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# **Materiality and automation of household practices: Experiences from a Danish time shifting trial**

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# Materiality and automation of household practices: Experiences from a Danish time shifting trial

## Abstract

There is widespread agreement that households' electricity consumption should be flexible in order to balance demand and supply in the future smart grid. One approach to demand-side management is to time shift households' consumption through economic incentives. This paper explores the experiences from a Danish household trial that combined static time-of-use pricing with electric vehicles.

On the basis of the empirical findings from qualitative interviews, the paper discusses what role materiality plays in the interviewed households' experiences with time shifting their electricity-consuming practices. The interviews indicate that in particular practices where some of the activities are delegated to technologies (automatized) are most likely to be time shifted. Examples of these practices are dishwashing (with delegation of activities to dishwashers), laundering (the washing machine and tumble dryer) and EV-charging (use of timers). The empirical observations point to an interesting interplay between the practitioners' bodily involvement in practices and the delegation of specific activities (tasks) to machines, which also relates to a more general discussion of (semi-)automatization.

In addition, the empirical findings indicate that not only the specific design of technologies but also the general materiality and physical layout of the home influence to what extent the households did time shift their practices. This also points to the importance of recognising how everyday practices of households are spatially embedded and how the time shifting of some practices might interfere negatively with other practices.

The empirical findings open up for theoretical reflections about the relationship between human and non-human actants and how this influences possible strategies for time shifting the electricity demand. As part of this, the concept of distributed agency within assemblages of practice could prove a useful concept in understanding and analysing time shifting of households' electricity consumption.

## 1. Intro

Like in many other countries, demand-side management (DSM) and time shifting of electricity consumption in households have increasingly come into focus in Denmark. The political target of a complete transition of the Danish energy system to renewable energy sources by 2050 raises the challenge of finding solutions on how to balance intermittent renewables (wind and solar power) with the electricity consumption (Danish Government, 2011 & 2013). As a result, DSM-solutions have attracted much attention from researchers as well as energy utilities.

This paper discusses findings from a Danish trial that combines static time-of-use pricing with electric vehicles. The combined trial involved 18 households in the Southern Jutland (Denmark) and the analysis is based on qualitative interviews with eight households. A

special focus of the combined trial was to promote the households to time shift their electricity consumption and, in particular, to test how the static time-of-use pricing influenced their behaviour with regard to charging the batteries of the electric vehicles.

Here, our analytical focus is on the role that the materiality of practices plays in relation to time shifting electricity-consuming activities. More specifically, we focus on the design of electricity-consuming household devices like washing machines and dishwashers and, more generally, the material layout of homes and how these characteristics influence the household members' experiences with time shifting daily practices.

In a practice-theoretical perspective, energy consumption is seen as an outcome of performing social practices. Further, material objects (and materiality in more general terms) are seen as one among several elements that co-constitute practices (Shove & Pantzar 2005, Gram-Hanssen 2010a & 2010b). Shove & Pantzar identifies three types of elements (meanings, competences and objects), while Gram-Hanssen operates with four types (know-how, institutionalized knowledge, engagements and technologies). Here, we focus on the role of material elements in co-constructing electricity-consuming practices and thereby the potential of time shifting these practices; not in order to ignore the importance of the other elements, but because we believe that previous studies to some extent have downplayed the importance of the material qualities and the role that re-delegation of activities to machines (automation). In order to understand these aspects better, the concept of “distributed agency” (Bennett 2005, Sahakian & Wilhite 2014 and Strengers et al. 2014, among others) could inform the analysis of the “time-flexibility” of everyday practices. The importance of materiality has also largely been overlooked among energy planners and designers and developers of smart grid solutions, like DSM, who often tend to conceptualize energy consumption as the result of deliberate decisions made by rational, choice-making individuals (Shove 2010, Strengers 2013).

Our paper is still “work-in-progress” and the following analysis and discussion should be seen as a collection of analytical thoughts organized around a number of empirical observations from the qualitative interviews. More specifically, we have organized our analysis by two overall themes: *Semi-automation of practices* through partly delegating practice activities to technologies and the role of the *material layout* of homes. These analytical themes have occurred from the empirical material and relate to the overall research question of how materiality shapes practices and their “flexibility” in relation to time shifting.

Before entering the analytical discussions of our empirical material, we make a short presentation of the trial and our methods in the following section.

