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Security and Risk in a Liberalized Electricity Infrastructure: Does Competition Compromise Resilience?

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During the past decades, large societal infrastructures such as electricity networks, gas, water supply, and telecommunications have been increasingly opened up to competition on international markets. This has been driven by several related aims: streamlining activities, improving efficiency, and increasing transparency among industries that operated as natural monopolies before (Graham, 2009). However, a number of criticisms, many of them by social scientists, have stated the unintended effects of market competition. According to this argumentation, increasing competition between different providers can compromise infrastructural resilience: If market liberalization increases complexity and interconnections in infrastructure systems, then their high-consequence, low-probability failures become almost inevitable according to the sociological Normal Accidents argument (Perrow, 1999). However, even if these systems were more prone to accidents than before, their reliable management can still mitigate risks according to another popular counter-argument (called High Reliability Theory, Roe & Schulman, 2008).

This paper interrogates these theories and explanations empirically by drawing from fault statistics of the Finnish electricity supply system between 1958 and 2013, published by the policy association Finnish Energy Industries (formerly Finnish Electricity Association), and running through the Finnish electricity market liberalization that started in 1995. Measuring energy system resilience through how long it takes for the customer electricity supply to be restored after disturbances, I present a longitudinal exploration of how different risks emerged in the increasingly internationally-connected and market-based electricity supply infrastructures. Specific emphasis is laid on the difference between city and country-side infrastructures, cross-border energy trading, weather events, and diffusion of renewable energy generation.

There is a growing number of studies of disasters, conflicts, and social crises triggered by electric power failures. Among these works, the most general argument states it is large systems as such that provoke critical breakdowns: Being a very tightly coupled and complex system, failures are inherent to any large-scale power grid (Stern et al., 2005). This sociological Normal Accidents perspective (Perrow, 1999) is however utilized in more depth by acknowledging contemporary changes in energy systems. It is now widely agreed by organizational scholars (Perrow, 2007; Roe & Schulman, 2008) and critical urbanists (Graham, 2009), but also by the energy industries at least in Europe (UCTE, 2007) that the deregulation of energy systems can have various kinds of unintended effects. Specifically, in exceptional cases, it can lead to volatile market transactions that the electricity transmission infrastructure was not originally designed for (UCTE, 2007). On the average, international collaboration raises efficiency and distributes risks among local energy companies; yet, according to critics, it creates a different risk of wide-ranging infrastructure failures that can cascade from one national system to another (Van der Vleuten & Lagendijk, 2010).
An initial look into the Finnish electricity interruption statistics seems to support the above critical discussions rather directly (see Figure 1). After World War II, the system was operated mainly by municipalities and the state and was centrally planned from 1980 through 1995 (Myllyntaus, 1991). The statistics suggest a constant decrease in failure levels until the Finnish electricity market liberalization in 1995. During the liberalization though beginning already in the 1980s, the volume of cross-border energy trading with Sweden, Russia, later Estonia, and to a lesser extent Norway has raised significantly (Nordel, 1978-2008). The amount of energy generated from renewable sources has also grown since the early 2000s, though with the exception of biofuels and hydro power the Finnish renewable generation remains modest compared to most other industrialized European countries (Eurostat, 2015). During the last twenty years, the amount of personnel has also decreased visibly in many utility sectors including electricity supply (Eurostat, 2012), doubtlessly due policy aims for cost efficiency under liberalization. After 1995 in the statistics, the duration of electricity supply failures begins to grow noticeably especially in what they understand as the Finnish country-side. This includes a number of difficult years such as 2001, 2013, and especially 2011, when country-side electricity interruptions rose to levels previously experienced in the late 1950s.

![Figure 1. Minutes of lost electricity supply per customer per year in Finland, 1958-2013. Sources: Finnish Electricity Association & Finnish Energy Industries.](image)

The first part of my subsequent full paper subjects the historical failure data to a more systematic statistical analysis. It asks whether the faults occurred in different years could be considered random events or whether there is measured correspondence between liberalization and electricity supply quality. Yearly measured data of electricity interruption durations from 1958 to 2013 is used to address this question on the general level. Potentially, the number of electricity interruptions per each day of the year from 2004 to 2013 (where data exists) could also be analyzed in depth in order to find more nuanced trends over these ten years. The second part of the analysis turns to more interpretation concerning the results and their statistical styles of reasoning. This task also means looking beyond these particular statistics and comparing them with other sources about energy in society.
One issue in this latter context is the aging of infrastructures: the large part of Finnish electricity networks was built in the 1960s and the 1970s and the average lifetime of all components in the Finnish power grid is 40 years (Energiavirasto, 2011), hence the components are approaching the end of their cycle and possibly more prone to failure. Initial large-scale electrification especially in the country-side was supported by regional and societal justifications as well as direct state funding (Myllyntaus, 1991; Kajser, 1994). However, for about ten years, the growing share of the Finnish population has been expected to live in cities, as elsewhere in the world (Kangasharju, 2004). Against this backdrop, it may no longer be straightforward to recur to public justifications and direct state of funding of rural electrification, especially as the infrastructure industries have been liberalised and are highly accountable for their investments and costs.

Let me also return to the factor that less people are working in electricity utilities now (Eurostat, 2012) even as the Finnish electricity infrastructures themselves have either stayed the same size or continued expansion in some areas. First of all, this decrease of personnel tends to weaken the sociological argument that electricity grids maintain “high reliability” due to the skills and safety culture among their human operators (Roe & Schulman, 2008). As crucial as skills and a culture of safety can be, the electricity infrastructure is actually being increasingly automated by adding information and communication technologies, resulting in expected “smarter” electricity grids (European Commission 2011). The benefits of these “smart grids” for activating energy consumers, managing risks, and cost-efficiency are often expressed by energy experts (Schick & Winthereik, 2013) as well as high-level policy makers (European Commission, 2011). Yet, its risks are not as well understood and pose potential research questions for further analysis. In the financial sector, for comparison, fully automated high-frequency trading has brought specific contagion effects, unforeseen consequences, and even inequalities caused by a varying access to information infrastructures (MacKenzie, 2014).

Lastly, statistically, the majority of reliability issues with Finnish electricity systems continue to be caused by weather such as storms, wind, snow, and ice. Technical researchers often raise this point and note that climate change will increase problems with the electrical supply (VTT Technical Research Finland, 2006). A detailed analysis of average days with storms and strong wind, levels of precipitation historically, and on the frequency of severe weather events in Finland could all be of interest to address this question. At the same time, the reliability statistics themselves seem to indicate that while the duration of electricity interruptions has changed over time, their average causes stay markedly similar over the decades: then as now, weather is the key culprit. This stability of causes can undermine the observation that contemporary electricity networks are disrupted by more difficult natural environments than before, as commentators have often suggested.

In sum, the questioning opened up by this paper paves way for a fuller analysis on several levels. Using statistical techniques, it is possible to dig deeper into statistical trends behind electricity power failures in Finland, utilizing the exceptionally detailed body of historical data that Finnish energy industries have produced about these matters and made available. On the more interpretative level, issues about aging infrastructures, the difference between rural and urban infrastructures, automatisation of “smarter” electricity grids, and effects of weather on the electricity infrastructure are all questions that need deeper analysis. Operating in society like the energy infrastructure, liberalization works alongside many different dynamics and temporalities of the energy systems and their change. How precisely it produces its effects amid other transitions requires further analysis to be developed in the full version of this paper.
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