# Referat

"Shifting" refererer til bevidst at flytte anvendelsen af energikrævende apparater til perioder hvor elprisen er lavere, eller hvor der er store mængder vedvarende energi. Dette medfører at folk er i stand til at reducere deres el-udgifter eller deres miljøbelastning, uden at skulle reducere deres samlede elforbrug. Dette felt er blevet studeret af adskillige forskere inden for menneske-maskine interaktion. Disse forskere har gentagne gange konkluderet at shifting, trods dets konceptuelle enkelthed, er svært at implementere. Dette skyldes at effektiv shifting kræver at udøveren er villig eller har mulighed for at omstrukturere deres hverdag, med henblik på at flytte aktiviteter der er afhængige af strømkrævende apparater til andre tidspunkter. Da sådanne aktiviteter ofte er forbundet til andre aktiviteter, bliver dette hurtigt et kompliceret virvar af planlægning, der skal gå op. Derfor er det vigtigt at opbygge en dyb forståelse både for brugerne, deres situation, og for shifting som en praksis.

I dette projekt har vi forsøgt at opnå denne forståelse ved hjælp af brugerinddragelse med participatory design og praksisteori. Vi har udført en deployment test med en prototype af et system som viser prisen for strøm på forskellige tidspunkter af dagen, samt en liste over apparater og et estimat af deres strømpris på forskellige tidspunkter af dagen. Prototypen var designet til at være beskrivende frem for foreskrivende, for at give brugerne mere frihed til at bestemme hvordan de ville inkorporere shifting i deres hverdag. Denne deployment-test varede en uge og inkluderede seks deltagere fordelt på fire husstande. Som resultat af denne deployment-test kom vi frem til en forståelse af shifting som praksis. Denne forståelse inkluderede blandt andet at friheden til selv at kunne vælge hvordan man integrerer shifting i sin hverdag er vigtigt for brugerne og, at for at kunne understøtte shifting endnu mere ved hjælp af et system, krævede det at brugerne fik feedback på deres shifting-adfærd.

For at finde ud af hvordan denne feedback kunne implementeres i systemet, udførte vi tre co-design workshops, hvor potentielle brugere havde mulighed for at forme denne funktionalitet. Workshoppen bestod af idégenerering efterfulgt af en aktivitet hvor deltagerne brugte udklippede brugergrænsefladeelementer til at danne designkoncepter. Som resultat af disse workshops kom vi frem til tre grundlæggende behov relateret til shifting. For at eksemplificere hvordan disse indsigter kan anvendes, udviklede vi et design baseret på resultaterne fra disse workshops, samt den tidligere deployment.

# Power to the People: Supporting the Practice of Shifting

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## ABSTRACT
Shifting refers to the act of intentionally moving one's electricity usage to other periods, either due to lower prices or an abundance of sustainable energy. This allows people to reduce their electricity spending, as well as their environmental impact, without necessarily reducing overall usage. This is a field that has been studied by multiple HCI researchers, who have repeatedly concluded that a deeper understanding of people and the practices involved is necessary to support shifting. As such, this paper is focused on quantifying what a participatory design approach, with a focus on practice, can uncover about the practice of shifting and how to support it through HCI. To do so, we conducted a deployment test of a research prototype, as well as co-design workshops which were analysed using practice theory. We argue that even with a deep understanding of the users and the practice of shifting, HCI is limited in its ability to cause meaningful adoption of shifting behaviours. We instead suggest appealing to more intrinsic motivations, and that HCI should be more focused on supporting larger initiatives, rather than trying to be the sole solution.

## INTRODUCTION
As electricity prices have increased, the general public's awareness of their electricity consumption has increased, particularly in regard to the cost accrued by consuming electricity (Energistyrelsen, 2023). While energy conservation is a popular topic within the field of sustainable human-computer interaction, energy shifting as a way of achieving this has seen less attention. Shifting refers to the act of intentionally changing the period in which one performs electricity-dependent tasks, so as to take advantage of periods of lower price per kWh, resulting in a reduction of personal electricity spending, without necessarily reducing overall electricity consumption. In addition to saving money, shifting can also be used to lessen one's environmental impact by moving one's electricity usage to periods where a larger amount of sustainable electricity is available through changes in weather, resulting in a larger proportion of one's electricity coming from sustainable energy sources such as solar panels or wind turbines.

Existing research on energy shifting has encountered multiple problems in regard to facilitating adoption of shifting behaviour, pointing towards a need for a deeper understanding of people, their everyday lives, and the practice of shifting as a whole.

Based on this, a research question was formulated:

*"What key insights can a participatory design process, in conjunction with practice theory, uncover regarding the design of an interactive system that aids people in adopting a practice of assisted shifting?"*

In an attempt to answer this research question, we conducted a deployment test and participatory workshops, each of which were analysed using practice theory as a framework.

Our primary findings take the form of elements in the practice of assisted shifting, and how these can be supported through an interactive design.

## BACKGROUND
Beginning at the end of 2020, the price of electricity has increased significantly throughout most of the world, and particularly in the EU (Council of the European Union, 2022). This, in conjunction with the rising prices of many consumer goods (J.P. Morgan Research, 2022), has resulted in a situation where many people may have found themselves needing to save money.

As a response to this, as of March 2022, 38% of Danes had, within the last six months, made intentional changes to the way they consume electricity. Of these 38%, half had adopted a form of shifting behaviour to some extent. Additionally, 82% of the 1024 respondents indicated that saving money was or would be one of the primary motivators for altering their electricity, while 52% indicated that they were or would be motivated by a desire to reduce their environmental impact. Lastly, 54% indicated that they were more motivated to reduce their electricity usage at the time, than they were 12 months prior. (Energistyrelsen, 2023).

