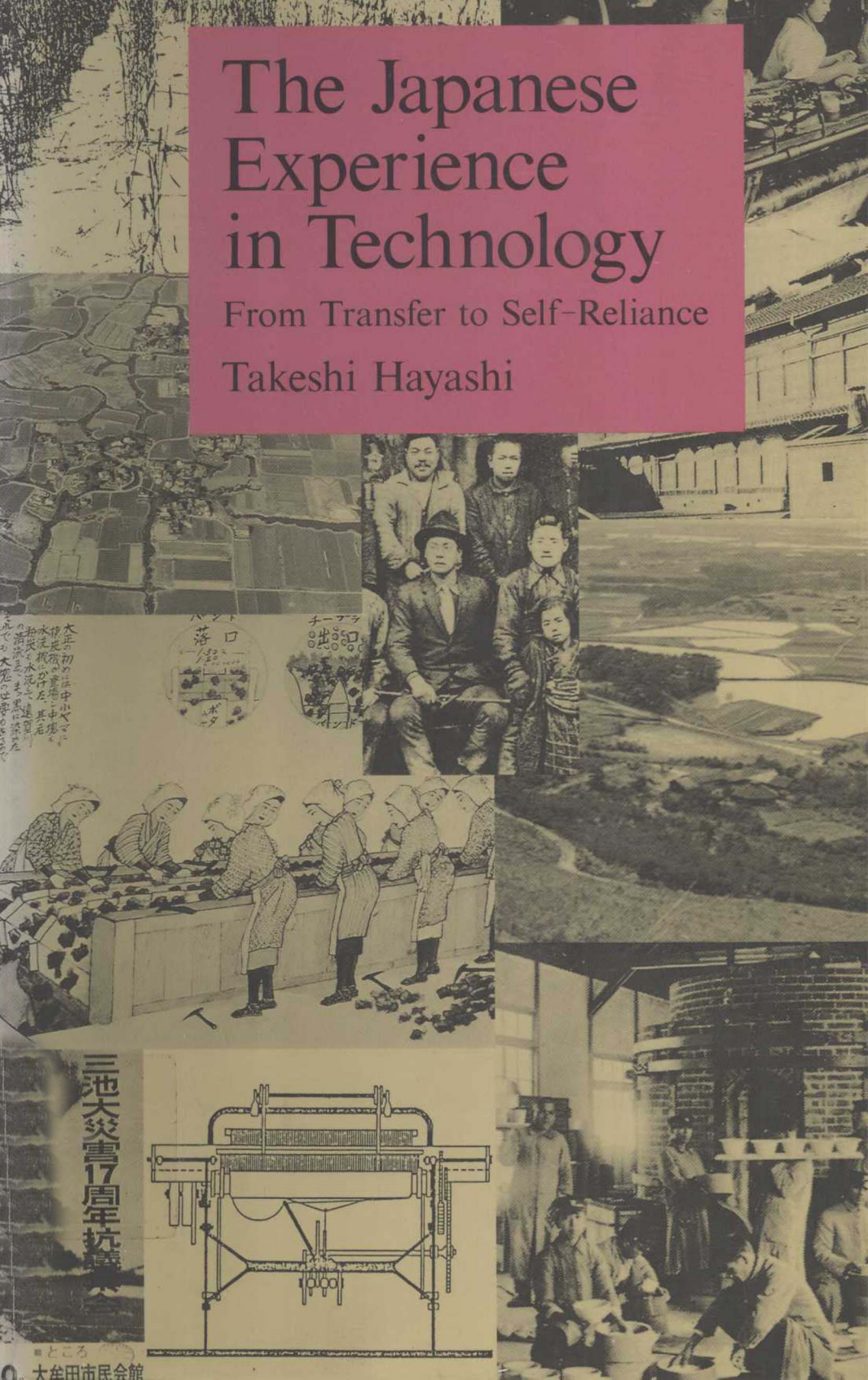
# The Japanese Experience in Technology

## From Transfer to Self-Reliance

Takeshi Hayashi



# The Japanese Experience in Technology: From Transfer to Self-Reliance

**Takeshi Hayashi**

United Nations University Press

The United Nations University project on Technology Transfer, Transformation, and Development: The Japanese Experience was carried out from 1978 to 1982. Its objective was to contribute to an understanding of the process of technological development in Japan as a case study. The project enquired into the infrastructure of technology, human resources development, and social and economic conditions and analysed the problems of technology transfer, transformation, and development from the time of the Meiji Restoration to the present. The research was undertaken by more than 120 Japanese specialists and covered a wide range of subjects, including iron and steel, transportation, textiles, mining, financial institutions, rural and urban society, small industry, the female labour force, education, and technology policy.
This volume constitutes a broad overview of the interaction between technology and development in Japan since the Meiji period.



United Nations University Press
The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome,
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# Preface

The United Nations University asked the Institute of Developing Economies in Tokyo to analyse what made it possible for Japan, once an importer of foreign technology, to become an exporter of its own technology.

What prompted the University to propose this was no doubt its realization that the solution of current development problems in the developing countries is a matter of global importance and that, for the development of each, technology transfer leading to self-reliance is necessary.

In addition, to delve into the history of industrial technology in modern Japan from the perspective of the development problem presented us with an interesting academic challenge. One principal difficulty, however, was also anticipated: the current thrust of comparative technological studies in Japan, in both academic and business circles, is overwhelmingly centred on comparison between Japan and the West, ignoring the third world.

Although not all the difficulties faced in our project, with its emphasis on field studies, were overcome, we were fortunate in securing the ready co-operation of more than 120 experts from all parts of Japan in various fields of industrial technology. The project involved a year of preparatory work and another year of editorial work, and the Institute of Developing Economies covered all expenses for several staff members assigned to the project. The contribution from the United Nations University went to research activities and also to building a network both within and outside of Japan.

