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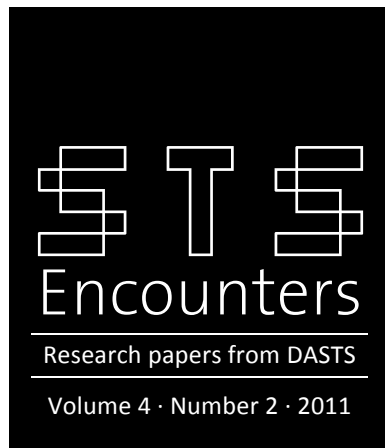
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Monitor Screens of Market Risks

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Finnish Control Room

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Monitor Screens of Market Risks

Managing Electricity in a Finnish Control Room¹

Antti Silvast

Electricity control rooms are the subject of many recent organizational studies. These studies have brought together the topics of technological risks and reliability with ethnographic methodologies and the broader themes in public policy and management. With a few exceptions, however, the technological artifacts of electricity control room work have received little systematic attention. This article tries to address this gap by discussing a technology that is pervasive in control room settings: the computer monitor. The research question asks what the effects of these devices are in electricity control room settings and especially in relation to the management of market risks in electricity supply. The article draws upon ethnographic research of an electricity control room in Finland. Motivated by sociological research on market devices, attention is paid to the 'screened' relationships between control room practices and the Nordic market of electrical energy. The analysis illustrates how market place bidding on monitors can discipline control room work and extend the capabilities that the control room workers have for calculating uncertainties and risk. However, while the screened market place on the monitors enacts a comprehensive global "economic world", the analysis also shows how the screened

1 An earlier version of this paper was presented at three different workshops: *9th Conference of the European Sociological Association (Disaster and Social Crisis Research Network session)*, September 4, 2009, Lisbon, Portugal; *Framing Screens: Knowledge, Interaction and Practice* PhD workshop, September 27-30, 2010, IT University of Copenhagen, Denmark; and *Tieto, tiede, teknologia* ("Knowledge, Science, Technology") research seminar, October 15, 2010, Tampere University of Technology and University of Tampere, Finland.

market prices and energy quantities are always shaped by local work practices. One example of this concerns the weather. The local weather impacts energy generation and consumption levels directly. Hence while calculating energy market bids the control room workers need to 'screen' upcoming weather and stay alert to weather fluctuations. Emphasis on local practice is also relevant as it highlights a salient aspect of control room monitors: the monitors' relation with working habits. Monitors, interacted with continuously in the control room, can become part of a working habit and appear to be mastered without that much constant reflection. The article concludes by relating its findings to debates on risks and markets. It claims that ethnographic knowledge from sites such as energy market control rooms adds to the understanding of market risks as it introduces a relevant and original aspect: management of uncertainties that works through real-time engagement with technological artifacts. In the case of the control room practice, market risks are not so much managed or 'perceived' by controllers alone. Rather they are dealt with through an assemblage of people, habits, numbers and monitors continuously working together to produce a reliable infrastructure service in ever-changing situations.

Introduction

Since the year 2000, Finland, Sweden, Norway and Denmark have all been integrated into a single energy market. It has also operated in Estonia since 2010. This market is called Nord Pool and is run by the Nord Pool Spot group. Nord Pool, as noted by the group's homepage, is "the largest market for electrical energy in the world" (Nord Pool Spot 2011a). There are 340 companies from 18 different countries that take part in the market and the trade among these companies covers over 70 percent of the electricity consumed in the Nordic countries (ibid).

Trading electrical energy in Nord Pool is actually organized as two co-markets that interrelate in temporal terms. One market is called

Elspot and is used for predicting the energy production of the next day or further ahead in the future. The *Elbas* is in turn an hour-ahead market place and permits the correcting of energy production levels during day-to-day work. Both markets are accessed through a technique called *bidding*. An energy market bid is a combination of quantities and prices and communicates how much a market participant is willing to buy or sell energy (measured in megawatt hours) for different prices (measured in euros) in specified hours of the day. Once every day, the participants in the Nord Pool collaboration produce an Elspot bid for each hour of the day ahead and send it to the stock exchange. These bids are next combined on the Nordic level and used to determine electricity's "system price" for each hour of the following day. During day-to-day work, the Nord Pool participants have to submit to the system price and if necessary, can also purchase or sell energy at each even hour from the Elbas market place.

The theory of electric energy trading goes roughly as above, as has been made vivid in a number of publicly available documents by Nord Pool Spot (e.g. Nord Pool Spot 2011a, 2011b, 2011c, 2011d, 2011e). Yet, at the same time, relatively little is known about the manners in which the energy market is produced in the immediate contexts of everyday work (see Heath & Luff 2000, pp. 10-12). My paper addresses this topic by studying an electricity control room in Finland. In particular it focuses on the computer monitors, a pervasive technology in energy market bidding and control room work. However these technologies have yet received relatively little attention in established science and technology studies on large electricity systems (e.g. Hughes 1989) or ethnographic studies on electricity control rooms and electricity supply reliability (Schulman et al 2004; Roe et al 2005; de Bruijne 2006; Roe & Schulman 2008). The research question asks what are the effects of monitors in electricity control rooms and the management of market risks in electricity supply.

