Consumers as active participants in a technology of welfare: the case of energy provision[1]

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Abstract

This paper explores the varying ways in which electricity reliability professionals operate large-scale distribution systems. Participatory methods, particularly ethnographic interviewing, were used to study a Finnish electricity distribution company's control rooms. We illustrate that there are divergent practical rules of thumb, professional judgments and improvisations which are deployed in order to protect the electricity supply systems from disturbances. At the same time, the professionals of this study are not merely acting in the context of maintaining electricity 'system goals'. Instead, also the consumers of electricity play various parts during control room operation. These include being callers to a control room's customer fault line; being recipients of various ways to raise consumer 'situational awareness' including text messages and Internet maps of electricity system faults; being municipal residents entitled in the operator's mind to public services and safety; and in exceptional disturbance cases, also being subject to energy rationing.

Introduction

In a present-day perspective, large infrastructures like electricity, water, heat, traffic and telephone networks are 'old' technologies that were mostly invented in the 19th century and diffused to the Western countries in the post WWII period (e.g. Graham & Marvin 2002; Edwards 2002). These systems have also always faced occasional breakdowns (e.g. Hughes 1989; Misa 2004). Yet, the breakdowns of infrastructures can be also considered as a more particularly 'contemporary' (Rabinow 2007) problem. For one, in the recent years many governments and EU have taken major initiatives to protect their 'critical' infrastructures from natural catastrophes, terrorism and various other hazards, as the disruption or destruction of these "vital systems" are seen as having serious impact on citizens and the functioning of governments (European Commission 2005; Abele-Wigert & Dunn 2006; Collier & Lakoff 2008). Also and particularly in respects the energy infrastructures,

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competition has been introduced to the formerly monopolistic infrastructure provision, and the management of these services is now being handled by new networks of both publicly operated and privately operated organizations (de Bruijne 2006, 11-12; Graham & Marvin 2002). The EU in particular has repeatedly stated its aspiration that establishing competitive energy markets shall provide the union with secure energy supply (European Commission 2007; see also Silvast & Kaplinsky 2007).

The ‘old’ technologies are thus being taken up by various emerging frameworks that anticipate and mitigate their risks. But while many technology and policy considerations of infrastructure supply security already exist (see e.g. Silvast & Kaplinsky 2007; Kumpulainen et al 2006), the more practical interconnection between different styles of reasoning, infrastructure risk and day-to-day action has rarely been studied empirically. The aim of this dissertation research project is to investigate this interconnection through detailed empirical case studies.

With *styles of reasoning* we refer to philosopher Ian Hacking and his long-time concern for the *taming of chance,* “of the way in which apparently chance or irregular events have been brought under the control of natural or social law” (Hacking 1990, 10). In this context, styles of reasoning means different enduring ways of thinking – for example statistical analysis, model construction, deduction or experimental exploration – that provide frameworks for making decisions about apparently chance or irregular events (ibid, 6). With respects infrastructures and their uncertainties, Collier and Lakoff (2008; also Collier 2008) have used the concept to contrast risk spreading through insurance with a number emerging forms of knowledge in the US security field. These forms include among others critical infrastructure protection.

Hacking’s notion of ‘reasoning’ is always linked with action. To grow and gain authority, a style of reasoning requires not only thought, but also for example techniques for collecting and analyzing data and institutions for defining and establishing what concepts mean (Hacking 1990, 6-7). The focus of his philosophical analysis is however still on the “investigation of concepts” (ibid, 7). While sharing his interest for the taming of chance and irregularities, our mode of investigation is more practical.

Thus, while the concept of *risk* has many meanings (Luhmann 1993), in this dissertation research project it is closely connected with practical uncertainty. The project takes at its focal point a number of concrete cases where styles of reasoning about infrastructure risks are mobilized. With concrete cases we refer to studying the both formal and informal ways that day-to-day activities of people are structured (Giddens 1984). The main research question is: *how do expert and lay actors who may face infrastructure breakdowns tend to realign the discordant situation?*

The project uses participatory approaches to study mobilization of risk knowledge on three field sites: (i) the control rooms of a Finnish electricity distribution company; (ii) the Finnish policy field whose practices control, distribute and utilize infrastructure risk; and (iii) homes where lay persons have faced electricity blackouts.

The first field site, whose data was collected by interviewing and observing electricity reliability professionals in 2008, is used to address a question of risk knowledge in action: *how is reliable electricity provision achieved in daily action if there are multiple responsibilities that have to be met and if coordination across organizations is also required?* The contention here is to illustrate the practical rules of thumb, professional judgments and improvisations which are deployed in order to protect the electricity supply systems from disturbances. Electricity infrastructure systems cannot be made completely fail-safe, which also places demands on their resilient action. As their empirical analysis and the gathering of material are still under way, the second and third field sites are not introduced in more detail in this paper.

Though several detailed case studies of the above field sites already exist, it has been less common to investigate the 'producers', 'designers' as well as 'consumers' of infrastructures inside the same study. Thus, the overall purpose of the empirical analysis is comparative, highlighting the varying contextual character of technological risk among the research sites and also within them. The connections among the field sites and their mobilizations of knowledge of risk are also discussed. That is, it is not assumed that merely 'experts' are dealing with the technological electricity systems with their system goals (Hughes 1989) and these experts, in turn, are not in connection to lay persons with their 'identities' and 'cultural' interpretations of risks (Douglas & Wildavsky 1982). Instead, the subsequent sections illustrate there are many hitherto rarely articulated interdependencies between infrastructure technologies' users and consumers.

The structure of the paper is as follows. First, the field site of the control rooms is introduced along with the key approaches and topics of the case study. Second, tentative research results are disseminated. The third part concludes with a brief discussion of the results. The appendix contains a list of the participants of the case study and the structure of the study's interviews.

Control rooms

Key approaches

In this empirical section, we will analyze how electricity system operators manage risks in action. The research question is: *how is reliable electricity provision achieved in daily action if there are multiple responsibilities that have to be met and if coordination across organizations is also required?* Based on social scientific and organizational studies literature of large technological systems, the responsibilities in respects supplying these systems include for example: providing services to everyone for 'public interest' thus also ensuring public safety (Graham & Marvin 2002; Boltanski & Thevénot 2006, 331; Collier & Lakoff 2008); maintaining technological efficiency and predictability (Steenhuijsen & de Bruijne 2009; Hughes 1989); and more recently, also obtaining market shares and minimizing the price of infrastructure services (Graham & Marvin 2002; de Bruijne 2006; Boltanski & Thevénot 2006, 260).