More than 120 interim papers and 20 volumes of reports were produced during and after completion of the project. Of the reports, 9 volumes have already been published—in Japanese—by the United Nations University and have been well received. Moreover, besides the present volume, a single-volume English translation-adaptation of two of the Japanese reports has been published by the UNU (*Vocational Education in the Industrialization of Japan*). The remaining reports—10 of which have been translated into English—await publication.

This book is a final report of the whole project on the "Japanese experience." The author served as the project co-ordinator, and though a great part of the information has depended on the project reports, this is not a summary of those reports. Instead, it is an independent work, although its subject and that of the reports supplement each other. Nevertheless, the author's views do not necessarily coincide with those expressed in the reports.

Since the aim of the present book is to provide materials for our "dialogue" with those in the developing countries who are responsible for the planning and administration of national development, in chapter 1 I have added an outline of the history of Japanese industrial technology after World War II, which had not been taken up in our project.

To facilitate more effective dialogue, I also present a theoretical framework: the five Ms constituting technology and the five stages of development, from technology transfer to self-reliance in technology. This framework is useful in explaining the roles played by the four chief industrial branches (iron and steel manufacturing, railways, mining, and textiles, or five if we add the shipbuilding sector, which became a supply source of domestically produced machines that could be used in mining and other branches) in the early years of industrialization in Japan and the links between them and industrial policy.

Our project was unable to cover such important industrial branches as the electrical industry or earthquake-resistant construction. Later research by this author found that the role of the food industry was also important. The OEM (original equipment manufacturer) system, commonly employed in today's electrical and machinery industries, had already been established in the food industry more than 100 years ago. This fact could have bearing on our understanding of biotechnology.

