Interpreting transnational infrastructure vulnerability : European blackout and the historical dynamics of transnational electricity governance

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Interpreting transnational infrastructure vulnerability: European blackout and the historical dynamics of transnational electricity governance

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ABSTRACT

Recent transnational blackouts exposed two radically opposed interpretations of Europe's electricity infrastructure, which inform recent and ongoing negotiations on transnational electricity governance. To EU policy makers such blackouts revealed the fragility of Europe's power grids and the need of a more centralized form of governance, thus legitimizing recent EU interventions. Yet to power sector spokespersons, these events confirmed the reliability of transnational power grids and the traditional decentralized governance model: the disturbances were quickly contained and repaired. This paper inquires the historic legacies at work in these conflicting interpretations and associated transnational governance preferences. It traces the power sector's interpretation to its building of a secure transnational power grid from the 1950s through the era of neoliberalization. Next it places the EU interpretation and associated policy measures against the historical record of EU attempts at transnational infrastructure governance. Uncovering the historical roots and embedding of both interpretations, we conclude that their divergence is of a surprisingly recent date and relates to the current era of security thinking. Finally we recommend transnational, interpretative, and historical analysis to the field of critical infrastructure studies.

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1. Introduction

In the emerging literature on Critical Infrastructure, electric power grids count among the most 'critical' of all modern infrastructure (Lukasik, 2003; De Bruijne, 2006; Gheorghe et al., 2006, 2007; Perrow, 2007; Kröger, 2008). Uninterrupted electricity supply is crucial to many economic and social processes as well as the functioning of other types of infrastructure. Moreover, the transnational character of present-day electricity infrastructure implies the presence of transnational vulnerabilities—disturbances in one country may affect economic and social life in others. Accordingly, electricity infrastructure is prioritized in European Union (EU) Critical Infrastructure Protection programs (Burgess, 2007; Fritzon et al., 2007), and electricity infrastructure reliability concerns found a prominent place in EU energy policy (e.g. Piebalgs, 2009).

Debates on transnational electricity infrastructure vulnerability and governance received a boost with several transnational blackouts. The so-called 'European blackout' of Saturday 4 November 2006, or 4/11, was particularly impressive in speed, geographical reach, and symbolic impact. Due to a curious

combination of events, a tie-line in North-Western Germany tripped that Saturday at 22:10:13. In about 20 s, a cascade of power line trippings spread as far as Croatia and Portugal; synchronization of the continental network was lost, and more lines and generating units failed as overloads and underloads proliferated throughout the subcontinent. The event affected over 20 countries where electricity supply was cut selectively to some 15 million households. Via the Spain-Morocco cable the 2006 disturbance even closed lights in North Africa (UCTE, 2006a,b, 2007). This event exposed the 'European integration' dimension of infrastructure vulnerability even more clearly than the infamous blackout of 28 September 2003, which affected a handful of countries but was—and is—generally referred to as 'the Italian blackout'.

Several commentators and investigation reports (Bialek, 2007; UCTE, 2006b, 2007) suggested that to understand what happened in such blackouts, one must look at history. In an earlier paper, we have followed up on that suggestion and examined how the logic of the 2006 'European blackout' was shaped by design choices from the past, resulting in a particular configuration of present-day electrical Europe with associated transnational vulnerabilities and governance structures (Van der Vleuten and Lagendijk, 2009). While doing so, we found that the debate following 4/11 is no less interesting than the event itself to the student of transnational infrastructure vulnerability and European integration. For 4/11 exposed two radically opposed interpretations of Europe's

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electricity infrastructure: To most newspaper journalists and EU policy makers, the 'European mega-blackout' showed that Europe's power grid was fragile and in need of a more centralized form of governance. Indeed, to them it was insufficiently 'European.' Power sector spokespersons, on the other hand, saw the event as a confirmation of the reliability and functionality of Europe's transnational power grid and the adequacy of its decentralized governance model: the 'system disturbance' was quickly contained and repaired with minimal inconvenience for consumers. Moreover, in this view the power sector and its (non-governmental) international organizations are the true hosts of continental Europe's electrical integration.

Understanding these conflicting interpretations of 'vulnerability/reliability', 'Europeanness', and associated governance preferences is important because they inform recent and ongoing negotiations on transnational electricity infrastructure governance. Vulnerability perceptions currently help legitimize an array of EU interventions, and the power sector struggles to handle this new situation.

This paper seeks to inquire these conflicting stakeholder interpretations and associated transnational governance preferences from a historical perspective. In the historical shaping and embedding of both interpretations we expect to find explanations for the evolution of their content, the roots of their conflict, and their persistency today. A historical perspective, then, may also help to understand what happened *after* 4/11. We trace the power sector's perception of high reliability to its efforts to build a secure transnational power grid for continental Europe from the 1950s through the turmoil of neoliberalization. Next we place current EU interpretations of power grid fragility and calls for governance centralization against the historical record of EU (and forerunner organizations) attempts to gain foothold in transnational electricity infrastructure governance. Finally, we interpret stakeholder responses to recent transnational blackouts and ongoing electric vulnerability debates from the perspective of these historical legacies.

To achieve this, we draw on recent work inspired by a transnational turn in technological history (Misa and Schot, 2005; Van der Vleuten, 2008) and infrastructure history in particular (e.g. Van der Vleuten and Kaijser, 2005, 2006). The contours of Europe's electrical integration have been sketched and analyzed in a dissertation by Lagendijk (2008) based on archival material from multiple international organizations. The present paper reinterprets some of this material for the questions at hand and draws on additional archival research, examining all vulnerability-related publications and archive minutes of the Union for the Coordination of Transport of Electricity since its establishment in 1951 as well as relevant material from the European Commission.

Before continuing, however, we will briefly illustrate the conflicting interpretations of European electricity infrastructure vulnerability after the 'European blackout' of 4/11 and embed our inquiry of these interpretations in the literature on infrastructure criticality.

