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Articulation work from the middle—a study of how technicians mediate users and technology

Trine Pallesen and Peter H. Jacobsen

This article studies the work performed by technicians in a large demonstration project, EcoGrid 2.0, in the Danish island Bornholm. Based on observations of household visits conducted by technicians, we demonstrate how these act as 'middlemen', mediating and linking together the smart technology of the demonstration and the involved users. Formally, technicians' work is to keep users online; however, they also perform a number of invisible tasks to keep users engaged and active. Our ethnographic study shows two broad categories of invisible work: first, technicians continually facilitate the willingness of users, recurrently affirming the social contract between users and demonstration project. Second, technicians facilitate the abilities of users by improvising informal training sessions of how to operate the system. These findings are used to discuss the importance of invisible articulation work of technical service workers in large scale real-world experiments.

Keywords: articulation work, ethnography, situated learning and training, middlemen, technical work, invisible work, organising work, technicians.

Introduction

Across the world, power consumption is increasingly being problematised in relation to a number of major environmental issues, such as climate change, nuclear accidents and pollution in general. So far, most attempts to influence consumption have focused on one of two strategies; either developing new technological solutions or instigating behavioural change amongst end users. Every so often, behavioural change is the expected outcome of technical changes. This is the case with smart grids, that is, 'an electricity network that can intelligently integrate the actions of all users connected to it—generators, consumers and those that do both—in order to efficiently deliver

Trine Pallesen (tp.ioa@cbs.dk), Assistant Professor in Organizing Technology, Department of Organization, Copenhagen Business School, Frederiksberg, Denmark.
Peter H. Jacobsen (Phj.ioa@cbs.dk), Post.doc in Organizing Energy Consumption, Department of Organization, Copenhagen Business School, Frederiksberg, Denmark.

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sustainable, economic and secure electricity supplies' (European Technology Platform, 2008, p. 2). Smart grids have gained widespread attention from policy makers, and are currently tested intensely around Europe (The Danish Government 2011; Energinet.dk 2012). This paper is born out of an ethnographic study of the organisation of one such smart grid demonstration, namely EcoGrid 2.0. In EcoGrid 2.0, technical experts seek to control and influence the power consumption of households on the Danish island Bornholm. The focus of this paper, however, is neither the work of system designers, nor the possible changes in consumer behaviour. Instead, we study the work of technicians who, as we will demonstrate, facilitate the interface between system and users.

Within the social sciences, smart grids represent occasions for studying the introduction of complex, engineered control systems into the 'mess' of everyday life unfolding in the private homes of citizens (Strengers, 2013). Studying consumption as an outcome of situated social practices (Hargreaves, 2011; Shove and Walker, 2014), these scholars engage critically with the behavioural assumptions inscribed into smart grid systems, such as rational decision-makers or economically rational individuals. Focusing on smart devices (Burgess and Nye, 2008; Wallenborn *et al.*, 2011), smart grid script (Jenle and Pallesen, 2017; Throndsen, 2017) or users (Hargreaves *et al.*, 2010; Nyborg and Røpke, 2015), they offer rich empirical accounts of the apparent gap between the engineers' design and the actual social practices of users, far removed from the behavioural assumptions of engineers. This gap, however, need not be a void. Drawing on recent studies of so-called 'middlemen' (Wade *et al.*, 2016, 2017), professionals working at the intersection of system and users can mediate the script of the system and the practices of individual households. This work of middlemen is likely to remain invisible (Star and Strauss, 1999) to social scientist studying smart grids from the situated practices of energy users. Just as importantly, we demonstrate that it remains invisible to the designers of the smart grid system.

Drawing on the concept of 'articulation work' (Strauss, 1985, 1988), we describe how the technicians working in EcoGrid 2.0 operate as the demonstration's middlemen, 'linking' together the technical system, the intentions of the technical experts and scientists and the users' practices. This work is described through our observations of 'problematic situations' (Suchman, 1987; Orr, 1996) occurring during service work in participants' homes. Formally, technicians are responsible for installing and repairing the smart technology in users' homes. But based on our ethnographic study, we illustrate how this position in the 'middle' entails tasks that substantially extend the formally defined work. Combining literature on 'invisible' work and situated learning, we explore the ambiguous relation between knowledge production and its evaluation in the demonstration project. In particular, we identify two categories of invisible work, namely (1) informal training to help users adopt the script developed by technical experts, and (2) work that establish and maintain a kind of social contract between demonstration and users. The invisibility of this work, we argue, has implications for what and how real-world experiments such as the demonstration studied here can be evaluated and possibly reproduced.

Setting the scene: the EcoGrid 2.0 demonstration

The empirical context of this study is the organisation of a large-scale demonstration of so-called flexible electricity consumption in the island Bornholm in Denmark. EcoGrid 2.0 is one among many energy demonstrations presently undertaken in Denmark, which test ways of sustaining the decarbonisation of the Danish electricity system. Increasing the share of wind power in the system is a key component of this ambition. But wind power, in contrast to thermal power such as coal-fired plants, cannot be planned according to fluctuations in demand. Accordingly, as the share of wind power in the electricity system rapidly increases, so does the need for new ways of balancing electricity generation and consumption, for example by making demand more flexible. Smart grids, such as EcoGrid 2.0, are conceived as part of the solution to this challenge, as a means for achieving flexible electricity consumption.