Although Japan was fortunate in having such native technologies, some 60 years were necessary for it to accomplish the first stage of industrial revolution, through technology transfer, and to form a national technology network. In the 1920s, the aforesaid four chief industrial branches and the hydraulic power industry were able to establish links among themselves on a minimal scale and at the lowest level, ensuring a "point of no return." The last to enter that process was the chemical industry, which benefited from the delaying of imports during World War I, followed by rapid growth of the machinery industry in the 1930s after the Great Depression.

Besides the external conditions favouring it, the Japanese economy was able to rehabilitate itself so rapidly in the face of the devastation caused by World War II because four of the five Ms were already in place at notably high standards.

Only after the 1970s did the links among the Ms grow deep enough and wide enough for Japan to become a genuine technology-exporting country, but even before that, Japan had won the world's top position in some technology sectors. It took Japan 120 years to attain high technological development, but that was only half what the West had required. And it is likely that Japan's Asian neighbours will require even less time, say half what it took

Japan, to catch up. An industrial revolution through technology transfer is possible, even if beset with sizable difficulties.

It has often been misunderstood that the latest technologies would prove the ones most appropriate for national development. In Japan's case, it did not always adopt only the latest technologies. When it did, it did so because that technology was considered to be the most appropriate.

It should be noted that the choice to transfer the latest technology is possible only after a country has attained primary self-reliance in technology, at which time it should then purchase only the necessary technological systems, ones without high social costs and conflict.

Self-reliance in technology does not mean autarky. Today's technologically advanced countries are not autarkic in technology. Self-reliance in technology refers to the ability to absorb all needed technologies, and the attainment of this self-reliance is accomplished not at a stroke but in stages.

The more advanced a technology is, the wider its links will be and the higher the level at which it will establish itself as a working engineering system. In other words, advanced technology requires high-level, intricate links between itself and technological pre-conditions and between itself and related services. This requirement explains the reason the technology gap between the North and South tends to widen. The question of utmost importance to a developing country is, therefore, how to form its national system of technology at a minimally effective scale and level.

Since its first stage in acquiring technological self-reliance Japan has been dependent on foreign countries for most of its raw materials, and this characterizes its development in technology. Technological development follows a spiralling rather than a straight path, and the question as to which sector of technology a country with a specific resource position may decide to start with is a matter of national consensus.

There is the "textile first" theory of industrialization, but, while it may describe the approach taken by the industrialized countries, it is not necessarily the path of development other countries should follow. A country may well begin its industrialization with power development, food processing, or communications and transportation. The conditions under which industrialization begins cannot be the same for every country; the only common element required is that a national consensus be formed.

One reason Japan could successfully absorb foreign technology in the nineteenth century was because most of the technology and machinery in those days consisted of an assemblage of assorted technologies. Some machines could be dismantled into separate components, and these components could be replaced by parts produced locally through the traditional skills of carpenters, blacksmiths, stone-cutters, metalworkers, etc. Although replacements were often less efficient and poorer in quality, they satisfied national needs in being less expensive and easier to maintain. The repetition of this process made it possible to eventually turn old technologies into new ones.

As with language, imitation is an important step in learning. This step can

be very much enhanced by making a thorough examination of traditional skills and technologies. Regrettably, this is not being done in many of the developing countries, where even basic data on meteorological, geological, and hydrological conditions and on natural resources are incompletely available. This is an area where international co-operation would be both useful and necessary, but even then, full use of the empirical knowledge of the local populace should be made.

Toward the end of the nineteenth century, Japan climaxed a decade of trial and error in the spinning industry by catching up with India, then an advanced country in this technology. This was possible because in Japan the basic spinning process was subdivided. After workers had acquired the skills of one process, they were transferred to another. This was an unusual but effective on-the-job method of developing worker skills. Although it proved successful in Japan, it may not elsewhere, especially in countries where the system of technology management is largely based on functionalism and where job-hopping among workers and engineers is common. Further, in Japanese industry generally, this style of training has been combined with the distinctive qualities of the Japanese engineer and with such practices as lifetime employment, rare in other societies.