2. Interpreting vulnerability

Reactions to the 'European blackout' of 4/11 by Europeanist politicians, power sector spokespersons, and the popular press clearly illustrate the above-mentioned interpretations of Europe's transnational power grid. Most newspaper reports were quick to foreground the alleged fragility of this grid, which they blamed in particular on its insufficient governance structure, decentralized in the hands of transmission companies and their international associations. This view was largely based on statements by pro-

European Union politicians. For instance, the Associated Press article 'German-triggered blackout exposes fragile European power network' (*International Herald Tribune* and *USA Today*, 5 November 2006) cited Europeanist politicians pleading for an increased role of the European Union in electricity matters. Italian Prime Minister and former European Commission President Romano Prodi argued that there is 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'.¹ The *Frankfurter Allgemeine* (6 November 2006) agreed that the existing decentralized and voluntary organizational framework 'was no longer *Zeitgemäß*'. EU Energy Commissioner Andris Piebalgs issued a press release stating that 'these blackouts ... are unacceptable' and 'confirm the need for a proper European energy policy. Energy security is better delivered through a common European approach rather than 27 different approaches' (Commission of the European Communities, 2006a). Later Piebalgs continued that 'it is now clear that the EU internal market needs stronger cooperation ... Soon I will propose concrete measures to address this problem', including an EU-level regulator, formally binding legislation, and perhaps a European priority interconnection plan (Commission of the European Communities, 2006b). An investigation report by the European Regulators Group for Electricity and Gas (ERGEG), established a few years earlier on EU initiative to support the introduction of EU legislation in Member States (De Palacio, 2003), further confirmed that 'the events of November 4 uncover a legal and regulatory gap in Europe's electricity market' and that EU action and legislation was needed (ERGEG, 2007, p. 4). This discourse of fragility and insufficient sector governance is important because it helped legitimize new EU legislation and a new EU-level regulator that have since been established or are well under way (Piebalgs, 2009; Commission of the European Communities, 2009).

The twin claims of power grid fragility and the necessity of EU-level intervention to repair it, however, were rejected by power sector representatives, arguing that disturbances like 4/11 are extremely rare. Moreover, in this particular event existing security measures and (decentralized) governance structures worked well to contain and repair the system failure. The lights stayed on for the overwhelming majority of European consumers. In those areas where power needed to be cut, the network was back on-line mostly within 30 min and completely within less than 2 h. The inconvenience for consumers remained minimal. On behalf of German Transmission System Operator RWE, Theo Horstmann therefore stated that 'the network's safety measures worked perfectly.' President André Merlin of the French transmission system operator RTE agreed that 'Europe's power network had worked smoothly' (both cited in the *International Herald Tribune* of November 5, 2006). Later this interpretation also characterized the final investigation report by the international association of Transmission System Operators (TSOs), the Union for the Coordination of Transport of Electricity UCTE (terminated and merged into the European Network of Transmission System Operators for Electricity ENTSO-E on 1 July 2009): 'due to the adequate performance of automatic counter-measures ... a Europe-wide blackout could be avoided. The decentralized responsibilities of TSOs have demonstrated their efficiency' (UCTE, 2007, p. 6, our italics).

To make sense of this situation academically, we may briefly refer to a parallel debate in organizational sociology on large technical system reliability. On one hand, Normal Accident Theory (Perrow, 1984, 2007) has foregrounded that modern technological

¹ Because of a spelling mistake in *Herald Tribune*/ *USA Today* articles, we here cite the same quote in *BBC News*, 6 November 2006.

systems have become so complex, with many feedbacks, causal loops, and possibilities for cascading failure, that they became susceptible to breakdown that cannot be predicted or anticipated. Breakdown and vulnerability thus became an inherent, ‘normal condition’ of such systems and are the subject of inquiry in this field of scholarship. Electricity supply is an often cited example, in particular nuclear power plant failures and cascading blackouts. On the other hand, High Reliability Theory was developed to study why many such complex technological systems in fact operate at exceptionally high reliability levels and rarely break down. Apparently build-in redundancies, continuous organizational adaptation, and other security measures go a long way in preventing disruptive failure (Roberts, 1990; La Porte, 1996; Rochlin, 1996). In this body of work, electric power systems are prominently included as examples of high reliability.

Recently this debate has been revived in Critical Infrastructure scholarship, and again electricity supply figures prominently. Several scholars rung the alarm bells and argued, with recent blackouts in mind, that Europe’s power grid is ‘at risk’ and that ‘a higher level of coordination’ or a new, Europe-wide regulatory body is needed (e.g. Gheorghe et al., 2006, 2007). On the other hand, a number of publications on critical infrastructure reliability after privatization, liberalization, and deregulation, found that large scale electric power, telecommunications, and water supply organizations developed new strategies to maintain very high levels of reliability (Schulman et al., 2004; Roe et al., 2005; De Bruijne, 2006; De Bruijne et al., 2006; De Bruijne and Van Eeten, 2007). Even during the infamous Californian blackouts of 2000/2001 ‘notwithstanding the popular view of rolling blackouts the lights by and large actually stayed on’ (Roe et al., 2005, p. 2).

In order to simultaneously grasp both the fragility and reliability perspective in one and the same analysis, we connect to the constructivist tradition in risk studies, which made the shaping of risk perceptions itself a subject of inquiry (Jasanoff, 1998; Summerton and Berner, 2003). Risk perceptions do not equate to ‘objective risks’ and develop in specific settings such as ongoing practices within organizations or interactions between stakeholders. The shaping of risk perceptions, in other words, involves historic processes in specific institutional settings (Boudia and Jas, 2007). We will follow up on this here and inquire the historic shaping of reliability as well as vulnerability perceptions regarding transnational electricity infrastructure in relation to transnational governance preferences and developments. We will do so for two distinct historical settings: the power sector’s international associations working on power system integration and reliability, and the European Union (and its direct forerunners) attempting to gain foothold in transnational infrastructure governance. As we shall see, regarding vulnerability issues these settings collided only recently.

