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When Worlds Collide: Government and Electrification, 1892-1939

Jonathan Coopersmith

Electricity, as a technology with scientific dimensions and as a utility requiring major investments, rapidly became an international business venture. However, electricity also had public dimensions that attracted public authorities. The State became involved in the electrification process not only as a regulator and standard setter, but also as a client and eventually as an investor, either through collaboration with the private sector or as the sole actor through nationalization. Although the State confined itself within the boundaries of its territory, there is no doubt that its gradual intervention had a significant impact on global electrification and that the constant presence of the State gave electrification a strong ideological dimension easily perceptible in speeches and decision-making.

One advantage of the geographically and chronically wide-ranging approach of global electrification projects is we can see trends and patterns that otherwise might be lost in the "thick history" of specific countries. Perhaps nowhere is that as clear as in understanding the major roles played by government in shaping the evolution of electrification.

"Government" covers a wide range of entities from the local to the supranational, and government involvement grew in specific phases worldwide at approximately the same times, albeit with large local and regional variations. This semi-lockstep movement reflects technological developments, similar economic and financial challenges, and the rapid speed of ideas, institutions, and individuals worldwide. In this paper, I outline the range of government entities, the phases of their involvement, shifting technological and financial paradigms, and examine specific regions.

Growing Role of Government

As with any technology, governments played significant roles in shaping the development of electrification (and, to a lesser degree, were shaped by

Jonathan Coopersmith is associate professor of history at Texas A&M University.

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it). Multiple levels of government ultimately became involved, including municipal, regional, state (or province), national (State), and supra-national authorities.

Evolution is the best concept to use in understanding government roles. These roles changed with the technological, institutional, financial, and political evolution of electrification, increasing along with the economic importance of electrification. Each country and colony elaborated their own set of laws and rules determining how electricity should be produced and distributed. This growing government involvement worldwide created an underlying pattern, shown in Table 1. The divisions are approximate, reflecting general trends rather than specific nations; overlap and local variations do not obscure these trends.

TABLE 1
Periodization of Laws

Preexisting	1870-1890
Local era	1880-1900
Regional	1900-1914
National	1914-1940
*Nationalization	1940-1970
*Deregulation	1970-2000

*beyond the scope of this paper

One reason for the pattern was the transfer of ideas flowing across borders even faster than technologies and capital. A potent force in promoting electrification and diffusing ideas and schemes were electrical engineers themselves. Technical societies, journals, conferences, consulting, higher education, visits, and job changes, bound together the international community of leading electrical engineers.[1] Perhaps the most prominent was Georg Klingenberg, the head of AEG's power plant design efforts. His *Bau grosser Elektrizitätswerke (Large Electric Power*

[1] Studying or working abroad was a particularly effective method of imbibing new ideas. Two-thirds of the forty prominent pre-revolutionary Russian electrical engineers and many leading Japanese electrical engineers had such foreign experience. In Denmark, the first generation of professionally educated electrical engineers also benefited from their foreign training. See Jonathan Coopersmith *The Electrification of Russia, 1880-1926* (Ithaca, N.Y., 1992), 38; Hoshimi Uchida, "The Transfer of Electrical Technologies from the United States and Europe to Japan, 1869-1914," in *International Technology Transfer: Europe, Japan and the USA, 1700-1914*, ed. David J. Jeremy (London, 1991), 224-25, 238-39; Henry Nielsen and Michael F. Wagner, "Technology in Denmark," in *Technology & Industry: A Nordic Heritage*, ed. Jan Hult and Bengt Nystrom (Canton, Mass., 1992), 18.

Stations), published in Berlin in 1913-14, reached and influential wide audiences throughout Europe.[2] Journals played a particularly important role in widely disseminating ideas and information.

We can divide the process of supplying electricity from its creation to delivery to the consumer into three stages: generation, transmission, and local distribution. In the early years, transmission distances were so limited that transmission and local distribution were the same. Government involvement occurred primarily at the municipal level, where central stations were built and operated. Transmission distances were so short (hundreds of meters) that stations had to be built in cities and towns, close to their customers. In the 1890s as electric stations grew in size and diffused outside capitals, and hydrostations and long-distance transmission became increasingly technically and economically feasible, government roles increased. The growth of electricity generation was due to the rapid expansion of markets for street lighting, indoor lighting, trams, and industrial power. Initially, each type of use had its own concession and operated its own station. Stations in major cities grew in capacity to megawatts (MW) and tens of megawatts, while smaller cities, towns, and villages installed stations in the tens and hundreds of kilowatts (kW). As engineers and managers appreciated the economic benefits of maximizing the load factor, they pushed for unified stations that provided electricity for lighting, industry, and trams in a city. The capital cost of the station was higher than separate stations, but the per-unit cost of generated electricity dropped.

Of necessity, the growing size of electric stations and long-distance networks of transmission lines raised issues such as eminent domain and right-of-way that the first generation of small, locally-oriented stations did not. Larger political and economic concerns also influenced the government role. World War I rudely demonstrated to states and industries how important electrification was, primarily though the painful combination of greatly increased demand and sharply reduced fuel and equipment supplies. State interest and control of utilities greatly increased with attempts to boost wartime electric power generation. This state intervention continued after the war in two major waves of government action. The first wave lasted into the early 1920s as a semi-technocratic urge to increase fuel autarky and create more efficient large-scale electrification networks. The second followed the Great Depression and emphasized economic autarky and the gains to the economy as a whole from electrification. Both waves, especially the second, linked electrification with the concept of planned economic development.

As electrification was capital-intensive, access to financing was very important. Not only municipal governments lacked capital for this

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[2] The first English version appeared in 1916 and Russian articles appeared in 1913-14 (e.g., “Generatory i oblastny tsentralnye stantsii,” *Elektrichestvo* 5 (1914): 151-55).

industry. Many countries' inadequate stock markets and other means of raising investment capital, combined with other pressing demands on budgets at all levels of government (ranging from abattoirs to railroads), meant that international investment was often the only way to finance large electrification projects. Consequently, government control of electrification and the economy, save for the Union of Soviet Socialist Republics (USSR), was not as complete as proponents might have desired. The need for financing meant that governments had to offer conditions attractive to foreign and domestic lenders.

Supranational organizations such as the World Bank and United Nations played an important role after World War II in financing and encouraging large-scale electrification. Earlier, the League of Nations also promoted electrification (its Committee for Communications & Transit had a Permanent Committee on Electric Power), though to a much lesser extent.[3]

Early Decades

Initially, existing laws and regulation provided the legal framework. Typically, rules concerning water or gas distribution, municipal enterprises, and concessions were extrapolated to include electric utilities.

Four concerns of many municipal governments were if electrical stations would harm existing (and possibly competing) enterprises, the financial feasibility of electric utilities, their safety, and the legality of such enterprises at the national level. The larger the municipality, the more attractive it was for an electric utility, but the more likely it had a gas works providing lighting. Would electric lighting harm gas sales, thus depriving cities of important funding? Even without that concern, could this capital-intensive technology make money? These fears and the greater consequences of failure were one reason concessionaires rather than risk-averse municipal governments usually pioneered the first electric utilities.

At the state, regional, and national levels, the pertinent laws typically concerned the formation and financing of companies and safety. In some countries, central governments limited or guided municipalities in their actions and abilities. Continuation of existing practices, allowing higher authorities to intervene on the local level with their technical and managerial staff, were generally based on tradition or on the weak legal status of municipalities, as France and Russia demonstrate.

A common problem for decades was local ignorance about electric energy. How could safe operations be ensured? A lesser issue was the

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[3] The League set up other permanent committees on air navigation, transport by rail, inland navigation, maritime ports and navigation, road traffic, and legal issues; see Hans Aufricht, *Guide to League of Nation Publications* (New York, 1951), 258-59.

relationship between utility wires and telephone and telegraph wires.[4] One major state role was ensuring the safety of utility operations by providing expertise, instructions, inspections, reviews, and other mandates at the national level.

In most countries, private firms constructed and operated the first central stations with a concession from the local government. Direct municipal interest and involvement in electrification grew as those stations proved profitable and the technological, political, and financial risks diminished in the 1890s. Two signs of this were the appearance of municipally operated stations and the first buyouts or takeovers of private stations.

The growing diffusion of electrification saw specific legislation empowering municipal electrification. Parliaments in the United Kingdom, Germany, Italy, and elsewhere encouraged municipalization or allowed municipalities to benefit from letting a concession of electricity generation and distribution. The goal was to reduce risks by establishing a solid legal framework providing incentives to both local governments and concessionaires. A major benefit of establishing this legal framework was guidance for local and regional officials. For example, the Russian 1897 "Model Agreement" provided a template for city administrators and state officials to negotiate with concessionaires. Such laws did not always emerge from the central government. The success of the Wisconsin Railroad Commission (established in 1907) in regulating electric utilities, together with its promotion by the National Electric Light Association, led to the adoption of state regulatory bodies in the United States.[5]

Establishing a legal framework proved very difficult due to issues ranging from the philosophical to the practical. One underlying assumption shared by governments and concessionaires was that electrification was a "natural monopoly," and direct competition should be discouraged because it would result in wasteful duplication of transmission and distribution networks. Instead, utilities should have monopolies of specific areas.