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The EcoGrid 2.0 demonstration involves close to 1000 participating households on Bornholm. The island is, so to speak, a living laboratory. The ambition is to make these participants the source for creating the desired flexibility. It seeks to achieve this ambition by changing user behaviour, designing a new market platform and develop and introduce a new actor in the market that control users' heat pumps and electric panels. As such, EcoGrid 2.0 is a technology-driven demonstration project, partly unfolding in the homes of users. As the name indicates, EcoGrid 2.0 succeeds a first demonstration project, Ecogrid EU (2012 until 2015) which tested the effects of variable electricity prices on user behaviour (Jenle and Pallesen, 2017; Pallesen and Jenle, 2018). The smart grid technology installed in EcoGrid EU is being reused in the new project, but the current ambition is to be able to turn on and off heat pumps and heating panels as a way of balancing generation and consumption in the electric grid. EcoGrid 2.0 was launched in 2016, and is undertaken by nine partners, including universities and industry. The latter group includes technical scientists, behavioural designers, software engineers, the local utility on Bornholm and organisations from the energy sector.

In this paper, we study the importance of the work undertaken by technicians from the local utility to the organisation of the demonstration. This is surely not to underestimate the role of the scientists and experts of the demonstration project, including scientists from the Technical University of Denmark. But in the real-world setting of the demonstration, devices constantly break down, or get disconnected from the internet, participants need to be informed, trained, guided and sometimes corrected. Not only do the technicians repair and maintain the equipment of the households, and keep it online, but even more important; they translate the demonstration project into the users' everyday life.

Articulation work and its (in)visibility

To understand the role of the technicians' work for the demonstration, we draw on the concept 'articulation work'. First introduced by Anselm Strauss (Strauss, 1985; Corbin and Strauss, 1993), articulation work identifies a type of work associated with coordination and integration. Work in general, and work in projects in particular, entails a division of labour and thus requires that actors continuously engage in linking or 'meshing' otherwise divided tasks: 'Since the plurality of tasks making up their totality, as well as the relations of actors to tasks, are not automatically articulated, actors must do that too, and often in complex ways' (Strauss, 1985; p. 2). Articulation work is a kind of 'supra work', or 'work to make work work' (Schmidt, 2002, p. 19). The concept articulation work was first used in relation to 'computer-supported cooperative work' (Schmidt and Bannon, 1992), but has also travelled to other domains, for example, service work (Korczynski, 2002; Hampson and Junor, 2005) professionalism in healthcare work (Dupret, 2017) and laboratory work (Fujimura, 1987).

Studies of articulation work have often distinguished between planned and well-defined activities and more spontaneous or emerging activities. Most prominently, however, is the distinction between visible and invisible work (Star and Strauss, 1999). Actually, to some scholars, articulation work as concept appears to be reserved exclusively to invisible and unplanned work, defining articulation work as:

> *'work that gets things back 'on track' in the face of the unexpected, and modifies action to accommodate unanticipated contingencies. The important thing about articulation work is that it is invisible to rationalized models of work'*
>
> (Star and Strauss, 1999, p. 10).

The visibility of work is not an inherent feature of work; what counts as work differs, and visibility to whom also differs (Suchman, 1995; Star and Strauss, 1999). In other words, what counts as work is a question of definition and indicators, and indicators of what counts as work are not *a priori* given, rather they are situated and also changing historically (Star and Strauss, 1999, p. 15–16).

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Studies of invisible work oftentimes have an overt critical and political ambition. Most prominently, Star and Strauss (1999) describe work done by maids, cleaners or child caretakers in domestic work settings performing invisible or 'shadow work' (Star and Strauss, 1999). Star and Strauss also point to the so-called disembedding background work performed by nurses, struggling to make their work visible because it is functionally invisible and taken for granted (Ibid. p. 20). Here, the increasing visibility of work is argued to counter devaluation of less privileged jobs. As Suchman argues, '[i]n the case of many forms of service work, we recognise that the better the work is done, the less visible it is to those who benefit from it' (Suchman, 1995, p. 9). The work of others is conveniently black-boxed. Other scholars, though not necessarily under the heading of invisible work, have provided descriptive accounts of often unnoticed knowledge-intensive work performed by technicians. Orr (1996) for example, demonstrates how technicians in problematic situations, where there exists no information in their manuals, perform highly skilled improvisations. These are the outcomes of the triangular relationship between technicians, users and machines (Ibid.). In this 'service triangle', it is sometimes the customer that needs to be fixed (Ibid.). Orr's work has been pioneering because it shows otherwise invisible aspects of technicians' work and thereby help break down stereotypes of blue collar work.

Recent contributions to social studies of energy research have called attention to so-called 'middle-actors' or 'middles' (Parag and Janda, 2014). These middle-actors or 'middlemen' (Wade *et al.*, 2016) and not least their potential in creating behavioural changes have largely been ignored by policy makers and industry alike:

> 'Despite indications that they could play an important part in shaping how people heat their homes, central heating installers have been largely overlooked'
>
> (Wade *et al.*, 2016, p. 39).

Together, these contributions challenge the dominating dichotomy by which change is seen as originating from either the technological systems or the users—they neglect the *mediating* middle: 'they [the middle-actors] are active participants in the system, capable of creating (and sometimes preventing) change above, below, and across other actors' (Parag and Janda, 2014, p. 103). One finding from Wade *et al.*'s study is the role of installers in decoding the social situation and capabilities in the individual household guiding the choice of which technology to instal. For instance, mechanical devices may still be installed in homes of elderly people, whereas younger people would have digital devices (Wade *et al.*, 2017). Although, these authors do not use notions such as articulation work or invisible work, what they describe is the unrecognised work of mediating between technical systems and users. In other words, middlemen bridge social worlds or act as brokers (Barley, 1996), and thus mesh together these very different worlds.

