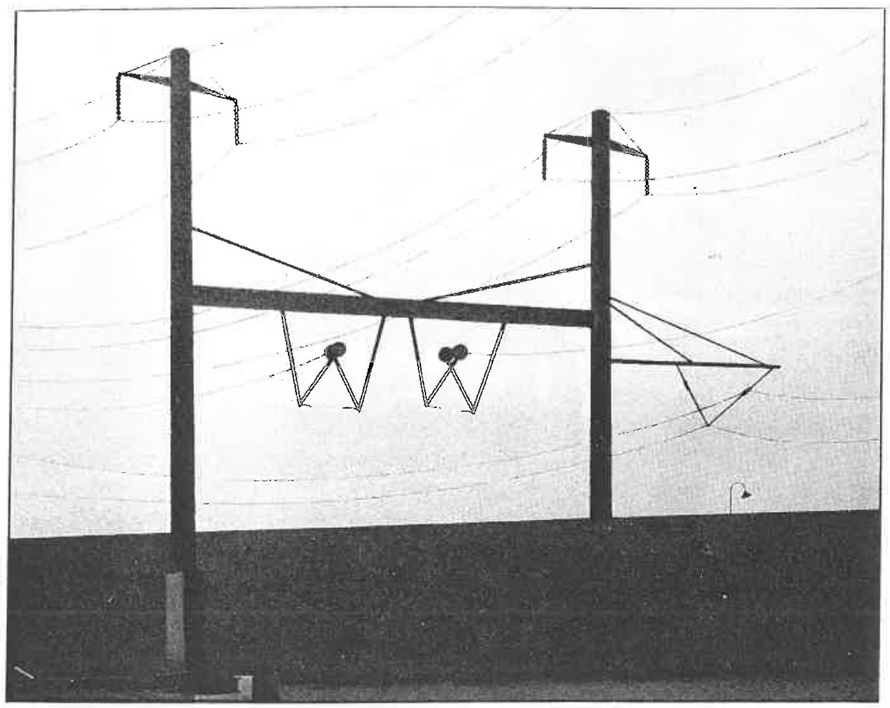
THOMAS P. HUGHES

Networks of Power

Electrification in Western Society, 1880-1930



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CHAPTER VII

Berlin: The Coordination of Technology and Politics

During the late-eighteenth, nineteenth, and early twentieth centuries, two waves of industrialization swept over the Western world. The first, commonly known as the Industrial Revolution, impressively transformed regions of England and Scotland; the second, occasionally called the Second Industrial Revolution, changed newly united Germany and the United States. The 1870s are often cited as the decade of transition from the first to the second industrialization phase. The British Industrial Revolution is usually associated with a system of production and transportation that was heavily dependent on coal, steam, and iron; the rapid industrialization of Germany and the United States involved these components, but steel, electricity, and man-made chemicals, both organic and inorganic, were layered on the earlier technologies as well. The second era of rapid industrialization is not as well understood or defined as the first, but when future historians probe its phenomena and structure, electric power—especially high-voltage transmission and the universal system of electric light and power made known to the world at Frankfort and Niagara Falls—will figure intricately and prominently in their interpretations and presentations. Just as Manchester, Birmingham, and other British cities were the centers of the first wave of industrialization, certain cities will be clearly identified as the sites of the second. Among the urban centers of the second wave will surely be Chicago and Berlin; among the cities by-passed will be London. Consideration of the electrification of the first two before 1915 and the laggard development of the third will provide some understanding of urban industrialization in the modern era.

During the four decades between the founding of the German empire and the outbreak of World War I, Berlin, the empire's capital, was a dynamic urban center. It became the leading industrial and commercial city on the Continent, and in wealth and population ranked behind only London and Paris. With regard to administration and organization, contemporaries named it the model city of Europe and praised its citizens for the remarkable burst of energy that transformed a provincial capital of Prussia into a cosmopolitan city of international eminence.[1] The municipal au-

[1] A. Shadwell, *Industrial Efficiency,* 2 vols. (London: Longmans, 1906), 1: 159–60; and Sigfrid von Weiher, *Berlins Weg zur Elektropolis: Technik-und Industriegeschichte an der Spree* (Berlin: Stapp, 1974), pp. 83–134.

thority was widely judged the ultimate in enlightened, efficient, and socially purposeful government in a progressive era that looked to its cities as standard-bearers in an urbanizing and industrializing civilization. On the Continent, and especially in Germany, a city was "idealized as a great family," organized for economic, political, and social ends and its government was seen as the means for obtaining these ends.[2] Among the means were public utilities, including transportation, water and gas, waste disposal, and lighting. By World War I, a hallmark of the modern progressive city was cultivation of a new and subtle form of light and power—electricity. Berlin was not found lacking.

Because the city government in Berlin so effectively regulated the private utility that provided the metropolis with light and power, and because the history of technological change in the city cannot be understood without taking the regulatory activities of the government into account, a brief description of the government's structure and functions is needed. In 1881 Berlin became an administrative area distinct from the Prussian province of Brandenburg, and subsequently the civil government of Berlin was organized into two major divisions, the *Magistrat* and the *Stadtverordnetenversammlung* ("common council"). The *Magistrat* consisted of an *Oberbürgermeister* ("chief mayor"), a *Bürgermeister* ("mayor"), and a *Stadtrat* ("city council") of thirty-two members, fifteen of whom were paid administrators and seventeen of whom served without pay. The 144 members of the *Stadtverordnetenversammlung* were chosen by manhood suffrage. For general decisions, the *Magistrat* and *Stadtverordnetenversammlung* met in common and sometimes named committees that were representative of the whole. These committees had jurisdiction over public services such as water supply, the lighting and cleaning of the streets, and drainage. Detailed contractual arrangements with the private company supplying Berlin with electric light and power were executed by the *Magistrat.*

Not only was Berlin progressive but it was industrial. As in Chicago, this fact deeply affected the city's electric utility. London and other European capitals had become world centers earlier, when cities were the focus of government, commerce, and religious activities. Berlin's formative years as a national capital coincided with Germany's rapid industrialization and rise to technological preeminence following the Franco-Prussian War and the country's unification. Berlin, more than Vienna, Paris, or London, was shaped by industrial imperatives and technological opportunities. By 1900 the quaint two-story houses so characteristic of Prussian Berlin had given way to business blocks that housed not only commercial enterprises but the headquarters of the industrial corporations and financial institutions (including the Reichsbank, Deutsche Bank, Diskonto Gesellschaft, and Jacob Landau) that served them. The administrative boundaries of "old Berlin," with a population of about two million, remained as they had been since 1860, encompassing only about twenty-nine square miles—six miles across and about five and a half miles from north to south. Industry, however, mushroomed in so-called "greater Berlin," radiating ten miles from city

[2] Frank S. Hoffman, "Municipal Activities in Germany," *Outlook* 58 (1898): 1063. I am indebted to Alan Steiner for calling my attention to the Hoffman article and to sources about Berlin's transportation systems.

center. More than 50 percent of the working population of old Berlin was employed by industry, and the percentage in greater Berlin, with a population around three million, increased as new industries and factories found ground there. Berlin manufactured wool, worked iron and steel, turned out heavy machinery (including steam engines and locomotives), produced sewing machines and bicycles, organized chemical processes, and designed and assembled heavy and light electrical equipment for Germany and the rest of the world. When burgeoning industry within the city threatened to demean the architecture and the environment, the municipal authorities constructed a great canal south of the city to connect the Spree and Havel rivers and provide a transport artery that would draw industry away from city center.

Berlin was not only an industrial city but one whose industry was notably electrical. Two of the world's leading manufacturers of electrical machinery, Siemens & Halske and Allgemeine Elektrizitäts-Gesellschaft (AEG), had central offices and factories in Berlin and its immediate surroundings. About 50 percent of the personnel of Germany's electrical industry worked there until World War II. With good reason, then, it has been called the *Elektropolis*.[3] This burgeoning industry helped maintain the vitality of Berlin's—and Germany's—economy during periods of mild recession in the three decades preceding World War I. Siemens & Halske's and AEG's presence also furthered the electrification of industry and transportation in Berlin. The histories of both companies involved at one time or another not only electrical manufacturing but also electrical supply in the city. In 1883 Siemens & Halske was party to the founding of Deutsche Edison Gesellschaft, which in time metamorphosed into AEG, which in turn, in 1887, founded the Berliner Elektricitäts-Werke (see pp. 68–77 above).

The founder of Siemens & Halske, Werner von Siemens (1816–1892), his associates, and the company stimulated an ethic of science and professionalization as well as invention and industry in Berlin.[4] In 1879 von Siemens was instrumental in the establishment of the Berlin Elektrotechnischer Verein (Electrotechnical Association), which in turn, in 1894, stimulated the founding of the Verband Deutscher Elektrotechniker (later the leading professional organization for the field in all of Germany). Von Siemens also urged the government to establish in Berlin an institute de-

[3] See von Weiher, *Berlins Weg zur Elektropolis.* On AEG in Berlin, see *75 Jahre AEG,* a booklet published by the firm in 1958, especially pp. 29–30. On the Berlin electrical industry after World War I, see Peter Czada, *Die Berliner Elektroindustrie in der Weimarer Zeit* (Berlin: Colloquium, 1969).

[4] Biographies of Werner von Siemens and histories of Siemens & Halske are numerous, due in part to the existence of the company's archives in Munich. Among the works are Werner von Siemens, *Inventor and Entrepreneur: Recollections of Werner von Siemens* (1892; reprinted ed., London: Lund Humphries, 1966); Georg von Siemens, *History of the House of Siemens,* 2 vols. (Freiburg/Munich: Alber, 1957); Jürgen Kocka, *Unternehmensverwaltung und Angestelltenschaft; am Beispiel Siemens 1847–1914: Zur Verhältnis von Kapitalismus und Bürokratie in der deutschen Industrialisierung* (Stuttgart: Klett, 1969); Sigfrid von Weiher, *Werner von Siemens: Ein Leben für Wissenschaft, Technik und Wirtschaft* (Göttingen: Musterschmidt, 1970); and Sigfrid von Weiher and Herbert Goetzeler, *The Siemens Company: Its Historical Role in the Progress of Electrical Engineering* (Berlin and Munich: Siemens, 1972). See also Jürgen Kocka, "Siemens und der Aufhaltsame Aufstieg der AEG," *Tradition* 17 (1972): 125–42; and, primarily for later developments, Czada, *Die Berliner Elektroindustrie.*

voted to basic research. In 1883, in an appeal to the Prussian government, he wrote, "Research is the firm foundation of technological progress; a country's industry has no hope of attaining an international, leading position and sustaining itself unless it is in the forefront of scientific research."[5] Siemens offered to finance the building of such an institute with funds that had been left to him in the estate of his brother, William. The German Reichstag eventually accepted a modification of Siemens's proposal and established the Physikalisch-Technische Reichsanstalt (Imperial Physical-Technical Institute), of which Hermann von Helmholtz (1821–1894), then Germany's leading physicist, became the first president in 1887. Besides these contributions to the scientific life and intellectual spirit of Berlin, Werner von Siemens was responsible for the installation of chairs in the new field of electrical engineering at German *Technischen Hochschulen* (see pp. 144–45 above).[6] These institutions, their engineers, and their scientists helped ensure that technology in general, and such advanced fields as electrical engineering specifically, would flourish in Berlin.

