

The following article appeared in *Science in Context* 8, 3 (1995), pp. 459-486. Please quote only from the published version.

DAVID GUGERLI

Sociocultural Aspects of Technological Change: The Rise of the Swiss Electricity Supply Economy

The Argument

The impressive growth of the Swiss electricity supply industry in late 19th century has usually been explained by Switzerland's abundant water power resources, its well-equipped financial markets and the high mechanical skills both of Swiss workers and engineers. The following article doesn't want to deny the importance of these factors. It rather seeks to explain how they could develop synergetic effects and how they were knit together. The argument will be put forward in three steps: First, I shall show the importance of the new technology's discursive integration, arguing that the development of a specialised electric discourse led to a social shaping of technology that was highly compatible with generalised cultural patterns of late 19th century Swiss society. The expressive dispositions and instituted means of expression the electrical discourse is constituted of were constantly pursuing and achieving effective resonances in other discursive fields. This allowed for a solid integration of the electrotechnical discourse in late 19th century Swiss society.

Second, I shall argue that electrotechnology was modelled in such a way that it became coupled with existing technological (and scientific) practices, such as the national mapping endeavour, the urban gas and water supply, the sewer systems, or the building and operating of telegraph networks. It is noteworthy that the compatibilization between electrotechnology and other practices in the technological field not only led to similar patterns in the design and management of both the old and the new technologies, but also led to direct links among them: in several cities electric generators were built into and operated with the existing water supply station.

Using the example of the electrification of Zürich, I shall then, in a third step, combine the two elements – discursive accomodation and practical assimilation–, in order to demonstrate their effects on the process of selection and construction of technology. The article's somewhat complex argumentative strategy allows for a differentiated interpretation of the phenomenon and shows the importance of taking into consideration the sociocultural dimension of technological development, if we want to understand the driving forces of an economic growth that had its roots in the diffusion of a new technology.

It has never been difficult to construct a seemingly smooth explanation for the rise of Switzerland's electricity supply industry. Historians could point to the high level of know-how among both engineers and skilled workers, to Switzerland's abundant unexploited waterpower, and finally to the country's well-equipped institutional financing system. When confronted with empirical evidence, however, this interpretation stands in need of serious reconsideration: First, the know-how of Swiss engineers and technicians did not really play an overwhelming role in the initial phase of electrification. The technology was, in fact, mainly borrowed from foreign patent holders and inventors. Likewise, the founding history of the famous Brown, Boveri, and Co. in Baden shows

that labor-skill was considered to be of marginal importance.¹ Second, to treat the availability of waterpower as a driving force in the electrotechnical development of Switzerland is to repeat a contemporary myth in an uncritical way. The argument does not take into account the fact that many countries had available waterpower resources but did *not* electrify in 19th century. Thus, historians substitute a necessary for a sufficient condition, as if the Silicon Valley boom had its roots in the relatively easy access of California entrepreneurs to the international silicon markets. Third and most surprising, the capital for the powerplant construction boom of the early 1890s did not come from institutional investors, but was rather provided either by small middle-class shareholders or by communities which had to justify their investments in electricity supply utilities to the voting public. Electrification as a popular movement? In fact, the Swiss public was obsessed by electricity. Public events such as the National Exhibition of 1883 in Zürich and the Frankfurt Electrotechnical Exhibition of 1891 had mobilized thousands of enthusiasts who eventually represented the political and economic bases for the first boom in construction of powerplants during the early 1890s, i.e., several years before the country's banks started to consider investments in the electricity supply economy of Switzerland. Despite the astonishing reluctance of the bankers to invest in the electric sector, in 1895 Switzerland already counted with well over 70 operating powerplants whose generating capacity had reached its highest annual growth rate in history.² (See fig. 1.)

Given the widespread popularity of electricity one would like to know why the Swiss public had become susceptible to the new technology and how this enthusiasm finally led to high growth rates in generating capacity. How did the excitement about the new technology narrow technological contingencies and how was it channeled into a collectively sustained agreement about the future of electrotechnology?

A simple explanatory model could seek to show that a collective consensus was achieved mainly through top-down manipulation of potential small investors by the nation's political and economic elite.³ However, this would imply a previous unification of expectations within the elite, including (among others) the executive boards of the Swiss banks. The banks' reluctance to invest as well as the federal parliament's lack of interest in establishing a coherent legislation on electricity in the early 1890's do not favor such an interpretation.⁴ On the other hand, recent studies in the field of sociotechnical change concentrate rather on the social construction of technological systems, on the latter's interpretative flexibilities, on sociotechnical debates and on their closures. This model implies the existence of competitive, controversial interpretations of the electric, each of which must be connected with the interests of a peculiar social group.⁵ Yet, the startling absence of any opposition to electrification projects in Switzerland until the 1920's makes the social construction approach just as unhelpful.

As an alternative for these explanations I propose to have a closer look at the contemporaneous formation of electrotechnical discourse and practice.⁶ In this paper I will develop a new perspective on the issue, mainly by discussing the intertwining or packaging of three equally important dimensions of technical development: First, I will discuss the discursive configuration of electrotechnology; second, I will describe the conditions of technological practices which preceded and accompanied electrotechnology in late 19th-century Switzerland, and, third, I will interpret the "social construction of technology" as a process of selection determined both by social and political forces and by the technical utility and cultural significance of electricity in Switzerland.

1 Ziegler 1937, 18. All quotes have been translated either from German or from French.

2 On the absence of bank investments, see *Neue Zürcher Zeitung* no. 306 I, November 2, 1893; and *Bericht über Handel und Industrie im Kanton Zürich 1895*, 121. See also Wyss 1964 and Grossmann 1918. On the number of operating powerplants see Wyssling 1946, 174–83.

3 See Zimmerman 1992, who describes electrification as a system of governance. See also Zängli 1989.

4 Cf. Schär 1905.

5 Bijker, Hughes, Pinch 1987; Bijker and Law 1992.

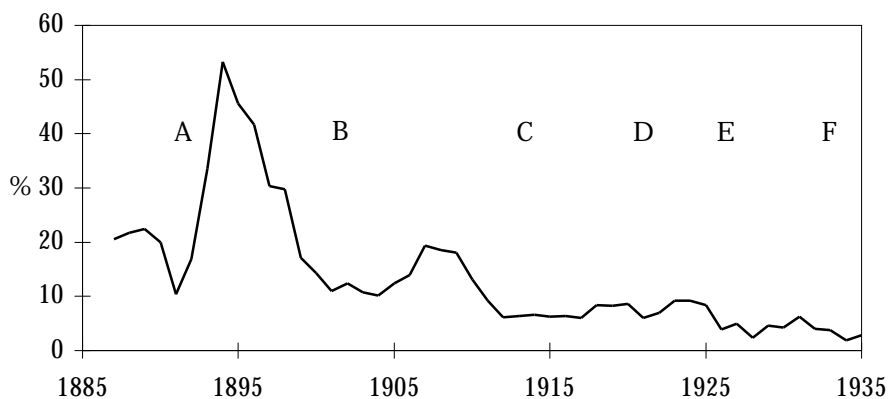
6 See also Gugerli 1994a and Gugerli 1996a.

Electrifying Switzerland: The Discursive Configuration of Electrotechnology

In January 1895, Johannes Pernet of the Swiss Federal Institute of Technology gave a public talk on electricity. In the physics lecture hall he set up several electrical devices in preparation for his popular demonstrations and waited for the audience to arrive. What happened then must have surpassed even the lecturer's wildest expectations: people virtually stormed his lecture hall. Nearly four times as many people as got into the hall remained outside the building, unable to catch a glimpse of even a single electric arc. Pernet had to repeat his talk the same evening, and the organizers of the lecture decided to offer two presentations each Saturday on the same topic. To prevent further turmoil, they distributed "free entrance tickets among the friends of electrotechnology."⁷ Several hundred of those friends, however, failed to get a ticket, as all were given away within hours. One newspaper commented a few days later: "This experiment demonstrates the strong demand of popular-scientific lectures. ... It's gratifying that our young workers are not just interested in playing cards, sports, and political agitation. Mister Pernet knows how to grab his audience through his clear, generally understandable performance. Supported by the excellent devices and installations of his lecture hall, he provided his audience, composed of people of all ranks and ranges of education, a clear notion of the elements of electrical science."⁸

Pernet's (and other's) talks about electricity informed a wide public about electrotechnical questions and have to be understood as a means to create general acceptance among present and future consumers of electricity. This popularizing discourse, however, also fell on the fertile soil of a language of "progress," "network growth," "expansion," "increased domination," and "modernity" which had been produced by the double process of unifying Swiss politics and humanizing Swiss nature. Since the late 1880s both discursive strains had become part of the electric discourse. This discourse depended very much on its capability of finding resonance in other group-specific discourses. The incorporation of the electric discourse into the unified nation's "federal language," and its allusion to other technological practices which helped to standardize nature, formed a very strong alliance and committed a broad range of social groups to participating in this discourse. Without its great public appeal, and without the support of the mass media of different political colors, this discourse would not have spread so rapidly across class barriers. The highly coded semantic was guaranteeing both standardized patterns of perception and a sufficiently fixed consensus on the future of electricity and its applications.

