000
Equipment	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Purchasing cost (c)	365,250	353,500	908,500	271,750	319,750	741,000	448,500	312,250
Total input: (d) = (b) + (c)	1,715,250	1,403,500	5,131,000	815,500	1,144,750	4,326,000	2,458,500	1,092,250
Cash flow: (a) – (d)	3,422,017	–562,781	4,351,844	–258,927	–209,612	2,028,628	493,622	-627,530
Cash flow/ha	3,001,769	–274,527	1,176,174	–186,023	–95,278	631,971	154,257	-498,040

Source: Internal project documents.

In Location 31 with social forestry, like slash-and-burn farming, there is a range in cash flow per hectare, in this case from a negative figure to Rp3,001,769. Soybeans and green beans were seriously damaged by insects in most sites, which resulted in negative cash flow for some farmers and a large disparity in cash flow among farmers. Even with such damage, when crops are raised twice a year, the average cash flow, Rp977,576 in this location, exceeds that of slash-and-burn farming.[10]

The average cash flow of crop cultivation for eleven of the locations under social forestry is Rp421,184, and since farmers raise crops twice a year, annual cash flow is Rp842,368 (US$105), which exceeds that of slash-and-burn farming, Rp708,850 (US$89, US$30 if consideration is paid to the fallow fields).

Although we were not able to gather actual data on fruit planting in Sebulu, some limited data on long-term projection for input/output for durian and mango are available from the literature written about fruit cultivation in Java (AKK, 1997; Onny, 1996; and Rahamat, 1997). Based on such literature, we tried to run a multi-year cash flow simulation for Block 88 by incorporating (1) the information obtained from farmers around the experimental forest who have fruit trees in their fields and (2) natural conditions of the Sebulu region. This simulation cannot cover rambutan and mangosteen, which are also planted in Block 88, because similar projections could not be

10. KTI and some farmers planted rice for the second cultivation, instead of maize, beans, and peanuts.

found in the literature. The simulation does provide a rough picture of cash flow generation from fruit tree planting.

In Block 88, soil preparation and planting were done by KTI. In addition, seedlings and fertilizer and insecticides are provided by KTI every year. In return, KTI receives one half of the yield from the farmer as repayment of those expenses.[11] Therefore, actual revenue for the farmer decreases to one half of the total yield. Taking into consideration the soil and weather conditions in Sebulu, in addition to interviews with fruit farmers around the experimental forest, we assumed that the yield of durian is 85 percent of that of Java and the yield of mango is 70 percent. Out of the harvest, 80 percent is suitable for sales. Labor costs are based on interviews with the farmer in Block 88, who recorded input data.

The result is shown in Table 6-6. At the bottom of the table is the present or future value of each year's cash flow at various discount rates. Year 3 in this table is 1998, the standard year.

In the fourth year, when mango trees bear fruit, the present value of the cash flow at a 10 percent discount rate is Rp743,862 (US$89), which is almost equal to the cash flow of slash-and-burn farming. Once durian begin bearing fruit, fruit tree planting generates a much higher cash flow than does slash-and-burn farming.

The issue is the negative cash flow during the first three years. In the first year the farmer faces negative cash flow of Rp315,298 to Rp440,375, depending on the discount rate. Slash-and-burn farmers are concerned about their lives in the immediate year; even the high probability of cash flow in the future may not be enough to induce them to participate in fruit tree planting unless they have other sources of cash flow. In fact, the farmer in Block 88 has his own crop fields, which KTI suspects made it easy for him to participate in social forestry. Thus, mixed planting of fruit trees and crops is a more realistic and viable approach.

Although we focused on the cash flow of the crop cultivation in Blocks 56 and 104, and Location 31, they are actually planting fruit trees. Whether the cash flow of crop cultivation, after offsetting the negative cash flow during the first three years of fruit tree planting in those blocks, can exceed the Rp708,850 of slash-and-burn farming depends on the location. Efforts to raise farmers' awareness about the long-term benefits from fruit tree planting, especially the higher cash flow in the future, are needed to overcome this hurdle.

PUBLIC AWARENESS. The participation of local people is a critical element of social forestry. Convincing people to participate is a long-term process that depends on provision of advantages and publicity about social forestry. An important factor in the decision to participate is the risk averseness of the people, which is usually high among poor rural people (Gregersen, Draper, and Elz, 1989, p. 319). Also, at the initial stage, participating farmers must be carefully selected from those convinced people.

In the Sebulu experimental forest, Sumitomo Forestry provides seeds, fertilizers, and equipment, so that the initial investment can be reduced, and technical assistance on which crops to plant and how to raise yields. Without this assistance, cash flow from social forestry could not have become comparable to that of slash-and-burn farming. The provision of these services not only introduces more efficient ways of cultivation but also mitigates the risks involved, such as damage by weather conditions or wild animals.

In the community around the experimental forest, public awareness of social forestry is increasing. In addition, the participating farmers' attitudes began to change (for example, during the forest fires in 1998 they desperately tried to protect their blocks). Before commencing social

11. KTI will spend a part of this revenue on expenses or investment necessary for the operations of the experimental forest.