Inspired by this interest in how the market works in practice, three themes of inquiry are developed in this paper. These have emerged from my interests in day-to-day work (Suchman 1993; Heath & Luff 2000; Gobo 2008), monitors and screens (Sobchack 1994; Suchman 2000; Knorr Cetina & Bruegger 2002; Schull 2005; Latour & Hermant 2006; Myers 2008) and sociology of the markets (Knorr Cetina & Bruegger 2002; MacKenzie 2008; Çalişkan & Callon 2010). The first theme situates a general curiosity about how economic actions are *screened* on computer monitors. There are various technological artifacts in an electricity control room yet the energy market operates largely through computer monitors. This situation was different before the energy market liberalization in Finland that occurred during 1995-1998. Before this period, electric energy was commonly traded on the phone. Hence the first theme of inquiry explores some of the specificities about how trading energy gets done on the computer monitor rather than, for example, over the phone with known business partners.²

The second theme concerns the 'production' of market-based bids. To form an energy market bid, megawatt hours and prices have to be entering into the user interface displayed by the monitors. Electricity hence acquires economic value and such values are always the result of work and efforts according to literature on the sociology of markets (see Çalişkan & Callon 2010, pp. 5-14) and others (e.g. Verran 2010a). More specifically, this theme concerns how electricity's values are monitored in the control room and what screens are used to calculate these values.

The third theme of inquiry develops the previous themes further by discussing the extent to which monitor screens *effect* electricity market values and risks in the daily practices of control room work. My claim is that the bids on control room monitors have agency in that they participate in ordering the control room work (see Verran

² For a corresponding discussion on currency traders, see Knorr Cetina & Bruegger 2002, p. 166.

2010a; see also MacKenzie 2009, p. 9). I wish to explore this order further by focusing on the “breakdown” between what might be called bidding logics and the more intuitive moves of human workers themselves. Another way to phrase this is what happens when the bid does not add up and how might ‘screens’ work to restore order and hence effect the management of market risks.

The structure of the article is as follows. I first introduce selected literature on control room work, screens, markets and risk. I then overview my research methodology and a control room that served as my field site. The thematic analyses outlined above are explored in the next three sections, followed by the discussion and conclusion.

Control room work, monitors, screens, markets and risk

Control rooms have been a frequent field site for workplace studies (e.g. Suchman 1993; Heath & Luff 2000; Gobo 2008) and they continue to attract the attention of researchers also in the context of electricity (Schulman et al 2004; Roe et al 2005; de Bruijne 2006; Roe & Schulman 2008). What might an analysis of *screens* add to this existing research?

The previous studies on electricity control rooms include numerous analyses on technological risks and reliability in terms of control room operator skills (Schulman et al 2004; Roe et al 2005; de Bruijne 2006; Roe & Schulman 2008). Control room monitors are acknowledged by these studies but, with a few exceptions, they appear only in two ways: as a “backdrop” in maps and photographs and field work introductions (de Bruijne 2006, p. 89; Roe & Schulman 2008, pp. 28-35) and as an irritation to working practice when they break down (de Bruijne 2006, p. 182; Roe & Schulman 2008, p. 166; p. 185). Such concern with electricity operators and their skills rather than technologies is of course important. Nonetheless, these studies pay relatively little attention to the salient technological artifacts, like computer monitors, that figure in the production and

coordination of workplace activities (Suchman 2000; Heath & Luff 2000, p. 6; Gobo 2008, pp. 175-178).

The significance of monitors and their screening characteristics in work practice is better supported by a number of social scientific studies in science and technology (Sobchack 1994; Turkle 1995; Suchman 2000; Knorr Cetina & Bruegger 2002; Schull 2005; Latour & Hermant 2006; Myers 2008). These studies share the assumption that screens effect practices. Observations of such effects generally start with the material device, for example the computer monitor of currency traders (Knorr Cetina & Bruegger 2002), the displays in an infrastructure control centre (Latour & Hermant 2006) or the digital display where people gamble (Schull 2005). Having pinpointed the material device, these studies then shift their attention to the manners in which displays bring interactions, practices and information together. This two-fold focus has informed findings from diverse sites that range from currency trading (Knorr Cetina & Bruegger 2002), infrastructure controlling (Latour & Hermant 2006) and gambling (Schull 2005) to civil engineering (Suchman 2000), protein modeling (Myers 2008), Internet use (Turtle 1995) and media technology (Sobchack 1994).³

My paper draws upon the above tension between *monitors* – which refer to material devices – and *screens* or *screening* – the various effects of these devices – and employs this tension as a methodological vantage point. I want to begin by observing the monitors of control room work while paying more systematic attention to their various relations with the control room work practices. Here work practices could refer to social interactions (Heath & Luff 2000), situated actions (Gobo 2008, pp. 175-178), engineering and bodywork

³ The two-fold focus also draws support from the English language concept of screen which can be used both as a noun and as a verb (I owe this insight to Peter Lutz, personal communication, and Bauke Steenhuisen, personal communication, respectively). Literally, screen means a device as well as the actions of for example projecting, selecting, considering, grouping, rejecting or concealing (Dictionary.com 2011).

(Suchman 2000; Myers 2008) or the controlling of the 'flows' of electricity in a large distributed network (Latour & Hermiant 2006, pp. 32-33). These elements are certainly relevant and some aspects are partially explored here. Nevertheless two dimensions, markets and risks, are particularly important in the context of electricity trade and control room work and will remain my underlying concern.