### Related Work in HCI
This project builds upon the findings of our previous paper in which a participatory approach was used to uncover key challenges related to taking control of one's electricity usage. This previous paper draws upon qualitative data from two participatory workshops, the first of these being an inspiration card workshop (Halskov & Dalsgård, 2006) where the participants ideated concepts. The second workshop was a co-design workshop where the participants

discussed, critiqued and redesigned a set of three low-fidelity app prototypes. The paper concludes with a set of guidelines for designing an interactive system that aids people in taking control of, and understanding, their electricity usage. (Hjort & Johannsen, 2022)

Though the idea of shifting is conceptually simple, one merely looks at the electricity price throughout the day, and starts appliances with a large electricity demand when the price is low, its practical integration in daily life can be tremendously complicated. In their 2021 study, Jensen et al. examined the usefulness of a prescriptive techno-solutionist approach to encouraging shifting behaviour, i.e. specific shifting recommendations, and noted that it did not align with the norms and values of individuals, stressing the importance of considering the practice of shifting in a larger everyday life context. Additionally, they encouraged the use of participatory design methods to ensure sufficient user dominion over design choices (Jensen et al., 2021). The importance of considering everyday norms and values is also present in Strengers' Resource Man paper, in which she underlines the importance of working with, rather than against, what she calls "the mess of everyday life" (Strengers, 2014).

In their 2016 paper Friis & Christensen explored the temporal flexibility of Danish households' electricity consumption. The paper aims to understand how households can adapt to shifting their electricity consumption to low-tariff hours. They draw upon qualitative and quantitative data from two smart grid projects and analyse the barriers hindering people from shifting their usage. The paper concludes that the households had limited flexibility in shifting their electricity consumption partly due to the natural rhythm of their everyday lives. Therefore, they suggest that future interventions should take the complexity and dynamics of interwoven social practices into account as this is crucial to households' capacity to alter their energy consumption behaviour. (Friis & Christensen, 2016)

## METHOD

Based on the suggestion proposed by Friis & Christensen to "acknowledge the temporal complexity and dynamics of interwoven social practices and how this affects the potential for time shifting energy demand" (Friis & Christensen, 2016), a participatory approach may prove valuable to effectively understand and address the complexity of the situation. This is further reinforced by Jensen et al. who suggests a participatory approach to take into consideration the everyday norms and values of the users (Jensen et al., 2021). This also aligns with Strengers' view of considering the mess of everyday life (Strengers, 2014). Additionally, as the personal everyday norms and values of people, and the way in which they navigate the mess of everyday life is likely encased in a web of tacit knowledge, participatory design methods would likely be particularly useful in uncovering these.

Participatory design is a design approach that aims to achieve a deeper understanding of users than traditional user-centred approaches. It achieves this through two primary ideas. One is the inclusion of users as active co-designers, rather than units to be measured. The other is the idea of empowering users to more easily express their needs and desires through the use of co-design tools, in which participants are provided the necessary tools to create simple designs, or express complex personal views, opinions, and experiences. These co-design tools could include design kits such as pen and paper or pre-created interface modules in cardboard, or diaries. (Bødker et al., 2022)

### Practice Theory

In order to apply the knowledge gained from designing with users, we used theories related to practice as well as the practice framework presented by Shove et al. (Shove et al., 2012). This allowed us to enhance and structure our understanding of the practice of shifting. This inclusion of practice theory also aligns with the findings of Friis & Christensen, and Jensen et al. (Friis & Christensen, 2016) (Jensen et al., 2021).

The practice framework by Shove et al. is one way of understanding a practice. It divides a practice into three parts: Materials, competences, and meaning (see Figure 1). (Shove et al., 2012).

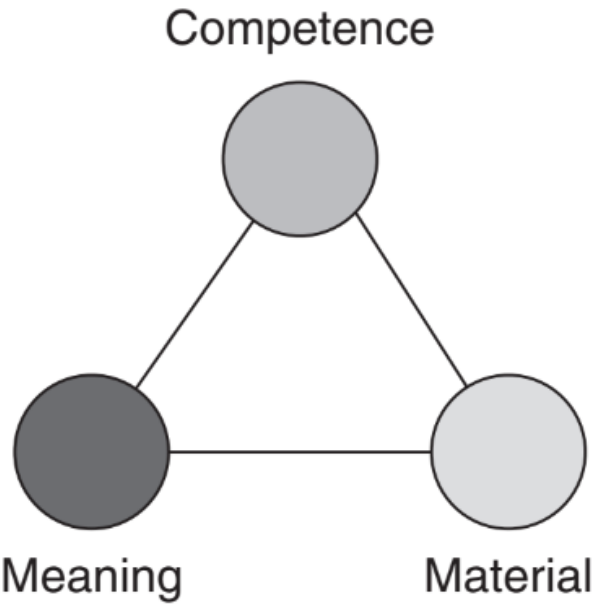


Figure 1 - The Practice Framework (Shove et al., 2012)

Materials are the objects necessary for conducting the practice. Materials may include tools, hardware, infrastructure, and even the human body itself. Competences are the skills necessary in order to conduct the practice. Competences can include understanding, technical ability, and practical knowledge. Meanings are the underlying reasons for engaging in a practice such as

values, emotional outcomes, and motivation. (Shove et al., 2012)

For example, for the practice of recreational running, the materials of the practice are running shoes, running clothing, a place to run, and the human body. The competences of the practice are route planning, tempo management, and the technical abilities to move one's body in the appropriate manner. The meanings of practice may vary from person to person, but could include having fun, improving cardiovascular health, expending calories, or simply feeling a sense of freedom.

It should be noted that the materials, competences, and meaning are often interconnected. Elements from materials, meanings, and competences, support each other and are sometimes interdependent. As a result of this, a change to one element could cause changes in the other elements. As an example, in the practice of cooking, the tools used dictate which competences are necessary. Likewise, if the meaning of cooking is to enjoy the process you may be more inclined to prefer a knife and cutting board over a food processor, thus changing the materials.