Table 6-6. Cash Flow Projection for Block 88

Year	1	2	3[a]	4	5	6	7	8	9	10
Total yield (Rp) (a)	0	0	0	4,904,900	17,728,920	28,830,791	55,971,079	87,230,053	152,409,164	235,970,154
Durian	0	0	0	0	1,542,750	5,091,075	16,800,548	36,961,205	81,314,650	149,076,858
Mango	0	0	0	4,904,900	16,186,170	23,739,716	39,170,531	50,268,849	71,094,514	86,893,295
Revenue for the farmer (Rp): (b) = (a)/2	0	0	0	2,452,450	8,864,460	14,415,396	27,985,539	43,615,027	76,204,582	117,985,077
Labor cost (Rp): (c)	521,154	597,727	657,500	890,340	1,384,482	1,807,631	2,705,510	3,670,030	5,563,764	7,865,997
Soil preparation	0	0	0	0	0	0	0	0	0	0
Planting	0	0	0	0	0	0	0	0	0	0
Maintenance	521,154	597,727	657,500	723,250	795,575	875,133	962,646	1,058,910	1,164,801	1,281,281
Harvesting	0	0	0	167,090	588,907	932,499	1,742,865	2,611,120	4,398,963	6,584,715
Durian	0	0	0	0	37,510	123,783	408,484	898,665	1,977,062	3,624,614
Mango	0	0	0	167,090	551,397	808,716	1,334,381	1,712,455	2,421,901	2,960,101
Cash flow: (b) – (c)	–521,154	–597,727	–657,500	1,562,110	7,479,978	12,607,764	25,280,029	39,944,996	70,640,818	110,119,080
Cash flow/ha (d)	–260,577	–298,864	–328,750	781,055	3,739,989	6,303,882	12,640,015	19,972,498	35,320,409	55,059,540
Present value of (d) (10%)	–315,298	–313,807	–328,750	743,862	3,392,280	5,445,530	10,398,971	15,648,975	26,356,633	39,129,787
Present value of (d) (20%)	–375,231	–358,636	–328,750	650,879	2,597,215	3,648,080	6,095,686	8,026,499	11,828,733	15,366,107
Present value of (d) (30%)	–440,375	–388,523	–328,750	600,812	2,213,011	2,869,314	4,425,620	5,379,174	7,317,548	8,774,636

a. The unit labor cost in 1998 (Year 3) is Rp7,500, and the annual increase is assumed to be 10 percent.
Note: The price of durian in 1998 was Rp7,500/kg and that of mango was Rp6,500/kg. It is assumed that those prices increase by 10 percent every year after Year 4
Source: Internal project documents.

forestry, most farmers had not worked hard to protect their crops from forest fires. The attitude of farmers toward "their" crops and land has become proprietary in nature, even though the Indonesian government still owns the land. This underscores the importance of participation by local residents in sustainable forest management. The benefits of social forestry, such as economic viability and technical assistance, are having a spill-over effect: the number of farmers who are explicitly showing their interest is increasing slowly but steadily.

IMPLICATIONS. Recognizing that reforestation of the Sebulu experimental forest is not feasible without changing farmers' minds about slash-and-burn farming, Sumitomo Forestry opted for social forestry. Since the lives of most farmers are at the subsistence level, social forestry cannot work unless its cash flow generation is at least equal to that from slash-and-burn farming.

We recognize the limits to our datasets because of the small number of samples and the interview method. Moreover, agricultural activities are greatly affected by weather conditions. (The rainy season was dry and the dry season was rainy over the 1997–98 season, but weather in 1995, when data on slash-and-burn farming were collected, was about average.) Damage by animals and insects in specific locations also influenced outcomes. But keeping these limitations in mind, we can say that crop cultivation in the Sebulu experimental forest is more economically viable than slash-and-burn farming. The average cash flow of crop cultivation in eleven locations under social forestry is Rp421,184, and since they raise crops twice a year, annual cash flow is Rp842,368, which exceeds that of slash-and-burn farming, Rp708,850 (Rp236,283 if consideration is paid to the fallow fields). As for fruit tree planting, a rough picture confirms that there will be negative cash flow until the trees bear fruit. Supplemental cash will be needed through crop cultivation. However, future cash flow should be quite high.

Slash-and-burn farming produces fully grown rice in six to eight months, and these farmers are often employed as day laborers in illegal logging during the rest of the year. Although payment for such labor improves the annual cash flow of slash-and-burn farmers, it is just a supplement to their slash-and-burn farming, which is the basis of their lives. Furthermore, the payment to daily laborers is unstable and low, because (1) it is subject to weather, (2) it is illegal, and (3) there is excess labor supply in Sebulu, where the pressure of population growth is high. In these respects, we simply compare the cash flow of farmers in social forestry with that of slash-and-burn farmers, without including the revenue from daily labor. If farmers can enjoy more stable and higher cash flow by raising crops twice a year in social forestry, they need not practice slash-and-burn farming and this will, at the same time, diminish illegal logging.

Several issues must be considered if social forestry is to expand. First, crop cultivation under social forestry uses the land continuously, and land productivity will decrease to some extent. Technical assistance on settled farming provided by Sumitomo Forestry and KTI is expected to counteract this negative impact. Second, in Location 31, yields from crops will decrease because of the increase in shade as dipterocarps trees grow. In the mid-term, moving the farmers to another location within the experimental forest to implement mixed planting of dipterocarps, fruit trees, and crops will enhance both reforestation and social forestry, keeping the farmers' income high and stable.

Although quantitative assessment is difficult, social forestry benefits the environment. In the Sebulu experimental forest, it may have stabilized watersheds and protected forest resources by braking slash-and-burn farming. Degradation of land productivity also may have been prevented.

Despite the above-mentioned outcomes, conditions for duplication in other countries, as well as in other regions of Indonesia, may not be right even though there is a need. In any case there is no single system that consistently outperforms the others, as is made evident by the dispersion in cash-flow generation, even in the Sebulu experimental forest.