More controversial was the question of public or private ownership of utilities. This issue had ideological (or philosophical or political), financial, technical, and managerial aspects. Regarding the last three factors, local governments were likely to lack the capital, engineering expertise, and administrative skills to build and operate a utility. A concession, especially one packaged to provide the necessary financing,

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[4] The dangers were real: electricity could kill; e.g., see Joseph P. Sullivan, "Fearing Electricity: Overhead Wire Panic in NYC," *IEEE* [Institute of Electrical and Electronics Engineers] *Technology & Society Magazine* 14 (Fall 1995): 8-16.

[5] Luther R. Nash, *The Economics of Public Utilities: A Reference Book for Executives, Investors, Engineers, and Students* (New York, 1925), 94-95; Richard F. Hirsh, *Power Loss: The Origins of Deregulation and Restructuring in the American Electric Utility System* (Cambridge, Mass., 1999), 18-26.

technology, and management, looked very attractive. Access to financing was as important as technology in utility construction proposals. However, direct control over utility operations and the income produced were very attractive. Municipalities often were more responsive to their citizens.

Of the eleven factors Renfrew Christie considered essential for a successful utility, the three most important were the concession, the financing, and competent technical management to build and operate the utility.[6] The first required good local political connections; acquiring the second, whether foreign or domestic, was a challenge that grew with cost; and the third was usually foreign until a domestic cadre of skilled engineers and managers developed, often through experience working for a multinational firm.

On the practical level, good political relations, if not connections, were essential, though rarely written about. In 1881 the Hartford, Connecticut Common Council denied the request of Elihu Thomson's American Electric Company to build a central station and erect transmission lines. The petition failed because Hartford mayor Morgan G. Bulkeley and other prominent Hartforders had a charter for a competing electric company.[7] Sometimes, as in Santo Domingo in 1891, local entrepreneurs obtained a franchise first, and then set about finding equipment and financing.[8] The priorities were correct; the technology, management, and funding could come from a range of sources, but the right to a concession was unique.

More open to discussion and to the public was the length of time allotted a concession. One common component of a concessionary agreement was a clause giving the municipality ownership of the operation after a specific time, usually a few decades. The 1888 revision of the concessionary period in the 1882 British Electricity Act from 21 to 42 years greatly increased the attraction of private investors. A 40-60 year period (usually the latter for the more capital-intensive hydrostations) became the norm in many countries.

Rapid technological development in all aspects of utilities invariably had economic and political implications. Long negotiations, if not outright conflicts, often accompanied the passage from isolated units to the local system or from the local to a regional or national system because this shift implied a technological break from one system to the other. Intervention

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[6]. "Fuel, water, land, wayleaves [right-of-way], machinery, financing, workers, knowledge, consumer contracts, absence of competition, and state approval" in Renfrew Christie, *Electricity, Industry and Class in South Africa* (Albany, 1984), 27.

[7]. W. Bernard Carlson, *Innovation as a Social Process: Elihu Thomson and the Rise of General Electric, 1870-1900* (New York, 1991), 176-77.

[8]. "Electric Light Franchise in Santo Domingo," *Electrical Engineering* (15 April 1891), 459.

by a public authority often eased the transition by offering—or enforcing—closure, incentives, or even an advantageous substitution. Inversely, privatization is a way to impose a new technology on a nationalized system that has become obsolescent or unresponsive.

These decades were a period of enormous and continual technological change and competition. The 1881 Paris exhibition displayed over fifty different arc and incandescent systems.[9] Generating stations moved from horizontal to vertical engines and then, after 1900, to steam turbines, gaining in efficiency and output. Equipment at the end of the circuit, whether lighting or motors, also experienced major gains in efficiency, cost, and reliability. The result was a continual expansion of the market for electric energy as its benefits grew and its cost dropped.

In the late 1870s, the standard provider of electricity was the isolated station. These were stations built and operated for individual use, such as a factory, mine, or street lighting, instead of providing electricity to a larger clientele. Users had to buy a complete system (engine, generator, wires, and auxiliary equipment) in order to use their motors or light bulbs. The self-contained nature of a plant made it transplantable anywhere worldwide as long as the owner could provide fuel and technicians to operate it. Isolated plants had several advantages: Electricity could be provided without a utility, there was no dependence on a utility for electricity, and often no need for a concessionary license.

Isolated stations were not confined to "developing" countries. Until 1887, Thomas Edison sold more incandescent lamps for isolated plants than central stations in the United States.[10] Edison's French subsidiary followed a similar approach, assuming, correctly, that central stations would follow isolated stations as more and more businesses and individuals demanded electric lighting. Tens of thousands of these stations were built, an order of magnitude more than utilities, by World War I.[11]

Isolated stations, usually the first appearance of electric lighting or power in an area, engendered great excitement and enthusiasm. Sometimes, especially in remote, non-urban areas, they formed the nucleus for a utility. More often, these stations operated until absorbed by a utility that expanded into that region. Because of their low cost compared to a central station, the diffusion of isolated stations did not require extensive capitalization or managerial innovation, though they could suffer the problems of undercapitalization and escalating expenses.

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9. Thomas P. Hughes, *Networks of Power Electrification in Western Society, 1880-1930* (Baltimore, Md., 1983), 50.

10. Harold C. Passer, *The Electrical Manufacturers, 1875-1900* (Cambridge, Mass., 1953), 118.

11. For example, in 1899 278 of St. Petersburg's 284 electric stations were isolated stations used for industry and lighting; see *Elektricheskie stantsii v S.-Peterburge* (St. Petersburg, 1900), 5, 9.

Isolated stations did not present the financial challenges of central stations, but neither did they offer the greater efficiency and capacity of central stations.

Companies often built isolated plants to generate light and power for themselves. Not until World War I did the utility generation of electricity for industry exceed that generated by firms for their internal use. The war forced this change by making governments eager to increase the efficiency of suddenly scarce fuel, equipment, and engineers.[12]

In contrast to an isolated station, a utility built and operated a central station to provide electricity to multiple users who paid only for the electricity, not for the power plant itself. This spread the cost of providing electricity among many customers, greatly reducing their individual cost and eliminating the need for them to hire technically skilled people to operate the generating system. Because central stations serviced many customers—in the 1880s often only a few hundred, by the 1990s tens of thousands—they were larger than isolated stations and consequently cost more. Financing this greater total cost (in contrast with the cost per installed kilowatt, which dropped) would become one of the great shaping forces of electrification.

Central stations were associated with the incandescent electric light. The attraction of incandescent lighting was its ability to illuminate offices, homes, and other inside rooms. The standard brightness of the early Edison lamps was 16 candlepower, compared with the 500 candlepower of the smallest arc lamp. Incandescents were also cleaner, smoother, and quieter, all important considerations for indoor operations.

Emerging from a sea of competing inventors, Thomas Edison demonstrated his light bulb in 1879 and opened the world's first central stations in 1882, in April at Holborn Viaduct in London and in September at Pearl Street in New York City near Wall Street. Edison succeeded partly because he designed his light bulb as part of a larger system that could compete economically against gas lighting. Another reason for Edison's success was his ability to obtain financing in the United States and abroad. Not by chance was Edison's first central station, Pearl Street, built to serve the Wall Street community.

The difference between isolated and central stations was, at least in the early years, often more administrative and political than technological. Surveys often did not distinguish between the two and many central stations were small; of 19 French central stations described in 1889, 6 had 37 kW or less, 5 were between 60 and 74 kW, 2 between 97 and 134 kW, and 6 between 222 and 600 kW.[13] But isolated stations were smaller; of

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12. C. O. Ruggles, "Some Economic Aspects of the Light and Power Industry," in *Facts and Factors in Economic History: Articles by Former Students of Edwin Francis Gay* (Cambridge, Mass., 1967), 498.

13. "President's Address," *Electrical World* (2 May 1889); "Notes," *Electrical Review* (31 May 1889), 627.

the orders received by the Edison Company for Isolated Lighting in a 3-month period in 1883, the 7 central stations averaged 1200 incandescent lamps compared with the 30 lamps of the 43 isolated stations.[14]

Perhaps the most visible technological development was the "battle of the systems" between direct current (DC) and alternating current (AC). DC was the current of choice for the first generation of utilities. AC was not always chosen, despite its advantages of more efficient long-distance transmission and industrial use (with 3-phase), proven practical by the late 1890s. In the absence of other criteria, municipalities and concessionaires through World War I preferred DC to AC stations. DC stations cost less to install and were easier to maintain, key considerations for utilities, both municipal and private, with limited finances and technical expertise.