By 1900 Berlin's Allgemeine Elektrizitäts-Gesellschaft was a larger manufacturer of electrical machinery and apparatus than Siemens & Halske. It had 17,300 employees, while Siemens had 13,600; it had 60 million marks in share capital, while Siemens (including its foreign subsidiaries) had 54.5 million.[7] When founded in 1887, AEG was primarily a financier and operator of electrical utilities and a maker of incandescent lamps. In contrast, Siemens was a manufacturer of equipment. Within a decade, however, AEG had expanded its manufacturing to include power equipment and had introduced a line of polyphase machinery. The company continued to finance and build central power stations and during the 1890s became especially active in the construction of electric streetcar systems. It acquired the rights to the designs of Frank Sprague, the American pioneer in electric traction. The company followed a policy of financing its customers, whether they were horsecar companies converting to electricity or companies with new franchises. In cooperation with banks in Berlin and elsewhere, it also financed and constructed power plants for electric supply utilities and industrial facilities that used heavy-power equipment. In 1888, for example, with the help of several banks, AEG established Aluminum-Industrie A.G. in Neuhausen, Switzerland. By 1900 AEG had established 248 power plants with a total capacity of 210,000 h.p.[8] AEG also grew by amalgamation, the establishment of *Interessengemeinschaft* (ad hoc common-interest organizations), and cartel (price-control) arrangements. With the Union Elektrizi-

[5] Quoted in Sigfrid von Weiher, *Werner von Siemens: A Life in the Service of Science, Technology and Industry* (1970; Eng. trans., Göttingen: Musterschmidt, 1975), p. 73.

[6] Von Siemens, *House of Siemens,* 1:115.

[7] If, however, the 7,400 employees of Schuckert & Co. are included, then the Siemens-controlled enterprise was larger. In 1903 Siemens & Halske and Schuckert & Co. of Nürnberg established a holding company, Siemens-Schuckertwerke. The new entity operated the electric power equipment manufacturing facilities of the two companies. The shareholding, management, and profits of Siemens-Schuckertwerke were weighted slightly in favor of Siemens & Halske. Siemens & Halske held 45.05 million marks of the holding company's capital; Schuckert, 44.95 million. Von Siemens, *House of Siemens,* 1:192, 196.

[8] Conrad Matschoss, "Die geschichtliche Entwicklung der Allgemeinen Elektricitäts-Gesellschaft in den ersten 25 Jahren ihres Bestehens," *Beiträge zur Geschichte der Tecknik und Industrie* 1 (1909): 62.

täts-Gesellschaft (founded by Ludwig Loewe and Thomson-Houston International), AEG formed an *Interessengemeinschaft* that divided the market and profits in the electric streetcar field, where Union had a firm position. In 1903 Emil Rathenau, the founder of AEG, reached an agreement with General Electric in America to divide their world markets: AEG would continue to be preeminent in Europe; GE, in North America. AEG and GE also agreed to cooperate in the development of the Riedler-Stumpf and Curtis steam-turbine patents when steam turbines began displacing reciprocating steam engines in power stations. AEG further strengthened its position in the turbine field by exchanging stock with the Swiss electrical manufacturing firm Brown, Boveri & Company, which held rights to manufacture the Parsons turbine.[9]

AEG's influence among German utilities through stock ownership was extensive. Because the control was that of a supplier over its market, the relationship resembled vertical integration. In 1911 AEG owned some part of 114 public power plants (*Elektrizitätswerke*), and these supplied 31 percent of the connected electric load in Germany. Siemens-Schuckert owned a part of 80 power plants, and these supplied 6.3 percent of the connected load. The two manufacturers held a disproportionate interest in the relatively few large-capacity plants rather than in the large number of small ones. Power plants with a capacity of more than 10,000 kw. supplied 34.6 percent of the connected load, and the two manufacturers owned an interest in the twelve of these that supplied 26.4 percent of the load.[10] Much of the capacity of the central stations in which AEG had invested was located in Berlin or its suburbs and was operated by the AEG subsidiary, the Berliner Elektricitäts-Werke (BEW).

Considering the investment network and AEG's pivotal role in it, it is not surprising that Emil Rathenau, the company's founder, was known in Germany as the inventor of the principle of market creation through investment financing. Rathenau also founded and presided over the Berliner Elektricitäts-Werke until his death.[11] Like that of Werner von Siemens, Rathenau's name looms large in the history of the electrical industry in Germany and also in the establishment of Berlin as its *Elektropolis,* but while von Siemens came to represent invention, engineering, and industrial science, Rathenau stood for the powerful and widely influential interaction of investment capital, industrial enterprise, and highly organized marketing. His son, Walther (1867–1922), succeeded him as head of AEG in 1915 and went on to display organizational abilities on an even greater stage than had his father. During World War I, Walther directed the allocation of Germany's resources, and shortly thereafter he served as minister of reconstruction (1921) and foreign minister (1922). He was assassinated by nationalistic and anti-Semitic fanatics who opposed, among other things,

[9] Ibid., pp. 64–65.

[10] Helga Nussbaum, "Versuche zur reichsgesetzlichen Regelung der deutschen Elektrizitätswirtschaft und zu ihrer Überfuhrung in Reichseigentum, 1909 bis 1914," *Jahrbuch für Wirtschaftsgeschichte* (Berlin, 1968), pt. 3, pp. 137–38.

[11] See pp. 66–78 above for a discussion of Rathenau and the founding of AEG and BEW. Biographies of Emil Rathenau include A. Riedler, *Emil Rathenau und das Werden der Grosswirtschaft* (Berlin: Springer, 1916), and Felix Pinner, *Emil Rathenau und das elektrische Zeitalter* (Leipzig: Akademische Verlagsgesellschaft, 1918).

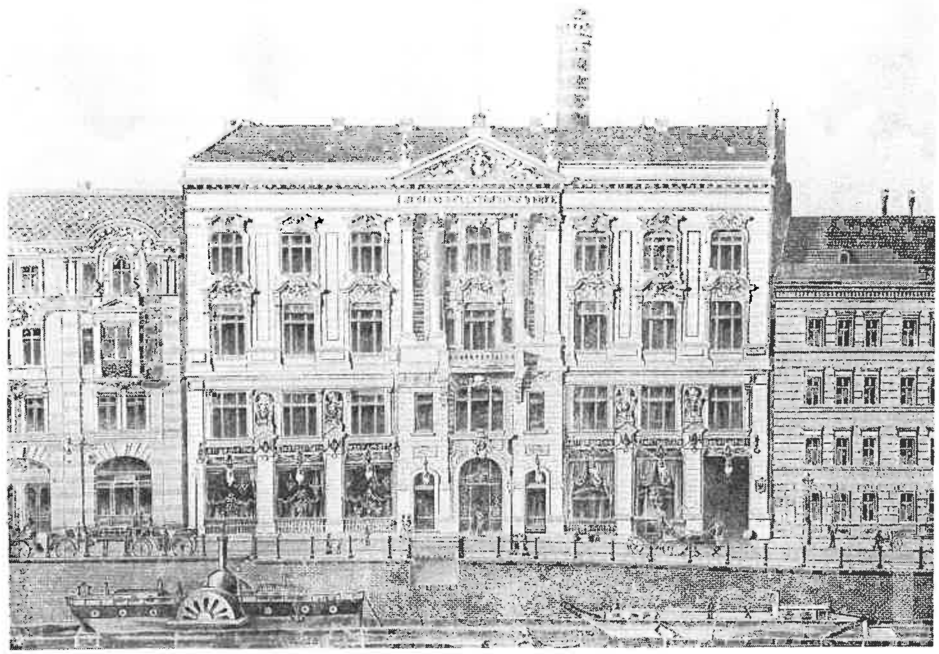


Figure VII.1. *Headquarters of Berliner Electricitäts-Werke and Allgemeine Elektrizitäts-Gesellschaft, Berlin, 1891. From* Offizielle Zeitung . . . Frankfurt am Main 1891, *p. 163.*

his desire to fulfill the reparations terms of the peace settlement. Walther, who was passionately committed to philosophy and the arts, probably encouraged his father to appoint the famous architect Peter Behrens (1868–1940) as art and architectural adviser to AEG. Behrens designed the famous 1909 AEG turbine factory in Berlin. He also designed various electrical appliances manufactured by the company.[12]

No account of the Berlin environment in which the Rathenaus nurtured AEG and BEW would be adequate without due emphasis on the role of the investment banks (*Kreditbanken*) there. Consideration of these and their relationship with the electrical industry focuses attention on Georg von Siemens. A cousin of Werner's, Georg rose through the ranks to become a head of the Deutsche Bank in Berlin after having worked for Siemens & Halske. The Deutsche Bank was one of the leading *Kreditbanken,* which were, in effect, a combination of commercial and investment banks, banks that have been characterized by many historians as the centers of great industrial influence—almost control—during the rapid industrialization of Germany after 1871.[13] Georg von Siemens advised and assisted in the financing of both Siemens & Halske and Rathenau's enterprises until AEG

[12] Books and articles about and by Walther Rathenau are numerous, but most focus on his political views, economic and social philosophy, and aesthetic interests. Hermann Brinckmeyer, *Die Rathenaus* (Munich: Wieland, 1922), does direct attention to his AEG association.

[13] Hugh Neuburger, "The Industrial Politics of the *Kreditbanken,* 1880–1914," *Business History Review* 51 (1977): 190–207, challenges the argument that the banks dominated the bank-industry relationship in Germany, a thesis advanced by Rudolf Hilferding, *Das Finanzkapital* (Vienna: Verlag der Weiner Volksbuchhandlung, 1923), and others. Neuburger sees the relationship as one among negotiating, autonomous powers. This view is also advanced in Kocka, *Unternehmensverwaltung,* p. 431.

became a strong manufacturing competitor of the Siemens firm. In 1896 Georg resigned his chairmanship of the board of AEG when his plan, which was for AEG to function primarily as a financer of utilities and power plants and Siemens as a manufacturer, was obviously no longer viable. Georg von Siemens had great respect for Rathenau, believing him to be the best financial and commercial head in the industry, but AEG's managers believed that Georg, because of his relatives, was too deeply involved in a conflict-of-interest situation. For his part, Georg thought that Rathenau was overextended as financier, manufacturer, and operator of electrical utilities. AEG made a profit from selling heavy machinery, selling the utility shares it took in payment for the equipment, and then from operating some of the utilities. Although Georg von Siemens, with his German sense of order and cooperation, was frustrated in his attempt to balance the activities of the two leading manufacturers, he was able to bring about the transformation of Siemens & Halske from a nonshare, family-owned enterprise to a stock company whose shares were owned by the family. This made it possible for banks such as the Deutsche Bank, which made loans to Siemens & Halske, to place members on the board of directors (*Aufsichstrat*) of the share company.[14]

Motivated by industrial needs and the desire to seize technological opportunities, Berlin developed an exemplary transportation system. As was the case in Chicago, Berlin's electric utility supplied the power when much of the city's transportation system was electrified. Earlier, the Prussian state became involved in the planning and funding of a transit system in order to facilitate military mobilization by railway. The location of industry, worker settlements, and middle-class suburban neighborhoods, as well as military considerations, shaped the structure of the state's transportation network. Berlin, like London and Paris, was a railway nodal point; twelve main lines converged on it. Concerned, as London had been, that additional main-line railway stations in center city would mar and congest, Berlin ringed itself with main-line stations. These were connected by a *Ringbahn* ("ring railroad"), which opened in sections beginning in 1872 and which, after 1882, fed into the *Stadtbahn* ("city railway") that extended across Berlin from east to west. Connecting with the *Stadtbahn,* streetcar lines honeycombed the city. The elevated portion of the *Stadtbahn* was carried about twenty feet above the streets, and its stations are rich in historical connotations—Friedrichstrasse, Zoologischer Garten, and Alexanderplatz. Despite both the excellence and the original excess capacity of the *Stadtbahn,* as well as the extensions of the streetcar lines, increased demand and growing congestion led in 1896 to the start of construction of an elevated and subway system across center city, mostly to the south of the *Stadtbahn.* The city demanded that the system go underground in the western section to eliminate noise and traffic in the choice residential areas in the vicinity of Charlottenburg. Earlier the city insisted that electric streetcars run off storage batteries in center city to avoid unsightly and dangerous overhead power lines. Because of technical problems with storage batteries, however, the requirement was subsequently eased. At the turn of the century the

[14] Von Siemens, *House of Siemens,* 1: 148–49, 154–58.