Carbon Sequestration by the Sebulu Experimental Forest

The Sebulu experimental forest serves as a carbon sink, which ameliorates rising carbon dioxide emissions. Annual absorption of carbon dioxide and, therefore, the amount of carbon sequestered by the experimental forest can be calculated by using growth projections, such as height, diameter, and survival ratio of representative species of dipterocarps and the fast-growing trees.[12]

Artificial Plantation

During the experimental forest's second stage (1996–2001), replanting was begun following the loss of artificial plantation areas from forest fires in 1998. As of December 1998, a plantation covered an area of 505 hectares with more than 600,000 seedlings. The plan was for an average of 80 hectares to be established in each year from 2000 to 2010. Seventy percent of the seedlings planted are dipterocarps, 20 percent are sungkai, and the rest are acacia mangium and fruit trees. As Table 6-7 shows, it is estimated that trees planted by the end of 1998 will have absorbed 1,984 tons of carbon, and that the experimental forest will absorb more than 39,000 tons of carbon between 1991 and 2010, which corresponds to 146,000 tons of carbon dioxide.[13]

Since most areas within the Sebulu experimental forest have been used for slash-and-burn farming or have been damaged by forest fires and since it is becoming difficult for farmers to keep enough fallow periods, the baseline estimate of carbon sequestration without the experimental forest is considered to be zero. Based on this estimate, the Sebulu experimental forest was approved in 1996 by the Japanese government as the "Japan Programme for Activities Implemented Jointly (AIJ) under the Pilot Phase."[14]

Some readers may feel that the estimated carbon sequestration per hectare in the Sebulu experimental forest from 1991 to 2010, 28.5 tons per hectare, is too small. It should be noted that ages of the trees vary. New area is established every year, so the forest will include seedlings as well as twenty-year-old trees. If the experimental forest consisted of only twenty-year-old dipterocarps trees, it could sequestrate 93 tons of carbon per hectare. One hectare of twenty-year-old Japanese cedar, which is the major species in Japan's forests, can sequestrate 65 tons of carbon.

Reforestation costs can be categorized as seedling production costs, planting costs, and forest development (weeding) costs. Seedlings can be grown in-house from seed or purchased from either Wanariset or the local residents. The order of planting work is clearing, site preparation, stake installation, and actual planting. After planting, early-stage forest development involves weeding and vine removal, with weeding required for the first four to five years after planting (three to four times in the first year, two to three times in the second year, and once or twice annually in years 3, 4, and 5). Each stage of the work can be carried out directly, or it can be

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12. There is no single formula to calculate the amount of carbon sequestration, because the tree growth is affected by various factors such as soil condition and climate. The one employed here is based on data accumulated through Sumitomo Forestry's operation in Southeast Asia.

13. This estimate does not include (1) reduction in carbon dioxide emissions arising from decreases in slash-and-burn farming or (2) absorption by secondary forests in abandoned fields that used to be used for slash-and-burn farming. The research on the latter has been conducted in the experimental forest, and the outcome will be discussed in the next section.

14. At the first meeting of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change, it was decided to establish a pilot phase for Activities Implemented Jointly (AIJ), which could be regarded as a trial phase for Joint Implementation (JI); it is open to developing countries. The estimated amount of carbon sequestration in the application to AIJ is different from that shown in this case study, which incorporated the actual records of artificial plantation after the application.

Table 6-7. Estimated Carbon Sequestration by the Sebulu Experimental Forest, 1991–2010

Year[a]	Areas of artificial plantation (m^2)	Accumulated areas of artificial plantation (m^2)	Accumulated amount of carbon sequestration (carbon tons)			
			Total	Dipterocarps	Sungkai	Acacia mangium
1991	5.0	5.0	1.7	0.3	0.6	0.9
1992	17.4	22.4	13.4	3.5	2.7	7.2
1993	31.0	53.4	51.8	15.1	7.6	29.1
1994	47.2	100.6	143.2	41.4	18.4	83.4
1995	83.1	183.7	333.5	94.8	41.7	196.9
1996	85.0	268.7	684.0	198.0	80.8	405.2
1997	35.4	304.1	1,224.9	359.9	140.9	724.1
1998	100.4	404.6	1,983.8	590.3	243.3	1,150.2
1999	100.0	504.6	3,022.0	951.4	385.9	1,684.7
2000	80.0	584.6	4,348.1	1,449.9	581.8	2,316.4
2001	80.0	664.6	5,947.1	2,116.5	844.6	2,986.0
2002	80.0	744.6	7,815.2	2,988.1	1183.3	3,679.7
2003	80.0	824.6	10,194.6	4,099.8	1,608.2	4,486.6
2004	80.0	904.6	12,911.3	5,487.0	2,128.4	5,295.9
2005	80.0	984.6	16,027.8	7,181.6	2,752.6	6,093.6
2006	80.0	1,064.6	19,612.9	9,218.8	3,488.2	6,905.9
2007	80.0	1,144.6	23,709.6	11,632.7	4,342.8	7,734.0
2008	80.0	1,224.6	28,354.7	14,456.2	5,323.4	8,575.0
2009	80.0	1,304.6	33,587.5	17,724.4	6,432.4	9,430.6
2010	80.0	1,384.6	39,443.9	21,465.1	7,676.7	10,302.1

a. Areas of artificial plantation for 1991 to 1998 are actual records; areas for 1999 to 2010 are planned numbers
Source. Authors' computations.

subcontracted, but it must be in line with the growth in the size of the experimental forest. The subcontract method has been the prevailing method since 1994.

Table 6-8 shows a trial cost analysis of the initial stage of reforestation at the Sebulu experimental forest. Between 1991 and 1993, the preplanting cost for a density of 2,500 trees per hectare was Rp1,097,785 per hectare under direct control; Rp1,225,000 per hectare has been the cost for subcontract planting employed since 1994. The breakdown of the preplanting costs for the 1991–93 period is 56.9 percent for seedling production, 5.5 percent for clearing and site preparation, 19.4 percent for stake installation, and 18.2 percent for planting; there is not a significant difference in the composition when the subcontract is employed. Weeding costs were Rp1,200,000 per hectare between 1991 and 1994; therefore, reforestation costs in 1994 were Rp2,425,000 per hectare, which corresponds to US$1,102 at the exchange rate of US$1 = Rp2,200.

