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Governance for climate-change adaptive capacity in the Swedish electricity sector

Do changes in structure and culture matter?

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Abstract

The article analyses the capacity for climate change adaptation (CCA) in the Swedish electricity grid sector. Utilizing two perspectives from organization theory it directs attention to changes in the sector, from the 1980s until 2010, with radical change with an NPM-reform in 1996. For the time before 1996 findings indicate a high CCA capacity. The reform led to a reduction in this capacity through an increased emphasis on economic efficiency, although there also has been some room for robustness-considerations. The article shows that organizational culture and formal structure influence the capacity to adapt to climate change.

Introduction

Southern Sweden was hit hard by the storm *Gudrun* on 8 January 2005. Some 70 million m^3 of trees were toppled over, equivalent to a year's forestry production. The high winds and falling trees ripped down pylons and the electricity distribution grid, leaving more than 600,000 consumers without power, some for up to twenty days (Swedish Energy Agency 2005:31). Restoring the electricity supply was a daunting task, with insufficient personnel and poor communications, and road access blocked by trees further reducing accessibility. The Swedish electricity sector had simply not been prepared for such an event.

In the future, the frequency of extreme weather is expected to increase in Sweden, in tandem with rises in precipitation levels and temperature, longer growing seasons, and possible changes in wind patterns (SOU 2007:60). With these changes in climate, the electricity sector will need to adapt and alter its approach to emergency preparedness and resilience building on the ground (Schlager and Heikkila 2011). While dramatic weather events will inevitably cause havoc, the preparedness of the energy utilities will significantly influence the severity of the damage. This view of adaptive

capacity is highly relevant for future climate change, but also for current vulnerability and adaptations.

This article looks into the deeper structures of the capacity for climate change adaptation (CCA) in Sweden's electricity supply, and asks: How do changes in formal structure and organizational culture influence and shape the ability of the sector to adapt to abrupt and gradual climate change? 'Formal structure' in the context of this article refers to regulations, rules and lines of command that determine who can do what; while 'organizational culture' includes dominant norms and values within the sector (Christensen and Peters 1999). *Adaptive capacity* is generally understood as the ability to change by reducing vulnerability or enhance resilience in response to observed or expected changes in climate or associated extreme events (Adger et al. 2007:720). In practice, CCA capacity will also depend on a range of additional social factors, as well as resources, knowledge and cost-benefit considerations (Adger, Lorenzoni and O'Brien 2009) and individual competencies (Van Wart and Kapuchu 2011).

In larger systems, decisions about adaptation costs and benefits are made in an organizational setting, and it is therefore necessary to look into this domain of adaptation. An organizational view on CCA capacity will typically focus on the factors that encourage building a resilient and robust grid system within the organization in question, for example an electricity utility. In the CCA literature, however, the importance of these factors has been generally overlooked (Berkhout, Hertin and Gann 2006; Inderberg 2011).

The article analyses how CCA capacity has changed in the Swedish electricity grid sector over a period of some 30 years: from the early 1980s to 2010. This sector, consisting of transmission and distribution companies, has responsibility for developing and running the grid, and ensuring security of supply, while being regulated by the Energy Market Inspectorate (EI).

Organizational changes in the sector have been formidable. In the 1980s the Swedish system was vertically integrated, with the same companies usually performing production and transport of electricity. The sector was also self-regulated: state-owned Vattenfall, the largest company, set the electricity prices, and the other utilities related to this price. In 1996 the new Energy Act completely restructured the country's power sector. The Act established competition between generation-companies while the grid companies, being natural monopolies, were made subject to government regulations. With these changes professional demographic and cultural changes followed, with a move from an engineer-dominated to an economist-dominated electricity sector.

As these changes in both cultural paradigms and formal structure in the sector emphasize different types of decisions, there is reason to expect that they have influenced the ability of the grid companies to adapt to climate change (Inderberg 2011). This article employs an *organizational-instrumental perspective* and an *institutional-cultural perspective* to shed light over CCA capacity (Christensen et al. 2007). These complementary perspectives illuminate important mechanisms that can be generalized between comparable cases (George and Bennett 2005). In addition, the role of external incidents is accounted for in the analysis. The analysis is thus an important step towards understanding the dynamics of Sweden's electricity industry, but also CCA capacity in general within an organizational context.

The empirical data used consist of official Swedish reports and research literature, as well as information gathered from interviewees. Ten semi-structured interviews have been conducted and representing a wide type of actors. The regulator officials were selected based on their knowledge of the regulating schemes over time, as well as com-

pany behaviour relating to this. Representatives from the large companies Vattenfall and E.On, and the small Kramfors Energiverk, were chosen specifically, as well as the interest organisation Swedenergy, and the Swedish Energy Agency and The Energy Market Inspectorate (EI). The individual interviewees were chosen based on experience due to the long time-perspective for the research, and were selected from mid- to high level professionals. This secured a broad representation both between organizations and types of actors.