Instead of assuming that these different responsibilities are necessarily in critical opposition to one another (cf. Graham & Marvin 2002; Boltanski & Thevénot 2006, 260), the aim of this section is to find empirical cases where the different responsibilities are managed and coped with in *practice*. The case study makes an 'inquiry' of the situations where practitioners are embedded, and attempts to give 'form' to the ways that they are solving problematic situations (Rabinow 2007, 7-11). In order to do this, the researcher has used her or his tentative understanding of the research problem and confronted the practitioners with questions while observing their day-to-day work. The goal of the inquiry is to discover those rarely articulated, underlying, tacit and often informally applied formulas that are constantly invoked in day-to-day activities (Giddens 1984, 22-23).

For a field site of studying the above discussed intertwining of various different principles in action, the control rooms of an electricity infrastructure company was selected. According to literature (e.g. Roe & Schulman 2008; Schulman et al 2004; de Bruijne 2006; Steenhuijsen & de Bruijne 2009), control rooms are at an interface of various networks of organizations with partly different, but also overlapping responsibilities (de Bruijne 2006, 19):

> Control rooms allow for interaction, communication and coordination across organizations through various technologies and methods (e.g. computers, markets, telephone calls, meetings). (…) (I)nterorganizational coordination (…) allows the organizations that manage these infrastructures to provide reliable services, despite the fact that these services are provided through networks of organizations. (de Bruijne 2006, 89.)

For electricity companies specifically, the control rooms are a place for monitoring energy flows on a real-time basis. Contrasting previous literature on large technological systems (Hughes 1989), the control room operators are not assumed to be just deskilled workers who routinely correct errors in electricity supply system performance (cf. Hughes 1989, 54). Rather, the aim is to study the ways that the operators take an active and often also improvising relationship to the various discordant situations that supplying electricity incorporates (de Bruijne 2006; Roe & Schulman 2008; Schulman et al 2004).

The case study

In the paper's case study, the operators of the control rooms of a Finnish electricity distribution company were investigated by interviewing and participant observation. The design of the empirical study is briefly summarized in Appendix 1. The structure of the interviews is in Appendix 2.

According to the Finnish Electricity Market Act (1995), electricity systems can be described as "interconnected entities" "consisting of power lines, substations and other electric devices and equipment, intended for the transmission or distribution of electricity". Electricity system operation means "placing the electricity system against payment at the disposal of anyone needing transmission and similar system services" (ibid). Distribution system, in turn, means an electricity supply system with a nominal voltage less than 110 kilovolts (ibid). Systems of this scale normally supply energy to small-scale customers in cities and the country side, in contrast to transmission system operators that supply voltage more than 110 kilovolts on a national level. The distribution company of this study is also responsible for supplying district heating for its area.

The company of the case study comprises two distinct control rooms for operating the distribution systems. In the early 2009, after the data had already been collected, the control rooms were also separated legally to different organizations. A schematic map of the rooms can be found in Figure 1. Both rooms have one to two operators faced by numerous computer screens, and the distribution control room also includes a projector screen which can be used to double some of the computer screens. The operators also have various telephones and other communication devices at their disposal. These devices are linked to or from other control rooms, maintenance teams and also electricity customers. The two control rooms are connected between each other with a door and a window; furthermore, the operators of both rooms share the same kitchen facilities. Both of the rooms also face the same view to a lake-side nearby.

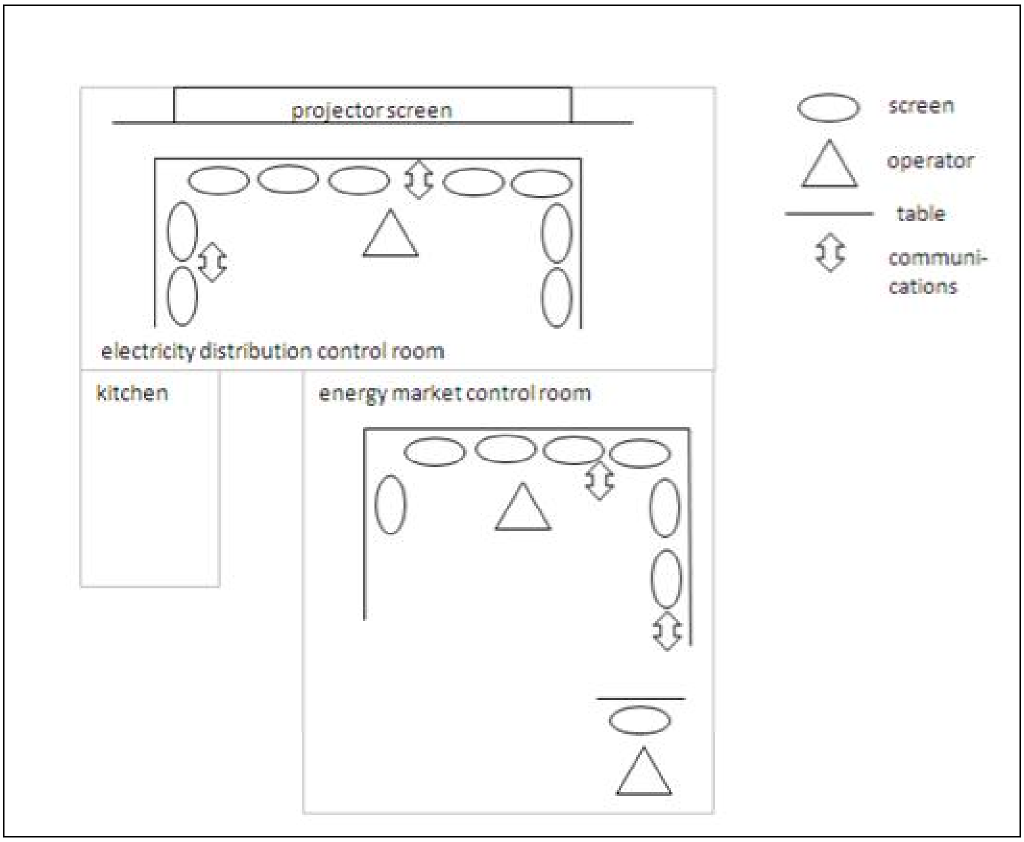

Figure 1: A schematic map of the control rooms in a Finnish electricity distribution company

Similar as they may seem by design, the operation done in the two rooms is different in many respects. The energy market control room is responsible for brokering on the energy stock exchanges and commanding the company's own power plants so that the balance between energy supply and demand is met continuously. Electricity supply differs from most other infrastructure services because electricity cannot be stored efficiently. This means that all the electricity used at certain moment must be generated in power plants at the same moment and be delivered to the customers via electricity transmission and distribution grids. The consumption of electricity does not also stay static, but alternates depending especially on the weather, the situation of the industries and the daily rhythms of people's ordinary life. The operators are thus brokering with a computer on an hourly basis on the common Nordic electricity stock exchange ElBas to balance energy supply with demand. All of the stock exchanges are anonymous. In contrast, while energy trading also existed before the market restructuring, it was done over the phone to other utilities and power plants, and there were also long-term contracts between some energy producers and consumers.