3. The making of a high reliability organization

The electric power sector perception of reliable transnational power grids developed in the context of international electric power collaboration, which emerged in the first-half of the 20th century and accelerated after the Second World War. We described elsewhere why and how such collaborations developed and how local, national, and international grid building were not simply successive developments, but—at least partly—simultaneous and mutually constitutive processes (Van der Vleuten, 1998, 2010; Van der Vleuten and Lagendijk, 2009). For our present inquiry, a key event is continental Europe’s power sector representatives setting up the *Union for the Coordination of Production and Transport of Electricity* (UCPTE, later UCTE, currently ENTSO-E) in 1951 to

coordinate a synchronized Western European power pool. They were motivated by economic as well as reliability reasons. Economic gains would for instance stem from sharing emergency power generating capacity so that investment costs for individual utilities could be reduced, and exploiting surplus hydropower resources that were wasted in member systems: henceforward all available water could be led through the turbines and fed into the power pool, enabling a decrease of fuel costs in thermal power stations elsewhere in the system (UCPTE, 1976). As for reliability, synchronous collaboration implied several possibilities for system stabilization. For instance, a frequency drop caused by any power station failure would be immediately counteracted by the still operational generators in the pool; the larger the pool, the more generators to stabilize the frequency, the less impact of failure. In this way, ‘all production units in the synchronous system jointly counterbalance the disturbance of one power station, regardless if this power station would be located in Lisbon, Palermo or Hamburg, le Havre or Vienna’ (UCPTE, 1976, p. 167), an arrangement known as primary control.

Importantly, from the beginning the UCPTE collaboration was organized in a decentralized fashion, which also came to characterize the topology of Europe’s power grids. To be sure, a centralized model of supranational power grid financing, building, and management had been repeatedly promoted by Europeanist politicians in the early 1930s and US Marshall Plan negotiators in the late 1940s, not to mention the pan-European power grid planned in Nazi Germany (Lagendijk, 2008; Van der Vleuten and Lagendijk, 2009). Power sector organizations and spokespersons, however, repeatedly resisted these initiatives because they favoured informal, decentralized collaboration on a voluntary basis, building cross-border power lines only if it provided sector advantages in terms of economy or reliability. Accordingly the UCPTE was set up as a non-governmental body of utility representatives and delegates of public administrations, who participated on a voluntary basis. Participating utilities remained fully in charge not only of network building and supply in their own supply areas, but also of financing, building, and operating cross-border connections, of which they maintained full ownership. As we shall see, this decentralized organization became an intrinsic part of the high reliability discourse of the power sector.

3.1. Securing the system

While synchronized collaboration gave reliability gains for the participating power companies, it also introduced the possibility of a different type of system disturbance in the form of cross-border cascading failure, where overloads and underloads transplant throughout the network—as happened on 4/11. The power sector’s international organizations such as the UCPTE, but also UNIPED and others, therefore amply studied measures of anticipating this new form of failure from the 1950s (De Heem, 1952; UCPTE, 1959; Cahen and Favez, 1964).

Indeed, the UCPTE made system reliability a cornerstone of its activity. By the mid-1960s, when the 1965 rolling blackouts in the United States provided a renewed sense of urgency, the UCPTE distinguished a number of potential system disturbances and associated countermeasures that their members should implement (UCPTE, 1965, 1966). The overall strategy was that the Western European system should consist of interconnected yet separately managed networks, and that decentralized network managers were responsible for reliability in their own supply areas. 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’ (UCPTE, 1966, pp. 6–7).

These principles inspired a set of precautionary measures, many of which helped to contain 4/11 almost half a century later. A number of design principles should reduce the chance of disturbance in all member areas. If disturbances should nevertheless happen, it was important to prevent long-lasting damage. Therefore, all system elements should possess protection equipment, automatically disconnecting the element if system parameters crossed predefined thresholds, shutting it down before it burnt down. Once the system parameters improved again, the element should be automatically re-connected. On 4/11, it was such automatic protection gear that caused the line and generator trippings, and soon after brought the equipment back on-line again.

To contain and counter such failures, UCPTE members should provide for sufficient back-up capacity throughout the interconnected system. This included generation capacity—members should at all times run back-up capacity (in the 1960s corresponding to some 3–5% of the expected load or the largest power station in the pool), and erect emergency generating units that could be started relatively fast, such as gas turbines. It also included other equipment: Cross-border interconnections, in particular, should have ample spare capacity to be used in case of incidents. Later the general rule became that entire systems must always be operated with at least the so-called single back-up capacity (N-1 back-up), denoting that if one system element fails, the other elements are able to absorb the additional load (UCPTE, 1990, p. 22). This rule was violated on 4/11.

Should cascading failure happen despite these measures, cascading overloads should be countered by automatically tripping generators, while cascading frequency drops should be contained by selectively disconnecting consumers. For this purpose members should 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 under a certain threshold. These should preferably be executed automatically by means of frequency relays. On 4/11, indeed the blackouts for some 15 million households were due not to malfunctioning equipment but to such controlled load shedding, which secured uninterrupted supply of the large majority of households in the infected zone.

Next, to restore the system after failure, UCPTE members were responsible for improving system parameters in their own supply areas. To facilitate coordination of such decentralized response, telephone and telex connections should be established between the control centres of neighbouring members. On 4/11, such coordination possibilities were used insufficiently to prevent the first line tripping in Northern Germany, but to contain and repair the subsequent cascading failure little additional coordination proved necessary. A final measure proposed in the mid-1960s was the introduction of monitoring equipment to detect irregularities in the operation of power stations, load centres, and international TIE lines. These later grew into data processing programs such as SCADA (Supervisory Control and Data Acquisition) and EMS (Energy Management System).