Methodology—learning from the work of middlemen

Our study of the technicians' work is conducted in parallel to a study of the system designers' work of developing the technical system (Pallesen and Jacobsen, 2018), as well as a study of users' interaction and adoption of the smart devices in their households. We draw inspiration from other longitudinal studies of work distributed across organisational contexts, for example, Orr's (1996) studies of technicians work, Schmidt and Wagner's (2004) study of the coordinative role of artifacts in architectural work and Vikkelsø's (2005) study of the effects of new information and communication technologies in the hospital ward's work practices. These ethnographic studies draw attention to the distributed nature of work, and involve studies of multiple sites. The technicians of our study spend their days travelling around the island to instal and repair smart technologies in users' homes. To follow their work has implied shifting between organisational contexts such as homes of users, the offices of the local utility

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Table 1: Collected data

30 home visits with technicians
51 semi-structured interviews with users, 28 hereof during home visits with technicians
7 semi-structured interviews with utility project managers and technicians
Observations of 1 introduction to EcoGrid for 7 users in the utility's facilities
Observations of 2 workshops for users organised by the local utility
Observations of weekly meetings among the demonstration's partners (2016–2018)

as well as the offices and laboratories of experts and scientists as they run the demonstration far from Bornholm. For the current study, we draw mainly on three sources of data: observations of technicians' work during home visits, interviews with users and observations of weekly meetings among scientists and experts responsible for the demonstration (for an overview, see Table 1).

Shadowing technicians' 'home visits' to users was our main strategy for collecting data, and had a double focus: it allowed us to study the situated, problem-solving work of technicians, and it granted us a way into the users' homes in a familiar context (service work) with a trusted person (the technician). Arriving with the technician made our visit somewhat less intrusive, and generally users accepted us as researchers studying the smart grid project in collaboration with the utility. As such, the technician also served as a kind of middleman in relation to our fieldwork at Bornholm, facilitating our meeting with users. The 30 home visits we observed lasted between 20 minutes and 6 hours, depending on the technician's task. During this time, technicians would usually start by figuring out why the household was offline. As mentioned, the technicians' formal task is to keep the users online in the project; smart devices in the individual households communicate via Wi-Fi connections and if an internet connection is for some reason disabled, the control of the households' heat is no longer possible for the project partners. Once the problem identified, the technician usually proceed to engage the user in a series of activities often involving the personal webpage, as well as discussions of flexible consumption and the demonstration in general. In addition to these home visits, we observed how technicians and the project team discussed technical issues and challenges at weekly meetings. During work, the two technicians often called each other or their colleagues at the office to get information and knowledge about particular work tasks, and from our observations of these interactions we saw how specific knowledge (and stories) about the individual users and their technical solutions was circulating and used in their daily work.

Alongside observations of technicians, we have conducted 51 semi-structured interviews with users participating in the demonstration. 28 interviews were conducted during service visits with the technicians, while the remaining 23 were also conducted in users' homes, but without the presence of a technician. These interviews served the main purpose to learn about users' experiences with flexible consumption in the demonstration. To study energy consumption is not straightforward: energy is not consumed for its own sake, but rather part of nearly all mundane, daily practices, such as laundry, cooking, watching TV etc. (Shove and Walker, 2014). Therefore, many users clearly find the topic uninteresting and difficult to relate to as such. Entering their homes with technicians opened new ways into the subject, starting from the problems experienced with the equipment, their participation in the demonstration and their consumption practices more generally. During our interviews, it became clear that technicians play a key part in these experiences. For example, during interviews users would refer to previous visits by technicians to make sense of their home in relation to their devices, for example, 'according to the technician, this heat pump cannot be controlled by EcoGrid'. Many users had not changed their settings in—or even entered—their personal webpage since the first visits by the technician, and in many instances, it was the technician who had defined the comfort levels of the home.

We also observed weekly meetings amongst the technical experts and scientists of the demonstration. In particular, we observed how the technicians' work of repairing the

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technical infrastructure became part of the discussions concerning the design and development work related to the demonstration. The technicians never participated in these meetings, but the utility was represented by a project manager working with the technicians. During these meetings, the local utility reported the number of households online and offline. In periods with many households offline, the source of the problem would be a topic of discussion—and not least how to solve it. Yet these problems were always of a technical nature, including examples such as poor data transmission from specific parts of the island due to local antennas, batteries or problems with the installed software. Our observations of these meetings have been key to identify the 'gap' between the expectations of the experts and scientists towards the work of keeping users online and the actual work we observed technicians undertake.

As we observed the technicians work over time, we became increasingly aware of what we define as the 'invisible' aspects of their work; during the household visits, technician's did far more than simply get users back online or just repair their devices. They also trained, instructed and assisted the users, and convinced some not to leave the demonstration project. Our access to study these different contexts (technicians everyday work, weekly meetings in the project and users experiences) over time in the demonstration project, allowed us to identify indicators of what is visible and invisible work in the project: as Star and Strauss (1999) argue, articulation work is taken for granted, and the distinction between visible and invisible work depends upon situated and contextual indicators. In our study of technicians, we draw upon a novel situated social practice approach to understand middlemen's work in relation to domestic heating (Wade *et al.*, 2016, 2017). Our analysis of articulation work evolves around what can be identified as 'problematic situations' related to a breakdown that opens for the technician's reflection to find a solution to a problem (Suchman, 1987; Orr, 1996). We use our different data sources to show how articulation work 'links' and mediate between different parts of the project.

