

Chapter 2

Worldwide Electrification from the 1950s to the 1970s

1. REPRODUCING THE GRID IN NON-WESTERN COUNTRIES

The electrification of non-Western countries had proceeded at a very slow pace in the period before 1945, but postwar international agencies promoted the idea that these countries would inherit the best of what Western engineers had developed. Electrification had indeed widened the rift between industrialized nations and the rest of the world. At the end of the war, no non-Western country had a level of household or industrial electrification that matched even the least-developed Western nations. But after 1945, with the onset of the Cold War, there was a surge of economic development activities sponsored by industrialized countries aimed at cultivating allies overseas by providing them with the tools they needed to “modernize” their economies. The United States, because of its vast economic resources, was at the forefront of this effort. Through international agencies such as the World Bank, the International Monetary Fund, and various unilateral or multilateral agencies, the West funded thousands of infrastructure improvements. Similarly, the Soviet Union and, to a lesser degree, the People’s Republic of China funded or supplied technology for numerous projects in foreign countries.

The theories of economic development fashionable at the time taught that when nations were supplied with basic services, such as transportation, communication, and power, they would begin to develop Western-style economies on their own. The Tennessee Valley Authority, particularly the TVA’s power grid, was frequently held up as a model. The TVA’s former director, David Lilienthal, personally promoted the TVA model of develop-

ment after 1955 when he helped organize the Development and Resources Corporation, a private company that undertook engineering projects all around the globe.⁵⁷ The World Bank, another international development agency, was established in 1945 to bring stability to international capital markets through the making of large loans. By the provisions of its charter, its loans were to finance specific development projects. Since 1948, the World Bank (as well as affiliated institutions such as the International Finance Corporation) has sponsored dozens of electric power projects in Africa, Asia, Central and South America, and even Europe.⁵⁸ Unfortunately, economic theories, Western technology, and capital infusions had mixed results when applied in various countries around the world.

2. CASE STUDIES FROM INDIA, SOUTH AMERICA, AND AFRICA

India, for example, was an area already partly “modernized” by centuries of British colonialism. It had a network of rail and water transportation, mainly oriented toward commercial traffic, extensive plantation agriculture, and some factory production. But in 1945 there was still little in the way of electrification, and so technical aid projects, mostly run by Americans, were initiated to electrify Indian farms. By the 1970s, the most common use of electricity in rural regions in India was for driving irrigation pumps and, to a lesser extent, operating other agricultural machinery. Electricity seemed to contribute to the growth of small, rural businesses, which often used the power for lighting to allow work to be carried on after dark. Other businesses used electrical machinery to carry out production operations, particularly in the case of grist and saw mills. Some studies indicated that the quality of life in certain respects changed considerably for rural families following household electrification. Families surveyed in India indicated that reading, especially among children, had increased. The material wealth of families with household electric service grew rapidly. Most of these families, at least in the 1970s when several surveys were undertaken, purchased electric irons and radios soon after receiving basic lighting service, and sewing machines and televisions were not far behind.

Yet the effects of electrification were not always beneficial, or even predictable. While reading increased in India, in Colombia many families reported only that television use had increased but reading had not.⁵⁹ The lifestyle changes made possible by the availability of electricity tended to amplify existing social distinc-

Case Study of Electrification: China

The electrification of non-Western countries in the postwar period cannot easily be summarized, because every country's experience was unique. While much of the world's population still has limited access to electricity compared to the United States, some developing countries did have considerable success in electrifying in the post-1945 period. Typically these were areas with a more advanced base of Western technical knowledge at the outset of the postwar period, but in several cases they broke away from the American style of centralized power production. One such example is China. The first major expansion of China's generating capacity came during the period when Japan occupied Manchuria. It was the Japanese who built the first large hydroelectric and coal-fired generating plants in China, at Supung and Fengman. After Japan was defeated in World War II, its presence was partially superceded by the influence of the Soviet Union. Just after the war, the Soviets partially dismantled the powerhouse at Fengman, reducing its capacity from 564 MW to 144 and causing enormous hardships for the Chinese.

Between 1950 and 1959, however, China expanded its electric generating capacity considerably. The Fengman powerhouse was restored to the original rating, and with international assistance from the Soviet Union and Czechoslovakia the total Chinese hydropower capacity had risen to 1000 MW by 1957. China had the world's largest reserves of potential hydropower, and dozens of projects were planned during the Great Leap Forward of the late 1950s. Most, however, were abandoned soon afterward or delayed because of continued political turmoil. Through the 1960s, almost all of China's electricity production (totaling about 60 billion kWh) was from thermal generators. It was not until the 1970s that several of the projects begun in 1958 were completed. Completed hydroelectric plants at Liuchiahsia, Yenkuochia, Chingtunghsia, Tanchiangkou, Hsinfengchiang, and Hsinanchiang have raised the nation's total capacity considerably, although by 1975 only 5 percent of the country's hydropower potential was being exploited.