U.S. consul general in Berlin attested to the artistic beauty, the architectural charm, the fitness, and the general excellence of the Berlin systems of mass transit.[15]

As in other industrializing cities, electric light and power helped shape Berlin's architecture; deeply influenced the design of its factories, and workshops, and chemical plants; stimulated industrial growth; determined the location of the city's transportation systems; provided telephone and telegraph communication; and, when substituted for steam power, lessened noise and dirt. In short, electrification affected the way in which workers labored, management organized, and Berliners lived. Because of this, the private company that supplied most of the electric light and power for Berlin until 1915, and the municipal government that regulated electrical supply, shaped the history of Berlin.

On the eve of World War I, the Berliner Elektricitäts-Werke (BEW) ranked as one of the world's leading electric supply utilities. Engineers and managers looked to it, along with the Commonwealth Edison Company of Chicago, as pacesetters in the establishment of world standards, both technical and commercial, for the electric supply industry. The city engineers of Melbourne, Australia, included Berlin and BEW on their world tour in 1912, observing that "on the Continent one naturally visits Berlin, being electrically the most important city, not only from an electric supply point of view, but on account of the fact that the two most powerful electrical manufacturing concerns in Europe have their factories here."[16] In 1913 Georg Klingenberg, head of AEG's power-plant division, brought the details of Berlin's electric supply system to the attention of the technical world in his analysis of the utilities in the German capital, Chicago, and London.[17] Samuel Insull of Commonwealth Edison included the Berlin system in his comparisons of the technical and economic characteristics of leading utilities. In Germany, BEW was the largest of the urban utilities.

Those who compared the state of electrification in various cities found that Berlin had lit the streets of the metropolis beautifully, in part with arc lighting from BEW and in part with gaslight from the city-owned plant. The delegation of engineers from Melbourne waxed eloquent. Berlin's streets, they said, were among the finest in the world—wide, smooth, and clean. Nowhere else was there a thoroughfare more beautiful than Unter den Linden as it stretched through the heart of the city and into the *Tiergarten.* Its lighting was supplied by newly introduced flame-arc lamps. The street was so smooth that "a considerable proportion of the youth, male and female, during their leisure, disport themselves on roller skates, incurring thereby some considerable risk from the rapid automobiles that abound everywhere." The leading thoroughfares, with or without skaters, had arc lights, and other streets had excellent gaslighting.[18]

[15] Frank H. Mason, "Transportation Problems and Progress in Germany," *U.S. Consular Reports,* no. 273 (June 1903), p. 176; idem, "New Electric Underground and Elevated Railway at Berlin," *Advance Sheets of U.S. Consular Reports,* 29 March 1902, p. 7.

[16] City of Melbourne, *City Electrical Engineers' Notes on Tour Abroad* (Melbourne, Australia, 1912), p. 13.

[17] Georg Klingenberg, "Electricity Supply in Large Cities," *The Electrician* 72 (1913): 398–400.

[18] City of Melbourne, *Engineers' Notes,* p. 38.

As early as 1890 Berlin's utility was superior, in many particulars, to that in New York, the city where Edison had inaugurated central-station electric lighting. John Beggs, vice-president of the Edison Electric Illuminating Company of New York, paid a professional visit to Rathenau's Berlin facilities in the spring of 1890, and his reports glowed with admiration. In his estimation—and he had inspected stations in America and Europe—Berlin's central stations had "attained the greatest degree of perfection reached up to the present time." He found them, "architecturally, mechanically and electrically considered, models of neatness, efficiency, reliability, economy and permanency."[19]

The history of central-station supply in Berlin before the establishment of AEG or BEW, its fully owned subsidiary, has already been told (see pp. 66–76 above). In 1884 Deutsche Edison Gesellschaft (DEG), the Rathenau company that held Edison patents, established the Städtische Elektrizitäts-Werke (StEW) to take over the supply franchise that had been given to DEG by the city of Berlin. The new company built central stations in Berlin on Markgrafenstrasse and Mauerstrasse, opening them in 1885 and 1886 respectively. In 1887 StEW's name was changed to Berliner Electricitäts-Werke, and Rathenau founded AEG. AEG then took over the management of BEW, located the BEW offices in the same building with its own on Schlegelstrasse, and formed a common management, or executive, board (*Vorstand*) consisting of Rathenau, Oskar von Miller, and Felix Deutsch.

The tone of the annual report of the Berliner Elektricitäts-Werke was sanguine for a year and a half after this reorganization. The lighting of Unter den Linden, the broad thoroughfare from Pariser Platz to Spandauerstrasse, was greeted "[by] the citizens of Berlin and by the entire electrical industry with joy."[20] The rapid increase in demand emboldened the company's directors to install capacity beyond the load that could be immediately connected. They were not concerned that capacity would stand idle; the demonstrated "preference of the public for electric light, especially the lively nightlife of the city, the erection of numerous new buildings and the rising living standards of the city" assured them that the system's load would soon again reach the limits of capacity.[21]

BEW soon ranked as the largest of the German utilities. The first annual statistics published in the 1895 *Elektrotechnische Zeitschrift*, Germany's most authoritative journal in the field, showed the Berlin utility ranking well ahead of its closest rivals, Hamburg, Frankfort on the Main, and Munich. At that time BEW had four central stations; all supplied direct current, and they had a total generating capacity of about 9,900 kw. The municipal works in Hamburg had a capacity of about 2,400 kw. A decade later, BEW, with a capacity of 85,100 kw., continued to outpace other urban utilities. The Hamburger Elektricitätswerke followed with 25,400 kw. In 1913, on

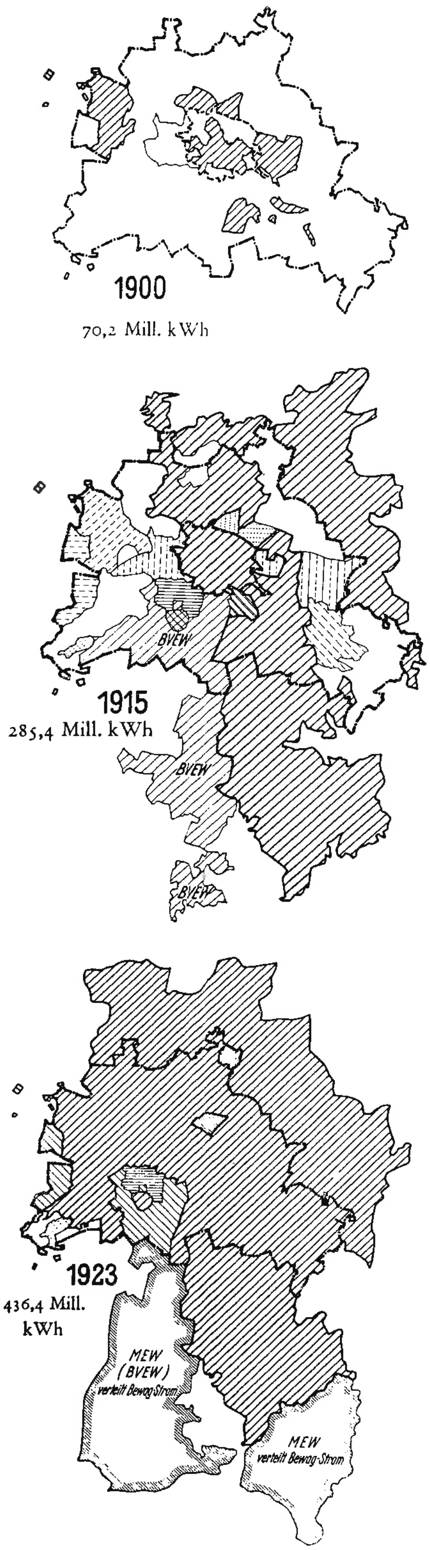


Figure VII.2. *Growth of supply areas in Berlin, 1900, 1915, and 1923. Area supplied by BEW = ▨. From Matschoss et al.,* 50 Jahre, *p. 63.*

[19] John Beggs to Board of Directors of EEI Co., New York, 8 April 1890, published in Payson Jones, *A Power History of the Consolidated Edison System, 1878–1900* (New York: Consolidated Edison Co., 1940), p. 331.

[20] Berliner Elektricitäts-Werke, *Sechster Geschäftsbericht der Actien-Gesellschaft Berliner Elektricitäts-Werke betreffend das Geschäftsjahr vom 1. Januar 1887 bis 30. Juni 1888* (Berlin: BEW, 1888), p. 1.

[21] Ibid., p. 2.

the eve of World War I, BEW was still ahead, with a capacity of 192,700 kw., compared to the Hamburg utility's 44,300 kw.[22]

Berlin, then, was an industrializing, well-ordered capital that sustained the development of modern technology, especially electrical technology. BEW used the most advanced light and power equipment and presided over the introduction of the general urban system that had been invented and developed during "the battle of the systems." AEG owned BEW and used it as a site for full-scale testing of new technology. Besides AEG engineers and managers, the experts at Siemens & Halske, by virtue of their presence in Berlin, stimulated BEW to excel. The Charlottenburg *Technische Hochschule* and the University of Berlin also enhanced the spirit of achievement. The municipal government was not, however, overawed by the technical, managerial, scientific, and financial power of its private utility. Berlin's officials drew upon the proud tradition of the Prussian civil service, demanding and receiving the same respect and authority that public officials of the state and national governments received. The strong Berlin government strove to direct and regulate its public utilities, including electricity, in order to fulfill its high standards and to satisfy the more broadly enfranchised electorate's increasing demand for public services. Always in the background, in an era of spreading municipal socialism, or municipal ownership of utilities, was the possibility that socialists and their allies in the *Stadtverordnetenversammlung* would take over the utility when its franchise expired. The socialists argued that government ownership would bring service that was more responsive to the electorate than that provided by the private utility. Until such an eventuality, however, the city was determined to tax the revenues of the utility in order to meet the increasing cost of social welfare.

