PROOF

The Making of Europe's Critical Infrastructure

Common Connections and Shared Vulnerabilities

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Inventing Electrical Europe: Interdependencies, Borders, Vulnerabilities

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Prologue: Contours of a critical event

November 4, 2006, late Saturday evening. German electric power transmission system operator E.ON Netz disconnects an extra-high voltage line over the Ems River at the request of a northern German shipyard. This should allow the large cruise ship Norwegian Pearl *to pass safely from the yard to the North Sea. Other power lines are supposed to take over the duties of the disconnected line as usual in this routine operation.*

This evening is different, however. When E.ON Netz switches off the line the burden on other lines in the network increases, as expected. Several of these are now operating near their maximum capacity. Further fluctuations of electric currents cause one line to overload and automatically shut down at 22:10:13. The following sequence of events is astounding. Within a mere 14 seconds, a cascade of overloads and power lines tripping spreads throughout Germany from northwest to southeast, each tripped line increasing the burden on the rest of the system. In the next five seconds the failure cascades as far as Romania to the east, Italy to the south, and Portugal to the southwest. The incident affects electricity supply in about 20 countries, and supply is cut selectively to some 15 million households. Via the Spain–Morocco submarine cable the disturbance reaches Morocco, Algeria and Tunisia, where lines trip and consumers are left in the dark.[1]

The failure is soon repaired but the event continues to live on in the press and in political debate.[2] *Newspaper reports, such as the Associated Press article "German-Triggered Blackout Exposes Fragile European Power Network," quote pro-European Union (EU) politicians, who argue that the blackout reveals an intolerable fragility of Europe's electric power grid.*[3] *They blame this fragility on decentralized, insufficiently "European," power-grid governance by transmission companies and their international associations. Romano Prodi – Italian prime minister and former European Commission president – sees "a contradiction between having European [electric power] links and not having one European [electric power] authority ... We depend on each other but without being able to help each other, without a central authority."*[4] *The EU Energy commissioner, Andris Piebalgs, stresses that "these blackouts ... are unacceptable" and "confirm the need for a proper European energy policy."*[5] *"European" here denotes EU intervention. Next follow debates about an EU-level regulator, formally binding EU legislation, and an EU priority interconnection plan.*[6]

Power sector representatives, however, completely disagree. If the events of 4/11 (European notation) prove anything, it is that existing security measures and governance structures work well, for the failure was quickly contained and repaired. The inconvenience to consumers remained minimal. The lights stayed on for the overwhelming majority of European households and businesses. Where supply was cut, it was cut by protection gear in a way that facilitated quick restoration, generally within 30 minutes (and completely within two hours). President André Merlin of the French transmission system operator RTE and others argue that "Europe's power network had worked smoothly."[7] The international transmission system operator organization UCTE (currently ENTSO-E) confirms that "a Europe-wide blackout could be avoided. The decentralized responsibilities of TSOs have demonstrated their efficiency."[8] A secure electrical Europe exists, successfully built and operated by the power sector, not the EU: the UCTE system connects some 450 million people "from Portugal to Poland and from Belgium to Romania" at an "electrical heartbeat" of 50 Hz.[9]

Introduction

For a brief moment in November 2006, Europe's electric power network became highly visible to the broader public by virtue of its disturbance. The event exposed a magnificent technological collaboration that spans and transcends the subcontinent. Since their inception in the 1880s, electricity networks had proliferated, and by 1970 Europe had been linked up electrically from Lisbon to Moscow and from Trondheim to Naples. This vast technological system, normally performing silently in the background, came to bind Europe's households, industries, and nations in electrical interdependency. Proponents were delighted: this transnational system allowed electric utilities to supply cheaper and more reliable electricity to consumers – for, contrary to Romano Prodi's complaint cited above, electric utilities have helped each other for about a century, providing mutual security and system stability across national borders. Yet the events of 4/11 also suggested that transnational electric power collaboration came with new transnational vulnerabilities, in which an incident in northern Germany can make the lights go out in Portugal and Tunisia.[10] Such events are all the more serious since during the twentieth century, households, industries, administrations, and other institutions developed an addiction to cheap and steady electricity supply.[11] Either way, for good or ill, electric power networks tie together economies and societies in a much more mundane way than EU politicians and institutions. Electrical interdependency constitutes a major site for Europe's "hidden" integration, occurring largely outside the spotlight of popular media, history books, and the formal European integration process represented by the EU and its direct forerunners – at least until very recently.[12]

The 4/11 failure teaches us yet another important lesson. In particular, its subsequent discursive career in EU policy-making shows that notions of "vulnerability" and "European" were, and are, interpreted and contested among stakeholders. Analysts should not take these terms for granted in any essentialist or predefined way: the very same events could mean proof of fragility and non-Europe to some, but reliability and successful European cooperation to others. Taking one of these interpretations as our a priori definition would imply taking sides and lending voice to one particular stakeholder while silencing others. Instead, our narrative and analysis must capture how electrical Europe and its associated interdependencies, reliabilities, and vulnerabilities were negotiated, shaped, and interpreted as part and parcel of one and the same historical process.[13]

This, then, is the aim of this chapter. We set out to inquire how, by whom, and why Europe's electrical interdependencies were built; how they were interpreted in terms of reliability and vulnerability, and how different forms of vulnerability were anticipated and reconciled in the process; and what was "European" about all of this, in terms of electrical integration and fragmentation, inclusions in and exclusions from institutional collaborations, and discursive claims to the notion of "Europe."[14] To achieve this we synthesize older, nation-centered electricity historiography with recent work on electric internationalism into a transnational history that appreciates and inquires about the complex, multilayered shaping of electrical Europe.[15] We have consulted the archives of relevant international organizations as well as contemporary government and engineering publications to investigate the role of perceived vulnerabilities herein. As we shall see, changing notions of interdependency and vulnerability were heavily implicated in the electrical wiring of Europe.

Inventing electric (inter)nationalism

Winter, 1921. An extraordinary drought in northern Italy reduces the production of Italian hydroelectricity and threatens the industries of the country's economic heartland, the Po Valley. Local governments ration the available power to industry, while foreign power companies come to the rescue. Coal power stations in Nancy and Vincey, France, produce electricity for Zürich and Geneva, Switzerland. This move frees production capacity of the Alpine hydropower plants at Brusio and Thusis, Switzerland, for emergency power supply into neighboring Italy. These emergency measures are possible thanks to recent interconnections of the power systems of the French, Swiss, and Italian utilities involved, and successfully prevent the shutdown of Po Valley industry.

After the crisis, this event, too, continues its career in politics. In March 1922, Paolo Bignami, engineer and member of the Italian chamber of deputies, reports to a League of Nations committee that the way in which northern Italy's problem was solved is "perhaps a first step towards the solution of wider and more interesting problems."[16] *Why should the collaboration between utilities providing mutual backup stop at national frontiers?*

So began international electric interdependency and vulnerability debates in the League of Nations (established 1919, succeeded by the United Nations in 1946), which would become an important setting for debating Europe's electrical integration in the interwar years. The 1921 event illustrates that, by then, several electrical cross-border collaborations had been established, but these constituted only "a first step" and much work remained to be done. In addition, the incident underscores the relevance of economic and electrical vulnerability perceptions as a *leitmotif* for this endeavor. Yet this time, cross-border collaboration by the electric power sector counted as a reliability-improving measure countering the threat of blackout, not as a source of vulnerability and blackout as in the EU view of 4/11. Also note that Bignami spoke of international and national power networks; the notion of a "European power grid" had not yet been born.

The birth of cross-border collaboration

Such talk of international and national electricity infrastructure itself was rather recent. Prior to the First World War, the national–international distinction had been much less an issue. High-voltage, alternating current transmission had developed rapidly since the 1890s but was rarely interpreted in national, let alone international, contexts. Early electric power systems instead served local or (micro)regional purposes. Since national borders were not yet key obstacles, and state governments not yet important players, such local or microregional systems were established within, as well as across, political borders.

Early cross-border systems took many forms. For instance, between 1894 and 1898 a dam and hydropower plant were constructed on the Upper Rhine at Rheinfelden, a binational town on the border between the Swiss canton of Aargau and the grand duchy of Baden, Germany. The formal border was the so-called *Thalweg*, the deepest continuous line along the Rhine watercourse. A bilateral agreement entitled each side to half of the electricity generated. The power system was co-funded by electrochemical firm Elektrochemische Werke, which built a plant near the hydroelectric station and became a major consumer. The system grew to supply nearby villages on both sides of the border, and from 1906 it extended to Guebwiller in Alsace, France, by means of a 40 kV line. The Rheinfelden system was now microregional, connecting consumers in three countries.[17]

Other models of early cross-border power systems include the Alpine hydropower station of Brusio in the Swiss Canton of Ticino, erected in 1907 for the purpose of commercial electricity export to northern Italian factories. The Silesian city of Chorzow became implicated in cross-border electricity exchange because of a border change: the city became Polish in 1922 but stayed electrically connected to the system of Zarborze, then still a German town (it later became Polish too). In still other cases, existing utilities connected across borders for mutual benefit. From 1915, collaborating municipal utilities in southern Sweden exported surplus hydropower to the thermal power-based rural district system of NESA, north of Copenhagen, Denmark, using a submarine power cable under the Øresund strait. The cable had been paid for by the receiving power company.[18]

In the continued absence of national power grids, microregional cross-border initiatives ensued after the First World War. Czechoslovakian utilities with access to large coal reserves near the German border engaged in cooperation with utilities in the German states of Bavaria, Silesia, and Saxony. In Hungary the first stretch of cross-border transmission line followed the electrification of the Budapest–Vienna railroad completed in 1932. The Rheinisch-Westfälisches Elektrizitäts werk (RWE) in Western Germany, still one of Europe's largest power companies today, connected its coal-fired system based in the Rhine-Ruhr area to the hydropowered

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system in the Austrian province of Voralberg by means of a 600 km transmission line. This well-advertised engineering feat was completed in 1930 and promised a bright future for long-distance power transmission.[19] By then, despite the lack of a single integrated network, individual utilities in Austria, Czechoslovakia, Denmark, France, Germany, Finland, Hungary, Italy, Lithuania, Luxembourg, the Netherlands, Norway, Poland, the Saar region (a League of Nations protectorate between 1920 and 1935), Sweden, and Switzerland engaged in some form of cross-border exchanges.[20]

These developments coincided with the propagation of electrical collaboration, though not necessarily across political borders, as state-of-the-art electrotechnical science. The argument had already been pushed in the 1910s – for instance, by a prominent international authority, professor at the Berlin Institute of Technology, and director of the large electrotechnical manufacturer Allgemeine Elektrizitäts Gesellschaft, Georg Klingenberg.[21] At that time, power stations were usually located near consumers, mostly in cities, and operated in isolation from other power plants. New electrotechnical science developments, however, enabled the interconnection of different power plants by high-voltage, alternating current power lines. The trick was to run such interconnected power plants synchronously, meaning that all electromagnetic machines operated in tune at one frequency. Once this was accomplished, existing power stations could run in parallel and form one power pool, in which multiple power stations jointly supplied much larger areas. Moreover, distant power stations sited near mine mouths or hydropower resources could be integrated into such pools. Adversaries pointed out that such power pools came with huge investments in high-voltage, alternating current power grids.[22] International authorities like Klingenberg, however, stressed their vast economic advantages. Electricity could be produced wherever it was cheapest in the pool at any given moment, thus exploiting the complementary characteristics of large (achieving economies of scale) and small (avoiding overproduction when demand was low) power stations, and of hard coal, lignite, diesel, and hydropower plants. Importantly, cooperation also reduced the necessary investment in local backup units for emergencies or maintenance: instead of guaranteeing full backup capacity for each and every power plant, this could be drawn instantly from the pool and thus be shared among partners. Electrical collaboration in power pools was therefore accompanied by a different way of providing backup and reliability management. In the following decades, secure and undisturbed operation thanks to mutual backup and system stabilization (the larger the pool, the more power stations instantaneously counteract any disturbance of the shared frequency) became a key motive for setting up ever larger synchronized power pools.[23]

Nationalization and internationalization

Along with the notion of power pools, however, came new actors and new categories for electrification. While existing electric utility owners – large and small commercial companies, municipalities and other lower governments, rural cooperatives – jostled for position in the booming electricity sector, national governments became an important new player. During the First World War, many state governments not only introduced obligatory border passport requirements that stayed in place after the war, but also increasingly committed to economic nationalism. After November 1918, as hostilities still loomed and coal markets remained distorted, governments often tried to interfere in electricity supply. Where successful, they tightened their grip on prices, hydropower resource development, electricity exports, electricity as a national service, and national power grid planning.[24] The nation-state, in short, became a potent additional category for electrification.