## 2. Trial and methods

The interviewed households took part in a combined electric vehicle and static time-of-use pricing trial. The electric vehicle trial was part of the “Test-an-EV” trial with plug-in electric vehicles, which was run by the Danish mobility operator CLEVER and involved about 1600 households in total. The aim of the trial was to gather knowledge about electric vehicle driving, including behaviours in relation to battery charging. The static time-of-use trial was

part of the “Dynamic Network Tariff” trial operated by the commercial electricity supplier and distribution system operator SE and involving about 184 customers in total. The trial offered the customers a static time-of-use pricing scheme (Darby & McKenna, 2012), which divided the network tariff into four categories (tariffs) during the day. For instance, the tariff was 10 times cheaper between 0-6 AM than in the peak hours 2-8 PM (0.4 and 4 euro cent/kWh, respectively). The trial aimed to test whether this financial incentive would motivate the customers to time shift their consumption from peak to low-demand hours. However, the network tariffs represented only a minor part of the total customer electricity price, which includes also the electricity production costs and taxes. The total electricity price was about 0.3 euro/kWh, which means that the maximum difference in the network tariff represents about 15% of the total price.

Eighteen households participated in both trials (the combined trial) from April 2012 to November 2012. Semi-structured interviews (Kvale 1996) with eight of these households were conducted during autumn 2012 and form the empirical basis for this paper. The households were selected with the aim of getting a high variation with regard to socio-economic background variables and the 1-2 hours interviews took place in the home of the households. Four women and four men were interviewed, six were married (the other two were singles) and three had children living at home (one single-mother and two married couples). The interviews focused on the households’ experiences with participating in the two trials within an everyday life context.

### 3. Analysis

All households made efforts to time shift some of their electricity consumption from high to low-tariff hours. However, they had quite different experiences with how difficult it had been to establish new routines; some found it relatively easy to time shift the performance of daily practices and managed to maintain their new habits over a longer period, while others found it very difficult and gave up after a short time.

Across the interviews, three areas of consumption (and their related practices) came up recurrently as the areas that most households had tried to time shift: dishwashing, laundering and charging the electric vehicle batteries. For this reason, we will in the following focus on experiences with these practices.

Overall, most households managed to run their dishwashers in the low-tariff hours between 8 PM and 8 AM. Also, many households time shifted their laundering activities (washing during the late evening or night), although this caused more inconvenience than time-shifting dishwashing and in general was experienced as challenging. Finally, the participants found it easy to adopt the new habit of recharging the electric vehicle batteries during the night hours. Several adopted the new routine of plugging in the cable for battery charging as part of their daily “shut-down-the-house” routine before going to bed. However, towards the end of the combined trial the manual charging was replaced by automated (remotely controlled) charging, which many households found more convenient.

The empirical material suggests that two (partly interrelated) themes would be worth of further enquiry in order to better understand how materials co-determine practices and their temporal flexibility: The material (physical) layout of the home and the delegation of activities to technologies (semi-automation). These will be elaborated further below.

### 3.1 Semi-automated practices

The reason why dishwashing and laundering were among the everyday practices that the households found most easy to time shift seems to be closely related to the fact that these practices integrate the use of technologies (dishwashers, washing machines and tumble dryers) that perform parts of the activities independent of direct bodily intervention. Thus, the dishwasher or washing machine can run during the late evening or night (low-tariff hours) while the household members are occupied by other activities (like watching television or sleeping). This indicates that semi-automated practices like dishwashing and laundering are among the practices that can most easily be time shifted.

The use of household appliances that semi-automate daily practices is related to convenience, which Shove (2003) describes as “associated with the capacity to shift, juggle and reorder episodes and events” in time. In other words, convenience relates to the degree of control over the temporal organisation of practices in daily life, which was also a central theme to the interviewed households. However, as noticed by Shove, convenience appliances also contribute to fractured timescapes through required moments of intervention (such as unloading the washing machine).