These measures and procedures required considerable investments in the 1950s and the 1960s, but they seemed to work: In the 1970s and the 1980s, the UCPTE system counted as highly reliable. Simulations suggested that local failures did not lead to cascading failure and did not compromise overall system security (e.g. UCPTE, 1986). The successful containment of a major failure in Brittany, France on 12 January 1987, where some 9 GW of generating power was lost, confirmed the system's resilience in practice (UCPTE, 1987; RTE, 2004: 256). At the eve of neoliberalization, the UCPTE concluded that although it could not provide absolute guarantees, coordinated purposeful action produces 'a very high degree of reliability of power supplies, without

incurring costs which are out of all proportion' (UCPTE, 1990, p. 20).

Importantly, the organization repeatedly emphasised that such reliability was best achieved in the informal and decentralized governance model of the UCPTE: 'Decentralization is indispensable for *economy, security, and continuity* of supply on the regional level' (UCPTE, 1976, p. 153, our italics). UCPTE spokespersons found that participating utilities in the collaboration knew the particularities of their own systems much better than any centralized organization could ever hope for: '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' (UCPTE, 1976, p. 188). Therefore, in sharp contrast to present-day EU policy initiatives, it was widely believed that a *centralized* transnational governance model would put the system *at risk*.

3.2. Reliability in the neoliberal era

Yet it is precisely the UCTE's decentralized model of transnational governance that has been accused of inadequacy in recent years. One often heard hypothesis is that neoliberalization changed the secure state of Europe's transnational power infrastructure. The restructuring policies of the 1990s (privatization, liberalization, and deregulation) led to institutional fragmentation, which might have affected the reliability of Europe's electricity infrastructure negatively: in the new unbundled institutional framework, UCPTE infrastructure vulnerability governance might no longer work. Current research on critical infrastructure in an institutionally fragmented environment, however, does not univocally support this hypothesis (Roe et al., 2005; De Bruijne, 2006; De Bruijne and Van Eeten, 2007). While on one hand critical infrastructure indeed became more complicated to manage, on the other hand infrastructure organizations worked hard to cope with the new challenges and found ways to secure systems even under these difficult conditions. They for instance developed resilience-based strategies rather than risk anticipation strategies, invested in real-time monitoring and control options, and stimulated 'thick communication' between control centres to facilitate creative response to unexpected failures. Although critical infrastructure presently operates closer to its limits, in general it still provides extremely reliable services.

We may make a similar case for the UCPTE, which continued its work for a reliable electric power system during the years of institutional restructuring. As the European Union pushed the Internal Electricity Market and the associated unbundling of electricity production and transport (see below), governing cross-border flows became a responsibility of what were now called Transmission System Operators. To anticipate these changes the UCPTE first changed from personal to company membership in 1996, then changed its name to UCTE in 1999 (dropping the P for production to signal that it was now an TSO organization), and finally in 2001 re-established itself as an international association under Belgian law: In the organization's own words, it had developed from a gentlemen's 'club' to a system security rule setter and system adequacy 'watchdog' association (UCTE, 2000, p. 27; UCTE, 2001).

In this new situation, too, the UCTE perception of Europe's electric power system remained one of high reliability. Initially the UCTE was alarmed by the new developments: competitive pressures might jeopardise system security and increase the possibilities of blackout (UCPTE, 1998, p. 15), and the common carrier principle might complicate international coordination. Unable to withstand or block EU policy, the UCTE engaged in a debate with the European Commission to accommodate its

concerns in EU policy. It was quickly reassured: a few years later the UCTE disagreed with critics who held that institutional unbundling, competition, and short term profit would necessarily compromise system security. UCTE spokespersons now argued that such fear was based on the ‘wrong assumption’ that power supply in the pre-competition era had been purely security focused and not cost-driven, while in reality economic and reliability concerns had gone hand-in-hand. Furthermore, deregulation of production and supply certainly implied mutations in vulnerability governance but did not make it impossible: ‘the UCTE believes that the new deregulated market environment is compatible with an adequate level of system reliability’ (UCTE, 2000, p. 25). To take just one example, the cost of primary control providing immediate reserve and frequency stabilization was previously integrated in the overall prices of generation and transmission. After deregulation and unbundling, power generators offered generation reserve to TSO’s, implying more complex contractual arrangements but also more transparency since the price of primary control was explicit. The UCTE itself distributed primary control responsibilities between TSOs and specified technical parameters; in accordance with the decentralized governance model, TSOs had decentralized autonomy in how to achieve these norms.

Meanwhile, new technologies geared to the new situation were explored, improved and introduced (Kling, 1994, 2002; Breulmann et al., 2000). For instance, by 2000 Wide Area Monitoring Systems (WAMS), as a supplement to SCADA/EMS systems, offered real-time information on grid conditions in over 30 key nodes in the UCTE network. Such monitoring equipment was accompanied by innovative Wide Area Control Systems (WACS). In addition, UCTE security rules were tightened, particularly with a security package in 2002. Existing rules were sharpened and systematized in the eight policies of the UCTE Operational Handbook (UCTE, 2004a), seven of which were in force on 4/11 (on load frequency control and performance; scheduling and accounting; operational security; coordinated operational planning; emergency operations; communication infrastructures; and data exchange policies). The remaining policy on operational training was released after the blackout. In order to enforce these standards, a multilateral agreement should make the operation handbook specifications legally binding for participating TSOs in the UCTE area, which entered into force in 2005. Finally, the so-called *Compliance Monitoring and Enforcement Process* was developed to verify TSO implementation of the agreed standards and define measures in case of non-compliance. A pilot was running in 2006 and published in 2007; this system was not yet fully operational during 4/11 (UCTE, 2007, p. 12).