Southerton expands on the theories about practices presented by Shove et al. Southerton argues for three themes in the relationship between practices and time. The first theme being time as a finite resource, meaning that practices compete for time and temporal location of the day, week, month etc. The second theme is that practices configure temporalities, meaning practices have temporal demands. The strength of these demands depend on factors such as to what degree they require coordination or synchronisation with other people or practices. Practices such as eating a meal with others require coordination, not just in terms of fitting each person's schedule but also being tied with other practices such as meal preparation and clean up. The third theme is collective and personal temporal rhythms. Societies tend to conform to temporal rhythms, which become collective rhythms for the people in those societies. Examples of collective rhythms include school and work hours, and meal times. Similarly to how practices configure temporalities, temporalities also configure practices. Practices are affected by the collective rhythms as the temporal demands of practices need to be compatible with institutionally timed events such as school, and work. As a result of this, phenomena such as "Monday is washday" have emerged. However, as the temporal demands of many practices have decreased due to factors such as extended opening hours for supermarkets, collective temporal rhythms are increasingly being replaced with individual temporal rhythms. (Southerton, 2012)

## DEPLOYMENT TEST

In order to understand how the practice of shifting could be affected through the addition of new materials, we conducted a deployment test.

In order to do so, an understanding of the practice of shifting as it exists now was necessary. A limited understanding had already been attained during our previous project (Hjort & Johannsen, 2022). These findings have been converted into meanings, materials, and competences in accordance with Shove et al.'s practice framework (Shove et al., 2012):

The materials include appliances suitable for shifting, a variable electricity price, and the person or persons performing the shifting.

The competences encompass knowledge of the electricity price at any given time throughout the day, and knowledge of the impact of the shifting.

Lastly, the meanings include a desire to reduce one's electricity bill, a desire to lessen one's environmental impact, and perhaps a need or desire for feeling in control.

Although the practice of shifting can be treated as a single entity, it consists of multiple practices, which have a common element of using electricity. Therefore, any changes to these practices result in changes to the practice of shifting. Consider a situation where a household switched out their old washing machine with one that could be scheduled to run at a specific time. This would not only change their practice of washing clothes, but also the encompassing practice of shifting. Similarly, any changes to the practice of shifting would necessarily result in changes in the underlying practices. Because of the connectedness of the underlying practices, a change to one of them is likely to result in changes to the others which creates the web of complexity which Strengers refers to as the mess of everyday life (Strengers, 2014).

Based on this, we created a research prototype. This prototype will function as a new material, intended as a tool to gain a deeper understanding of the practice of assisted shifting, through trying to support it based on our current understanding.

### The Prototype

For the deployment, an interactive research prototype was created (see Figure 2). This prototype was created in Figma (Figma, n.d) and was designed based on our understanding of the challenges of shifting and the practice of shifting itself. Both of these were garnered through the process of creating the aforementioned previous paper.

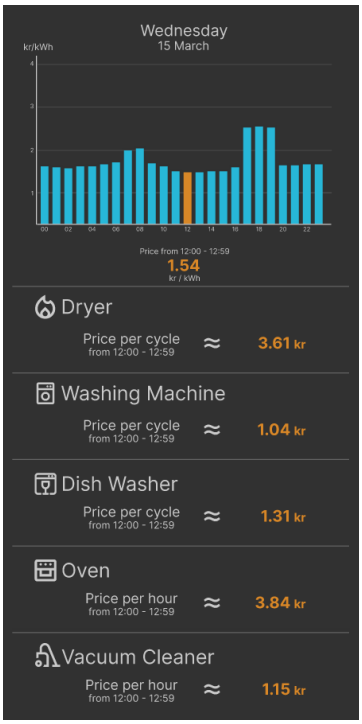


Figure 2 - The research prototype

The prototype is intended for use on mobile devices. This was chosen as it likely results in a smaller barrier to using the system throughout the day, as compared to a desktop application or stand-alone device. This is relevant both in regard to the deployment, and if the system were to be made publicly available, as in both cases the barrier to using the system should be as low as possible.

The prototype attempts to support the practice of shifting, through supporting elements in a new proto-practice of assisted shifting in which the app becomes a material that simplifies the acquisition of necessary competences and supports meanings.

To accommodate for the mess of everyday life, the app is designed to be descriptive rather than prescriptive. That is to say, the app does not tell the user what to do, but provides the necessary information needed for the user to make an informed decision. By doing so, the user is not pressured into optimising the use of all their appliances, but can instead consider what appliances can be shifted and to what degree, in order to reduce usage costs, without requiring excessive compromises to their daily schedule.

Specifically, the app provides access to two main pieces of data: The total electricity price, including all tariffs and additional charges, throughout the day; as well as an overview of the price accrued by different appliances, were they to be started at a specific time. This directly supports all of the competence elements. Knowledge of the electricity price is directly provided, while also reducing obfuscation through displaying the total price, rather than only the raw electricity price, while knowledge of the impact of shifting is provided through displaying the price of using appliances at specific times. Together, these support the competence of daily planning, by making available all information regarding planning variables; i.e. the user is able to clearly see when it would be most sensible to start a appliance, how much deviations from the most optimal time-frame would cost, and make judgments that strike a balance between how much extra they are willing to pay in order to align activities with their daily schedule.

### Recruitment

For the deployment, a total of six participants across four households were recruited. These participants were between 23 and 33 years old and had differing levels of education and income (see Table 1). The recruitment criteria for this deployment were that the participants must have a variable price agreement with their electricity supplier. Some of the participants were acquaintances of the project group members and some were recruited through snowball sampling (Dudovskiy, 2019).

| Participant # | Age | Occupation | Household |
|---|---|---|---|
| P1 | 30 | Full-time employment | Solo apt. |
| P2 | 24 | Full-time employment | Shared apt. |
| P3 | 24 | Student | |
| P4 | 33 | Full-time employment | Solo apt. |
| P5 | 23 | Student | Shared apt. |
| P6 | 23 | Student | |

Table 1 - Participants for the initial deployment

### Study Design

The participants were given access to the prototype and asked to use it for a week. In order to not affect how the participants would normally interact with the prototype, they were not given specific instructions on how often to use it, or what to use it for. They were however given an overview of how it functioned, and informed that the prototype was intended to aid people in shifting.

