Electricity infrastructures

During the 20th century, the supplying of electricity became a transnational force in several ways. First, in the realm of ideas, the planning of transnational electricity systems intertwined with broader ideas of regional integration. Since the 1920s electrical integration has been ideologically linked to the creation of interdependency, joint prosperity and peace, especially in Europe. Second, international organizations promoting infrastructure were among the earliest and most successful experiments in global community building. The electricity supply sector produced its own international organizations after 1920, hosting structural interactions between individuals and organizations from across the world. Finally, on a purely material level, economies and societies were electrically interconnected. Some cross-border links date from the early decades of the 20th century, but electrical integration was more systematically pursued only in the century's second half. These developments were far from homogeneous or smooth. They resulted in asymmetrical patterns of interconnection and collaboration even within the most advanced regional power pools.

If electricity became a connecting force only in the 1910s and 1920s, this is in part due to the sector's internal development. Systems to supply electricity to the public had been established since the early 1880s. However, using low-voltage distribution (typically 110 or 220 volts) these had an economic reach of only a few kilometres. They were inner-city or even village systems. Relative power losses decrease with increasing transport voltages, and the introduction and diffusion of medium-voltage transmission (often 10 kilovolts) in the 1890s increased the transmission range to some 30–50 kilometres, enabling an increase of supply areas and scaling up of power stations. Several of such increased power systems grew to cross national borders. Most important for our topic, however, is the notion of interconnecting power stations in a power pool, using still higher transmission voltages (often higher than 50 or 100 kilovolts). This notion of power pools was much debated in the 1910s. Well-advertised advantages included integrating distant lignite or hydropower plants into the system; allocating production to those power stations in the pool producing cheapest at any given time; and mutual provision of backup capacity in case of breakdowns within the pool. These promises inspired projects for national as well as transnational power pools.

Electricity and ideas of regional integration

The notion of transnational electricity systems first entwined with emerging ideas of regional integration in interwar Europe. Engineers evoked political notions of a pan-European Union in their thinking about electricity supply; simultaneously, functionalist politicians embraced electrical integration as a practical, 'technical' alternative to the troublesome 'high politics' road to European integration. Both groups enthusiastically debated how transnational electricity networks could make the energy of Europe's unevenly distributed coal fields and hydropower sites available to all its countries. Moreover, this process would create electrical interdependencies that would secure peace better than any political treaties on paper. Like railroads in the 19th century and information and communication technologies networks today, electrical interconnection promised cooperation, prosperity and peace. By the early 1930s several engineers were proposing all-European power grids fed by hydropower plants in Scandinavia and the Alps. Meanwhile the League of Nations discussed electrical integration in the context of a wider scheme for European public utilities.

While the promises of electrical cooperation boosted functionalist thought on regional integration, in reality such collaboration remained rather limited. Until the 1940s, the competing idea of creating national power pools ensuring national energy independence proved stronger. The idea of regional electrical integration gained a coercive character when Nazi Germany, too, sought to integrate an envisaged *Neuropa* by electric power networks, by which occupied territories' energy resources would feed Germany's war economy.

In postwar Europe promises of prosperity and peace via electrical integration re-emerged, although the functionalist ideology was often downplayed relative to the promise of sectoral efficiency gains of cooperation and concerns to create large markets for projected nuclear power plants. Still, electrical integration remained an important concern to political bodies working for regional integration.

The United Nations Economic Commission for Europe (UNECE, 1947), the Organization for European Economic Co-operation (OEEC, 1948), and the Council of Mutual Economic Assistance (COMECON, 1949) all included electricity supply in their regional integration efforts.

In the 1990s, neoliberal thinking strengthened interlinked notions of regional and electrical integration: regional markets require transnational networks. The European Union includes electricity in its Trans European Network programme to forge economic, social and territorial cohesion (1992). In comparable phrasing, the Economic Community of West African States (ECOWAS) set up a West African Power Pool (WAPP, 1999) to achieve 'physical integration by means of infrastructures'. A similar constellation of ideas led the South African Development Community (SADC) to establish the South African Power Pool (SAPP, 1995), the Association of South East Asian Nations (ASEAN) to plan an ASEAN power grid (1998), and the NAFTA countries to set up the North American Energy Working Group (NAEWG, 2001) to 'enhance North American energy trade and interconnections', including electricity.