Many electricity control room workers today trade electricity on online energy market places. As mentioned, these markets are accessed through computer monitors hence it is plausible that the control room monitors function as *market devices*. Analysis of such devices contributes to discussions on 'economic agency' and the construction of markets as several social scientists have emphasized in recent years (Knorr Cetina & Bruegger 2002; MacKenzie 2008; Çalışkan & Callon 2010). At the same time, it can also be argued that electricity control room workers are managing a service whose functioning is critical to number of other provisions (Graham & Marvin 2001; Roe & Schulman 2008; Collier & Lakoff 2008). Failure to provide electricity is thus a *risk* in that it is an unwanted event whose impacts need to be minimized (Beck 1992; Adams 1995; O'Malley 2004; Collier & Lakoff 2008; Lehtonen & Liukko 2010). When I speak of control room 'screens' I am thus interested in the manners in which control room workers anticipate and mitigate – or 'screen' – unwanted events through computer monitors.⁴ The following section offers a background to the empirical methodology I employ to explore control room monitors and their 'screening' effects.

4 For lack of space, the paper cannot engage more systematically with theories and debates on markets and risks. It thus simply refers to these discussions to add to the integrity and relevance of the analysis. At the same time, my study may also help 'localize' discussions on risk governance and the benefits and demerits of markets. Such local configurations have also been an emerging topic in recent debates about risk technologies (O'Malley 2004; Collier & Lakoff 2008; Lehtonen & Liukko 2010) and market devices (Knorr Cetina & Bruegger 2002; MacKenzie 2008; Çalışkan & Callon 2010).

3. Methodology and the field site

Above I introduce a study of how computer monitors figure in the practices of managing electricity trade. Ethnographic data can be effectively drawn upon when exploring this topic. For example, ethnographic data may emphasize technological infrastructures as socially and organizationally performed (e.g. Steenhuisen 2009). Rather than merely reading theories or instructions on electricity grid management in text books, web pages or instruction manuals, an ethnographic approach implies going to where the electricity system is produced and technologies reconfigured as part of the daily practice.

With this in mind I went to the control rooms of an electricity distribution company in a Finnish city in 2007 and 2008. The research permission was arranged through the company's CEO who is one of the supervisors of my research project and the direct managers of the control room workers. These people did not require that I conceal the name of the company however, it was still appropriate to hide the identity of the workers who I interviewed about sensitive topics like accidents and working errors.⁵ Henceforth I will refer to the company as *the electricity distribution company*. One of the managers did stress that I should not disseminate any market-sensitive information from the control rooms. Hence no actual market numbers (prices, megawatt hours) will be referred in this paper. As the paper is about monitors and monitored numbers, the prohibition to report such numbers does somewhat steer my focus. When I discuss numbers, I will emphasize how people use numbers to make sense of their work and to arrange their working routine and do not aim at reporting what the numbers' magnitudes are in mathematical terms (see also Verran 2010a).

5 My introduction letter to the informants assured that neither the workers nor the company will be identifiable in the presentation of the research results.

A schematic map (Figure 1) shows the company's control room setup. There are two control rooms. One is responsible for operations on the energy market while the other manages the local electricity distribution network. The rooms are connected by means of a door and a window and both rooms share the same kitchen facilities. Each control room comprises one or two operators who are sitting in front of one or more computer screens. Information and events are displayed on the screens while the workers type in commands and navigate the screens with the mouse.

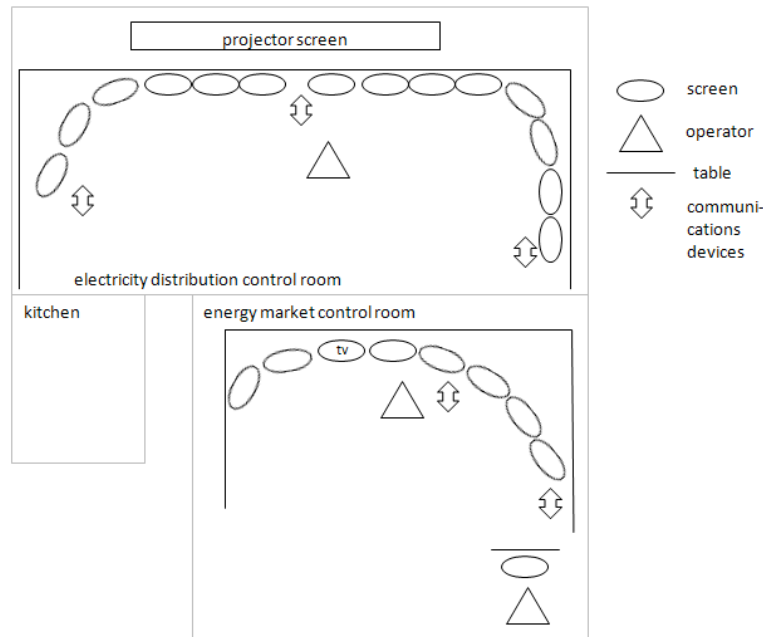


Fig. 1: A schematic map of the physical setup and technological artifacts of the control rooms in the electricity distribution company.



Fig. 2: The energy market control room.

Above I highlighted my theoretical interest in monitors as market devices. Hence my analysis centers on such devices found in the market control room where I carried out interviews and did participant observations for approximately 12 hours. I interviewed all seven control room employees. The interviews were recorded and transcribed or written down in my notebook along with my observations about control room work. With the interview questions I sought to address different themes of the daily work. This included the worker's background information, education to work, daily working routine, the management of accidents and security and operations on the energy market. Screens or monitors were not the initial theme for the interviews but their significance emerged while discussing work routines.