3.3. Interpreting blackout

As the result of this sustained effort to secure European electricity infrastructure in years of radical restructuring, many stakeholders and analysts still considered continental Europe’s electric power system extremely secure. The UCTE system adequacy forecast for 2003–2005 and other documents noted that although cross-border power flows were increasing and in some locations the system was operated near its limits, ‘the security of the UCTE system as a whole seems to be not at risk’ (UCTE, 2002b, p. 5). The large ‘Italian Blackout’ of 2003 did not fundamentally change this view: to the UCTE it confirmed that there was little slack in the system at some points, not least concerning Italian reserve generation capacity and load shedding programs. Yet the disturbance (which originated in Switzerland and threatened to infect France, Austria and Slovenia) was contained everywhere except in Italy. Besides, in Italy itself

supply was restored within 5 h in Northern Italy and 10 h in the entire mainland. The UCTE found ‘no fundamental deficiencies in the existing rule setting of the UCTE system’ (UCTE, 2003, p. 11; 2004b). Also the existing decentralized governance model 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*’ (UCTE, 2004b, p. 10, our italics). In the next year, UCTE members again succeeded to run their systems in ‘a highly secure and reliable manner’ (UCTE, 2004c, p. 5). A year later the adequacy forecast for 2005–2015 did not anticipate major risk and expected a ‘reasonable security margin’ by 2010 (UCTE, 2005, p. 5).

The UCTE interpretation of 4/11 as a demonstration of the well-functioning of UCTE reliability measures and its associated decentralized governance model closely follows the historical lineage portrayed in this section. Although the UCTE final investigation report recommended improvements in UCTE rules and practices, reconstructions of 4/11 showed that the disturbance had never been beyond control. After all, it was not equipment malfunctioning but pre-installed equipment protection gear that caused the trippings as it was supposed to, securing the equipment from harm, and enabling quick recovery when system parameters improved. Controlled load shedding and other predefined measures kept the lights on for most consumers. The areas sacrificed to achieve this overall system performance were back on-line mostly within 30 min (and everywhere within 2 h) thanks to effective decentralized management responses. In the final analysis the impact of 4/11 on consumers was limited, especially when compared to disturbances in low and medium voltage distribution networks (where by far most faults happen). In the Netherlands, for instance, for consumers and small businesses 4/11 made up less than 2% of the annual average power outage per consumer per year (Ministry of Economic Affairs, 2007, p. 11). Hence, the power sector interpretation of 4/11 as a demonstration of well-functioning transnational power infrastructure security measures and governance.

We conclude this section by observing that some economists have taken the interpretation of infrastructure reliability a step further. Prior to 4/11 a group of Dutch economists issuing a number of reliability studies emphasised that what is needed is not a zero failure perception of reliability, but rather a so-called social optimum: additional security is possible only at disproportionately high cost. Yet ‘the power grid of most Western European countries is highly reliable. Most utilities provide power more than 99% of the time’ (Baarsma et al., 2005, p. 1). This argument is close to the power sector’s self-understanding. But then these economists argue that from such a social optimum perspective, the system may be *too* reliable: the current high reliability levels resulting from the past ‘engineering practices’ might have lead to *over-investment* in power grids (Baarsma et al., 2005). From an economic perspective, consumers might prefer a reliability *decrease* if it comes with lower electricity costs (Baarsma, 2004, p. 9; compare Kling, 2007).

This sector perception of high reliability, let alone the cited economists’ perception of excessive reliability, contrasts sharply to the message conveyed in most newspaper reports after 4/11 and subsequent EU policy making. We shall now turn to this perception of extreme system vulnerability.

4. Governing power: the EU and transnational infrastructure governance

To make sense of the EU perception of, and response to, 4/11, we have to consider quite a different historical setting: The

process of EU (and EU forerunner organizations) involvement in transnational infrastructure governance.

We start by noting that by the time the Brussels organizations became important players in this game, European transnational infrastructure development and governance were already well established (Van der Vleuten and Kaijser, 2005, 2006; Van der Vleuten et al., 2007; Schipper and Van der Vleuten, 2008; Schot and Lagendijk, 2008). For the case of electricity, we already encountered the UC(P)TE as a major player in transnational electricity infrastructure governance. In addition the *International Electrotechnical Commission* (established 1906), the *International Council on Large Electric Systems* CIGRE (established 1921), the *Union of Producers and Distributors of Electricity* UNIPED (established 1925, currently EURELECTRIC), the *World Power Conference* (established 1924, currently *World Energy Council*), the *International Energy Agency* (established 1974), and also electricity commissions of the *League of Nations* (1919), the *United Nations Economic Commission for Europe* UNECE (established 1947), or the *Organization for European Economic Cooperation* OEEC (established 1948) engaged in transnational electricity infrastructure governance. All predominantly used ‘soft power’ tools such as facilitation and negotiation, research, standard and best practice development, recommendations, and voluntary agreement (Lagendijk and Van der Vleuten, 2009). The bottom line is that for over a century a number of international organizations engaged in transnational (electricity) infrastructure governance. This implies that the persistent habit of EU spokespersons to equate cross-border European cooperation and integration with EU institutional history is highly problematic. It also implies that we may analyse the history of Brussels-involvement in transnational infrastructure governance as a long and strained negotiation process between the EU (and its forerunner organizations) and other international organizations.

4.1. Prelude

In the 1950s, 1960s, and 1970s, the balance of power between stakeholders resulted in placing transnational infrastructure governance in the hands of sector representatives, active in sector-specific international organizations or the infrastructure committees of more general purpose organizations such as the UNECE. Direct EU forerunners born as collaborations between six member states Belgium, France, Italy, Luxembourg, the Netherlands, and the Federal Republic of Germany, i.e. the *European Coal and Steel Community* ECSC (established 1951), the *European Economic Community* EEC and *Euratom* (both established 1957), and the *European Communities* merging these organizations (established 1967), were largely bypassed. This is remarkable, because integrationist thinkers and politicians at the time saw transnational infrastructure as a producer of integration spillovers and thus a major candidate for common policy (Schot and Schipper, 2009; Schot, forthcoming).