Figure 1. Annual Growth Rate of Total Swiss Electric Powerplant Capacity 1886–1936 (3-year moving average)



7 Neue Zürcher Zeitung no. 21 A2, January 21, 1895.

8 Neue Zürcher Zeitung no. 24 M, January 24, 1895.

However, neither the electrotechnical discourse nor the productive capacity of the Swiss powerplants had a uniform, continuous development. Irregular annual growth rates of accumulated electricity generating capacities characterize the first fifty years of electrical development in Switzerland. It is noteworthy, that each downswing provoked an intensified public debate and the production of a new discourse on fundamental issues of the political economy of the Swiss electric supply industry (fig. 1). Such *fundamental debates* occurred (A) around 1890 on transmission and distribution of electricity; (B) between 1900 and 1902 regarding the expropriation rights for the construction of powerplants and electricity transmission lines, closing with the federal law on electric power; (C) during World War I on the nationalization of water-power, the electrification of the national railway system, and the foundation of state-owned powerplants; (D) and (E) on quotas for export of the national electricity production to neighboring countries and on the electrification of the household in order to reduce overcapacities in the early and late 1920s; and finally (F) on rural electrification in the 1930s.⁹ Hence, each of the growth rate's downswings coincided with an apparent need for sociotechnical and discursive reorientation. The literal discursive tides or fundamental debates during the downswings led, after their closure, to reassure the investors (private or public ones). In turn, they established new patterns of consumption and led to an accelerated growth of the generating capacities of the Swiss electricity supply industry.¹⁰ Such fundamental debates formed an important condition and a main directive force for electrotechnical growth in Switzerland.

In contrast, Pernet's talk formed part of what I would call a "*base discourse*." This imbued its audience with a general competence in dealing with electricity in everyday life. Sustained by a broad network of public talks, general information on electric issues in the press, as well as writings of the electricity supply industry, it laid the foundation for the general acceptance of electric utilities and their property rights. Both the "base discourse" and the fundamental debates incorporated electric technology into the sociopolitical and cultural framework of 19th and early 20th-century Swiss society.

The enthusiasm of Pernet's audience for the electric, which transcended all class barriers, was not unique. The "base discourse" obtained its popularity through many different channels. The Frankfurt electrical exhibition of 1891, with its more than a million visitors, might have been limited in access to the wealthy techno-pilgrims. Nevertheless, during the 1890s there were countless occasions for everybody to listen to talks on electricity in Switzerland, even in small towns like Langenthal, Andelfingen, Wetzikon, or Döttingen.¹¹ Wherever the Charitable Society, the Machinist's and Boilermen's Association, the Liberal Organization, the Technical Society or the Commercial Society advertised a lecture on electrotechnical questions, the hall was filled to the last seat.¹²

Furthermore, since the beginning of electrical development, every kind of federal or state celebration represented an excellent occasion for electrical demonstrations. Choral festivals, shooting matches, anniversaries of medieval battles – in short, not a single patriotic event went without dazzlingly bright arc lamps. In the collective memory, national exhibitions represented the

9 Transmission debate: Gugerli 1994b; expropriation debate and 1902 electric law: Meili 1900; waterpower debate: Amt für Wasserwirtschaft 1916; electrification of the national railway system: Imhof 1925; exportation quotas: Vereinigung exportierender Elektrizitätsunternehmen 1976; household electrification Bütikofer 1921; rural electrification: Günthart 1936.

10 On closure see Pinch and Bijker 1987, 44–6.

11 See *Neue Zürcher Zeitung* no. 231 II, August 18, 1892. Kopp 1893. Bleuler-Hüni 1903. "The county of Zurzach and especially the region of the lower Aare are observing with their highest interest the progress of the big electric powerplant in Beznau. One expects of the new plant an economic upswing for the whole region. In order to provide the public with some orienting information, the chairmen of the Charitable Society of the County of Zurzach invited the public last Sunday to an informal meeting in Döttingen. The meeting was very well attended and the hall of the "Ochsen" [the local inn] was crammed with people." *Neue Zürcher Zeitung* no. 39 M, February 8, 1900.

12 See note 11 above and *Neue Zürcher Zeitung* no. 337 A2, December 4, 1896: "The talk of Director Emil Huber in Oerlikon on newer electric applications, which was organized by the Commercial Society of Zurich, was so well attended that many people could not find a seat."

climax of these scattered demonstrations. I quote from a report on the Swiss National Exhibition of 1883: “In front of the industrial hall was a square, in the middle of which a fountain with some twenty water jets was booming. At some distance from this water spectacle, five electric arcs hung from each of the two high poles. At nine o'clock these lamps flashed their white light over the square. Now the scenery became fairy like. ... The eye reveled in these majestic pictures. ... Since the atmosphere was elevated anyway, the music underscored the patriotic atmosphere and expressed it with a potpourri of national melodies.”¹³

Even years after the event, people were talking about the “irresistible attraction exercised by the magic flow of light poured over the festival ground and the fountain.”¹⁴ In subsequent national exhibitions, electricity represented one of the main attractions, with demonstrations of big multiphase generators in Geneva's 1896 exhibition and electric locomotives in Bern's exhibition of 1914. In Zürich's exhibition of 1939, electricity reached another peak of popularity. High voltage experiments, an electrically driven waterfall, and an idealized hydrotopographic model of the Swiss landscape were admired, and the public could even ride on little boats through a park of hydropower metal monsters, i.e., the huge Kaplan and Pelton turbines presented by Escher & Wyss.¹⁵

The festive union of nationalistic self-representation with industrial pride, information, and entertainment presented the products of both the electricity supply industry and manufacturers of electrical devices or machines with the patina of a national exhibition. Through such national exhibitions BBC, Escher & Wyss, Rieter, Cuénod et Sautter, Bürgin and Alioth, Landis and Gyr, Sprecher & Schuh, Huber & Suhner, Kummler & Matter, to name only a few, introduced themselves to a wider public as integral parts of Swiss electrotechnical culture.¹⁶ Most of them have preserved to this day a solid “corporate identity.” Exceptions, like the symbolically painful decline of the old BBC, prove this fact *ex negativo*.¹⁷

Even those who could not participate in public shows, those who did not visit the national or international exhibitions, were provided by the daily press with a huge amount of information concerning electrical development. The *Landbote*, the *Neue Zürcher Zeitung*, the *Bund*, the *Vaterland*, the *Journal de Genève*, the *Feuille d'Avis* in Lausanne, as well as smaller newspapers, continuously discussed questions of public electricity supply utilities and presented new applications for electricity in industry, workshop, agriculture, and household. The 1903 report on business and industry claimed that “all social classes of the population” showed “a vivid interest” in electrotechnology. “Everybody is trying to become familiar with the nature of electricity,” the report claimed.¹⁸

The way electric technology became popularized is surely the key to understanding the extraordinary fascination large parts of Swiss society felt for the new technological paradigm. I would argue that the lack of popular opposition to electrification was due to the swift and strong ideological fitting-out of the electrotechnical discourse. During the 1880's, this discourse had already started to shape electrical technology through a series of locutions that became systematically organized around a small number of commonplace notions such as “the utilization of unexploited waterpower,” utility, and progress.

It is very difficult to find contemporary reflections on the shaping of this discourse. Only a few publications indicate its significance, and then only where people are trying to develop an anti-discourse. Among those publications we find papers defending the position of the old gas companies, writings against powerplant projects, or speeches of federalist members of parliament who feared an additional round of centralization that would provide the federal government with

13 Neue Zürcher Zeitung May 15, 1883.

14 Burkhard-Streuli 1890, 8.

15 See Exposition Nationale Suisse, 1898. Bauer 1914; for the integration of national exhibitions into the company's marketing strategy see Maschinenfabrik Oerlikon 1914. Lusser 1939, 321–22; Bauer 1939, 287–306.

16 Landry 1939, 286.

17 See Catrina 1991.

18 Bericht über Handel und Industrie im Kanton Zürich 1903, 148.

an enhanced ability to decide questions for the electricity supply industry.¹⁹ On the whole, however, the formation of the huge discursive power of the electricity supply industry took place to a large extent beneath the threshold of conscious perception. Hence, the only way to apprehend the formation of the discourse is to study its notions, commonplaces and argumentative figures. This will also entail us to explain why the electrotechnical discourse met with little substantial opposition until the 1920s.

One of the most successful and most important notions was “Gemeinnützigkeit” (utility or common good). This was particularly convincing because it could be used and interpreted in a sufficiently obscure and flexible way. On the one hand, public utilities as such were called “gemeinnützig,” which implied a popular access to the services of public utilities. On the other hand, every kind of entrepreneurial activity could be called “gemeinnützig” since it promised to raise the standard of living within a community.²⁰ Furthermore, the notion addressed central elements in the sociopolitical ideology of both liberal and democratic circles. Hence, electricity supply companies were generally sailing under the flag of “Gemeinnützigkeit,” whatever they or the voting (and paying) political community meant by this notion. The electricity supply industry was supported very early by the *Neue Zürcher Zeitung*, a newspaper that upheld and reinforced the officially accepted linguistic terms. In 1891, this newspaper categorically declared: “The general interest [*das gemeine Interesse*] demands a rapid exploitation of the newly discovered power source.”²¹ However, electricity supply was not only connected with the nation's general welfare in the financial and economic center of Switzerland. The assembly of the voting men in Glarus simply declared that any bigger electric powerplant had to be considered of public benefit even if useful only for a single entrepreneur, since it was “paying a service to the industry, the source of welfare.”²²

Hence, “Gemeinnützigkeit” obtained in contemporary semantics a generalized and standardized meaning. Of course, this meaning also included derived notions like “for the general welfare” or “in the interest of the community.” For the operating of the powerplants, this semantic configuration was very important. First, it made waterpower concessions and permits to construct a powerplant easier to obtain. Second, it represented an important tool in the tedious construction of transmission lines. In November 1898, the supreme court declared: “If private interest is supported by public interest in the execution of an enterprise it is reason enough to declare the right of enforced expropriation. ... Furthermore, the transmission of electricity even for private purposes can be seen as within the interest of the public.” Moreover, the supreme court's decision maintained that any supply of electric power lay in the public interest and served the public welfare “if it generally stimulated and supported the manufacturing and industrial activity of a town.”²³

This view leads us directly to the second field of important notions in the discourse of electricity, this one centered around waterpower: “Waterpower [was] a national good [that] had to be utilized in the interest of the general welfare of the people and to promote the national economy”²⁴ and that had “to be put into the service of everybody.”²⁵ While the *Neue Zürcher Zeitung* in 1883 expressed the opinion that there was not enough waterpower available for the illumination

19 Schilling 1885. Fuchs 1910, 27: “It's an unpleasant phenomenon of our time that technicians permit themselves to judge esthetic questions and very often claim that their technical endeavors do not disturb nature's beauty but that they rather embellish nature – as if this could possibly be! – or [they claim] that they are at least creating new beauty, instead of simply saying: we demand this railway or this powerplant for economic and technical reasons, regardless of the detriment to natural beauty. The latter must give way as of minor importance. Thus, the battleground is shifted very cleverly to the realm of taste.” See also the debate in parliament on the waterpower legislation of 1915/16.