International organizations

A different type of transnational force is global community building through the work of international organizations. In the history of international organizations, infrastructure-related organizations count among the earliest and most successful examples. Electricity-related organizations emerged rather late, as did the field of electrotechnical science.

Prior to World War I, the main organizations fostering coherence and community in the electricity supply world were electrical equipment manufacturers and leading national electrotechnical engineering bodies such as the American Institute of Electrical Engineers (AIEE, 1884; renamed IEEE in 1963) and its German counterpart, the Verein Deutscher Elektrotechniker (1893). In 1906 these and others founded the first international organization in the field, the International Electrotechnical Commission (IEC). Based in London (and later in Geneva), the IEC codified technical standards, definitions and symbols. By 1914 it had produced several lists of terms and symbols; since 1938 it has published the multilingual International Electrotechnical Vocabulary, which currently comprises some 20,000 terms. Today the IEC associates experts from industry, government, academia, test labs and others from over 130 member or affiliated countries.

In the interwar years several international organizations were added. The broadest of these was the London-based World Power Conference (WPC, 1923; later renamed World Energy Conference and World Energy Council), serving as a 'non-commercial, non-aligned' forum to discuss the world's energy questions, including electricity. Its first congress (1924) attracted some 1,700 delegates from 40 countries; by the 1990s it associated member committees in nearly a hundred countries. Again, members included representatives from power companies and electrotechnical manufacturers, but also policy makers, academic researchers, and user organizations.

Specifically focusing upon electric power exchanges, the International Council on Large Electric Systems (CIGRE, 1921) was set up as a platform 'to develop and distribute knowledge' related to electricity generation and high-voltage transmission. Today it links over 4,000 individual and collective members in some 80 countries. The International Union of Producers and Distributors of Electrical Power (UNIPEDE, 1925) was established by the electrotechnical industries of Italy, France and Belgium, but quickly gained more members. It prime task was the study of problems of efficiency and operation and to promote the electrotechnical industry. It included non-European members, but focused mainly on Europe. In 1999 UNIPEDE merged with the European lobby group Eurelectric (1990). Also the International Energy Agency (1974), founded in response to the first oil crisis, includes primarily European countries among its 26 industrialized members.

Electrical integration and fragmentation

The earliest cross-border interconnections linked producers and consumers or individual utilities on different sides of the border, rather than interconnecting power pools or countries. These include a hydropower system in the bi-national town of Rheinfelden, which expanded into Germany and Switzerland from 1898, and a transmission line across the US-Canadian border at the bi-national

Niagara Falls in 1901. Many such rather local projects followed in the next decades. From 1916, subnational power pools in Eastern Denmark and Southern Sweden were linked by a submarine cable.

Structural attempts for regional electrical integration took off from the 1950s and 1960s. However, its asymmetrical and incomplete nature puts the transnational dimension of electricity into critical perspective. Electricity trade is generally dwarfed by the domestic production of individual countries. According to US Energy Information Administration statistics in 2004, transnational power flows worldwide only amounted to about 3 per cent of net domestic production, meaning that an overwhelming 97 per cent of electricity flows circulate within national borders. Moreover, transborder power exchange developed a regional scope only in 'Europe' (here including former COMECON countries) and 'Eurasia' (the former Soviet countries). There, virtually all countries participated in regional power pools. In 2004 'European' exports amounted to some 312 terawatt hours (TWh), constituting about 9 per cent of net domestic production. The figures for 'Eurasia' were 83 TWh and 6 per cent, following a significant decline in the 1990s.

In 2004 significant transborder power flows existed in the Americas, but these were completely dominated by a few bilateral exchanges. These include US imports from Canada (33 TWh) and the Paraguayan yields of the giant bilateral hydroelectric power projects at Itaipú (1984) and Yaciretá (1995), which were almost completely exported (45 TWh) to Brazil and Argentina respectively. Transnational power exchanges in the Middle East and Asia remain negligible. In Africa exports rapidly increased in the last decade following the creation of several regional power pools mentioned above; compared to domestic production, however, they remain minor.