Questions were directed on developments over time, and included questions about formal regulations, changes in these and how the companies responded to them, vulnerability to climate change, appropriate actions to these, and changes in culture in the sector. The interviews mapped background information but also specific indicative data on informal changes in legitimate actions and core thinking. As precise numbers or formalized data on for example professional demographic changes or cultural change do not exist, personal accounts provide data on indications about cultural and informal change within the sector.[1] These are triangulated and differences in the accounts are noted in the text.

All interviewees were asked similar specific questions but were also asked to reflect freely on the issues.

The next section presents the assumptions and expectations of the instrumental and the institutional-cultural perspectives. Section three maps the changes in the Swedish energy sector, before we turn to the influence of changes on the CCA capacity in the electricity grid sector in section four. Finally, in section five, conclusions are drawn about the changes in the sector, how they have influenced the ability to adapt, and what these findings may mean for CCA capacity more generally.

Organizational perspectives on adaptive capacity

Analyses of adaptive capacity have often emphasized general formal factors like resources and information, *or* a more cultural approach (Oppermann 2011; see also O'Brien et al. 2006; Yohe and Tol 2002). While individual characteristics and awareness of vulnerability are important for adaptation and emergency management (Van Wart and Kapucu 2011, Grothmann and Patt 2005), the institutional settings yields important influence for CCA capacity (Næss et al., 2005). This article combines formal and cultural factors, and explores how CCA capacity is influenced in an organizational setting. It uses perspectives inspired from organization theory, as called for by Berkhaut et al. (2006). The two perspectives, the *organization-instrumental perspective* and the *institutional-cultural perspective* (Christensen et al. 2007) are useful for illuminating different dimensions of CCA capacity.

For the *organizational-instrumental* perspective, a key hypothesis is that formal organizational structures influence actions, and therefore can be perceived as tools or instruments for behaviour (Christensen et al. 2007:144). A consequential logic drives action, and modifying structures are embedded within the intra- or inter-organizational structure. Bounded rational organizational agents, who satisfy goals and yield limited information, will act on the basis of formal rules creating incentives for desired behaviour, and sanctions against undesired behaviour. The formal rules can be changed

[1] Based on information from Sanela Cehic in the Swedish Energy Market Inspectorate November 2010, formal data on professional demography does not exist.

according to the desired goals, thus modifying rationality limitations to satisfy different organizational goals (March and Simon 1958; Simon 1976).

CCA capacity will be constrained by the resources and information available. The formal structure – as in the form of definition of the boundaries between organizational units or public regulatory schemes – can both facilitate or hinder adaptation to climate change, and is therefore a crucial factor for CCA capacity. By changing the rules or structures to fit the different goals, the formal structure can influence and channel attitudes and actions, resulting in a different organizational outcome.

According to this perspective, high CCA capacity involves a clear distribution of responsibility between organizational units, clarity in the distribution of professional competence, and clear expectations to the grid companies as regards grid maintenance and back-up. It should also create incentives for maintenance and robustness-building of the technical system, while making available the resources to do so.

The *institutional-cultural perspective*, on the other hand, sees organizational actors as constrained by institutional factors – leading and stable routines, norms, and values that can both restrict and empower action. The old definition of institutionalization is still valid: the process whereby organizations or organizational fields are infused with value over time, beyond the technical requirements of the task at hands (Selznick 1957:17). The values infused provide stability, but may lead to organizational inertia (Hannan and Freeman 1984). Behaviour is based on perceptions of 'appropriateness' as defined by shared tacit assumptions – norms, values, beliefs – which underlie administrative behaviour (Christensen and Røvik 1999; March and Olsen 1989). Individuals and organizations thus fulfil or enact identities by following informal rules and procedures that they consider appropriate to the situation at hand, matching roles and situations through such informal 'rules' (March 1994; March and Olsen 1989).

Different patterns of appropriate behaviour can also appear in implicitly agreed *institutional logics* within an institutional setting or organizational field (Thornton and Ocasio 2008). These can often be captured by professional values or other entities (Reay and Hinings 2009), and may compete, co-exist, or be defined out, through organizational processes of change (Lounsbury 2007; Reay and Hinings 2009).

On this backdrop, CCA capacity depends on a normative and legitimacy basis *where adaptation is an appropriate consideration for grid companies*. Barriers to CCA will exist where the institutionalized values fail to provide a legitimate basis for implementing of adaptation actions. Organizational high CCA capacity is in evidence when the prevailing culture in the organizational field provides a legitimate basis for maintenance, social responsibility, robustness of the system, and for taking climate changes seriously. Where the organizational culture is in accordance with reducing vulnerability and/or increase resilience, this will favour adaptation and adaptive capacity. If these goals of adaptation are not seen as legitimate organizational goals, the organizational culture will reduce adaptive capacity.