It is also possible to draw on other data from the field site to qualify the role of the control room monitors such as photographs, maps

and observational notes. Figure 2 is a photograph of the control room. It shows that the room has various different computer monitors. Most of them are displaying a different image while one is blank. Six monitors are visible on the photograph and the map in Figure 1 shows that there are altogether eight monitors in front of the worker. The monitors that appear in the background of the photograph through the door are from the other control room. According to my field notes, these monitors display from left to right:

1. Information on the production of electricity (possibly non-interactive).
2. Information on the electricity network (possibly non-interactive). An extended work desk from monitor 1.
3. A television (not on in Figure 2).
4. Email software and information on temperatures. Information on the production of district heating (possibly non-interactive).
5. An extended work desk from monitor 4.
6. Spreadsheet software. Interface to the Elspot energy market place.
7. A graph on the balance between electricity production and electricity consumption.
8. Interface to the Elbas energy market place.

According to my notes, workers interact mostly with their email and spreadsheets (4-6) and market-related monitors (6-8). These brief field notes, although somewhat generic, help outline the diversity that computer monitors can figure in control room work practice. The next section explores this diversity further in relation to how computer monitors screen economic actions in the control room, the first main theme of my inquiry.

4. Trading on monitor

Private competitive electrical energy markets are not a new phenomenon. The earliest interconnected large-scale electricity networks date back to the early 20th century (Graham & Marvin 2001, p. 46) and energy has been commonly considered a commodity that can be traded through these networks (Nye 2010, pp. 203-207). If trading electricity has already been possible between two electricity companies, what difference does a 'screened' market relationship make?

Based on talking to the control room workers and observing their work, it appears that the first salient characteristic of Nord Pool trading is its disciplined nature. For example, bidding on the Nord Pool obliges workers to complete electronic forms on monitors and submit them by a certain time, as well as intensely follow the Nordic market situation on an hour by hour, if not minute by minute basis. When asked about changes in the trading of energy, one of the workers (W1⁶) in my study recollects how energy trading used to be "much more casual" over the phone. The same worker concludes that the "work has become much more exact" after the introduction of Nord Pool. Several other workers confirmed that they were not as financially accountable prior to today's market. For example, if prior to the market restructuring the company was imbalanced regarding electricity production and consumption, state-owned electricity company managed the gap for a price that was always affordable according to several workers.

Another important feature of Nord Pool trading is its volume. It is not obligatory for electricity companies to take part in the Nord Pool collaboration. Instead, the companies might rely on their own local power plants or trade energy outside the Nord Pool market. A study suggests in fact that Finnish electricity companies who generate locally or trade outside Nord Pool often acquire cheaper electricity (Lehto 2011). In practice however, and as mentioned earlier, most of

⁶ To distinguish between the talk and actions of different informants, I use the codes (W1-W7) to refer to the workers.

the electricity supplied in the Nordic area is traded through Nord Pool. It would seem that this trading introduces the companies with certain benefits. This brings me to a third point.

As mentioned, the situation created by Nord Pool is markedly different from previous practices of trading energy in that the whole market operates in real-time. Nord Pool is also used for trading electric energy for the next day and more, but the energy trading on Nord Pool continues up to one hour before the delivery of the energy. According to Nord Pool Spot's (2011b) homepage, there are two underlying reasons for initiating this practice: real-time trading of energy "reduces the risk of imbalance (between energy consumption and production)" but it also provides "the opportunity for better prices than in the day-ahead market" and "opportunities for economical profit for all participants". While the last remark has been contested (see again Lehto 2011), these are still rather binding inscriptions. It is apparent that energy trading that strives to minimize electric power imbalance and acquire financial profit in real-time compels the workers to observe and study the market continually, day and night.

The 'screened' relationship between the control room practice and the Nordic energy market is hence specific for multiple reasons. Economic actions are not new in electricity supply, but the market on the monitors seems to enhance and augment economic activities and relationships. The workers are submitted to discipline and visible trading which works through software and routine inputting of bidding numbers on computer terminals. These software and routines tell the workers what they should do: for this hour (H) of the day, the company will buy or sell (X) amount of energy, for the price of (Y) per unit.

Electricity companies are hence assumed by the software to calculate their maximum profit and financial risks in varieties of ways offered by the market equipment. When the Nordic "system price" of energy is calculated in the Nord Pool collaboration, it is similarly assumed that the calculation corresponds with the economic model

of supply and demand. The Nordic price of the energy is determined by economic equilibrium, i.e. the point where the price of producing energy by all the participating companies is equal to the desire of buying energy by the companies (Nord Pool Spot 2011e). To recapitulate, electricity trading existed before the energy market restructuring and the creation of the Nordic common market. Yet it is obvious even from this brief introduction that the current anonymous online trading on monitors is different from the previous practice of trading with business partners and other companies over the phone (see also Knorr Cetina & Bruegger 2002, p. 167).