Berlin before World War I, therefore, is an excellent setting for a study of the interactions of an effective, informed, and strong regulatory authority with a well-managed, well-financed, and technologically advanced private enterprise supported by various financial and banking interests. The various contracts negotiated between the city and the utility manifest not only the city's determination to share in the revenues of the private company but also the kind and extent of services the municipality believed its consumers—whether household, commercial, traction, or industrial—should have. In addition to the profit drive, the contracts reflect the utility's decisions about what was, or was to be, technically feasible. Finally, the arrangements made between the two parties manifest the technical style of a large-scale, capital-intensive, science-based enterprise. As in England, regulatory legislation could have retarded technological change by imposing conditions that reflected an outmoded state of technology or by imposing limits to growth, but in Berlin this was not the case. As in Chicago, politicians could have been so pliant as to have little effect on the utility, but, again, this was not true in Berlin. Berlin managed to coordinate technical and political power and create a working political economy.

[22] These statistics are taken from *Elektrotechnische Zeitschrift* 16 (1895): 223–26; 26 (1905): 24; and 34 (1913): 1450. Numbers have been rounded off to the nearest 100 kw. In the statistics for 1913, Düsseldorf-Reisholz and Gleiwitz rank ahead of Hamburg, but these are assumed to be area supply stations rather than urban utilities.

The first contractual agreement was reached in 1884 between the city and Deutsche Edison Gesellschaft and incorporated essential categories found in later agreements. Berlin required an income from the utility, and the contract specified that 10 percent of the utility's gross income and 25 percent of its annual net profit would go to the city. These percentages were calculated after a dividend of 6 percent on share capital was declared and deducted. In addition, the city would regulate rates by requiring *Magistrat* approval of prices for electricity supplied to customers. Because the city wanted the exciting new light for its streets and public buildings, the price for this service was specified. The utility was required to supply any customers who agreed to take service for three years.

The wording on compulsory purchase and the duration of the franchise caused debate and created problems. The Berlin negotiators undoubtedly recalled the confusing and generally negative impact of the compulsory-purchase clause enacted by the British Parliament in 1882. According to the Berlin-DEG agreement, the franchise was intended to extend for thirty years, but upon two years' notice after 1 October 1895 the city would be able to demand purchase at the tax value. If the city raised the taxes on the utility, the purchase price for the city then increased (a subtle control). The agreement specified as well that the utility had to set aside 2 percent of its gross income yearly until it had a depreciation and replacement fund amounting to 20 percent of the share capital. This provision guarded against a private concern's running down its plant before the time of compulsory purchase.

An interesting article in the 1884 contract provided that the city would have to pay 150 percent of the appraised value if the utility was taken over after fifteen years, and 3.33 percent more for each year less than the fifteen. For each year in excess of fifteen, the price would be reduced by 3.75 percent. The intent was to compensate the owners for too short a period in which to obtain a return on their investment. The effect was that after twenty-eight years Berlin could purchase the utility without paying a premium.[23]

What did the private company receive? In essence, the city conceded a monopoly on an inner-city area with a radius, centered on the Werdersch Market, of about half a mile. The area matched the economical distribution area of the early d.c. plant at the Pearl Street station in New York. In this area the utility could lay conductors under the street, thus also following the Pearl Street precedent. Considering the state of the technology, the area was appropriate. Technical change would soon extend the range of distribution, however, and then the company would want the franchise extended.

Before the two sides reached an agreement, the *Stadtverordnetenversammlung* engaged in heated debate. To some members, the granting of a monopoly to a private enterprise was a blow struck against progressive municipal practice. Others found it hard to believe that the city would consider cultivating an electric lighting system in private hands while it

[23] Hugo Meyer, "Municipal Ownership in Germany," *Journal of Political Economy* 14 (1906): 563; Robert C. Brooks, "Municipalization of the Berlin Electric Works," *Quarterly Journal of Economics* 30 (1916):192.

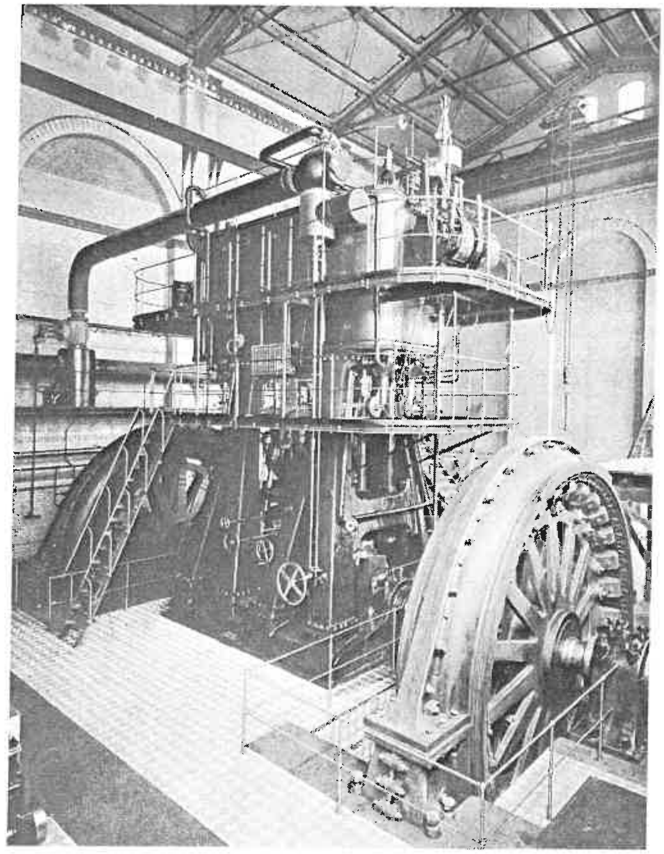
owned an operating gaslighting plant in which it had invested heavily. The persuasive argument in favor of the contract was the same as that used in England: because electric lighting was a new, unproven technology, private enterprise should take the risks, and the franchise-granting government should share the income and look forward to compulsory purchase after the utility had been tried and proven. Taxpayers' money was not—it was thought then—to be invested in technical innovations of a commercial kind. In time a large majority of the common council accepted the Berlin-DEG agreement. According to the enthusiastic endorsement of one Berlin newspaper, "Nothing characterizes the significance of a new creation better than that at the moment of birth it is recognized as a common good for all." Other cities and utilities throughout Germany patterned their relationships on the Berlin arrangement.[24]

In later years BEW negotiated contractual revisions as Berliners outside the original monopoly zone sought service. Requests for extension of service brought a response from the municipal authorities. The franchise service area was extended to provide a load for the direct-current stations on Markgrafenstrasse and Mauerstrasse and for the Spandauerstrasse station, which opened in 1889. In 1890, however, the *Magistrat* refused to allow expansion of BEW's facilities beyond the three central stations already in operation and another under construction (Schiffbauerdamm). Furthermore, the city limited expansion of BEW's total plant capacity to 28,000 h.p. This was probably done to protect the lighting market of the city-owned gasworks. The rapidly increasing demand for electricity, however, soon brought strong pressure against these constraints. Within the territory of supply, BEW made adjustments by thickening its network of distribution lines and, when the distances of transmission exceeded good d.c. practice, by building storage-battery substations that could be charged from the central-station generators during the low-load daylight hours and then be used to supplement the supply during the heavy-load evening hours. But the moratorium on the building of central stations and the limits on plant capacity frustrated the drive of BEW's managers and engineers to enhance the development of electric light and power.

The demonstration of a universal supply system at the Chicago exposition in 1893 and of the technology of high-voltage power transmission at Lauffen-Frankfort in 1891 made obsolete—from the viewpoint of BEW's engineers—the 1884 contract between the city of Berlin and BEW. In 1896, polyphase equipment was introduced at a new central station on Schiffbauerdamm (Fig. VII.3). At the central station on Markgrafenstrasse, engineers installed transformers and converters to change 3,000-volt polyphase current from Schiffbauerdamm into 220-volt direct current for distribution. The transformation of the Markgrafenstrasse station—the first central station in Germany—into a substation was indicative of the shift to the universal system. The new technology challenged old legislation, and the contradiction between technology and legislation sharpened further as

[24] Conrad Matschoss, "Geschichtliche Entwicklung der Berliner Elektricitäts-Werke von ihrer Begründung bis zur Übernahme durch die Stadt," *Beiträge zur Geschichte der Technik und Industrie* 7 (1916): 8; Conrad Matschoss et al., *50 Jahre Berliner Elektrizitätswerke, 1884–1934* (Berlin: VDI Verlag, n.d.), p. 12.

Figure VII.3. *First polyphase generator in Berlin, Schiffbauerdamm central station, 1896. Courtesy of Berliner Kraft-und Licht AG (formerly BEW).*



the central-station managers in Berlin sought to supply the recently electrified urban transit system with power. BEW wanted to build a large polyphase station outside city center in order to satisfy the demand not only for lighting but for stationary and traction power. The utility's goal reflected the interest of AEG, the manufacturer-owner, in introducing the new polyphase equipment its engineer Michael Dolivo-Dobrowolsky had developed. Emil Rathenau considered building a "gigantic central station" on the Spree River about ten miles from the city where real estate was cheaper, cooling water was available, and coal delivery and ash removal were easier. The station would supply Berlin by using three-phase transmission to reach substations and the center-city distribution system.[25]

BEW's negotiations with the municipality to obtain the rights to fulfill these technical possibilities were drawn out and difficult. Discussion extended from the summer of 1897 until the end of 1898. Besides the utility's determination to expand by fulfilling technical possibilities and to obtain profits from related economies, there was the underlying issue of private versus public ownership, which the Social Democrats in the city government kept alive, and the related practical question of when the city should exercise the power of purchase. BEW wanted a clear and precise understanding about the purchase option so that it could plan its expansion and

[25] "The History of a Great Electrical Company," *Electrical Review* 37 (1895): 627.

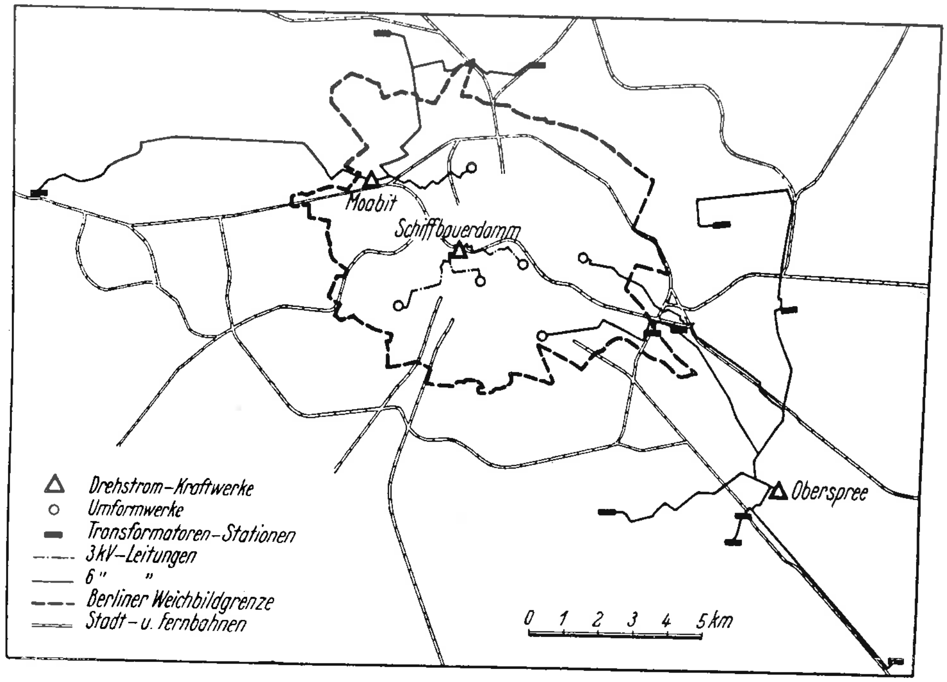
establish profitable rates. On the other hand, the majority of the *Magistrat* and *Stadtverordnetenversammlung* wanted the utility to flourish so that consumer needs would be met and the utility would be sound when taken over. The situation called for constructive negotiation rather than adversary confrontation.