The transformation of the Swedish electricity sector

Sweden's electricity network predominantly facilitates the flow of power from the north of the country, where most of the generating capacity is located, to the south, where there is greatest power demand. The national grid is owned, developed and managed by the Transmission Network Operator (TSO) Svenska Kraftnät. The larger production companies typically own the regional transmission grids of the 13 regions, consisting of 70-KV to 130-KV lines. This network transports electricity between the national grid

and to the distribution networks, which bring it out to the end users (International Energy Agency 2008). Approximately 180 local grid companies distribute electricity to end users through the low-voltage grid.[2] Some 90 per cent of Swedish power supply is generated by hydropower and nuclear power, in approximately equal shares.

The Swedish electricity system began as a vertically integrated self-regulating system. The years before deregulation are often referred to as the 'monopoly times' (Norleden 2003:61), since the companies produced, transmitted and distributed electricity on the basis of area or line concessions, with no competition. By the 1980s, a self-regulatory system had been developed, in effect regulating the electricity price more or less without real political interference. Since the early years, a price commission has been available for consumers wishing to file complaints against electricity prices (Söderberg 2008:43). However, since prices were largely based on self-cost, there was in reality little need for this safety valve. The state-owned energy company Vattenfall, which dominated the 'market', was highly influential, with the other companies largely related to the prices set by Vattenfall. This also applied to some privately owned companies, like Sydkraft and Gullspång, and contributed to the implicit self-regulation of the system.

Sweden's electricity policymaking was from early on heavily influenced by the 'iron triangle' of industry, labour unions and government (Nilsson 2005:212). The low power prices helped to boost electricity consumption, effectively reducing petroleum dependence while spurring Swedish industrial growth. From just under 5 TWh in 1920, electricity consumption rose exponentially every year to 127.4 TWh in 1987, before flattening out (Högselius and Kaijser 2007:48f). These developments were facilitated in various different phases: a boom in hydropower capacity from 1945 to the mid-1970s; then the years 1979 to 1985, when nuclear power capacity was developed. In the same period the transmission and distribution grid expanded as well.

Municipalities and/or electricity-intensive industries owned most electricity utilities. For these owners, the importance of low electricity prices to facilitate other public goals outweighed short-term corporate economic considerations in the generating company itself (Högselius and Kaijser 2007:36). The general view in the sector was that cheap electricity would contribute to a positive upward spiral of wider developments, with continually reduced prices accompanied by expanding electricity usage, and this pushed short-term economic gain in the background. Also for the largest company, state-owned Vattenfall, the goal was not to extract large revenues, but to produce cheap electricity for the good of the nation (Högselius and Kaijser 2007:45).

Until the 1980s, the authorities focused on increasing generation capacity, and the organizational demography reflected this. In Vattenfall around half of the staff were engaged in engineering and construction activities. After 1985 these departments became less relevant, and maintenance and systems-operation gained importance (Högselius and Kaijser 2007:50). The goal of producing cheap electricity still dominated and directed behaviour, even though the companies became increasingly complex, and future trends seemed less certain after the long boost period ended in 1987.

Due to the structure of the sector, it was naturally dominated by engineers. We lack exact data on professions, but all the interviewees indicate that the engineering norm was the dominant paradigm of management at the time. The more experienced actors, in particular the interviewees from Vattenfall, E.ON and Kramfors describe this engineering norm as emphasizing the functionality and national developments of the system. This paradigm meant that long term thinking and investments to secure system

[2] The exact figure depends on how one calculates, and for which time period.

operation were generally prioritized over short term cost-benefit. However, the interviewees from Vattenfall also pointed out that also economic factors were relevant in decision-making, but still in a long-term perspective. This point was exemplified by one representative from Vattenfall, who argued that the marginal price was informally an important guiding principle for pricing strategy at the time – even with the core organizational culture still based on the engineering paradigm.

Towards the late 1980s, younger cohorts of electricity economists entered the field, although they remained marginalized (Högselius and Kaijser 2010). This group was important in contributing to sparking a cultural change later on; they emphasized economic considerations as more legitimate than the previous paradigm. However, prior to the reform of 1996, the impact of these norms was fairly limited. Some electricity economists were employed at important research facilities in the late 1980s and early 1990s, but they had yet to penetrate the whole field, including the regulator authority and the grid companies.