20 Cf. the critical remarks in Pflughart 1904, 60–61.

21 *Neue Zürcher Zeitung* no. 314 b, November 10, 1891).

22 *Amtliches stenographisches Bulletin* 1900, 583. See also Pflughart 1904, 61.

23 *Wasser- und Elektrizitäts-Werk Romanshorn* 1899, 18.

24 See *Amtliches stenographisches Bulletin* 1915, 170, session of the Nationalrat (house of representatives), September 20, 1915.

25 Klöti 1905, 27.

of Switzerland's cities²⁶, in 1884, H. F. Weber from the ETH pointed to the “masses of water rushing out of the alpine valleys,” which represented “mechanical work of a nearly infinite quantity.”²⁷ One year later the *Schweizerische Bauzeitung* wrote that Switzerland did not have coal, “but [the country] has better [things]: more abundant hydro-power than any place in Europe.”²⁸ Finally, in 1888, the *Neue Zürcher Zeitung* too agreed with this view, claiming that electrification was a great advantage, “especially for Switzerland, poor in coal and almost too rich in waterpower.”²⁹ Swiss waterpower resources were thus embedded in the framework of the electric discourse as a source of national independence. In 1900, a deputy in the national parliament emphatically declared during the debate on new electric power legislation: “We should come to a point where not a single drop of water runs from the hills without doing its work for the national welfare. This is a Swiss maxim we must not forget”³⁰ This perception of waterpower was not a matter of course, as the 1883 point of view of the *Neue Zürcher Zeitung* demonstrates. Moreover, this faith in waterpower was the result of an ideological effort that found in the discourse of electricity both its expression and its instrument.

Towards the end of the century, Swiss society made its demands on waterpower resources in terms wider than those of the prevailing nationalist ideology. Through electricity, “nature's inexhaustible stocks of energy” had also become “accessible for cultural development.” For many writers it was even possible to maintain that “the cultural progress of Switzerland as such” depended on the development of electrical networks.³¹ Waterpower, cultural development and the electric became more and more intertwined and the “electrifying” notions of “progress” and “modernity” were discursively bound to the total development of electric technology. The mysterious complexity of technological (and cultural) development was consequently explained by a model of transcendent, irresistible progress. Moreover, “progress” and “modernity” substituted for the lost teleological or eschatological perspective on the future. In the late 19th century, they allotted to nature, norms, or values in earlier times: that of sources of security.³² Thus, progress provided the assurance that an orderly sequence of events would continue into the future, which lessened anxiety about the rapid passage of time. Fears of social complexity or an uncontrollable future were domesticated by the establishment of this time-line. The projection of an overwhelming problem as a series of smaller problems seemed to offer the possibility of solving this sequence step by step; the future predicted by a sequential developmental process (usually characterized as “progressive” and “modern”) stimulated utility-oriented planning activities. The 19th-century world had to be a world of planning. Progress, the idea of a future reached through predictable steps, could be guaranteed for the future by connecting progressiveness to scientific and technical invention³³ and, simultaneously, by perceiving inventive activity as a human necessity. Even though progress as such could not be calculated, it was characterized by *the calculable unknown*, which could be proved and secured by making reference to the past technological and economic – perhaps even social – “progress.”³⁴

In 1887, the Swiss engineer Arnold Bürkli-Ziegler formulated the problem of the *calculation of the unknown* in electrification as follows: “One can have various opinions concerning the extension of electric illumination in the near future and beyond; but one has to agree that even the most limited initial implementation should be able to be constantly and limitlessly amplified.” Nevertheless, this “future expansion” could not be determined right now, “since one would get

26 *Neue Zürcher Zeitung* no. 162 II, June 1, 1883.

27 Weber 1884, 54.

28 *Schweizerische Bauzeitung* March 7, 1885, 59.

29 *Neue Zürcher Zeitung* no. 24 I, January 24, 1888.

30 *Amtliches stenographisches Bulletin* 1900, 606.

31 Quotes from *Schweizerische Bauzeitung* July 4, 1896, 1, and *Schweizerische Bauzeitung* January 2, 1904, 4–5.

32 Cf. Luhmann 1982, 271–88.

33 See the title of the *Elektrotechnischen Rundschau, Zeitschrift für die Leistungen und Fortschritte auf dem Gebiete der angewandten Electricitätslehre*, 1882–; or Beck 1912.

34 Cf. Koselleck 1975, 410.

totally exaggerated numbers which are very clumsy since there is no guarantee that they correspond to future conditions.”³⁵ On the other hand, the concept of progressive action provided security and reduced the complexity of the contingent present future, i.e., the future as perceived in the present.

The shift from a future loaded with both utopian promise and insecurity toward a notion of technological progress that legitimized present action even crossed class barriers. Not only did the bourgeoisie and upper class become convinced of the rectilinear development of society, large parts of the small business class, the craftsmen and members of the working class shared this view as well.³⁶ Karl Bürkli, for instance, a radical activist in the democratic movement, claimed in 1868: “Our people are swimming in the century's great stream of progress,” while the socialist newspaper *Die Tagwacht* claimed in 1880: “Machines are the redeemers of mankind, if they are properly used In a democratic organization of work and society machines will be an advantage for everybody. ... Hence, mankind will reach an unmeasurable cultural level and the intellectual *niveau* of the masses will be greatly increased.”³⁷ Thus, the late 19th century maintained a strong conviction of the *benefit of technological progress* and of the *progressiveness of technology* for the entire society.

Since technological progress was perceived as self-propelled, depending on the invention of engineers and scientists rather than on any kind of political preference and choice, it was also inevitable. There was no way to stop the development of electricity, “the newest progression of the human inventive spirit.”³⁸ Since the early 1880s, hundreds of articles, talks, brochures, pamphlets, scientific newsletters, and introductory readers had connected electrotechnology with “progress” and “modernity”; by 1890, these terms were nearly equivalent.³⁹ Even the legal dogmatists started to defend electricity as legally protected in *modern law* and pointed to the “new dangers” to which “the modern world is exposing us with its electric charges and devices.” Manufacturing catalogues carried the adjective “modern” in the title – surely stunning proof for the convincing force of the word.⁴⁰

The notion of “progress” was even easier to advocate. As early as 1882, the *Zürcher Freitagszeitung* called Zürich a “city of progress” since “the entryways of the railway station are now brightly illuminated with electric light.” The time “when electric illumination will be introduced in all Zürich is not far off.” Moreover, the surrounding towns would promptly be connected with the center by telephone. Concerning the electric light, one had simply to wait for the permit to extend the cables from the central station, “so that the hotels and restaurants near the main station, as well as the shops and inns on the *Bahnhofstrasse*, could be illuminated.” The machines were large and powerful enough to make such amplification possible and could “be increased without difficulties,” the newspaper claimed.⁴¹

The news article just cited contains all of the most important elements of the discourse on progress. The first attempt of private initiative to introduce electrical illumination was concerned with the railway station – the outstanding symbol of modern trade and economy. On May 23, 1882, only ten days after the article was published, the railway line through the St. Gotthard tunnel was officially opened. One part of it now began from the electrically illuminated hall of the main station in Zürich. The connection of electric light to the Gotthard as a national symbol is significant. The construction of the Gotthard tunnel was one of Switzerland's most important high-tech programs, which finally managed to tame – with the well-coordinated application of modern construction tools, steam power, scientific knowledge, and topographic survey techniques – even the granite of the country's ideological cradle. Zürich, now connected to the world, could receive masses of

35 Bürkli-Ziegler 1887, 6.

36 Müller and Tanner 1988; on the bourgeois middle-class in Switzerland see Brändli 1990, 151–276; and Tanner 1988.

37 Cit. after Müller and Tanner 1988, 336 and 334.

38 Furrer 1892, 406ss.

39 The physicist August Kundt claimed in a talk of 1891: “The day Werner Siemens invented the electrodynamic machine ... modern electrotechnology was born.” Kundt 1891, 5.

40 The maxim of Meili 1900 runs: “Electricity is an independent asset of modern law.” Second quote from Meili 1899, 7. See also *Maschinenfabrik Oerlikon* 1901.

41 *Zürcherische Freitagszeitung*, May 13, 1882.

tourists and direct them to Lucerne or St. Moritz. Zürich seemed to be keeping up even with Paris, London, Vienna, and the hot spot of electric illumination – Berlin. And because the hotels had to satisfy international businessmen, electrical illumination became as much a requirement of a decent hotel as the waiter's white gloves and the French card of the *maitre de service*.