Regional electrical integration was relatively successful only in Europe, but a closer look reveals ruptures even there. European electrical integration typically proceeded in distinct mesoregional blocks. The OEEC set up the Union for the Coordination of Production and Transport of Electricity (UCPTE, 1951; currently UCTE) to arrange multilateral electricity exchanges, but only for Western Europe. The COMECON set up its own regional power pool, the Interconnected Power System of the Central Dispatch Organization (IPS/CDO, 1962), The IPS/CDO synchronized and cooperated with a third pool, the USSR United Power Systems (UPS). Simultaneously, utilities in the Nordic countries – where Nordic economic integration still counted as a viable alternative to Western European integration – set up their own Nordic electric power collaboration called Nordel (1963). French, Spanish and Portuguese utilities established the Union Franco-Ibérique pour la Coordination de la Production et du Transport de l'Électricité (UFIPTE, 1963). Italian, Austrian, Yugoslavian and Greek utilities too established their own cooperation (SUDEL, 1964).

UFIPTE and SUDEL coordinated networks which operated synchronously with the UCPTE, of which they became full members in the 1980s. Nordel, which currently coordinates the best integrated power pool in the world, did not join the UCPTE. However, it did develop an intensive collaboration with UCPTE members through submarine high-voltage direct current power cables (which do not require system synchronization). After 1989 the Central Eastern European IPS/CDO was dissolved. Several members disconnected from the successor to the USSR network and synchronized with the UCPTE network instead, culminating in the so-called Trans-European Synchronously Interconnected System (TESIS, 1995). The former Soviet system continued as a separate international power pool as former Soviet republics gained independence. Here several countries were caught in a dilemma. The Baltic republics of Latvia, Estonia, and Lithuania, for instance, chose electrical disconnection from the USSR system as a key arena to achieve national independence in the late 1980s. Later they found their power exports to Russia too valuable to lose, and continued to cooperate, while slowly exploring collaboration to the North and West.

Electrical integration thus proves a deeply political phenomenon. In terms of power flows, it is still much less important than (sub)national electricity circulation. However, recent transnational blackouts suggest that economies and societies have nevertheless become electrically interdependent, albeit in an unexpected way. Breakdowns may cascade through interconnected systems across national borders. In the 'Northeast blackout' of 2003, a failure in Ohio caused a power outage for some 50 million Americans and

10 million Canadians. In the same year, a failing Swiss-Italian cross-border line plunged some of Switzerland and almost the entire Italian peninsula into darkness. In November 2006, a power failure in northern Germany cascaded through the network as far as Morocco and Croatia. Experts expect more such failures to occur in the coming years.

Vincent Lagendijk
Erik van der Vleuten

Bibliography

Cardot F. (ed.) 1987. *1880–1980: un siècle d'électricité dans le monde: actes du premier colloque international d'histoire de l'électricité*. Paris: Presses Universitaires de France.

Hughes T. P. 1983. *Networks of power: electrification in Western society 1880–1930*. Baltimore: Johns Hopkins University Press.

Lagendijk V, 2008. Electrifying Europe: the power of Europe in the construction of electricity networks. Unpublished doctoral dissertation, Eindhoven University of Technology, Eindhoven.

Lagendijk V. 'High voltages, lower tensions: the interconnections of Eastern and Western European electricity networks in the 1970s and 1980s', in Bussière E., Dumoulin M. and Schirmann S. (eds) 2006. *Milieux économiques et intégration européenne au XXe siècle: la crise des années 1970 de la conférence de La Haye à la veille de la relance des années 1980*. Brussels: Peter Lang, 137–65.

Trédé M. (ed.) 1992. *Electricité et électrification dans le monde: Actes du deuxième colloque international d'histoire de l'électricité*. Paris: Presses Universitaires de France.

Van der Vleuten E. and Kaijser A. (eds) 2006. *Networking Europe: transnational infrastructures and the shaping of Europe 1850–2000*. Sagamore Beach: Science History Publications.

Related essays

borders and borderlands; broadcasting; European Union (EU); intergovernmental organizations; international non-governmental organizations (INGOs); Internet; League of Nations system; mail; pan-isms; radio; railways; regional communities; regions; technical standardization; telephone and telegraphy; transportation infrastructures; world orders