Before each participating household's deployment week started, a short semi-structured preliminary interview (Sharp, Preece, Roger, 2019) was conducted. These interviews revolved around how they currently consumed electricity, their thoughts regarding their electricity consumption, whether or not they currently engaged in any electricity-saving behaviours, and their motivations

regarding this. Additionally, as the prototype was created in Figma, and thus was not an actual mobile application, each participant was asked to, and instructed on how to add a bookmark to the prototype to their phone home-screen. This was done to lessen the barriers to opening the prototype, and create the illusion that it was an actual app.

After each participating household's deployment week ended, we conducted another semi-structured interview (Sharp, Preece, Roger, 2019) with the members of the household. These interviews focused on the extent to which they had used the prototype, what they used it for, whether they found it to be useful, how successful they were in integrating it into their daily rhythms, and whether they had any suggestions for redesigns or additional features.

In addition to these interviews, one member of each participating household was sent three messages with questions throughout the week. These three messages were (translated):

1. *Have you used the prototype? What have you used it for?*
2. *Have you gotten into a rhythm with using the prototype? When do you use it?*
3. *How has the prototype affected your week? Has it required more of you in terms of planning, or has it simplified it?*

These questions served both as in-situ journaling, as well as a reminder for the participants to use the prototype.

**Analysis**

For the analysis, a top-down thematic analysis using the practice framework was conducted as this could help us understand how the findings from the deployment relate to the practice of assisted shifting. The analysis was done in Miro, which is an online collaborative whiteboard tool (Miro, n.d).

Before the analysis we reviewed the recordings of the interviews to become familiar with the data. Then we coded the data, by extracting main points, quotes, and remarks. This was done in separation to avoid introducing unnecessary bias, before comparing them to create the final set of codes. Next, the codes were divided into materials, competences, and meanings from the practice framework. If codes were suitable for more than one of these, they were duplicated and put into both. Within the materials, meanings, and competences, the codes were reviewed and arranged into emerging themes. Then, with all the codes separated into themes within materials, competences, and meanings, the themes were given descriptive names. Lastly, connections were drawn between the materials, meanings, and competences to gain a deeper understanding of the interconnectedness of the elements. These were based on whether elements were reliant on other elements, affected each other, or had shared characteristics.

**Results**

From the preliminary interviews it was clear that the participants differed greatly in their attitudes toward energy saving and their abilities to implement electricity saving practices. P1 stated that because they work long hours their time at home is sparse, limiting their ability to shift their electricity usage. Furthermore, because they use a shared washing room, they have no financial incentive to use these outside peak hours. P2 and P3 were generally conscious of not wasting electricity and tried to not leave appliances on standby. However, they did not engage in shifting behaviours beyond minor initiatives such as charging their laptops and phones outside peak hours. P4 seemed uninterested in saving energy but was aware of its importance because of the coverage it has been getting in the news due to the surge in energy prices. According to themselves, this lack of interest stems from the fact that their income is high enough for them not to worry about their electricity bill. While environmental concerns were a motivator for them, they felt powerless to make any meaningful impact. P5 and P6 were very engaged in energy conservation behaviours and had been for a long time, even before the energy crisis. They were used to checking the electricity price on a daily basis and also used an app to monitor their electricity usage. They stated that their primary motivation was saving money as they were both students and therefore had a low income.

From the analysis of follow-up interviews, an understanding of the proto-practice of assisted shifting was garnered. The elements of this practice are:

*Materials*

Assisting System

This is the primary element that differentiates the practice of assisted shifting from the regular practice of shifting. This material encompasses the system itself, as well as its features, envisioned as sub-materials. These include an overview of the electricity price throughout the day, and a list of appliance usage prices. For the appliance price list, the participants noted that in order to ensure its usefulness, it should be possible to change which appliances are shown in the list, as well as adding a larger array of different appliances. Additionally, some of the participants were sceptical of the validity of the figures shown in the appliance price list.

Appliances Suitable for Shifting

As with the practice of shifting, the practice of assisted shifting requires appliances that are suitable for shifting. The deployment did however show that what appliances are suitable differs from person to person, although all of the participants noted an unwillingness to shift the usage of their stove, despite it being the most expensive appliance featured in the prototype. The participants clearly stated that they did not wish to move their meal times, indicating that maintaining their daily temporal rhythms were more important to them than the possible savings.

*"Dinnertime is hard to move around" (P2 - translated).*

The material elements of a variable electricity price and the people performing the shifting remain unchanged from the practice of shifting to the practice of assisted shifting.

### *Competences*

Knowledge of the Electricity Price

In order for people to shift their usage it is necessary to know when to shift it to. Therefore, knowledge of the current and future electricity price is essential. Some of the participants noted that they were familiar with the general patterns of the electricity price, including peak-hours and when it is cheap. Some of the participants were experienced with checking the electricity price regularly and had established simple guidelines to make it easy for them to act on it.

*"When the price is below one krone, it is a good time to use electricity" (P5 - translated).*

*"When the price is below the average price for the day, it is good" (P6 - translated).*

Integrating Shifting in Everyday Life

This competence includes ways in which the user manages to integrate the act of shifting into their daily lives. This includes establishing a rhythm or pattern for when to check the electricity price, and may include the ability to be more flexible regarding some appliance-reliant activities. One participant noted a desire for the prototype to include notifications that serve as reminders, reducing the need for an established rhythm or pattern.

Evaluate Long-Term Impact

The competence element of "Evaluating long-term impact" relates to the ability to understand and evaluate the positive impact small daily savings can result in over time. This primarily ties into the idea of remaining motivated over time, ensuring long-term usage. This may be especially important in regard to convincing users of the effectiveness of shifting, as several of them indicated that they perceived it to be an ineffective approach.