All of this motivates, I believe, speculation that the current equipment of energy markets is "performative" (MacKenzie 2008): when computer monitors assume that control room technicians are anonymous and rational economic decision makers, maybe an empirical reality is created where they become these non-human actors, at least when they 'screen' electricity through market bids (see also Turkle 1995). It is also apparent that computer monitors, computer software, and market bids can extend or "distribute" (MacKenzie 2008) the capabilities of the control room workers. Two numbers (quantity and price) for each hour of the day is, at least in some respects, effective for making sense of a large distributed electricity network and a market that comprises 340 companies from 18 different countries. But as such this discussion is still limited. As the sociology of markets argues, market prices are one thing but their production is a different matter (see Çalışkan & Callon 2010, pp. 5-14; see also Verran 2010a). How does electricity gain its quality as a value to be input into the NordPool bid? This question denotes a second theme of my inquiry and is assessed in the following section.

Screening electricity values

One of the workers, whom I interviewed in the night shift after the order for that day had already been sent, described the Elspot bid this way:

In the morning shift we make the next day's prognosis, where the power plant's generation power is defined based on the weather situation, and from there the electricity. From there on we also send to Norway [to the energy stock exchange] the order, which has for each hour the information on which price we are willing to sell and buy [energy]. (W1.)

As mentioned, the company communicates to the Nord Pool stock exchange about the prices for which it is willing to sell and buy energy during the following day. However, the worker points out that there is something behind the number: the prognosis of buying and selling energy is based on the ongoing weather situation. From a strict economic perspective this is not obvious. The weather affects people's demand of heat but in Finnish cities it is not normal to have buildings with electrical heating. The energy market room is hence not selling heat as a commodity as such. Why did the workers still need to pay attention to the predicted weather?

One reason can be found in the structure of the energy production that the workers are managing. This and many other Finnish towns relies on district heating; a system where heat is generated in centralized power plants from wood, oil and other fuels and distributed to people in the form of hot water in pipes. Moreover, district heating and electric energy are generated inside the same power plant. Heat generation is the primary product of the plant but it also generates electricity as a kind of "side product". Therefore, when people need more heat it requires the generation of more district heating, which then also generates surplus electricity. That is why the workers need to acknowledge the following day's weather when making the bids for Elspot. (Finnish Energy Industries 2010.)

Based on direct observations and interviews with the workers, predicting the weather situation is a complex and varied practice. In everyday life we may assess the "weather situation" by simply going

outside or looking at the sky. However in the control room this does not suffice. Instead the weather has to be transformed into a number for each hour of the following day. What is needed, thus, is some kind of weather 'screen'. Similarly to the weather predictions of meteorological institutes, data on the weather situation has to be "(g)athered together, added up, standardized and averaged out" (Latour & Hermant 2006, p. 10). Upon asking about the matter, it turns out that the workers are doing more to this end than following weather predictions on television or the Internet. When I asked about the use of weather predictions, a relatively new female worker explained:

Yes, we have separate services, so that these temperatures are as accurate as possible. So here it is [shows me a spreadsheet on a computer monitor], this day's weather. In fact this has been done this morning, there's the thing that we have to make this spot offer by one o'clock, telling what we want to buy. So here are the predicted temperatures. And here is a sort of comparison day, where the temperature for instance has been as close as possible and usually also the day of the week has to be the same, because there are differences between a Saturday and a weekday. (W7.)

My participant notes the weather prediction service provided to the company. However, determining the status of the weather situation merely starts here. The prediction is entered into a spreadsheet on the monitor where each hour of the day is juxtaposed with various data, not only on the temperature but also on the predicted electricity consumption as several workers confirmed. The computer monitor is hence an essential interface to the weather as the monitor mediates or 'screens' between weather data and the number that the workers want to produce.

As the worker remarks in the quote above, it is particularly important to find a comparison day; a day that has had similar temperature and consumption patterns as the predicted day. The same days of the week are preferred as working days tend to have different energy consumption patterns to the weekend. Contingencies in the following day's local electricity production also have to be taken into account, such as stopping a power plant for maintenance or starting one for the winter months. As I observed from a worker (W5) who had to handle such situation, staying up-to-date with these kinds of events requires making constant phone calls with the local power plants.

One can see therefore that the Elspot order is not just drawing on individual economic thinking. Instead, the order has to be 'screened' in diverse and, from a strictly economic perspective, unpredictable manners. Different computer monitors are studied, archival data is gathered and phone calls to the local power plants are made before the control room workers can make "our estimate of electricity production and distribution" (W7) or the Elspot bid to the Nord Pool. The bid is merely an end result of a long chain of elements that works together to produce an estimate of the next day's electricity.

At the same time, my interviews and observations indicate that the important practice of prediction is still missing from this account. One aspect was continually repeated when I discussed about the Elspot prediction. When I asked about it without observing the actual making of the prediction, the answers were brief and general. When I asked the worker to show the making of the prediction on the spreadsheet on the monitor, the answers were much more detailed. I do not believe that some workers were less precise than the others. Rather, the making of the Elspot bids on the computer screen had become a habit (Kilpinen 2000) which can be difficult to describe and was easier to explain in practice next to the monitor. One of the workers even reported that he used his "gut feeling" to predict energy demand any one day of the week:

Tuesday, Wednesday, Thursday, they could be similar to 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. (W1.)

A habit, pragmatist theory argues (Kilpinen 2000, p. 57), is a generalization from particular experiences. One can also assume here that the worker has predicted the following day's energy on several occasions. Therefore he has a "hunch" that he can rely on for every occasion he makes a prediction.