During the late 1980s, monolithic Vattenfall was inflexible as regards steering, due to its close linkage with the Swedish Parliament *(Riksdagen)* and the government. Most company decisions had to go through laborious processes in the parliament and the cabinet (Bladh 2005). This was a rigid system; by contrast, comparable companies abroad, like Statkraft in Norway, were more flexible (Högselius and Kaijser 2007:84). From 1988, Vattenfall was gradually transformed from a public corporation to a publicly owned limited company, a process that was completed by 1992. Previously, Vattenfall had also owned the main grid (Kärrmarck 2001:204). In 1992 Vattenfall was split up, and the newly established Svenska Kräftnet (SvK) took over full responsibility for the main grid.

The decision to unbundle Vattenfall was officially grounded in the dual purpose of efficiency: the expressed goal was to raise efficiency both in the public administration and through greater competition. Some analysts still question whether a lack of efficiency was a real problem in the sector (Bladh 2005:9f). At that point, the Swedish electricity industry *was not* generally regarded as a 'system in crisis'. On the contrary, 'The Swedish Model' was viewed as a success story (Högselius and Kaijser 2007). This lack of crisis seems to have led to a milder reform than what might otherwise have been the case. More emphasis should be put on the surroundings of the sector. Even though the Swedish reform was driven by efficiency considerations, the background can perhaps be traced back, at least partly, to general liberalizing tendencies, as well as the debate occasioned by earlier reforms in the UK and in Norway.

The reform and after

The 1995 adoption of the Energy Act was an important step towards the formal restructuring of the sector. This is the most significant change in the Swedish energy sector since its inception in the late 19th century, this time politically initiated from the top with the Energy Act. Vertically integrated companies were split up into generation and grid – the former exposed to full competition, while the grid utilities were placed under monopoly regulation. Through the unbundling of the sector, and later changes involving the metering of electricity, the character of the electricity sector 'changed from club to market' (Bladh 2002a:69): a change from gentlemen's agreement between the companies, to competition. This de- and re-regulation of the electricity market from 1996 can be seen as an important step towards New Public Management (NPM)-inspired liberalization. This consists of breaking up of organizational units into

autonomous ones, accompanied by the use of market measures, economic efficiency, and reduction of hierarchical structures (Pollitt 2001). This development is in line with trends within Sweden as well as from the UK and the USA (Bladh 2005). Several other sectors – among them, telecommunications, railroads, taxi services, and postal services – underwent similar processes (Statskontoret 2004).

Spot tariffs were now introduced, whereby the user pays for feeding in or taking out electricity at a point in the grid, and through this obtains the right to full access to the national network (International Energy Agency 2004:99). The same tariffs must thus apply uniformly to all customers in the same class regardless of location, although some adjustments are made for losses in transmission. For example, in Sweden, feeding into the grid is more expensive in the north than in the south of the country.

The sector was now unbundled, but how to regulate the natural monopolistic network utilities was not established by the Energy Act. In effect, the utilities remained unregulated for the first two years, according to representatives from the EI and the companies. However there were in reality certain limits as to how much increase in tariffs the grid utilities were allowed (Damsgaard and Green 2005:93). The grid companies continued business as usual. Consumers still had the right to appeal against the regulator's decision after 1996, but this opportunity was seldom used in the period, at least at the higher court levels (Söderberg 2008:43). Complaints against individual companies to the regulator, on the other hand, were quite frequent: according to interviews with the EI, this led to 'organizational constipation'.

The next step in regulation also was rather loose in 1999. It took the form of general restrictions on the distribution utilities, to prevent them from increasing prices faster than the weighted average of comparable prices (Jamasb and Söderberg 2010:251). This lasted up to 2003, when a Norm Model Regulation (NMR) was put in place. Interviewees from the EI and Swedenergy indicate that the inspiration came from the Finnish regulatory scheme rather than the more economic efficiency-geared Norwegian model (see Table 1 for overview of regulatory models). The NMR was based on a fictive optimal grid for the concession area of the grid company. This optimal grid was then compared to the real grid to illuminate efficiency considerations, before the revenue cap was determined after the regulatory period – *ex-post* regulation. Grid utilities were thus to decide investments based on an unclear regulation.

Table 1: Regulatory periods for grid utilities, Sweden

Period	Type of regulation
Pre-reform, until1996	Self-regulatory system/ no formal regulation
1996–1999	Little formal regulation
1999–2003	Price cap regulation, 'light-handed regulation'
2003–2007	Norm Model Regulation, ex-post
2007–2012	Intermediate regulation: 'light-handed regulation'
2012–-	Ex-ante regulatory framework

The model received heavy criticism from the grid utilities. There is significant consensus among all the interviewees that the NMR model was 'not complete' or 'not developed enough' when it was introduced as a regulatory scheme in 2003. It was neither transparent nor predictable for the companies; after regulatory inspections, most companies had to pay back dividends – to their surprise. The impression of a 'black box' regulatory model was thus established, and the NMR model suffered from a lack of legitimacy. The director of the inspectorate, Håkan Heden, was criticized for not

listening to the industry. Even though the model had been tested prior to implementation, its legitimacy was low. These claims are also explicitly confirmed by the interviewees from the regulator EI.