The distribution control room is responsible for switching the electricity distribution grid to various different configurations and in the process, also for monitoring the grid for alarms. Once alarms occur, the operators' task is to diagnose the fault and possibly send a maintenance team to the field. While technically quite similar to before the electricity market restructuring, there are also many new aspects in the work. Many of the activities previously associated with electricity utility companies, particularly electricity network maintenance, have now been outsourced. It is now generally believed that task-specialized organizations will produce these services more efficiently, at smaller cost and with fewer machines, fewer facilities and smaller work force than the electricity distribution companies (Partanen et al 2005). In the last 15 years, legislators, regulators as well as the electricity customers who can phone the control room have also placed growing pressures on diagnosing the faults and minimizing their impacts. New computer systems with their fault databases and schematic maps of electricity networks permit as well the growingly detailed diagnosis of electricity grid faults.

Two main reasons motivated the selection of this particular distribution company for the case study. First, there are only a couple of electricity utilities with two distinct control rooms such as these in Finland. As the research problem was about finding failures of action and analyzing how action is then restored, it is safe to assume these situations can be found in a site where the main responsibilities of the control room operation have been recently reconfigured. The company is also known for its strong emphasis on crisis management, hence that introduces another possible logic that regulates and constitutes action. Second, the activities of the control rooms involve many sensitive issues such as worker safety, customer welfare, recovery from possible crises and non-discrimination on the markets. Hence control rooms are not an easily accessible field site for everyone. But as the then CEO of the company is in the steering panel of Antti Silvast's PhD, the access to the control rooms was granted with his help. During the analysis we will however also consider how knowing the CEO might have impacted the comments that the operators made of their practice and its possible errors.

In the following we will present an empirical analysis of both of the two control rooms. The analysis of each room, in turn, will be dealt with in three parts. For the first part, the different responsibilities of the control room are described. In the second part, it is illustrated how the control room operators attempt to solve problematic situations and continue their daily actions. The third part is a discussion of the hindrances that might exist in respects the resolving of the situations.

The energy market control room

Intertwining of responsibilities

Generally speaking, the day-to-day working routine of the energy market control room assumes two types of responsibilities: brokering on the energy markets (involving e.g. principles associated with non-discrimination and obtaining market shares) and maintaining the balance between energy generation and consumption (involving e.g. principles associated with reliability, efficiency and predictability). The work itself happens in three shifts: the morning shift, the day shift and the night shift. The morning shift begins by planning the generation, purchasing and selling of energy for the following day. As an operator explains:

> In the morning shift we make the next day's prognosis, where generation power is defined, based on weather the generation power is approximated, and from there the electricity. From there on we also send to Norway [to the electricity stock exchange] the order, which has for each hour the information on which price we are willing to sell and buy [energy]. (Mm1[4].)

So, based on a weather prognosis, but also statistics from electricity use and the situation of the energy generation plants that are operated by the same parent company (Mm4), the operator of the control room makes the plan for each hour of how much energy is generated in the parent company's plants and how much is to be purchased from the common Nordic energy stock market. The goal of this planning process is to create conditions for both supplying the right amount of energy for the customers and minimizing the customers' electricity prices (Mm4).

After the plan has been sent out through a computer interface, a real-time phase of the operation begins, and keeps carried out for all the different work shifts, including the night shift. In a computer screen that is faced by the operator, there are two graphs: the *predicted* difference and the *actual* difference between energy consumption and energy generation, the latter of these being measured every three minutes. The predicted and actual balance between consumption and generation should be as close to each other as possible in order for the company not to be generating too much or too little energy. The requirement is not only technical: the company's participation in the electricity markets also sets it a legal obligation for "balance responsibility" in the distribution area.

[4] See Appendix 1 for the meaning of these codes.

By and large it seems that the predictions made in the previous day are seldom wrong, and observing the room it even seems like there is not much happening all the time. In fact, the managers have decided to include a television set in the control room to serve as “a breathing spot for the operators” (Mf1). However, all of the operators also emphasize on the ever-changing contexts of the day-to-day practice. The following piece of conversation illustrates how hard it is to pinpoint the work either as completely routine-like or constantly changing:

> Interviewer: Is this work routine-like or does it change daily?
>
> Mm2: Yes, I mean it changes in principle. Or it is kind of similar, but every moment this is such guess-work. There is no such moment where you could throw your foots to the table, moments when the shift would go through without any disturbances. There is never such a moment that is hundred percent sure, that you could say what is the temperature for instance and it depends on that so fully.

For another operator, “this work is always sort of seeking, there is no crystal ball. You cannot make the electricity stock exchanges beforehand so that it goes spot on. This work is momentary.” (Mm1.)

The changing weather of the city seems to be behind the most frequently occurring discordances. In a matter of minutes, it can become dark enough for all the city’s numerous street lights to switch on; however, the time of this event tends to change from day to day. Rain, snow, sunlight and temperatures also directly impact the demand of heat and lights and hence also energy. Like an operator explains: “If there is for example a surprising showery rain in the summer, our district heating network starts to pull much more and demand grows and generation has to increase.” (Mf1.) But even though these rapid changes in daily conditions cannot be always predicted, there are several ways through which the balance between energy use and production can be improved. These shall be returned to in the subsequent subsection.

Yet, every problem in the control room operation is not mundane and routine-like, as more serious disturbances with electricity distribution have also tended to occur. These events are relatively rare, and I was not able to observe any; indeed it is highly suspect if an outside observer would have been permitted to stay in the room if something had occurred. Hence I had to ask the operators to imagine a more serious breakdown for their working routine. In general, they could only remember one or two occasions when something serious had happened during their long careers, but were still willing to help in this respects.

