Electricity in Brazil—Part 2

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As discussed in "Electricity in Brazil—Part 1" (the "History" column in the March/April 2011 issue, pp. 8–12), the period following World War II (WWII) saw a considerable increase in demand for electrical power throughout Brazil, particularly in the industrialized states. After WWII, the regions of São Paulo and Rio de Janeiro faced a serious shortage of electric energy. For many reasons, power companies did not meet this demand. The problems were pervasive: the depression years of the 1930s had seen a low investment in electrical generation; the international turmoil in manufacturing during WWII made it very difficult to import equipment; the movement of the population from rural to urban areas increased the demand for power as did the immigration of displaced people from Europe after WWII; from early 1950 to 1955, a long dry season in the Southeast worsened the situation; and many more. Power failures symbolized and reflected the exhaustion of the previous model of coexistence between a smaller local national capital and larger foreign companies. Together, these companies constituted isolated systems in terms of technique and planning, which resulted in the business being unable to meet an increase in demand that was beyond the ability or willingness to expand.

The two major foreign companies that owned 80% of the power concessions in Brazil, a situation that continued until 1960, did not do enough to improve their service quality, although their installations had long since become obsolete all over Brazil. Blackouts and restrictions on power consumption severely damaged the companies' reputations. At the same time, the automobile industry had established itself in the metropolitan area of São Paulo city; more industry and urbanization implied a continuously growing electric demand. To summarize, the Brazilian economy grew about 2.5% annually while the energy increased by 1.9%, presenting an untenable situation.

THE FIRST IEEE SECTION WAS ESTABLISHED IN RIO DE JANEIRO IN 1956.

The government concluded that it must work to have more control over electrical energy systems. This decision marked the beginning of firm government regulations and the creation of government power companies. It was then that the state decided not only to increase its regulatory capacity but also to start investing heavily in new hydroelectric plants. This led either to the sale of foreign companies to the state or their expropriation, where old "Light" was renamed Eletropaulo, and American and Foreign Power Co. (AMFORP) became Companhia Paulista de Força e Luz (CPFL). Only a few concessions remained in private hands. The new cycle of development coincided with the military regime (1964–1985).

Construction Under State Ownership

The year 1950, in addition to representing a paramount crisis of electric energy that entailed a significant electric energy shortage in the following years, also marked the beginning of engineering studies for the Barra Bonita hydroelectric plant. Barra Bonita dam, a hydroelectric plant designed, commissioned, and operated by the new São Paulo state electric power structure, was completed in January 1956.

State intervention and participation increased from 1950. The foreign companies were bought by the government, and so ex-AMFORP (in 1975) and ex-Light (in 1979) became part of the state machinery, which could then provide the entire chain of electric generation, transmission, and distribution (a vertical utility). Their common ownership facilitated planning and constructing the backbone of the state's electric generation, the hydroelectric plants of Bariri, Ibitinga, Caconde, Euclides da Cunha, Limoeiro, Barra Bonita, Jupiá, Ilha Solteira, Porto Primavera, Promissão, Avanhandava, Água Vermelha, Taquaruçu, Rosana, Capivara, Canoas, Xavantes, Jurumirim, Paraibuna, and Jaguari.

Regulation, Deregulation, and Privatization

The history of the electric sector in the mid-20th century was marked

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not only by the supply crisis faced by companies and consumers but also by the rekindling of ideological and cultural questions aroused by nationalist ideas, then defended by several social sectors of different hues. The first decisive Brazilian state intervention in the electrical area was the publication of the Federal Water Code in 1934. During the end of the 1940s, the Inspectorate of Public Works was created in the state of São Paulo, subordinated to the Secretary of Roadways and Public Works, and in 1951, the Water and Energy Department came into being. New government power companies included Companhia Estadual de Energia Eletrica (CEEE), Rio Grande do Sul state (1943); Companhia Hidro Elétrica do São Francisco (CHESF), Federal in the Northeast (1945); Companhia Energética de Minas Gerais (CEMIG), Minas Gerais state (1952); Furnas, Federal (1957); and Companhia Energética de São Paulo (CESP), Sao Paulo state (1966).

When Lucas Garcez (a professor at the Escola Politécnica of São Paulo University) took over office as the governor of São Paulo in the beginning of 1950s, a number of state-owned power companies were created: Paranapanema River Basin Electric Plants [Usina Hidro Elétrica do Paranapanema (USELPA)] in 1953; Pardo River Hydroelectric Corporation [Companhia Hidro Elétrica do Rio Pardo (CHERP)] in 1955; and finally, CESP in 1966, which incorporated the previous ones as well as most of the smaller private companies. Thus began the construction of higher capacity power plants that became the largest hydroelectric generation complex in the country.