The point is that every country must find its own way of development. However successful the Japanese experience may appear to be in the eyes of other nations, it was an experience unique to Japan and not one for other nations to follow to the letter. All the Japanese can do is attempt to answer questions about its success and contribute something to the information developing countries need as they search for their own development.

Our project differs in approach from conventional studies, and we have given consideration to such areas as vocational education, general trading companies, cottage industries, and problems of pollution. We hope the information provided here will lead the reader to the more detailed information contained in our individual reports.

Our project on the Japanese experience was first proposed by Professor Mushakoji Kinhide, vice-rector at the United Nations University, and the University's Dr. Uchida Takeo contributed much help as the project moved along. In bringing out this English edition, particular mention must be made of the good offices of Mr. Noguchi Noboru in getting the Grant-in-Aid for Publication of Scientific Results from the Ministry of Education, Science and Culture. The author's deep gratitude is due to these persons and to all those concerned with our project. It is his great pleasure that this work is being brought to the attention of English-language readers.

Also, for much of the work on which the book is based, as with the other books in this series, the author owes a great deal of thanks to his colleague, Professor Tada Hirokazu, and to others at the Institute of Developing Economies who worked under his co-ordination in bringing the project to fruition. The translation into English was done by Mr. Yamauchi Takeo and Mr. Nakai Masao, the author's former colleagues at the Institute. Indi-

vidual names of others involved are not given here, but the author is in deep gratitude to all of them.

Takeshi Hayashi
Project Co-ordinator

Technology Transfer, Transformation, and Development:
The Japanese Experience
Project Co-ordinator, Takeshi Hayashi

*General Trading Companies: A Comparative and Historical Study*, ed. Shin'ichi Yonekawa
*Industrial Pollution in Japan*, ed. Jun Ui
*Irrigation in Development: The Social Structure of Water Utilization in Japan*, ed. Akira Tamaki, Isao Hatate, and Naraomi Imamura
*Role of Labour-Intensive Sectors in Japanese Industrialization*, ed. Johzen Takeuchi
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*The Japanese Experience in Technology: From Transfer to Self-Reliance*, Takeshi Hayashi
*Vocational Education in the Industrialization of Japan*, ed. Toshio Toyoda

The United Nations University (UNU) is an organ of the United Nations established by the General Assembly in 1972 to be an international community of scholars engaged in research, advanced training, and the dissemination of knowledge related to the pressing global problems of human survival, development, and welfare. Its activities focus mainly on peace and conflict resolution, development in a changing world, and science and technology in relation to human welfare. The University operates through a worldwide network of research and post-graduate training centres, with its planning and co-ordinating headquarters in Tokyo, Japan.

The United Nations University Press, the publishing division of the UNU, publishes scholarly books and periodicals in the social sciences, humanities, and pure and applied natural sciences related to the University's research.

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Part I

# Overview

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# Development and Technology in Post-war Japan

## Japan in the World

Japan's share in the total GNP of the world was 9.0 per cent in 1980, a position exceeded only by the United States and the Soviet Union.

Because at the beginning of the twentieth century Japan accounted for a mere 1 per cent of the world's total GNP, compared with 30 per cent for the United States and 20 per cent for the United Kingdom, this rapid structural change, and the Soviet Union's rise to second position, are remarkable. The changes in the scope and the structure of the world economy are readily apparent in the 1980 shares of world GNP held by the United States and the United Kingdom, 21.9 per cent and 3.6 per cent, respectively.

In terms of per capita GNP, Japan has achieved a level comparable to that of both the United States and the United Kingdom, inasmuch as its population is slightly more than half that of the United States and slightly less than that of the United Kingdom. In other words, over the past 80 years, the Japanese economy has grown 30 times as fast as the US economy and 20 times as fast as the UK economy. However, this is merely a matter of flows; in stocks, it should be noted, unfavourable gaps remain for Japan compared with either the US or the UK, the latter especially.