Thus, one could imagine a severely leaky pipe in the district heat networks which then result to one of the company's own power generating plant shutting down. As the energy market exchanges have already been planned ahead and hence that plant had promised to generate energy which was also to be sold, this would also cause problems with the energy market brokering (Mm3). In other words, the responsibilities associated with technology can interfere with the responsibilities associated with markets. Also, an opposite type of event can be imagined: the energy brokering on the markets causing problems with the other responsibilities of the organization. From five years back, an operator recalled what he called a "senseless" event in this respect: the so-called "Black Monday" of the Nordic energy stock exchanges.

> It was a situation that suddenly on Monday, when our spot market order came, the prices of that Monday were terrible. They were senseless, they were like the maximum prices that the energy stock exchange can have. We did not have enough electricity and then we had to buy it from the markets and it was terribly expensive. The guy who operated that day of course faced the worst. (Mm2.)

But as bad or even 'worst' as these situations may seem, they were still not unmanageable according to the operators. This is a theme which shall be handled in the following subsection.

Finally, it can be briefly highlighted what kinds of electricity-related problems were not very much embedded in the operations of this control room. For one, small-scale electricity blackouts, even though irritating for many customers (Silvast et al 2006), do not seem to have much of an impact to the energy market room, apart from the fact that when some customers are without energy there is actually too much generation for the part of the power plants and that energy has to be brokered on the markets (Mf1). Also according to one operator, the 'unbundling' of the electricity markets from the electricity networks is more concern for the company's managers than the operators (Mm3). Activities related to customer service and outsourced maintenance teams did not normally seem much related to the room, though as will be shown in the following chapters they feature extensively in the other control room of the company. What seemed particularly taken for granted was that decisions made on the fields of municipal politics (an 'actor' they had named "the white house" after the town hall's colour) and national and EU energy policy were simply made and had to be approved.

These brief remarks are a reminder that infrastructure risk is not uniform, but divergent depending on the context where it occurs and is practically managed; and sometimes these changing contexts can be also set by the physical boundaries of the control rooms.

Responding to problems

As was indicated previously, the balance between energy use and energy production is not always met during everyday work. However, several methods exist for improving this situation. Technically speaking, the parent company's power generation plants can be requested to produce more energy. A second, more market-oriented option is to use the common Nordic online electricity stock market called Elbas to purchase more energy or sell extra energy. Elbas is in operation 24 hours a day and seven days a week, with exchanges being made up to one hour before delivery. The company's own energy purchasing and selling in the stock market appear in dedicated colour on one of the operator's computer screens, and whenever I look at it, there are already several of those. Thus, similarly to work of financial analysts, being able to switch between predictions and real-time response to data is essential for the control room operation. The principal tool for doing this seems to be a sheet that is open on the computer software Excel. It is not just storage for knowledge from various different systems but is also "constantly tinkered with" (Bm1).

If the above steps fall through, the energy still has to be physically distributed to its demand. In this case, the company gets charged afterwards by the national transmission system operator that provides them so-called adjustment electricity. This however tends to be avoided by the control room as the price of this electricity is not easily predictable and in principal the room should operate with the electricity stock market.

> Interviewer: Is this adjustment electricity the last option?
>
> Mm5: Yes, we try until last that we should not buy it, because it is not cheap for us either. Or it can be sometimes cheap, it tends to be however. Sometimes the stock market has prices such that the adjustment electricity is better or cheaper, but you never know. But anyway, the goal is [this], because we cannot deviate from it [the balance] for a long time. That is why we try to fix it with the stock market, so that the balance is sound.

As can be seen, the actions in day-to-day discordant situations tend to rely on constant adjustments in strategy, updating of previous understanding and improvisational behaviour (Schulman et al 2004). The above examples suggest that the operators even take some amount of pride in improvisations made under pressure (Roe & Schulman 2008, 88). Industrial sociology has also for long pointed out that industrial arrangements are more complex than just production functions. They also rely on skills and "know how" that are rooted in local practices, something that is also an obstacle to their transferability (see Boltanski & Thévenot 2006, 315).

Of course, the improvisations illustrated thus far have been closely connected with breakdowns which occur on a daily basis and cannot always be anticipated before hands. On the other hand, the control rooms of the study handle more than routine breakdowns. Let us assume for a moment that major discordances to the work, such as extreme weather conditions or large-scale technological malfunctions, are managed in the control rooms as *risks*.

Risk in its technical sense implies that unwanted events can be placed in a quantitative calculative framework and thus anticipated and mitigated before hands (Roe & Schulman 2008, 124; Lehtonen et al 2008, 5). For example, techniques associated with critical infrastructure protection (Collier & Lakoff 2008) and disaster modelling (Collier 2008) have introduced various calculative frameworks through which new knowledge about uncertain events can be generated and linked to diverse mechanisms of mitigation (Collier 2008, 226). Organizations that manage complex networked technological systems, such as nuclear aircraft carriers, nuclear power plants and air traffic control centres, also tend to employ anticipatory analysis methods with the aim of preventing unwanted events from happening (Roe & Schulman 2008, 54-56).

Yet, based on the electricity company operators' comments, the more exceptional situations share similarity to all the other situations in that practical improvisation is also required. When imagining a serious event, an operator exclaims:

> It could be that a power plant comes down. (…) Then we start repair it and there we start the power plants in a way, and then the pack of the trading is all mixed up, but it gets built back step by step. If you start to build from scratch and you don't know exactly, what is the activation time of a power plant, then you simply have to *guess* what it is. (Mm3, emphasis added.)

This infrastructure operation on-the-spot is not only "guessing" by the one person but also *guessing with* persons from various different organizations. Steenhuijsen and de Bruijne (2009) have analyzed the control room operators of rail transport infrastructures in the Netherlands in an extensive field study. According to their analysis, the operators' situational awareness in discordant situations relies essentially on collaborative coping responses. A complex system such as rail transport is inherent with what Steenhuijsen and de Bruijne call value-conflicts: for instance, according to one of their informants the trade-off between two trains competing for the same track include safety, non-discriminatory treatment, an optimal flow of trains, complying with the plan, transparency of the trade-off, predictability and the maximum utilization of capacity (ibid, 5). The system's operators have to be able to both recognize and control these conflicts because trade-offs occur on a daily basis. This proactive coping also involves information sharing and collaborations between organizations (ibid, 8). In similar a case study derived from an underground line control room, the real-time management of dynamic technological systems assumed "considerable teamwork which often requires a substantial amount of communication" (Garbin & Artman 2006).

One of the problems an operator of the energy market control room imagined is the severely leaky pipe in the district heat networks which results to one of the company's own power generating plant shutting down. When I ask in more detail, it turns out that the step by step recovery from this is also done in close practical coordination with other organizations.