The most recent direct costs of reforestation were estimated to be Rp3,072,500, or US$385 per hectare, at the exchange rate of US$1 = Rp8,000 in 1999. Since the Sebulu experimental forest can sequestrate 28.5 tons of carbon per hectare, the direct cost for artificial plantation in the experimental forest can be recovered, if carbon is traded at or above the price of US$13.5 per ton in the carbon emission trading market.[15]

15. The costs estimated here are direct ones and do not include the administrative costs of KTI, raw material, and equipment costs.

Table 6-8. *Artificial Plantation Costs by Activity, Selected Years 1991–99*
Unit: Rp

Activity[a]	*1991–93 period*	*1994*	*1999*
Seedling[b]	625,000 (56.9%)	750,000 (61.2%)	635,000 (49.9%)
Clearing and ground preparation[c]	60,000 (5.5%)	100,000 (8.2%)	250,000 (19.6%)
Stake installation[d]	212,765 (19.4%)	187,500 (15.3%)	200,000 (15.7%)
Planting[e]	200,000 (18.2%)	187,500 (15.3%)	187,500 (14.7%)
Subtotal	1,097,765 (100%)	1,225,000 (100%)	1,272,500 (100%)
Weeding	1,200,000	1,200,000	1,800,000
Total	2,297,765	2,425,000	3,072,500

a. Direct control was employed during the 1991–93 period; the subcontract method has prevailed since 1994. The daily wage for clearing and ground preparation, stake installation, and planting under direct control was Rp4,000 per day.
b The purchase cost was Rp250 per seedling for the 1991–93 period, Rp300 for 1994, and Rp254 for 1999.
c. Rp100,000 per hectare under the subcontract method.
d. Forty-seven seedlings per person per day for direct control and Rp75 per seedling for subcontract work.
e. Fifty seedlings per person per day for direct control and Rp75 for subcontract work.
Note: 2,500 trees per hectare.
Source: Internal project documents.

Carbon Sequestration of Fallow Forest

There is little agreement on how well slash-and-burn farming fallow acts as a carbon sink. Some say that population pressure is so huge that slash-and-burn farmers become unable to rotate between fields; others say that fallow fields, abandoned as part of the slash-and-burn farming cycle, are soon covered with secondary forest. Although it is not included in the above calculations, the carbon absorbed by fallow forests, which grew in the aftermath of slash-and-burn farming, has been estimated in the experimental forest (Ministry of Forestry, 1995, pp. 84–87).

Before the 1982–83 wildfires, the site of the experimental forest was a lowland evergreen rain forest dominated by dipterocarps, and the above-ground biomass of the forest was 509 tons per hectare. After the fires the area was changed into secondary forest of pioneer species or grassland. Based on plot-by-plot measurement, above-ground biomass of one-year-old forests ranged from 8 to 9 tons per hectare, that of five-year-old forests ranged from 23 to 27 tons, and that of ten-year-old forests ranged from 45 to 68 tons. The estimated mean biomass of tropical dry forest in South and Southeast Asia is 83 tons per hectare, which implies that the carbon storage of fallow forests is considerable.

Based on biomass measurements, carbon storage in fallow forests is an estimated 3.6 to 4 tons per hectare in one-year-old forests, 10 to 12 tons in five-year-old forests, and 20 to 30 tons in ten-year-old forests.[16] Since the tropical rain forest area in the Asia and the Pacific region in 1980 was

16. This may be an overestimation, because the total plot area is small and actual forests have various forest cover types.

19 million hectares and the forest cover that changed to fallow during the 1980s was approximately 5.2 percent, fallow area in the region was 10.35 million hectares (Ministry of Forestry, 1995, pp. 84–87). If the carbon storage capacity of this fallow was equivalent to that in the experimental forest, the new capacity would be 134 million tons. On the other hand, carbon released to the atmosphere by deforestation in Asia and the Pacific region is estimated to be 2,390 million tons. Thus fallow forests absorb 5.6 percent of the carbon released to the atmosphere. These results imply that, if abandoned fields become forests, the carbon storage of those forests is large. Even fallow forests might help to offset the effect of anthropogenic carbon dioxide emissions.

Implications

A model case, the Sebulu experimental forest can encourage other forestry firms in developed countries, especially Japan, to participate in the Joint Implementation (JI) and Clean Development Mechanism (CDM) projects. The experimental forest also represents a small step to recover the ecosystem, especially in terms of biodiversity. Several habitats of the orangutan once existed within the boundary of what is now the experimental forest. However, after forest fires in 1982 and 1983, they were seen less often. Slash-and-burn farming, illegal logging, and repeated forest fires forced them out of the area. As the rehabilitation of the tropical forest with indigenous trees proceeded, the orangutan began to come back to the Sebulu area, as did other animals such as wild boar and deer.

The planting and maintenance of the trees in the Sebulu experimental forest generated employment as well as environmental benefits. Between seventy and one hundred people in Sebulu are daily employed in reforestation.

Research Activities in the Sebulu Experimental Forest

Because of the complexity of tropical forests, sustainable management is difficult. The diversity of tree species in these forests has limited the success of management practices developed under other environments, and uniform management systems are out of place. Unfortunately, financial investment in research and development on genetic tree improvement, ecologically sound silvicultural and management practices, appropriate technologies for the economic recovery of harvestable timber, and commercialization of nontimber forest products have progressed little (D'Silva and Appanah, 1993, pp. 29, 32).