We organise our analysis around a single household visit. This visit is selected because it is 'typical' or exemplary (Flyvbjerg, 2006). It represents aspects of the technicians' work that we observed during all 30 household visits with technicians: to repair technical equipment and to engage with participants involving elements of training related to the use of the equipment. Furthermore, these observations were confirmed during interviews with users, granting the technicians a central role in their engagement with flexible consumption. Sometimes users would get annoyed or become disinterested in the demonstration, and wanted to leave. Here, technicians and the support team at the local utility in general, facilitated users' willingness to participate through concrete work activities as well as through their enthusiastic and service-minded attitude towards users, such as; taking time to explain the demonstration, upgrading the equipment, installing browsers, drinking coffee etc.

To produce descriptions of work such as the one at hand is obviously not neutral:

> 'If descriptions are active constituents of the world and may afford managerial imagination and political negotiation, the question of resistance is just as relevant to 'descriptive' as to 'interventionist' research'
>
> (Vikkelsø, 2007, p. 304).

Though the technicians at no point resisted description, they did early on ask directly: 'are you evaluating my work?'. Potentially, the observations of the technicians' fragmented work could be used 'against' them by other partners in the demonstration. They are in the precarious situation working in a temporary demonstration project where most of their work is invisible and difficult for others to understand. Reassuring them that evaluating their work was not our task, but rather our ambition was to do a close description of the many aspects of their work, they would also see the value of our descriptions making at least some aspects of their work visible.

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Findings: working the middle

In the following, we pursue the articulation work conducted 'in the middle' by the technicians of EcoGrid 2.0, here understood as the work of linking and coordinating the technical system and the households. The findings are primarily organised around a single typical household visit (to Irene's), but we also include observations from other household visits and observations from other contexts. We start by what we refer to as visible work. The tasks we associate with visible work are *visible* in more than one sense; firstly, visibility is associated with the formal description and expectations of technicians' work, and in particular that they make sure participants are 'online', that is, their smart devices are connected to their Wi-Fi. Visibility is also a concrete visual feature, because households that fail to be online will be flagged in the 'dashboard' in the computer screen of the local project manager (see Figure 1)—and a successful home visit by the technician will make the household return to online status on that very same screen.

The dashboard provides the project management with an overview of the total number of households in the project, and their status as online or offline. Households which fail to be online are problematic, because their heating cannot be controlled (i.e. turned on/off) by the project team. The dashboard also includes statistics of number of visits performed to the individual home and the work technicians have performed during these visits. As such, the dashboard plays a double role in relation to articulation work: on the one hand, it helps the technicians identify problems that need fixing. On the other hand, it provides visibility of the technicians' work, by documenting and summarising it. However, the dashboard and what it can possibly document is closely associated with the formal representation (Suchman, 1995) of the technicians' work.

While shadowing the technicians, we noticed the numerous tasks performed by technicians unrelated to their formal work description, which remain invisible to most, if not all, other stakeholders. This is not in itself surprising—after all, this is the very nature of work as described above (Suchman, 1995; Star, 1999; Star and Strauss, 1999). Operating as 'middlemen', technicians facilitate the *middle*, here understood as the meeting between the engineered system and the participants and their everyday life. The implication of the invisibility of these tasks, not least to system designers, will be the subject of the discussion following the findings.

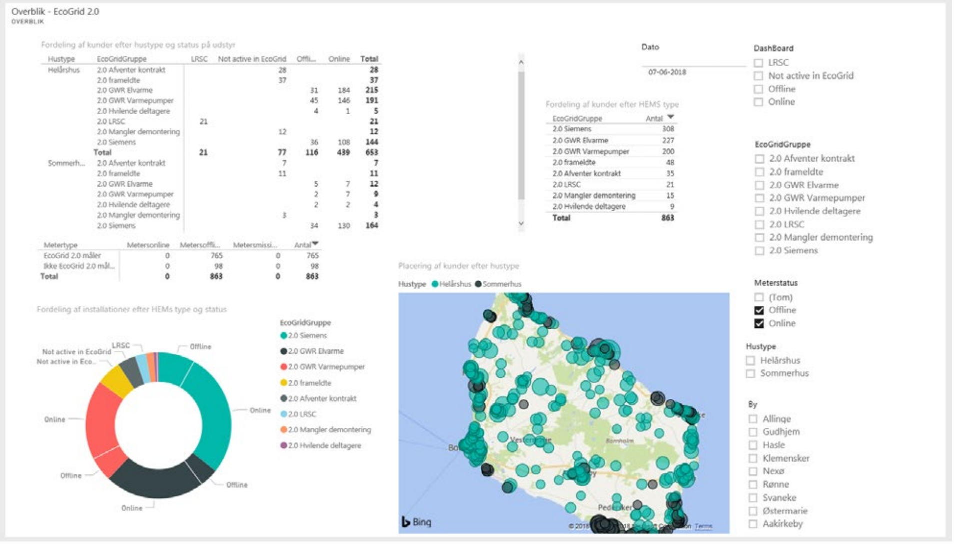

Figure 1. Screenshot of dashboard

Visible work: repairing devices and users

Most often, the work of the technicians starts when a household is identified as being offline. This may be identified through the dashboard, as described above, where the project manager identifies a problem with the communication to a distinct household. At other times, it is the EcoGrid users themselves who call the office of the utility to report a problem. Usually, the technician is provided with a general description of the problem, before entering the user's home. In the following we present observations from a home visit. We accompany the technician, Brian, as he visits the home of a retired couple. It is only the woman, Irene, who is home at our arrival. Before visiting the household, Brian has collected information about the household's equipment, but he does not know yet why the home is offline.