> Interviewer: What kinds of means do you have to repair? Do you communicate with others?
>
> Mm3: We are communicating with the district heat control room, that what is the situation, so that we get information ourselves. The power plant does the conversation between these control rooms on what is to be expected.
>
> Interviewer: Is it very different then than normal working, when there is an exceptional situation?
>
> Mm3: You have to be more in contact to get information, and they don't have the information either and then we try to guess and you have to be play with that and against the markets. [You have to] (g)uess how much you have to buy and how much the power plants possibly generate.
>
> Interviewer: Lots of guessing?
>
> Mm3: It is guessing, Part of it comes of course from experience, (…) but everyone experiences it differently, the experience is always different.

Moreover, coordination exists among various organizations as was pointed out above, but also between the two control rooms. Even though the rooms have been physically separated, an operator (Mm2) tells that the operators of the different room tend to help each other out occasionally. For example, an exceptional situation could be occurring in the distribution room and the operator from the market room could help the distribution room by answering its phones. There was only one control room when the energy company was still a single utility, and the practice of collaborating has stayed on. But the conditions for coping activities will seem different when designed task specifications are proscribed to the operators (see again Steenhuijsen & de Bruijne 2009).

Hindrances to coping

The previous part illustrated that according to the operators, the discordant situations of the control room always have to be dealt with when they occur. Major contemporary uncertainties, for example climate change and terrorism, also tend to get placed in this context: “I don’t think about them. You cannot do here anything [before hands] and our work always comes only afterwards. We have to act when something happens.” (Mm2.) A plan that deals with exceptional crisis situations has in fact been trained to the operators, but its place is inside a binder:

> Interviewer: Do you know about or have you received some training here about crisis situations?
>
> Mm3: In principle everyone has had to receive it and in principle everyone gets it. Then it is everyone’s own responsibility how much you read it. But of course it can be found in the binder.

This type of attitude towards major uncertainties has been interpreted by some commentators as sign of ‘fatalism’ among professionals (see Silvast 2006; see also Douglas & Wildavsky 1982). But the way that the operators insist on improvising and being sensitive to one’s own circumstances, as was indicated in the previous section, offers another kind of explanation.

When operating a large-scale technical system, the anticipation of uncertainties is very often prescribed to the operators in so-called contingency scenarios. In the case of rail transport these include scenarios such as what to do in case of a delayed train or blocked railroads (Steenhuijsen & de Bruijne 2009). Even though the scenarios often mitigated disturbance situations according to an analysis of rail operators (ibid), they also tend to cause problems for the operators’ situational awareness. In the words of a rail operator, the scenarios prescribe "a make-believe certainty, as if there is an ideal solution." (ibid, 6.)

Ideal solutions, it seems, belong to the same category as formal methods and written instructions: their place is justified inside a binder from where they can be invoked if needed, not always in the practical solving of the discordant situation. Working experience, on the other hand, is the more legitimate key to stock-pile examples and cases through which learning can occur (see also Boltanski & Thevénot 2006, 247). When Schulman and Roe were able to observe a recovery exercise in a control room of an American electricity transmission operator, they noticed that

> no recovery scenario proceeded the same way. Different teams across different weeks of training restored their grids in different scenarios during the simulation exercise. Certainly no two teams we observed on one day restored their grids in the same way. (Roe & Schulman 2008, 129-130.)

Yet, the above practice of training through simulated breakdowns is itself something that was not always valued very high by the operators of this room. When I ask about training, an operator responds that market prices vary from one situation to the other and cannot be thus simulated:

> In practice we don't have anything like that, that we would for example simulate something. Because they are so hard to develop, when you never know about those market prices, when even if you have some large situation, nobody knows the market prices. And they cannot be simulated either. (Mm2.)

Instead of relying on simulations, learning happens through the concrete problematic cases that have occurred. According to the same operator "of course everyone then investigates them [the problematic cases] even though he had not worked [at that shift], of course he looks, that what has to be done and what was done and what should have been done." (Mm2.)

In the comments of the operators, a particularly frequently occurring ‘spokesperson’ that is used to defend the operators’ context-sensitive local practice is new computer software that has been introduced recently. This software should be able to predict energy supply and demand for the following day, thus replacing the operators in this respect. However, one of the operators describes that it is his “gut feeling” that is used to predict energy demand in a working week. "Tuesday, Wednesday, Thursday, they could be similar among each other in the middle of the week, then you have Friday, Saturday, Sunday, even Monday, they are little bit different. But that starts from your guts in a sense, that you somehow suspect that they have some small difference." (Mm1.)

Not surprisingly then, in the comment below the computer software turns out to be “not as good as” the operators. Furthermore, its “unreliability” also proves to the speaker that the work in the control room cannot be outsourced to another organization.

> One has not succeeded in developing reliable prediction software for this [work]. Something was developed recently, but it did not turn out to be better than we are. This would be much easier, if this had some reliable prediction software, with which one could do the trading. Then it would be, that it could be in principle done by anyone. You would just have to see, that our price is this and there that price is offered and thus, but when one does not know the quantities. But yes, if this was outsourced and sold to someone else, then it would not have the same professionals doing this work. (Mm2.)

It has been pointed out previously that operating large-scale technical systems relies on collaborating across organizations as well as across hierarchy structures. Yet, in some cases the operators also insisted that their work is highly task-specific to brokering on the energy markets. The finding is both important and surprising because according to previous literature, retreating to formal tasks and deliberately avoiding complex coordination issues is often the opposite type of response from the “proactive coping” that is typical of infrastructure operation (Steenhuijsen & de Bruijne 2009, 8).

A younger operator in particular is often not prone to talk about "things that do not belong to the work here" (Mf1). This reaction is especially faced when I mention the concept of *security*. Another, more experienced operator highlights a similar disposition during a conversation. I have introduced to him my PhD project that is guided among other by the then CEO of the company. I tell him that this CEO is focused on issues around security and the managing of exceptional situations in respects electricity supply. (This is done to indicate how I have been introduced to these topics myself and also with the aim of finding common ground to discuss.) I then ask what happens in the scenario of a power plant failing in the grid, something which I propose to be “an exceptional situation”. The operator first argues how he does not think this situation to be exceptional, and then responds after a long pause:

> Mm1: There is nothing else to it. District heating has so many additional heat plants. The only thing is that money gets burned.
>
> Interviewer: So it is just costs then?
>
> Mm1: Yes, there is not, *there is no security risk* (*in a louder voice*). Except if a boiler explodes, then for the boiler men. But there is nothing else. If some plant is dropped out of production, one scrapes together the energy and heat from elsewhere.