Sumitomo Forestry decided to base the tropical rainforest rehabilitation in Sebulu on the planting of dipterocarps. The unstable supply of seedlings because of this tree's erratic flowering and other characteristics cause a shortage of planting stocks. Tree-growing technology for replication of the original forest is different from that used in commercial forest plantations. Therefore, the company recognized that research and development in a number of areas (such as seed, nursery, silviculture, and genetic improvement of dipterocarps) as well as studies of planting site conditions were necessary for the implementation of the Sebulu experimental forest.

Research and Development

As stated earlier, research and development in the Sebulu experimental forest is implemented jointly by Sumitomo Forestry, KTI, the Forest Research and Development Agency, the University of Tokyo, and the Research Association for Reforestation of Tropical Forests. This institutional setting can effectively facilitate guidelines and input material for experiments, process data, disseminate information, and provide financial resources. The major activities and their outcomes are described in this section.

Pedological, Edaphological, and Geological Studies. The bedrock in the Sebulu experimental forest is made up of thin rock layers composed of various elements such as sulfur, iron, manganese, calcium, and phosphorous. The bedrock additionally contains a seam of coal, surrounded by rock layers containing iron sulfides, a source for acid sulfate soil. The soil distributed throughout the forest area has inconsistent chemical properties, leading to disparity in levels of trace soluble ferric and manganese and metathetic calcium. The soil's overall characteristics are a pH around 5; a carbon content of 2 percent in the 10 to 20 centimeters deep A-horizon, signifying a lack of organic matter; and an extremely low percolation speed in the subsoil.

The physical properties of the soil are thought to have an effect on the growth of the trees. A marked disparity in the growth of planted trees in the Sebulu experimental forest led to the establishment of experimental plots and the examination of the chemical and physical properties of the soil, the root growth, photosynthesis, and the nitrogen content in foliage. Comparison of a plot where trees had reached a height of around 4 meters within a year of planting and a plot where trees had reached only about 1 meter in the same period revealed that the soil in the poor-growing plot was hard and compact, and roots had not penetrated below a depth of 12 centimeters. It is believed that the underdeveloped root system had retarded absorption of nutrients and water and stunted the growth of the trees.

The acid sulfate soil is highly acidic and not suitable for the growing of plants. The area is not suited to forestry.[17] In cases where planting is intended to rehabilitate degraded or spoiled land, however, acid-tolerant tree species such as *Acacia mangium* would be apt. *Shorea roxburghi* of dipterocarps is also acid tolerant and can survive in the area of sulfurous soil in the experimental forest; however, growth is slow.

The poor permeability and porosity of the soil affect the survival rate of any seedlings, and further research is required to determine the optimum size of holes for seedling planting. To study the possibility of planting in hard-soil areas, Sumitomo Forestry began experimentation in 1999 on growth enhancements through cultivated planting.

Seedling Nursery. From results of research on environmental conditions for a seedling nursery, it is evident that the stomatal reaction to light and the air, including vapor-pressure deficit, is highly sensitive to varying soil conditions (such as the presence of soil moisture and the inhibition of root growth). Additionally, dipterocarps trees are highly adapted to dry soil conditions because they are able to offset water loss through transpiration by decreasing foliage when the soil gets dry. Given sufficient soil moisture, they increase foliage to grow actively. Based on this, it can be speculated that once dipterocarps trees have fully rooted, normal dry soil conditions will not lead to trees dying.

The key issue in the planting of trees in open areas where they are exposed to direct sunlight, as occurs for fields after slash-and-burn farming, is the rooting rate. Traditionally, dipterocarps seedlings are said to not survive in open areas exposed to sunlight. In the experimental forest potted seedlings of seven varieties of the *Shorea* genus were nursed in both shaded and open areas, and the relative growth rates were compared. For *Shorea leprosula*, seedlings grown in open areas showed better growth in terms of both the diameter at the base of the trees and root development. For *Shorea stenoptera*, on the other hand, the seedlings grown in shaded conditions grew faster. For the remaining five varieties, no significant difference in growth for the two condition

17. Block 88 and Location 31 for social forestry are two of the better quality areas within the experimental forest. Plans are afoot for analysis of the physical and chemical properties of the soil in these areas and research on the correlation between soil quality and crop yield rates.

types was seen. The leaf area weight of all varieties other than *Shorea seminis* was greater for unshaded seedlings (Ministry of Forestry, 1996, pp. 68–72). This research demonstrated that, except for a few selected varieties, it is possible to produce sun-resilient hardy seedlings.

Based on these research findings, high mortality rates for dipterocarps in open area planting are attributable to nursing techniques and planting methods rather than to the low tolerance of the species to exposed conditions. Most deaths in planted seedlings occur in the few months of relatively high rainfall, when trees are not going to be affected by dry soil conditions.

It is now well known that introducing ectomycorrhiza to the root zone improves the availability of nutrients to tree roots, but when the experimental forest was established, there was little research on root inoculation techniques during nursing. It is not practical to manually inoculate around 100,000 seedlings, and some cheap, simple, and reliable method of inoculating seedlings to the maximum effect was required.