*"One krone will probably not make a difference to most of us" - (P4 - translated).*

Knowledge of the Price of Using Appliances

Knowing the costs of using appliances and which appliances draw the most electricity is important when determining which shifting behaviours should be prioritised. The participants expressed a general understanding of which appliances used the most electricity but also appreciated the list of appliance usage prices included in the app. However, when talking about their shifting behaviours, some of the participants focused on activities such as charging their phones which seemingly unbeknownst to them has negligible savings potential as the electricity usage is insignificant.

### *Meanings*

Saving Money

This was the primary meaning supported by the prototype and expressed by the participants. It relates to the motivational aspect of saving money by showing the exact price differences at different times. Participants did however note that this could be amplified by extrapolating price data to make the long-term savings more obvious, and to motivate the user through the use of the appearance of larger savings.

Environmental Concerns

Some of the participants also mentioned environmental concerns as a motivation to shift their energy usage. However, this was mentioned as a secondary motivation with the primary motivation being saving money. Some of the participants who were students expressed that they expected environmental concerns to be of a higher priority for them once they finished their education and got a higher income.

Intrinsic Motivation

Beyond economic and environmental motivations, many of the participants expressed other, more intrinsic, motivations for wanting to shift their electricity usage. These motivations included feeling in control, feelings of accomplishment, and a desire to self-monitor.

*"Now it feels like I am winning, because the price is below average" (P4 - translated).*

Freedom to Choose When to Shift

This, and all of the "Freedom to…" elements relate to the descriptive, rather than prescriptive, nature of the prototype. The freedom to choose when to shift specifically relates to the user not being told specifically when to shift the use of an appliance to, empowering the user to not necessarily shift an appliance to the most optimal time, but to instead shift to a time that aligns more favourably with their daily temporal rhythm, and still provides some benefits as opposed to other times.

Freedom to Choose What to Shift

This element is similar to the freedom to choose when to shift-element, but instead relates to the prototype not dictating which specific appliances to shift, but instead allowing the user to shift whichever appliances they wish. This too empowers the users to strike a balance between doing what is optimal, and doing what is feasible in regard to their temporal rhythm. This was particularly evident when it came to shifting of the stove, which allows for the greatest positive impact if shifted, but which was disregarded by all of the participants due to the inconvenient nature of shifting meal times.

Freedom to Choose Level of Integration

The freedom to choose level of integration-element is the most abstract of the "Freedom to…"-elements. It relates to the participants' desire for the prototype to not demand a certain level of time investment, and in turn not requiring

intentional integration into their everyday lives. This was exemplified by the participants who chose not to open the prototype at specific times in order to plan their electricity-dependant tasks, but rather open the prototype before performing a task in order to evaluate how long of a timer to set on the appliance, or whether to wait for a period of time in the case of activities such as vacuuming.

Ease of Integration
This element refers specifically to a meaning that all of the participants noted as an important aspect in terms of choosing to engage in the practice of assisted shifting as opposed to the regular practice of shifting. That being, that the system itself should be easy to integrate into their lives. In practice, this means that the system should provide the necessary information in a way that is easily understandable and actionable, and not demand unnecessary attention or an excessive level of time investment.

*Element Interconnectedness*
From the analysis, a total of eight connections were identified. All of these are connections between a competence and either a material or a meaning, and are organised in terms of which competence they connect to. These connections illustrate how elements in different categories are reliant on other elements, affect each other, or have shared characteristics.

Integrating Shifting in Everyday Life
This element connects to four meanings: All of the "Freedom to…" meanings, and the "Ease of integration" meaning. These connections illustrate how the need to integrate use of the system into everyday life can be supported by not requiring a certain level of user engagement, and how consciously making the system simpler and faster to use reduces the difficulty of integration into everyday life.

Knowledge of the Electricity Price
This competence connects to the "Overview of electricity price" sub-material. This connection illustrates perhaps the simplest truth in the practice of assisted shifting, that in order to make informed decisions about when to shift, one needs to know the daily electricity price.

Knowledge of the Price of Using Appliances
This connection runs from the sub-material "Personal appliance list", to the "Knowledge of the price of using appliances"-competence. This illustrates that in addition to knowing when to shift appliances to, the knowledge of usage prices for different appliances is important in order to make decisions about what appliances to shift. The "Personal appliance list" sub-material also connects to the meaning element "Freedom to choose what to shift", indicating the idea that the user should be able to freely choose what to shift, and gauge the impact of choosing not to shift certain appliances.

Evaluate Long-term Impact
Lastly, the connection between the competence of "Evaluating long-term impact" and the meanings of "saving money" and "Environmental concerns" illustrates how the motivational drive of wishing to save money or living more environmentally sustainably can be supported by allowing the user to evaluate the long-term impact of the shifting they perform.

*New Sub-Materials*
From the analysis, two sub-material elements not already present in the prototype, but evidently valuable based on the analysis, were uncovered. These were "Feedback" and "The average electricity price". Beyond this a collection of minor general improvements were also uncovered.

Feedback relates to the idea of being able to access an overview of how one's shifting behaviour has positively affected the total price of one's electricity consumption, as well as one's environmental impact, something that was noted by the participants as likely to increase their motivation. This relates to both the meanings of "Saving money" and "Environmental concerns", as well as the competence of "Evaluating long-term impact".

The ability to see the average electricity price for the day was a feature requested by multiple participants. This would act as a marker to help the user to more easily and accurately evaluate the current price relative to the rest of the day. Some of the participants who were used to checking the electricity prices said that as a rule of thumb they would try to use electricity when the price is below average and noted that it *"feels like winning"* when they manage to use energy demanding appliances during these times. As such, this sub-material ties into not only the meaning of "Saving money", but also intrinsic motivation as it gives the user a greater sense of accomplishment.