Indeed, Klingenberg's early call for synchronized power pools had already appealed to state governments as carriers of this development. While the suggestion was very controversial on Klingenberg's home ground – Germany – such schemes were actively discussed in the state governments of Saxony, Baden, Bayern, Prussia, and Württemberg before the end of the First World War.[25] By then these discussions had been picked up elsewhere in Europe.[26]

To the West, the British government was alerted to the coal-saving advantages of power pools during the war. By 1919, power pools were officially identified as a potential source of national industrial strength in an Electricity Act that pushed utilities towards voluntary national collaboration. By 1926, Britain's loss of national prestige and power was blamed explicitly on its continued backwardness in electrical technology compared with Germany and the United States. In response, a new Electricity Act set up the Central Electricity Board to build a synchronized national power grid (power stations remained private until after the Second World War), by and large operational ten years later.[27]

To the East, Russian electricity generation and distribution were completely nationalized and forged into the largest electric power collaboration to date. As in Britain, the decision process was rife with fears of electrical backwardness and its implications for the national economy. Vladimir Lenin famously argued that

> *Communism is Soviet power plus the electrification of the whole country.* Otherwise the country will remain a small peasant country . . . Only when the country has been electrified, and industry, agriculture and transport have been placed on the technical basis of modern large-scale industry, only then shall we be fully victorious [original emphasis].[28]

Lenin then initiated and supervised the State Commission for Electrification of Russia (GOELRO) in 1920, producing the *План электрификации Р.С.Ф.С.Р*, an electrification plan for the entire Russian socialist republic including some 30 high-priority large power stations and extensive transmission networks. Less centralized electrification schemes, privileging smaller urban and rural systems, existed but were bypassed. This national electrification scheme, too, was largely realized within a decade.[29]

In between East and West, governments interfered in various ways to varying degrees of success. For instance, in the 1920s the Belgian, French, Luxembourg, Portuguese, and Swedish governments adopted national power grid schemes.[30] In countries where direct national government interference was ultimately rejected, such as Denmark or the Netherlands, they still influenced the pattern of electrification.[31] Overall, the strategic importance of energy and electrification for the national economy was increasingly emphasized. In countries possessing vast black, brown, or white coal energy resources, these were relabeled as "national resources," which demanded national government control. In France and Switzerland, the debate was about nationalizing hydropower resources.[32] Berlin pushed hard to hold on to Upper Silesia and its coal resources, without which "Germany will fall apart completely."[33] Austria lost most of its coal assets after the war, and its government embarked on a national electrification scheme to utilize hydropower.[34] Governments of energy-importing countries often pushed national electrification schemes in order to optimize the use of resources on a national level – electrification should benefit the national economy rather than urban or microregional ones.[35] Electric nationalism came with notions of national economy, autarky, and what we today would call national energy security. Thus, in our interpretation, state-initiated electrification often aimed to counter perceived national economic vulnerabilities. As a result, the national element in electrification progressed steadily and constituted an additional layer to microregional and local electrification patterns.

This development of electric nationalism, however, was contested not only by existing players such as private, municipal, or cooperative utilities, resisting state interference with varying degrees of success; often national grids only emerged after the Second World War. Electric nationalism was also countered by a new electric internationalism.[36] Much of this movement was initiated and carried by industry. Electrotechnical manufacturers and financial institutions joined forces in multinational holding companies in order to construct power systems worldwide. Examples include Elektrobank (Allgemeine Elektrizitäts Gesellschaft combined with German and Swiss banks) and Motor (Brown Boveri with Swiss finance).[37] Moreover, the electrotechnical industry and electric utilities used international organizations to create larger markets for equipment and to liberalize cross-border electricity flows. The emerging debates at the League of Nations were an example from the highest political stage of the attempt to shift the dominant concern for national energy security towards the promises of mutual cooperation. In addition, international cooperation was strengthened by setting up a series of new international organizations addressing the electricity domain. The standard-setting International Electrotechnical Commission had already existed since 1906; in the 1920s followed the International Council on Large Electric Systems, established in 1921 to provide a platform for the exchange of information about electricity generation and high-voltage transmission in large systems; the World Power Conference (currently World Energy Council), conceived in 1923 to restore a shattered European electricity industry, although the agenda immediately expanded to cover all forms of energy; and the International Union of Producers and Distributors of Electrical Power (currently Eurelectric), established in 1925 on the initiative of Italian, French, and Belgian utilities.[38]

The rise of the national as a category for electrification thus came with new structures for international collaboration. Notably, while the new international organizations gladly used terms like "international" and "world" in their names, their membership was overwhelmingly, and sometimes exclusively, European. Still, "Europe" as such had not yet been claimed as a lead category for electrification. So far when we have spoken of "Europe" we have implicitly projected a broad yet imprecise geographical notion of the term – thus made sure to include Russia, unlike many present-day political identifications of "Europe" with the EU. When "Europe" became an explicit actor category for electrification around 1930, it did indeed have a pan-European scope (Figure 3.1).

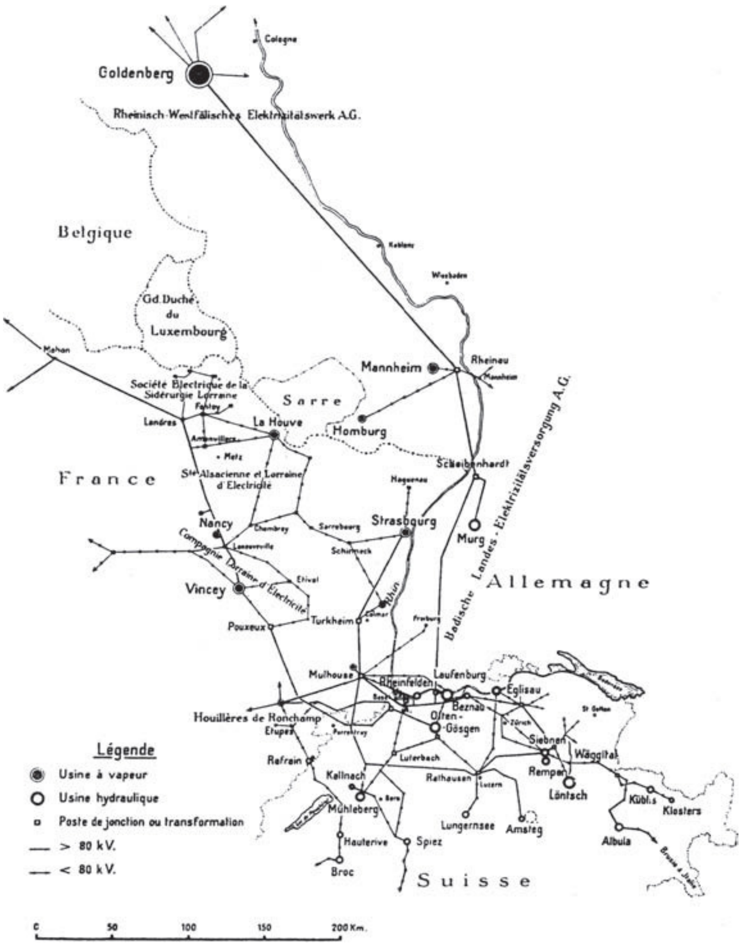

Figure 3.1a Early cross-border microregional and national electricity systems.
(a) The microregional system around Rheinfelden extending into three countries around 1926.
Source: Niesz 1926, p. 1026. Used by permission of the World Energy Council.

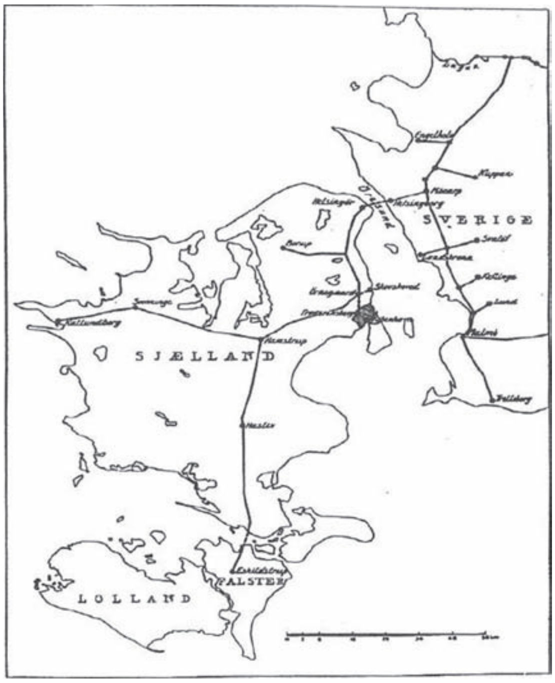

Figure 3.1b The southern Swedish–eastern Danish power pool across the Øresund straits by the mid-1920s.
Source: NESA 1927. Used by permission of DONG Energy.

Imagining electrical Pan-Europe

November 20, 1932. The Dortmunder Rundschau *newspaper enthusiastically reports from an exhibition by architect Hermann Sörgel.*[39] *The exhibition displays a plan of unprecedented imagination, ingenuity, and magnitude. For one, it displays technical drawings and scale models of a dam closing the Mediterranean at the Straits of Gibraltar. Since more Mediterranean water evaporates than rivers contribute, this would cause the water level to decrease and create new space for human settlement. Next, hydroelectric power plants situated at the Gibraltar dam and several secondary dams would produce more electricity than all Europe's existing power plants combined. This electricity would be distributed all over the continent by means of a pan-European high-voltage grid. Uniting Europe's states in electrical interdependency, the scheme would provide unity, prosperity, and peace for a war-prone continent: "the integration of Europe by power lines is a better peace warranty than treaties on paper; because in destroying these power lines, each nation would destroy itself."*[40]

The plan is originally presented as the "Panropa project" to express support for the flourishing Pan-European movement. Its new 1932 name of "Atlantropa project" further denotes that Europe and Africa will be forged into a new continent able to withstand the rising powers of Asia and America. After the Nazi takeover the plan is adjusted

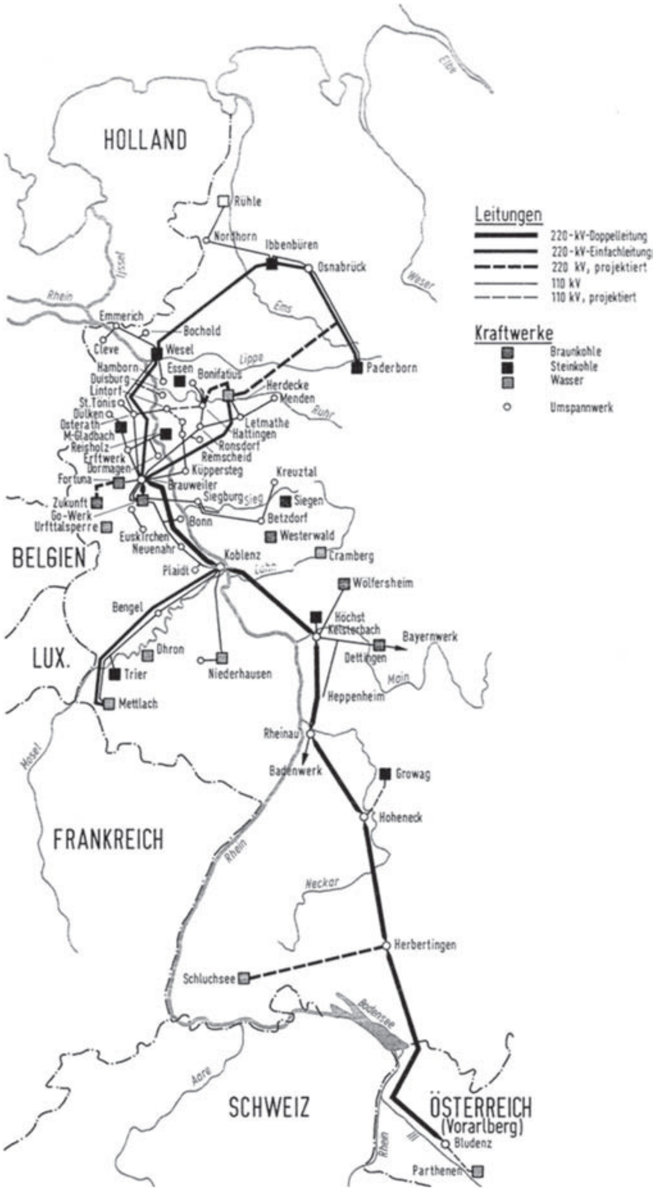

Figure 3.1c A very large microregional system: the RWE system in 1928.
Source: Boll 1969, p. 45. Used by permission of BDEW Bundesverband der Energie – und Wasserwirtschaft e.V.