The rapid increase in electric street railway load after 1896 posed a major issue for negotiation. In 1879 Werner von Siemens had displayed an electric locomotive at a Berlin trade fair, but the importance of this mode of transportation did not become clear until the 1890s. In 1894 the power load (traction and stationary) on BEW was only one-tenth of the total; in 1900 the traction load matched the combination of stationary power and light load. The city wanted the rate for traction power to be low in order to facilitate the transportation of lower-income groups, especially the increasing number of industrial workers. The utility wanted to increase the power load in order to utilize enlarged plant capacity more fully, improve the load factor, and lower unit capital costs. The two parties finally agreed that all electric-streetcar franchises granted by the city would require that the enfranchised enterprise take electricity from BEW. In return, the utility agreed not to exceed charges of 10 pfg./kwh. for the electric-streetcar power supply; this was substantially lower than the 16 pfg./kwh. that had been charged since 1894 for power current, a rate which had scarcely exceeded costs. The company took the risk that economy of scale and improved load factor would lower costs below the price. Each five years the price was to be renegotiated, but it was not to be higher than that charged by the three largest German cities that supplied current for electric traction from steam-generating plants.

On the issue of the area of BEW's supply monopoly and the duration of its tenure before compulsory purchase was possible, the 1899 contract provided a monopoly for all of Berlin and specified that the compulsory-purchase option could not be exercised before 1915. The ceilings placed on generating capacity were raised but not eliminated in 1899, again suggesting a reluctance on the part of various interests represented in the city government to see electric light and power rapidly displace gas lighting. The agreement of 1899 stated that capacity inside Berlin should be limited to 42,500 kw. and that power for the city originating outside Berlin should not exceed 37,000 kw. This provided for the high-voltage polyphase capacity BEW wanted outside the city and at the same time assured compulsory purchase of these facilities along with those in the city (see Fig. VII.4). The contract also specified that all electric generating plants and supply franchises held by AEG as well as BEW within a radius of 30 kilometers from the center of Berlin would be subject to purchase in 1915. By means of this understanding, the two parties avoided the possible dilemma of the private enterprise extending its facilities beyond the political jurisdiction of the government authority holding a purchase option—a chronic problem in London before World War I.

Increasingly burdened by expenditures for city services, Berlin took advantage of the renegotiation of the contract to raise its share of BEW's income. Berlin continued to take 10 percent of the gross income, but doubled its share of the company's profits. The 1899 contract specified that the municipality would receive 50 percent of the net profits after a 6 percent

Figure VII.4. BEW polyphase system, 1900: Central stations (△); motor-generator conversion substations (○); and the city limits of Berlin (- - -). From Matschoss et al., 50 Jahre, *p. 127.*



dividend on stock shares had been declared and deducted.[26] (In 1911–12 the total income of the city from BEW was 7 million marks.)

The city also specified that when profits (*Reingewinn*) exceeded 12.5 percent of the share capital, customer rates would be reduced by up to 10 percent. By 1913 (a year for which comparative rates with other major world cities are available) BEW, with city approval, charged 40 pfg./kwh. for lighting, with discounts based on the annual bill for current; 16 pfg./kwh. for night service and advertising; and 11 pfg./kwh. for power. (There was no charge for meters.)[27]

Differential rates favoring industrial consumers, both traction and stationary, kept light a luxury for private consumers but spurred industrialization. In 1914 only 6.6 percent of Berlin households were connected for electricity supply; only in 1927 did the number reach 50 percent (see Fig. VII.5).[28] As observed, the share of light in the total load dropped sharply after 1894, and the traction load far surpassed the light load at the turn of the century. The most notable change in the load mix after 1900 was the steady increase in stationary power load (see Fig. VII.6). In 1900 BEW

[26] *Saling's Börsen-Jahrbuch, 1900/1901,* p. 1090; 1901/1902, pp. 1176–77.

[27] The County of London Electric Supply Co., Ltd., *Public Inquiry Held by the Electricity Commissioners in Connection with Application for Consent for the Erection of a Power Station at Barking: October 6, 7, 8, 9, 1920: Justification of Evidence Given by Mr. Charles H. Merz,* app. 3, "Electricity Supply in Great Cities Throughout the World" (item in Merz & McLellan Co. Archives, Amberley, Killingworth, near Newcastle upon Tyne, England). The information on Berlin is for the years 1911–13; see p. 258 below for a comparison of rates for Berlin and other cities. Another source, City of Melbourne, *Engineers' Notes,* p. 13, reported the municipality's income from BEW revenues in 1910–11 as £174,000. The city's share of the utility's income combined with its share of the profits totaled 37 percent of BEW's gross income. W. Fellenberg, "Die Entwicklung der Starkstrom technik in Deutschland und in der Vereinigten Staaten von Nordamerika," *Elektrotechnische Zeitschrift* 30 (1909): 1199.

[28] Matschoss et al., *50 Jahre,* p. 56.

Figure VII.5. *Increase in electricity consumption in Berlin: Percentage of Berlin households connected* (table left); *increase in kilowatt-hours consumed per capita* (graph right). *From Matschoss et al.,* 50 Jahre, *p. 56.*

Jahr	angeschlossene Berliner Wohnungen vH
1910	3,5
1914	5,5
1918	6,6
1922	11
1925	25
1927	50
1928	55
1929	60
1930	68
1931	70
1932	74
1933	76

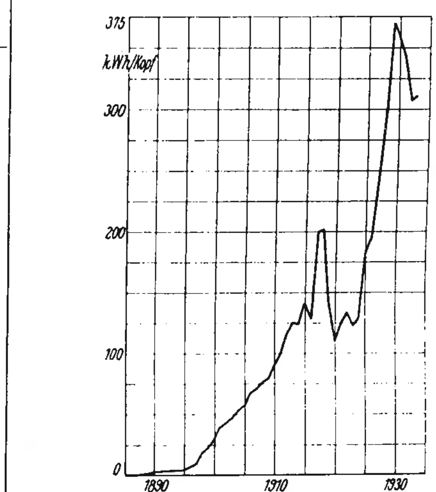
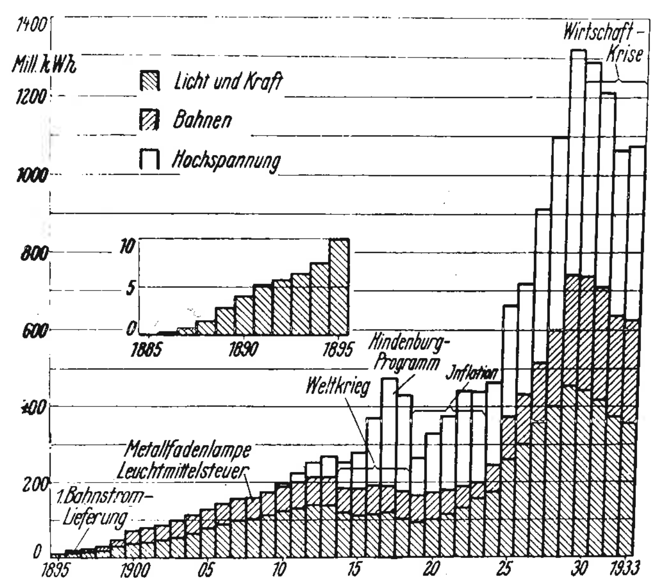


Figure VII.6. *Development of various loads, BEW: Light and power* (Licht und Kraft); *electric traction* (Bahnen); *and high-voltage transmission* (Hochspannung). *From Matschoss et al.,* 50 Jahre, *p. 89.*



supplied 52,014,612 kwh. Connected to the Berlin network by the end of fiscal year 1899/1900 were 4,964 motors, 303,304 incandescent lamps, 12,396 arc lamps, and 676 miscellaneous apparatus. The total connected load was 36,350 kw. In addition, the streetcar load amounted to 8,000 h.p. Of the total consumption, in contrast to connected load, light amounted to 28 percent; stationary motor power, 24 percent; and streetcar, or traction power, 48 percent.[29] In 1900 the connected stationary power load surpassed

[29] *Saling's Börsen-Jahrbuch, 1901/1902,* p. 1176. These statistics refer to the business year 1 July 1899 to 30 June 1900.

TABLE VII.1. MOTOR LOAD OF BERLINER ELEKTRICITÄTS-WERKE IN BERLIN CLASSIFIED ACCORDING TO USE, 1914

Load	*No. of Motors*	*Kw.*
Metal Working	7,023	24,155
Elevators	4,940	28,939
Woodworking	3,816	11,464
Presses	3,749	8,997
Ventilators	3,297	1,240
Meat Packing	1,724	5,287
Sewing Machines	1,638	1,280
Washing Machines	1,026	1,947
Pumps	880	5,813
Paper Mills	698	1,831
Cloth Cutting	630	390
Leather Working	571	1,615
Grinding and Polishing	493	1,381
Dough and Butter Machines	400	1,881
Stirring, Mixing, and Grinding	395	2,154
Spinning	274	558
Dynamo Drive	188	2,743
Coffee Making	156	273
Tobacco Manufacturing	146	393
Hat Pressing	53	113
Various	4,686	14,030
Total	36,783	116,484

Source: Berliner Electricitäts-Werke, *Geschäftsbericht . . . 1914/15*, pp. 10–11.

the connected light load for the first time. (As noted, traction load about matched the combination of stationary power load and lighting load.) From that point on, BEW was primarily a power company. By 1907 the traction and stationary power loads were about equal. After 1910, when BEW began supplying industrial consumers by means of 100-h.p. motors directly from a high-voltage network rather than from the regular 220-volt system, the stationary power load surpassed the traction load and continued to grow larger. BEW promoted in factories the introduction of electric motors to replace steam engines with belt-transmission systems by renting motors at a modest cost and allowing their return or purchase after thorough testing and evaluation. The close coordination between AEG, the manufacturer of these motors, and BEW furthered the electrification and industrialization process.[30] (See Table VII.1.)

Further breakdown of the load according to type of consumer throws light on the nature of industrialization in Berlin. In 1910–11 the total output of BEW, including energy used in its own central stations, amounted to 198,031,743 kwh. The total was categorized as follows: lighting, 26 percent; power, 37 percent; traction, 32 percent; and high-voltage supply (probably stationary power), 5 percent. In contrast to the output, the connected load was 206,726 kw., 39 percent of which was in lighting, 54 percent in power and heating (mostly stationary and traction power), and 6 percent in high-voltage supply.[31] In 1911 the connected load for all German central stations was 38 percent lighting (incandescent and arc) and 60 percent

[30] Matschoss, "Berliner Elektricitäts-Werke," pp. 20–21.

[31] City of Melbourne, *Engineers' Notes*, p. 13. Klingenberg, "Electricity Supply in Large Cities," p. 398, lists BEW's 1910–11 output as 192,100,000 kwh.