Shortages of electricity led to severe restrictions both on domestic and industrial electricity usage throughout the 1970s. Electrical codes limited rooms to one light bulb each, and factories frequently had to have scheduled shutdown periods to avoid overloading the grid.

The technologies used to generate electricity in China have come from a variety of sources inside and outside the country. The Chinese electrical manufacturing industry remained small through the late 1950s. Only through the transfer of Soviet and European technology could new power generation and distribution projects be undertaken. Still, the Chinese persevered to design their own versions of foreign technologies and improve upon them. By the 1960s, the Chinese had not only caught up but were innovators in generator and electric motor engineering. Chinese engineers, for example, innovated a water-cooled design in place of the standard gas cooling for turbines.

Another area in which the Chinese have excelled is so-called intermediate-scale energy technology, which combines a labor-intensive, traditional approach to construction, local materials and skill, and minimal capital investment. Official encouragement of this approach has led to the exploitation of small coal mines in rural areas, small hydropower stations, solar energy, and biogas technology. By 1975, there were over 60,000 small and medium (i.e., less than 1000 kW) hydroelectric facilities and several remarkable tidal power stations. The latter use special horizontal turbines and can operate with extremely low "heads" on the order of just a few inches.

The production of electricity rose very rapidly after about 1970, from under 100 billion kWh to over 650 billion kWh by 1990, doubling during the 1980s alone. A significant part of China's energy came from some 25 nuclear power plants. But household electrification was still limited, and industry used between 75 and 80 percent of the total electric output compared to around 35 percent in the United States. Much residential heat and light in smaller towns and on farms comes directly from oil lamps and coal or wood furnaces, and only 42 percent of urban households own, for example, an electric refrigerator. Electric service in China is still much less extensive than it is in the West, but the Chinese are finding their own path to electrification.

Ziao-lin Xi and M. Granger Morgan, "Energizing China: First Itself, Next the World," *IEEE Spectrum* 26 (March 1989): 59-63; Mark D. Levine et al., "China's Energy System: Historical Evaluation, Current Issues, and Prospects," *Annual Review of Energy and the Environment* 17 (1992): 412, 416; T. J. Wilbans, "Implementing Environmentally Sound Power Sector Strategies in Developing Countries," *Annual Review of Energy* 15 (1990): 256-261.

tions, elevating the wealthy and grinding the poor further down. Because electricity customers in India were required to pay part of the cost, the richest people in local villages got electricity first. There was evidence that poorer families, attempting to emulate the wealthy, would sacrifice large portions of their available cash resources in order to get electric service and run electrical appliances, making electricity a greater hardship for them.⁶⁰

The benefits of electricity in less developed countries were much easier to identify in the cities, where the economic barriers to electrification were lower. City dwellers live in close enough proximity that the investment necessary to extend lines to homes is lower than in rural areas where the population is dispersed. In Bangkok, Thailand, for example, the first electric power plant was actually built in 1890, but electricity served only wealthy households for the next sixty years. Nevertheless, international aid gradually helped Thailand electrify its largest cities, though the results did not become clear until the 1980s. One index of the use of electricity in Bangkok was the market penetration of electric refrigerators in households, which was only about 26 percent in 1976. By 1984, after a decade of rapid infrastructure building, it had risen to 62 percent.⁶¹

In several countries, particularly in Africa, large electric generating and transmission projects sometimes took on disturbing political overtones. Electrification in South Africa, for example, has reflected that country's history of extreme political and social inequalities between black and white citizens. Large electric

Case Study of Electrification II: Kenya

The story of electrification in Kenya illustrates some of the ways developing countries have been subject to the vagaries of Western theories about economic development. Some of these countries have become directly or indirectly dependent on the United States and Europe for their electric service. Kenya had virtually no electric power before 1945, but built up a significant central station generating capacity after that time using foreign technology and funding. Most electricity in the country today is generated by falling water or by burning fossil fuels, and there is one 45 MW geothermal plant as well. By 1986, the nationalized power industry reported 2206 gWh in sales, but noted that 59 percent of total supply was used by commercial enterprises in Nairobi and Mombassa.