This bypass has already been investigated for telecom and transport infrastructure. A common telecommunications policy, though suggested in the Spaak report (Spaak et al., 1956) preparing the EEC and EURATOM treaties, was not included in the EEC treaty due to lack of consensus. Some EEC member governments continued to push for a common telecommunications policy, including improvement and operation of a transnational telecommunications network. Yet they failed as other members preferred less restrictive organizational settings with much broader membership such as the *International Telecommunications Union* and the *Conference of European Post and Telecom administrations*, set up in 1959 as a sector-based, non-

governmental, broad-membership alternative to EEC governance (Laborie, 2006).

The Spaak report also recommended a common transport policy, and indeed transport did make it into the 1957 EEC treaty, announcing a Common Transport Policy as a logical next step in the integration process. Yet it failed to come off the ground until the European Court's *inactivity verdict* of the EU's transport efforts marked a new beginning in 1985 (Schipper, 2008). Again, this does not mean that European transnational transport collaboration and governance did not exist; rather, European governments and other stakeholders preferred collaboration outside the EEC framework in institutions such as the UNECE and the Conference of European Ministers of Transport established in 1953 (Van der Vleuten et al., 2007; Henrich-Franke, 2007; Schipper, 2008; Schot and Schipper, 2009), jointly developing and implementing for instance the European E-road network. In this period EEC initiatives in European patent and research cooperation, too, poorly developed as member governments and stakeholders preferred to cooperate outside the EEC framework (Kranakis, 2004, 2008).

An explicit common energy policy, like telecommunications policy, lacked in the 1957 EEC treaty. However, failure of a common response to the reopening of the Suez Canal in 1957—which threatened domestic coal production in several EEC Member States—placed a common energy policy firmly on the agenda by the early 1960s, aiming for a common energy market and security of supply (Daintith and Hancher, 1986). Similar to the transport case, however, a common energy policy failed to materialize, and observers have commented that, [t]here is general agreement that energy policy must be ranked as one of the Community's major failures' (Padgett, 1992, p. 56; compare Kohl, 1978). Again Member State governments making EEC decisions could not agree on a community energy policy, leaving transnational energy governance implicitly or explicitly in the hands of stakeholders and international organizations outside the Brussels framework.

Moreover, if energy policy was addressed, it largely excluded electricity infrastructure. In marked contrast to present-day EU debates, already the 1956 Spaak report found that electricity and gas infrastructure was dealt with quite satisfactorily by sector organizations, which it found well prepared to address their technical and economic specificities. Hence, these domains were less urgent candidates for a common policy (Spaak et al., 1956, p. 126). Work on a common energy policy in the early 1960s, located at an Interexecutive Working Group on Energy (set up jointly by the ECSC, EEC, and EURATOM in 1961), also foregrounded energy source problematics rather than infrastructure issues. Such a common policy on fuels, in turn, was repeatedly frustrated by Member State concerns for domestic coal market protection (Lucas, 1977, p. 35). By 1964 a Protocol of Agreement on Energy Policy intended to introduce a fairer competition between energy sources, a wider diversification of oil supplies, and prices as low and stable as possible. Another major point would be the provision of Community procedures to harmonize national measures in the energy sector (Hassan and Duncan, 1994, p. 164). Yet much of the momentum created by the 1964 Protocol and the subsequent Suez crisis vanished and no concrete measures were taken.

With the 1967 merger treaty, the three Communities ECSC, EEC, and EURATOM combined and the Working Group on Energy was replaced by the Directorate-General for Energy. Only in 1968 the Council accepted Guidelines for a Common Energy Policy to change the situation of severely hindered trade and transit of energy within the Community (Commission of the European Communities, 1968), seeking secure primary fuel supply and low and stable prices. This time, network-dependent energy forms like

electricity were mentioned as needing common regulations for open access and tariffs. But again results were disappointing. Even the 1973 OPEC oil embargo did not lead to an extension of Community energy policy; rather it proved once more that energy 'is an extremely sensitive area of national sovereignty' in which member states were reluctant to tie their hands in the Brussels cooperation (Kohl, 1978, p. 111).

4.2. Stepping up involvement

The Brussels organizations only started to interfere seriously with electricity infrastructure governance in the 1980s, in parallel with new initiatives in the domains of telecommunications and transport. The first breakthrough was the adoption of the Single European Act in December 1985, which set a target date (1992, later postponed) for realizing a common energy market, including an internal market for electricity (Commission of the European Communities, 1987, 1988; Schmidt, 1998). The 1992 Treaty on European Union added EU involvement with Trans-European Network planning and financing, and by 1994 the first priority interconnection lists were decided, including a number of transnational power lines (European Council, 1994).

In this period, the EU managed to assert itself firmly as an important player in transnational electricity infrastructure governance, despite protest from the electric power sector. Following the promise of low electricity prices for their domestic industries and associated employment benefits, Member States now tended to back the European Commission instead of electric power interests. This change in the balance of power made opposition by power sector representatives less effective. As an alternative strategy, power sector organizations now started to lobby the EU and their national governments for modifications in policy packages with varying degrees of success: The negotiated character of this process shows for instance in the different ways of 'downloading' EU policy to the national level, where different member states arrived at different solutions (Padgett, 2003). At the international level, power sector organizations such as the UC(P)TE and UNIPED reoriented their efforts towards Brussels. The UCTE settled permanently in Brussels in 2001. In further anticipation of increasing EU influence, the UCTE, the Scandinavian power association *Nordel*, and the TSOs of Ireland and Great Britain jointly established the *European Transmission System Operators* ETSO in 1999 to harmonize network access and conditions for usage, in particular for international electricity trade (UCTE, 2002a, p. 27). Finally, the European Commission set up the *European Regulators Group for Electricity and Gas* ERGEG in 2003 as an association of national regulators to assist the implementation of EU directives in Member States (De Palacio, 2003, p. 34).