Figure 3.1d The British national grid.
Source: Legge, 1931, p. 123.

to Nazi ideology, posing Greater Germany and the Italian Empire as Atlantropa's pillars. In 1949 the Atlantropa Institute advertising the project has about 700 members and eight branches in different German cities. In 1952, Sörgel dies, nuclear power takes over hydropower's role in [the] political and public imagination, and Atlantropa fades to the background. The Atlantropa Institute is closed in 1960. Decades later, Sörgel's Gibraltar Dam re-emerges in public discourse as an example of technocratic megalomania and ecological nightmare. By contrast, his transmission grid design implicitly echoes in present-day sustainable energy visions of a "supergrid," a single high-capacity power grid integrating off-shore wind parks in the North Sea, Baltic Sea, and Mediteranean; Nordic and Alpine hydropower plants; and Sahara and Arabian desert solar power plants, thus joining Europe, the Middle East and north Africa in energy and environmental unity.[41]

Thus reads an abridged biography of the most imaginative of interwar visions of electrical Europe. It was conceived around 1930 along with several other schemes of what we today would call a "supergrid."[42] In 1930, George Viel, president of the southeastern section of the French Association of Electricians, proposed a power pool including 3000 km of ultra-high-voltage power grids stretching from Trondheim, Norway, in the north to Naples, Italy, in the south, and from Lisbon, Portugal, in the west to Russia in the east. It would integrate Europe's massive, yet scattered, hydropower resources into one energy economy. At the World Power Conference held in Berlin that same year, Oskar Oliven, director of the Gesellschaft für elektrische Unternehmungen, presented a European electric power program involving 9750 km of power lines. This power pool had a similar geographic reach and was fed by large hydropower stations, mostly in Scandinavia and the Alps, and thermal power plants near Europe's major coal deposits. In 1930, Ernst Schönholzer published another, fourth, vision of a "European power grid" in the leading Swiss engineering journal. His scheme involved no less than 15,000 km of power lines from Dublin and Lisbon to Istanbul and Moscow.[43]

Three aspects of this sudden boom in European electrification schemes are important to our analysis. First, "Europe" became vigorously promoted as a category for electrification. While Viel presented his design as an add-on to a French national power grid, the others foregrounded "Europe" as the preferred unit for electrification. Their designs differed in detail but all clearly interpreted Europe on a macroregional scale, embracing or even transcending the Continent.[44] Schönholzer, like Sörgel, prioritized the promise for Europe's future that electrification held and did not eschew technological challenge. His design, accordingly, included power lines reaching Moscow in the East and Dublin, Glasgow, and Manchester in the West; the latter came with a dam across the English Channel.[45] Sörgel's scheme, as we saw, did not even accept the Mediterranean as Europe's southern border: the sea should be connector rather than border, as it had been in ancient times, and his power grid extended well into northern Africa and the Middle East – in a clearly colonialist mindset. Oliven and Viel, by contrast, were more concerned with the technical and financial feasibility of their schemes. They discussed state-of-the-art electrotechnical science and construction possibilities, and provided cost estimates. This led Oliven, deterred by the technical challenges of crossing the English Channel and the vast distances of Russia, to exclude Britain, nearly all of Russia, and the Baltic states. Still, his design had quite a pan-European scope, stretching from Lisbon and Calais in the West to the Donets River basin (a River Don tributary) across the Ukrainian-Russian border in the East. After all, he added, if freight transport, telecommunications, and radio networks crossed the Continent, why not electric power systems? Certainly electricity grids were much less difficult to establish than railroad lines, which by then traversed the Continent from Lisbon to Vladivostok.[46]

Second, in our reading, pan-European electric integration was articulated as a response to several perceived political and economic vulnerabilities. In this respect they resembled nation-based electrification schemes aimed at countering national economic and political problems. Yet they differed in spotlighting nationalism itself as the main problem. The authors here drew on increasingly popular ideas of European political unification and the European movement, which experienced an apogee in this period.[47] Oliven connected to this tendency superficially by framing electric power as a challenge "for all peoples of Europe" and emphasized how "the idea of peaceful cooperation between all people . . . is steadily gaining currency."[48] Sörgel and Schönholzer explicitly announced support for the pan-European movement and imported some of the fears of this movement into the electricity domain. Pan-European movement spokespersons sought to unite Europe politically as a counter move to, on the one hand, the intrinsic capacity of Europe's states to prioritize national self-interest at the expense of economic fragmentation, military expenses, and the permanent threat of war and self-destruction; and, on the other hand, the rising powers of the United States, the Soviet Union, and Asia.[49] Schönholzer and Sörgel explicitly reproduced these concerns: In Schönholzer's words, "what if we, usually so 'clever' Europeans, . . . set aside our 'political tensions' once and for all, and created *international power highways* as a symbol of a basic cultural community, which will not bring military expenses and war to individual states but profits for the economy? [original emphasis]"[50] For Sörgel, electrical interdependency was a better peace guarantee than paper treaties: "Europe is a large cage with singular cells [the individual countries]. Those who dare open their cage for the sake of a beautiful idea [Europe's political unification] become prey of the others. Only a common, simultaneous interlinking in a high-voltage network creates a European Union."[51] This unification was all the more urgent since Europe was increasingly squeezed between the rising powers of Asia and the Americas, and Sörgel envisaged a world of three great powers: the three As – Asia, America, and Atlantropa.

Third, it is important to note that none of these schemes was realized. Though for the most part technologically and financially possible, they did not gain sufficient support. Only for a brief period of time did ideas of a pan-European power pool gain strong momentum. Political support came particularly from the League of Nations and the International Labour Office.[52] The League added European electricity system planning to the agenda of its Commission of Enquiry for European Union at the suggestion of Belgian representatives.[53] The International Labour Office promoted a European electricity grid to diminish international political tensions and provide employment during the Great Depression. However, their envisioned model of top-down construction of a European power grid, backed by political will and international financing, became a road not taken. In a context of economic depression and increasing national strategic interests, international financing plans for a European power grid were torpedoed. Domestic pressures, not least coal-mining interests, caused even the Belgian initiators to shift sides.[54] Many engineers now favored a gradual and decentralized approach to European interconnection, based on national electrification schemes that could subsequently be connected. The Europeanists became isolated, and the push to build a supranational electricity system ended. System-building activity was left to power companies and national governments. The concept of a European power grid countering economic and political vulnerabilities, however, was there to stay. It was now seen as a patchwork of gradually emerging and collaborating national networks, rather than a supranational system to be built from scratch.

At the end of this period, another unrealized pan-European electrification scheme added yet another aspect to the theme of electricity and vulnerability. The role of electricity supply in war had been acknowledged since the First World War. English and German governments found power pools attractive instruments to economically power their war industries in times of fuel shortages; the French government pushed transmission lines to cater to the Maginot Line, the fortifications on the Franco-German border; and the entire Dutch-Belgian border was sealed by a 1.80 m high, 2,000 Volt electric fence to electrocute war refugees, deserters, volunteers to the Allied forces, spies, and smugglers.[55] In response, electricity supply system elements themselves became important military targets.[56] Worse, in the age of aviation, bomber planes could follow power lines to key centers of consumption, including strategic war industries. When designing a European power grid to integrate an envisioned Neuropa from the Atlantic to the Ural Mountains, Nazi engineers therefore opted for an underground system. Fritz Todt, general inspector for water and energy and a civil engineer, argued that underground cables were safe from atmospheric disturbances, air attacks, and sabotage. Besides, they did not disfigure the landscape and did not interfere with electric communications.[57] This underground system was not realized either, as its implementation was delayed and started only a few months before the final defeat of the Nazi regime. The military vulnerability of overhead power systems, however, was widely recognized after the war, especially when interrogated Nazi military leaders stated their surprise that Allied bombers had neglected this major vulnerability of their war economy (Figure 3.2).[58]

Wiring and securing mesoregional Europe

Bretagne, western France, January 12, 1987. Very cold weather and massive use of electrical heaters by consumers trigger the failure of three out of four active units of the Cordemais thermal power station. Nine thermal and nuclear units in neighboring power stations fail in turn. Lights go out in Paris and Le Havre, and the disturbance threatens the integrity of the French system as well as the synchronized power pool of the Union for the Coordination of Production and Transport of Electricity (UCPTE), which by now covers most of Western Europe.[59] Network operators of Électricité de France massively disconnect consumers in order to rebalance production and demand. In addition they draw power from Spanish, German, and Belgian partners. Belgian operators, in turn, import power from German and Dutch plants. Belgian network operators prevent further electricity export as their own system threatens to break down; Swiss operators start two hydropower units to counter a domestic frequency dip; and Italian dispatchers start additional power units to stabilize their frequency. Yet consumers in these countries, and in eastern France, do not notice the stress on their power grids at all; the failure is successfully contained and repaired. The incident inspires a sharpening of French security measures but is widely cited as an example of effective international collaboration to contain and counter power system disruptions.[60]

The events of January 12, 1987, exposed a large-scale increase in power pools in the postwar era. Power supply in western France was now embedded in the

Figure 3.2a Early proposals for a European "supergrid."
(a) Sörgel's Atlantropa Plan.
Source: Sörgel 1938, p. 91.

transnational synchronized power pool of the UCPTE, which we characterize as a mesoregional collaboration (as opposed to subnational microregional power pools and imaginary interwar macroregional, pan-European pools).[61] By 1987 it included power companies from many countries in Western and Continental Europe, but excluded Scandinavia, Britain, and so-called Eastern Europe. These areas possessed synchronous transnational power pools of their own. Cooperation

Figure 3.2b (b) The European plan of George Viel.
Source: Viel, 1930.

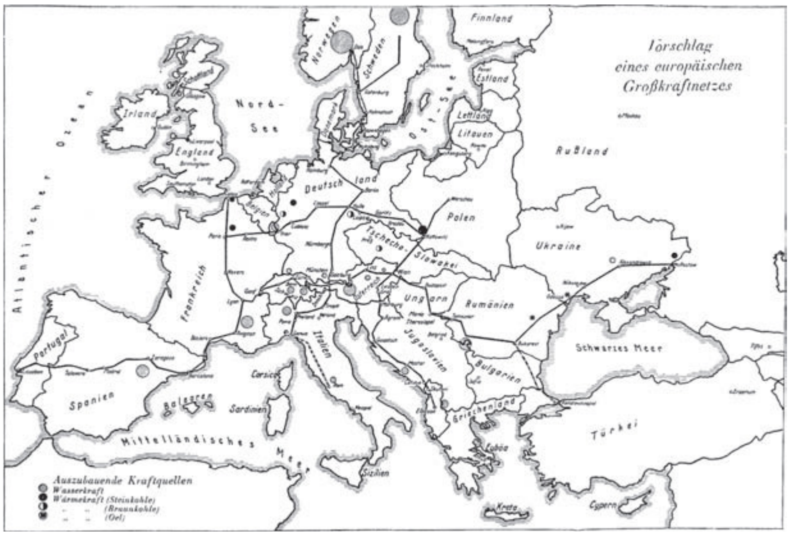

Figure 3.2c (c) Oskar Oliven's plan for a European system.
Source: Oliven 1930. Used by permission of the World Energy Council.

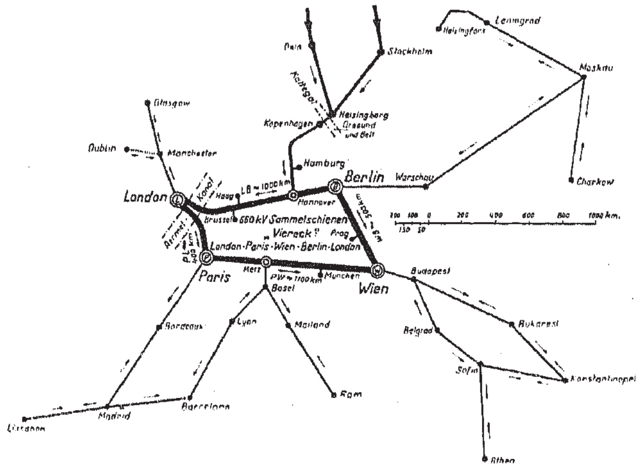

Figure 3.2d (d) A European grid plan by Schönholzer.
Source: Schönholzer 1930. Used by permission of the Schweizerische Technische Zeitschrift.

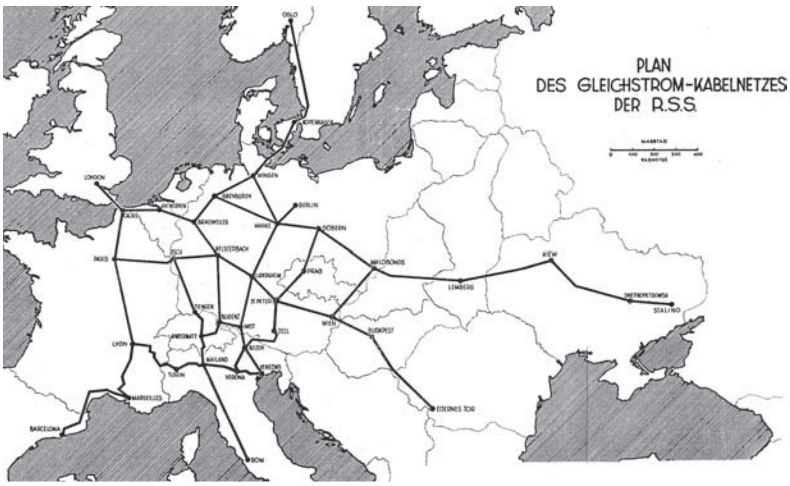

Figure 3.2e (e) The Nazi proposal for a European network.
Source: Maier 2006, p. 131. Used by permission of Helmut Maier.

between such mesoregional power pools existed but took an asynchronous, and therefore less immediate and tightly coupled, form.