Utilities that chose DC tended to be smaller geographically as well as in capacity, so AC's better transmission efficiencies did not matter. In 1909, 1858 of 2770 German stations were DC. Not until 1913 did German AC stations outnumber DC stations (1882 to 1880). Seventy-eight of Russia's 115 utilities in 1908 were DC, 33 AC, and 4 had dual capability.[15]

ACs eventual triumph over DC was partly due to the growing significance of different political criteria, especially the desire for standardization and the ability to transmit large quantities of electricity over a high voltage transmission line. Standardization ("normalization") of current, components (plugs, for example), and rules played an important role. The wide range of voltages and frequencies of existing DC and AC stations challenged every state attempting to connect existing stations and transmission networks and to create regional systems.[16] State efforts to create a single form of electric energy were part of larger technocratic efforts to rationalize economies and improve efficiency.

AC's rise was a victory for larger power plants and long-distance transmission—in short, a victory for greater systems efficiency and centralization. Often this triumph was mandated from above, as part of wartime and postwar efforts to diffuse and deepen electrification throughout countries. Public authorities led this process, most often with the agreement of the larger firms in the private sector.

Less controversial than the AC-DC choice but no less important was the development of the Parsons steam turbine in the 1890s. By

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14. "Contracts Closed," Edison Co for Isolated Lighting, *Bulletin* 7 (19 Aug. 1883), 1. CC002; TAEM 97:7, Thomas A. Edison papers.

15. "Installations, Systems and Appliances," *Electrical World* (24 Feb. 1910), 478, "German Central-Station Statistics, *Electrical World* (10 Jan. 1914), 105-06.

16. Prewar Hungarian stations operated on DC, 1-, 2-, and 3-phase AC, and 25, 26, 42, 50 cycles, not to mention different voltages; see L. de Verebely, "National and Regional Planning and Their Relation to the Conservation of Natural Resources; Regional Integration of Electric-Utility Facilities," *Transactions: Third World Power Conference,* 10 vols. (Washington, D.C., 1938) 6, 410, hereafter, *3rd WPC.*

dramatically increasing the energy extracted by burning coal, the steam turbine enabled the construction of larger central stations, supplying entire towns or cities at far less cost per kilowatt-hour than the reciprocating engines it replaced.

Even as the output per unit increased, so did the size of central stations as capacity grew to meet the growing demand. Although the cost per kilowatt and kilowatt-hour dropped, overall costs increased greatly to build the new stations, expand long-distance and local transmission networks, and replace obsolescent equipment. Reinvestment and new investment were essential for central stations. These increasing financial demands forced manufacturers to develop ways for utilities to afford their equipment. Financial syndicates, investing or accepting payment in utility stocks and bonds, special banks, holding companies, and other financial mechanisms enabled electrification to expand rapidly beyond the isolated station into central stations and regional power systems.

The economic and technical feasibility of long-distance transmission networks, demonstrated in Germany and the United States in the 1890s, created new legal challenges for electrification. Regional and national governments had to become involved to settle issues such as right-of-way for transmission lines, eminent domain, and the ownership and exploitation of rivers. Because most governments considered natural resources as state rather than private property, resolution of these issues, often between ministries, was essential for electrification to proceed.

A good metric for serious state involvement in electrification is a country's passage of its first law governing right-of-ways for long-distance, high-voltage transmission systems, or hydropower, or set nationwide rules for electric utilities. Indicative of the gap between rapidly and slowly electrifying countries, over a decade passed between the creation of national laws for hydropower and transmission lines in Scandinavia and central Europe. As shown in Table 2, laws passed in clusters.

For foreign and domestic companies, regional growth increased their uncertainties as well as their opportunities. Regional systems were more expensive and complex to build and to expand; they generally required collaboration with competitors and public authorities. In truth, foreign collaboration with domestic partners was a standard feature of foreign investment; the scale, number of actors, and commitment, however, were much larger.

Sometimes domestic opposition to "foreign ownership of our natural resources" helped create to a new generation of investors, leading, as in Switzerland, to the "suissification" (or domestication) of the electrical industry, and forcing international investors to look towards Mediterranean and South American municipalities (like Rosario in Argentina) or cooperation with well-connected domestic partners.

Another form of government involvement, primarily at the national level, was promoting hydropower and other forms of electric power by funding electrical engineering education and research. Governments also established state commissions, agencies, and laboratories to study the hydropower potential of regions and manage its development. Such national surveys were another indicator of growing state awareness.

TABLE 2
Major Laws

Country	Year	Type
Sweden	1902[a]	Transmission lines
France	1906	Transmission lines
United States	1907	State regulation
Norway	1906[b]	Hydropower
Russia	1917[c]	Transmission lines
Hungary	1918[d]	Electricity supply
Sweden	1918[e]	Hydropower
Bulgaria	1919[f]	Hydropower
Czechoslovakia	1919[g]	Electricity supply
France	1919[h]	Hydropower
Austria	1921-1922[i]	Hydropower and transmission laws
Poland	1922[j]	Electricity supply
Great Britain	1926	National grid
Hungary	1931[k]	Electricity supply
Czechoslovakia	1931[l]	Hydropower
Bulgaria	1935[m]	Electricity supply
United States	1933	Regional grids
Germany	1935	National grid
France	1936	National grid

Sources:
[a] Gosta Malm and H. M. Molin, "Organization, Financing, and Operation of Publicly Owned Electric and Gas Utilities in Sweden," *3rd WPC,* 6, 172.
[b] Ingvar Wedervang, "National and Regional Planning and Their Relation to the Conservation of Natural Resources," in *3rd WPC,* 6, 433.
[c] Coopersmith, *The Electrification of Russia*, 124-25.
[d] L. de Verebely, "National and Regional Planning and Their Relation to the Conservation of Natural Resources; Regional Integration of Electric-Utility Facilities," *3rd WPC,* 6, 411.
[e] W. Borgquist, "Planned Utilization of Water Resources," *3rd WPC,* 7, 292.
[f] "Organisation, Finanzierung und Betrieb von Oeffentlichen Elektrizitaetgesellschaften," *3rd WPC,* 6, 27.
[g] O. Herzl, "Organisation, Subventionnement et Exploitation des Entreprises d'Electricite et de Gaz Financees avec des Fonds du Tresor Public," *3rd WPC,* 6, 47.
[h] L. T. Fournier and J. Butler Walsh, "Public Regulation of Private Electric and Gas Utilities," *3rd WPC,* 9, 346.
[i] Bundesministerium fur Handel und Verkehr, "The Development and Utilisation of Water Power in Austria," *Transactions of the First World Power Conference: London June 30th to July 12th 1924* (London, 1924), 1, 698; hereafter *1st WPC.*
[j] Polish National Committee, "Polish Power Resources and Their Development," *1st WPC,* 1, 1099, 1128-29.
[k] Sz. Hankiss and E. Theiss, "National Power and Resources Policies," *3rd WPC,* 9, 132.
[l] F. Kneidl and J. Wolf, "Planned Utilization of Water Resources in Czechoslovakia," *3rd WPC,* 7, 96.
[m] Bureau of Electrification, "Public Regulation of Private Electric Utilities in Bulgaria," *3rd WPC,* 9, 359.

Indeed, another possible metric for determining the interest of national governments is when they established institutes or committees to conduct nationwide surveys of natural resources for electrification and other forms of industrial exploitation. Austria and Hungary began prewar surveys of potential power resources. New nations, like Estonia, Poland, and Yugoslavia, did not instigate similar surveys until after the war. World War I served as the impetus necessary for the Russian government to establish KEPS, the Committee for the Study of Natural Productive Forces.[17] Such studies often provided data and blueprints for later plans for electrification.

World War I

World War I was a major turning point in the evolution of electrification, causing a major jump in state interest and involvement. National and local governments recognized the economic significance of electricity generation when industrial demand for electricity increased greatly. Meanwhile, the war sharply disrupted fuel supplies and the flow of equipment across borders, creating a scissors crisis. Obtaining adequate fuel and producing electric energy more efficiently became important priorities not just at the local, but also increasingly on the regional and national levels.

The war, as many engineers noted, demonstrated the "necessity of organization and rational utilization" of all resources.[18] This lesson would not be forgotten as engineers and government officials tried to make the nation or region and not the city the basic unit for development.

