Pasta, Pancakes and Power Peaks

Sebastian Ljungman
Abstract

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Uppsala is growing, and with it the need for electricity. During certain times of day, the Uppsala electricity grid is struggling to meet power demands, and so it is desirable to decrease the amount of power consumed during these peaks. The Tiunda school kitchen contributes significantly to these power peaks, and while there was power data available for the school as a whole, there was no data on the use of which kitchen appliances was causing its power peaks.

To help the Tiunda school kitchen even out its power consumption, this thesis explores the use of an application to make staff more aware of their power consumption, as well as collect data on their use of kitchen appliances. The application presents a live graph of the school's total power consumption, and staff click on a map to indicate when appliances are being used.

Interviews with staff showed that the application has improved staff's awareness of kitchen power use, and the data collected through the application has potential to inform future strategies to even out power peaks. While staff sometimes found it difficult to remember clicking, teamwork was identified as facilitating the application's use.

Combined with other interventions, the application can help address the Tiunda school kitchen's uneven power consumption and, with modifications, also that of other kitchens.
1 Introduction

During 150-200 hours per year, the amount of power that can be supplied by the Uppsala electricity grid fails to meet the demand of citizens and industry.\[1\] This is mainly due to an increased demand for electricity, development of the electricity grid failing to keep up with this demand, and a decrease in electricity from cogeneration. Cogeneration is the combustion of fossil fuels or biomass to generate both electricity and heat, the profitability of which has declined in the Uppsala region.\[1\] This prevents the establishment of some new infrastructure, power intensive production and city development, which is why it is desirable to decrease the amount of power consumed during these peaks. The peaks are especially severe during certain times of day, particularly on workday mornings and in early evenings, and during cold winter days. These peaks can be alleviated by redistributing some power intensive activities from these peaks to times with lower power demands.

The Tiunda school kitchen contributes to these peaks, which is why it is desirable to make its staff more aware of the power usage in their kitchen, and how they can influence it. This thesis will examine the use of an application that attempts to present available power data (total power consumption of school facilities), while also collecting data from staff interaction to gain insight into how their use of kitchen appliances contributes to power peaks in the Uppsala electricity grid.

The goal is for the user experience to be as seamless and unobtrusive as possible, while furthering the reduction of power peaks caused by kitchen activity. Necessary research and programming is done to implement the prototype application, and qualitative data about the user experience is gathered through interviews with staff. Quantitative data is gathered through staff’s use of the prototype application. These data are then analyzed to evaluate the prototype and provide a basis for further development.

This thesis attempts to answer the questions: What is the behavioural response from staff when introducing this application in a school kitchen? What can be learned from the data collected from its use?

1.1 Electricity in Swedish school kitchens

Energy intensive steps in the preparation of meals in professional kitchens tend to coincide with cities’ power peaks, and so substantially contribute to them. The potential to decrease this contribution is assumed to be considerable; a behavioral study at the Hovås school kitchen in Gothenburg showed potential to reduce yearly electricity use by as much as 12%, by changes in kitchen staff’s behavior alone.\[2\] Reducing the highest power peaks through behavioral changes should therefore be even more feasible, as it can be a matter of rescheduling the use of machines to avoid peaks rather than reducing total consumption. A prestudy of products and staff education as means to make professional kitchens’ electricity use more efficient, concluded that a lack of technology
to measure electricity used by kitchens made evaluating behavioral changes difficult. In the cases where electricity was being measured, another issue was that measurements were made on facilities as a whole, rather than the kitchens in isolation, and so provided less accurate data.[3]

STUNS Energi, in collaboration with Uppsala kommun Skolfastigheter and Mältdsservice, runs a project financed by the Swedish Energy agency, the aim of which is to reduce the intensity of the highest power peaks occurring in five different Uppsala school kitchens, by 25%. This is to be accomplished through a combination of technical and behavioral measures, the effectiveness of which is also evaluated. The Tiunda school kitchen in Uppsala daily produces 2500 meals for students at schools and elderly at retirement homes, and is a significant contributor to Uppsala’s power peaks. Currently the total power consumption at the school is being measured at high resolution, 1 sample/30 seconds.
2 Theory and Related work

2.1 Review of workplace interventions

A systematic review of workplace interventions attempting to decrease electricity usage in workplaces (particularly office environments), published in 2016, uses the The Behaviour Change Wheel (BCW) to classify the interventions used in 22 different studies.[4] The BCW contains three Sources of Behaviour: Capability, Opportunity and Motivation, each with two subcategories. For a desired behavior change to occur, these must be sufficiently high, and deficits can be addressed by nine different Intervention Functions (which address different Sources of Behaviour): Education, Persuasion, Incentivisation, Coercion, Training, Restriction, Environmental Restructuring, Modelling and Enablement (see Figure 1).[5] The interventions are enabled by seven different Policy Categories.