Furthermore, progress, as conceived by the *Freitagszeitung*, required a telephone network, or at least the general interconnection of the city and its surroundings with a dense network of wires – be they electrical cables or telephone wires. The statement *that the time is not far off* is very important: progress continues, progress is granted and progress cannot be stopped. Spare capacities had been reserved, amplification was already planned, and no difficulties were perceived in following progress into the future.

Why this strong concern about time? As we will see in the second section of this paper, 19th-century society's attempts to dominate nature were mainly concerned with reshaping the temporal and spatial structure of the natural environment. Furthermore, the process of standardizing nature produced a language of progress and modernity that met the needs of a restructured time model. A discourse which was configured around “progress” allowed for a reduction of social complexity and for amplified possibilities of communication on issues like development and planning. Hence, it also supported the temporal reshaping of the natural environment by planned technical means. Railways, telegraph lines, hydraulic systems of the rivers and the cities' undergrounds, telephone wires and the fast spreading power networks changed the time of nature, while the nature of time was transformed into a model of linear development and planning.

Moreover, electrification itself changed the structure of time on many levels, a process which without doubt had a feedback on its semantics. Electricity itself was a means to dominate time in the same sense as the electric discourse promoted electrical systems: First, there was virtually no temporal difference between central production and remote, decentralized consumption of electricity; likewise, there was *no history* for generated electricity, since storage devices (accumulators) were only marginally used and generated electricity had to be progressively consumed. Second, natural time limits became increasingly blurred as electric arc lights turned night into day, allowing for a continuous industrial production that was completely independent of any “natural” light; electricity's space of action was open-ended. Third, electric tramways accelerated urban transportation, while small electric motors managed to speed up small workshop production. Accordingly, electricity was a literal means of progressing and growth. Finally, central electric watches guaranteed a uniform social time in urban contexts. The sweeping fluid movement of their second hands was a perfect representation of 19th-century's model of time as a continuous flux.⁴²

However, the story to be told here is even more exciting. Electrification was not just strongly connected with a progressive model of time, nor was it only shaping late 19th and early 20-century's temporal structures. Construction of electricity supply networks also promoted those discursive networks which in their turn had promoted and would promote new investment and further expansion of power supply networks. Each village that was connected to the electric grid was also connected to a powerful discursive network. Installation firms started to promote their products, to construct show-rooms and electrically illuminated show-windows; each household that received electricity automatically received the utility's propaganda along with popular versions of federal and cantonal legislation on electric systems.⁴³ Hence, in the case of electric power supply, discursive and technical networks had a strong symbiotic relation.

42 Kern 1983, 20. On space and time as a modern mode of experience see Berman 1982, and Harvey 1992.

43 Bertschinger 1914. Stiefel 1935.

Conditions of Technological Practice in 19th-Century Switzerland

The formation of the electrotechnical discourse was intertwined with a large set of contemporaneous technical practices that equally configured the way Swiss society dealt with electrotechnology. If we are justified to speak, with Pierre Bourdieu, of the *habitus*, the “embodied history, internalized as a second nature and forgotten as history”, if we want to understand this “infinite capacity for generating products – thoughts, perceptions, expressions and actions – whose limits are set by the historically and socially situated conditions of its production,” of which one knows that the “conditioned and conditional freedom it provides is as remote from creation of unpredictable novelty as it is from simple mechanical reproduction of the original conditioning,” then we should take a closer look at the general characteristics of 19th-century Switzerland’s technological practices, in order to juxtapose them with the expressive dispositions and instituted means of expression the electrical discourse is constituted of.⁴⁴ This will prevent us from interpreting the discursive configuration of electrotechnology as a mere ideological or idealist recording of the electrification process. Discourse and practice will rather appear as two forces that simultaneously shape technology. This view will also enable us to apprehend, in the last section of this paper, the conditions and the conditioning of those selective processes which eventually led to the Swiss social construction of electricity supply utilities.

The way in which 19th-century Swiss society usually dealt with nature is best described as a *technical and systematic disciplining of nature*. While 18th-century sciences started to administrate nature by constructing systematic nomenclatures, the so-called bourgeois era gave this constructive achievement material form through the creation of technical networks. Thus, the natural environment was conquered, separated, and coordinated through technical devices.⁴⁵

In this management of space, new techniques of cartography, land surveying, and cadaster maps increased the availability of and the control over land and soil. These techniques culminated in the work of the Swiss Civil War general Guillaume-Henri Dufour (1787-1875). A recent popular study on Dufour’s work goes so far as to compare his military achievements with his topographical and scientific work. Thus, the founding-father general continued the conquest of his country after 1848, producing a scientific representation which could be – and actually was – offered as a centerpiece of Swiss culture in the country’s pavilions at most international exhibitions.⁴⁶ Dufour and his collaborators virtually covered the landscape with triangulation points defining the outline of a seamless, invisible web that offered the possibility of conquering and representing it scientifically.⁴⁷

Mapping, however, was just one field of Dufour’s engineering activity. In the early 1820s he also pioneered in the construction of cable suspension bridges.⁴⁸ It is astonishing how closely Dufour himself connected this construction of cable suspension bridges to the later topographical work. In 1824, he wrote that “everybody felt the usefulness that this new method of construction could have in a country such as Switzerland, which is cut by rivers and deep canyons that make it often virtually impossible to cross with a normal bridge.”⁴⁹ While his early bridge construction tamed the wilderness of the Swiss landscape and crossed its deep canyons, the survey work achieved the “topographic crossing of the Alps,” connected the country with triangulation networks of the neighboring countries, and led to a uniform and scientific representation of Switzerland’s natural environment. By gathering the net of triangulation into its coordination center in Bern, Dufour probably held the country together as efficiently as he did later as a politician in the federal upper chamber.⁵⁰

One of the most important technological achievements of the young confederation was clearly based on Dufour’s improvements in topographical surveying. After the founding of the

44 Cf. Bourdieu 1992, 54–9.

45 Cf. Walter 1990.

46 Graf 1896, 249.

47 See Gugerli 1996b.

48 See Peters 1987; Brulhart 1987.

49 Dufour 1824.

50 On Dufour’s topographical work see Graf 1896.

federation in 1848, booming construction activity provided Switzerland with a railway network that created completely new conditions of time and space.⁵¹ The transport facilities of the newly connected towns and cities multiplied all at once, while other settlements became relatively less accessible. Since the custom barriers between the 22 cantons had been eliminated, moreover, new connections between remote regions of the country started to emerge. This new means of transportation demanded a strongly centralized organization, coordination, and a systematic effort to attain uniformity within the networks of each railway company. Schedules, employee training, fee systems, security devices, and transport capacity were determined mainly by modern, centralized management.⁵²

Like the traffic of goods and persons that were bundled together on rails, information was technically channeled through the establishment of telegraphic wire networks. Telegraphs and railways developed a symbiotic relation, since telegraphs were widely used in the operating of railways, while the railways offered the opportunity to “realize” orders and offers made through the new communication system, i.e., to transport the goods from one side of the country to the other. Because the telegraph system had been under federal control since 1851, it was even more centralized and unified than any other contemporary technology.⁵³ Its spider web network very quickly spread out over the whole country, where an increasing number of telegraph offices provided new fixed points or landmarks of communication. Again, both space and time were technically transformed and gained a different social significance.

Hydraulic engineering joined the rail and telegraph networks in the transformation of the natural environment and landscape. Wild rivers were forced into straightened riverbeds, swamps were drained, and water levels were carefully monitored throughout the country. The conquest of new, hitherto only marginally exploited, soils through the construction of dams and the digging of drainage ditches transformed the Swiss landscape. The land became easier to exploit, less dangerous, and therefore less difficult to administer; in other words, it became civilized and disciplined.⁵⁴

While Dufour described the natural spaces of Switzerland cartographically, others followed with a hydrometric description of the same landscape. The director of the Federal Hydrometric Central Office, Robert Lauterburg (1816-1893) published in 1876 a survey of the flow of the Swiss hydrological network.⁵⁵ The importance of this work lies in its presentation of the Swiss rivers as a *network*, reflecting a totally new perception of the natural environment. In this work, Lauterburg applied his practical experience as a former manager of the local cantonal floodgates near Thun to the entire country. The floodgates in Thun were not only used to manage the lake's water level, but also to provide the local shipping companies twice a week with a sufficiently big flood to continue operating even in times of a low water.⁵⁶ Using scientific methods of measurement and estimation, Lauterburg began to study the effects of those floods along the extended river system. His reshaping of nature, his new perception of Swiss rivers, lakes, glaciers, and precipitation as a network with its own rules and regulative mechanisms provided the fundamentals necessary for making decisions about hydraulic engineering, for calculating the nation's waterpower potential, and for regulating waterpower concessions. Therefore, Lauterburg's model established control over natural hydrological conditions in Switzerland and helped realign the expectations of entrepreneurs and politicians about the utilization of “unexploited” waterpower.⁵⁷

Swiss engineers not only tamed wild torrents and high water rivers; they also attacked the mountains. As Adolf Guyer-Zeller noted, “while only a few decades ago nearly all journeys to the Alps were expeditions of discovery in unknown regions, nowadays the entire world of the Alps has

51 See Eidgenössisches Amt für Verkehr 1947–1964. For the transformation of space and time through the railroad see Cronon 1991, 74–81.