The 1987 events also reveal an important change in vulnerability perceptions and priorities. Synchronous power pools originally served to reduce socioeconomic, political, and military vulnerabilities. Once in place, European economies and societies increasingly depended on their undisturbed functioning, and securing a power supply itself became a major concern. The 1987 events confirmed to many observers that transnational power pools did this job well. By the late

1980s, some organizational sociologists even called electric power pools "high reliability organizations": in an age of increasingly complex technological systems, they provided a remarkably high degree of service reliability.[62] The 1987 events also demonstrate a particular form of coping with potential failures: emergency response in Western Europe was decentralized in the hands of individual power companies, not their international organizations or government institutions. We now turn to the historical processes shaping this particular material, institutional and discursive makeup of postwar electrical Europe.

Two models for mesoregional collaboration

Postwar mesoregional collaborations came in two different models of electrical interdependency, each with its own implications for vulnerability. A first and very influential model developed in the continental part of Western Europe. After several years of debating and preparations, power company representatives from Belgium, the Federal Republic of Germany, France, Italy, Luxembourg, the Netherlands, Austria, and Switzerland founded the non-governmental UCPTE in 1951. Its chief aim was to coordinate a transnational power pool. Seven years later, synchronized operation in the UCPTE supply area was operational.[63]

Two observations on this collaboration are particularly important to us here. First, UCPTE spokespersons regularly claimed to work for "Europe." In 1955, Heinrich Freiberger of the Vereinigung Deutscher Elektrizitätswerke hoped that the UCPTE "shall be allowed to continue to work silently and effectively for Europe and therefore for the greater good of humanity and of peace."[64] On the occasion of its 20th anniversary, Italian UCPTE president P. Facconi emphasized the organization's "historic importance for its remarkable contribution to the ideal of a 'United Europe'."[65] Most of the time, however, European integration ideals were absent. The 1954 statutes do not speak of "Europe" at all but foreground internal power sector advantages. Importantly, these had an economic and a reliability component. As for economics, a transnational power pool enabled an economic mix of power stations, and should in particular help to eliminate losses of excess hydropower in postwar Europe. In a synchronous power pool, all available water could be led through the turbines and fed into the power pool, instantaneously enabling a fuel cost reduction in thermal power stations elsewhere in the system. Hydropower wastes had largely been eliminated in the UCPTE system by 1970.[66] As for reliability, the key motive was that in a synchronous collaboration, any power-station failure would be counteracted in a matter of seconds by other generators in the pool. In this way, "all production units in the synchronous system jointly counterbalance the disturbance of one power station, regardless if this power station is located in Lisbon, Palermo or Hamburg, Le Havre or Vienna."[67]

Second, and contrary to the next model of transnational collaboration we discuss below, these concerns for economic and reliability advantages translated into a decentralized model of transnational organization. This choice had been in the making for several years. After a devastating Second World War, Western European policy-makers and utility representatives looked to the United States for examples. US Marshall Plan (1947–1951) negotiators pushed supranationally owned and financed European power plants in a centrally planned and controlled power pool.[68] Such a system would boost the Western European economy and thereby provide a barrier to the spread of communism. Accordingly, the Marshall Plan's International Power Program should finance "projects [...] selected without regard to national frontiers."[69] As in the 1930s, however, electric utility representatives preferred a looser collaboration. Visiting the United States on a Marshall Plan Technical Assistance Mission, they were impressed by the centralized, state-of-the-art Pennsylvania–New Jersey Interconnection, which used a single control center to manage electricity production and load management of the entire collaboration in an effort to optimize the overall system economy. However, they found this system unfit for Europe. The South Atlantic & Central Areas Group example would serve better: this huge interconnected system connecting the Great Lakes to the Gulf of Mexico and was organized in a decentralized way as a voluntary association of over 80 partner companies. Each partner managed power supply in its own supply area.

Just as the operators of the South Atlantic & Central Areas Group found that by far the larger part of the economic advantages of interconnected operation could be gained within the relatively small systems of single companies, so it has been found in Europe that the major advantages are to be gained within national frontiers.[70] Back in Europe, these power company representatives accordingly managed to divert funds from the International Power Program to distinctly national projects. Additional cross-border power exchanges were to be left to free negotiations between partners, and the UCPTE was established to coordinate this effort.[71]

In this scheme the UCPTE was intentionally set up as a non-governmental, coordinating body of power company and power authority representatives who participated on the basis of personal membership and voluntary adherence to UCPTE recommendations.[72] Power companies in the UCPTE pool remained fully in charge of their control centers, network-building, and supply in their own supply areas. They also decided on, financed, built, owned, and operated cross-border connections. The UCPTE merely provided coordination and facilitation.[73] Importantly, UCPTE spokespersons stressed that "decentralization is indispensable for economy, security, and continuity of supply on the regional level," for individual power companies knew the particulars of their situation best. Thus "a European centralized control centre ... does not exist and could not function properly, because it would not be able to see the needs of the separate regional networks."[74] The events of January 12, 1987 illustrate UCPTE procedures in which power-grid disturbances were not countered centrally by the UCPTE but by individual power company operators restoring supply in their respective supply areas.

This decentralized organizational form was reflected in power-grid construction and electricity flows. In some areas, utilities were internationally minded and developed power grids and exchanges accordingly, most notably in the case of Austrian and Swiss power collaborations with neighboring power companies. In other parts of the UCPTE zone, cross-border grids and exchanges remained minor, and microregional or national power circulation was clearly dominant. To the dismay of the European Commission, by 2000, countries such as Germany and France had a poor "interconnection capacity" (the import capacity relative to

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domestic generating capacity) of less than 10 per cent. Italy, Greece, Spain, and Portugal, which had joined the UCPTE later, did not even reach 5 per cent.[75]

A second model of mesoregional collaboration developed in the Soviet Union in the late 1950s, when the Russian United Power System embraced other Soviet republics into one huge transnational synchronized system. Incidental links had preceded this initiative, such as a 1955 link to Estonia. Yet in 1959, Nikita Khrushchev unrolled a formidable electrification scheme in his Seven Year Plan, which was accepted by the 21st Party Congress. The plan envisaged a set of mutually interconnected power pools including a Center Pool (around Moscow) interconnected to a Middle Volga pool and a Ural pool, a Southern Pool (Ukraine and Moldova), and a Northwestern Pool (the Baltic region and Belorussia).[76] Not unlike the Russian GOELRO plan of the 1920s, the rationale was to boost industrial growth by pooling power resources scattered throughout the Soviet Union, thus allowing efficient deployment of available power stations, avoiding load peaks by combining consumers in six different time zones, and sharing backup capacity "to maintain the reliability of a power supply."[77] In 1965, experts calculated that a power pool in the European part of the Soviet Union could save more than 1,000 MW of installed capacity and another 600 MW by reducing peak loads. By the late 1980s the United Power Systems consisted of no fewer than nine interconnected power pools, extended into Central Europe, Siberia, and the Trans-Caucasus, and covered some 10 million sq. km – equalling the size of conventional geographical Europe from the Atlantic to the Urals (Figure 3.3).[78]

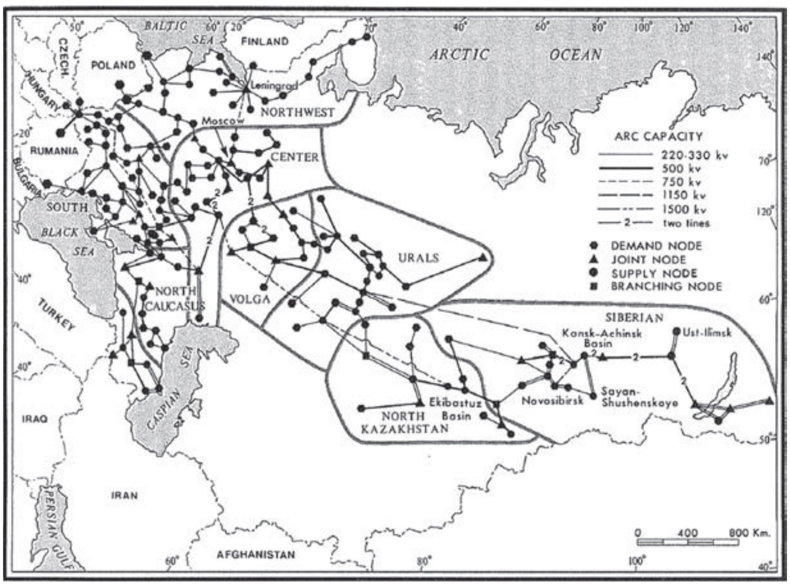

Figure 3.3 The United Power Systems by the early 1980s pierces the Urals as a potential border of Electrical Europe.

Source: Sagers and Green, 1982, p. 292. Reproduced by permission of *The Geographical Review* and the American Geographical Society.

This impressive collaboration differed in several ways from the UCTPE collaboration discussed above, with due implications for vulnerability issues. In line with prevailing paradigms of centrally planned economies, the Soviet Union's transnational system was centrally planned, managed, and controlled. Since the inauguration of the Moscow Central Dispatch Center in 1926, additional control centers had been established for the Southern pool (Ukraine/Moldova) in 1940, for the Urals in 1942, for Siberia in 1959, and for the Middle Volga in 1960. Yet to manage the new mesoregional collaboration, in 1967 a renewed Central Dispatch Center was set up in Moscow to serve the entire Soviet Union. This monitored the other integrated systems, controlled the trunk lines interconnecting them, and administered power exchanges between collaborating pools.[79]

This leads us to a second and related difference. While both collaborations aimed at industrial and economic growth, the UCPTE partners focused on exchanges and projects within national borders and set up the UCPTE itself as sort of add-on. The Soviet scheme, by contrast, was designed to transport huge amounts of energy across the borders of participating republics. This was particularly urgent as 90 per cent of the Soviet Union's energy resources lay outside the urbanized areas in the "center zone." Thus the Center Pool around Moscow massively imported power from the Northwestern, Southern, and Volga systems.[80] Notably, transporting large capacities across vast distances required a "backbone supergrid system" for high-capacity exchanges, which in Western Europe had been envisaged in the 1930s but never got off the ground.[81] This, in turn, demanded massive investment in ultra-high-voltage transmission technology. By the end of the Cold War the Soviet system operated interconnections up to 750 kV, transported capacities between participating power pools up to 5 GW, and was preparing for 1,150 kV transmission. By comparison, UCPTE partners used transmission voltages of up to 380 kV.[82]

Finally, we observe that the UCPTE claimed to work for "Europe" even though, as critics would have it, it included only a string of states on the western side of the peninsula.[83] By contrast, the Soviet system covered much larger parts of geographical Europe and beyond, but eschewed any reference to the term "Europe." This absence partly reflects the fact that Europe's Ural border was erased by electric power networks. In addition, it follows a broader discursive change. During the revolutionary period, Trotskyist authors had interpreted "Europe" as an economic term and included Russia in an economically modernizing Europe, discursively opposed to "Asian" tsarist autocracy and traditions. From the Second World War, however, "Europe" was increasingly perceived as an area divided between a "true" socialist half and a "false," US-dominated capitalist half.[84] In Khrushchev's famous words in the journal *Foreign Affairs*, the main category for economic development now became the "community of socialist countries," increasing their economic power and consolidating world peace, since "the material might and moral influence of the peace-loving states will be so great that any bellicose militarist will have to think ten times before risking going to war."[85] Accordingly, transnational electrification schemes rhetorically bypassed the notion of "Europe" and foregrounded first the Union of Soviet Republics and then the Socialist Brotherhood, regardless of its geographical position, as its primary object. This discursive shift, by the way, did not prevent pragmatic explorations of electricity collaboration and interconnection to Western European partners by the mid-1960s, motivated not least by prospects of massive energy exports to Central and Western Europe.[86]

Electrical alliances on the move

These two models of mesoregional electrical collaboration inspired similar initiatives elsewhere on the subcontinent. Their nearly simultaneous establishment in the first half of the 1960s suggests a mutual influence. By 1970 these externally connected, internally synchronized transnational power pools linked up power stations and consumers from Lisbon to Moscow. This particular configuration of electrical Europe is illustrated in Figure 3.4.