![Behaviour Change Wheel](image)

Figure 1: Behaviour Change Wheel

The review identifies Enablement, Environmental Restructuring and Modelling as particularly useful strategies in decreasing electricity usage: Enablement: ‘increasing means/reducing barriers to increase capability or opportunity’; Environmental Restructuring: ”changing the physical or social context”; Modelling: ”providing an example for people to aspire to or imitate”. While almost all studies reviewed took a holistic approach to decreasing energy usage (consisting of several Intervention Functions), making it difficult to identify the individual contribution of each Intervention Function, these three Intervention Functions emerged as particularly successful: ”We find that interventions creating social and physical opportunities for employees to save energy
are the most successful i.e. which constitute Enablement (including direct support and greater control to employees), Environmental Restructuring (particularly automated and retrofitted technologies) and Modelling (various forms of social influence).”[4]

2.2 Fogg Behavior Model

Another behavior model is the Fogg Behavior Model (FBM).[6] The FBM attempts to break down how a design can ”persuade” the user to engage in the desired behavior. The model consists of two axes, ability and motivation, as well as a trigger component. The model states that a behavior change occurs if a user’s ability and motivation are sufficiently high, and there is a trigger for performing the target behavior. Similarly to the BCW, the FBM highlights that prerequisites must be fulfilled for a behavior to occur, but takes a more quantitative approach; there are three dimensions of core motivators: pleasure/pain, hope/fear and acceptance/rejection. These must not all be positive for a certain behavior to occur, i.e. there must not be pleasure, hope and acceptance all at once, but the sum of the dimensions must be sufficiently high along the y axis.

For ability, the reasoning is that the simpler the behavior is for the user to engage in, the more likely it is that they will engage in it (provided sufficient motivation and triggers). Ability is provided by six different simplicity factors, which are linked: ”These six parts relate to each other like links in a chain: If any single link breaks, then the chain fails. In this case, simplicity is lost.” The simplicity factors are: time, money, physical effort, brain cycles (non-trivial thinking), social deviance and non-routine. If the cost within one of these factors is too high for the desired behavior, e.g. the behavior requires too much money or is too non-routine, the chain breaks and the user will not engage in the behavior. By decreasing these costs, i.e. making the behavior cheaper and more routine to engage in, the user will have sufficient ability for the given behavior.

Finally, there are three kinds of triggers: sparks, which increase motivation; facilitators, which increase ability; signals, which increases neither but only serve as reminders. When motivation or ability is lacking a spark or facilitator may be used respectively, whereas signals work best when both are sufficiently high.[6]

2.3 Visualizations of electricity use in the workplace

Two connected studies presented by Katzeff et al. (2013) explore the visualization of electricity usage in two types of workplaces, factories and offices, using two different approaches.[7] Both approaches involved the use of projected light to provide employees with information about their electricity usage at work, but the intervention at offices required more active participation: The factory prototype, ”Watt-Lite”, used light bulbs
to project circles onto the floor, the sizes of which represented minimum, maximum and current power consumption of the factory for the current day. The office prototype, "Watt-Lite TWIST", instead used a projector to display a pie chart: employees would set the size of the pie chart, representing a number of kilowatt hours between 0.1 kWh and 2 kWh, and the "used electricity" section of the pie chart would increase as wireless electricity sensors reported the use of electricity. Employees were free to plug the sensors into different machines, in order to explore their electricity usage.

One group of employees using the Watt-Lite made the connection that larger circles meant better productivity, as the use of electricity is essential to their work. It also functioned as a reminder to make sure all machines were turned off at the end of the day. The Watt-Lite TWIST typically engaged many employees in the beginning, but then interest faded. For both prototypes, participants reported frustration that they could only influence their electricity consumption to a very limited extent; they received information about it, but felt like it was not actionable. The article also notes the difference between domestic and workplace electricity use, in that people at home have a financial incentive to decrease their electricity consumption (as they pay the electricity bill) that they do not have at work.[7]

2.4 Ancestral Tendencies

In a 2012 article, Griskevicius et al. argue for the importance of considering ancestral tendencies when trying to change people's behavior.[8] "They propose that many modern environmental and social problems are caused or exacerbated by five adaptive tendencies rooted in evolutionary history: (1) propensity for self-interest, (2) motivation for relative rather than absolute status, (3) proclivity to unconsciously copy others, (4) predisposition to be shortsighted, and (5) proneness to disregard impalpable concerns."[8] They also propose that these same five tendencies can be used as leverage when trying to solve these problems, and so should be taken into account when trying to change people's behavior.