With regard to the power of a nation to influence the international community, the United States and the United Kingdom are in a far better position than other nations because English is a nearly universal language. The Japanese language, on the other hand, is not even treated as an official UN language. Thus, when it comes to the question of a country's international political influence, its economic power is not always the decisive factor; this is obvious in the examples of China and India.

Taking population as a criterion, a country with a population of more than 100 million may be regarded as big, but Japan has barely enough population to enable it to count itself among the big countries. Even the United States and the Soviet Union are far smaller in this regard than China and India.

A country with less than US$10,000 per capita national income and less than 100 million population may not be expected to make effective use of a full set of modern technologies because it cannot realize economic efficiency at a level these technologies would require.

Judged, then, in different aspects, Japan may fall outside the group of front runners, but it may be inappropriate to place it among the second-group runners considering the great distance between the two groups. Seen in terms of its industrial power and its governmental system, Japan is Western, but culturally it remains Asian.

Beginning in the 1960s and continuing for more than a decade, the Japanese economy was able to achieve what was then called a miraculous annual growth rate exceeding 10 per cent. Though this was in many ways ascribable to the previous low level of its economic development and to the nation's recovery from World War II, it also reflected the rapid expansion of the scope of production through technology transfer.

Worth noting here is the difference between Japan and the other industrial countries in how it coped with the oil crises of the 1970s, an epochal situation in contemporary history that threw most of the world into hard times. Whereas most countries viewed the crises as a stoppage of the oil supply, Japan saw them as signs of the need to rationalize through technological innovation.

When the economies of the industrially advanced nations were confronted by stagflation, and the United States, which had led the post-war world, suffered a growth rate that had declined to as low as 3.5 per cent (the EC countries had an average of 3.1 per cent), Japan managed to maintain a growth rate not lower than 5 per cent. By the end of the 1970s, much to the perplexity of the Japanese, the world looked to Japan and West Germany to play the role of locomotive, to pull the world economy out of its recession.

It is beyond my ability to fully answer the question of how Japan managed to surmount the crises of the 1970s. One answer that has been offered relates the Japanese success to its capacity for technological innovation, and without doubt, technology has contributed much to the high economic growth rates of Japan since the mid-1960s, a ratio of contribution calculated at 30 per cent. Just as it managed to tide over the oil crises that had brought the high-growth period to an end, Japan also managed to overcome the difficulties caused by industrial pollution that emerged in the 1960s and 1970s by developing technologies to control or prevent pollution and others to conserve energy. These accomplishments brought world recognition to Japan as a technologically advanced country.

Is Japan the front runner of the developing countries, or is it running on the heels of the developed countries? It may be that it has elements of both. In some technologies, though, it is without doubt a leader.[1]

From the time we undertook this project, and especially since 1980, an unusually keen world-wide interest has centred on technology. It seems that the second oil crisis, in 1979, and the ensuing economic difficulties compelled many countries to seek technological innovation as a way to change the status quo.

Something that made it less difficult for Japan than other industrial nations to cope with the oil crises was that industry largely accounted for Japanese oil consumption, thus relegating that portion used by individuals to a less important position than in other countries. This made it easier to develop energy-saving technologies and possibly easier to implement them with more resounding effects. Yet no one can say for certain that technology will be able at all times to play the lead role as a problem solver, as perhaps it has until now.

Indeed, technology alone has not the power to solve economic and related problems. Managerial skills are absolutely vital, as the Japanese experience shows; at the same time, Japan's strategy must be acknowledged as a general solution and not one that is peculiarly Japanese. Thus, it could be said that the Japanese solution is merely one form of the general solution. There have been some studies that pursue this perspective, but we need to examine the question further before coming to any conclusions.

Although technology is not all that counts, its importance is undeniable. In this context, it is not surprising that Japanese technology, with its peculiar history of formation and its unique structure, should have aroused interest among other nations. It is with this in mind that we decided to study the problem.