Another example of delegating activities to technologies was the use of timers to control the start of washing machines, dishwashers and charging of the electric vehicle batteries, which several interviewees mentioned. For instance, a middle-aged, married father had even installed a timer for one of their lamps and a middle-aged single-father explains: “...particularly during weekends I ... installed the timer on the washing machine to finish the program in the morning”. Similarly, a single-mother explains how she uses her watch alarm to remember to start the recharging of the electric vehicle after the high-tariff hours finish at 8 PM: “I had to set the alarm of my watch for eight o’clock because otherwise I would simply forget to plug-in the charger.” A married woman in her thirties tells that she programs the timer on their dishwasher to start at midnight and that she is also considering that their next washing machine should have a timer (their washing machine had just broken down before the interview), which would make it possible for her and her husband to start doing the clothes washing during the night. Similarly, a married father also considers that their next tumble dryer should have a timer.

These examples illustrate how timers and alarms are used by several households to help remembering starting electricity-consuming activities at specific hours determined by the variable network tariff scheme. Activities, which would traditionally be done in connection with other sets of practices; e.g. starting the dishwasher right after finishing the evening meal. Here, the previous bundling of practices is broken and new routines of programming the dishwasher timer (or alarm clock) were developed.

However, even though semi-automation and the use of timers certainly seem to support the households in developing new routines in relation to their daily activities, the interviews also include examples of how the required moments of intervention mentioned by Shove (2003) were a source of inconvenience. This in particular applied to time shifting the laundering practice from daylight/evening hours or weekends to night hours, which implied unloading the washing machine and hang-up wet clothes for drying in the morning. This new, additional routine in the morning appeared to make the mornings more stressful and, as also described in the next section, challenges the families' experiences of "togetherness" in the morning.

In relation to laundering, another material (nonhuman) element, the bacteria that thrive under damp conditions, limits the time-flexibility associated with the intervention of unloading the washing machine, as newly washed clothes cannot be left in the washing machine for many hours before getting musty. Thus, running the washing machine during the night hours implies hanging up the laundry in the morning hours before leaving the home for work.

As these examples illustrate, the use of technologies like the washing machine, tumble dryer, dishwasher and timers semi-automate sequences of practices and in this way relax the temporal and spatial constraints associated with their performance. This makes these practices more flexible for time shifting compared to other practices such as dinner preparation, entertainment and schoolwork. However, the automation is only partly (as indicated by the term "semi-automation"), as the technologies still require a number of interventions, which – in the case of laundering – have a limited time-flexibility due to natural, biological processes of bacteria.

### 3.2 The materiality of the home

The interviews also indicate that the broader materiality of the home (its physical characteristics and layout) also played a role in determining the households' experiences with time shifting electricity-consuming practices. Three forms of material implications were identified in the interviews: the location of technologies in relation to the social life of the residents, noise and the design of the outdoor areas.

With regard to the location of technologies, several households experienced how the location of the washing machine in a room (e.g. bathroom, cellar or utility room) away from the common areas, in combination with the new habit of unloading the machine in the morning, would threaten the valued "family togetherness" around the breakfast table. As a married father explains: *"Before, we were united here in the kitchen, now it is more like one [of the parents] is outside hanging laundry up, while another is inside un-loading the dishwasher."*

Thus, the introduction of the new doing of hang-up laundry in the morning challenges the performance of 'breakfasting' and its associated meaning of togetherness. Especially important here is the lack of co-location between breakfasting and hanging-up clothes. In comparison, the households in general found it much less inconvenient to time shift dishwashing, even though this also would introduce a new habit of unloading the dishwasher in the morning. The dishwasher was placed in the kitchen, i.e. co-located with the

breakfasting, which means that unloading the dishwasher did not in general disrupt the family-togetherness.

This example shows how practices are partly tied to the location of the technologies that are involved in performing these practices (like a washing machine in the cellar), which is determined by the overall layout of the home. The lack of co-location of time-shifted practices with other valued practices of the family might limit the “flexibility” of time shifting these practices.

Another example of how the layout of the home can play an important role for the likeliness of households time shifting their daily practices is related to sound from machines. As a married mother in her thirties explains:

*“... then the new washing machine was ordered, I was actually caring about how much noise it makes. Until now I haven’t been thinking about how much noise a washing machine makes, but now, I’ve been thinking about how many decibels it should have.”*

This quote refers to her experience with how washing during the night can disturb the family members’ sleep due to the noise that the washing machine makes. Depending on the location of the washing machine in relation to the bedrooms, the sound can interfere with the sleeping activity. This might be a particular challenge in apartments, which are in general smaller than detached homes (all households in our study lived in detached homes) and with close-living neighbours. Thus, the example with noise also indicates that not all types of housing are equally suited for time shifting noise-making practices, such as laundering, to the night hours.