For example, people's proclivity to unconsciously copy others means that they're likely to engage in the same behavior as others, whether "good" or "bad", and their proneness to disregard impalpable concerns means that a problem that feels distant is easier to ignore, but can also be made more difficult to ignore by making it more palpable. Therefore, rather than informing about how many people engage in "bad behavior" or their consequences in a far away place, it is a more successful strategy to instead stress how many people engage in "good behavior", and show the environmental impact of behavior on a local scale.[8]
3 Problem analysis

3.1 Preparatory work within a course setting

In the Uppsala University course Advanced Interaction Design, spring 2021, the main project was to construct design hypotheses that addressed the Tiunda kitchen staff’s lack of power awareness concerning their work, and its relation to peaks in the Uppsala electricity grid. A tour was given of the kitchen, during which students could also ask questions to kitchen staff to understand the context of use. Many hypotheses were created by different student groups, which focused on different aspects of staff’s work: Many were planning/simulation apps, attempting to make staff aware of the estimated power consumption of their tasks ahead of time, thus allowing them to foresee and avoid contributions to power peaks. One group, of which I was part, however, decided to go for a conceptually simple design. Based on the assumption that the individual power consumption of each kitchen appliance could be measured and accessed through the internet, with the use of Internet of Things-like technology, the group wanted to display real-time information to the staff on a screen, in a useful and intuitive manner.

The course introduced the Fogg Behavior Model and its three factors: Motivation, Ability and Triggers.[6] The group deemed staff’s motivation sufficient for the target behavior, but ability and triggers were lacking: Staff had received graphs of their past power usage, but this information was not put into the context of when the power grid experienced its peaks, decreasing staff’s ability to make adjustments to their work. Moreover, this information was no more than a static e-mail, which fails to trigger the target behavior on a daily basis.

With this in mind, the group’s hypothesis assumed that given enough accessible information (increasing ability) and being reminded (providing triggers), staff would reduce their kitchen’s contribution to the power peaks. Ideas developed and evaluated within the group using the online user interface design tool Figma. Figure 2 illustrates the final design: Assuming an interactive screen in portrait mode, live data for the school kitchen’s total power consumption is displayed in a graph at the top. The graph also includes a ”power allowance”, a theoretical indicator of how much power the kitchen could consume at different times without overly contributing to power peaks. A user can toggle this graph between a ”work hours”, ”24 hours” and ”7 days” view, the latter there to allow comparisons with previous days. In the middle, a short list of the most power consuming appliances (expandable to an ”all appliances” view upon clicking), as well as a color coded map of the kitchen (gray meaning turned off), attempting to aid users in connecting what they see in the application to physical reality. At the bottom, a stacked bar chart trying to convey the proportions of different appliances’ power usage. Color use is consistent, so that one color represents one appliance in all contexts.
3.2 Delimitation and goal specification

This thesis builds on the preparatory work done in the Advanced Interaction Design course (section 4.1 above), with the ambition of developing a usable prototype. After initial research, the use of Internet of Things (IoT) technology to provide live data on the individual power consumption of each kitchen appliance turned out to not be viable for
Although a lot of consumer products exist that provide exactly this data, the wattage rating of the appliances proved to be a limiting factor: Consumer IoT products for this purpose are usually rated only a few kilowatts, while many of the most power intensive appliances in the kitchen consume tens of kilowatts. The way the appliances were connected was also an issue, as many of them did not use standard power plugs. A custom-made solution at the electrical enclosure was not viable either, due to limitations of space, time and cost.

Because of these limitations, another way to find correlations between the total power consumption and the use of individual appliances was necessary for the time scope of this thesis. The kitchen staff had previously tracked their use of appliances by taking notes with the help of pen and paper, and mapping these notes to past data showed a correlation between appliance use and power (see Figure 3).

![Figure 3: Staff notes mapped to power consumption](image)

Although not entirely accurate due to the source of the data (the underlying graphs shows a 15 minute kilowatt hour average, and staff’s notes were of approximate times), and the manual nature of the mapping, it showed that data collected from staff’s active participation held promise as a basis for a visualization: While not providing any data on how much power each appliance is using, this temporal data could still allow some conclusions to be drawn about individual appliances’ impact on total power consumption. As there were already plans to display live power data to staff (overlapping with our design hypothesis from the previous course), combining this display with the collection of data seemed natural.
4 Design

As a means to collect appliance usage data, it was decided to have staff click on buttons to indicate appliances’ status as either on or off. Using the UI design tool Figma, a non-interactive mockup was created (Figure 4): The application would be run on a laptop, so a landscape layout was most suitable. At the top is a graph of total power usage, similar to the previous mockup (Figure 2), and the layout with a list of machines to the left and a map to the right has also been preserved. Unlike the previous mockup, the layout of the appliances on the map now approximately match that of reality, and the on (colored) status and off (gray) status is changed by clicking on the map’s appliance buttons rather than by IoT power data. The list shows all turned on appliances, ordered by a detected ”power trend” since appliance was turned on. The name of each appliance, its maximum wattage rating, the time it was turned and its ”power trend” is displayed.