Once we enter Irene's home, Brian immediately begins his work of identifying the source of the problem, namely that Irene is 'offline'. He starts by inspecting the smart grid technology installed next to the electric metre in the scullery. Then he asks Irene to help him locate the rest of the smart technology installed around the house. Brian needs to find the Gateway that connects house and system, or 'the brain', as he often calls this specific device when he explains the system to the participants. With Irene's help, Brian locates the Gateway on the first floor, and he immediately sees that it is disconnected from the Wi-Fi; his assumption is that the users have changed their internet connection to a 'fiber net' recently, as he recognises the internet cables placed behind the Gateway. Irene confirms. This new connection has caused the problem, Brian concludes, and explains why the household has been 'offline' and could not be controlled by the EcoGrid 2.0 partners.

In order to get the household back online, Brian has to instal a small device that reconnects the Gateway to the Wi-Fi. This is quickly solved. Brian then goes back into kitchen to check his laptop, to make sure Irene now appears as online in the system. While doing this, he explains Irene how the smart technology in the kitchen works. Although this aspect of the visit is still aimed at solving the problem, it also takes on a more instructive character, as Brian explains his actions to Irene. After testing the external link between the household and the system, Irene and Brian go upstairs to the living room where Brian is testing the internal communication between the devices in the house. To conduct this test, Brian puts up power notes in the living room to test if they are communicating with the Gateway. Internally in the house, he concludes, the equipment is also working!

Most home visits performed by the technicians are about detecting and solving problems, such as the one Brian encounters during his visit to Irene's. Here, articulation work is focused upon maintaining the direct communication between the technical experts and scientists situated far from Bornholm, and the individual households in the island. Without this direct communication, there is no demonstrations and tests. During meetings amongst scientists and experts, these home visits are summarised as the numbers of houses brought back online, for example: 'recently, we have managed to bring 20 houses back online' (project manager in a status meeting). However, the various problems causing households to be offline are rarely discussed in detail in the status meetings. In fact, the experts care little about the nature of the problems, not least because these often relate to house-specific installations or unexpected user behaviour.

At other times, technicians are confronted with problematic situations that are not caused by technical failures—and often, these are more complicated to repair than technical ones. To illustrate, we followed Brian to an apartment identified as offline in the dashboard. In his car, on the way to the apartment, Brian describes this as a 'tricky case'. Sometimes a household is *offline* because the user has turned off the equipment, and this particular apartment has received 18 visits in the past. Once arrived, it immediately turns out that Brian's intuition was right: 'I have come all the way here just to push a button'. The problem is the same every time: someone has turned off the equipment. The apartment is a rental apartment, and tenants come and go without necessarily learning about the EcoGrid system and its role in the apartment. Brian calls the owner and leaves him a message: '…the relay was turned off – there was no problem

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in the system…'. To try to prevent going to the apartment again, the technician decides to try something new: to put up small notes on the installation itself, reminding tenants not to turn off the equipment. Before we leave the house, Brian documents what has been done.

The articulation work performed in this situation by the technician still serves the purpose of getting the household back online—and the effect is visible to project managers and other project partners through the dashboard. But 'fixing' the problem is not straightforward. Leaving notes on the installations in the apartment is an attempt to make the connection between household and system visible to users. However, *vis-à-vis* the system designers, the efforts associated with instructing and educating users are not necessarily visible; problems with Wi-Fi connections are simply expected to be technical, or at least easily solved by providing information to the users.

As it is repeatedly stressed, the boundary between visible and invisible work is both blurred and negotiable (Star and Strauss, 1999). What we have described above as visible work hinges on two principles: the formal expectations towards the work of the technicians, and the visibility performed through statistics of online households. These statistics are recurrently exchanged with other project partners, summarising the current state of the system. The nature of the work needed to achieve this remains, however, unrecognised. Often, technicians draw on past experience to do their work. Both technicians were involved in installing the smart grid equipment in the homes at Bornholm years ago. And for many homes, they recall the very distinct installations, as well as past problems experienced in the individual households, and often it is the technicians' knowledge of past problems that informs solutions of the present (Orr, 1996). This helps technicians in the problem identification process: Brian quickly recognises the problem inferred by a new internet connection in Irene's home, and he immediately identifies the problem as a 'user-problem' in the rental apartment. The scope of knowledge and skills required by technicians to keep participants online is entirely black-boxed (Suchman, 1995) by scientists and experts. In the following section, we continue our description of the technicians' articulation work, however, this part of the articulation work is unrecognised and ignored by system designers and scientists, why we refer to it as invisible work.

Invisible work: informal training and maintaining a social contract

During the trouble shooting sessions and their efforts to repair the technical equipment, such as described above, technicians also engage in talks about the experiment at large and inform participants about the possible use of the equipment. In the following, we continue our visit to Irene's, to describe how Brian, now having repaired the Wi-Fi problem, initiates a series of situated training and learning sessions.