Kenya's attempts to provide household electricity have had mixed results. In 1973, Kenya instituted an ambitious rural electrification program with Western assistance. But the program, underwritten indirectly by the Swedish government, was aimed mostly at electrifying rural industries rather than homes, and often electricity was used to replace existing power sources such as diesel engines, rather than being offered to new users. The high cost of extending lines from central stations to rural customers retarded the growth of the network. By the late 1980s, the only significant residential use of electricity was for heating water, but owners of domestic water heaters were only allowed to use electricity in off-peak hours. Consumer usage was controlled by the power plant operators, who switched on and off power to the villages using a technique euphemistically known as "ripple control." As Western aid agencies in the 1980s dislodged the idea that central stations were the single best way to provide electricity to homes, rural electrification at last began to succeed. Between 1987 and 1990, almost 10,000 homes were electrified using free-standing power plants based on small solar panels. While ordinary Kenyans now have better access to electricity, the country still depends on the West for engineering skill, equipment, replacement parts, and new technologies. Electrification has arguably changed the standard of living for some Kenyans; it has not resulted in economic development that is likely to persist if aid is cut off.

Hjort, Anders, *Socio-economic Effects of Rural Electrification: An Interim Report* (Institute for Development Studies, University of Nairobi, Nairobi, Kenya; 1974); Walubengo, Dominic, *Energy Systems in Kenya: Focus on Rural Electrification*, (KENGO Regional Wood Energy Programme for Africa, Nairobi, Kenya; 1992), 27-29, 44.

power generating facilities were put in place during the first three decades of the 20th century, but were used almost exclusively to the benefit of whites, either to supply power to cities, to power electric trains, or to run machinery in coal, diamond, and other mines. Power facilities became the targets of political protest, and a mine-mouth station built in South Africa in the 1960s had to be built with an anti-sabotage design.⁶² The long-distance transmission of power also took on new political implications in developing countries. A high-voltage dc transmission line from a large, expensive hydroelectric site built with Western assistance in Mozambique, which supplied power to South African industry,

was put out of service for much of the 1980s as a protest measure, demonstrating the vulnerability of the centralized systems relying on long, high-capacity transmission lines in times of political unrest.⁶³

Sometimes, as in the case of Nigeria, Western central station generation and transmission technologies failed both for political reasons and because of the lack of skilled engineers and trained managers. While the country had received American-style generating and distribution facilities after 1945, by 1990 the system had fallen into disarray. Working on a model based loosely on the Tennessee Valley Authority, the Nigerian power administration supplied electricity to all customers at extremely low rates subsidized by the government. The theory was that commercial and residential customers would quickly adopt electric service and gradually increase their power usage, as they had done in the United States. Unfortunately, the Nigerians were less successful than the TVA had been in stimulating high levels of household or industrial consumption. Since government subsidies became a permanent fixture, the government-owned power provider became locked into the position of providing electricity at low levels of efficiency (and thus at a high cost), but had no way to pass on costs to customers.

However, because the Nigerian Power Administration was expected to pay its own expenses, the perennial shortfall made it impossible to expand or even maintain the grid, so that after a while few new residential customers were being added. That meant that industry became the chief beneficiary of the low-cost, subsidized power. As a result, most Nigerian households simply did without electricity. Further, because of the neglect of maintenance and general lack of money, technical problems with the system became chronic. Blackouts occurred regularly, and power availability dropped as low as 50 percent. An estimated 30 percent of the energy actually generated was lost through inefficient operation. Trained employees were difficult to retain because they were so poorly paid, owing to inadequate sales of underpriced energy. In the end, blackouts forced industrial customers to install their own backup generating facilities, demonstrating their lack of confidence in the public utility but also highlighting the failure of subsidization as a long-term policy, because the small generators that they operated provided energy at a higher rate than they would

have paid if the government electricity was not subsidized. They were, in other words, prepared to pay more for their electricity than they were currently paying the government. In Nigeria, the transfer of this Western technological system had failed to take root in a non-Western culture and economy.⁶⁴

3. FAILURES IN RURAL HOUSEHOLD ELECTRIFICATION

While many other industrial and urban electrification projects around the world succeeded, by the late 1970s many rural electrification programs in developing countries were falling into disrepute. In too many countries, large power plants served mainly industrial consumers rather than households, and the plight of farm families was symbolized by the long-distance transmission lines that cut through the landscape, carrying electricity that was all but inaccessible to the majority of people. The theory that building an electric power “infrastructure” would lead to rapid modernization was proving to be untrue.⁶⁵

Blame for the apparent failure of Third World rural electrification through the end of the 1970s was placed primarily on governments, local elites, or international aid agencies and not on the engineers who conceived the technology. Most critics still believed that electric service based on the Western model was the best way to provide electricity anywhere in the world. But in the 1980s and 1990s those opinions changed. As one expert put it,

The orthodox approach of central station generation, which is ideal for industrialized countries and urban centers, may not make sense for rural areas, where the demand per consumer is only a small fraction of a kilowatt.⁶⁶

As late as the early 1990s, a few high-income nations still generated more than half of the world's electricity, but two billion people had no electricity at all.⁶⁷