The next period of regulatory scheme coincided with a restructuring and leadership change in the regulator in 2007. While the Energy Agency formerly had a dual role as facilitator of generation and inspectorate within one body, as of 1 January 2008 the EI was established as a fully separate body (Energy Market Inspectorate 2008). The new director, Yvonne Fredriksson, took cognizance of the challenges involved in the NMR model, and cancelled it. This was also a response to the EU, which had challenged the transparency of *ex-post* regulations such as the NMR model. In 2007, the EI acknowledged that regulatory scheme should be more transparent and predictable for the individual company, and announced its intention to introduce *ex-ante* regulations. With this, the Swedish regulatory scheme entered a new 'intermediate phase'. Another light-handed regulation to prepare for the introduction of *ex-ante* regulation is to be put in place from 2012. This last step is clearly better-grounded. Interviewees in the grid companies, interest organizations and the IE see this last step as a good move for achieving a long-term regulatory framework with greater legitimacy.

The trend toward *structural change*, where unbundling leads to various mergers between production and distribution companies, was less strong than expected, at least initially (Norleden 2003:62). To some extent, cooperation and partnerships between companies compensated for the need to merge, but there have been some mergers. From well over 200 grid utilities in 2000, the total had been reduced to 177 companies running the distribution grid by 2007 (Jamasb and Söderberg 2010:257). Most of these mergers have involved companies within the same ownership structure, which gives the impression of a more dynamic sector than might actually be the case.

The reform also led to changes in *organizational culture.* However, interviewees from Kramfors, Vattenfall, E.ON and the EI have claimed that cultural changes have been less far-reaching than expected. The reform was inspired by similar changes in the UK and Norway, although these took place in a less abrupt fashion. Still, an important element in Sweden was the demographical change in the sector and the following shift in institutional logic. While, no formal data are available on the share of professions in the sector, all interviewees independently confirm that there has generally been an increase in economists – and more so in the larger utilities than in the smaller ones. The Kramfors interviewee along with the representatives from the larger Vattenfall and E.ON indicate that the small utilities often copy behaviour from the larger and more economist-dominated companies. As in other countries, the electricity economist has thus come to play an increasingly important role within the organizational field. So-called 'market thinking' has seeped into the sector, reinforced by Sweden's entry into the NordPool power exchange and its mutual ownership with Norway from 1996. This has also produced new types of companies, like electricity brokers and traders, forcing the whole sector into the new mode of thinking (Bladh 2002b). Gradually the culture has shifted towards a more economics-driven line of thought, while retaining some elements of the old paradigm. Sweden's Ministry of Finance has been dominated by economists, whereas the Ministry of Enterprise was traditionally dominated by engineers. From the 1980s there came a gradual trickle into the Ministry of Enterprise of younger economists who focused on energy markets (Högselius and Kaijser 2007:78). The basis for the two logics is summed up in table 2.

Table 2: Changes in culture in the Swedish electricity sector

Institutional logic	Core value	Appropriate decisions
Engineer	System function. Long term focus.	Investments that secure or increase system function.
Economist	Economic efficiency. Short time-horizon.	Cost efficiency is the legitimate criterium for decisions.

Put bluntly, the 1996 reform 'implied a redefinition of the boundaries between technical and economic competences within the electricity industry, to the advantage of the latter' (Midttun 1995:145). Whereas the earlier logic of decisions had been based on arguments that stressed system reliability and robustness, economic arguments gained importance – even though economic efficiency never became the primary goal.

According to interviewees from both the electricity companies and the regulator, some external incidents are worth noting due to their impact on organizational field culture. In particular the *Gudrun* storm was mentioned by all of the interviewees. It brought major problems for the electricity supply in southern Sweden in 2005, destroying much of the distribution grid and causing electricity outages for over 600,000 customers (Swedish Energy Agency 2007). Almost exactly two years later, another storm of similar intensity, *Per*, hit Sweden – but it resulted in less heavy damage. This would appear to be due to learning and heightened preparedness on the part of the grid utilities.

Prior to the *Gudrun* experience, some grid companies had opted for voluntary compensation to customers who suffered outages, but practice varied greatly. Representatives of the regulator and the companies alike hold that the impact of the storm raised Swedish awareness about security of supply and led to two major immediate changes, one formal and one informal.

First, the EI proposed a formalization of compensation to individual customers on an increasing scale, based on the length of the period of outage (Swedish Energy Agency 2005:9). This was implemented by 1 January 2006, and was tightened further in 2011 (Energy Market Inspectorate 2009:22).