Having established Irene's connection, Brian shows her the installation. As the following conversation illustrates, Brian starts out expecting that Irene actually knows the EcoGrid experiment, but he quickly ends up in the challenging situation that Irene rejects the basic premise of the experiment:

> Brian: … and I connect it here, because then we can better turn you on and off.
>
> Irene: turn us off?
>
> Brian: yes, like turn off your heat….
>
> Irene: but… but we do *not* want you to control our heat!
>
> Brian: well, but that is kind of what the whole experiment is about.
>
> Irene: we may have overlooked this.
>
> Brian: it is not like we control your heat as such. But when the grid is congested, then we buy our electricity from Sweden… or we need to produce it.
>
> Irene: I see.

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Brian: then we turn you off for a little while. And you have granted us permission to do so.

Irene: ok, I see.

Brian: over a period of say two hours, we may 'steal' 15 minutes.

One of the most common, yet unrecognised, tasks performed by technicians during home visits is communicating what the demonstration is really about to users. All users have signed contracts and received extensive information concerning the demonstration, yet many users have no idea that they have delegated control of their heat to external parties. Here, the technicians perform a crucial task: they explain the experiment to users, and they connect the electricity system to social practices in the private homes of users.

We move back upstairs to Irene's small office. Brian now wants to demonstrate how Irene can monitor her consumption using her own computer. As many other users, Irene has forgotten her password for her personal EcoGrid webpage. While instructing Irene how to enter the webpage, Brian continues to explain the scientific tests and demonstrations constituting the EcoGrid project. When Irene finally enters her personal site at the webpage, Brian explains how she can set the temperature intervals for her house. These intervals are very important, because they define the range in which the system operators can turn off the heat of the household. The wider the intervals defined by users, the more flexibility can be 'extracted' from their homes.

Finally, we go back to Irene's kitchen. Brian has brought a power note, something which he hopes can increase the value of the EcoGrid system to Irene and her husband. Power notes can be added to most appliances and measure their consumption. Once connected, the energy consumed by the appliance can be visualised in the personal website. Brian connects the power note to the coffee machine and demonstrates to Irene, how she can measure and visualise the coffee machine's electricity consumption in kWh. Brian has opened Irene's personal account on the webpage.

Brian: ok, here you see your coffee machine [pointing to the screen]…. So, we only just turned it on, but had it been there for a day or a week, then you would have seen many more numbers.

Irene: I see.

Brian: then you could calculate how much it cost you, how many kWh it consumes… Well, for now it has not even consumed one kWh, but that is because we only just installed it…

Irene: I see, otherwise it would probably have been more.

Brian: yes, exactly. And here you see the time of consumption.

In situations such as this, the technicians 'extend' the demonstration and add a new device to the system. Such additions only occurs when the technicians judge that the user has the abilities to understand and benefit from it. In other situations, even the simplest aspects of the system become difficult: during a home visit to an elderly man, who had called to inform that his EcoGrid equipment failed and his heat was off, we observed Brian check all the installed devices. Brian took his time to go through and explain the individual devices to the user. Upon leaving the house, the researcher asked what the problem was, as this did not seem obvious from the home visit. Brian explained that the user had simply not turned on the heating panels. Brian spotted this after a few seconds in the house. In fact, the reported problem had nothing to do with the EcoGrid equipment at all. However, the technician did not tell this to the participant, but 'pretended' to make a thorough inspection of the installations. When we left the house the heat was on again—Brian had simply turned on the panels. Here, the technician deliberately kept his work invisible to the user, to avoid exposing the user's ignorance. This work of evaluating the abilities of the individual users sometimes leads to extension of the system, at other times it leads to technicians 'bypassing' the user.

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The training and assistance we observed during Brian's visit to Irene's home was far from an exception. During most home visits, the technicians carefully explain the demonstration, train users in the use of the personal webpage and technical devices in general, and provide narratives to allow the users to connect their individual consumption with the needs of the electricity system. Although these tasks constitute a large part of the technicians' work during home visits, they remain entirely invisible to the experts conducting the experiment. Also, in several situations during home visits we observed electricians guiding consumers not only practically about 'where' (on the website) to define the intervals, but also in terms of the specific temperatures suitable to the life lived in the home. Furthermore, our observations indicate that the majority of the users do not revisit or change the temperature intervals once set by the technicians at the moment of installing the equipment. In the situations, where we observed technicians change users' temperature intervals, they carefully instructed them in (1) the use of the website, (2) household comfort and temperature intervals and (3) how temperature intervals are used by EcoGrid 2.0 partners in terms of control.

Although these training sessions are clearly oriented towards better equipping users, they also serve as motivation for the users to stay part of the demonstration. Failing equipment, disappointment in the offered functionalities or simply lack of interest prompts some users to leave the demonstration. Here, the technicians play a crucial role in 'convincing' users to stay aboard. During a home visit to another user, Michael, who wanted to leave the demonstration, the technician Lars, offered him an alternative technology to make Michael stay in the project. After the visit, Lars explains that he knows Michael to be a very technically competent person, who can and will use the functionalities in the new technology. Offering to change his installations, which requires substantial work, will make Michael stay part of the demonstration.

Discussion: the ambiguous relation between knowledge and evidence

So far, we have described the articulation work performed by middlemen of meshing users and system. To fully grasp the implications of this invisible work, however, it must be situated in the context of the demonstration project and its purpose. As described above, the ambition of EcoGrid 2.0 is to demonstrate the generation of consumer flexibility. This purpose entails at the same time producing knowledge *and* evidence (Mackenzie *et al.*, 2006). The ambiguities resulting from concurrent demands for knowledge production and evaluation has been explored in recent studies of 'policy piloting' (e.g. Nair *et al.*, 2015), which in many ways resemble demonstrations such as EcoGrid 2.0. Among other things, these studies show that pilots have multiple purposes and these often change over time (Ettelt *et al.*, 2015). Also, it is argued that pilots often work under 'exceptional conditions' (Bailey *et al.*, 2017) and may be better understood as exemplification than experimentation (Mackenzie *et al.*, 2006). To understand the implications of the technicians' work on the larger demonstration, we now situate it in the work of the technical experts and scientists responsible for designing and conducting the demonstration. Before doing so, however, we briefly discuss the role of articulation work in laboratory experiments to call attention to the relevance and implications of our study.