Importantly, throughout these changes in transnational electricity governance, EU spokespersons and documents rarely questioned electricity infrastructure reliability and the power sector's decentralized governance mode, as it would later. The vulnerability-perception of Europe's electric power infrastructure had not yet taken root. For instance, in its policy document *The Internal Market* the European Commission (1988, pp. 27 and 68–69) still praised the highly interconnected electric power system and recognized that international exchanges were managed well by sector organizations such as UC(P)TE and *Nordel* without government interference. The Commission was concerned chiefly with social and economic cohesion and making Europe more competitive. To reduce 'the costs of non-Europe' (Commission of the European Communities, 1988, p. 6) affecting European economic performance, it therefore prioritized 'economic and competitive aspects of electricity' (Commission of the European

Communities, 1988, p. 75), leading to other governance issues such as monopoly control, the common carrier principle, and competition between power producers. Security of supply was only mentioned as an add-on. Also in the next step, the formulation of the Trans-European Network program for electricity infrastructure, reliability and its governance were not problematized. Focus remained on economic advantages and much attention went to electric power grids in Central and Eastern European countries through the PHARE and TACIS programs.

4.3. The invention of vulnerability

The EU perception of electricity infrastructure as 'vulnerable' only entered centre stage with the 'Italian Blackout' of 2003 and smaller blackouts in Denmark, Sweden and the UK that same year. As UCTE President Martin Fuchs observed, the issue of 'security of supply' 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' (UCTE, 2003, p. 4). Indeed, the energy security debate launched by the European Commission in 2001 still had been all about fossil fuel import dependencies, the necessity of keeping oil stocks in EU member countries, and diversifying supply; electricity did not figure at all, as it does in current EU energy security documents. Yet a week after the 'Italian blackout', the Italian Minister of Productive Activities Antonio Marzano, chairing the EU Energy Ministers Energy Council, together with European Energy Commissioner Loyola de Palacio, placed the 'security of energy systems, in particular electrical power' at the top of the agenda for the next meeting of EU energy ministers (Commission of the European Communities, 2003). Two months after the 'Italian Blackout' the European Commission proposed a directive for the security of electricity infrastructure. It suggested rules for member state governments and TSOs on electricity infrastructure security and was formally adopted after several amendments in 2005 (EurActive, 2007).

From 2003, then, electricity infrastructure vulnerability became a key concern of EU policy makers and entwined with other policy initiatives; it became an integral part of the movement of extending EU influence into the domain of transnational electricity infrastructure governance that we summarized above. Why was this so? We propose—pending further research—that the foregrounding of infrastructure vulnerability, so different from the sector's own perspective, resonated well with the rapid emergence of security thinking in EU contexts. EU analysts have observed a rapidly emerging policy concern with security and safety of European citizens in the last decade or so: They speak of a new EU 'security identity' associated with an emerging 'protection policy space', which addresses transboundary threats from disaster response and counter-terrorism to food safety and avian influenza (Boin et al., 2006). This development produced an acceleration in the formal European integration process as EU interference in these fields proved hard to resist: fear is a powerful driver. The EU program for Critical Infrastructure Protection negotiated in the wake of 9/11 (2001) and the Madrid (2004) and London (2005) terrorist attacks fits this pattern (Burgess, 2007). We may also interpret the renewed focus on energy (import) security in the early 2000s, following 1999 oil price increases, as an early sign of this concern. More recently, the framing of the recent Third Energy Package presents EU energy policy as a response to the threats of global warming and energy vulnerability. Even the familiar concern for an internal energy market, previously framed as an economic growth and employment boosting strategy, is recast in defensive terms as a

vulnerability counter move (for ‘investments will not be made in an uncertain regulatory environment’) next to threats to Europe’s competitive position (Piebalgs, 2009, p. 5).

We propose that the combination of ongoing EU attempts to add energy to its sphere of influence, which became more successful since the mid-1980s, and the growing EU security identity since the late 1990s, led EU politicians to react very differently to the 2003 ‘Italian Blackout’ compared to power sector representatives. This pattern was repeated and reinforced following 4/11. EU Commissioner Piebalgs found in the ‘European blackout’ a confirmation of the transnational security threat stemming from electricity grids, and captured the opportunity to strengthen his argument for EU policy measures he was in the process of designing. Incidentally, more recently Piebalgs also used the 2008 financial crisis as a supportive argument for the Commission’s energy measures (EurActive, 2008). Given the current balance of power between stakeholders, EU advance in the domain of transnational energy and electricity infrastructure governance seems rather successful so far and resulted in a number of unprecedented policy measures, 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 (*The Independent*, March 25, 2006).

Unable to resist this increasing EU pressure, the UCTE did not manage to convince policy makers of its interpretation of high reliability and adequate transnational sector governance, as it had done successfully in earlier decades. Once more it now needs to anticipate and accommodate increasing EU influence, for instance by organizing security conferences and by establishing a stronger collaboration with other regional TSO associations in the new *European Network of Transmission System Operators for Electricity* (ENTSO-E (established in 2008)). From an institutionalist perspective this sector strategy of being a ‘proactive step ahead’, anticipating the establishment of an EU-level regulator, seems to draw the power sector even further into the EU version of European integration (compare Sandholz and Stone Sweet, 1998).

5. Conclusions

Let us briefly summarize our main argument. While studying the transnational blackout of 4/11 2006 (Van der Vleuten and Lagendijk, 2009), we observed a remarkable discrepancy in stakeholder interpretations of the vulnerability of Europe’s transnational power infrastructure and its governance. For EU policy makers Europe’s power grid proved fragile and in need of a more centralized form of governance. For power sector spokespersons, the event was a confirmation of the adequacy of Europe’s transnational power grid and its decentralized model of transnational governance. These conflicting interpretations are important because they inform recent and present day negotiations on transnational electricity infrastructure governance, which regularly find EU policy makers and the power sector at cross purposes.