Mentioning the CEO might have of course led the operator to avoiding the issue of working errors. But arguably, he does not mention anything precisely about errors above. Rather, the responsibility that is fenced off from the operation of room is the topic of *security risk*.

From the data here, one cannot indicate what those practical situations are where formal tasks are retreated to or even whether these constitute a hindrance to coping. The important finding is, however, that just mentioning the concept of ‘security’ leads some operators to insist on their formal responsibilities. The relationship of the operators to this concept shall be returned to in the subsequent section about the other control room.

The electricity distribution control room

Intertwining of responsibilities

Even though both are control rooms by design, the work done in the distribution control room is in many respects different from that of the energy market control room. The utility had only one control room before the electricity market restructurings, yet, today only one of the operators of the study is able to work in both of the control rooms. He makes the following comparison of the rooms:

> The energy market control room is like keeping watch of a camp fire. You have to be constantly keeping up a small flame, that is, you should not fall behind from the energy stock exchanges. Working in the distribution control room, on the other hand, is like being a tin soldier. Not anything is happening all the time, however, when someone calls you have to be ready on-the-spot. (Bm1.)

Generally speaking three types of responsibilities are associated with the distribution control room: first, maintaining a functioning electricity distribution system; and in so doing, second, maintaining the well-being of customers; and third, operating the system so that large-scale material losses are avoided (Bm1). More specifically during daily work,

> we are monitoring [the electricity grid] and also using remote operated stations and switches and other accessories. And the normal use is that when a load-change causes a situation or because of building operations the switching [of the energy grid] has to be occasionally changed. (Dm4.)

The most typical routine of the working day is testing remotely newly installed accessories of the electricity grid in cooperation with teams of mechanics on the field. At the same time the room is also monitoring the consumption of so-called “waste power” in the electricity cables continuously (Dm4). Out of these monitoring tasks, the control room operators are no longer responsible for following the situation of the water turbines of a near by water power plant which was outsourced to another company in an organizational reform (Dm4).

The components of the grid may also issue alarms at any moment: these are related either to the level of voltage, to the level of current or to the component’s temperature (Dm4). When I ask about the number of alarms on a typical day, an operator says that he has not counted them (Dm2), but checks an “event list” that has on the computer screens 36 pages of events for that day, although some are such that do not issue an alarm to the operator. It is never the less clear that alarms are very frequent in the room. The task of the operator upon an alarm is to first report the details of the fault to a computer system, then determine whether a maintenance team is needed and if it is, send the team to the field and coordinate with them henceforth. The control room operators are both remote supervisors of the maintenance work and also continue to switch the electricity grid to new a configuration if necessary (Dm4).

Outside office hours, the control room also serves as a customer service point with direct phone line from electricity customers to the room. An operator describes the procedure of solving a customer fault as follows:

> Interviewer: When customers phone you, what kind of problems to household customers and industry customers have?
>
> Dm3: Well, it starts from their own faults, for instance a fuse has burned and they call here, that we have a fault. And we instruct them, look first at your own fuses there and if there is and if there is no fault, then we start to seek from our own network, about what is the cause. It might be that a fuse has burned in a transformer or a fuse from a distribution station which feeds that house or consumers.

In other words, similarly to the market control room the different responsibilities of the room intertwine with one another during everyday practice. In this room's case, it is particularly often the responsibilities associated with the customers electricity supply that are interfering with the responsibilities associated with maintaining the distribution system. It should be highlighted that these are indeed seen as separate domains of responsibilities, as many of the operators emphasize on electricity blackouts not being mere breakdowns to be solved technically. Instead, as one of the operators frames it, the practice of the control room is about "the physical well-being of people" (Bm1), and this should also be acknowledged inside the company.

As important as their problems are to solve, many of the operators had also come to the conclusion that the customers "have become more and more demanding. I have noticed when these markets were opened that they known their own rights, it is quite clear." (Dm3.) Some customers, it seems, do not tolerate blackouts well according to the operators. This also requires new type of situational awareness for the part of the operator: "This is not just cold technology. Many times when the customer calls, you must consider if the granny in the cottage is even a little sane. Can you say to her that go check the fuse box, if the fuse is intact or not." (Dm2.)

There is also more technological explanation to the increasing amount of customer calls than the above introduced weakly tolerant 'attitude'. As one operator notes, "it is this cellular phone age that has done this" (Dm1). He continues that this also impacts the daily practice:

> Of course it is always a problem that if those calls start to come and you are alone and you have to try to answer all of them. And if someone wants to report that I have trimmed the tree line here, during a twenty [kilovolts] fault. And he does not get through necessarily because there is so much [calls]. And for some [callers] the information about fault is also not enough. (Dm1.)

So, the day-to-day practice is frequently interrupted by various different occurrences. Similarly to the energy market room, these discordances are placed in the context of everyday practice rather than in the context of abstract notions such as those from the field of energy policy. The energy market opening, for example, is more a topic for the other control room than this room according to one of the operators (Dm3). But the following section highlights there is one highly abstract concept that also serves as resource for everyday practice: the concept of *security*.

For the more exceptional situations in the rooms, an operator (Dm4) recalls two major storms in the 1990s. During these storms (called Janika and Pyry, respectively), more than 800 000 Finnish customers suffered from a momentary blackout and over 1 600 household were without electricity for more than five days. The handling of these types of situations as well as more frequent discordant situations is covered in the following subsection.

Responding to problems

In the previous sections about the energy market control room, it was discovered that the operators of the room rely on an improvisational approach to solving practical problems. The case is similar in this control room though not always straightforwardly. Practical actions and ever-changing contexts are emphasized upon by the operators. However, at the same time the room incorporates many highly formal methods for solving faults, such as those associated with electrical safety while maintaining grid or fixing faults by rerouting electricity with the circular structure of the distribution grid (Dm1).

Let us see a conversation on this topic:

> Interviewer: Are there many rules that are followed even though the situations change?
>
> Dm3: Well, of course security and other sets rules about what has to be done. You have to go according to them. And every man has to have the same viewpoints to those things. That does not change according to who sits here.
>
> Interviewer: And then you are talking about electricity security? Electric shocks and others, fires?