The UCPTE model was more or less copied in Northern and Southern Europe, although forms of collaboration between mesoregional groupings might differ. In Southern Europe, Iberian UCPTE membership was complicated: the Spanish and Portuguese dictatorships were international *personas non grata* and sought political and economic isolation.[87] Spanish, Portuguese, and French power companies therefore set up their own Franco-Iberian Union for Coordination and Transport of Electricity (UFIPTE) in 1963. Its motives – hydropower pooling and mutual system stabilization – and statutes were similar to those of UCPTE. Through France, UFIPTE operated synchronously with the UCPTE pool from 1964:

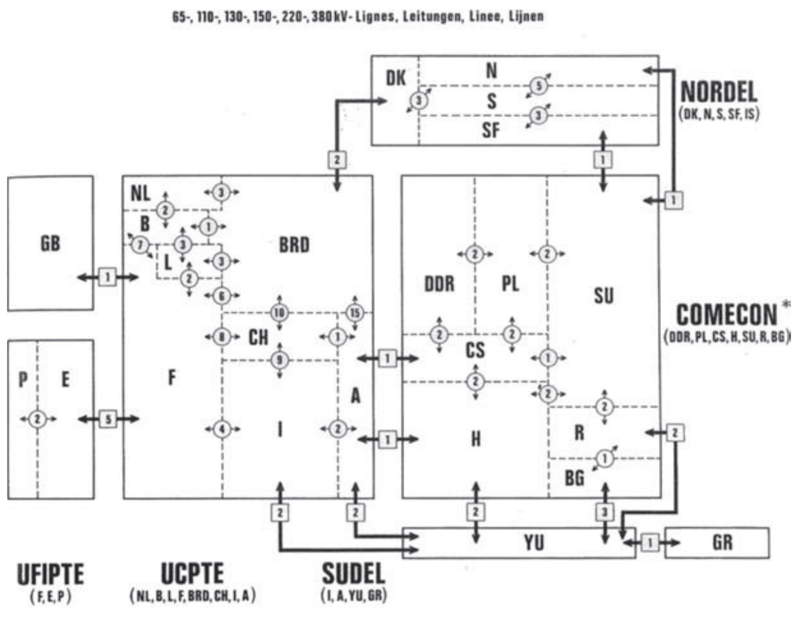

Figure 3.4a Electrical Europe by 1976 is represented by mutually connected mesoregional power pools. Numbers represent power lines.
Source: UCPTE 1976, p. 199. Reproduced by permission of ENTSO-E.

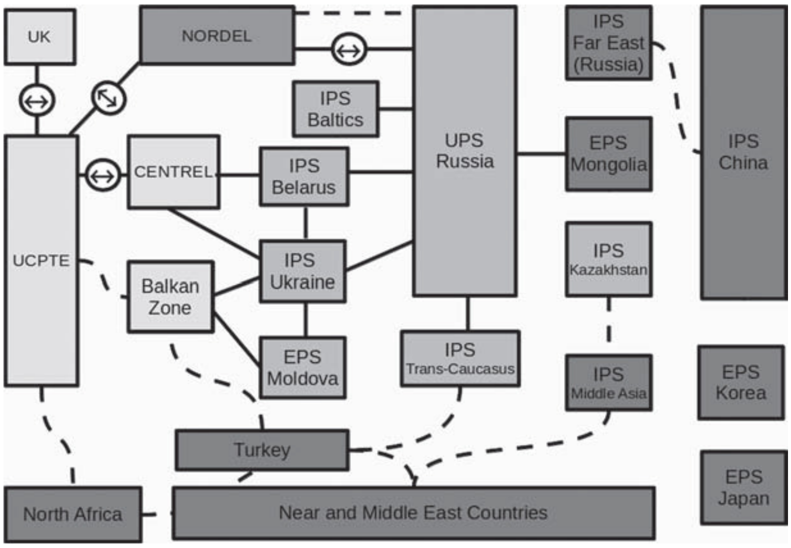

Figure 3.4b Electrical Europe in the early 1990s. The symbol ↔ represent asynchronous connection. Dotted lines represent planned projects.
Source: Based on Hammons et al. 1998.

institutional fragmentation masked physical integration, until the Iberian partners became full UCPTE members in 1987.[88] Likewise, Austrian and Italian power companies, desiring a politically sensitive collaboration with hydropower-rich Yugoslavia, founded SUDEL in 1964, which again resembled the UCPTE. SUDEL and the UCPTE cooperated synchronically from 1975 to achieve greater reliability, particularly for the Yugoslavian (and the soon-to-participate Greek) system. SUDEL members also became full UCPTE members in 1987.[89] All parties agreed that expansion of the synchronous zone improved the stability and reliability of the joint system. Scandinavian power companies also mimicked the UCPTE model but adopted asynchronous collaboration with other groupings that still holds today. In postwar Northern Europe, a Nordic political and economic integration process initially was considered to be a valid alternative to Western European integration, which resulted in a Nordic Council (1952), a Nordic Passport Union (1954), and – at the suggestion of the Nordic Council – the Nordic power collaboration NORDEL (1963), coordinating a Nordic power pool. NORDEL, too, was set up along the decentralized and voluntary model of the UCPTE.[90] The two groupings collaborated on asynchronical high-voltage direct current submarine cables, which do not transmit frequency, do not require tuning of both systems, and accordingly lack the advantages of immediate mutual system stabilization and support. Plans for synchronous collaboration were discussed in the 1960s but rejected as expensive and risky; the necessary modifications to the existing system would not outweigh the gains.[91] The exception that proves the point was the NORDEL partner in continental western Denmark, which for similar economic reasons chose to maintain its traditional synchronous collaboration with northern German UCPTE partners. It collaborated by asynchronous direct current links with its NORDEL partners, including eastern Denmark.[92]

The vulnerability implications of direct current connection were foregrounded in the British choice. In the late 1950s a study committee recommended a synchronous alternating current connection to the UCPTE pool to benefit system stabilization, among other reasons. Yet the committee noted that asynchronous, direct-current connections had other reliability advantages, such as providing a barrier to cascading frequency disturbances that can only travel in systems with frequency synchronization. Intensive Swedish lobbying on behalf of Swedish direct-current cable manufacturer ASEA ultimately won over the French and British parties for a direct-current connection. The British national grid was connected to France by direct current in 1961 and remains so today.[93]

Finally, a major division in postwar electrical Europe followed the so-called Iron Curtain or, in this case, the "Electric Curtain" between East and West.[94] Central Eastern European utilities were inspired by the system in the Soviet Union. In the context of the Council for Mutual Economic Assistance (COMECON, 1949), members discussed the pooling of fuels and an international power grid by 1954. In 1956, COMECON discussed the construction of interconnections between the German Democratic Republic (GDR) and Poland, with a possible extension to Czechoslovakia. An internationally interconnected electricity system was seen as the next move.[95] Rules of cooperation were established in December 1957.[96] In a first phase the GDR, Poland, Hungary, and Czechoslovakia were connected through 220 kV lines between 1957 and 1960. Western Ukraine followed in 1962, with Romania and Bulgaria in 1963–4. Their Interconnected Power Systems, also known as the Mir or Peace Grid, now involved seven socialist states. In terms of governance the new power pool partly followed the Soviet model: bilateral negotiations between national power authorities continued to dominate in practice as in the West, but a common, centralized control center established in Prague in 1962–3, the Central Dispatch Organization, was allowed to implement electricity exchange schemes between member states on a day-to-day basis.[97]

Externally the Central Eastern European pool was synchronized with the Soviet system in 1962.[98] In the 1960s, both pools formed a bipolar system with key control centers in Prague and Moscow. In the 1970s, however, the collaboration increasingly functioned as a single centralized power pool, as the Moscow control center took charge of frequency regulation as well as the exchange programs of individual countries.[99] Conversely, collaboration across the Electric Curtain was difficult and marginal – certainly when compared with the successful establishment of East–West trade in natural gas (Chapter 2, this volume). In electricity supply, however, energy trade was not the sole driver of transnational collaboration, as we saw above. System stabilization was an equally important, if not more important, concern, and in this respect the UCPTE was hesitant to pursue synchronous collaboration with Central and Eastern European systems that did not comply with UCPTE security norms.[100] This is not to say that visions of large-scale power trade were absent; yet they were less dominant than in the case of natural gas pipelines, and more easily thwarted. Thus a promising 1963 plan to export Polish coal-based power via Czechoslovakia to Bavaria in West Germany was successfully blocked by NATO.[101] Only a few asynchronous connections between East and West materialized, including the link via Yugoslavia (supported by NATO to lure Yugoslavia further away from the socialist block), a link between Czechoslovakia and neutral Austria, and Finnish-Russian and Bulgarian-Greek links.[102]

The end of the Cold War did not eliminate the Electric Curtain but pushed it eastward. Polish, Czech, Slovak, and Hungarian power companies now set up yet another organization, CENTREL (established in 1992; terminated 2006), halted synchronous collaboration with the former Soviet system and began synchronized cooperation with the UCPTE in 1995.[103] Their motives included envisioned lucrative power exports to the West, besides the traditional arguments of pooling reserve capacity, emergency support, and frequency stabilization. Full UCPTE membership was obtained in 1999. Traditional partners, such as the western Ukrainian, Romanian, and Bulgarian power authorities, followed in 2002 and 2004.[104] In the northeast, Estonian, Latvian, and Lithuanian power companies developed similar plans, but economic interests in power exports to Russia prevented that move for the time being.[105] Europe's Electric Curtain now roughly followed the border of the late Soviet Union.

The UCPTE power pool, meanwhile, had grown considerably. After absorbing Southern, Central, and Eastern European members, it began synchronous collaboration with Moroccan, Algerian, and Tunisian power companies via the 1997 Spain–Morocco submarine cable. Again, reliability considerations weighed heavily: the cable was designed for an anticipated change to more economical direct-current operation, but this change was not implemented because synchronous connection greatly improved the stability of the Moroccan system.[106] The huge synchronized area became known as the Trans European Synchronously Interconnected System.

Thus "Electrical Europe" emerged as it (by and large) still looks today. Vulnerability considerations informed choices for either synchronous or asynchronous collaborations between distinct power pools. Synchronized power pools provide instantaneous backup and stabilization to participants; asynchronous links did not have these advantages but are able to halt cascading blackouts of the sort that threatened the synchronous UCPTE system on January 12, 1987. The "European blackout" of November 4, 2006 clearly exposed the present geography of electrical interdependency: the frequency disturbance traveled from northern Germany to the Iberian peninsula, Central Eastern and Southeastern Europe, and northern Africa. By contrast, it could not cross the asynchronic barriers to Scandinavia, Britain, the Commonwealth of Independent States, the Baltic Republics, and Turkey.[107] Notably, in 2010, Turkey joined the synchronous "European" power pool, illustrating that the attractions of synchronous collaboration may still outweigh its risks, and that the dynamics of European electrical integration differ from those of political integration – negotiations on Turkish entry into the EU remain cumbersome.

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The making of high-reliability organizations

How, then, did transnational collaborations deal with this trade-off between the pros of automatic system stabilization and emergency support, which increased with the size of synchronous power pools, and the cons of potential cascading blackouts? How did they produce such high levels of reliability that caused organizational sociologists to view electricity supply as high-reliability organizations? In the exemplary case of the UCPTE we have already seen that system stabilization was a major argument for the establishment and subsequent expansion of the power pool. Yet from its beginning the organization acknowledged that synchronized collaboration also introduced the possibility of cross-border cascading failure, where frequency disturbances are transported throughout the network. Indeed, it quickly decided to make system reliability a cornerstone of its activity.[108] The UCPTE developed a double strategy: working for the expansion of synchronized collaboration was accompanied by measures to prevent or contain this new form of failure. By 1965, when large-scale rolling blackouts in the United States prompted a renewed sense of urgency, the UCPTE had identified a number of potential hazards and associated countermeasures that its members should implement.[109] The overall strategy was that its power pool should consist of interconnected, yet separately managed, networks, and that decentralized network managers were responsible for reliability in their own supply areas. Decentralized organization and vulnerability management thus went hand in hand. Another crucial principle was that allowing short time disruptions was “more acceptable than the effects of a comprehensive network disturbance with an unavoidable interruption of supply for a long time.”[110]

These principles inspired a set of precautionary measures. A number of design principles were intended to reduce the chance of disturbance in all member areas. If disturbances should occur nevertheless, it was important to prevent long-lasting damage. Therefore all system elements should have protective equipment, to automatically disconnect the element whenever system parameters fell below predefined thresholds, shutting it down before it burned out. Once the system parameters rose back above their thresholds, the element should be automatically reconnected. In the blackouts of 1987, 2006 and so on, it was such automatic protection gear that caused the line and generator trippings, and soon after brought the equipment back online.