Government actions included:

a) Establishing users' priorities to handle shortages. Often, these were the first state surveys of electrical use and a major expansion of state power.

b) Shutting industrial power plants and connecting them to central stations for more efficient use of fuel. Firms were usually very reluctant to

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17. E.g., Austria established a Hydrographical Central Office and Poland the State Geological Institute and Central Hydrographical Bureau; see Bundesministerium fur Handel und Verkehr, "The Development and Utilisation of Water Power in Austria," *Transactions of the First World Power Conference: London June 30th to July 12th 1924* (London, 1924), 1, 686; hereafter *1st WPC*; Polish National Committee, "Polish Power Resources and Their Development," *1st WPC,* 1, 1099; also, Esthonian [sic] Ministry of Trade and Industry, "Water Power Resources of Esthonia," *1st WPC,* 1, 821; L. de Verebely, "General Survey of Hungary's Power Resources and their Future Development, with Special Reference to Electrification," *1st WPC,* 1, 921. For KEPS see Alexander Vucinich, *Science in Russian Culture, 1861-1917* (Stanford, Calif., 1970), 220-22.

18. L. de Verebely, "National and Regional Planning and Their Relation to the Conservation of Natural Resources; Regional Integration of Electric-Utility Facilities," *3rd WPC,* 6, 409.

give up their assured power in return for the promise of utility-generated electricity.

c) Promoting development of local or domestic fuel supplies instead of imported or distant fuels. In many countries, this meant the exploitation of hydropower; because these sites were often located far away from the consumption centers, it was necessary to create major transmission networks. Another approach was the construction of "supercentrales," large thermal power stations generating inexpensive electricity through improved steam turbines fueled by low-quality "color coals" and sent by high-voltage transmission lines to distant points of consumption.

The war halted the normal flow of goods, materials, and people. Some consequences were nearly disastrous. St. Petersburg lost access to British smokeless Cardiff coal, which utility boilers were designed to use, forcing the capital city to find substitute fuels. Not only combatants were affected. Wartime shortages raised the prices of coal and oil, accelerating development of hydropower along with greater government involvement in electrification in neutral Sweden and Norway.[19] These shortages created intense interest in local fuel sources, such as peat and lignite, whose low energy content normally made them less attractive than black coal and oil. The resultant desire for greater economic or fuel autonomy continued into the postwar period and was important in shaping many countries' energy policies.

In some countries, World War I sparked intense anti-German and nationalist feeling, which, when channeled, promoted the sequestration and nationalization of German properties, including utilities. In Russia, such actions occurred first at the city level; action by tsarist officials, possibly more mindful of international law, trailed by many months.[20]

Postwar Europe

Government interest in electrification did not diminish after the war; it actually expanded for three reasons. First, problems of fuel supply (quantity, quality, and cost) remained. Second, electricity, to use Alain Beltran's expression, was transformed from a "fée" (fairy) to a "servante" (maid).[21] Increasingly, people viewed electricity as an essential element of everyday life rather than something magical, and, ideologically, no longer saw electricity as a privilege for the happy few or for big consumers such as industrial plants or tramways. Third, governments saw electrification as a

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19. W. Borgquist, "Regional Integration of Electric-Utility Facilities," *3rd WPC,* 7, 679; Gunnar Nerheim, "The Development and Diffusion of European Water Turbines, 1870-1920," in *Technology Transfer and Scandinavian Industrialisation*, ed. Kristine Bruland (New York, 1991), 355.

20 Coopersmith, *Electrification of Russia*, 104-06.

21. Alain Beltran and Patrice A. Carre, *La fee et la servante: La societe francaise face a l'electricite, XIXe-XXxe siecle* (Paris, 1991).

means of rapid and efficient industrialization that also bolstered their political power and prestige.

Electricity was increasingly a symbol of modernization. Consequently, it played an important role in national and ideological identities. "Maîtres chez nous!" was a major theme in the campaign that led to the nationalization of electricity in Quebec in 1963, but similar cries were uttered decades earlier, including Lenin's famous "Communism is Soviet power plus the electrification of the whole country." The political dimension of electrification was important in justifying promotion of centralized, large-scale power over alternatives. Central governments eager to claim the prestige of electrifiers promoted much of this modernizing effort. Thus, most schemes promoted large-scale development, often national or regional in scope, rather than local. In this regard, the electrical engineers and central government officials shared a common interest.

Since the beginning of the twentieth century, a strand of engineering, government, and public opinion had actively promoted "power to the people," using government and other incentives to accelerate the widespread diffusion of electric light and power. The targeted groups were those whose inclusion in distribution networks would not obviously result in a profit: the poor and the rural. In the 1900s, the technological impetus came from the development and introduction of incandescent lightbulbs with tungsten and other filaments. Up to four times as efficient as earlier carbon lamps, these new bulbs offered, or so it seemed to some, the opportunity to extend low-cost electric lighting to people whom hitherto could not afford it. This "democratization of lighting" occurred at the city level, and usually involved changes in concessions.

Extending electrification to rural populations was a far costlier issue involving, of necessity, the active interest and financing of provincial and national governments. Standard economic criteria could not justify the high cost of installing transmission lines through scarcely populated areas. However, including farmers and peasants to overcome the rural-urban divide had great political and social importance. Every electrification plan at the regional or national level during the 1920s and 1930s contained provisions for providing electricity to the countryside. Ultimately, such electrification demanded dedicated agencies, like the Rural Electrification Administration in the United States and departments of rural electrification in Ministries of Agriculture elsewhere.

Those schemes, however well-intentioned, had lower priority than other proposals to intensify the electrification of already electrified areas. At the heart of these plans were very large power stations, usually fueled by coal or water, long-distance high-voltage transmission lines, and often goals for the extensive industrialization and modernization of a region, not just a city.

The main attraction was the greater efficiencies gained from increasing the scale of operations. Although less costly per installed megawatt, the greater size of these regional stations, combined with the need to build expensive transmission networks (and obtain the land) meant a much higher cost than for smaller urban stations. Financing such expensive schemes meant creating new mechanisms, such as foreign and domestic bank syndicates, often working in consort with regional and national governments which might have to provide political and financial guarantees.

Engineers and governments in many countries proposed and debated such schemes during the 1920s and 1930s. The names differed ("rationalization," "unification," "centralization," and "systematic electrification"), but they shared an interest in centralized control for more efficient operations over a wide area. It is noteworthy that many postwar government proposals were a continuation of wartime actions or first proposed before or during the war. In the United States, Giant Power and Superpower attracted great interest in the 1920s, while the Roosevelt Administration created the Tennessee Valley Authority (TVA) in the 1930s. Germany had its Ruhr scheme, Ireland its Shannon scheme, the Soviet Union had GOELRO (the State Commission for the Electrification of Russia), and other countries explored similar wide-ranging plans.

Governments took a wide range of initiatives to electrify their countries in two waves, an early postwar effort at economic recovery, and a post-Depression effort at greater economic autarky. The major activities were:

a) Passing laws to establish a legal framework for a greater government role in promoting and shaping a more systematic and coordinated electrification of their country;

b) Conducting surveys of natural resources and industrial needs and writing draft plans for electrification;

c) Unifying existing stations into networks for greater efficiency; and

d) Providing financial incentives for municipalities and concessions to develop utilities.

State governments often encouraged municipalities to build their own utilities by offering advantageous conditions, such as easier access to funding, exemption from some taxes, or not requiring the posting of a security bond.[22] As a rule, laws favored government over private operations in the length of concessions or exemption from taxes (for example, government hydropower concessions lasted 90 years in Austria compared with 60 years for private enterprises) while still seeking to entice foreign capital investment.[23]

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22. E.g., Gosta Malm and H. M. Molin, "Organization, Financing, and Operation of Publicly Owned Electric and Gas Utilities in Sweden," *3rd WPC,* 6, 187, and Watercourse and Electric Dept. and Norwegian Gas Works Association, "Public Regulation of Private Electric and Gas Utilities in Norway," *3rd WPC,* 9, 359.

23. Bundesministerium fur Handel und Verkehr, "The Development and Utilisation of Water Power in Austria," *1st WPC*, 1, 698.

In particular, the new and existing nations of post-war Central and Eastern Europe found themselves with unprecedented powers and problems, including inexperience, loss of territory, financial collapse, and the destruction of prewar "normal" trading relationships, as well as the typical postwar recovery problems. For many reasons, states found themselves playing a larger, more direct role in shaping their economies. With the exception of the Soviet Union, private enterprise remained a major factor in most sectors of the economy, including electrification.[24]

Within 5 years of the GOELRO plan, several countries in Central and Eastern Europe had discussed, created, and even started to implement state plans for national, or systemic, electrification. Just as shortages led to more state regulation and control during the war, so too did postwar fear that the "existing unsystematic method" of siting and building central stations needed a centralized perspective. Typical of these concerns, the Czechoslovak Ministry of Public Works "together with other interested authorities" created a plan for the systemic electrification of the country, based on a network of 100 kV high-voltage transmission lines connecting minemouth power plants and hydroplants to distribution networks.[25]

Inadequate capital seriously constrained activities. Across central Europe, the Hungarian refrain of "*The main difficulty is the lack of sufficient capital*, both national and private" resounded throughout the interwar period.[26] The need for foreign investment was as great as it was sometimes unrealistic. As late as 1924, the Estonian Ministry of Trade and Industry hoped that Russian as well as English capitalists would invest in a 62-khp hydrostation on the Narowa river.[27] Realistically, countries knew that the demands on their limited domestic capital necessitated foreign capital to turn large-scale electrification from plans into powerplants.[28] Because of insufficient capital, political ideology, and decentralized authority, nearly every country had a variety of types of utility ownership. As the Table 3 indicates, privately owned and operated utilities remained a very significant factor everywhere west of the Soviet Union.