52 See Eidgenössisches Amt für Verkehr 1947–1964.

53 See Federal Law of December 23, 1851. Generaldirektion PTT, 1952–1962.

54 Vischer 1986.

55 Lauterburg 1876. See also Epper 1907 and Vischer 1988, 1184–91.

56 Vischer 1988, 2.

57 Lauterburg 1891; see also Neue Zürcher Zeitung no. 176 b, June 25, 1891; Jegher 1894; Schär 1905.

become the accessible common property of the people.”⁵⁸ The regularly published “Alpine Chronicle” of the *Neue Zürcher Zeitung*, the country's most respected newspaper, gives evidence of the wide ranging conquest of the Alps. On the heels of the pioneers, the members of the Swiss Alpine Club followed (all of them well-equipped with Dufour's maps), and after them came the hoteliers, the operating authorities of mountain railways, and finally the international crowd of tourists. “After the Rigi and some smaller lines *were clapped in irons*, the railways to the Pilatus and the Brienz Rothhorn succeeded.”⁵⁹ In other words, the “unbound Prometheus” put nature in irons. The construction of mountain railways became a strategy in the industrial conquest of nature, and, driven by the alleged “human urge to conquer the summits,” tracks, steam power, tunnels and cogwheels tamed the alpine wilderness.⁶⁰

Meanwhile, down in the flat land, urban authorities were gaining experience in handling complex technological systems. First, they had to deal with water supply systems. Reliable regulation of the standards of water quality and the pressures within the mains required management by a centrally directed, politically legitimate authority.⁶¹

The second technological system operating in urban networks was the gas supply. Gas supply companies started to operate in cities like Zürich, Geneva, Lucerne, and Basel in the late 1840s. Gas lighting installations transformed the nighttime topography of the cities, separating bright, representative zones of urban life from dark and dangerous districts. Night became increasingly civilized and accessible to the city's bourgeoisie, once the illuminating beams of the gas lamps began to eradicate nocturnal shadows and obscure figures.⁶²

Finally, two-way telecommunication became available in the larger cities through the introduction of the telephone, which soon spread out into the cities' immediate surroundings. For a time, Switzerland became a European leader in telephone technology; its networks probably developed much faster than those of any other European country. The centrally controlled *Telegraph Office* successfully built telephone networks in Bern (1881), Geneva (1882), and Lausanne (1883); it nationalized the Zürich network in 1886, and started to integrate local networks into a national grid.⁶³

To summarize: systems, networks, and a general attempt to dominate and conquer natural spaces were common technical practices in Switzerland when the first electrotechnical devices showed up in exhibitions, shooting matches, choral festivals, and commemorative events. Dufour's topographical survey, hydraulic engineering leading to Lauterburg's hydrometrical system, the railways, the telegraph, urban water and gas supply utilities, as well as the recent telephone, formed and represented a genuine part of bourgeois urban techno-culture. All these technical developments spread from the cities into the flat land and even over the “frontier” into the hitherto “wild” Alps. Increasing domination of nature by means of technical networks was thus supported by a discourse that connected technical innovations to notions of progress, general wealth, and economic growth. The world became malleable to control and transformation as facts, values, and standards were inserted into technical, discursive, and social practices.⁶⁴ Thus, 19th-century Swiss society not only favored a network approach in its domination of nature, it also discursively

58 Guyer-Zeller 1896, V.

59 Guyer-Zeller 1896, V. The railway to the Rigi was built in 1871 and the one to the Pilatus from 1886 to 1889.

60 “The urge to the summits is deeply rooted in the interior of man, and in all epochs the mortals have considered hills and mountains as the holy sites of gods, where they erected them places of worship.” Guyer-Zeller 1896, V. See also Allen 1967. On alpine tourism see Bernard 1978; Seitz 1987; Schmidt 1990.

61 See Bürkli-Ziegler 1878.

62 See Zollikofer 1928; Gas-, Wasser- und Wärmeversorgung der Stadt Bern 1993; Schivelbusch 1983.

63 Bericht über Handel und Industrie im Kanton Zürich 1889, 18. *Neue Zürcher Zeitung* June 20, 1881. *Neue Zürcher Zeitung* June 17 and 18, 1881. See also Generaldirektion PTT 1952–1962. Stadelmann and Hengartner 1994.

64 See Lenoir 1992, 160–63.

constructed its natural environment as a malleable field that allowed for virtually infinite growth of technological systems.

Sociopolitical Selection and Construction of Electrotechnology

The neo-Schumpeterian discussion of the 1980s has attempted to “model formally economic competition and growth, technical choice and diffusion, and technologically induced fluctuations as an evolutionary process.”⁶⁵ Considerable attention has been devoted to the problem of selection of technology. Yet, this discussion was concerned only with the selection of *finished* technology; it paid little attention to the possibility of learning about technology by building and operating systems and then scaling them up.⁶⁶

Recent studies in the field of sociotechnical change propose to concentrate on the social construction of technological systems.⁶⁷ As a consequence of this theoretical shift, selective processes almost disappeared from view, even though the definition, the acquisition, and the application of criteria of selection, classification, and interpretation and the application of those criteria in contingent situations shape those learning processes that lead to the social construction and shaping of technology.⁶⁸ I propose that “the rather messy contingencies” (Bijker / Law) of technology, the social world, and the course of history come to “closures” precisely through selective processes. Without criteria of selection there cannot possibly be a closure on any kind of debate. However, I will show that these processes of selecting technology are heavily determined by political, social, and cultural factors, i.e. by the *habitus*, and that they define a sociopolitical strategy for building, operating, and scaling up new technological systems. In Zürich, as we shall see, electrotechnical selections were made in a way that allowed for an incremental strategy of investment.

During the last decade of the 19th century, electrical transmission wires began to structure natural space through the formation of sales areas and new types of economic regions. This development did not stem exclusively from the “nature” of electricity, even if it is difficult to perceive the horizon of lost alternatives hidden by the technological selections once they were made. The decision not to build steam-driven block stations as Edison did, the decision to found city-owned electricity supply companies, the selection of alternate current systems rather than direct current systems, the promotion of small electrical motors for small workshops, the decision to renounce large accumulator systems, the substitution for horse-pulled and steam-driven streetcars of electrified tramways – all these processes of selection can be related as much to the political as to the technological and economic necessities of the epoch. One can hardly overemphasize this fact, particularly since the 19th century believed both in a theory of the autonomous development of technology and in the unavoidability of progress as the reason and legitimation for technological change. Thus, not only in today's sociology but also in 19th-century society, processes of selection and their sociopolitical dimensions nearly disappeared from view.

Using the example of the electrification of Zürich, I will demonstrate the extent to which sociopolitical rather than economic or technical motives led the city's authorities to choose a specific electrical system.⁶⁹ As we shall see, the social shaping of technology even enters those realms that are normally considered to be within the exclusive province of the competence of technicians.⁷⁰

⁶⁵ See Nelson and Winter 1982; Dosi 1988. Quote from Silverberg 1988, 538.

⁶⁶ Rosenberg 1982, 120–40.

⁶⁷ See note 5 above.

⁶⁸ Cf. Siegenthaler 1993.

⁶⁹ See also Gugerli 1995.

⁷⁰ The following section is based on the proceedings of the commission for the preparation of electrical illumination 1888–1890 (Akten der Kommission für die Vorbereitung des elektrischen Lichtes 1888–1890), Archives of the City of Zurich V Bc 5.

Early in 1888, a commission appointed by the city council started to study the question of electrical illumination in Zürich. At this point the so-called battle of the systems was reaching its climax. Unlike engineers in Germany or the United States, Swiss engineers did not make an article of faith out of the selection of AC or DC systems. Nevertheless, there existed considerable confusion among the commission members and the community of technicians. The commission was confronted with a great number of inconsistent recommendations, reports, counter-reports and interventions. Even experienced technicians like Bürkli-Ziegler did not know what to make of these different opinions.⁷¹ Although a paper prepared by the city's engineer preferred an alternating current system, the question of selecting a system caused many discussions within the commission. "Electrotechnicians have been split into two camps and are defending their opinions with rising warmth,"⁷² commented the *Schweizerische Bauzeitung*.

Without going into detail, let me suggest that all the members of the commission had in the end a good deal of information concerning the advantages and disadvantages of both systems.⁷³ They also knew quite well that they did not have to decide which system was "the better one." Their discussion was concerned rather with the question of which system would better satisfy the city's actual and future needs.⁷⁴ Hence, they had to come to an agreement on what role electrical energy was to play and how electricity should be integrated into the existing sociopolitical context. In other words, electricity was to be shaped to fit into the local conditions of Zürich, and the commission had to make a technical selection that was politically desirable.⁷⁵ For instance, should the city go into competition with its own gas plant, bought only two years before from a private operating company, by introducing a new technique of illumination? Would it not be better to leave the whole question up to private initiative? Should electrical illumination completely replace gas, or illuminate only the important civic squares and buildings in the inner city? Should one consider the supply of electrically-driven motors? Should the city draw its primary energy from the existing waterpowerplant with its very limited capacity, or should it try to set up various block stations driven by steam power?⁷⁶ In short, the commission had to decide about the future function of electricity within the increasingly complex framework of public utilities. All these selections and recombinations, which allowed for the construction of the "most compatible" electric system, were genuine political decisions. They were roughly outlined in the announcement of the competition in August 1888, which called for publicly supplied illumination of various widespread points of the city. For instance, the paper asked for the utilization of the existing waterpowerplant, either through an enlargement of this plant "or through a waterpower transmission as provided by the local water lines system," whereas the question of small power supply to workshops was considered to be marginal – such motors could be connected to the city's water supply system for small water engines.⁷⁷

Seven of the eleven projects presented to the commission were immediately refused.⁷⁸ Among those rejected was a project presented by the well-known company of Thomson &

71 In summer 1890, Bürkli once favored the DC system (session of August 16, 1890), while shortly before he vigorously advocated an AC system (session of June 28, 1890). See Protokoll und Akten der grosstadträtlichen Kommission betr. Einführung der elektrischen Beleuchtung 1890, Archives of the City of Zurich V Aa 14 (1).