Ethnographic studies of work in laboratories have come far in describing the often invisible aspects of experimental work by scientists (Latour and Woolgar, 1979). A prominent example is Fujimura's study of cancer research in the laboratory of a biotech company (Fujimura, 1987). Her study, as well as many other studies of laboratory work (for an overview, see Knorr-Cetina, 1995) have scientists as the principal actors performing articulation work. To Fujimura, articulation work is crucial to scientists' construction of so-called do-able problems that connects social worlds, laboratories and experiments:

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> *From the perspective of [the] researcher, his hands-on technical experimental tasks are his production work, while the gathering and coordination of other resources (funding, staff, space and time) are his articulation tasks. I am putting articulation tasks into the foreground of the picture of doability. We notice the lack of articulation when the work process breaks down and 'things don't work out'*
>
> (Fujimura, 1987, p. 262)

Here, scientists conduct experiments and they work to connect the results produced in the laboratory to the outside world. When Fujimura (1987) argues that alignment is reached through articulation work, she takes point of departure in scientists' efforts to construct research problems. In this paper, however, we argue that we need to pay attention to the articulation work performed by middlemen and how they govern the demonstration project far from the laboratories of the demonstration's technical scientists responsible for the tests and evaluations of the demonstration. This is not to say that scientists in EcoGrid do not perform articulation work. They do. However, the division of labour in the real world experiment studied here is different from studies of more traditional experiments (etc. Fujimura, 1987; Knorr-Cetina, 1999; Latour and Woolgar, 1979). The particular articulation work includes the alignment of interests between experimenters and subjects, translating the experiment's purpose into local settings, maintenance of infrastructure etc.

The main reason herefor is the distributed nature of the EcoGrid demonstration. In the demonstration, the alignment between the scientists' laboratories and the households is of great importance. This real world experiment not only takes place in the technical laboratories, but also in the 1000 private households distributed across the Island. They constitute a large, 'living lab', so to speak. The technical scientists, however, generally reduce users to their status as online/offline, or to consumption graphs (e.g. see www.electricitybaseline.com) etc. However, the invisible parts of the articulation work performed by technicians facilitate what the technical experts expect users to do in the experiment and we discuss two overall categories of work: (1) to facilitate active participation, and (2) to maintain a social contract between the demonstration project and participants. Below we structure our discussion around these categories of work stressing the way in which it articulates alignment from the periphery (Yanow, 2004), all the while remaining invisible to the scientists evaluating the success of the demonstration.

Invisible work makes users able to participate

The experts and scientists of EcoGrid work towards the successful achievement of flexible consumers. Yet, to them, users are predominantly a number figuring in the dashboard and given in official presentations of the demonstration—they are 'black-boxed' so to speak (Kaghan and Bowker, 2001). Flexible consumers let their household's heat be controlled by external parties, and flexible consumption can be evaluated and documented in number of kWh moved in time. To the scientists, the households are 'standardized packages' that make their work possible (Fujimura, 1987). However, our observations demonstrate how technicians train, instruct and teach users how to operate the smart technology and the webpage—in sum, to become the flexible users envisioned by the scientists and experts. At other times, they act on behalf of users, for example, defining their temperature intervals, or even downloading browsers on users' computers to have them access their webpage. In doing so, technicians recognise that no users or problematic situations are alike (Orr, 1996). Each user is a complex mix of abilities (education, skills to operate a pc etc.), the characteristics of their homes (type of heating appliances, insulation, number of rooms etc.), their motivation (how willing are they to change behaviour), the kind of life lived (life with kids, working at night etc.) to be taken into account to make them behave as flexible users. In other words, for households to become 'standardized packages', technicians continuously have to 'push' the user to the personal website, and assist them in multiple ways.

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Nearly all the training sessions we observed involved basic assistance from technicians, including identifying the personal webpage and get new passwords for users to log on. As this work remains invisible, experts and scientists do not realise the extent to which system and users are constantly linked or 'meshed' by technicians—and as such, they ignore the work required for the successful achievement of constructing flexible users (Pallesen and Jenle, 2018). Therefore, the alignment cannot simply be understood as scientists 'enrolling allies' in constructing doable problems (Fujimura, 1987; Latour, 1987). Rather, it illustrates that technicians constantly attend to countless problems and challenges encountered in the homes of users, in order to make the scientists' visions materialise. As demonstrated in studies of policy piloting, '[w]hen complexity is encountered then exceptional arrangements or working practices become necessary to find solutions' (Bailey *et al.*, 2017, p. 216). The situated problem-solving work performed by technicians described above seems to be an example of such exceptional arrangements. This kind of exceptionalism prompts, according to Bailey *et al.*, the question of how to detach the results of the demonstration from the 'exceptional conditions of their emergence' (Ibid.). Although this is obviously a relevant question, our study points out that the exceptional conditions may remain invisible to those responsible for 'detaching the results'.