The participants also requested general improvements to make the system easier to use, and quality of life changes such as indicating the current hour on the bar chart, and having the current hour be selected when the system starts. These changes would support the ease of integration, lowering the barriers to adopting the practice.

## WORKSHOPS
To gain a better understanding of how the new sub-materials could be incorporated in a system, we conducted three identical participatory co-design workshops to allow potential users to shape these. Especially the "Feedback" sub-material requires considerations regarding the type of feedback, its intrusiveness, and the way in which it is communicated to the user. Therefore exploring the "Feedback" sub-material and how it could be implemented was the main focus of these workshops.

### Recruitment
For the workshops, a total of six participants were recruited (see Table 2). For each workshop, two of the participants

took part. The participants varied in age from 23 to 28 years.

| Participant # | Age | Occupation | Workshop # |
|---|---|---|---|
| P7 | 23 | Student | 1 |
| P8 | 28 | Full-time employment | |
| P9 | 27 | Unemployed | 2 |
| P10 | 27 | Student | |
| P11 | 27 | Full-time employment | 3 |
| P12 | 23 | Student | |

Table 2 - Workshop Participants

### Workshop Design

Each workshop was attended by two participants and consisted of an ideation and a co-design session. This format of two participants at a time was chosen due to several factors. It enabled us to follow the participants' thought process more closely than if more participants were present. Additionally, working in pairs allowed the participants to exchange ideas, feedback and insights, which may facilitate a deeper exploration of concepts.

#### *Ideation*

The first part of the workshop consisted of an ideation session. For this, a reworked version of the brainwriting pool method (VanGundy, 1984) was used. For this, each participant was given a piece of paper and a pencil, and tasked with creating three ideas of how the system could provide feedback to the user. Before doing this, the concept of shifting was explained to the participants, and they were shown the prototype from the deployment (see Figure 2). This ensured that they were aware of what features were already present in the system, allowing them to focus entirely on the feedback aspect. After having created the ideas, both participants would present and discuss their ideas with each other and us, before being asked to create three new ideas. These new ideas had to expand on, or be inspired by, the other participants' initial ideas (VanGundy, 1984). After this, the participants would present and discuss the final version of each idea.

From this process, a total of 36 ideas were created across the three workshops.

#### *Co-design Session*

For the second part of the workshop, the participants were tasked with jointly creating one concept. To facilitate this, The Jigsaw Puzzle Activity (Hare, 2016) was used. For this, we printed a set of generic UI components, as well as some domain specific ones (see Appendix A). Using these, a print-out phone frame, and a pencil, the participants were asked to create their vision for how the system should provide feedback to the user. This final concept could include multiple ideas created through the ideation, or the one idea they agreed on as the best.

From these co-design sessions, three concepts were created across the three workshops (see Figure 3).

Figure 3 - The participant-created concepts

### Analysis

The analysis consisted of three parts. First, all of the ideas from the ideation sessions were categorised. These categories were based on the core of each idea.

Having done this, each of the concepts from the co-design sessions were inspected to see how the different idea categories were represented in the concepts.

From this, a total of three key findings were identified. These key findings are based on ideas that were the most common across all three concepts, and were emphasised the most by the participants.

Lastly, these three key findings were related to the practice of assisted shifting, based on which elements the findings were similar to or could expand on.

### Findings

From our analysis of the concepts (see Figure 3) and the ideas from the ideation session, the three key findings were identified. These findings represent core needs of the users that relate to elements in the practice of assisted shifting:

1. Overview of usage compared to electricity price
2. Simplification of performance
3. Relating one's usage to something

#### *Overview usage compared to electricity price*

A recurring idea from workshops was to show the user's previous usage along with the correlating electricity price at the time of usage. This would provide the user with the necessary information to understand their shifting behaviour. If their usage is low while the electricity price is high it is a sign that the user is successfully shifting their

electricity usage. In the concepts, this idea manifested itself as a graph containing data about the electricity price, usage and on one occasion also the "greenness" of the electricity. This was also suggested in a forward looking manner in which the user is able to see their average usage for upcoming periods.

In regard to the practice of assisted shifting, this finding is related to the meanings "Saving money" and "Environmental concerns" as it is a direct measure of their performance on those metrics, as well as the competence "Integrating shifting into everyday life" and the meaning "Ease of integration". By understanding one's previous usage tendencies it may be easier to change them, as it creates awareness. Additionally, having a forecast of one's expected performance for the day could make it easier for the user to understand the changes needed to more optimally align their usage with the upcoming electricity price. A similar approach could be used for sustainability, by swapping out price for environmental impact.

*Simplification of performance*

This finding relates to quantifying the user's performance, not in terms of specific savings, but in simplified terms such as good or bad. This idea was present in two of the created concepts, and in at least one idea from each workshop's ideation session. One version of this used smiley emoticons to indicate shifting or usage performance, while another used colours, i.e. red for bad, green for good. Some of the participants noted that they would prefer this to more comprehensive feedback, as it requires no specific knowledge of electricity usage, but still allows them to gauge their performance objectively.

This relates to the meaning element "Intrinsic motivation" by tying the user's performance to something that is not necessarily related to money or being environmentally friendly, but instead to the somewhat intangible quality of simply being "good".

*Relating one's usage to something*

This finding relates to multiple ideas regarding comparing one's usage to different metrics. The participants suggested metrics such as one's previous usage, the average usage of people with similar households, or the integration of a community-feature, allowing users to compare their usage to that of their friends or family. Alternatively, users suggested the inclusion of a budget-setting feature, where the system could help the users create a realistic budget based on their household.

This relates to the meanings of "Saving money" and "Environmental concerns", as it provides objective measures allowing the users to gauge their performance. Similarly to the "Simplification of performance"-finding, this too relates to the meaning of "Intrinsic motivation" by providing the user with a metric that simply tells them whether or not they are doing well.