72 *Schweizerische Bauzeitung*, November 30, 1889, 133.

73 *Schweizerische Bauzeitung*, November 30, 1889, 133.

74 Burkhard-Streuli 1890, 9. The commission asked the city councils of Berlin, London, and Paris for advice. See their answers in Archives of the City of Zurich V Bc 5 no. 39 (Berlin), no. 40 (London), and no. 41 (Paris).

75 Burkhard-Streuli 1890, 9.

76 "I repeat that due to the wide spatial extension of the area to become electrically illuminated in the city and its surroundings, we had to refrain from the beginning to set up a block station in the center of consumption and to apply direct current in normal tension because of the high costs of building such a network." Burkhard-Streuli 1890, 24.

77 Archives of the City of Zurich V Bc 5 no. 65.

78 The following firms presented projects: Crompton & Co, Chelmsford England; J. Ehrenberg, Littau-Luzern; Escher Wyss & Cie., Zurich; Fabrik für elektrische Apparate, Uster; Maschinenfabrik Oerlikon;

Houston, which was considered “very incomplete on the illumination of houses, which was the main issue in Zürich.” It did fulfill the requirements of street illumination for a city like Milan, which was accomplished by a large number of lamps in series. Yet it would not fulfill Zürich's needs, the report of the experts claimed.⁷⁹ Finally, the proposals were reduced to four: a pure AC proposal by the Zürcher Telephongesellschaft, a five-wire direct current project by Siemens and Halske, as well as two mixed AC and DC systems brought in by the Maschinenfabrik Oerlikon and the company of Stirnemann and Weissenbach.

The commission's instructions to the experts stipulated that, “apart from costs, the following points are decisive: the effectiveness of the arrangement especially *in connection with the given circumstances at hand, the systematic and harmoniously beautiful formation of the device, the ability to respond to any demand for electric light, and a cheap and reliable operation.*”⁸⁰ The experts in their turn slightly modified these criteria and asked first “which system of electrical illumination ... would be the most appropriate for the circumstances of Zürich.” Hence, they voted for the adoption of a mixed system: direct current for arc lights and alternate current with a limited number of transformation stations for incandescent light, with the capacity of a switch from AC with transformers to DC with accumulators.” This arrangement, they held, would satisfy the contemporary conditions in Zürich “and even more for the probable future design of electric illumination.”⁸¹

In the commission's opinion, Siemens & Halske's proposal was quite complicated; it was also the most expensive (1.8 million francs). The pure AC project of the Zürcher Telephongesellschaft was the cheapest (1 million francs). Yet, as already mentioned, the experts' decision for a mixed system had already been made. Among the two mixed systems, the project of Stirnemann & Weissenbach did not offer the option of operating with accumulators in the future. So the order went to the Maschinenfabrik Oerlikon, which, in collaboration with Escher Wyss & Co., was to build a mixed system of four DC- and six AC-dynamos at an estimated cost of 1.3 million francs.

And what was the end of these deliberations? The Maschinenfabrik Oerlikon built a pure AC network in Zürich. In the proceedings of the city council of August 12, 1891, we find the following explanation for this sudden about-face: “In the city council's talks held on this issue and later on in the special commission of the great city council, it was declared that if adopted, the DC system for public illumination – which was in the end the most adequate from a technical point of view – would make it necessary to construct the whole installation immediately, or at least to lay the wires, even though the street lamps would not be installed for a long time. The [implied] financial consideration led [the commission] completely to abandon the use of DC for public illumination, to supply the electrical street lamps with AC and to connect them, like the private lamps, to the next transformers. Thus ... one gains a quite important simplification in management ... and the *possibility of a progressive implementation of the public illumination system according to desire and necessity.*”⁸² This justification leads right back to the original public call for offers: “The disposition of the device should foster as much as possible the option of its progressive implementation.”⁸³

In the fall of 1890, a credit of 2.3 million francs was given to the city council for the “progressive implementation of the public arc light illumination.” Walter Wyssling, an engineer who became the first professor of electrical technology at the Swiss Federal Institute of

E. and P. Sée, Lille; Siemens & Halske, Berlin, with two projects; Stirnemann & Weissenbach, Zurich for Ganz & Cie in [Buda]Pest, F. Schuckert & Cie in Nürnberg und Gebrüder Sulzer in Winterthur; Thomson & Houston, Hamburg, Zürcher Telephongesellschaft, Zurich. Burkhard-Streuli 1890, 17–18 and Archives of the City of Zurich V Bc 5 no. 92.

79 See also Schweizerische Bauzeitung, August 3, 1889, 28–30.

80 Burkhard-Streuli 1890, 17. The experts were Emil Bürgin from Basel, Théodore Turrettini from Geneva, and G. Veith of the ETH in Zurich. Archives of the City of Zurich V Bc 5 nrs. 82, 83 and 127.

81 Bericht der Experten, cit. in Burkhard-Streuli 1890, 20 and 21.

82 Proceedings of the City Council, August 12, 1891, Archives of the City of Zurich V B a 5 no. 574.

83 Archives of the City of Zurich V Bc 5 no. 65, 5.

Technology,⁸⁴ commented that the desire for a gradual implementation of the installations, based on financial considerations, led to the abolition of DC for public arc illumination “because it would have required the immediate construction of all transmission lines from the central station, whereas the connection of the arc light with the general AC network permitted the construction of individual areas.”⁸⁵

Apparently, decision makers in Zürich were quite fascinated by the idea of a progressive implementation of public utilities. The same kind of extension also took place in the political arena. The incorporation of eleven nearby towns into the city of Zürich was decided August 9, 1891, only shortly after the first steps of the city's electrification. The expansion of the city's political and administrative field of activity into the incorporated towns, which signified a population increase from 28,000 to 121,000 inhabitants, depended heavily on the city's ability to offer public utilities that could not have been provided by the former independent small towns around Zürich. Among the most attractive potential advantages of an amplified city were public utilities like electricity supply, water supply, gas supply, and public transportation. The latter became electrified just after the political incorporation of the surrounding towns.⁸⁶ I quote from an article of Emil Huber, the director of the Maschinenfabrik Oerlikon: “Only through the network of tramways will the people of Zürich participate in the benefits of their city; only then will even the former suburbs join with their center, the old city, when a *network of traffic veins will interweave the whole*. We hope this development serves the honor and benefit of the city. Modern technology should be able to participate in this work.”⁸⁷

The story of the electrification of Zürich shows to what extent technological selections depend upon political programs, financing possibilities, and preferences in the shaping of public utilities. The city's authorities managed to install an expandable electrotechnical nucleus, to learn the criteria for operating its relatively limited network, and to enlarge it in the following years within the framework of existing and expected sociopolitical conditions.

1893 was the first full year of operation for Zürich's new electric plant. The technical and administrative report for this year reveals the extent to which engineers and technicians underwent a continuous learning process. While they tried to construct a very simple primary network with only few transformers in the inner city, they soon realized that they had to change their strategy in the suburbs. Suburban electricity demand was characterized by a “small number of scattered objects,” while the inner city showed a locally concentrated, uniform and constant demand. For the suburbs it was therefore a better strategy “to split the primary lines and to construct small, individual transformers.”⁸⁸

84 Eidgenössische Technische Hochschule, then known as Eidgenössisches Polytechnikum. For an account of the development of electric engineering at this institute see: Eidgenössische Technische Hochschule 1855, 424–40.

85 Schweizerische Bauzeitung, January 7, 1893, 4.

86 See also the discussion of different strategies for electrification as an expression of a city's political preferences in Todd 1987.

87 Neue Zürcher Zeitung no. 33 b, February 2, 1893; see also Neue Zürcher Zeitung no. 31 b, January 31, 1893. The Neue Zürcher Zeitung had discussed in September 1891 the connection between the “big city of Zürich” and the tramways: “A rational operating of the actual streetcar network and its future amplification is only possible if the network is centrally controlled. This is necessary for the setting-up of an interlocked operating and fares system, and it definitely would be to the detriment of the public that uses the tramway if the different lines be conceded to different parties. ... Even if one had a cool or quite hostile attitude to the question of nationalization of the railways, one could eventually conclude it to be more rational and a greater service for the general interest if the tramways be operated by the city.” Neue Zürcher Zeitung no. 253 I, September 10, 1891. See also Neue Zürcher Zeitung no. 252 I, September 9, 1891 and Schweizerische Bauzeitung, March 18, 1893, 68. “[Tramways] amplify the cities, develop the surrounding countryside. The benefits obtained through suitable implemented tramways are so big and so concrete that no progress-oriented city should lose time waiting for the system of the future and making it accessible for its inhabitants.”

88 Wyssling 1894, 40. On “learning by using” see Rosenberg 1982.

A second learning process occurred in the administration of the powerplant. “We soon had to fight against the prejudice that our light was prohibitively expensive. ... Manifold instructions, the introduction of discounts, and the chances of a imminent reduction of the ground tax gradually improved the mood.”⁸⁹

Third, statistical observation helped to analyze and to optimize the management of the load. Only by operating the plant could one define the effectiveness of its different parts, the variations of electricity demand during the day, the week, and the year; only by operating the networks was it possible to analyze and possibly reduce transmission losses and to obtain firm information on prime costs of electricity generation. In the case of Zürich, a first analysis already suggested the abandonment of flat rates for each connected bulb or electric arc and the introduction of electricity meters to define and charge for actual power consumption.⁹⁰

Finally, the operating board started to promote the use of small electric motors, even though this contradicted the original intentions of the city's electrification commission. “In order to improve the load management during the day, the City Council decided at the end of the year to reduce the charge for the connection of motors.”⁹¹ Small electric motors became a big success. They not only helped to improve the powerplant's load factor during the day, but also turned out to provide important momentum for the electricity supply's future expansion. This process of “learning by operating” made electricity even more compatible with local political necessities; it also allowed for the steady development of the centralized city's possibilities to offer infrastructural goods.