To further contain and counter such failures, UCPTE members were to provide for sufficient backup capacity throughout the interconnected system. In the 1960s, members were to run extra generator units at all times, corresponding to some 3–5 per cent of the expected load or the largest power station in the pool. In addition, they were supposed to invest in emergency generators that could be started relatively quickly, and cross-border interconnections in particular were to have ample spare capacity to be used in case of disruptions. Later the general rule became that the entire system must always be operated with at least what was called “single backup capacity” (so-called N-1 backup), denoting that if one system element fails, the other elements are able to absorb the additional load.[111]

Should cascading failure happen despite these measures, cascading overloads would be countered by automatically tripping generators, while cascading underloads were to be contained by selectively disconnecting consumers. For this purpose, members were supposed to develop predetermined load-shedding programs – that is, emergency plans preparing the controlled disconnection of electricity users (households, industry, and pump storage plants) if the frequency dropped below a certain threshold. These should preferably be executed automatically by means of frequency relays. The blackouts of 1987 and 2006 were due not to malfunctioning equipment but to such deliberate and controlled load shedding, which temporarily sacrificed selected consumer areas in order to secure others. Next, to restore the system after failure, UCPTE members were responsible for improving system parameters in their own supply areas. To facilitate the coordination of such a decentralized response, telephone and telex connections were to be established between the control centers of neighboring members. A final measure proposed in the mid-1960s was the introduction of monitoring equipment to detect irregularities in the operation of power stations, load centers, and international tie lines. These latter grew into data-processing programs, such as Supervisory Control and Data Acquisition systems, and Energy Management Systems (compare Chapter 8, this volume).

These measures required considerable investments in the 1950s and 1960s but seemed to pay off: in the 1970s and 1980s the UCPTE system was considered to be highly reliable. Simulations suggested that local failures did not lead to cascading failure and did not compromise overall system security.[112] Incidents such as the 1987 failure confirmed this picture. On the eve of neoliberalization, the UCPTE concluded that although it could not provide absolute guarantees, its coordinated purposeful action produced "a very high degree of reliability of power supplies, without incurring costs which are out of all proportion."[113] As noted, the organization emphasized time and again that such reliability was best achieved in the informal and decentralized governance model of the UCPTE, for, as observed above, the partners knew the particularities of their own systems much better than any centralized organization could ever hope to.

In the centrally planned, managed and controlled power pools of the Soviet Union and COMECON, however, one may find similar discourses of high reliability. According to Vladimir Semenov, long-time employee of the Moscow control center and professor at the Moscow Power Institute, "centralized control disciplines and standard protection schemes, coupled with advances in technology, have continually improved the security and reliability of this transmission system."[114] Thanks to "this high standard of service," major Soviet system blackouts were few and far between, including a blackout in Moscow in December 1948 and one in Kazakhstan in 1975.[115]

A number of measures resembled those in Western Europe. For instance, the COMECON system was equipped with protective gear against short circuiting, telephone circuits for communication between control centers, and measuring devices. In terms of operation, the system would function at 50 Hz with a maximum deviation of 0.5 Hz; if such deviations lasted longer than 30 minutes, the load dispatcher was allowed to intervene directly in the planned electricity exchange scheme or shed part of the load.[116] And as in the West, the 1965 blackouts in the United States inspired renewed attention to the reliability of the Eastern European systems.[117]

Different from the West, however, was the hierarchical nature of balancing supply and demand, both in planning and in operation. In the Soviet system, hierarchical planning meant adjusting generating capacity and power line capacity on a 5- to 20-year basis. In addition, Soviet power authorities developed a three-tier hierarchical system of operational and emergency control, in which over 60 regional control centers were subordinated to the area control centers of the regional power pools, which in turn answered to the central Moscow dispatch center. Orders coming from higher levels were mandatory; lower dispatch control levels had the freedom to counter local problems only within these operational guidelines. Since the operating staff at the highest level was responsible for the security and economy of the overall system, preserving the overall system had institutionalized priority over subsystems. High reliability discourse in communist Europe thus applied to the integrity of the primary grid, rather than continuous supply to individual power consumers. When praising Soviet reliability management in the late 1980s, Moscow Power Institute engineers observed that the grid operated most reliably with average outages of up to merely six "system minutes" per annum, without any system collapses in the last decades. They did not provide any information on outages for consumers, which became the primary indicator of reliability in Western Europe.[118]

The technological and organizational means to achieve primary grid reliability, accordingly, included the central control of power station output and power flows in the grid. In addition, a comparative study found that "auto-regulation of consumption" played a large role compared with decentralized systems of the UCPTE or NORDEL.[119] In other words, "disconnecting some of the least essential consumers" was a key strategy for balancing supply and demand.[120] In large parts of the centrally controlled grids of communist Europe, coping with periodic power rationing was a daily routine for end users. In Bulgaria, communist-era power supply is still remembered as the "disco era" since the lights flashed on and off.[121] In Byelorussia, blackouts were usually quite short and selective – for example, alternating between large apartment blocks.[122] In this scheme of securing the primary grid first, the overall system could be kept up despite ensuing shortages. Construction delays persisted especially during the 1980s, supply shortages were common, particularly in winter, and operational reserve capacity of about 1 per cent was way below the planned level (and below the level in the decentralized UCPTE system).[123]

These different control regimes collided in 1991 when Central Eastern European power authorities announced their wish to disconnect their synchronous links with the Soviet system and connect to the UCPTE instead. The UCPTE demanded tighter frequency control and national defense plans, whereas load shedding had previously been arranged by the Prague Central Dispatch organization.[124] Interestingly, these and other changes were consistently phrased as "power quality improvements" rather than adaptation to a different system, reflecting the quality perceptions of the UCPTE collaboration. After four years of preparation, the new collaboration became operational.

The invention of vulnerability

September 28, 2003, 3:20 a.m. Sunday. A severe storm tips a tree over a power line carrying Swiss electricity exports to Italy, igniting overloads in Swiss, French, and Italian power systems. In marked contrast with the events over 80 years earlier at the Swiss-Italian border, French and Swiss power authorities now cut their connections to Italy to prevent blackout at home. Soon the entire Italian peninsula plunges into darkness. In Rome, where a million people are participating in the celebration of the Notte Bianca ("White Night") festival, subways and elevators come to a halt, trapping passengers inside. Traffic lights fail and cause massive traffic jams, while 110 trains carrying over 30,000 passengers come to a sudden standstill. Hundreds of people panic. Nationwide, hospitals report a surge of accidents involving elderly people.[125]

After reparation of the failure, Italian, French, and Swiss power authorities blame each other, but their conflict fades into the background when EU officials get involved. Earlier European Commission energy security debates had focused on fuel imports and bunkers. But a week after the "Italian blackout" the security of energy systems, in particular electrical power, tops the agenda for the upcoming EU energy ministers meeting.[126] *Two months later the European Commission proposes its first directive for the security of electricity infrastructure. Further encouraged by the "European blackout" of November 4, 2006, a new EU Agency for the Cooperation of Energy Regulators is set up in Ljubljana, Slovenia. Furthermore, the power sector yields to EU pressure and terminates international associations like the UCPTE (now UCTE) and NORDEL, which had dominated the scene for over half a century, replacing them with an EU-wide association – the European Network of Transmission Systems Operators for Electricity.*

Thus ended an era in European electric collaboration. The power sector's discursive hegemony on economy and high reliability was definitely challenged, as was its associated decentralized model of transnational governance. Enter the EU perception of "transnational vulnerability," its claim that only EU-level organization can make Europe's power system sound and secure, and its persistent equation of "Europe" with the EU polity and territory in matters of electric power as well. By then, vulnerability challenges had already exploded in the Commonwealth of Independent States due to rapid liberalization of the former Soviet system. What is more, this system was increasingly externalized as "non-Europe" as EU discourses on "Europe" became hegemonic. While the implications for Europe's actual material infrastructure remain to be seen, the stage seems set for reinventing electrical Europe on the EU level.

The dynamics of electric EU-ropeanization

We read the entrance of the EU and its direct forerunner organizations as a political drama in three acts.

In the first decades of experimenting with new forms of supranational governance in continental Western Europe, energy had been claimed as a major arena for political integration. Indeed, two of the three European communities – the European Coal and Steel Community (1951) and the European Atomic Energy Community (1957) – were related directly to primary fuels. Electricity infrastructure had been considered for the third community, the European Economic Community (1957), but was ultimately bypassed. This is remarkable because, at the time, integration theorists and politicians from the six participating states – Belgium, the Federal Republic of Germany, France, Italy, Luxembourg, and the Netherlands – saw transnational infrastructure as a producer of integration spillovers and thus a major candidate for common policy.[127]

The reason for this bypass was suggested in the influential Spaak Report preparing the 1957 Treaties of Rome. According to the report, electricity and gas infrastructure differed from other potential policy domains in their "technical and economic specificities," making them less well-suited candidates for a common policy; they were well dealt with by specialized sector organizations.[128] Thus when coal issues led the three communities to jointly set up an Interexecutive Working Group on Energy in 1961, they foregrounded energy source problems – such as security of supply in the case of oil and diminishing coal production – rather than infrastructure issues. By the way, despite a number of attempts, a common fuel policy did not take off either; it was repeatedly frustrated by member states' concerns for domestic coal market protection. Of these failing proposals, a 1964 Protocol of Agreement on Energy Policy intended to introduce fairer competition between energy sources, a wider diversification of oil supplies, and prices as low and stable as possible. In 1967 the Working Group was replaced by a Directorate-General for Energy, which developed Guidelines for a Common Energy Policy, seeking secure primary fuel supply and low and stable prices. Here electricity was mentioned briefly as a candidate for common regulations on open access and tariffs. Neither was implemented as energy remained "an extremely sensitive area of national sovereignty"; not even the oil crises of the 1970s inspired a Community community energy policy.[129] The result relevant to us here is that international electricity infrastructure governance was organized outside the European Communities framework in the more voluntary and broader membership organizations that we discussed in the previous sections. Interestingly, the same happened with transport and communications infrastructure.[130] In addition, in terms of perceived vulnerabilities, electricity issues seemed negligible compared with concerns about fossil-fuel energy security and miner employment.

The Second Act, in which electricity became a policy target, opens with the emerging concept of an Internal Market in the early 1980s, formalized in a European Commission White Paper by 1985 and the Single European Act by 1986. By now the Communities also included Denmark, Ireland, Britain, Spain, and

Portugal. Dissatisfied with de facto trade flows, the aim was to reinvigorate the economic integration process by combating internal frontiers. The White Paper listed some 300 legislative measures that could reduce physical, technical, and tax barriers to trade. The Single European Act set a target date for a liberalized common market by 1992 and defined steps accordingly. It included a target date (1992, later postponed) for realizing a common energy market, meaning an internal and liberalized common electricity market. The Treaty on the European Union (1992), finally, added EU involvement in the planning and financing of a "Trans-European Network"; by 1994 the first priority interconnection lists were compiled, including a number of transnational power lines.[131]

Importantly, EU electricity policy-making aimed at economic integration and (neo)liberalization, not reliability management. EU spokespersons and documents rarely questioned the reliability of electricity infrastructure and the power sector's decentralized governance model; the perception that Europe's electric power infrastructure was vulnerable still had not taken root. The 1988 European Commission policy document "The Internal Energy Market" praised Europe's highly interconnected electric power system and recognized that international exchanges were managed well by sector organizations such as the UCPTE and NORDEL without government interference.

Instead, EU electricity policy targeted perceived economic and political vulnerabilities. The European Commission itself was concerned chiefly with social and economic cohesion and with making Europe more competitive. Note that in this context "Europe" was identified with EU internal market integration: newspeak of "the costs of non-Europe" referred to internal fragmentation and barriers to trade hampering European economic performance, which was deemed problematic in an ever more competitive world and emerging economic recession.[132] Thus the cost of non-Europe in the energy sector is affecting our economic performance . . . The potential benefit of "more Europe" would be twofold: a reduction in costs as a result of greater competition and a reduction in certain unit costs as a result of the effect of scale and the optimization of investment or management.[133] To counter "non-Europe" in electricity, the European Commission prioritized "economic and competitive aspects of electricity," leading to governance issues such as monopoly control, the common carrier principle in which users would be able to purchase electricity from any power producer instead of being tied to the producer in their specific supply area, and open competition between power producers. The envisaged beneficiaries were large electricity-intensive industries, which had been lobbying for these principles, but also small users without substantial political representation. Electricity system reliability was mentioned only as a sector-specific concern, not as a primary target; security of supply still exclusively denoted the availability of primary fuel. Even in the next step, the formulation of the Trans-European Network program for electricity infrastructure, reliability and its governance were not problematized.