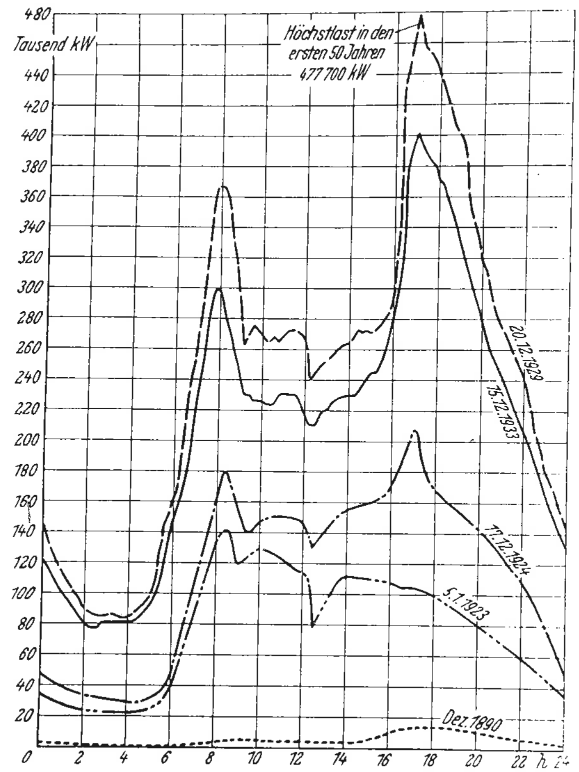


Figure VII.7. *BEW load curves on days of highest load* (Höchstlast). *From Matschoss et al.,* 50 Jahre, *p. 71.*

power and heating (stationary, 43 percent; traction, 15 percent; and heat, 2 percent).[32] The correlation between Berlin and the rest of Germany, urban and rural, in load mix is partially explained by the fact that while Berlin had about 8 percent of the total connected load on central stations in Germany, other large cities also had substantial shares. Like Berlin, the large cities were industrializing and providing mass transit. The traction share of the total power load, however, was much higher in Berlin than in the rest of Germany.

By World War I, BEW had created a universal supply system of the kind found in Chicago, a system that was still notably absent in London. BEW had taken the initial step toward establishing such a system in 1896 with the inauguration of polyphase supply at the Schiffbauerdamm central station. Its major move was made in 1899 (at the time of its new contract with Berlin) with the takeover of the Oberspree power station from AEG (see Fig. VII.8). This was a large station located outside Berlin. AEG had put Oberspree into service in 1897, before BEW was authorized by the city to operate power plants outside the city. With an initial capacity of 1,000 kw., the power plant had the advantages of lower-cost real estate, available cooling water, and easier coal and ash handling. Oberspree was also equipped for power transmission to western Berlin and the city's western suburbs at 6 kv., but before 1899 the plant supplied industry in the immediate vicinity, including an AEG cable-manufacturing plant (see Fig. VII.8, p. 193). After

[32] Georg Dettmar, "Die Statistik der Elektrizitätswerke in Deutschland nach dem Stande vom 1 April 1913," *Elektrotechnische Zeitschrift* 34 (1913): 1447–50.

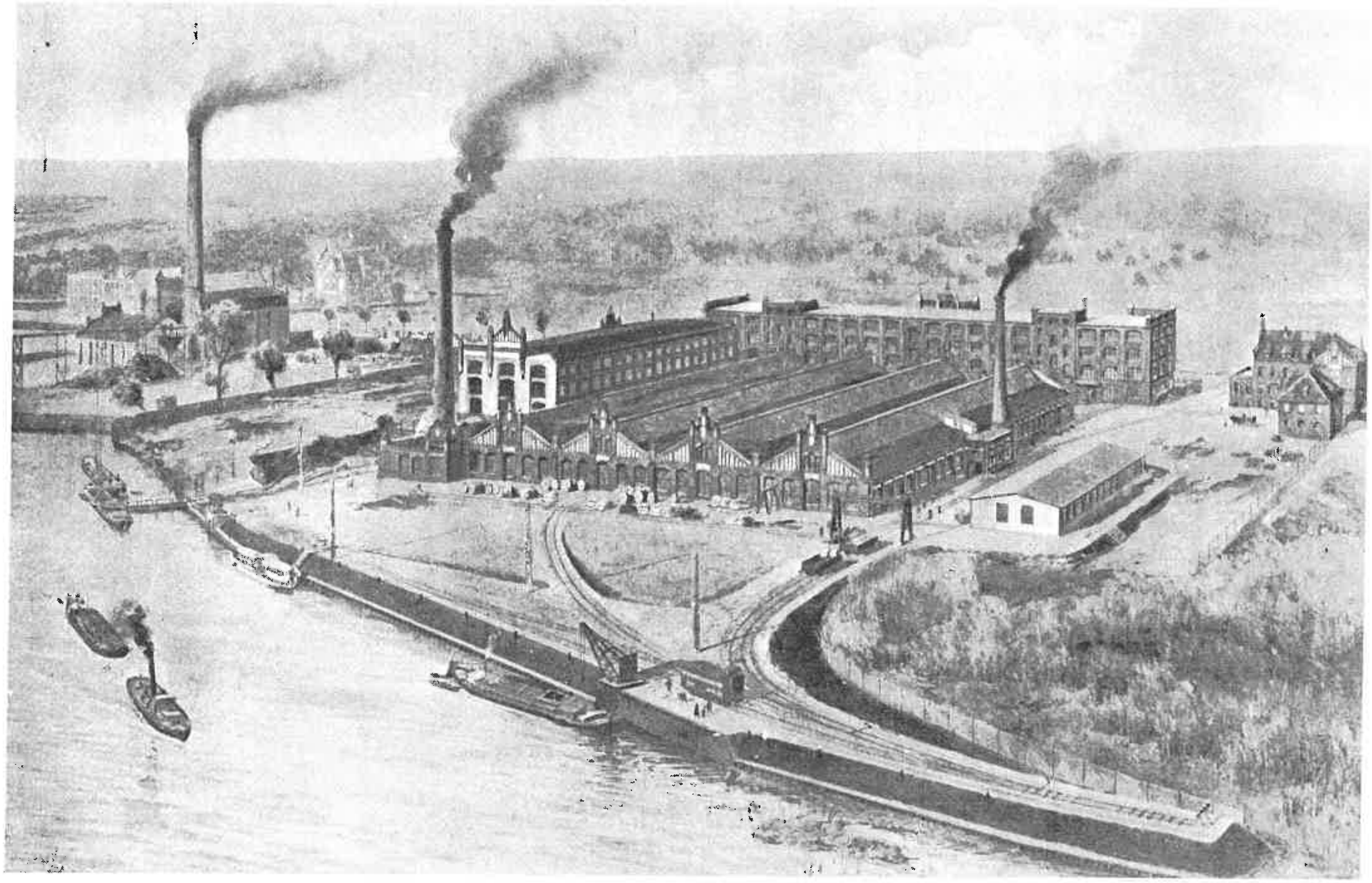


Figure VII.8. *The polyphase central station at Oberspree* (left) *and the AEG Cable Works, its primary load* (right), *1897. From Matschoss et al.,* 50 Jahre, *p. 30.*

capacity restrictions on BEW were eliminated in 1907 by a revision of the 1899 contract, BEW increased the capacity of the Oberspree plant, installing 52,000 kw. by 1912.

As the load within the area of the city already supplied with two-wire, 110-volt current steadily increased, BEW decided (in 1899) to enlarge the capacity of its distribution system by raising the voltage to the consumer from 110 to 220. BEW was the first utility in Germany to move to the 220-volt system, and it set a precedent that spread throughout the country, much of the Continent, and to England. (The United States stayed with the 110 system.) With the change, BEW assumed the cost of converting consumers' appliances and motors to the higher voltage. The consequent lowering of distribution costs because of more economical distribution (less copper) would compensate the company. Development of a metallic incandescent-lamp filament capable of withstanding the higher voltage made the changeover possible.[33]

The metallic-filament lamp introduced in Berlin in 1906 used only one watt for each candle power of illumination and about one-third the energy of the carbon filament. The attendant reduction in the cost of lighting

[33] Matschoss, "Berliner Elektricitäts-Werke," p. 19.

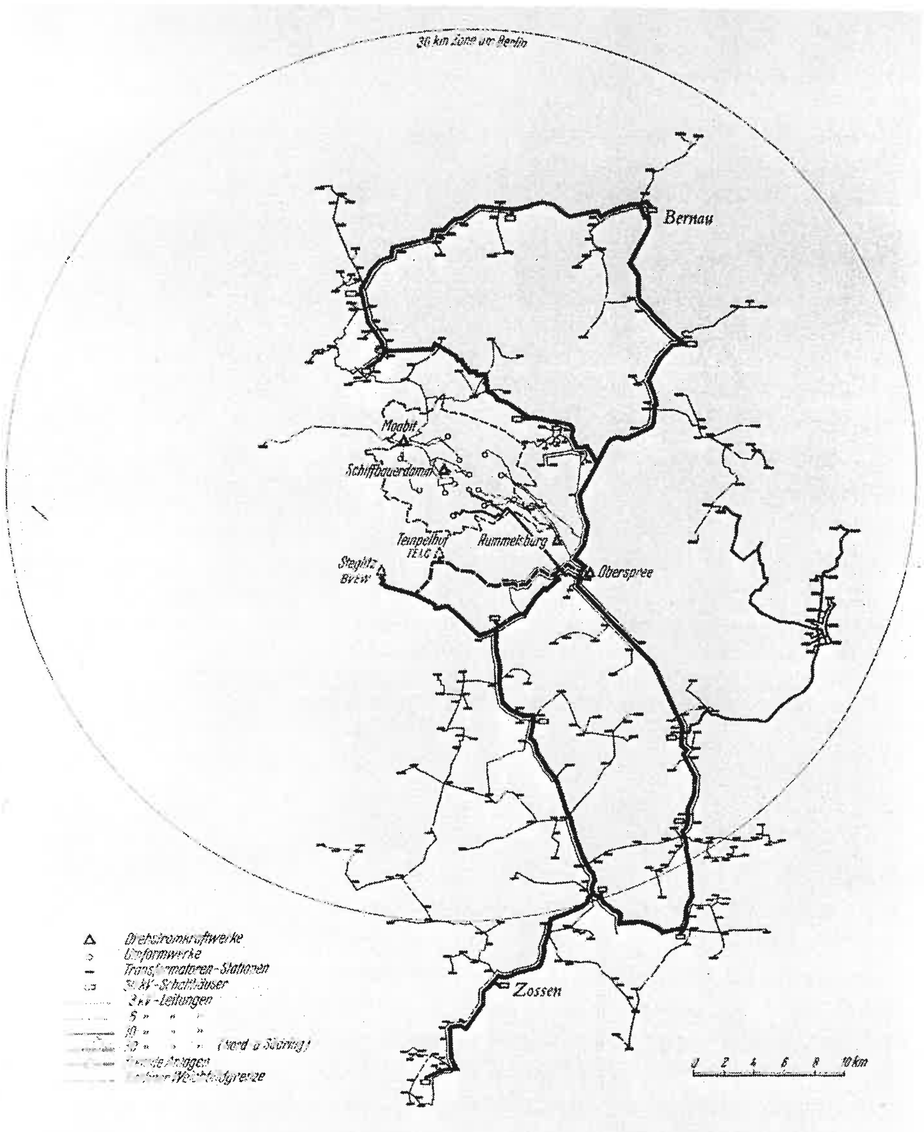


Bild 126. Drehstrom-Netzgebiet 1915

Figure VII.9. *Polyphase supply system, BEW, 1915:* △ = *central stations;* ○ = *current conversion (motor-generators);* ▬ = *transformer stations. From Matschoss et al.,* 50 Jahre, *p. 168.*

made the incandescent lamp attractive to an even larger segment of the population that had formerly used gaslight.[34] Several years earlier BEW had reached out for lower-income customers after being sharply challenged by the lower rates of small isolated stations operated by the owners of large apartment and office buildings for their own and their tenants' use. These "block stations" were able to offer lower rates because they did not use the streets for distribution, needed no revenue-sharing franchise from the city, and concentrated on high-load districts. To meet the challenge, BEW had lowered its general lighting rates in January 1904 to 40 pfg./kwh., a reduction of 25 percent. Instead of an increase in demand, however, BEW experienced a sharp downward movement in consumption during the win-

[34] Matschoss et al., *50 Jahre,* p. 38; Hans-Joachim Braun, "Gas oder Elektrizität? Zur Konkurrenz zweier Beleuchtungssysteme, 1880–1914," *Technikgeschichte* 47 (1980):13–14.