Conclusion

Contemporary sources, as well as many historical accounts, claim that electricity supply systems had a great influence on 19th-century Swiss society. Some writers even maintain that such influence was “cultural.” The present article provides empirical evidence for another interpretation of the relation between society and electricity. Swiss society shaped electrotechnology for the most part as it already had shaped its natural environment during the 19th century. In fact, electric power networks were made compatible with a more general attempt to dominate nature through technical and systematic means. Nevertheless, “culture” – or the “*habitus*,” if we accept a different theoretical framework – played an important role in adjusting electrotechnology to the needs and conditions of Swiss society.

On the one hand, technical practices like mapping, hydraulic engineering, the construction and operating of railway, telegraph and telephone networks, gas and water supply systems followed the same patterns as late 19th-century electrotechnology in the administration and domination of time and natural spaces did. Those practices defined a range of opportunities and the necessary criteria for selection, interpretation and classification of new devices, wherever electrification was taking place. The case of the electrification of Zürich shows that the social construction of electrotechnology clearly depended upon cultural, political or habitual patterns; it also shows that these patterns were altered in their turn by feedback derived from the practically determined process of learning by operating and enlarging the first electric nucleus of the city.

On the other hand, the electrotechnical discourse was an equally important directive force in the sociocultural shaping of electrotechnology. The rise of the Swiss electricity supply industry depended on this discourse in two ways. First, fundamental public debates on central issues reassured investors. Periodically they established new patterns of consumption; they also defined at the debate's “closure” (e.g., federal legislation acts) the direction of the electric supply industry's immediate future. Second, a “base discourse” produced a general competence in dealing with electricity in everyday life through public talks, newsletters, propaganda of the utilities, and exhibitions. Both types of electrotechnical discourse were largely determined by only a few central

⁸⁹ Wyssling 1894, 41.

⁹⁰ Wyssling 1894, 63.

⁹¹ Stadtrat von Zürich 1894, 203–4.

notions, such as “Gemeinnützigkeit,” “waterpower as a national good,” “modernity,” and “progress.” These notions provided politicians, administrators, engineers, investors, as well as the voting and tax paying public with orientation. They also guided political action and conveyed the sense of security which permitted the remarkable growth rate of the Swiss electric supply industry – for more than one century.

References

- Akten der Kommission für die Vorbereitung des elektrischen Lichtes 1888–1890, Archives of the City of Zurich V Bc 5.
- Allen, Cecil John, 1967. *Switzerland – its railways and cable ways, mountain roads and lake steamers*, London.
- Amt für Wasserwirtschaft, ed., 1916. *Die Wasserkräfte der Schweiz*, Bern.
- Amtliches stenographisches Bulletin der schweizerischen Bundesversammlung*, Berne.
- Bauer, Bruno, 1914. “Die Schweizerische Elektrizitäts-Industrie an der Landesausstellung in Bern 1914,” *Bulletin Schweizerischer Elektrotechnischer Verein* 5:289–302 and 337–46.
- , 1939. “Wasserkraft und Starkstrom,” in *Die Schweiz im Spiegel der Landesausstellung 1939*, Zurich.
- Bauer, Hans “Eisenbahnverkehr,” in *Handbuch der Schweizerischen Volkswirtschaft*, vol. 1 (Bern, 1955), pp. 367–71.
- Beck, Wilhelm, 1912. *Die neuesten Fortschritte auf dem Gebiet der Elektrotechnik*, s.l.
- Bericht über Handel und Industrie im Kanton Zürich für das Jahr*, Zurich.
- Berman, Marshall, 1982. *All that is solid melts into air*, New York.
- Bernard, Paul P., 1978. *Rush to the Alps: the Evolution of Vacationing in Switzerland*, New York
- Bertschinger, J., 1914. *Das Verhalten gegenüber elektrischen Anlagen*, Kilchberg-Zurich.
- Bijker, Wiebe E. and John Law, eds., 1992. *Shaping Technology / Building Society: Studies in Sociotechnical Change*, Cambridge, Mass.
- Bijker, Wiebe E., Thomas P. Hughes, and Trevor J. Pinch, eds., 1987. *The Social Construction of Technological Systems*, Cambridge, Mass., 1987.
- Bleuler-Hüni, C., 1903. *Die Versorgung des Kts. Zürich mit elektrischer Kraft unter besonderer Berücksichtigung der projektierten Wasserwerkanlagen am Rhein und am Etzel, Vortrag, gehalten in der Delegiertenversammlung des Handwerks- & Gewerbevereins des Kantons Zürich am 4. Oktober 1903 in Wetzikon*, Zurich.
- Bourdieu, Pierre, 1992. *The Logic of Practice*, Stanford.
- Brändli, Sebastian, et al., eds., 1990. *Schweiz im Wandel. Studien zur neueren Gesellschaftsgeschichte*, Helbing und Lichtenhahn: Basel and Frankfurt.
- Brulhart, Armand, 1987. *Guillaume Henri Dufour: génie civil et urbanisme à Genève au XIXe siècle*, Lausanne.
- Burkhard-Streuli, W., 1890. *Projekt für die Einführung der elektrischen Beleuchtung in Zürich im Anschluss an die Wasserwerksanlage: Bericht des Stadtgenieurs*, Zurich.
- Bürkli-Ziegler, Arnold, 1878. *Übersicht des Wasserversorgungswesens in der Schweiz, im Auftrag des schweizerischen Ingenieur- und Architekten-Vereins zusammengestellt*, Zurich.
- , 1887. *Die Elektrische Beleuchtung des Quaigebietes in Zürich*, Zurich
- Bütikofer, Ernst, 1921. *Die Elektrizität im Haushalt*, Zurich.
- Catrina, Werner 1991. *BBC – Glanz – Krise – Fusion: 1891–1991 von Brown Boveri zu ABB*, Zurich
- Cronon, William, 1991. *Nature's Metropolis: Chicago and the Great West*, New York.
- Dosi, Giovanni, et al., eds., 1988. *Technical Change and Economic Theory*, London and New York.
- Dufour, Guillaume Henri, 1824. *La Description du pont suspendu en fil de fer, construit à Genève*, Geneva.
- Eidgenössische Technische Hochschule, ed., 1955. *Eidgenössische Technische Hochschule 1855–1955. Ecole Polytechnique Fédérale*, Zurich.
- Eidgenössisches Amt für Verkehr, ed., 1947–1964. *Ein Jahrhundert Schweizer Bahnen 1847–1947*, Frauenfeld.
- Elektrotechnischen Rundschau, Zeitschrift für die Leistungen und Fortschritte auf dem Gebiete der angewandten Electricitätslehre*
- Epper J., 1907. *Eidgenössisches Hydrometrisches Bureau: Die Entwicklung der Hydrometrie in der Schweiz*, Bern
- Exposition Nationale Suisse, 1898. *Genève 1896: Rapport Technique publiée par order du Haut Conseil Fédéral*, Geneva
- Fuchs, Carl Johannes, 1910. “Gutachten über eine Stauanlage am Silser See im Auftrag der Gemeinden des Oberengadins erstattet,” in P.C. Planta, ed., *Vernehmlassung der Oberengadiner Gemeinden zur Frage der Benutzung des Silsersees für ein Wasserwerk im Bergell nach Projekt Zschokke und Lüscher*, Chur.
- Furrer, A., 1892. *Volkswirtschafts-Lexikon der Schweiz*, Berne.
- Gas-, Wasser- und Wärmeversorgung der Stadt Bern, ed., 1993. *Von der Gaslaterne zum Erdgas*, Wabern-Berne