Two reflections are relevant here on the role of control room screens. The first is that bodywork seems to be a resource – or in other words, a form of 'screening' – when using a control room computer monitor. This observation corresponds with other case studies on computer-based civil engineering work (Suchman 2000) and modeling of proteins with computer software (Myers 2008). The second and somewhat different comment is that over time people get used to and 'inhabit' monitors and their effects, like the above worker who can 'screen' electricity levels on the monitor without giving it that much conscious reflection. This observation is especially relevant as it highlights what might happen with monitors after they lose their status as an innovative technological artifact (cf. Sobchack 1994; Turkle 1995). Rather than the monitors being a novelty whose role needs to be constantly reflected, it appears that the control room workers can master the monitors as part of their working habit. Here it is not just bodywork and habits that are the issue. Rather, the artifacts have *rubbed together* and into the bodywork and habits of control room market practice.⁷

To sum up the findings here, producing an electricity market bid is neither an automatic routine nor is it simply based on economic or

⁷ Peter Lutz, personal communication.

other theories. It is not the kind of work that can easily be done with computer software alone. As one of the workers explains, “they have 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.” (W2.) But nor is a prediction made by a skillful and trained worker alone. The same worker did not feel that his work “could in principle be done by anyone” (W2.). Producing a value for electricity, in brief, is a matter of skillfully using technologies and consulting other people: one might say that the habits of the workers are co-configured with technological artifacts and social interactions and one requires the other respectively (Suchman 2000; Myers 2008). Control room practices rely on monitors but also it appears that the monitors themselves enliven the local control room practices, habits and interactions (Suchman 2000, p. 6).

6. Bids and ordering

The previous section documented the role of monitors and diverse forms of ‘screening’ in producing of the Elspot bids that predict the energy flows for the following day. However, the work of the control room does not stop at predicting. The electricity supply has to be managed in real-time, hour by hour, even during the night shift. On one of the computer monitors (number 7 in section 3) that face the operator there are two graphs. These show the predicted difference and the actual difference between energy consumption and energy generation. The latter is measured every three minutes and requires action if it deviates markedly from the prediction. 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 market also sets it a legal obligation for “balance responsibility” in the distribution area (see Fingrid 2010).

By and large it seems that the predictions made on the previous day are seldom markedly inaccurate. After next day’s prediction has been made, it even appears that there is not a great deal of continuous activity. For example, the workers can carry out an interview with me while working and they were allowed to watch regular television programs. The latter is possible as the management has put a television set in the control room to serve as “a breathing spot for the operators” (W7). Yet when I discuss it more, it turns out that the notion of having time for less intense “breathing spots” is itself somewhat problematic in the context of the work.

All the operators of my study emphasize the ever-changing contexts of day-to-day practice and the monitors certainly heightened this intensity. Even while the work might seem quite similar from day to day, the following conversation illustrates how hard it is to pinpoint the work either as completely routine-like or constantly changing. I prompted this worker by asking if this work is routine-like or if it changes daily and his reply was:

Well, it changes in principle. Or it is kind of similar, but every moment is a matter of guesswork. There is no particular moment where you could put your feet up on the table, moments when the shift would go through without disturbance. No situation is hundred percent sure. For example, you cannot predict what the temperature is going to be, and the work depends on the temperature so much. (W2.)

Hence, not much happens but the worker’s main task is to *stay alert*. In fact, one of the workers summarized energy trading as watching a camp fire: “You have to be constantly keeping up a small flame. That is, you mustn’t fall behind the energy stock exchanges.” (W6.) Another worker emphasizes how the district heating makes the working situation “alive” all the time.

The process is alive all the time. And we try to keep up with the district heating network and as a counterweight to it. It's alive all the time. (...) When we make some guess about the temperature, and what could be the consumption, it's a living process (...) even though there have been similar temperatures in the past. It's alive and production is alive too. (W3.)

For yet another operator, "this work is always sort of seeking, there is no crystal ball. You cannot do the electricity stock exchanges beforehand so that it goes dead-on. This work changes from moment to moment." (W1.) For example, the weather might change and alter the levels of energy production and consumption (W7); or it might become dark enough for the city's street lights to switch on, which creates a marked shift to the required level of electricity production yet tends to occur at slightly different hours of the day (W4).

But even though the rapid changes in daily conditions cannot always be predicted, there are several ways of improving the balance between energy use and production. The local power generation plants, which are owned by the same parent company, can be requested to produce more energy. To this end the workers have a phone that connects with the plant's workers. A second option is to use the real-time online electricity stock market Elbas to purchase more energy or sell extra energy. This option operates on the monitor and on the market and I will assess it further in the light of the paper's interest.

Elbas is in operation 24 hours a day and seven days a week, with exchanges being made up to one hour before the delivery of energy (see Nord Pool Spot 2011b). Like with Elspot participation in the market is done online. A computer monitor introduces the participant with other market actors' bids that buy or sell energy for selected hours for a defined price. The operator can also make his or her own anonymous bid on every even hour. The company's own energy purchasing and selling in the stock market appear in green

on the monitor and whenever I observed there were several such trades in action.

The principal tool for doing the Elbas trading is another monitor, already mentioned with the prediction practices, that shows a computer spreadsheet that provides temperatures, consumption patterns and electricity generation information. The spreadsheet is studied by the worker to produce a new estimate of the consumption and generation balance and exactly on the hour, to make a bid on the Elbas market, thus correcting the energy balance. It is apparent here that the market numbers on control room computer monitors do not need to be treated as stable facts. Instead, the numbers gain their quality as facts by once in a while performing as fleeting "screenshots" (Verran 2010b) that can many times be interchanged with new "screenshots" when the situation demands it.