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[24] Gyorgy Ranki and J. Tomaszewski, "The Role of the State in Industry, Banking and Trade," in *The Economic History of Eastern Europe, 1919-1975*, 3 vols., ed. M. C. Kaser and E. A. Radice, (New York, 1985), 2: 3-48; Ivan T. Berend and Gyorgy Ranki, *Economic Development in East-Central Europe in the 19th and 20th Centuries* (New York, 1974).

[25]. Marsarykova Akademie Prace, "Review of the Natural Sources of Energy and Their Use in Czechoslovakia," *1st WPC,* 1, 760.

[26]. L. de Verebely, "General Survey of Hungary's Power Resources and their Future Development, with Special Reference to Electrification," *1st WPC,* 1, 941 [emphasis in original].

[27]. Esthonian [sic] Ministry of Trade and Industry, "Water Power Resources of Esthonia," *1st WPC,* 1, 821.

[28]. E.g., Leopold Wellisz, *Foreign Capital in Poland* (London, 1938), 238.

TABLE 3
Private-Public Comparisons, 1934

	Stations		MW		MkWh	
	Private	Public	Private	Public	Private	Public
Bulgaria	n.a.	n.a.	61	57	80	58
Hungary	33	119	439	236	518	290
Czech.	n.a.	n.a.	485	216	732	367
Poland	340	350	671	225	1356	310
Romania	128	93	107	109	196	190
Sweden	n.a.	17	491	931	1427	2384
Norway	n.a.	322	74	553	388	2522

Sources: Bulgaria: "Organisation, Finanzierung und Betrieb von Oeffentlichen Elektrizitaetgesellschaften, *3rd WPC,* 6, 27; Czechoslovakia: J. Tichy and F. Kneidl, "Power Resources, Their Importance and Utilization in Czechoslovakia," *3rd WPC,* 2, 131; Hungary: E. Haidegger and A. Kun, "Organization, Financing, and Operation of Publicly Owned Electric and Gas Utilities," *3rd WPC,* 6, 119; Poland: Polish National Committee, " Statistical Tables of the Power Sources and Their Utilization in Poland," *3rd WPC,* 2, 332; Romania: Dorin Pavel and Eugen Bodea, "Power Resources of Roumania, Their Development and Utilization," *3rd WPC,* 2, 359-60; Sweden: A. F. Enstrom and Erik Upmark, "Power Resources, Development and Utilization," *3rd WPC,* 2, 384; Norway: Norwegian National Committee of WPC, "Power Resources, Development and Utilization," *3rd WPC,* 2, 307.

Conclusion

The rising role of government in the development of electrification was evolutionary, intertwining both conflict and cooperation with the market. Electrification was a symbol of and path to modernization and economic development. Following that path required far more resources –mostly financial but also technological and managerial—than most municipalities, regions, and states could muster. From the 1880s, the private sector was essential for electrification to proceed, whether spontaneously or under the aegis of a state with a plan.

Government involvement reflected the growing economic and political importance of electrification. The general increase in state planning for, and control over, the economy also contributed to the greater government role. Its importance for wartime industrialization made electrification a central underpinning of economic development schemes, of 4-Year Plans and 5-Year Plans. The desire for economic autarky and reducing imports pushed states to promote hydropower and lower quality fuels. The many laws passed after World War I reflect these desires and serve as statements of independence by the new states.

APPENDIX I. PREWAR COUNTRIES

Russia

Utilities did not begin increasing in numbers in Russia until after 1898. The weak domestic ability to finance electrification was a major factor as was the administrative maze created by the tsarist government; just as important was the lack of a legal and administrative framework for both municipalities and the tsarist government. The 1897 Model Agreement between the 1886 Company and the St. Petersburg city council provided that framework, giving cities and towns with little knowledge of concessions, not to mention electric energy, a written guide.[29]

The tsarist government treated electrification with benign neglect until World War I; its development suffered from a mindset that "everything which is not permitted is prohibited." To gain permission to operate its own electric utility or a concession, a city government had to submit a proposal to the *gubernator*, the tsar's administrator of a region or city. If approved, the city sent the proposal to the Main Administration for Municipal Affairs of the Ministry of Internal Affairs, which, if approved, sent the proposal to the Ministry's post and telegraph administration and technical construction committee. If the proposal included a request for foreign capital, the Ministry of Finance, which approved the statutes and capital of every new company, also had to approve.[30] Not surprisingly, years could elapse between a request and final approval.

Despite its impressive inventors and electrical engineers, Russia remained technologically and financially dependent on the West through World War I. Of the 139 million rubles invested in utilities in 1914, Russian money comprised 10 percent compared with 25 percent for Belgian and 50 percent for German capital.[31] Because of the funneling of some German funds through Belgian firms, the total German contribution was undoubtedly higher. This money was invested in Russian joint stock companies, listed on the St. Petersburg stock exchange.

Moreover, the largest utilities were foreign-owned. The 1886 Company, established by Siemens & Halske, was the primary utility for St. Petersburg and Moscow. The 1886 Company introduced new technologies into Russia, such as 3-phase AC in 1897, trained numerous engineers and managers, and served as an administrative, technical, and legal model for other utilities and municipalities.[32]

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29. E. R. Ulman, "Razvitie tsentralnykh elektricheskikh stantsii v Peterburge za desiatiletnyi period," *Elektrichestvo* 4 (1912): 118-20.
30 Coopersmith, *Electrification of Russia*, 13-14.
31 V. A. Djakin, *Germanskie kapitaly v Rossii* (Leningrad, 1971), 268-69.
32 Coopersmith, *Electrification of Russia*, 57, 69-70.

After the St. Petersburg council renewed the 1886 Company's concession in the mid-1890s, the municipality signed agreements with six other firms. One, Helios, was German; two companies were soon purchased by the Belgian Company for Electric Lighting, two were gas companies trying to compete, and the sixth was Nikolai V. Smirnov's firm which suffered from undercapitalization and the owner's departure to operate a utility at Rostov-on-Don.[33] St. Petersburg's utilities remained foreign-dominated.

Baku, known primarily for its oil production, was the third largest consumer of electricity in tsarist Russia. German-owned Electricheskaia Sila (Electric Force) started providing AC power in 1901 and generated 82 percent of the 187 MkWh produced in 1914.[34]

As in other countries, Belgian firms dominated the electric tram concessions. Belgian firms operated 20 of Russia's 40 electric trams in 1913, as well as two horse and one steam tram. These concessions were in the largest cities.[35] Russian firms held only 12 percent of the 94 million rubles in tram firms in 1914, compared with 73 percent for Belgian and 13 percent for German firms.[36]

As in the Russian case, foreign financiers sometimes allied with a local bank, consulting firm, dignitaries, or other contacts to provide local guidance and visibility, reducing the negative perception of a foreign presence. In the Russian case, the International and Private banks provided that domestic presence.[37] For foreign firms, at least until 1914, Russia was profitable: The median dividend was 5-8 percent, slightly better than the 4-9 percent range for all foreign profits from 1890-1914.[38]

The inability to develop commercial hydropower was one of the biggest failures of tsarist industrial development. Although individuals and firms offered more than a dozen proposals between 1894 and 1917 to build hydroplants to supply St. Petersburg, none won tsarist approval.

The proposers evolved from Russian engineers with their own small firms to the Finnish Sitola company to, in 1912, Imatra, a Brussels-chartered firm with 30 million Belgium francs. Imatra was a syndicate of 9 German, Belgium, and Russian banks and 8 electrotechnical firms, including the 3 major St. Petersburg utilities. French banks supported a competing firm, the St. Petersburg Company for the Transmission of Power from Waterfalls.