In 1992 Sumitomo Forestry's Tsukuba Research Institute experimented with inoculation of potted dipterocarps seedlings on trays in a greenhouse. Trees near the inoculated plants became infected by way of mycorrhiza spreading between neighboring pots through holes in the pots, and growth was more rapid than for uninfected seedlings. To investigate the practical implications of these results in nursery plots, a 1 meter by 5 meter bed was established within the experimental forest in February 1994, and 1,155 potted seedlings were used to verify the effect when trees inoculated with *Scleroderma* fungi were planted at 2 meter intervals. Trees close to the inoculated trees tended to grow taller. As the distance from inoculated trees increased, the proportion of relatively small trees grew. Mycorrhizae occurred more frequently nearer the inoculated trees. The evidence demonstrates that by planting inoculated trees at various points in the nursery bed and having the *Scleroderma* infect other plants through subsoil mycorrhiza, large quantities of seedlings in a nursery bed can be inoculated (Sota, 1995, pp. 171–95). This method is currently being employed within the Sebulu experimental forest, and there is additional ongoing research into the relation between the potting-mix soil morphology and fungus infection. The aim of the research is to develop a soil type that supports consistent, reliable infection.

The growth of seedlings and the success of seedling production are affected greatly by the type of media placed in the pot with the seedling. In 1994, in an attempt to develop the optimum potting mix, seedlings were planted in thirty-five different forms of soil made up from various combinations of red soil, sand, surface forest soil, NPK, TSP, urea, cow manure, and other substances. This revealed that fertilizer made up from a combination of organic cow manure and the chemical fertilizers NPK and urea produced the best growth rates. Use of organic fertilizer is desirable wherever possible. The seedling mix now utilized in the experimental forest is 70 percent lower stratum red soil, 10 percent cow manure, and 20 percent sand. Research continues on the optimum soil for nursing seedlings.

Around 170,000 dipterocarps seeds were obtained from the upper reaches of the Mahakam River in February 1994. Then full-scale production of seedlings from seeds commenced utilizing the research outcomes.

PLANTING. Four different planting methods were tried: open planting, where trees are planted in completely cleared plots; line planting, where strips between 6 and 20 meters wide are cleared for planting; gap planting, where a square with side lengths between 5 and 20 meters is cleared for planting; and planting under canopy, where the forest is thinned and grounded after planting. For open planting, trees were experimentally planted at different densities. The major difference in the planting environment for seedlings comes in the degree of exposure to direct sunlight, which is longest in open planting, diminishes for line and gap planting according to the width of the cleared area, and is shortest in planting under canopy.

According to the traditional wisdom, saplings of dipterocarps will not survive in open areas exposed to bright light. Dipterocarps seedlings reportedly exhibit greater root taking and growth rates when nurtured in lightly shaded conditions than when grown in open areas. However, in experiments within the Sebulu experimental forest, seedlings grew to nearly 2 meters in a year even when open planted, suggesting that according to soil and other environmental conditions, they will grow sufficiently even in bright light. All areas used for planting trials had been used for slash-and-burn farming. They differed in the types of vegetation and trees growing naturally on them, according to the amount of time that had elapsed since being cleared. The particular planting method for a given area is selected based on the purpose of the planting experiment and the state of natural vegetation on that site.

The six most common varieties of dipterocarps were tested for reforestation suitability. Their survival and growth rates were followed under the four planting methods. Generally speaking, trees planted under canopy took root the best, whereas open-planted and widely line-planted trees grew the fastest. *Shorea leprosula* and *Dryobalanops lanceolata* both root and grow well in direct sunlight and are considered the most suitable varieties for reforestation because of the ready availability of seedlings. The next most suitable varieties are *Shorea multiflora* and *Shorea ovalis*. *Shorea seminis* grows slowly and is labor intensive since it requires weeding of the surrounding area. *Shorea paciflora* has the lowest survival rate of the six varieties tested and is a slow grower, so it is perhaps best for planting under canopy. Based on the findings of these physiological and ecological characteristics, different varieties of the same dipterocarps genus appear to have different developmental qualities, and no single planting method is going to be optimal for them all. Collecting more varieties and carrying out planting experiments on them will increase the number of varieties suitable for reforestation purposes.

Tissue Culture Technique. The seedling production costs account for nearly 60 percent of preplanting costs. The price per purchased seedling was Rp250 between 1991 and 1993, and Rp300 in 1994. The cost of growing seedlings from the seed, including seed collection costs, was Rp68.5 per tree. It is apparent that the cost of in-house growing of seedlings from seed is as much as 80 percent cheaper than purchasing ready-grown seedlings. By switching to in-house seedling production and pegging back the nearly 60 percent share of overall costs occupied by seedling production, growers can reduce reforestation costs dramatically. Since 1994 the experimental forest has switched over extensively to in-house seedling production.

However, there is unavoidable instability in seed supplies, since dipterocarps release seeds only once in several years, and the number of mother trees is decreasing rapidly. Even if seeds were available, they remain viable only for a relatively short time (one or two weeks). To alleviate this, it is vital that large-scale cutting techniques through genetic improvement are developed.

The company has succeeded in establishing a tissue culture technique that makes mass propagation of *Shorea roxburghi*, one of the dipterocarps species, possible for the first time anywhere in the world. Multiple shoots were induced from a shoot apex. Many shoots elongate from those multiple shoots, which can be proliferated repeatedly. Large numbers of high-quality plantlets can be produced in a short time regardless of the season. Moreover, it will be possible to produce clones of "elite" trees with desirable characteristics such as varieties resilient to disease and insect damage and those that bear high-quality wood.[18]

This propagation technique enhances the rehabilitation of tropical forests that were damaged by forest fires or slash-and-burn farming in recent years. It may be applied to generate other tree

18. For details, please refer to the Web site of Sumitomo Forestry Co., Ltd. (http://www.sfc.co.jp/rainforest.htm).

species whose seeds have short periods of viability, a typical characteristic of many tropical trees, thereby helping to conserve and protect the genetic resources of such trees from extinction. If applied to yield improvement and nitrogen fixation, social forestry can extend to such regions of marginal soil where subsistence agricultural production on a small scale has persisted. Thus sustainable forest management, especially social forestry, in Sebulu is expected to benefit from further application of tissue culture techniques.