> Dm3: Yes, all of these, when the switching is done in such a secure manner and in the same way, that is where it starts. Of course [there are?] situations where anything can come.
>
> Interviewer: Yes, yes. Do you have machine standards then?
>
> Dm3: Of course. We have certain standards and we make security guidelines ourselves.
>
> Interviewer: Well, is this then, this seems very specific this taking care of infrastructures. It seems that the use of these technologies cannot be set by strict rules, rather, the situation lives and you have to go along with that.
>
> Dm3: It is like that for sure. Because every fault is little different and there will be faults, and you have to consider each time separately every thing about how you act then.

This long piece illustrates a practical conflict in respects coping with uncertain situations. On the one hand, it is emphasized that the practice of the room follows strict rules and standards when "security" is considered. Similarly, when Finnish rail control room operators were interviewed after several railroad system breakdowns in 2008, they insisted on following a "security principle": "If a fault is even suspected with traffic control, the whole traffic has to be stopped in spite of the danger of you being roasted, because it is a question of security." (Moilanen & Seuri 2008.)

On the other hand, the way "security" is guaranteed is still to some extent improvisatory and dependent on the circumstances. This can be seen in the way that framing is switched during the last question-answer pair above – from the following and making of strict security guidelines to the actions on-the-spot. Arguably, the last question might have been leading the participant to different way to approach the topic, and perhaps he was following the lead or simply being polite when answering. But another of the operators has reflected on the similar converse between security and action:

> Interviewer: Earlier you mentioned that all the work is mutually agreed and standardized, then how much is this regulated by such standards, different standards and laws?
>
> Dm4: In principle electricity work is usually highly standardized. If everyone follows the standard, then it is highly kind of structured. There is the problem, however, that when you go to the work destination, the destination might be highly varying. And then comes *your own adaptation* of how you want to do it. (Emphasis added.)

As a rule, the electricity grid should be switched back on and during the maintenance work that part of grid is set dead of voltage. But the latter practice also involves a trade-off: this has to be done in such a way that there is not “an unreasonable harm to the other customers” (Dm4) who will also lose their electricity for the time of the fixing. Hence proactive coping with ‘value-conflicts’ (Steenhuijsen & de Bruijne 2009) is again required by the operators.

As was indicated earlier, more exceptional situations for the distribution control room are also possible and the few occurrences of these have been caused by major storms. When I ask an operator if the normal working routine had to be modified during the Pyry and Janika storms, he responds that the control room had extra help in the form of another operator. When switchers of the remote using went off, one of the operators wrote the fault down and another switched them back on. However, it is not easy to see that these situations had been unmanageable. Conversely, it seems to have been even instructive and to some extent cumulative in respects performance: during the faults one of the operators invented a new practice for writing down faults that is still in use in the room (see also Roe & Schulman 2008, 177).

But the management of uncertainties is not done just by technical experts with the security rules and adaptations to them. Rather, in this particular control room’s case, the electricity customers also often play a role during disturbances. It was already pointed out that it is often challenging to answer all the incoming customer calls during discordant situations in the control room. But several communication techniques exist for improving the customers’ and also media’s “situational awareness”. An automatic message about the electricity blackout is generated for an answering machine to which the customers are automatically directed if they do not specifically demand to speak with an operator. A fault report is promptly issued to the web pages of the company that can be reached by customers with their laptops and mobile broadband even during blackouts. Some other electricity companies in Finland have also introduced text messages that are automatically sent to customers in the event of a blackout at home. Moreover, detailed Internet maps exist at some companies’ homepage for locating the geographical extent of electricity faults.

In the cases when the supply and demand is seriously out of balance, the distribution room operator is also responsible for rationing electricity for customers in order to preserve the electricity distribution system. During the rationing, highest priority is given to hospitals and to the industry that handles dangerous substances such as explosive chemicals; household customers, on the other hand, receive lowest priority (Dm3). The public sector and commercial actors lie in between. These priorities, it seems, are completely prescribed before hand as none of the operators highlight on the possibility of improvising in their respect. In other words, when the electricity distribution fault are constituted as a regional or even national security problem, then quantitative frameworks for anticipating and managing risks take a highly legitimate role also in practice (see Collier & Lakoff 2008).

At the same time, the possibility that household customers take more active relationship to discordances, for instance by saving energy, was never mentioned by the operators. This active relationship, it would seem, has been preserved for the industry and its "demand-side response" during peak-load situations (Silvast & Kaplinsky 2007, 49-50).

Hindrances to coping

Let us reconsider the hindrances that may exist to coping with discordant situations where "security" needs to be maintained, but practical improvisation is also to greater or lesser extent required. First of all, it was pointed out during the analysis of the energy market control rooms that its operators did not always rely on formal simulations because they provide solutions that are often difficult to follow real-time (see also Roe & Schulman 2008, 151). In the distribution room, however, the disposition towards simulations is very different. New computer systems permit the use of simulation training even for small teams during everyday practice. An operator sports positive view of a larger simulation exercise that had been arranged one year earlier (Dm1). In fact, another operator (Dm3) sees it as a shortcoming that the simulation training is only arranged to that operator who happens to be on the shift. Similarly to the market room, however, the control room operators did not report reflecting often about major contemporary uncertainties such as terrorism more often than before, even though it is possible that these types of events featured in the simulation exercises as part of a "worst-case scenario".

As another potential problem, the market restructuring have placed the control room to be increasingly reliant on outsourced maintenance teams. But instead of being seen as a major issue, the role of the teams is often placed in the context of professionalism: "they do their work well" (Dm3) according to an operator. The same person, however, also reflects that the outsourced organizations might have their specific practical procedures, and sometimes it turns out that the control room and the outsourced teams are "talking about the same thing but in a different manner" (Dm3). The practical problem with the team, thus, has to do with interorganizational coordination and communication (de Bruijne 2006).

Surprisingly, none of the operators talk about the potential issues caused by outsourced maintenance teams often working with fewer machines, fewer facilities and smaller work force than the previous maintenance teams of utility companies (Partanen et al 2005). These efficiency measures, however, might introduce a lower amount of reserves, which has also been reported as a problem for the practical management of electricity control rooms (Roe & Schulman 2008).

Computer information systems also introduce an important new aspect to the day-to-day practice. On the one hand, having more information for instance about the upcoming weather permits the more efficient anticipation of the needed maintenance teams (Dm4). But having more information that deals with the day-to-day practice also means that

> information is fragmented; sometimes you have to seek for it. There is so much of it that you cannot memorize it all. You have to sometimes check a help-list for ‘wait a moment, it is here somewhere’. But you will find it when you dig for it. (Dm4.)

The above comment can be seen as another indication of what might happen to situational awareness when new tasks are proscribed to the operators. Once there are more computer systems, the amount of information also increases. And when there is large amount of information, the relevant information cannot be ‘filtered’ out as easily as before, hence the ability to cope is also potentially altered.