In addition, the new push for liberalization and Europeanization did not much affect the power sector's perception of high reliability. Initially, the UCPTE (soon renamed UCTE, dropping the "P" for production following the separation of production and transmission activities) was alarmed by the new developments: competitive pressures might jeopardize system security and increase the possibilities of blackout, for the common carrier principle might complicate international coordination.[134] Unable to withstand or block EU policy, the organization engaged in a debate with the European Commission to accommodate its concerns about EU policy. The result was positive: "the UCTE believes that the new deregulated market environment is compatible with an adequate level of system reliability."[135] New technologies geared to the new situation were explored, improved, and introduced.[136] For instance, by 2000, Wide Area Monitoring Systems (WAMS), as a supplement to earlier monitoring technology, offered real-time information about grid conditions in over 30 key nodes in the UCTE network. Such augmented monitoring was accompanied by innovative WAMS. In addition, UCTE security rules were tightened, in particular through a security package in 2002. Existing rules were sharpened and systematized in the eight policies of the *UCTE Operational Handbook*.[137] As a result, on the eve of the major blackouts of 2003 and 2006, many stakeholders, analysts, and politicians still considered continental Europe's electric power system to be extremely secure. The UCTE system adequacy forecast for 2003–5 and other documents noted that although cross-border power flows were increasing and the system was operated near its limits in some locations, so "the security of the UCTE system as a whole seems to be not at risk."[138]

In the Third Act, the "Italian Blackout" of 2003 inspired EU policy-makers to challenge the high-reliability consensus head on. The ground was prepared by several other large blackouts that same year – the northwestern blackout in Canada and the United States, in London, and in Sweden and eastern Denmark. The 2006 European blackout underscored the transnational nature of present-day power grid vulnerability.

Interestingly, these events did not change the high-reliability discourse in power sector organizations such as the UCTE. The Italian blackout might confirm that there was little slack in the system at some points, not least where Italian reserve generation capacity and load-shedding programs were concerned. Yet the disturbance was contained everywhere except in Italy. Besides, in Italy itself, supply was restored within five hours in northern Italy and ten hours in the entire mainland. The UCTE found "no fundamental deficiencies in the existing rule-setting of the UCTE system."[139] The existing decentralized governance mode also remained unquestioned: "The blackout and subsequent investigation has cast no doubt on this [decentralized] model in principle. On the contrary, the lack of a grid operator's empowerment and independence could be identified as a potential security risk."[140] In the next year, UCTE members again succeeded in running their systems in "a highly secure and reliable manner"; a year later the adequacy forecast for 2005–15 did not anticipate any major risks either, predicting a "reasonable security margin" by 2010.[141] The UCTE interpretation of the "European blackout" of November 4, 2006 follows the same line of interpretation: most consumers remained unaffected, while supply to most of those affected was back online within 30 minutes and to all within two hours.

Yet the UCTE president, Martin Fuchs, observed how, following the Italian Blackout, the "security of supply issue has come to largely dominate the discussion in terms of energy policy. Transmission system operators' functions and activities have never before been a matter of such considerable interest to politics and public."[142] Electricity infrastructure vulnerability quite suddenly became a key concern of EU policy-makers and entwined with other policy initiatives; it became an integral part of the movement to extend EU influence into the domain of transnational electricity infrastructure governance that we summarized above. Why did this happen? In our interpretation, this concern resonates well with the rapid emergence of what EU analysts term an EU "security identity" associated with an emerging "protection policy space."[143] In the last decade or so, EU policy-makers increasingly focused on transboundary threats, from disaster response and counterterrorism to food safety and avian influenza. Moreover, member-state governments were increasingly inclined to grant the EU powers in such matters of transnational citizen protection, thus contributing to a qualitative as well as a quantitative change in the formal European integration process. We expect, pending further research, that this context made EU policy-makers sensitive and receptive to transnational electricity disruptions such as the 2003 and 2006 blackouts. Either way, unprecedented policy measures followed, not least the EU's Third Legislative Package (then still in draft), including plans for an EU-wide electricity infrastructure regulatory agency. Notably, in March 2006 – half a year before the 4/11 blackout – member states had still rejected the notion of such agencies.[144] The interconnection of energy networks itself was inscribed into the Treaty of Lisbon, the amended "European Constitution" that came into force in 2009.

This EU pressure was stepped up even further after the rejection of the proposed European Constitution by French and Dutch voters in 2005. In response, the new European Commission charm offensive foregrounded the leading role of the EU in combating climate change, thus adding yet another layer of vulnerability and urgency to legitimate EU interference.[145] Facing these combined pressures of economic, security, and ecological vulnerabilities, the UCTE and other sector organizations' interpretation of economical, clean, and high-reliability performance and adequate transnational sector governance were no longer politically convincing. Moreover, important electricity producers recognized new business opportunities, such as foreign expansion and green subsidy schemes, and this supported ongoing political developments. In the realm of electricity infrastructure, international sector organizations followed the European Commission's suggestion to merge into the EU-wide European Network of Transmission System Operators for Electricity (ENTSO-E). Accordingly, the old mesoregional organizations were terminated in 2009. While continuing to contest the EU notion of transnational electric vulnerabilities, this new infrastructure organization implicitly copied and implemented the EU version of electrical Europe institutionally and discursively: "We are the European TSOs. We are ENTSO-E . . . [with an EU mandate] to ensure optimal management of the electricity transmission network and to allow trading and supplying electricity across borders in the Community."[146] As for the infrastructure hardware, the new organization inscribed the aim of an "interconnected European grid" in its mission statement. One of its first activities was to publish a call for projects developing a roadmap towards a pan-European supergrid to counter Europe's various electricity threats.[147] Based on the findings of this chapter, we perceive this initiative as confirmation that yet another round of interpreting and negotiating Electrical Europe is currently taking place.

Epilogue

November 25, 2005. Heavy snowfall causes electric power interruptions throughout the Netherlands. Supply to the town of Haaksbergen (25,000 inhabitants) near the German border is interrupted for between 30 and 61 hours.[148] *The Dutch Royal Air Force flies in emergency generators to serve elderly homes and husbandry farms. Local entrepreneurs blame the responsible network company Essent Netwerk BV and quarrel about damages. The Dutch parliament is shocked and demands a thorough inquiry into the adequacy of the Dutch power grid.*[149] *This inquiry concluded that the Haaksbergen failure could not jeopardize the rest of the Dutch system, but the town itself is vulnerable: it is located at the end of a transmission line. Connecting Haaksbergen and other towns in a similar position into a ring structure to secure supply from two sides would cost €90 million annually, while annual profits would amount to only €4 million.*

A year later the 2006 European blackout passes nearly unnoticed in the same parliament.[150] *In contrast with EU politicians, Dutch MPs are not impressed. After all, many more faults happen locally, particularly in low- and medium-voltage distribution networks. Indeed, for consumers and small businesses, the blackout of November 4, 2006 accounted for less than 2 per cent of the annual average power outage per consumer per year.*[151] *Events such as the Haaksbergen local blackout seem much more disruptive and important. In 2010, Haaksbergen gets its second cable connection.*[152]

We started this chapter with the so-called European blackout of November 4, 2006. At first glance this event seemed to represent a remarkable historical irony. Historical actors set up large transnational synchronous power pools that facilitated, next to power exchanges, immediate mutual support and system stabilization: a disturbance anywhere in the system would instantaneously be counteracted by all other machinery in the pool. Transnational electric interdependency thus reduced much electric vulnerability. Yet it also produced a new vulnerability in the form of cascading blackout, as the November 2006 events demonstrated: today a disturbance in northern Germany can turn off lights in Portugal or Tunisia within seconds. On closer inspection, however, this displacement of electric vulnerabilities proved subject to diverging interpretations: while the geography of the blackout signaled a new form of transnational vulnerability to EU policy-makers, to power-sector experts its successful containment and quick repair confirmed the secure state of the European power supply. Electric vulnerabilities, in short, are subject to interpretation, contestation, and negotiation in concrete historical and institutional contexts.

Our subsequent investigation confirmed that vulnerability perceptions were key, yet moving, targets in the shaping of Electrical Europe: electrical interdependencies and vulnerabilities were framed differently in the eras of isolated power systems, interwar electric nationalism and internationalization, postwar reconstruction, and ongoing electric EU-ropeanization. One implication is that present-day EU, state government, or power-sector claims about electric vulnerabilities should not be taken at face value. Rather, these should be related to their respective institutional logics. Another implication is that any measure to reduce present-day vulnerabilities will undoubtedly be criticized in the future for producing new vulnerabilities of its own. The currently celebrated promise of European "smart grids," for instance, may facilitate better real-time control of transnational power flows and fluctuations, and also balance out disturbances caused by new unstable renewable energy generators like wind or solar power. Yet simultaneously, smart grids heavily increase the dependency of electric power supply on information and communication technology infrastructure that can fail or be hacked.[153]

It is thus in the context of such ongoing EU-ropeanization of electricity supply that we end this chapter with the 2005 Dutch Haaksbergen event. After discussing magnificent electrotechnical collaborations spanning from Ireland to Siberia and from Norway to North Africa, the Haaksbergen incident is a welcome reminder that in the age of pan-European and global systems, the local remains a crucial unit of design, use, concern, identification, and vulnerability. Moreover, borders still matter: high-capacity power lines have pierced the Urals and the Mediterranean as electrical borders of Europe, yet the proximity of Haaksbergen to the Dutch-German border meant that the town was situated at the end of a transmission line. The primary grid crosses borders, but lower-level transmission lines usually do not, even in countries that have been at the heart of Europe's electrical integration project. Far from being a homogeneous space, Electrical Europe is a complex, multilayered entity of interwoven local, microregional, national, mesoregional, and transcontinental systems, transcending borders but not erasing them. Europe's electrical vulnerability geography follows suit: local failures are frequent, while rare transnational failures, such as the 2006 European blackout, provide a glimpse of the selective geographical extension of these complex systems. The importance of local vs. long-distance failures is interpreted and weighted differently in EU policy-making, national governments, power companies, and local communities.

It is a key task of transnational history to highlight and interrogate such entanglements between international, national, and local processes, not to obscure or erase them. To further this sort of inquiry, the following chapters zoom in on the interpretation and building of electrical Europe and its vulnerabilities "from below."

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Notes

1. This event is well documented in UCTE 2007. For further analysis, see Van der Vleuten et al. 2010a.
2. Van der Vleuten et al. 2010b.
3. *International Herald Tribune*, November 5, 2006.
4. Because of a spelling mistake in the *International Herald Tribune*, we here cite the same quote in *BBC News*, November 6, 2006.
5. European Commission, "Energy Commissioner Andris Piebalgs Reacts to Saturday's Blackouts," press release, November 6, 2006.
6. European Commission, "Blackout Last November Calls for Increased Cooperation Between TSOs Says Commissioner Piebalgs," press release, December 19, 2006.
7. "German-Triggered Blackout Exposes Fragile European Power Network", *International Herald Tribune*, November 5, 2006.
8. UCTE 2007, p. 6.
9. http://www.ucte.org, consulted on August 17, 2004. UCTE 2007, p. 12. The organization claimed to make "historical contributions to the ideal of a united Europe" for a long time. See UCPTE 1971, p. 1.
10. Using 4/11 for shorthand, we acknowledge that the infrastructure-related terrorist attacks of September 11, 2001 (9/11 in US notation) and March 11, 2004 (also known as 3/11) were, of course, much graver.
11. Nye 1998.
12. Misa and Schot 2005.
13. For a further discussion, see Van der Vleuten et al. 2010b.
14. For the development of these research questions and their embedding in different literature, see Van der Vleuten and Kaijser 2005; Van der Vleuten and Kaijser 2006; Van der Vleuten et al. 2007; and Kaijser et al. 2008.
15. Highlights in comparative, nation-centered electricity historiography include Millward 2005 and the all-time classic of Hughes 1983. For recent international electricity historiography, see Lagendijk 2008 and Hausman et al. 2008. On transnational technological history, see Van der Vleuten 2008.
16. League of Nations, Advisory and Technical Committee for Communications and Transit, Procès-verbal of the second session, held at Geneva, March 29–31, 1922. UNOG Archives, C.212.M.116.1922.VIII, Annex 7: "Report to the president of the advisory and technical committee on communications and transit on the requested action by the League of Nations for facilitating the cession by one country to another of electric power for operation of railways of international concern", p. 33. Also see Lagendijk 2008, pp. 39 and 61ff., and Schipper et al. 2010.
17. Cioc 2002, pp. 131–132; Lee 1991, p. 203; Kleisl 2001, pp. 25–26; Rathenau 1985, p. 7.
18. Rüegg 1954; Kittler 1933, p. 141; Kaijser 1997, p. 6; Van der Vleuten 1998, pp. 139–140 and 150–155.
19. Legge 1931, pp. 68 and 77; Halacsy 1970, p. 145; Maier 2006, pp. 134–135.
20. Lagendijk 2008, p. 45.
21. Klingenberg 1912, pp. 731–735; "Elektrische Grosswirtschaft unter Staatlicher Mitwirkung", *Elektrotechnische Zeitschrift* 35 (1916), pp. 81ff, 119ff, and 149ff. These arguments were picked up and propagated in neighboring countries, such as Van der Vleuten 1998 and 1999.
22. Van der Vleuten 1998.
23. Haas 1926, p. 989; Legge 1931, p. 5; Laporte 1932, p. 113.
24. Lagendijk 2008, pp. 56–57. Compare Millward 2005.
25. Van der Vleuten 1998, p. 129.
26. For example, in the Netherlands, Doyer 1916. In Denmark, Angelo 1917. For Britain, see Hughes 1983, pp. 289–291.