**Design**

Based on the findings of the workshops, as well as the previous deployment, a final prototype was created (see Figure 4). The design of this prototype exemplifies one way in which these findings could be manifested in a system. The prototype consists of: A budget feature, an average price overview, a usage graph, and the price graph and appliance price list from the deployment prototype.


Dashboard | Price Page | Usage Page

Figure 4 - Prototype pages

The budget feature allows the user to set a monthly budget for their electricity usage, based on the price of this usage, rather than the total usage in kWh. This budget can be created for the user by the system based on the average usage for similar households, and customised by the user, if they wish to create a budget that is more or less restrictive. At the top of the dashboard, an overview showing the users total usage, and how that compares to what it should be at this current time of the month, based on their budget, is shown. This feature is based on the "Simplification of Performance"-finding, allowing the user to gain an understanding of their performance based on a single number, which is coloured to indicate whether their performance has been good or bad, as well as the "Relating one's usage to something"-finding, by potentially correlating the budget to the average price of similar households.

The average price overview provides the user with information about what price they pay on average for their electricity. This acts as an indicator of their shifting performance by comparing the user's average price to the highest and lowest electricity price for the period. This is shown at the bottom of the dashboard, however, if the user is interested in more information about their shifting performance they can press the panel to navigate to the usage page. Here the user is presented with the usage graph, which is an overlaid bar chart which shows their usage in kWh throughout the selected period overlaid with the electricity price for the corresponding period. This graph aims to help the user gain a deeper understanding of their average price and how it is a result of their consumption behaviours. Above the graph the user can select to view this data for a single day, week, month, or year. The graph can be scrolled to select which day, week, month, or year to show. If the current or upcoming day is selected the usage graph shows the user's average usage for each hour of the day accompanied by the electricity price. Using this information the user can identify problems in their usage tendencies and correct them by shifting their usage. At the bottom of the page is the "Your average price"-list, which shows the average price the user has paid for electricity, as well as the average price for electricity used by each appliance. This allows the user to identify if there are specific appliances they continually use at inopportune times.

Lastly, the price page, which features the same price graph and appliance price list as those in the deployment prototype, is incorporated. Both of these are still core features that allow for shifting by supporting the competences in the practice of assisted shifting. Conceptually, the appliance price list has been expanded in two ways. Firstly, in order to accommodate household differences, which appliances are shown can be customised, and secondly, the intention is for the user to be able to specify the model or wattage of specific appliances.

It should be stressed that this is simply one way in which the findings could be used to create a design. Additionally, what the system emphasises could also be changed, if different features were deemed more important.

## DISCUSSION

### Shifting

Based on the findings of our previous study (Hjort & Johannsen, 2022), it was decided to focus on energy shifting for this project. Previous studies (Jensen et al., 2021) (Friis & Christensen, 2016) of energy shifting have uncovered similar difficulties in regard to encouraging everyday shifting for ordinary households, noting the need for either temporal flexibility or enough motivation to continue with one's shifting endeavours despite the toll it takes on one's daily temporal rhythm. Both of these studies suggest a deeper focus on the practice of shifting and user-incorporating activities, in an attempt to ensure that a potential system functions within the mess of everyday life, rather than try to fight against it.

Based on this, we chose to adopt a participatory design mindset, in conjunction with the use of Shove et al.'s practice framework (Shove et al., 2012), for this project.

While this was clearly beneficial in terms of gaining a deeper understanding, it did also illuminate the fundamental problems with the idea of an electricity-saving strategy based on shifting.

We argue that motivation is the primary barrier in regard to fully committing to an energy shifting lifestyle. This is caused by two factors. Firstly, energy shifting is, as evidenced by multiple studies including this one, tremendously difficult to incorporate into everyday life, primarily due to the need for continuous planning and restructuring of one's day. Secondly, due to the perceived lack of effectiveness in terms of meaningful monetary or environmental impact, the reward seems insufficient when compared to the effort required. In terms of Shove et al's practice framework, we can perceive this as the meaning elements being insufficiently "meaningful" in order to motivate people to engage in the practice.

In an attempt to combat this, we propose the idea of focusing on motivational factors not directly associated with the total savings or environmental impact, but intrinsic values such as feeling in control, feelings of accomplishment, and a desire to self-monitor. Alternatively, the numbers associated with these could have been recontextualized by focusing on the proportionate savings, or extrapolating the data to show the impact over a longer period of time, perhaps making the immediate impact seem greater and providing a better understanding of the long-term impact. This idea of increasing motivation through increasing the perceived impact, also aligns with the previously mentioned findings, in which actual increases in the price of electricity caused more people to engage in shifting practices (Energistyrelsen, 2023).

### Practice Framework as a Design Tool

Although the practice framework proposed by Shove et al. is not intended specifically as a design tool (Shove et al., 2012), in this project it was used as such. The practice framework is designed to analyse and understand practices, the activities that make up a practice, and the interconnectedness between multiple practices. Understanding is an integral part of the design process. In this endeavour, utilising tools from other fields, such as ethnography, is not uncommon. In this context, Shove et al.'s practice framework (Shove et al., 2012) is an ideal choice for design processes that are concerned with understanding the qualities that make up a practice.

When choosing a design tool, it is important to be aware of how a specific tool affects the scope and focus of the design process. In the case of this project, the use of Shove et al.'s practice framework (Shove et al., 2012) resulted in a system that is focused on supporting the fundamental competences and meanings associated with a practice, rather than trying to tackle specific problems experienced by current practitioners.

This focus on the basic necessities of a practice results in a system that is more general in nature, focused on providing non-practitioners with all of the necessary competences and supporting the most common meanings, rather than reducing friction for existing practitioners who may already possess these competences.

This is neither a negative nor a positive attribute of using the practice framework as a design tool. However, it may indicate that its use is more appropriate when designing systems intended for broad demographic use, rather than specialised tools for experienced practitioners.