Our conception of technology and development may differ from the usual. While science is universal, technology is not. What may be called the internal and external links of technology cannot be broken when innovation occurs. In other words, although the internal logic or built-in mechanism of a technology is autonomic, the external conditions under which it must operate are not. Herein lies the dilemma of technology.

## Economy and Technology in Post-war Japan

With the world's mining and manufacturing production index for 1975—the year after the oil crisis hit—given as 100, the corresponding figure for Japan in 1980 was 124. By 1980, the economies of all the industrialized countries except Japan stagnated, and the index for the United Kingdom fell below even the 1975 level.

The first to recover from this crisis was Japan, its corresponding index scoring 142 in 1981, followed by the United States (128), France, and West Germany. In terms of per capita GDP in 1980, ignoring the oil-producing countries of the Middle East with figures as high as US$30,000, the Japanese figure, at US$9,890, was 61.8 per cent of the Swiss figure and 89.9 per cent of the US figure. This placed Japan seventeenth among all countries (though fifteenth in 1975). Japan has the smallest personal income gap between rich and poor.

To give a fuller picture, we must consider that Japan depends on imports for 95 per cent of its energy consumption, for 90 per cent of the important raw materials for its manufacturing and mining industries, and for more than 60 per cent of its food requirements. It must be said, therefore, that Japan,

though often called an economic superpower, is a vulnerable power—even a minor power in respect to natural resources—a nation that has no other choice but to keep itself going on the basis of technology and foreign trade. Despite the high economic figures for Japan in terms of flows, the livelihood of its people, if not poor, is still far from being rich if seen in terms of stocks. A European Community leader once aptly commented that the average Japanese is "a workaholic who lives in a rabbit hutch."

Even so, the Japanese living standard, not well-to-do but not badly off, is something enviable for people in the third world. The Japanese may live in rabbit hutches, but in the third world even a small dwelling would be satisfactory if clean and sanitary and supplied with tap water and electrical home applicances. For many people in the third world, beset with chronic underemployment or latent unemployment and lacking decent homes, Japan could be a not-so-far-away goal at which to aim. Note too that Japan grew nearly to what it is today in not much more than a quarter-century.

While Japan scored 124 in the mining and manufacturing production index in 1980, the Republic of Korea registered 210. Obviously, the movement of the production index, like that of the growth rate, has no direct bearing on amount in absolute value. The smaller the absolute value of production, the greater the index movement might be, and conversely, the greater the absolute value of production, the smaller the index movement. The continued rapid economic growth of post-war Japan indicates that, because of the great war damage the country suffered, its economic reconstruction had to start from limited, but deliberate, activity and a low level of living.

## Post-war Recovery

The cities of Hiroshima and Nagasaki were each destroyed by a single atomic bomb. A great many Japanese cities, with the well-known exceptions of Kyoto and Nara, ancient capitals of Japan, suffered from bombing: in the 119 cities bombed, 2.2 million houses (about 20 per cent) were destroyed and 9 million people made homeless. Because few new houses were built during the war, in post-war urban Japan more than one family—sometimes several—would be jammed together into a house that was already past its prime.

The devastation affected everything connected with daily life, from factories, roads, bridges, electric lines, and waterworks to schools, hospitals, and communications systems. About 40 per cent of civilian national wealth was lost, and the few machines and pieces of equipment that survived were overused, poorly maintained, and short of parts and accessories.

For several years after the defeat, the nation's standard of living hovered at a level of 30 per cent of the top pre-war (1935–1937) level; mining and manufacturing production in 1946 stood at a mere 6.6 per cent of the pre-war high. The greatest losses were in shipping: from a total tonnage of 6.3 million, only 1.53 million (or 24 per cent) had survived.

The railroads were more fortunate, with track loss at 50 per cent and rolling stock loss at a mere 10 per cent, and hydroelectric power plants had