All these efforts were in vain. The Ministries of Internal Development, Trade and Industry, and Transportation could not agree,

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33. Ibid., 52-56; *Elektricheskie stantsii v S.-Peterburge*, 9.
34 "Statisticheskie svedeniia ... za 1914 god," *Elektrichestvo 1914*, 4-6, 98.
35 V. Shelgunov, "Belgiiskii tramvai v Rossii," *Izvestiia Moskovskoi gorodskoi dumy* 1914, 2, 83.
36 Djakin, *Germanskie kapitaly v Rossii*, 268-69.
37 Ibid., 41-44, 84-85.
38 P. V. Ol, *Foreign Capital in Russia* (New York, 1983), 251.

despite years of negotiations, on a common approach to ownership rights, compensation, inspection, oversight, and jurisdiction. Without such an agreement, hydropower and long-distance transmission lines went nowhere in Russia.[39]

Eastern Europe

Electric power arrived slowly in Eastern and Central Europe, reflecting that region's low levels of urbanization and economic development, and governance by the Russian, Hapsburg, and Ottoman empires. Electrification was concentrated primarily in capitals and industrial regions. Consequently, the "new geography of national and international finance" needed to finance electrification had barely started to penetrate Eastern Europe before World War I.[40]

This late start had a Gerschenkronian effect, influencing the size of the institutions, public as well as private, which financed electrification. A country that started its electrification in the 1920s required more important institutions than a country that did the same during the 1880s. Considering that the public institutions are generally bigger than the private ones, the process favored them.

TABLE 4
First Central Stations

Country	Year
United States	1882
Britain	1882
France	1882
Italy	1883
Russia	1886
Hungary	1887[a]
Czechoslovakia	1895[b]
Bulgaria	1900[c]

Sources:
[a] E. Haidegger and A. Kun, "Organization, Financing, and Operation of Publicly Owned Electric and Gas Utilities," *3rd WPC,* 6, 117.
[b]Marsarykova Akademie Prace, "Review of the Natural Sources of E and their use in Czechoslovakia," *1st WPC,* 1, 759.
[c]*3rd WPC*, 6, 27.

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[39] Coopersmith, *Electrification of Russia*, 82-87.
[40] Albert Broder, "Banking and the Electrotechnical Industry in Western Europe," in *International Banking 1870-1914*, ed. Rondo Cameron and V. I. Bovykin (New York, 1991), 469.

Nonetheless, progress did occur, albeit of a very geographically stratified nature. By 1914, Hungary had 227 central stations, mostly privately owned or operated. In some cases, a municipality paid for the station's construction, but a private firm operated the station and paid rent to redeem the loan raised by the local government.[41] In 1919, Czechoslovakia had 412 central stations with a capacity of 231 MW. Most of these stations were small and operated independently from other utilities.

Scandinavia

Hydropower found its earliest acceptance and diffusion in Scandinavia. Geography made hydropower possible: industrial and consumer demand, coupled with a solid legal structure, made it happen. Prewar activities set the pattern because they fit the political-economic structures of those countries and the war did not disrupt them as it did the empires of Europe. Foreign and domestic investment in electrochemical and electrometal plants spurred the development of hydropower starting in the 1890s.[42] Hydropower for utilities, however, was very much domestically developed and financed.

Although hydropower became synonymous with Scandinavia (90 percent of Sweden's electricity in 1935 came from falling water), conventionally fueled thermal stations often introduced electricity to Swedish and Norwegian cities. In many cities, the local government built the first central stations, usually fired by coal. Starting around 1890, central stations began to appear, including those in Oslo and Stockholm in 1893 (following the expiration of a gas company's monopoly on conduits in the city). In that first decade, municipalities owned 17 of the 28 stations in Sweden. From 1900-10, 40 of the 52 stations were public. By 1910, the first connections of municipal distribution networks and large hydrostations began.[43]

In Sweden, the national government's ownership of major waterfalls, the result of a long-term project of acquisition, ensured a dominant role in hydropower's development. The state, as owner of the very large Trollhattan waterfall in central Sweden, considered in the early

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[41] Haidegger and Kun, 118; L. de Verebely, "National and Regional Planning and Their Relation to the Conservation of Natural Resources; Regional Integration of Electric-Utility Facilities," *3rd WPC,* 6, 410; F. Kneidl, "Regional Integration of Electric-Utility Facilities in Czechoslovakia," *3rd WPC,* 7, 529.

[42] Gunnar Nerheim, "The Development and Diffusion of European Water Turbines, 1870-1920," in *Technology Transfer and Scandinavian Industrialisation*, ed. Kristine Bruland (New York, 1991), 351.

[43] Gosta Malm and H. M. Molin, "Organization, Financing, and Operation of Publicly Owned Electric and Gas Utilities in Sweden," *3rd WPC,* 6, 170, 185; W. Borgquist, "Regional Integration of Electric-Utility Facilities," *3rd WPC*, 7, 655, 681.

1900s whether to lease the hydro site to a private firm or develop the power station itself. From 1906-10, the Royal Board of Waterfalls emerged, which became part of the State Water Power Administration together with local authorities.[44]

The first large Norwegian hydroplants appeared after 1895, starting with Lillehammer. Laws in 1906 and 1917 gave Norwegians preference over foreigners in acquiring waterfalls and the state the right of preemption.[45]

Lacking waterfalls, Denmark followed a different path. The widespread diffusion of municipal gas stations for lighting delayed the spread of electric stations in Denmark because cities feared electric lighting would compete, though that did not prevent some firms, like Carlsberg, from installing stations for their own industrial use.[46] Following the success of the first Danish central station in Koge, south of Copenhagen, in 1891, other cities allowed electric lighting and trams. Most of these stations were privately-owned and all were DC. Ownership began to change after 1904, when Copenhagen had three profitable municipal stations with a total capacity of 2 MW. As gas sales were not hurt, other local authorities began buying out private stations when their concessions expired.

In 1905, NESA, a joint public-private company in North Sealand, built the first AC station and high voltage (220 kV) transmission line in Skovshoved. A decade later, NESA introduced inexpensive hydropower from Sweden via an underwater cable.

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[44] Malm and Molin, 170-76.

[45] W. Borgquist, "National and Regional Planning and Their Relation to the Conservation of Natural Resources," *3rd WPC,* 6, 434.

[46] This section is based on Henry Nielsen and Michael F. Wagner, "Technology in Denmark," in *Technology & Industry: A Nordic Heritage*, ed. Jan Hult and Bengt Nystrom (Canton, Mass, 1992), 18-20, 27.

Appendix II. Postwar Countries

Soviet Union

The most significant expansion of state control over electrification occurred in the Soviet Union, where a totalitarian government tried to control every sector of society. What made electrification unique, at least until the late 1920s when absorbed by Stalin's superindustrialization policy, was the political significance given it by the Communist Party. When Lenin declared in December 1920, "Communism is Soviet power plus the electrification of the whole country," he was tying his political fortunes to the GOELRO plan of state-directed electrification.

The complete nationalization of electrification did not preclude efforts to obtain foreign funding and technology; indeed, the GOELRO plan assumed both. Problems with compensation for nationalized properties, the drive for economic self-sufficiency, an essential feature of Soviet policy by 1925, and the continuing paranoia and distrust between Soviet and Western leaders led to a semi-isolation of Soviet electrification from the rest of the world, although Soviet engineers did participate in international congresses.

Central and Eastern Europe

A major postwar problem was the disruption of prewar fuel supply patterns, caused by the destruction of the Hapsburg Empire. Coal and oil shipments within the empire now became valued exports and dreaded imports, filling and emptying foreign reserves. Hungary lost most of its prewar "good and cheap coal," gas, and oil resources, 94 percent of its theoretical 2.86 Mhp hydropower potential, 75 of its 227 prewar central stations, and 67 of the 72 small, industrial hydrostations.[47]

These geographic losses helped push domestically-produced fuel for electrification, including poor quality coals, such as lignite, peat, and, of course, capital-intensive hydropower. These low quality coals, often with less than half the energy content of black coal, were usually burnt at the mine (hence the phrase, "minemouth plants") with the electricity transmitted by high voltage lines for consumption. Although these resources were sometimes abundant, their exploitation was more technically and economically challenging than conventional fuels.

From the demand side, there was great need for foreign capital, especially when connected with foreign technology and management. Within governments, electrification had to compete with other government functions, obligations, and desires. Even those states that

[47] L. de Verebely, "General Survey of Hungary's Power Resources and their Future Development, with Special Reference to Electrification," *1st WPC*, 919-29; E. Haidegger and A. Kun, "Organization, Financing, and Operation of Publicly Owned Electric and Gas Utilities," *3rd WPC,* 6, 118.

advocated large-scale electrification found other immediate and threatening challenges took precedence in financing. Public debt, railroads (the traditional tool of economic development), and other needs took the lion's share of investment.[48]

From the supply side, what was the attraction of providing the desired financing? For private firms, banks, and investors, electrification had to compete with other opportunities, opportunities that might be more profitable, easier, more flexible, or arouse less nationalistic opposition. In interwar investing in electrification, those who did not participate are as interesting as those who did. Siemens and AEG, reversing prewar direct investment in foreign utilities, did not participate. These German companies decided their limited capital could be better used elsewhere.[49] The lack of exploitation by Siemens and AEG paralleled a shift in credit centers for Central and Eastern Europe from Berlin, Paris, and Vienna to Paris, London, and New York.[50] British and American banks, syndicates, and firms moved in, joining Belgian and Swiss competitors.