In 1960, the government created a Mine and Energy Department to administer the use of minerals and energy. In 1962, Eletrobrás was created to manage the development of electrical energy. Eletrobrás' role was to foster studies, construct projects, and operate generating plants, transmission lines, and substations designed to provide electric power to the country. The new company started to decisively contribute to the expansion of electric power and development of the country.

In 1975, the Mine and Energy Department created Centro de Pesquisas de Energia Elétrica (CEPEL) to promote scientific research and infrastructure development of advanced technology for electrical system and equipment. Today, CEPEL is the largest research center in Latin America as well as in the southern hemisphere.

> TODAY, CEPEL IS THE LARGEST RESEARCH CENTER IN LATIN AMERICA AS WELL AS IN THE SOUTHERN HEMISPHERE.

In the 1990s, Brazil started studies for institutional reforms and the privatization of power-distribution systems. The model created three different segments, generation–transmission–distribution, and created a free market to commercialize energy produced by the generation segment. Many government power companies had to reorganize, splitting into different segments before beginning the privatization process. An example is Eletropaulo, which was classified into four independent companies by end of 1990s—Empresa Metropolitana de Água e Energia (EMAE) for generation, Empresa Paulista de Transmissão de Energia Elétrica (EPTE) for transmission, and Eletropaulo and Bandeirantes for distribution. Another example is CESP, which was separated to maintain CESP for generation, Companhia de Transmissao de Energia Elétrica Paulista (CTEEP) for transmission, and CPFL and Elektro for distribution. The generation segment in CESP is one of the largest in Brazil.

During the military dictatorship, which ruled Brazil from 1964 to 1985, energy planning and technical integration among various states and regional systems were forcefully enhanced, resulting in their joint operation and supervision, controlled by a new federal agency, Eletrobrás. This was also a period of great hydroelectric projects, such as Itaipu in Paraná state and Ilha Solteira in São Paulo, constructed with external financing. National and international political decisions resulted in heavy debt services, while the government's National Economic and Social Development Bank imposed rules that practically turned electric investments prohibitive for the state-owned companies.

The earlier model of almost total control of the electric sector by state companies providing generation, transmission, and distribution under a single vertical authority was replaced by a model where the businesses were subdivided and mostly transferred to private corporations. In São Paulo, where most of the electric power was supplied by the three state companies (CESP, Eletropaulo, and CPFL), foreign-controlled and private companies again appeared in the scene, such as AES Tietê and AES Eletropaulo (both belong to AES Corporation in the United States), CTEEP (Colombian ISA), Duke Energy (the United States), and others, coexisting until today with a relevant part of the state-owned CESP, though CESP has been reduced to a fraction of its former generation capacity.

Electrical Standards

A hindrance to the expansion of the electric systems was the lack of standardization of voltages and frequencies. States influenced by American companies tended to adopt 60 Hz and 110 V as the final consumer voltage; states where there was a considerable German influence adopted 50 Hz and 220 V; and elsewhere there were other variations including 40, 42, and 125 Hz for independent installations. Brazilian regulations started work to define a frequency in 1929. This was not easy. After WWII, acquisition of electrical equipment from Europe was difficult and influence from the United States became dominant. The 127-V standard was adopted in the 1960s and the 60-Hz frequency in the 1970s. This was also the time when the authorities created nationally integrated systems that dispatched and shared power efficiently. A larger integration with Latin American neighbors has been more difficult to achieve.

Manufacturing and Patents

In the early 20th century, all electric equipment were imported until the local manufacture of electric cables began in 1923. Competition between foreign and

fledgling national products appeared in several electrical applications. At first, local inventors and their products displayed lower quality and higher prices, but these products became increasingly better and cheaper. Notwithstanding this improvement, several Brazilian electrical inventions did not materialize into products because of the lack of interest of local capitalists from a continuation of centuries of no confidence in Brazil's capacity as a manufacturer. A few relevant examples are as follows:

- electric furnaces for metal processing (a Brazilian patent was transferred to a Belgian industry after unsuccessful pledges of funding by the government)
- electrolytic transformers (the patent was sold to a French industry, which later exported them back to Brazil)
- submarine lightweight batteries.