27. Hughes 1983, pp. 289–291, 319–323, and 350–362.
28. Lenin 1920/1965.
29. Coopersmith 1992, pp. 150–152 and 160; Coopersmith 1993.
30. Lagendijk 2008, p. 56; Hausman et al. 2008, p. 148.
31. Van der Vleuten 1999.
32. Varaschin 1997, pp. 100–101; Gugerli 1996, p. 288ff.
33. Hunt Tooley 1988, p. 59.
34. "Verhandlungen über die Wasserkraft und Elektrizitätswirtschaft mit den Landesvertretungen Salzburg" (undated), Deutschösterreichische Staatsamt für Handel und Gewerbe, Industrie und Bauten, Z.26064 III 1919, OeStA, Box 2184H, Folder 425–1.
35. For example, in the Netherlands and Denmark, see Doyer (1916) and Angelo (1917).
36. Compare Schot et al. 2008.
37. Hertner 1986; Hausman et al. 2008, pp. 52ff and 97ff.
38. Persoz et al. 1992; Fells 1998; Lagendijk et al. 2009.
39. Here we follow Gall 2006. See also Gall 1998 and Voigt 1998.
40. Sörgel 1932, pp. 118–119.
41. Trieb and Müller-Steinhagen 2007, map on p. 213. Compare the DESERTEC concept and program, see www.desertec.org/EN/concept (consulted on February 14, 2010).
42. See, for example, Higgins 2008, pp. 42–46.
43. Viel 1930; Oliven 1930; Schönholzer 1930. Compare Gall 2006 and Maier 2006.
44. On micro-, meso- and macroregions, see Troebst 2003.
45. Schönholzer 1930, p. 385. For a discussion about utopianism vs. the feasibility of Sörgel's Atlantropa-project, see Gall 2006.
46. Anastasiadou 2011.
47. For example, Pegg 1983.
48. Oliven 1930, p. 875.
49. Coudenhove saw European unity as a countervailing force to the rise of the Soviet Union and the United States. Coudenhove-Kalergi 1931, p. 4. On the European security of maintaining empires, see Adas 1989, pp. 385ff.
50. Schönholzer 1930, p. 385. The emphasis and quotation marks are as in the original.
51. Sörgel in 1938, cited in Gall 2006, p. 114.
52. This was the office of Albert Thomas, the director of the International Labour Organization.
53. League of Nations 1930.
54. Lagendijk 2008, pp. 69ff.
55. Hughes 1983; Bouneau 1994, pp. 794–795; Vanneste 1998.
56. Segreto 1994, pp. 68–71; Morsel 1994.
57. Maier 2006, pp. 131 and 138–149.
58. Maier 2006, p. 144. Allied bombings targeted electrical installations in only 0.04 per cent (RAF) and 0.05 per cent (US Air Force) of cases. See United States Strategic Bombing Survey 1945, pp. 83–85.
59. UCPTE 1987, p. 5; RTÉ 2004, p. 256.
60. UCPTE 1978, pp. 6–9.
61. For this distinction, see, for example, Troebst 2003.
62. Roberts 1989. This argument still echoes today – for example, De Bruijne et al. 2007.
63. UCPTE 1977, p. 103.
64. UNIPEDE 1955, pp. 126–127.
65. P. Facconi cited in the preface of UCPTE 1971.
66. UCPTE 1976.
67. UCPTE 1976, p. 167.
68. CEEC 1947, p. 10. See also Lagendijk 2008, p. 125ff.
69. CEEC 1947, p. 11.
70. OEEC 1950, p. 24.

71. For a detailed discussion, see Lagendijk 2008, pp. 144ff.
72. UCPTE 1952, p. 5.
73. UCPTE 1952, p. 4. For a detailed overview, see, UCPTE 1976.
74. UCPTE 1976, pp. 153 and 188.
75. Verbong 2006.
76. Steklov 1960, p. 138 and Högselius 2006, p. 249.
77. Steklov 1960, pp. 136–137 and Lebed 2005.
78. Djangirov et al. 2002, p. 1, and Bondarenko et al. 1992.
79. "1921–2002 gody," http://www.so-ups.ru/index.php?id=925 (consulted on March 2, 2010). Michel et al. 1964, p. 208, and Sagers et al. 1982.
80. Sagers et al. 1982, p. 291.
81. Venikov et al. 1989, p. 19.
82. Michel et al. 1964, p. 217; Sagers et al. 1982, p. 301, and Bondarenko et al. 1992, p. 386.
83. Myrdal 1968, p. 626.
84. Neumann 1995, pp. 118 and 127.
85. Khrushchev 1959, p. 8.
86. Lebedev (General Secretary USSR Committee for the USSR participation in international power conferences) to Sevette, December 1, 1964, UNOG Archives, registry fonds GX, file 19/6/1/15-32212. Also see Bondarenko et al. 1992, p. 388.
87. Johnson 2006.
88. "Note sur la constitution de l'Union Franco-Ibérique pour la coordination de la production et du transport de l'électricité," April 4, 1963, Historical Archives of the European Union, fonds OECD, file 1157.8, EL/M(63) 1, Annex II, HAEU.
89. SUDEL 1984 and Lagendijk 2008, pp. 181–183. On the special case of Yugoslavia, see Lagendijk and Schipper, forthcoming.
90. Kaijser 1995 and 1997. The United States also tried to forge more cooperation between these countries through the Marshall Plan. See Lagendijk 2008, pp. 145ff.
91. Wistoft 1992, p. 87.
92. Wistoft 1992, p. 88 and Van der Vleuten 1998.
93. Fridlund 1998, pp. 185–190.
94. Persoz et al. 1992, pp. 62–65.
95. "Vorschläge der DDR für die Arbeit der Ständigen Kommission für Elektroenergieaustausch zwischen den Teilnehmerländern des Rates für gegenseitige Wirtschaftshilfe und für Ausnutzung der Wasserkräfte der Donau," Berlin, April 10, 1956, BArch, fond DE 1, file 21753.
96. These steps included a quadrilateral (GDR, Poland, Hungary, and Czechoslovakia) energy conference in Budapest in 1956, a second one with load dispatchers and related experts, and lastly one in December that laid the groundwork for what would become the CDO. Ministerium für Kohle und Energie, Berlin, "Durchzuführende Massnahmen die sich aus dem Schlussprotokoll der vierseitigen Energiekonferenz in Budapest vom 26.1–10.2.56 ergeben," March 20, 1956, BArch, fond DG 2, file 14218; "Protokoll der Beratung der Arbeitsgruppe über Fragen der Vorbereitung eines Vorschlages über Grundprinzipien des Dispatcherbetriebes, der mit dem Austausch von Elektroenergie zwischen den Teilnehmerländern des RfgW im Zusammenhang steht," Budapest, December 1957, BArch, fond DG 2, file 14218.
97. Savenko 1983, pp. 9–14, 33ff, and 57–58; UNECE 1963, p. 69; UNECE 1964, p. 25; Kaser 1965, pp. 58 and 81; Maximov 1963; and Persoz et al. 1992.
98. Kaser 1965, p. 81.
99. Thiry 1994, p. 4.
100. Riccio 1964, p. 4, and Gicquiau 1981, p. 153.
101. Lagendijk 2008, pp. 184–190.
102. Lagendijk and Schipper, forthcoming; Allmer 1985 and Lagendijk 2008, p. 190ff. See also Chapters 4 and 5, this volume. On Austria–Czechoslovakia links, see Savenko et al. 1983, pp. 120–121. An earlier PhD thesis focused on this, see Schneider 1994.

103. Persoz et al. 1992 and Hammons et al. 1998.
104. Hammons et al. 1998 and Feist 2004, pp. 1226–1228.
105. Högselius 2006.
106. Granadino et al. 1999 and Zobaa 2004, pp. 1401–1403.
107. Van der Vleuten and Lagendijk 2010a.
108. De Heem 1952; UCPTE 1959, pp. 130–138; and Cahen et al. 1964. See also UCPTE 1976.
109. UCPTE 1965 and 1966.
110. UCPTE 1966, pp. 6–7.
111. UCPTE 1990, p. 22.
112. For example, UCPTE 1986, pp. 39–43.
113. UCPTE 1990, p. 20.
114. Semenov 1997.
115. Venikov et al. 1989, p. 19. Compare Makarov et al. 2005.
116. "Protokoll der Beratung der Arbeitsgruppe über Fragen der Vorbereitung eines Vorschlages über Grundprinzipien des Dispatcherbetriebes, der mit dem Austausch von Elektroenergie zwischen den Teilnehmerländern des RfgW im Zusammenhang steht," Budapest, December 1957; Anlage, Entwurf. "Grundprinzipien zur Erarbeitung einer Vereinbarung über Fragen der Betriebsführung im Falle eines gemeinsamen Betriebes der Energiesysteme," BArch, fond DG 2, file 14218.
117. "Einschätzung der 21. Tagung der Ständigen Kommission Elektroenergie des RGW," Sofia, December 14, 1965, BArch, fond DC-20, file 19589.
118. Ibid. Compare Voropai et al. 2005.
119. Working Group 37.12 1994, p. 2.
120. Semenov 1997, p. 3.
121. "Gas Crisis Revives Memories of Communist Era in Bulgaria," *EUbusiness*, January 7, 2009, http://www.eubusiness.com/news-eu/1231354021.63. (consulted on April 30, 2010).
122. Thanks to Nadzeya Kiyavitskaya for observations on Byelorussian blackout patterns in the 1980s. Their interpretation in a system-management context is ours.
123. Bondarenko et al. 1992, p. 384.
124. Riccio 1964, p. 4; Savenko et al. 1983, p. 118; UCPTE, "Protokoll über die Sitzung der UCPTE-ad-hoc-Gruppe Ost-West-Verbund am 30. Mai 1994 in Wien," May 30, 1994, p. 4, UCTE Archives; Houry et al. 1999, p. 638; and Centrel, "Charter of Centrel," October 11, 1992, p. 1, UCTE Archives.
125. "Italy Slowly Comes back to Light," *BBC News,* September 28, 2003.
126. Commission of the European Communities 2007.
127. Schot et al. 2011 and Schot 2010.
128. Comité Intergouvernemental créé par la Conférence de Messine 1956, p. 126.
129. The quote is from Kohl 1978, p. 111. See also Lucas 1977; Hassan et al. 1994; and Commission of the European Communities 1968.
130. Laborie 2006; Henrich-Franke 2008; and Schipper 2008.
131. Padgett 1992; Schmidt 1998, p. 191; Commission of the European Communities 1987 and 1988.
132. Commission of the European Communities 1987, p. 6.
133. Commission of the European Communities 1988, p.6.
134. UCPTE 1998, p. 15.
135. UCTE 2001, p. 25.
136. Kling 2002; Kling 1994; and Breulmann et al. 2000.
137. UCTE 2004.
138. UCTE 2002, p. 5.
139. UCTE 2004, p. 11.
140. UCTE 2007, p. 10.
141. UCTE 2004, p. 5, and UCTE 2002, p. 5.
142. UCTE 2002, p. 4.

143. Boin et al. 2006, p. 405.
144. Stephen Castle, "EU Summit Fails to Address Protectionism Fears," *The Independent*, March 26, 2006.
145. For further interpretation of the current transition in European energy regimes, see Van der Vleuten and Högselius 2012.
146. See www.entsoe.eu (consulted on April 20, 2010).
147. ENTSO-E 2010.
148. Directie Toezicht Energie 2006, p. 20.
149. "Vragen van het lid Hessels aan de minister van Economische Zaken a.i. over de langdurige stroomstoring in Haaksbergen afgelopen weekeinde (Mondelinge vragenuur)," in *Handelingen van de Tweede Kamer der Staten Generaal*, vol. 27 (2005–2006), pp. 1852–1854.
150. "Vragen gesteld door de leden der Kamer, met de daarop door de regering gegeven antwoorden (657)," in *Aanhangsel van de Handelingen van de Tweede Kamer der Staten-Generaal*, 2006, pp. 1411–1413.
151. Ministry of Economic Affairs 2007.
152. Directie Toezicht Energie 2010.
153. Misa 2011.