In Poland, Romania, and Bulgaria, the Belgium Electrobel (*Compagnie generale d'Entreprises electriques et industrielles*) and Swiss Hydrofina (*Compagnie financiere d'Exploitation hydroelectrique*) were major investors. Poland also found the London-based Polish Power & Traction Finance Co. (Poland), Ltd. and the New York firms of Ulen & Co. and Harriman involved. In Yugoslavia, the Swiss Konzern fur Elektrowerke was the main investor as the Swiss Bank fur elektrische Unternehmungen was in Hungary.[51]

Poland

The Polish government actively pursued electrification. In 1922, the Constituent Assembly passed an Electricity Supply Bill to regulate concessions and plan for systematic electrification. The bill gave the Ministry of Public Works the authority to grant eminent domain, monopolies for private concessions, tax reductions for hydropower, and the right, after 25 to 60 years, for the state to buy out a utility. Bills to regulate water and mining completed the legal framework. A second law in 1933 extended the range of tax exemptions and other encouragements

[48] I. Spigler, "Public Finance," in *The Economic History of Eastern Europe, 1919-1975*, ed. M. C. Kaser and E. A. Radice (New York, 1985), II, 117-69.
[49] Harm Schroter, "Siemens and Central and South-East Europe between the Two World Wars," in *International Business and Central Europe 1918-1939,* ed. Alice Teichova and Philip Cottrell (New York, 1983), 182.
[50] R. Notel, "International Credit and Finance," in *The Economic History of Eastern Europe, 1919-1975*, ed. M. C. Kaser and E. A. Radice (New York, 1985), II, 170.
[51] Ibid., 170.

to promote electrification. Although it was unusual for the time and region, the law did not extend the power of the state.[52]

The central government considered electrification of "enormous significance," and "of no less importance than bringing passenger and goods transportation, telegraphic and telephone communications to a high pitch of perfection."[53] Consequently, although encouraging and subsidizing electrification, the state neither owned any central stations nor provided incentives that differed greatly from those offered to encourage other areas of economic development.[54]

When local and national governments did think about electrification, they ranked it highly, reflecting both its importance and cost. In 1931, the Ministry of Public Works published its list of most urgent public works. Of the 5385 million zlotys in projects, electrification came first with 2400 million zlotys (45 percent), followed by roads and bridges at 1725 million zlotys (30 percent) and waterways at 860 million zlotys (15 percent). The Union of Towns estimated city needs required 35 million pounds, of which waterworks and sewers would demand 13.8 million pounds (40 percent), electrification 7 million pounds (20 percent), and abattoirs and roads 5.1 million pounds (14 percent).[55]

A variety of financing mechanisms was deployed to aid electrification. Some foreign investments were made without any state guarantees, but most had some form of state endorsement. The Treasury guaranteed some loans, and provinces and cities issued bonds for improvements in "waterworks, sewerage, electrification, gasworks, abattoirs, market halls, suburban railways, etc."[56]

Foreign investors viewed Poland favorably. After the war, 43 million zlotys of foreign capital were invested without any government guarantees in ten joint-stock firms to build and operate central stations. Between 1923 and 1936, British firms invested over 3.5 million pounds in Polish electrification as part of their overall investments in banking and the chemical and iron and steel industries. In all, foreigners had placed over 6.2 million pounds in the stock and reserves of Polish electrification firms.[57]

The Polish government provided loans and guarantees in the 1920s and 1930s to electrify intercity and suburban railroad track. British firms benefited the most, including the London-based Polish Power & Traction

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[52] Polish National Committee, "Polish Power Resources and Their Development," *1st WPC*, 1, 1099, 1128-29; Wellisz, *Foreign Capital in Poland,* 241, 243.
[53] Wellisz, *Foreign Capital in Poland,* 238.
[54] Ibid., 167-68, 175-76, 197.
[55] The ministry list wish excluded railroads, shipping, telephone systems, and urban investment (Ibid., 198-203, 256-57).
[56] Ibid., 119.
[57] Ibid., 115-16, 153, 247. Wellisz, however, also states on page 247 that only 1.7 million of the 6.2 million pounds is postwar, contradicting himself.

Finance Co. (Poland), Ltd. and the more established English Electric Co., Ltd and Metropolitan Vickers Electrical Export Co., Ltd.[58]

The Polish Power & Traction Finance Co. (Poland), Ltd. (PPTF) was a major player in electrifying railroads and cities. For the 1923 electrification of the Warsaw-Grodzisk suburban railroad, the company combined with the Brussels-based Trust Metallurgique, Electrique et Industrial to create the Electric Suburban Railways Joint Stock Company. To build electric trams in the Dabrowa coal basin, PPTF helped form and assist the Dabrowa Basin Electric Tramways Co. (Tramwaje Elektryczne w Zaglebiu Dabrowskim), which also had its loans guaranteed by the Polish Treasury. PPTF also provided nearly a million pounds in goods and credits to Polish firms to electrify at cities. Another British firm, Utilities Corporations (Poland), Ltd. assisted at least once.[59]

TABLE 5
Independent Financing of Electrification

Year	Place	Financing	Source
1928	Province of Silesia	$11.2M 30-yr bond	Stone, Webster and Blodget
1930	Gdynia	4 M Swiss francs	Zurich Schweizerische Bankgesellschaft
1925-26	11 towns	$13.8M bonds	Ulen & Co.
1925-26	3 towns	Goods credit	Atlas-Diesel Co. of Sweden

Source: Leopold Wellisz, *Foreign Capital in Poland* (London, 1938), 119, 126-29.

The dilemma between the desires for foreign investment and domestic control was best demonstrated in 1929, when the W. A. Harriman & Co. presented the government with a large-scale electrification plan. If implemented, the firm would have electrified 105 towns in 69 districts, built 3 power plants, over 700 miles of high voltage transmission lines, and invested up to $100 million. In exchange, the company would receive a monopoly in those regions for 60 years and major tax relief. After much public and cabinet debate, the government rejected the proposal because the monopoly was too excessive. The

[58] Ibid., 97, 113-15.

[59] The firms were Elektrownia Okregowa w Zaglebiu Dabrowskim, Elektrownia Okregowa w Zaglebiu Krakowskim S.A., S.A. Sieci Elektrycznych, and Elektrownia Okregowa Warszawska S.A. (Wellisz, *Foreign Capital in Poland*, 116).

government did pay Harriman for the plan and actually began to implement parts of it.[60]

Foreign investors were not the only outside parties promoting electrification. The League of Nations' Permanent Committee on Electric Power of the Committee for Communications & Transit at one point asked the Polish government to prepare a plan "for the extension of the system of electric-power plants in Poland."[61]

Czechoslovakia

The new Czech government was one of the most dynamic in promoting electrification. Based on the July 1919 State Law of Electrification, the Ministry of Public Works established new organizations and maximized the impact of its funding by spending it in coordination with local and regional governments and private enterprises. In July 1921, an amendment revised the law to allow the Ministry of Public Works to force utilities to combine to improve efficiency. The Ministry program envisioned the rational utilization of indigenous fuels by minemouth and hydroelectric plants linked by high-voltage networks. This goal was typical; what was different was how much effort the state government put into accomplishing it.[62]

Hydropower, because of its higher capital costs and potential to reduce fossil fuel consumption, was a focus of the Ministry of Public Works' department of water power, which estimated that the country had realized less than 10 percent of its hydropower potential. A combination of the federal government, provincial government, and private firms would construct and finance hydropower.[63]

The law provided a state financial commitment to approve electrification schemes. Government units from the municipal to federal level would provide a minimum of 25 percent but ideally 60 percent of a project's capital, as well offering such undertakings as access to state lands and eminent domain for private land, tax exemptions, and other legal and financial incentives.[64]

Czechoslovakia had approximately 500 utilities with a capacity of 300 MW in 1918, reflecting its comparatively high levels of urbanization and industrialization in the Austro-Hungarian Empire. According to a 1924 report, the establishment of so many small central stations by

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[60] Ibid., 245-47; Ferdynand Zweig, *Poland Between Two Wars: A Critical Study of Social and Economic Changes* (London, 1944), 96-97.
[61] Leopold Wellisz, *Foreign Capital in Poland* (London, 1938), 240.
[62] F. Kneidl, "Regional Integration of Electric-Utility Facilities in Czechoslovakia," *3rd WPC,* 7, 529-30.
[63] Marsarykova Akademie Prace, "Review of the Natural Sources of Energy and Their Use in Czechoslovakia," *1st WPC,* 1, 753-55.
[64] Ibid., 1, 760-61; J. Tichy and F. Kneidl, "Power Resources, Their Importance and Utilization in Czechoslovakia," *3rd WPC,* 2, 150.