The final example of the role of materiality relates to the design of the outdoor areas of the home. Several of the interviewed households expect that they would be unwilling to go outside in winter (due to the cold weather) to plug in the charging cable before going to bed (the trial was done during the summer half-year). This indicates how the design of the garage and the route of connection between the garage and the home influence the willingness of the household members to time shift the charging of the electric vehicle. If there is no roofed connection between the heated spaces of the home and the garage, this makes it less likely that the households would continue time shifting the recharging of their electric vehicles during wintertime.

Another example relates to whether it is possible to dry the laundry outside protected from rain. Several households had the habit of hanging-up laundry outside for drying (instead of using a tumble dryer), and they typically would dry the laundry when at home during weekday evenings or in weekends. Due to this, they would be able monitor the weather and bring in the clothes in case of rain. However, with the time shifting of the laundering to the night hours and the new habit of hanging-up the laundry in the morning before going to work, they would not be able to bring in the clothes in case of showers during the daylight hours. As one single-mother expressed: *“well, it can be stressful to remember to hang-up the laundry and be anxious about the weather (...).”*

This indicates that the design of the outdoor areas plays an important role for whether it is regarded as possible to time-shift laundering; having a roofed area outside could protect the laundry against showers and in this way make it more likely for households to time shift their laundering practices.

As these examples show, the material (physical) layout of the home has implications on the performance of practices, their interaction with other practices and the likeliness of households developing new habits in order to time shift daily practices.

#### 4. Concluding analytical remarks

The empirical analysis demonstrates how materiality plays a role in relation to the (experienced) flexibility of time-shifting practices related to laundering, dishwashing and recharging electric vehicles. In this section, we conclude with a discussion of wider analytical and design-related implications of our findings.

First of all, the empirical examples demonstrate that practices related to electricity consumption are far from only being based on rational and conscious decisions being made by individuals. The material design of technologies and the materiality of the home do indeed play an important role and determine to what extent it is likely for households to time shift their electricity-consuming practices. In this way, the examples add complexity to our understanding of daily practices and their temporality, which makes the strategy of DSM even more complicated. However, it also points to the possibility of including also the material qualities of convenience technologies and homes in the strategy towards DSM. Thus, if homes and technologies could be designed in ways that would facilitate time shifting, this would make it more likely to achieve DSM as a long-term goal. For instance, low-noise designs of washing machines and dishwashers could be important design criteria in order to make these “smart grid ready” (and maybe much more effective than enabling remote control of these machines, which is what traditionally has been associated with this term). Thus, findings like those presented in this paper can have important design implications that, if adopted by technology designers, could facilitate the time shifting of everyday practices.

On a more general-analytical level, question arises on how to theoretically understand the role of materiality for time shifting. Obviously, theories of practice acknowledge the role of material objects as one of several co-dependent elements constituting practices. In that sense, it is trivial to conclude that materiality plays a role in relation to time-shifting practices. However, the empirical material also hints at other more elaborated analytical generalisations that could help us to better understand the role of materiality. One of these relates to the semi-automation of practices through technologies like dishwashers, timers and washing machines. Another relates to how the broader materiality of the home influences the timing of practices through localising practices within the layout of the home and shaping their interaction with other practices (like sleeping or breakfasting). Here, (co-)location of practices within the space of the home seems to play a vital role.

The concept of “distributed agency” might inform our understanding of these empirical examples. Strengers et al. (2014) subscribe to an understanding of agency as distributed

among humans and nonhumans (inspired by Jane Bennett, among others). Thus, they define agency, and “agentic capacities” more broadly, as “the capacity for a human or nonhuman actant to act in the world, the ability of which emerges in relation to other actants and their interactions within an assemblage.” (p. 5) Following this approach, agency is “always the outcome of an assemblage, in which agentic capacities are variously, but not necessarily equally, distributed.” (p. 6).

In this way, agentic capacities are decentred from the individual human and are instead seen as a capacity that emerges through the interaction of human and nonhuman actants involved in assemblages of practices. This understanding could help understand how, e.g., bacteria and noise-making machines (interfering with the practice of sleeping) limits the level of (experienced) flexibility related to a practice such as laundering. The concepts of practice assemblages and distributed agency further emphasises the before-mentioned need to focus on what role the design of materials involved in the performance of practices plays for the possibilities of time shifting these practices.

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