### Economy Vs. Environment

The two main drivers of the practice of shifting are the financial and environmental incentives. This project, and the resulting design, has focused primarily on the financial incentives. This focus comes as a direct result of what the participants chose to focus on when discussing their electricity usage, and incentives to shift it. This could be explained by the time period in which this project was conducted. Due to the previously noted increases in electricity prices, the general focus and awareness on electricity usage, and specifically the price associated with it, has increased substantially.

Additionally, the financial situation of the participants, most of them being unemployed students or in the early stage of their career, may also have played a part in the monetary gains being the primary motivator for them.

Although it is a possibility that the interest in monetary gains is a result of the time period and participants of the project it may also be persistent in the future and across a wider user group. However, this will remain unknown without further studies on the subject.

Lastly, it should be noted that if the intention is to reduce the environmental impact of electricity consumption on a larger scale, this focus on the financial incentives does not subvert that entirely. Particularly in countries with a large amount of renewable energy infrastructure, the electricity price correlates to the availability of renewable energy, as this abundance of additional electricity causes the price to decrease. This means that even if a user is solely focused on using the system to reduce their electricity spending, they would also likely reduce their environmental impact inadvertently.

### Have We Taken On Too Much?

While the explicit focus of this project has not been on creating a solution to effectively reduce the large-scale environmental impact of electricity consumption, the system's merits in this regard is worth discussing.

While shifting itself can be effective in terms of reducing one's environmental impact, we are not convinced that a system like this can create such an effect at a large scale.

In their 2022 paper, Bremer et al. presents a critical review of the sustainable HCI landscape and its shortcomings. They note that, despite the dramatic increase in focus, SHCI has failed to create meaningful change towards a sustainable future. There are two primary reasons for this. Firstly, persuasive technologies intended to coerce people to alter their behaviour tends to have a low adoption rate, particularly if the surrounding circumstances do not support this behavioural change, and secondly, even if wide-spread adoption was achieved, the solutions tend to be low-impact, often limited to a reduction of less than 10 percent. Instead, they advocate for what they call "Green Policy Informatics", an approach in which HCI is focused, not on creating specific solutions based on persuasive design, but instead create systems that support policies, or play a role in a larger initiative. (Bremer et al., 2022).

Shifting-focused systems such as the one presented in this paper can inform people, or help them make more informed decisions regarding their electricity usage, supporting people in aligning their behaviour with the intention of such policies.

## CONCLUSION

Based on existing literature, it was clear that a deep understanding of people and their needs, as well as the practice of shifting was necessary in order to create a system that aids people in shifting. With this project we aimed to achieve this by incorporating elements from participatory design and practice theory.

This project consisted of three distinct phases. The first phase consisted of the deployment test, and culminated in defining and understanding the practice of assisted shifting. This phase was primarily focused on the practice of assisted shifting, what elements it consists of, and how these elements differ from the practice of shifting. From this, it was clear that motivation was a primary barrier to adopting

shifting behaviour. In order to overcome this barrier two new sub-materials were proposed. These being "Feedback" and "The average electricity price" which are related to the financial, the environmental, and intrinsic motivations.

The second phase consisted of the co-design workshops, and was focused on the users' needs, how these needs could be fulfilled, and how an interactive system could provide the support needed to achieve this fulfilment, specifically as this relates to feedback. In this phase, we identified three key needs in regard to engaging in the practice of assisted shifting. These needs were "Overview of usage compared to electricity price", "Simplification of performance", and "Relating one's usage to something". All of these relate to the idea of making shifting and its impact more understandable. Based on our findings, we believe that a system that supports these needs is more likely to result in users adopting, and continuing, shifting behaviours.

The third phase consisted of creating a design that exemplifies one way in which the findings of the project could be used to create a system that aids people in shifting.

Through this process, we have uncovered a possible answer to our research question:

*"What key insights can a participatory design process, in conjunction with practice theory, uncover regarding the design of an interactive system that aids people in adopting a practice of assisted shifting?"*

Our primary findings are the elements in the practice of assisted shifting and their interconnectedness, as well as the key findings from the workshops. In the meanings category, besides the meanings related to saving money or lessening one's environmental impact, we also uncovered three elements related to the importance of freedom in regard to shifting, indicating that in order to allow people to fit shifting into their everyday lives, it is important that the system does not prescribe specific actions, but instead describe the context in which choices can be made, allowing the user to make informed decisions. Lastly, in regard to motivation, we also discovered the role that intrinsic motivation can play and how a system can appeal to this in order to engage users.

In regard to competences, these remain the same as those from the regular practice of shifting. The main findings in this regard, relate to how these can be provided through materials.

In regard to these materials, the primary findings were the features of the system, imagined as sub-materials, that had to either support or appeal to meanings, or provide the user with the necessary competences.

These findings define a practice of assisted shifting, and three core needs related to it, pointing towards one way in which HCI can support people in adopting a practice of assisted shifting. To do so, design considerations in regard to how to appeal to or support these elements have to be made. The design proposed in this paper exemplifies one way in which an understanding of these elements can form a design.

This seems to indicate that HCI can support people in their shifting behaviour, however, if it proves unsuccessful in providing the necessary motivation, it seems unlikely that it, in and of itself, could cause people to fully adopt shifting behaviours.

## FUTURE WORK

As noted, the proposed design is simply one way in which these findings could be used to create a design. In addition to this, it is possible that the findings lack important aspects or nuances. To better evaluate the validity of these, we propose conducting another deployment, either with the final prototype presented in this paper, or another design based on the findings of the paper. Based on the findings of this deployment, alterations to the design could be made, or the findings themselves could be revised, paving the way for a new design based on these revised findings. Alternatively, it may be concluded that wide-spread shifting is not achievable only through HCI, and the scope of the project may therefore need to change entirely, either to better align HCI with a larger overall initiative to promote shifting, or to the creation of a design intended for people who are already engaging in energy shifting.

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