The Sebulu experimental forest was not initiated as a business of the Sumitomo Forestry Company but as a purely social activity. No commercial returns were expected. The experimental forest put Sumitomo Forestry in a win-win situation, however, because it could develop the tissue culture technique, which will be protected by patent.

Dissemination of Research Outcomes

Outcomes of research activities in forest management often are poorly disseminated. The financial resources available for research and development are limited, and most of the funds are spent on research in lieu of dissemination of research results. The personnel rotation system of many forestry projects supported by developed countries keeps experts and consultants at the project sites for two to five years. This short stay often undermines the continuity of the research activities, and valuable observations and research results are not applied.

KTI and Sumitomo Forestry have developed a sense of mutual trust and achievement through their long-standing partnership in Indonesia. For the furtherance of the Sebulu project and diffusion of technology, an environment must be provided in which researchers from Japan can reside for long periods. This would be difficult without the mutual trust and support of the local residents.

Furthermore, capable local staff must be secured by KTI in order for the forest to be managed smoothly and technology diffusion to take place. Fortunately, many former KTI field staff were still living in Sebulu Ule village, and they have acted as integral members of the project administration team from the inception of the experimental forest to the present. Under their supervision, younger staff members have been trained as local administrative staff who plant and measure the growth of the forest and accumulate experimental data. Traditional local skills acquired when the stand started as a timber concern more than twenty years ago are being resurrected as reforestation skills. Indeed, the skills of the local people help technology diffusion to progress well.

Successful transfer of research outcomes requires capable staff hired locally, foreign staff who speak the local language, an equal partnership between local and foreign staff, and diffusion of the latest technical skills through locally available materials and tools.

Lessons Learned from the Sebulu Experimental Forest

The final outcome of the Sebulu experimental forest is yet to be seen, since it takes many years for trees to grow and social forestry was initiated only a few years ago. Despite criticism that most of the social forestry projects in Southeast Asia have not been successful, we can say that the experimental forest has been on the right path to achieving its initial objectives: replication of the conditions of the original tropical forest as closely as possible and stabilization of and improvement in the income level of the local community. This concluding section draws lessons from the Sebulu experimental forest that may be applicable to reforestation and social forestry projects in other countries.

Factors for Success: Applicability to Other Countries

No one model will be effective in all cases. Projects are subject to the particular constraints and opportunities existing in the local communities. In the Sebulu experimental forest the strong tie between the Japanese forestry industry and Indonesia was important. The unique setting for this project, however, does not preclude the applicability of the win-win approach to other countries. Planners should consider successful practices in existing projects to see if at least some of them can be adopted.

The success of the Sebulu experimental forest is attributable to several factors. First, a private firm took the initiative for the project. It developed the technique and technology necessary to replicate the original tropical forest. As stated before, it is difficult to propagate dipterocarps, which are indigenous to Kalimantan. The firm's know-how in forest management based on its long-term operations in many countries, including Indonesia, and on-site research and development activities made it possible to restore not only the forest of dipterocarps but also the original ecosystem in the region. The Sumitomo Forestry Company had less administrative overlay and more autonomy than other entities. Without the initiative by such a company, the stakeholders, including local people, would have relied on fast-growing trees or easy-to-propagate trees exotic to the project sites. Advanced knowledge was translated into easy-to-understand words, and the equipment necessary for the implementation of the experimental forest was locally procured. This enabled the technique and technology of reforestation to be easily used by the local people.

A second factor in the Sebulu success story is the long-term commitment of Sumitomo Forestry. It initiated the project out of social considerations based on corporate philosophy and because research and development was needed to propagate dipterocarps. In its implementation of social forestry, the company took steps to provide farmers with techniques and knowledge regarding more productive settlement cultivation. This kind of commitment strengthens the local community's awareness of the Sebulu experimental forest, thereby increasing the participation of former slash-and-burn farmers. Again, serious consideration needs to be given to business entity initiatives in order to facilitate long-term follow-up.

A third factor is the data and information collected in the preparation and implementation processes. Planners need information from prospective participants in order to define objectives and approaches properly (Gregersen, Draper, and Elz, 1989, pp. 119–30). In the case of the Sebulu experimental forest, a survey team led by a professor was dispatched three times to design the basic concepts of the project. Information about the local communities was accumulated during the long-term operation of Sumitomo Forestry. This helped the mission reach the decision for social forestry. Once the project was implemented, the *Economic Survey* was taken so that Sumitomo Forestry could understand the priorities of people in the local community and the resources available to them in the Sebulu region. Observation of physical conditions, such as types of crops, conditions of trees and crops, and conditions of soils, by KTI staff has been providing information necessary for adjustments.

Fourth, cooperation with the local community was a priority. In Indonesia land is owned by the government, and the government gave KTI the right to use the area for the experimental forest. Slash-and-burn farming is still competing with the experimental forest for the land. However, the company never tried to expel slash-and-burn farmers from the experimental forest, even when it encountered them cutting trees. The law may hold no meaning for these farmers; enforced banishment would have generated tension between farmers and the company, undermining the existence of the experimental forest. Sumitomo Forestry tries to communicate with slash-and-burn farmers and then allows time for them to understand the importance of the forest as well as the benefits from social forestry. In addition, it emphasizes the dissemination of information from farmers participating in social forestry to slash-and-burn farmers.

The priority given to the local community is also observed in human resource management. Although Sumitomo Forestry has provided the initiative and the financial, technical, and technological support, the actual implementation has been done by KTI. Its staff consists of local people with only one Japanese expert from Sumitomo Forestry. The local staff, who have discretion in the daily operations, attract the interests of the community, because they are a part of the community.