Invisible work maintain willing users through everyday interactions

To the technical experts and scientist conducting the demonstration, the number of active users is also important for the validity of the claims to be made about user flexibility. The number of enrolled households is a fixed item on the agenda of the weekly meetings; a figure to be monitored continuously and which must remain stable to construct baselines and aggregations from households. Yet, the work that goes into the achievement of this number is also invisible to the system designers. The technicians are aware of the importance of keeping participants in the project, and an important part of their work is to maintain a kind of 'social contract' with the users, to have them stay on board. Maintaining the social contract is an integrated part of aligning the level of the scientists' laboratories with the users. However, this articulation work is also performed from the periphery of the project: willingness to be a part of the demonstration project is a negotiable aspect that is situated and distributed—continuous support to the experiment is maintained and repaired by the middlemen and support staff as a part of everyday work.

The articulation work of maintaining the social contract between the project and the users is carried out by technicians in at least three different ways: first, they adjust the technologies to user needs, as illustrated in the example of Michael who received an alternative installation. Second, they provide a high level of service and assistance, often far beyond what could be expected. Examples include looking after kids during a home visit, installing browsers and in general taking their time to listen and talk with participants: 'we have a lot of coffee and cake during these visits', and that is part of the work, as Brian instructed before leaving for the first home visit. Third, many users have volunteered for the demonstration to support the island—not because they are interested in energy issues or 'becoming flexible users': 'we help put Bornholm on the map', as many explain their participation. Being local 'islanders', technicians are seen as an embodiment of the ties to the island and the local community, and they use their ties as part of narrating the often technical aspects of the system design.

What ties together the technical system, and the user is often an outcome of technicians' work of maintaining the social contract. In the demonstration project an important part of the successful alignment is to be found in the mundane and everyday interactions between the support team and the users. The users' willingness to participate in EcoGrid 2.0 is related to the trust in the increasingly personal relationship build between them and technicians. Users know they can call staff from the local energy supplier if, or when, they have a problem with the equipment. And the service is free of charge. Also, many potentially critical questions never get raised, because of this

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social contract: 'we trust them', is a common answer to questions regarding users concerns of delegating control over their heating to external parties. With 'them', users refer to technicians and their colleagues at the local utility. This trust implies accepting that participation in the experiment may involve increased energy consumption, as illustrated in the following example: A user called Lars, one of the technicians, because he could detect an increase in the consumption in his currently empty summer house. He asked Lars to figure out if there was a problem. Lars could inform the user that the house was currently used for testing, and the test was the reason for the increase in consumption. The user simply accepted the explanation, as he had willingly signed up for the demonstration.

What we have tried to demonstrate here is that the multiple sites of a large scale experiment such as EcoGrid 2.0 requires an organising work, which is not undertaken by the scientists and experts themselves, but in the case studied here, by technicians. This work includes alignment, coordination and translation of the interrelation between the different sites of the experiment. The implications of this fragmented work is only fully grasped when it is situated in the larger demonstration work in EcoGrid 2.0—and its effects on the possible evaluation of the demonstration. Whereas, the technical experts and scientists usually highlight Bornholm as being 'representative' of other parts of Denmark, and thus the possibility of achieving similar results in terms of consumer flexibility, our study rather points to dedicated technicians and participants bound by a highly local social contract mediated by the technicians. And technicians, on their side, seem committed to engage with problems and situations in a way that seems rather exceptional. To the extent that the scientists who evaluate the results lose sight of technicians' work, they also miss out on the complex and intensive work of making flexible consumption possible—let alone the work involved in operating the system.

Conclusion

Despite widespread belief among designers and policy-makers, user behaviour cannot 'simply' be changed through the implementation of new technological solutions (Strengers, 2013). Recent studies suggest a novel approach, namely that behavioural changes may be instigated by middlemen, operating the middle between system and users (Parag and Janda, 2014; Wade *et al.*, 2017). The technicians of our study are, we have argued, in many ways the middlemen of the EcoGrid 2.0 demonstration. Their articulation work mediate between users and technical system, and cannot be reduced to 'keeping houses online', but also include training users to operate and relate to the system, and to keep them on board as participants. Our study shows that technicians continuously translate and mediate ideas and scripts to the users in situated interactions at the periphery of the larger demonstration.

The 'middleman' of this study is, paradoxically, also an exemplary instance of what Yanow (2004) calls a 'peripheral worker'. Like the drivers described by Yanow, the technicians work at a 'double periphery', that is, they are vertically positioned at the *bottom* of a hierarchy, and horizontally operating *outside* the organisation's borders. They are at once subject to and far removed from the centre of the organisation's formal power. Though it is often discounted or dismissed, the local knowledge that is produced in this double periphery is of great value to the organisation. And to Yanow, failing to identify and support the translation of such local knowledge towards the 'center' presents a missed opportunity for organisational learning.

In the case of EcoGrid, this missed opportunity for organisational learning from the periphery entails failing to fully grasp the extent to which it takes work to link system and users—and thus to create flexible consumers. To system designers, the demonstration is first and foremost an occasion for testing and evaluating the technology and the possible achievement of user flexibility, including an evaluation of user acceptance in a 'real-world' setting. Given the number of participants and the

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substantial investments in the smart technology, the demonstration is considered central to the further development and rollout of smart grids in a Danish context. However, making users behave as flexible consumers is the result of a social contract between local technicians and service workers, and the continuous training and assistance of users. These tasks are characterised by exceptionalism: technicians continuously exceed their formally defined tasks to make the demonstration a success. Failing to see how this work affects the results of the demonstration also affects conclusions of how to reproduce similar technological systems with expectations of similar results elsewhere.

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