Thus, with only partial success, the industrialization effort did not complete itself; this shortcoming of actually patenting and producing items was felt not only in electrical inventions but also in the overall industry.

Local Electric Expertise

An important aspect of the process was the simultaneous improvement of the national engineering capacity for hydroelectric works, a basis for the future Brazilian consulting and design companies that gradually replaced foreign experts who had traditionally been in charge of this service. Many young engineers were graduates of Brazilian universities; many others were educated, highly motivated immigrants who left Europe after WWII. Together, they provided intellectual capital for new companies that contributed to the country's economic development, including the petrochemical and industrial projects in general.

Brazilian Electrical Engineering Schools

Military applications came first. Around the 1690s a school in Brazil colony began teaching basic construction of fortifications to defend the colony in Rio de Janeiro from attacks by other nations. In Salvador, in 1710, the courses of artillery and fortification were conducted by military instructors from Portugal. The first true engineering school was established in 1810, the Brazilian engineering academy (Academia Real Militar) to serve the military needs in Rio de Janeiro, and in 1874, the Escola Politécnica de Rio de Janeiro separated from military engineering to focus on civil engineering. This civil engineering school continues today as the Escola Politécnica da Universidade Federal do Rio de Janeiro. (The record is not clear, but the authors speculate that the electrical engineering discipline was introduced into Escola Politécnica of Rio de Janeiro and São Paulo in 1911 to form departments of electrical and mechanical engineering, the first electrical engineering discipline in Brazil.)

Engineering schools in São Paulo followed during the Old Republic, with the Escola Politécnica de São Paulo, in 1894, were state funded and public (free). Later, it was incorporated with the first Brazilian university, the University of São Paulo (1934), now called Escola Politécnica da Universidade de São Paulo. Mackenzie College (1896), privately owned (founded by the American Presbyterian missionaries) and later part of Mackenzie University, is now Escola de Engenharia da Universidade de Mackenzie. Both schools established electromechanical engineering courses in the 1910s, and their graduates became part of the state's industrialization takeoff. The new engineers took several initiatives:

- to defend national products versus imported ones
- to suggest the integrated use of energy resources (coal, hydro, oil, sugar cane, and alcohol), while emphasizing hydroelectric power as the best suited to the country
- to promote schools for intermediate-level technicians
- to apply electricity to steel mill furnaces (however, larger steel mills had to wait until the end of WWII, still under the Vargas regime—a serious threat to industrialization and a waste, given that Brazil has the largest and some of the best iron ore mines in the world)
- to apply electricity to rail transportation (mass and freight).

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It was due to this happy conjugation of factors, i.e., a surplus of capital generated by coffee exports, the expansion of the labor force, and the formation of educated technicians, that São Paulo state was able to lead the industrialization process. The Industrial Revolution finally occurred, transforming São Paulo city into the Brazilian manchester.

The IEEE in Brazil

On the basis of the power companies' growth and the influence of Light and other foreign companies, the first IEEE Section was established in Rio de Janeiro in 1956, covering Rio de Janeiro and Espirito Santo states. In 1966, the São Paulo IEEE Section came into being for the state of São Paulo (source, South Brazil section). Later, this expanded to the IEEE South Brazil Section covering São Paulo, Paraná, Sta Catarina, and Rio Grande do Sul states. The Bahia Section was established in 1975 to cover the northeast region of Bahia, Pernambuco, Rio Grande do Norte, Ceará, Sergipe, Alagoas Paraíba, Maranhão, and Piauı states. In 1977, the IEEE Brazília Section was organized in 1977 to serve Acre, Amapá, Amazonas, Goiás, Mato Grosso, Pará, Rondônia, Roraima, Tocantins, and Brazília DF. More recently, the IEEE Section Minas Gerais was organized in 1993 to cover the state of Minas Gerais. All sections are under the Brazil council (source, IEEE Brazil Council).

Today

Ordem e Progresso (order and progress) is a reality. Public electricity began with six arc lamps in Rio de Janeiro in 1879. Today, Brazilian total electrical energy generation capacity is 117 GW, 72% hydraulic, 25% thermal, and 3% other (as of May 2010, according to the Brazilian Mine and Energy Department).

Acknowledgments

This article deals with only a few aspects of the history of electricity in Brazil. It is not comprehensive. Insights were collected from the items listed below as well as from other sources. Readers who are interested in learning more may refer to these references as well as other literature on the subject.

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