Discussion

The analysis in the previous section indicated that the overall disposition of the operators to risks is active. Styles of reasoning such as population security and critical infrastructure protection tend to introduce general plans to be followed during daily action, such as anticipating some uncertainties through calculative frameworks. These types of techniques have the capacity to both regulate and constitute practice. But the key to the operation, that is at least attempted to be reached, is still experimental improvisation. Indeed, with the exception of energy rationing even the strongly regulated practices such as maintaining worker and customer safety still incorporate certain amount of on-the-spot adjustments.

Basic to the active contesting of the styles of reasoning is not just the operators’ conscious reflection. When working methods were objected to in the control rooms, it was rarely done because the operators considered themselves to be more reflective or intentional than for example formal plans, written instructions or computer programs. The key to the contesting lies, rather, in embracing good working habits. Habits are thus not understood by the operators as mindless repetition of industrial work (cf. Hughes 1989, 54), but rather, as an active element in forecasting the future and its unexpected turns. For further discussion of this finding, linking it to the current social scientific theoretical developments on habits and social conduct offers a promising direction (Kilpinen 2000).

Yet, ensuring good working habits was not the only context of the daily operations. Instead, it was illustrated in the empirical part that also the consumers of electricity play various parts during control room actions, such as being callers to the customer fault help line; being recipients of various ways to raise consumer ‘situational awareness’ including text messages and Internet maps of electricity system faults; being municipal residents entitled in the operator’s mind to public services and safety; and in exceptional disturbance cases, also being subject to energy rationing.

Upcoming research might link the two of the above topics to each other: habits and social conduct, on the one hand, and minimizing harms and increasing security, on the other hand. It is already widely known that “risk-based routines and practices pervade most areas of our life” (O’Malley 2004, 1), where risk refers to techniques of aggregating, calculating and thus anticipating unwanted events. But what happens when the focus of governing is displaced from *aggregated* events to *uncertain* events that are imagined as singular, infrequently recurring or unique (ibid, 13)?

For O’Malley (2004, 23-24), the various configurations of governing uncertainty entail for example employing common sense knowledge instead of probabilistic knowledge of the frequencies of unwanted events; applying precaution when some harms need to be avoided; dealing with situations where expertise is unavailable or in doubt and local and informal techniques need to be deployed; and receiving expert diagnoses where not all ‘relevant’ details of the future are known or knowable. These types of techniques – for example interruptible electricity contracts, citizen leaflets about surviving electricity blackouts and politically placed maximum durations for customer blackouts – already exist and have been deployed also in a mass scale for governing the impacts of European electricity supply failures. How that in turn shapes us into subjects who are expected to govern themselves, imagine the world and prepare for the future is a question that should be discussed in upcoming research (O’Malley 2004, 7).

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Appendix 1. Implementing the empirical study

The participants of the empirical study work in both of the control room of the distribution company. In order to conceal their identity, codes are used in the analysis text when the persons are quoted. The code consists of three parts:

(i) The control room where the person is working (M=energy market control room, D=electricity distribution control room, B=both control rooms)

(ii) The gender of the person (f=female, m=male)

(iii) The index of the person, running from 1.

The following persons participated from the energy market control room. All of the interviews were done by Antti Silvast in the control room during these persons' work shift; most of the interview transcriptions and their initial analysis were done by Eini Nyman.

- Mm1 (interview recorded and transcribed)
- Mm2 (interview recorded and transcribed)
- Mm3 (interview recorded and transcribed)
- Mm4 (no recorder present, Antti Silvast's own notes)
- Mm5 (interview recorded and transcribed). This person is not one of the operators but sits in the back of the room (see Figure 1).
- Mf1 (interview recorded and transcribed)
- Mm6 (refused recording of interview, Antti Silvast's own notes).

The analysis of this paper is done from the persons Mm1 to Mm5 and Mf1, but not yet Mm6, as he refused from taping the interview and there is hence no transcription.

The following persons participated from the electricity distribution control room. All of the interviews were done again by Antti Silvast in the control room during these persons' work shift; most of the interview transcriptions and their initial analysis were done by Eini Nyman.

- Dm1 (interview recorded and transcribed)
- Dm2 (interview recorded and transcribed)
- Dm3 (interview recorded and transcribed)
- Dm4 (interview recorded and partly transcribed)
- Dm5 (recording did not work, Antti Silvast's notes)

The analysis of this paper is done from the persons Dm1 to Dm4, but not yet Dm5, as for him the recording did not work.

Additionally, another participant of the study (Bm1) worked in both of the control rooms. He was interviewed in the energy market control room by Antti Silvast. Unfortunately, recording did not work for this participant. However, some of Antti Silvast's notes are used in the analysis as the person was highly relevant for the study because of sharing the responsibilities of both control rooms.

Together these participants comprise all the persons who work in the control rooms of the electricity distribution company of the case study.

Moreover, Antti Silvast has spent together about 20 hours in both of the control rooms observing the work and taking notes.

Appendix 2. Interview structure

The following set of themes and topics guided the interview situation. All of the participants received before hands a question sheet with these themes and topics. The sheet also included an introduction which briefly summarized the purpose and the time table of the study and highlighted that the responses are dealt with confidentially and anonymously.

The original questions were in Finnish, and they have been translated by Antti Silvast to English.

Background information

The following information is asked: the name of the respondent; date and time of the interview; year of birth of the respondent; gender; education (school, possible major subject, year of graduation); and home city.

Education to work

In this part, it is investigated how the operators started working for the company and what kind of training they received to the work.

Daily working routine

In this part, it is investigated how electricity is supplied under typical conditions. Topics include a description of a typical working day, different organizations that participate in it, tools and machines, tasks that are related to technical reliability, tasks that are related to market profitability and finally, the way that laws, regulations and standards are followed in the work.

Electricity supply and exceptional situations

In this part, we move on to the exceptional situations of electricity supply. Topics include describing exceptional situations that also impact energy consumers, actions during these situations including communication with other organizations, training to these situations including the use of simulations, communicating with electricity customers during blackouts, and more general question of if secure electricity supply can be achieved and how the operators themselves are able to influence on initiatives in its respect.

Electricity supply and markets

In this part, it is investigated how the opened energy markets work. Topics include the difference of the work to time before market restructuring, the new demands of the work, the interrelationship between electricity supply reliability and open markets, the interrelationship between market logic and working efficiency, and the operator's own thoughts on the direction of the energy markets.