The paper investigated the historical shaping and embedding of these conflicting interpretations. The debate between Normal Accident Theory and High Reliability Theory helped us to make sense of our two conflicting positions, and a constructivist notion of risk suggested that these could co-exist and develop in two distinct institutional settings. We then studied two such settings. We traced the power sector perception of high reliability to many decades of dedicated work on transnational system building and associated security arrangements. These security measures rely on decentralized TSO agency, which is why power sector

representatives repeatedly portrayed centralized governance, allegedly insensitive to member system particularities, as a security threat. By contrast, the EU perception of power grid fragility developed in a quite different historical setting of binding together a Europe of war prone states in a supranational organization committed to building a peaceful and economically strong Europe after the Second World War. Its incorporation of policy domains accelerated in the 1980s, but the decentralized mode of transnational electricity infrastructure reliability governance remained largely unquestioned—until the current era of increasing concern to protect citizens from transnational security threats, which produced recent EU interventions and its push for stronger international cooperation between international TSO associations. We conclude that the collision of both interpretations is very recent. Still, both tie into strong, historically shaped rhetoric reservoirs that give them their pervasiveness in present debates: the power sector interpretation was developed in the 1950s and the 1960s and subsequently adapted to the neoliberal era, while the EU interpretation recently linked vulnerability issues to the pervasive rhetoric of core values in the EU project.

In addition to providing a historical understanding and explanation of these conflicting interpretations in present day transnational electricity infrastructure governance debates, our case suggests several other contributions to the field of critical infrastructure (CI) studies.

First, it illustrates the relevance of transnational analysis to this field. Several CI authors have suggested that one of the most ‘critical’ features of modern critical infrastructure resides in its transnational character (Gheorghe and Vamanu, 2005, p. 218) or even that new critical infrastructure-related risks are ‘international by nature’ (Gheorghe et al., 2007, p. 6). The great majority of CI studies, however, address (sub)national cases. There is a need for transnational analysis in CI studies, which is about questioning and examining rather than presupposing relations between local, national and international developments (Van der Vleuten, 2008). Examining a case of transnational infrastructure vulnerability, we found that the ‘international by nature’ argument is not beyond dispute. Counter arguments—like vulnerabilities in Europe’s high voltage grid being much lower than local, medium and low voltage distribution networks, where by far most faults happen and which account for the great majority of power interruptions for consumers—seem to call for further refinement of this theme.

Second, our case underscores the relevance of interpretative analysis of critical infrastructure issues. Constructivist authors have demonstrated such relevance for the fields of risk and risk management (e.g. Jasanoff, 1998; Summerton and Berner, 2003). Similarly, the transnational criticality of modern infrastructure is subject to interpretation and contestation that needs further study. Notably, to inquire interpretations seriously and impartially means that it will not do to dismiss one of several competing interpretations as ‘incorrect’—much like risk perception studies in older psychometry work distinguished between the ‘real risks’ as assessed by experts and ‘perceived risks’ in the heads of lay persons (Jasanoff, 1998). Inquiring competing interpretations on their own terms, this paper brings into view the logic and pervasiveness of each. It also spotlights the realm of interpretations as an important site of negotiating transnational governance forms.

Third, this leads us to the relevance of historic inquiry for CI as well as energy policy studies. Several papers in this journal have, implicitly or explicitly, made the case for historic studies as a welcome addition to the other forms of analysis of present-day energy and infrastructure issues (e.g. Van der Vleuten and Raven, 2006; Verbong and Geels, 2007; Högselius, 2009; Lehtonen and Nye, 2009). Next to producing knowledge from empirical sources

on which further theoretical inquiry can build, such studies produce historical explanations of the particularity of the current situation that may escape predominantly theory-driven approaches. Furthermore our case demonstrates that the shaping and pervasiveness of two conflicting positions on transnational infrastructure vulnerability should be understood in the context of sequences of events that span decades or more. Finally, a long-term perspective brings into view the important irony that dedicated work to reduce certain types of infrastructure vulnerabilities (say interconnection of continental Europe's power plants to provide mutual back-up and system stability) may itself produce new types of vulnerabilities (in our case, the possibility of cascading failure). This paradox has been observed in national case studies (e.g. Disco and Lintsen, 1998; Van der Vleuten and Disco, 2004) and seems to apply equally to transnational infrastructure vulnerability. In sum, infrastructure develops in 'infrastructural time' and begs for scholarly perspectives that transcend the short memory of political and media time (Edwards, 2003).

Finally, this paper speaks to an emerging literature on the role of technology and infrastructure in European integration (for a research agenda and recent overview see Misa and Schot, 2005; Van der Vleuten, 2008). Transnational infrastructure has been an important arena for the interpretation and negotiation of European integration and fragmentation (Van der Vleuten and Kaijser, 2005, 2006; Van der Vleuten et al., 2006; Lagendijk, 2008; Schot and Lagendijk, 2008; Schipper, 2008; Schot and Schipper, 2009; Badenoch and Fickers, forthcoming). In line with ongoing historical research on critical European infrastructure (Kaijser et al., 2008), our case brings into view the potency of vulnerability perceptions—fear and threat—in such processes. Outside the formal EU integration project, vulnerability considerations were a key driver for UCPTE work on Europe's electrical integration way ahead of formal political integration efforts. Within the formal EU integration process too, crises acted as catalysts: 9/11 and subsequent terrorist attacks (Burgess, 2007), the Ukrainian gas crisis of 2006 (Westphal, 2006), and—despite their minor impact for citizens—the transnational blackouts discussed in the present paper provided windows of opportunities for EU-led European integration.

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