- Generaldirektion PTT, ed., 1952–1962. *100 Jahre elektrisches Nachrichtenwesen in der Schweiz 1852–1952*, 3 vols, Berne.
- Graf Johann Heinrich, 1896. *Die Schweizerische Landesvermessung, 1832-1864. Geschichte der Dufourkarte*, Berne.
- Grossmann, Heinrich, 1918. *Die Finanzierungen der Bank für elektrische Unternehmungen in Zürich*, Zurich.
- Gugerli, David, 1994a. "Der Ausbau der äusseren Organisation». Funktionale Differenzierung und diskursive Integration elektrowirtschaftlicher Institutionen in der Schweiz bis 1918," in David Gugerli, ed., *Allmächtige Zauberin unserer Zeit. Zur Geschichte der elektrischen Energie in der Schweiz*, Chronos: Zurich.
- , 1994b. "Technikbewertung zwischen Öffentlichkeit und Expertengemeinschaft. Zur Bedeutung der Frankfurter elektrotechnischen Ausstellung von 1891 für die Elektrifizierung der Schweiz," in Andreas Ernst et al., eds., *Kontinuität und Krise. Sozialer Wandel als Lernprozess. Beiträge zur Wirtschafts- und Sozialgeschichte der Schweiz*, Chronos: Zurich.
- , 1995. "Für grössere Städte eine unabweisbare Notwendigkeit. Zur infrastrukturpolitischen Modellierung städtischer Elektrizitätsversorgungen in der Schweiz des ausgehenden 19. Jahrhunderts," in Josef Wysocki (ed.), *Kommunalisierung im Spannungsfeld von Regulierung und Deregulierung im 19. und 20. Jahrhundert*, forthcoming.
- , 1996a. *Redeströme. Zur diskursiven Modellierung einer modernen Technik. Die Elektrifizierung der Schweiz 1880–1914*, Chronos: Zurich, forthcoming.
- , 1996b. "Politics On The Surveyor's Table: The Helvetic Triangulation of Cartography, Politics, and Representation," in Timothy Lenoir, ed., *Writing / Science*, Stanford, forthcoming.
- Günthart, A., 1936. *Elektrizität und Landwirtschaft*, Zurich.
- Guyer-Zeller, Adolf, 1896. *Das Projekt der Jungfraubahn: Wissenschaftlich, technisch und finanziell beleuchtet*. Zurich.
- Harvey, David, 1992. *The Condition of Postmodernity. An Enquiry into the Origins of cultural Change*, Cambridge Mass. and Oxford.
- Imhof, Alfred, 1925. *Die Elektrifikation der Schweizerischen Bundesbahnen*, Zurich.
- Jegher A., 1894. *Bericht über die Wasserverhältnisse der Schweiz*, Berne.
- Kern, Stephen, 1983. *The Culture of Time and Space: 1880–1918*, Cambridge Mass.
- Klöti, Emil, 1905. *Die Neuordnung des Wasser- und Elektrizitätsrechtes in der Schweiz: Kritik und Vorschläge*, Zurich.
- Kopp, R., 1893. *Populäre Vorträge über Electricität, gehalten vor dem Heizer- und Maschinisten-Verein Zürich und Umgebung* Andelfingen.
- Koselleck, Reinhart, 1975. "Fortschritt," in *Geschichtliche Grundbegriffe: Historisches Lexikon zur politisch-sozialen Sprache in Deutschland*, vol. II, Stuttgart.
- Kundt, August, 1891. *Die neuere Entwicklung der Electricitätslehre: Rede*, Berlin.
- Landry, Jean, 1939. "Coup d'oeil Général," in *Die Schweiz im Spiegel der Landesausstellung 1939*, Zurich.
- Lauterburg, Robert, 1876. *Versuch zur Aufstellung einer allgemeinen Übersicht der aus der Grösse und Beschaffenheit der Flussgebiete abgeleiteten Schweizerischen Stromabflussmengen*, Berne
- , 1891. *Die schweizerischen Wasserkräfte eingetheilt in grössere und kleinere Stromsektionen und berechnet nach der durchschnittlichen Wassermenge der Klein- und Mittel-Wasserstände*, Berne.
- Lenoir, Timothy, 1992. "Practical Reason and the Construction of Knowledge: The Lifeworld of Haber-Bosch," in Ernan McMullin, ed., *The Social Dimensions of Science*, Notre Dame.
- Luhmann, Niklas, 1982. *The Differentiation of Society*, New York
- Lusser, Florian, 1939. "Elektrizitätswirtschaft," in *Die Schweiz im Spiegel der Landesausstellung 1939*, Zurich.
- Maschinenfabrik Oerlikon, ed., 1901. *Moderne Apparatenanlagen*, Oerlikon.
- , 1914. *Die Fabrikate der Maschinenfabrik Oerlikon auf der Schweizerischen Landesausstellung*, Berne.
- Meili, Friedrich, 1899. *Die elektrischen Stark- und Schwachstromanlagen und die Gesetzgebung*, Zurich.
- , 1900. *Der schweizerische Gesetzesentwurf über die elektrischen Stark- und Schwachstromanlagen*, Zurich.
- Müller, Felix and Jakob Tanner, 1988. "Der Zwang zum Fortschritt," in Karl Lang et al., eds., *Solidarität, Widerspruch, Bewegung: 100 Jahre Sozialdemokratische Partei der Schweiz*, Zurich.
- Nelson, Richard R. and Sidney G. Winter, 1982. *An Evolutionary Theory of Economic Change*, Cambridge Mass.
- Neue Zürcher Zeitung und schweizerisches Handelsblatt*
- Peters, Tom F., 1987. *Transitions in Engineering: Guillaume Henri Dufour and the early 19th Century Cable Suspension Bridges*, Basel and Boston.
- Pfleghart, Ad., 1904. *Das Recht zur Erstellung elektrischer Leitungen nach der schweizerischen Bundesgesetzgebung*, Basel.
- Pinch Trevor J. and Wiebe E. Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," in Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, eds., 1987. *The Social Construction of Technological Systems*, Cambridge, Mass.
- Protokoll und Akten der grosstadträtlichen Kommission betr. Einführung der elektrischen Beleuchtung 1890, Archives of the City of Zurich V Aa 14 1.

- Rosenberg, Nathan, 1982 "Learning by using," in Nathan Rosenberg, *Inside the Black Box*, Cambridge.
- Schär, Oskar, 1905. *Die Verstaatlichung der schweizerischen Wasserkräfte*, Basel.
- Schilling, 1885. *Bemerkungen über den gegenwärtigen Stand der elektrischen Beleuchtung (im Auftrage des Aufsichtsrathes der Gasbeleuchtungs-Gesellschaft für die Generalversammlung der Actionäre am 26. September 1885)*, Munich.
- Schivelbusch, Wolfgang, 1983. *Lichtblicke. Zur Geschichte der künstlichen Helligkeit im 19. Jahrhundert*, Munich.
- Schmidt, Aurel, 1990. *Die Alpen. Schleichende Zerstörung eines Mythos*, Zurich.
- Schweizerische Bauzeitung. Wochenschrift für Bau-, Verkehrs- und Maschinentechnik. Organ des Schweizerischen Ingenieur- und Architekten-Vereins und der Gesellschaft ehemaliger Studirender des eidgenössischen Polytechnikums in Zürich*, 1883–
- Seitz, Gabrielle, 1987. *Wo Europa den Himmel berührt. Die Entdeckung der Alpen*, Munich.
- Siegenthaler, Hansjörg, 1993. *Regelvertrauen, Prosperität und Krisen. Die Ungleichmässigkeit wirtschaftlicher und sozialer Entwicklung als Ergebnis individuellen Handelns und sozialen Lernens*, Tübingen.
- Silverberg, Gerald, "Modelling economic dynamics and technical change: mathematical approaches to self-organisation and evolution," in Dosi, Giovanni, et al., eds., 1988. *Technical Change and Economic Theory*, London and New York.
- Stadelmann, Kurt and Thomas Hengartner, 1994. *Ganz Ohr. Telefonische Kommunikation*, Bern.
- Stadtrat von Zürich, 1894. *Geschäftsbericht des Stadtrates der Stadt Zürich. Elektrizitätswerk*, Zurich.
- Stiefel, E., 1935. *Werbetätigkeit städtischer Elektrizitätswerke*, Zurich.
- Tanner, Albert, 1988. "Bürgertum und Bürgerlichkeit in der Schweiz. Die "Mittelklassen" an der Macht," in Jürgen Kocka, ed., *Bürgertum im 19. Jahrhundert: Deutschland im europäischen Vergleich*, Munich
- Todd, Edmund N., 1987. "A Tale of Three Cities: Electrification and the Structure of Choice in the Ruhr, 1886–1900," *Social Studies of Science* 17:387–412.
- Vereinigung exportierender Elektrizitätsunternehmen, 1976. *50 jähriges Bestehen der Vereinigung exportierender Elektrizitätsunternehmen: 1926–1976*, Lausanne.
- Vischer, Daniel, 1986. *Schweizerische Flusskorrekturen im 18. und 19. Jahrhundert*, Zurich.
- Vischer, Daniel, 1988. "125 Jahre Hydrometrie auf Bundesebene. Die Rolle des Ingenieurs Robert Lauterburg," *Schweizer Ingenieur und Architekt* 43:1184–91.
- Walter, François, 1990. *Les Suisses et l'environnement*, Carouge-Genève.
- Wasser- und Elektrizitäts-Werkes Romanshorn, 1899. *Dritter Jahresbericht und Rechnung Romanshorn*
- Weber, H. F., 1884. *Schweizerische Landesausstellung Zürich 1883: Bericht über Gruppe 32: Physikalische Industrie: Wissenschaftliche Instrumente*, Zurich
- Wyss, Anton, 1964. *Die Entwicklung der Finanzierung in der schweizerischen Elektrizitätswirtschaft*, Basel.
- Wyssling, Walter, 1894. "Einige Resultate vom Bau und Betrieb des Electricitätswerks der Stadt Zürich," *Jahrbuch des Schweizerischen Elektrotechnischen Vereins* 5.
- , 1946. *Die Entwicklung der Schweizerischen Elektrizitätswerke und ihrer Bestandteile in den ersten 50 Jahren*, Zurich.
- Zängl, Wolfgang, 1989. *Deutschlands Strom. Die Politik der Elektrifizierung von 1866 bis heute*, Campus: Frankfurt and New York.
- Ziegler, Willy Heinrich, 1937. *Die wirtschaftliche Entwicklung der A.G. Brown, Boveri & Cie., Baden, des Brown-Boveri-Konzerns und der A.G. Motor-Columbus, Brugg*.
- Zimmerman, Andrew David, 1992. *A Political History of Electricity in the USA*, Ph.D. thesis, University of Delaware.
- Zollikofer, H., 1928. *Notizen zur Geschichte der schweizerischen Gasversorgung und Gasindustrie*, Zurich.

Acknowledgments

The author thanks Timothy Lenoir and Cheri Ross for their support and encouragement during his stay at Stanford University, where a preliminary version of this article was presented. For their critical remarks he is deeply indebted to Anthony Grafton, Thomas P. Hughes, Rudolf Jaun, Linda Paulson, Ulrich Pfister, Craig Stillwell, and Elena Lazos Chavero.