The second implication has been the influence on organizational field culture, with awareness-raising as to the importance of grid robustness and security of supply. This has led to greater legitimacy for investing in system robustness. The concrete impact is evident in grid-utility investment patterns: almost all grid companies showed a doubling or tripling in their investments budgets after the storm *Gudrun* (Swedish Energy Agency 2007:47). In practice this has taken the form of more efficient tree clearance around overhead lines, and relocating the distribution network underground. For instance E.ON, the largest grid utility in Sweden, has confirmed its investments of 12 billion SEK (about €1.3 billion) in a distribution grid undergrounding programme (between 2005 and 2010), resulting in 17,000 km of subterranean distribution grid.

Almost exactly two years later Sweden was again hit by an extreme storm. This hit about the same area, and was of similar strength. The changes made by the grid utilities, however, led to significantly reduced vulnerability: about 440.000 customers experienced blackouts (more than 600.000 for Gudrun) and most got it back already after 5 days – although for some it took two weeks (Swedish Energy Agency 2007).

Summing up, we can say that the Swedish electricity grid sector has undergone considerable changes, both in formal structure and organizational culture. Splitting up the sector and exposing it to market forces still left the grid companies to be natural monopolies, regulated by inconsistent models over time. Some leeway for investing in

robustness of grid has generally been retained in the regulatory models. The organizational culture has shifted, from an engineering perspective which was also aware of economic considerations, to an predominantly economic line of thought which is also aware of engineering perspectives.

Change in formal structure and culture – change in CCA?

Prior to the 1996 reform, considerations of economic efficiency were overridden by the primary goal of expanding and tailoring the sector to serve the Swedish public. That included a focus on low electricity prices; however, prices were easy to revise as necessary because the system was in effect self-regulated and in practice controlled by the dominant company, state-owned Vattenfall. The *organizational-instrumental perspective* asks: how have changes in formal structure influenced the sector's CCA capacity? The pre-reform structure indicates a high CCA capacity because, as the system was being built out, the focus was on robustness and system resilience, with funding readily available through control over the price of electricity. Even though awareness of *climate change* was low at the time (indeed, it was not yet on the agenda), the system was able to handle potential vulnerabilities in relation to weather, and was constructed with robustness in mind. Since the electricity price was not divided between the cost of electricity and the cost of running the grid, these two functions were regarded as parts of a single system. This vertical integration kept the responsibility for robustness and adaptation within the companies while at the same time empowering them with the means to fund projects deemed necessary.

The formal structure of the electricity sector was radically changed by the Energy Act of 1995, which was bound to have implications also for CCA capacity as regards climate change. The restructuring of the sector has involved planned and intentional – instrumental – means to increase efficiency. This implies a choice between goals – such as economic efficiency, which gained importance at the expense of other goals in the goal hierarchy. This is shown by the unbundling of the sector, which exposed power generation to market forces (with expectancy of increased efficiency), while the transmission and distribution parts were put under government regulations.

According to the instrumental perspective, a weak formal structure or a structure with other goals than flexibility and robustness will mean low CCA capacity. On the one hand, a weak formal structure cannot be expected to steer behaviour towards desired organizational goals, or to increase adaptive capacity. Swedish regulatory models have been many in number and swift in their changes after the reform in 1996. The instrumental perspective also holds that it is necessary to account for information and limited rationality (Simon 1976), where frequently changing formal structures will take time for the grid-companies to process and relate to. The relatively short time-horizon with the price-cap regulation in anticipation of a changing regime, and the low legitimacy and short life of the NMR model, led to the network utilities to relate to the regulatory regime to a lesser degree than might have been the case in a consolidated regulatory framework – producing a weak formal structure with low legitimacy in general. This weakened the influence on the formal structure on company behaviour, and led to reduced CCA capacity. These problems were addressed by introduction of fines for blackouts in 2005.

On the other hand, in comparison to the Norwegian regulatory model, the later Swedish models have left room for larger investments in grid structure, as exemplified with measures aimed at greater robustness, including it as an increased value of

infrastructure. This serves to formalize robustness as a goal within the regulatory scheme and makes funding available for building a robust infrastructure. By the instrumental perspective this is interpreted as an increase in CCA capacity, albeit still lower than pre-reform. The introduction of fines for interruptions in supply exceeding 12 and 24 hours in the formal regulatory scheme has further prompted the companies to seek to secure a robust supply system.

The natural tests offered by the two severe storms, *Gudrun* in 2005 and *Per* in 2007, provide additional evidence. If not identical, the two were certainly similar, and the Swedish Energy Agency has concluded that robustness and resilience of supply were improved on the course of the two years between the storms (Swedish Energy Agency 2007). Heavy investments by the grid companies in grid and emergency preparedness show this. Large-scale programmes have been conducted for the undergrounding of distribution grids, with the sole rationale of achieving greater robustness and reliance in the face of extreme weather conditions. These adaptations have been carried out also by companies that were not directly affected by the storms, and are a clear indication of heightened CCA capacity.