It is not always the case that balancing work is so flexible. Instead, it is possible that both practices of correcting the energy balance fail. The parent company might not have enough local generation and the worker might not be in time to purchase it from the market either. Technically, this would result in an electricity supply failure. In practice, however, the national high-voltage electricity transmission operator steps in to fill the gap between production and consumption. This gap-filling electric energy is called "balancing energy" (Fingrid 2010) and the electricity distribution company is charged for it afterwards.

The charge for this balancing energy is not a fine. But the charge is not always affordable either which, according to the workers, was the case before the energy market liberalization. Instead, the gap-filling electricity is 'bought' (by coercion) from a market place. The prices of this electricity are highly unpredictable. According to one of the operators (W3), the balancing prices cannot really be known beforehand. Another is explicit that he does not want the company to "take a lot of energy" (W1) from the national transmission operator. One of the operators even thinks that the balancing energy can cause "serious economic risk situations" (W5). The balancing energy

is hence screened to the control room in terms of financial accountability rather than for example a sort-of public intervention, as was the case before the recent decades' shifts. However the workers do not seem to want to be accountable for using this energy and hence avoid it.

This balancing energy and its costs, it might be claimed, is another disciplinary technique that encourages the control room workers to be responsible economic actors. A different interpretation is also possible and goes closer to the previous studies of electricity control room and operator skills. Perhaps the workers want to feel that they are decisive with the monitors and their screening effects and not let the national operator fix the energy imbalance (see also Roe & Schulman 2008, p. 88). We would then be observing an active effort to control the risk of imbalance in the local practice. Or to take the conclusion one step further, perhaps the control room operators take some amount of pride in sorting out problems locally even if this means that they have to make "just in time" real-time decisions and work under pressure (ibid).

7. Discussion and conclusion

This paper has explored the interrelationship between the role of monitors in an electricity control room and the management of electricity supply. Specific attention was paid to computer monitors that depict the Nordic energy market to electricity control room workers. Three themes guided the inquiry of these monitors and their effects: the specificity of 'screened' market relations; the production of monitored market values; and the effects and adjustments of these values in the context of everyday work. It was shown how the depictions to the markets enable the control room workers to predict the levels of electricity production. It was also documented how these workers are engaged in balancing energy production and consumption as they were creating local adjustments to the balancing based on working habits, interactions and knowledge of real-time risks

such as weather fluctuations. Situation-specific layers were hence constantly 'added' on the control room monitors.

The findings in this paper indicate that skills and artifacts are not separate in the control room setting. As was shown, computer monitors, like operational decisions and procedures in the previous studies on electricity control rooms (e.g. Roe & Schulman 2008), need to be understood and used by the workers to play a legitimate role in the everyday practices. Skills can hence mediate technological artifacts (Suchman 2000, p. 12). Indeed, it does not seem that the monitor-mediated global energy markets are "everything" for the control room practice. This contrasts with a finding about currency traders who appear to be engaged with monitored markets all the time (Knorr Cetina & Bruegger 2002, p. 168) but certainly artifacts like computer monitors can mediate local practices on intense, on-going basis. For example, it was shown how computer monitors may discipline control room work, extend the calculative capabilities of the control room workers, make weather status more tangible and become part of a habit when the workers simply repeat what has worked with monitors before without giving it that much conscious reflection. Overall, the paper stressed a process of mutual shaping going on: the monitors continuously shape local work practices while local work practices continuously shape how the monitors are used.

I wish to conclude by relating the last point to broader debates on markets and risks. In social sciences, it has been established that risk is the property of an individual observer and his or her *risk culture*. This approach is called the theory of "risk perception" (e.g. Adams 1995). Yet the findings here suggest a somewhat different conclusion on risks and the management of uncertainties. Ethnographic knowledge from the energy market control room adds to the understanding of risk as control room risks are not so much managed or 'perceived' by controllers alone. Rather, we can observe an assemblage of people, habits, monitors, numbers and market mechanisms that continuously works together to produce a reliable infrastruc-

ture service in ever-shifting conditions. As the “marketization” (see Çalışkan & Callon 2010) of electricity continues to gain support, these kinds of socio-technical assemblages demand even more attention from future research.