municipalities actually had hindered the expansion of electrification because they were large enough to handle public and private lighting but too small to supply industrial demand. Although it wanted to purchase small stations to lay the groundwork for larger, more systemic development, the Czech state lacked the resources to do this.[65]

In the first few years of the law, companies with a capitalization of 250 M crowns of capital were established to build 3000 km of transmission lines and five stations with 100 MW. Three private stations also began construction with 77 MW of capacity.[66]

The Ministry of Public Works funded and promoted the establishment of twenty-three large utilities, which were either publicly owned by local governments or mixed enterprises financed by private and public funds from the State, provinces, districts, and communes. By 1934, these public utilities had a capital of 567 million Kc of which approximately one-fifth (123 million Kc) came from the state). Although this was impressive, 3 billion Kc had been invested in utilities.[67]

Hungary

In 1918, a law gave the Royal Hungarian Ministry of Commerce the authority to issue utility concessions. The emphasis was on hydropower, but the Treaty of Trianon removed most of Hungary's hydroelectric potential.[68]

In 1923, imported fuel supplied over a quarter of Hungary's total energy budget, costing 45 million Swiss francs, a significant outflow of foreign currency. Consequently, the Hungarian government wanted to reduce coal imports and maximize use of its indigenous low-quality brown coal and lignite by promoting electrification and minemouth plants and high-voltage transmission networks. Electrifying industries would reduce black coal consumption. The goal was a sevenfold increase in generation from the 300 MkWh (80 percent or 232 MkWh produced for Budapest, indicating the poor diffusion of electrification nationwide) produced by utilities in 1923 to 2000 MkWh. One proposal envisioned five large plants

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[65] Marsarykova Akademie Prace, "Review of the Natural Sources of Energy and Their Use in Czechoslovakia," *1st WPC,* 1, 759-60.

[66] Ibid., 761-62.

[67] J. Tichy and F. Kneidl, "Power Resources, Their Importance and Utilization in Czechoslovakia," *3rd WPC,* 2, 145; O. Herzl, "Organisation, Subventionnement et Exploitation des Entreprises d'Electricite et de Gaz Financees avec des Fonds du Tresor Public," *3rd WPC,* 6, 48.

[68]. L. de Verebely, "National and Regional Planning and Their Relation to the Conservation of Natural Resources; Regional Integration of Electric-Utility Facilities," *3rd WPC,* 6, 411.

using peat, lignite, and brown coal.[69] Combined with the Great Depression and restrictions on imports, these measures reduced imports of coal and coke to 5-20 percent of all power consumption from 1925-35.[70]

Through the 1920s, the state's role was minimal, despite its earlier intentions. Coal companies played a role in electrification by building their own stations or incorporating existing stations to ensure robust markets for their coal.[71] British money financed the construction in 1928-30 of a large, state-owned minemouth power plant in Banhida by the Hungarian Transdanubian Electric Co., Ltd., which provided power to Budapest, 160 kilometers away.[72]

In 1931, Act No. XVI greatly increased central control over electrification, with the goal of nationalizing (devolving) transmission lines to the state, and local distribution networks to communities. Only utilities would remain in private hands, which reflected a lack of money more than ideology. The Ministry of Industrial Affairs would supervise all aspects of electrification, ending the earlier disfunctional diffusion of responsibility. Although intended to attract private investment, the heavy nationalization scared it away.[73] Indeed, when the Ministry for Industrial Affairs submitted a national plan of electrification in late 1935, the lack of available financing proved yet "another handicap to quick & complete electrification."[74]

Bulgaria

Bulgaria passed two laws in 1919 and 1935 that greatly shaped its electrification. The 1919 law encouraged the development of hydropower by water syndicates. The January 1935 law drastically changed the legal framework for electrification, effectively placing it fully under state control. Private firms could and did still exist, but the effective unit of government moved from the local to national level. Existing concessions could be annulled, much to the dismay of the Association of Private

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69 L. de Verebely, "General Survey of Hungary's Power Resources and their Future Development, with Special Reference to Electrification,"*3rd WPC,* 1, 931-36.

70 Hubert and Magashazy, "Significant Trends in the Development and Utilization of Power Resources," *3rd WPC,* 9, 255.

71 L. de Verebely, "National and Regional Planning and Their Relation to the Conservation of Natural Resources; Regional Integration of Electric-Utility Facilities," *3rd WPC,* 6, 413; Bodocsi and Haidegger, "Organization of Private Electric and Gas Utilities," *3rd WPC,* 9, 337.

72. L. de Verebely, "National and Regional Planning and Their Relation to the Conservation of Natural Resources; Regional Integration of Electric-Utility Facilities," *3rd WPC,* 6, 419.

73. Ibid., 413-14.

74. Sz. Hankiss and E. Theiss, "National Power and Resources Policies," *3rd WPC,* 9, 133.

Electric Utilities, and were subject, in theory, to application of more uniform regulations. In addition, the Bureau of Electrification received responsibility to draft a national plan.[75]

Scandinavia

By the mid-1920s, the "Swedish system," a mix of State, municipal, and private enterprises which coordinated, cooperated, and competed in production and transmission, was well established. While monopolies did not exist technically, agreements to divide supplied regions did. Of electric power generated in 1935, the Swedish state produced 30 percent, private firms 20 percent, municipalities 15 percent, and industrial firms the remaining 35 percent, some of which sold excess power to consumers.[76] By 1936, 311.2 million Swedish kronor ($84 million at 1 krona = $.27 US) had been invested in State hydroplants.[77]

Starting in 1925, the Royal Water Board worked to reduce the substantial geographical variations in the cost of power. By 1936, there were standardized tariffs countrywide, with ranges depending on type of usage, location, and total demand.[78]

Paralleling its Swedish neighbor, Norwegian hydroplants and utilities began connecting neighboring plants by short-distance tie lines. By 1922, coordinating these links around Oslo Fjord demanded the creation of a formal committee. By 1927, that committee had hired a systems chief dispatcher and created an organization around him to ensure the seamless, problem-free flow of electric power. In 1932, the committee dissolved, replaced by the Association for Parallel Operations, Ltd.[79]

The Swedish government's advisory electrification commission created a plan for the entire country in 1915, which proved a "surprisingly true prophet" in envisioning mixed modes of ownership.[80] Planning did not achieve a strong foothold in Norway both because of the country's

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75. Konigl. Bulgarisches Ministerium fur Offentliche Arbeiten, Elektrifizierungs-abteilung, "Nationale und Regionale Planwirtschaft und ihr Verhaeltnis zur Erhaltung von Natuerlichen Kraftquellen in Bulgarien," *3rd WPC*, 6, 323; Association of Private Electric Utilities, "Organization of Private Electric Utilities," *3rd WPC*, 9, 338; Bureau of Electrification, "Public Regulation of Private Electric Utilities in Bulgaria," *3rd WPC*, 9, 359.
76. W. Borgquist, "National and Regional Planning and Their Relation to the Conservation of Natural Resources," *3rd WPC,* 6, 446.
77. Gosta Malm and H. M. Molin, "Organization, Financing, and Operation of Publicly Owned Electric and Gas Utilities in Sweden," *3rd WPC,* 6, 179.
78. Ibid., 180-81.
79. H. Barnholdt, "Regional Integration of Electric-Utility Facilities," *3rd WPC,* 7, 665-68.
80. W. Borgquist, "National and Regional Planning and Their Relation to the Conservation of Natural Resources," *3rd WPC,* 6, 445.

limited means and because of the sense that its hydropower was so abundant that no planning was necessary. A 1923 Parliamentary plan to supply electric energy throughout the country, the product of 4 years of work, never received a vote, partly because it was so expensive.[81]

The strong Danish cooperative movement, with its emphasis on self-reliance and local control, worked against the concept of networks and centralization of power. After 1920, collaboration between neighboring stations increased with the goal of creating a standardized system of AC stations mutually linked to each other by high voltage transmission lines. The benefits were security from a local breakdown, a high load factor for maximum generating efficiency, and the creation of a single national market for products like lamps. As local and regional networks grew to envelop the country, growing questions about cooperation, boundary disputes, and other issues caused the passage of a 1934 law weakly regulating transmission lines.[82]

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81. Ingvar Wedervang, "National and Regional Planning and Their Relation to the Conservation of Natural Resources," *3rd WPC,* 6, 428, 433, 437-38.

82. Hartz, "Public Regulation of Electric Utilities in Denmark," *3rd WPC,* 9, 352.; Henry Nielsen and Michael F. Wagner, "Technology in Denmark," in *Technology & Industry: A Nordic Heritage*, ed. Jan Hult and Bengt Nystrom (Canton, Mass., 1992), 18-20, 27.