However, there are also parts of the sector's formal structure that weaken CCA capacity. Compared to the period before the reform when the companies regulated their own financial means, the current framework conditions for CCA by the grid utilities are determined by the national regulatory body EI. While it seems that financial resources have been allowed for the companies to implement adaptation measures, there has also been talk of a 'responsibility gap'. Whereas the companies are expected to ensure supply to the level desired by society, they do not necessarily have the incentives or control of means to do so (Palm 2008). In this lies a paradox: While the goal of the reform was to increase efficiency for the common good, it may have also created a potential liability: uncertainty as to the security of supply in the Swedish power grid. This is a classic problem of goal conflict, and quality and security of supply are usually less observable than cost and efficiency. If the quality of services cannot be observed and controlled, the incentives for quality come into conflict with the incentives for reducing costs (Damsgaard and Green 2005). There is no doubt that legally the grid utilities have the direct and immediate responsibility to adapt, but uncertainty about the responsibility for robustness in the long run may reduce CCA capacity – although this problem seems to be an inherent property of any unbundled electricity sector.

To sum up, in terms of the *organizational-instrumental perspective,* the adaptive capacity of the Swedish electricity sector has been reduced since the period prior to deregulation. A responsibility gap has emerged, and the regulatory schemes have been weakened by frequent changes. On the other hand, we must note some factors that modify this conclusion. The regulations after 2007 and 2012 are better grounded and more well prepared, and can thus be expected to be more stable. The fines system included in the regulations after 2005 has further created incentives for the companies to invest in a robust grid. Also, the Swedish regulatory scheme has accorded space for investments to promote greater robustness, by recognizing the increase in real value of the grid through such measures.

Also the *cultural-institutional perspective* can contribute to explaining change in CCA capacity in Sweden. While March and Olsen's work with neo-institutional theory and the logic of appropriateness (March and Olsen 1984, 1989, 1995) has focused largely on democratic governance, or often in a more general institutional setting, it can be fruitfully applied also in more specific bureaucratic settings as well, along with the application of *institutional logics* (Thornton and Ocasio 2008). We have seen that there

has been a cultural transformation in the Swedish electricity sector, with a shift from a predominantly engineering logic that accorded priority to technical robustness, to a logic with greater emphasis on economic efficiency. Although there are signs of balancing the two, both before and after the reform, the question is: how has this shift in culture influenced the sector's capacity to adapt and react to climate change?

The 'old' culture was clearly more focused on robustness and system functionality, and since the engineer's logic emphasises robustness and system functionality, we would expect this to be a cultural logic that delivers higher adaptive capacity than what is delivered from the economist logic. While this was largely the case, there were some modifying factors as well. First, Swedish culture was certainly not unaware of economic considerations prior to the reform. The marginal price principle was clearly included in the decision-making processes, and helped to make the Swedish sector a quite efficient one. This balancing of legitimate considerations in turn seems to have led to less of a crisis in efficiency or identity as a result of the energy reform. It has also facilitated a continuation of the balancing of legitimate logics, even if the emphasis shifted towards the economic line after the reform. The minor change in culture meant reduction in adaptive capacity, because the somewhat lower legitimacy of CCA decisions.

What is particularly interesting about the Swedish case is how the institutional logics have interacted to influence adaptive capacity to climate change. Ways of co-existence have been variously described in the literature as cooperation, co-existence, competition, co-opting, or capturing (Lounsbury 2007; Reay and Hinings 2009; Thornton and Ocasio 2008). In the Swedish case, there has been a balancing and deliberation between the two perspectives which illustrates points both from an institutional logic perspective, and also in the way CCA capacity is influenced. For the former, it can show how institutional logics can co-exist. While *both* economic efficiency *and* technical robustness have to be taken into consideration in order to balance them, here there seems to be a *fusion* of the two. This may have to do with Swedish deliberative traditions in general, but is underlined in both the informal way of thinking as well as in the structuring of the regulatory scheme(s) (formal structure). The schemes imply this balance of institutional logics also in the formal structure *by design* – it pays off to invest in measures that promote robustness, as seen in the extensive shift to a subterranean distribution grid.