A fifth factor contributing to the project's success was sufficient infrastructure for starting the experimental forest. In 1970 KTI was established, and it has remained committed to selective cutting to maintain forest resources. Human resources and physical infrastructure (roads, schools, and other public facilities that KTI provided during its heyday) have been maintained, even after KTI was forced to stop its operations in 1983. There are many former employees with forest management know-how as well as sympathy toward Sumitomo Forestry. The company, on the other hand, has acquired knowledge of local organizations and economic structures. These strong ties with Indonesia, especially in the Sebulu area, have facilitated cooperation with the local community. Sumitomo Forestry admits that it could not have been involved in reforestation in Latin America, where it has no ties, because a relationship of trust with the local people is a prerequisite for gaining support for social forestry. However, the experience of the Sebulu experimental forest bodes well for North-South cooperation such as between European firms and African countries and between U.S. firms and Latin American countries.

Sixth, the Sebulu experimental forest involves the private sector, the public sector, and academia under the umbrella of the Research Association for Reforestation of Tropical Forests (RETROF). Cooperation between Sumitomo Forestry and the University of Tokyo has been mutually beneficial. The experimental forest serves as a site of field research and experiment for faculty members and students, and Sumitomo Forestry can mobilize the university's resources for its research activities in dipterocarps propagation. Financial support by the Japanese government, through RETROF, has enhanced the technological cooperation between Sumitomo Forestry and Indonesia. Promotion of across-the-sector research for reforestation helped to speed up the research activities in the experimental forest. This framework is a model for collaboration between the private, public, and academic sectors in various countries.

Future Tasks

The Sebulu experimental forest is still ongoing, and many tasks remain for the future. For example, the ultimate success of the experimental forest will occur when it no longer requires financial, technical, and technological assistance from Sumitomo Forestry and RETROF. In order for the experimental forest to become self-reliant, local farmers need to accumulate more know-how, and the experimental forest must be able to generate its own operational resources. In response to population growth around the experimental forest, social forestry needs to expand. There is no end to the line of farmers who claim land tenure within the boundary of the Sebulu experimental forest. As the number of those farmers increases, the "no-concern-for-speed" approach to social forestry is no longer manageable.

By itself, the Sebulu experimental forest cannot end the deforestation caused by slash-and-burn farming. Plantation of dipterocarps via the tissue culture technique is not a panacea; nor is social forestry. The main problem lies in the system of landed property rights. Unfortunately, this issue is out of the control of Sumitomo Forestry, and we can only suggest that the Sebulu experimental forest be used as an example to encourage proper management of land by the authorities. Also beyond the control of Sumitomo Forestry is the stability of the social and economic situation in the region. Although remote from Jakarta, the Sebulu region is not insulated from the disturbances arising from political turmoil and price hikes.

References

AKK. 1997. *Budidaya Durian.*

Bega, Kalie M. 1994. *1994 Budidaya Rambutan Varietas Unggul.*

D'Silva, Emmanuel, and S. Appanah. 1993. *Forestry Management for Sustainable Development.* EDI Policy Seminar Report, 32. Washington, D.C.: World Bank.

FAO (Food and Agriculture Organization of the United Nations). 1992. *Forest Resource Assessment, 1990.* Rome.

———. 1998. *State of the World's Forests, 1997.* Rome.

Gregersen, Hans, Sydney Draper, and Dieter Elz, eds. 1989. *People and Trees: The Roles of Social Forestry in Sustainable Development.* EDI Seminar Series. Washington, D.C.: World Bank.

Japan International Cooperation Agency. 1991. *Domestic Committee on Forestry Sector Projects.* Tokyo.

Mahisworo, Kusuno Susanto, and Agustinus Anung. 1994. *Bertanam Rambutan.*

Ministry of Forestry of the Republic of Indonesia, P.T. Kutai Timber Indonesia, Sumitomo Forestry Co., Ltd., and the University of Tokyo (shortened to Ministry of Forestry in the text). 1993. *Research Report on the Sebulu Experimental Forest 1992.*

———. 1994. *Research Report on the Sebulu Experimental Forest 1993.*

———. 1995. *Research Report on the Sebulu Experimental Forest 1994.*

———. 1996. *Research Report on the Sebulu Experimental Forest 1995.*

———. 1997. *Research Report on the Sebulu Experimental Forest 1996.*

———. 1998. *Research Report on the Sebulu Experimental Forest 1997.*

Mitsuhashi, Tadahiro. 1997. *Mori to CO_2 no Keizaigaku (Economics of Forests and Carbon Dioxide).* Tokyo.

Onny, Untung. 1996. *1996 Durian Untuk Kebun Komersial dan Hobi.*

Rahamat, Rukmana. 1995. *1995 Papaya Budidaya dan Pasca Panen.*

———. 1997. *Mongga Budidaya dan Pasca Panen.*

Sasaki, Satohiko. 1997. *Nettairin Saisei Gijutsu Kenkyu Seika Hokokusyo (Report on Research Concerning the Reforestation of Tropical Forests).*

Sota, Akira. 1995. "The Development of Nursery Methods for Dipterocarps Trees Using Ectomycorrhiza." *Research Report of the Research Association for Reforestation of Tropical Forests.* Tokyo: RETROF.

Suhardiman. 1997. *1997 Budidaya Pisang Cavendish.*

Sumitomo Forestry Co., Ltd. 1998. *Sumitomo Forestry Annual Report 1998.* Tokyo.

Westoby, Jack. 1989. *Introduction to World Forestry: People and Their Trees.*

World Bank. 1994. *Review of Implementation of Forest Sector Policy.* Washington, D.C.

World Resources Institute, the United Nations Environmental Programme, the United Nations Development Programme, and the World Bank. 1997. *World Resources 1996–1997.*

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