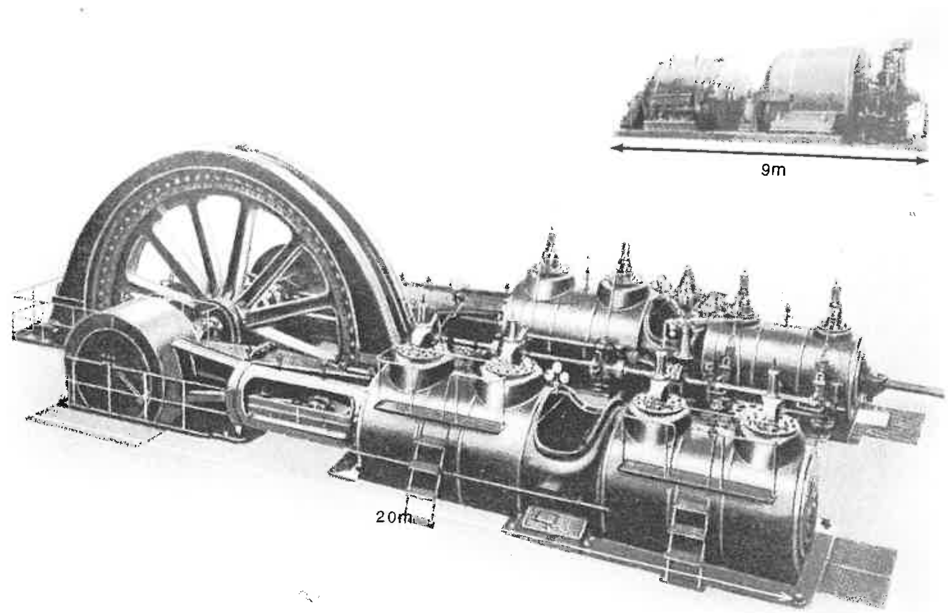


Figure VII.10. Comparative size of reciprocating steam engine with generator (bottom) *and steam turbine with generator* (top). *From Matschoss et al.,* 50 Jahre, *p. 132.*

ter of 1908/9. This resulted in part from the introduction of the more efficient metallic-filament lamp, but it also followed the government's limiting shop hours to eight, the more efficient use of electricity by streetcars, and the city-owned gas plant's reduction in rates. BEW countered with further rate changes, especially those that encouraged the large power users.[35] The enticement of heavy power consumers was a response to the endemic problem of the isolated plant from which large industrial consumers supplied their own needs. As the graphs of BEW output show, the trend was again steeply upward in 1909. (See Fig. VII.5.) Isolated plants supplying individual industries continued to offer substantial competition, however; in 1913 it was estimated that isolated plants and "block stations" supplied about 40 million kwh., or the equivalent of almost one-fifth of the energy sold by BEW.[36]

BEW continued to build a generalized system by introducing steam turbines beginning in 1902 (see Fig. VII.10). The early history of turbine use by BEW shows the close relationship of AEG as manufacturer and BEW as full-scale testing ground. AEG entered the turbine field soon after early installations of Parsons turbogenerators in England and Parsons-type turbines built by Brown, Boveri & Co. of Baden/Mannheim, a subsidiary of the Swiss firm, in Elberfeld, Germany, provided strong indications of the invention's practicality and potential improvements. AEG made a false start by attempting to develop the Riedler-Stumpf design. The Riedler-Stumpf turbine was an adaptation of the basic constant-pressure design introduced by the Swedish inventor Carl G. P. de Laval in 1883. By means of large cross-sectional turbine blades and the reordering of additional steam nozzles, AEG hoped to hold the speed of rotation to practical limits. The first large turbine of this design was installed in 1902 in BEW's Moabit power station (see Figs. VII.11 and VII.12). At its maximum speed, 3,800 rpm,

[35] Matschoss et al., *50 Jahre,* pp. 37–38.
[36] Klingenberg, "Electricity Supply in Large Cities," pp. 398–99.

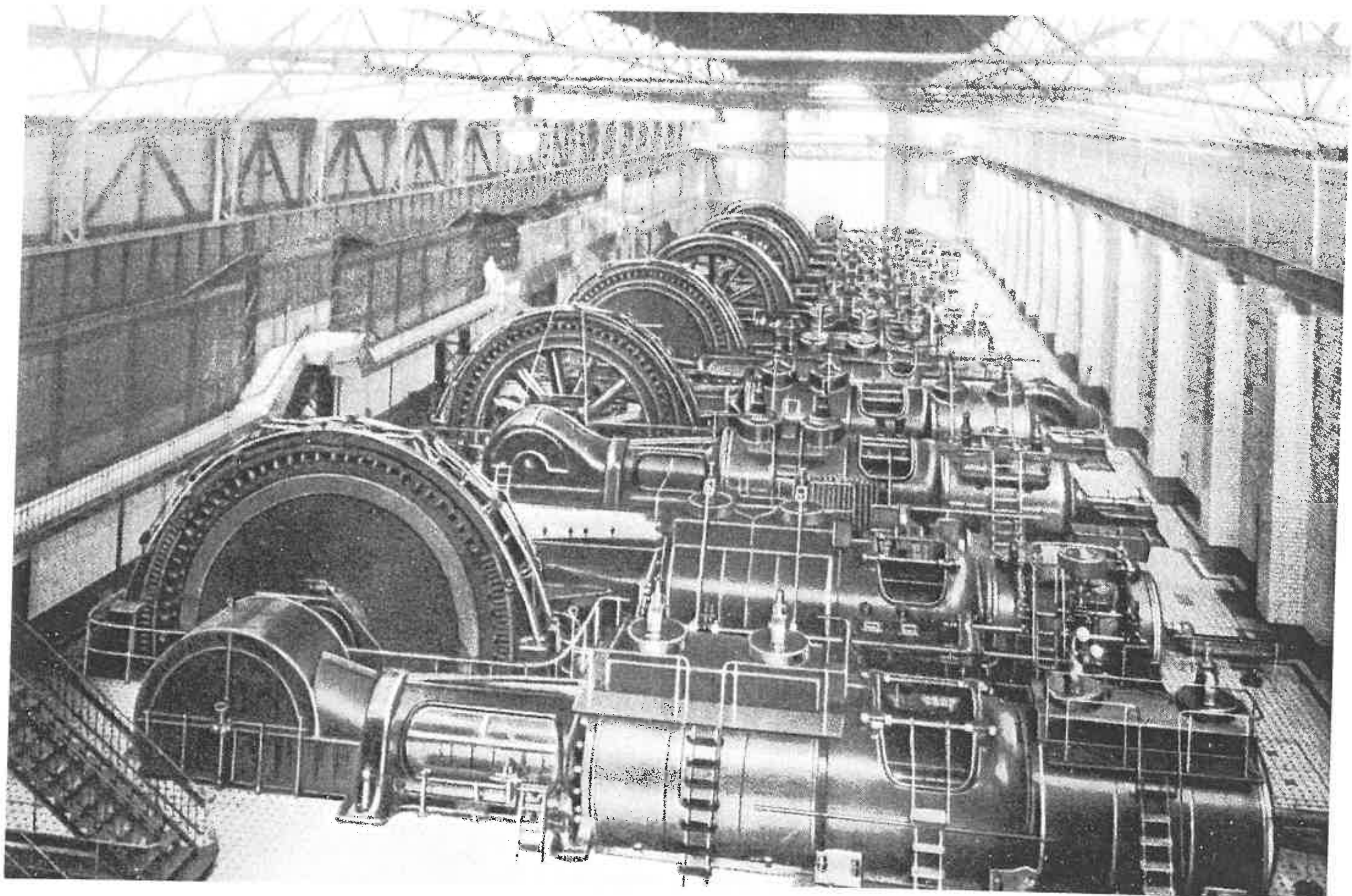


Figure VII.11. *Moabit central station, 1907: Reciprocating steam engines and generators* (foreground); *turbines* (rear). *From Matschoss et al.,* 50 Jahre, *p. 36.*

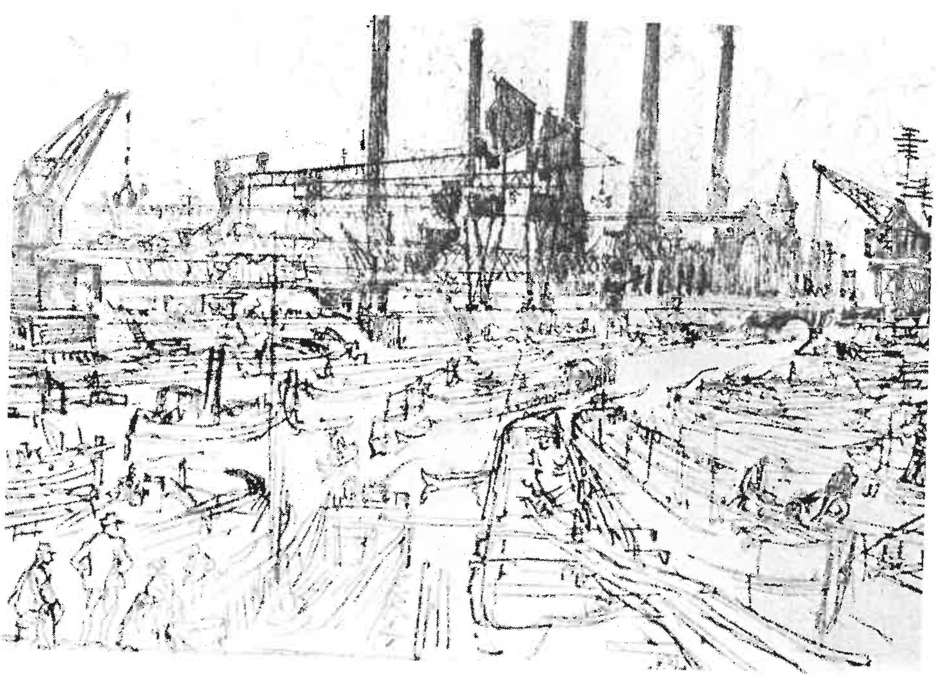


Figure VII.12. *Moabit central station, 1914. Drawing by Joseph Pennell. From Matschoss et al.,* 50 Jahre, *p. 33.*

the Riedler-Stumpf turbine produced 2,000 h.p., but AEG decided that larger models would have stability problems and be prohibitively expensive to install, so it abandoned the design.