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References

- Adams, J. 1995: *Risk*. London: UCL Press.
- Beck, U. 1992: *Risk Society: Towards a New Modernity*. London: Sage. (German original 1986.)
- Bruijne, M. d. 2006: Networked reliability: Institutional Fragmentation and the Reliability of Service Provision in Critical Infrastructures. Dissertation for Technische Universiteit Delft.
- Çalışkan, K. & M. Callon 2010: "Economization, Part 2: A Research Programme for the Study of Markets" In *Economy and Society* Vol. 39, No. 1, pp. 1–32.
- Collier, S. & A. Lakoff 2008: "The Vulnerability of Vital Systems: How Critical Infrastructures Became a Security Problem" In Dunn Caverty, M. & K. S. Kristensen (eds.): *Securing "the Homeland": Critical Infrastructure, Risk and (In)security*. London: Routledge, Pp.17-39.
- Dictionary.com 2011: "Screen." Word definition. Published on <http://dictionary.reference.com/browse/screen> (accessed 18 July 2011).
- Fingrid 2010: "Definitions." Web site. Published on http://www.fingrid.fi/portal/in_english/services/balance_services/definitions/ (accessed 24 March.2011).
- Finnish Energy Industries 2010: "Kaukolämpö." ("District Heating.") Web site. Published on <http://www.energia.fi/fi/kaukolampo/kaukolampo> (accessed 24 March 2011).
- Gobo, G. 2008: *Doing Ethnography*. London: Sage.
- Graham, S. & S. Marvin 2001: *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*. London: Routledge.
- Heath, C. & P. Luff 2000: *Technology in Action*. Cambridge: Cambridge University Press.
- Hughes, T. 1989: "The Evolution of Large Scale Technological Systems" In Bijker, W.; T. Hughes & T. Pinch (eds.): *The Social Construction of Technological Systems*. Cambridge, MA: MIT Press. Pp. 51-82.
- Kilpinen, E. 2000: The Enormous Fly-wheel of Society: Pragmatism's Habitual Conception of Action and Social Theory. University of Helsinki, Department of Sociology Research Reports, No. 235.
- Knorr Cetina, K. & U. Bruegger 2002: "Traders' Engagement with Markets: A Postsocial Relationship" In *Theory, Culture & Society* Vol. 19, No. 5/6, pp. 161-185.
- Latour, B. & E. Hermant 2006: Paris: Invisible City. Link checked 7.8.2010: http://www.bruno-latour.fr/livres/viii_pariscity-gb.pdf
- Lehto, E. 2011: "Electricity prices in the Finnish retail market" In *Energy Policy* Vol 39, No. 4, pp. 2179-2192.
- Lehtonen, T-K & J. Liukko 2010: "Justifications for Commodified Security: The Promotion of Private Life Insurance in Finland 1945-1990" In *Acta Sociologica* Vol. 53, No. 4, pp. 371-386.
- MacKenzie, D. 2008: "Ten Precepts for the Social Studies of Finance" In Mackenzie, D. (ed.): *Material Markets: How Economic Agents are Constructed*. Oxford: Oxford University Press. Pp. 8-36.
- Myers, N. 2008: "Molecular Embodiments and the Body-work of Modeling in Protein Crystallography" In *Social Studies of Science* Vol. 38, No. 2, pp. 163-199.
- Nord Pool Spot 2011a: "About us." Web site. Published on <http://www.nordpoolspot.com/about/> (accessed 24 March 2011).
- Nord Pool Spot 2011b: "The Elbas market." Web site. Published on <http://www.nordpoolspot.com/trading/The-Elbas-market/> (accessed 24 March 2011.)
- Nord Pool Spot 2011c: "The Elspot market." Web site. Published on http://www.nordpoolspot.com/trading/The_Elspot_market/ (accessed 24 March 2011.)
- Nord Pool Spot 2011d: "Bid Types." Web site. Published on (accessed 24 March 2011.)

Nord Pool Spot 2011e: "System price." Web site. Published on http://www.nordpoolspot.com/trading/The_Elspot_market/Price-calculation/ (accessed 24 March 2011.)

Nye, D. 2010: *When the Lights Went Out: A History of Blackouts in America*. Cambridge: MIT Press. Kindle edition.

O'Malley, P. 2004: *Risk, Uncertainty and Government*. London-Sydney-Portland: Glasshouse Press.

Roe, E. & P. Schulman 2008: *High Reliability Management: Operating on the Edge*. Stanford: Stanford Business Books.

Roe, E.; P. Schulman; M. v. Eeten & M. d. Bruijne 2005: "High Reliability Bandwidth Management in Large Technical Systems" In *Journal of Public Administration Research and Theory*, Vol. 15, No. 1, pp. 263-280.

Sobchack, V. 1994: "The Scene of the Screen: Envisioning Cinematic and Electronic Presence" In Gumbrecht, H. & L. Pfeiffer (eds): *Materialities of Communication*. Stanford: Stanford University Press. Pp. 83-106.

Schull, N. D. 2005: "Digital Gambling: The Coincidence of Desire and Design" In *The ANNALS of the American Academy of Political and Social Science* Vol. 597, pp. 65-81.

Schulman, P.; E. Roe; M. v. Eeten & M. d. Bruijne 2004: "High Reliability and the Management of Critical Infrastructures" In *Journal of Contingencies and Crisis Management*, Vol. 12, No. 1, pp. 14-28.

Steenhuisen, B. 2009: *Competing Public values: Coping Strategies in Heavily Regulated Utility Industries*. Dissertation for Technische Universiteit Delft.

Steenhuisen, B. 2011: Private correspondence, 8 April 2011.

Suchman, L. 1993: "Technologies of Accountability" In Button, G. (ed.): *Technology in Working Order: Studies of work, Interaction and Technology*. London: Routledge. Pp. 113-126.

Suchman, L. 2000: "Embodied Practices of Engineering Work" In *Mind, Culture & Activity* Vol. 7, No. 1-2, pp. 4-18.

Turkle, S. 1995: *Life on the Screen: Identity in the Age of the Internet*. New York: Touchstone.

Verran, H. 2010a: "Number as Generative Device: Ordering and Valuing our Relations with Nature" In Wakeford, N. & C. Lury (eds): *Inventive Methods: The Happening of the Social*. London: Routledge.

Verran, H. 2010b: Private conversation at the *Framing Screens: Knowledge, Interaction and Practice PhD workshop*, 27-30 September 2010, at IT University of Copenhagen, Denmark.

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