Perhaps the weight could have been expected to shift more towards the economist institutional logic with the reform than it actually did, since the number of economists working in the sector increased, the sector was exposed to market forces, and regulative schemes included economic incentives. However, some external incidents intervened to boost the legitimacy of the engineering logic. Due in particular to the storm *Gudrun* in 2005, and after the storm *Per* two years later, costly robustness measures have been implemented. Even though the regulatory framework allows for such investments, their sheer magnitude cannot be explained by the instrumental perspective. Company representatives cite 'company reputation' in investing, signalling that it is not acceptable to ignore robustness of supply. In this way, such external weather events have contributed to maintaining the legitimacy of the engineering logic throughout the post-reform period. It has been allowed to co-exist with the economic considerations in a *mutually legitimate* way, without further impairing CCA capacity due to the cultural-institutional perspective.

When we look at the different regulatory periods for Sweden's grid companies after the reform in 1996, what is most striking is the change in models and the number of different schemes. Analyses of the regulatory scheme and its impact on the

distribution utilities are available (Jamasb and Söderberg 2010) – however, from a formal perspective, and under ideal circumstances. Such studies fail to consider the low legitimacy of the NMR model and the brief period the model was in place. The findings reported in this article shed light on these gaps in knowledge and show that the changes in formal structure have yielded important influence on the CCA capacity. The pre-reform system of direct regulation provided stronger incentives for adaptation. The NMR model was implemented in a top–down manner, and most grid companies failed to understand it. To them, the model appeared as a 'black-box' type of regulation, as they had scant control over the factors that changed the revenues allowed. This reduced the legitimacy of the formal structure and made less of an impact on the behaviour of the grid companies. Together the change and interplay between the formal and the cultural factors in the sector acted to undermine CCA capacity – but less so than if the economic efficiency considerations in the regulatory regime and the culturally appropriate thinking had stood stronger after the reform.

Conclusions

This article has shown how adaptive capacity to climate change of the Swedish power sector has been influenced by formal organizational structure and the cultural factors inherent in organizational fields. This has been substantiated by applying two theory perspectives: the organizational-instrumental perspective, and the cultural-institutional perspective. These two illuminate and explain different but also related barriers to CCA.

The organizational-instrumental perspective detects a reduction in the adaptive capacity of Sweden's grid utilities between the period prior to the 1996 deregulation and afterwards. This was caused by a gap in the responsibility to adapt, and the regulator's responsibility to provide framework conditions to enable this. Prior to the electricity reform, the self-regulatory system had provided the companies with both the responsibility for and the means of providing and ensuring a robust electricity supply. Unstable and low-legitimate regulatory models have been a weak instrument for steering the behaviour of grid companies. This has been modified by clearer regulations and incentives for the companies to invest in robustness and security of supply after 2005, more recently backed up by what appears to be a well-prepared new regulatory scheme set for implementation in 2012.

We can observe a similar picture in the shift that has taken place in the culture of Sweden's electricity sector, albeit less significantly. Prior to the 1996 reform, the technical or engineering institutional logic prevailed, contributing to a high CCA capacity due to the high legitimacy for building robustness. However, an awareness of economic principles had always been present. This, combined with a lack of a crisis prior to the reform, did not de-legitimize the engineer considerations, and helped to 'soften the blow' of the change. In turn this contributed to the continuation of the balancing act between the two relevant considerations. Even though the weight clearly shifted towards an economic paradigm, this ability to balance has helped to maintain within the Swedish electricity sector an emphasis on robustness considerations and CCA capacity.

We have also noted how external weather incidents – in this case, two severe storms – influenced sectoral culture and formal structure, by increasing adaptive capacity when the vulnerability of the system to extreme weather events was exposed. In the case of storm *Gudrun*, which created havoc in southern Sweden, the engineering logic gained legitimacy. This was amplified by institutional factors; the engineering logic was never de-legitimized to the extent it was in neighbouring Norway (Inderberg 2011).

Increased awareness of vulnerability and willingness to invest in measures to promote grid robustness followed, boosting the perceived legitimacy of the engineering logic.

As regards theory, this article has shown that institutional logics can interact and co-exist within the same organizational field, producing synergies and a more optimal outcome. The findings here indicate that institutional logics, even with crucially differing on basic assumptions, does not need to be in conflict, but can be balanced if neither is clearly de-legitimized. For practitioners these insights are useful for awareness about the limits of formal regulatory framework, given the dominance of different institutional logics, and the interplay between these, both in the long an in the short run. The premises for such cooperation are not fully clear and merits further study. Some lessons for political reforms and regulatory schemes can be drawn. Public regulations establish many of the conditions under which most sectors operate. These direct (regulative measures) and indirect (sectoral culture transformations) conditions are vital for understanding actual CCA capacity. When these factors change, the capacity for CCA changes with them. Further, when reforms are prepared, in particular for large technical systems, a long-term perspective is essential as regards the choice of development paths. Public services usually have a range of considerations to take into account, in addition to being economically efficient. Mapping and including these considerations at an early stage in the reform process will save time and effort. And finally, we should never disregard the importance of contingent learning from other countries and other sectors.

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