AEG then made an agreement with the General Electric Company of America to use the Curtis design that GE had developed and patented. The manufacturers also agreed to exchange development and operational experience as they worked on the turbine. From 1904 until 1917 all BEW turbines except one were of the Curtis type. The exception arose when AEG was unable to supply within a short time a Curtis turbine when BEW's load demand suddenly increased sharply in 1905. The utility therefore placed a Brown-Boveri-built Parsons type of turbine of 5,800-kw. capacity into operation at Oberspree. More turbines were installed at Oberspree, but BEW's first all-turbine station—a station comparable to the Fisk Street station opened in 1903 in Chicago—was Rummelsburg, which began operating in November 1907 with a 13,500-kw. capacity. Further evidence that the post-Edison era had arrived was the complete conversion, in the same year, of the original Markgrafenstrasse direct-current station to a substation.[37]

By the eve of World War I—and the takeover of the utility by Berlin in 1915—BEW had acquired salient characteristics that define leading urban systems even today. Its supply area spread beyond the 5-kilometer radius of old Berlin out to the 30-kilometer radius specified in the 1899 contract. Drawing heavily on the Oberspree plant, BEW supplied about a hundred small districts, or local authorities, mostly to the east, south, and north of Berlin (see Fig. VII.13). This suburban region had a population of about 2.5 million (compared to the 2 million within old Berlin). By 1915 BEW had two other polyphase plants (Moabit and Rummelsburg) and three inner-city plants (Mauerstrasse, Spandauer, and Schiffbauerdamm). These six plants had a combined capacity of 155,000 kw. There were twenty-four substations (twelve within the city) for the conversion of polyphase current to direct current and for transformation of voltage. Transmission and distribution cable extended 7,740 kilometers. Within the city, general distribution was almost entirely 440/220-volt direct current for the lighting and small-power consumers. Also available in this area were 550-600-volt direct current for traction and 6-kv. polyphase current for heavy stationary-power users. After 1904 the level of transmission voltage was raised. Oberspree and Moabit supplied distant substations with 10-kv. transmission, and in 1911 BEW pioneered on the Continent by constructing a 30-kv. ring supply for Berlin's northern and southern suburbs. The increase in voltage necessitated the introduction of oil-cooled switches into the system.[38]

Georg Klingenberg, the engineering head of AEG's power plant design and construction division, an engineer of international reputation and author of definitive works on power-plant design and operation, described and analyzed BEW around 1913.[39] Comparing the Berlin utility with those in Chicago and London, he found that the capital cost of the power stations

[37] Matschoss et al., *50 Jahre,* pp. 133–5, 218–19.
[38] Ibid., pp. 43, 165–70.
[39] Klingenberg, "Electricity Supply in Large Cities," pp. 398–401.

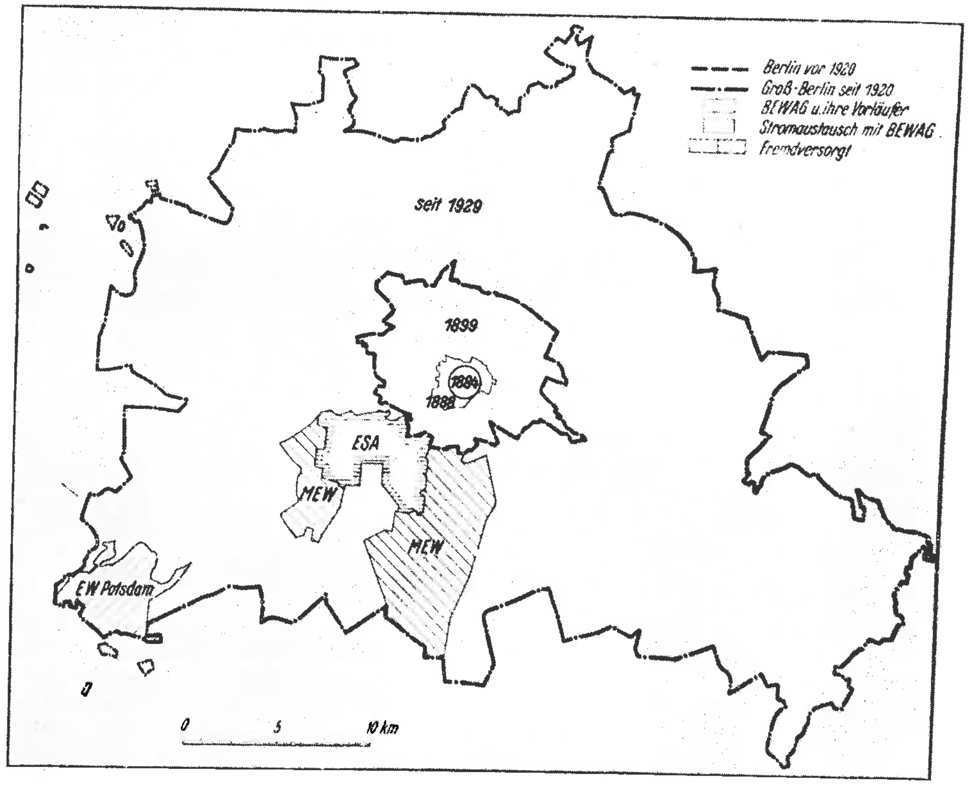


Figure VII.13. *Expansion of BEW:* Inner boundary, *Berlin before 1920;* outer boundary, *Berlin after 1920;* crosshatching, *other utilities. From Matschoss et al.,* 50 Jahre, *p. 89.*

and the capital cost of the distribution system per installed kilowatt were lowest in Berlin. Berlin's per-capita consumption of current was higher than London's and lower than Chicago's, but the comparison did not take into account block and isolated stations, of which there were an unusually large number in Berlin. Klingenberg also noted that Berlin had the most evenly balanced lighting, traction, and stationary-motor loads. Berlin's load factor, the highly significant indicator, was higher than London's and lower than Chicago's. Examining the cost characteristics of the three systems, Klingenberg observed that the Berlin utility's operating costs were the lowest, and he concluded that this resulted from lower wages and lower fuel consumption per kilowatt-hour of output. Economy in the consumption of coal was counterbalanced, however, by the higher price of coal in Berlin compared to Chicago and London. The total cost per kilowatt-hour, then, was higher in Berlin than in Chicago. Not only was the price of coal higher there, but the Berlin government took a large share of BEW's revenues. (See Fig. IX.9, p. 258 below, for a detailed comparison of the three cities' utilities.)

In view of the large revenues the city derived from BEW, some contemporaries expressed surprise that Berlin would seriously consider exercising its contractual right to take over BEW in 1915. The Social Democrats in the common council advocated municipal ownership for ideological as well as economic reasons. The utility could be more easily directed toward the fulfillment of various social objectives if it was owned and operated by the city, they argued. Rates, for example, could be adjusted to favor lower-income groups. In addition, the socialists argued, profits taken by the

Figure VII.14. Georg Klingenberg, an AEG engineer noted for central-station designs. Courtesy of Berliner Kraft-und Licht AG (formerly BEW).

private owners, especially AEG, should come to the city. By 1915, those who favored the takeover believed that since the period of high financial risk had passed, it was appropriate for the utility to be government owned and managed, as were other, older utilities such as gas. They also believed that full government control of the city's electric power supply would bring increased control of the city's industrial development.

Empowered by contract to purchase the utility in October 1915 if notice of intent was given two years in advance, the city began negotiating with BEW in 1911 the question of extending the contract or purchasing the utility. The principal points at issue were rates and the relationship between BEW and AEG. The city wanted lower rates (for which there was precedent in Germany) and less AEG influence. Having lowered its rates consistently over the past thirty years, BEW argued that further reduction was impossible unless costs were substantially lowered. If, BEW insisted, the city allowed it to take advantage of advanced transmission and generation technology by constructing a large mine-mouth power plant at the Bitterfeld lignite fields almost eighty miles from Berlin, lower costs would follow.

The imperial German government, however, frustrated BEW's plans for a Bitterfeld power plant. It seized the lignite deposits to exploit them for critical wartime needs and then, in 1916, supported the construction of the Golpa-Zschornewitz power plant there (see pp. 288–89 below). Deprived of the cost-reducing technology, BEW agreed only to an extension of the existing franchise—and the existing or slightly modified rate structure for the next six years. Led by an *Oberbürgermeister* who favored municipal ownership, a *Stadtverordnetenversammlung* dominated by socialists and their allies, and a *Magistrat* that had come to agree with the common council, the city then purchased the Berliner Elektricitäts-Werke and took over management of the utility in October 1915.

Like the general contractual arrangements between the city and the utility, the specific provisions for purchase were complex and ingenious. Before the renegotiation of the contract in 1899, the city had had the right to purchase BEW at the tax value determined by two experts, one appointed by the city and the other named by the utility. They were to "appraise the properties as an interdependent whole according to commercial principles."[40] In 1899, the parties had agreed that the plant and real estate would instead be purchased according to book value. Subsequent analysis showed that the book value (original cost) of the utility's real estate was 4,195,000 marks lower than the appraised value in 1915, but that the book value of the plant was 1,700,000 marks higher than the appraised value in 1915. The book-value purchase price of plant and real estate in 1915 was, therefore, 2,495,000 marks lower than the appraised value. The city council voted to purchase BEW for 130 million marks; the exact sale price was 132,400,000 marks.[41]

Judging by its unwillingness to negotiate purposefully after the collapse of the mine-mouth power-plant proposal, AEG may not have been reluctant to sell BEW in 1915. The sale provided AEG with substantial capital for new investments; moreover, the years of BEW ownership had brought

[40] Brooks, "Berlin Electric Works," p. 192.

[41] Ibid., pp. 188, 193; Matschoss et al., *50 Jahre*, p. 223.

"quite acceptable dividends to shareholders" and had proved "a veritable gold mine to the holding company [AEG]."[42]

In America, utility managers, who often found themselves in an adversary, even hostile, relationship with government, may have been surprised to learn that leading executives from the private German company were taking jobs in the municipally owned plant. The newly named Städtische Elektrizitäts-Werke Berlin (StEW) was determined to have the best managerial and technical talent available and was willing "to pay accordingly."[43] Members of the *Vorstand* ("executive committee") were to receive a guaranteed salary of 15,000 marks as well as increment according to net income, so long as the total did not exceed 39,000 marks. Dr. Herman Passavant from BEW's *Vorstand* became a member of StEW's *Vorstand.* Gustav Wilkens, who had been a deputy member of the old *Vorstand,* held the same position in the new committee. Emar Wikander, a manager at BEW, became a member of StEW's *Vorstand* and technical director of the plant.[44] On 18 April 1915 the Berlin common council voted to purchase BEW, and on 1 October 1915 the utility passed into new ownership. Emil Rathenau died on 20 June of that year.

[42] Brooks, "Berlin Electric Works," pp. 190, 191–92.
[43] Ibid., p. 193.
[44] Matschoss et al., *50 Jahre,* pp. 44, 95.