Figure 4: Mockup for prototype
5 Implementation

As internet connectivity was part of the application’s design from the start, building it as a web-based application was a natural choice. Especially during the current Covid-19 pandemic, minimizing the amount of on location maintenance is beneficial; updates to the application are done on the server side, with no physical visit or cumbersome remote access necessary. Vue was chosen as a front-end framework to implement the application: Vue allows the development of reactive web applications in JavaScript, while still using HTML and CSS for content and style respectively. "Vue.js itself is not a full-blown framework - it is focused on the view layer only. It is therefore very easy to pick up and to integrate with other libraries or existing projects."[9]

Graphs for visualizing the Tiunda school’s total power consumption were already available through the web application Grafana. Grafana is an open source web application for analysis and visualization of data.[10] For maximum flexibility, the use of other JavaScript libraries was investigated; graphs of average kWh/15 minutes data present in early screenshots of the application reflect these experiments. In the interest of time however, all versions of the app that were used in practice showed embedded graphs from Grafana, with static background colors (white, green, yellow and red) indicating the "severity" of power peaks.

The application is structured around Vue components: a main "App" component, a "MachineList" component and a "KitchenMap" component. In "App", there is an array of JavaScript objects, "allMachines", with each object containing properties for id, type of appliance, name of appliance (in Swedish), wattage rating, when it was last turned on, if it is currently turned on, and what image and shortened name should show on its map button. "allMachines" is passed as a prop to "KitchenMap", which renders the map using HTML and CSS. When an appliance’s button is clicked, the color of the button is toggled with CSS and an event is emitted from "KitchenMap" to "App", changing the value of the on/off property of the corresponding object. A POST request is made to a PHP server, containing a JavaScript object of the id of the clicked appliance, the current time as a Unix timestamp and whether the appliance was turned on or off: This is the data collected by the app, which is saved in JSON format. When a button is clicked, the current state of "allMachines" is saved to local storage, allowing the application to resume its state if its browser tab is closed.

"App" passes a computed property list of turned on appliances (objects in "allMachines" with property "isOn" set to true) to "MachineList", sorted by wattage rating. In "MachineList" the name, wattage rating and time turned on is listed for each appliance, with a second set of column headers rendered only when the first column is full. The adding/removing of elements to/from the list is animated, and the "Shuffle" button in the first version screenshot (Figure 5) is from the development of these animations.
While the first version of the app was designed at a 2560X1440 resolution, some changes were made in later versions to better fit the 1920X1080 resolution of the laptop that staff would be using. Short names were added to the map to make distinguishing appliances easier, especially the ones within the same category, which have the same color. A red dot marked "PC" was also added to the map where at the laptop’s planned position, to facilitate orientation.

Figure 5: First version of application

Figure 6: Later version of application
The final version of the application prototype contains the Grafana graph embedded, as well as some additional appliances: two pot washers, a tunnel dishwasher, and food heating in the school cafeteria. These were added by requests from kitchen staff: On 05/05 dishwashers were requested, and 10/05 the food heating was requested. The list and the map had to be re-scaled to make space for these additional appliances, and their placement on the map is less true to life than others, as they are in other rooms. The wattage rating of the "FRIMA" appliance was updated, as the previous rating was incorrect, and the "PC" dot was moved to reflect the actual placement of the laptop in the kitchen.

![Final version of application](image.png)

Figure 7: Final version of application

6 Evaluation

On 2021-05-05, the laptop was deployed to the Tiunda kitchen, along with a larger screen that showed a complementary Grafana graph of only the current power consumption (Figure 8). Staff were interviewed to evaluate the prototype, with a focus on: how they felt about using the application, particularly as part of their normal work as individuals and as a team; how they perceived the design of the application and the information it presents; and how the application has impacted their understanding of power usage, especially in regards to their work.
Besides the interviews, a mapping of the collected data onto a Grafana graph is also made (see Visualization of collected data), which is analyzed (see Discussion).

6.1 Method

Six semi-structured interviews with kitchen staff were made on 2021-05-25 using video conferencing software. These interviews were carried out in accordance with guidelines for good research practice[11], and yielded approximately an hour of recorded video. The results have been summarized in English under Results below, and the script for the interviews can be viewed in the Appendix.

6.1.1 Participants

Participants had used the application for 12 days when interviewed, and included men and women of different ages with different duties in the kitchen: One had mostly administrative duties, two were chefs and three were kitchen assistants. All had received
basic instructions on how the application worked, but the purpose and background of the application was more well known by certain staff members.

6.2 Results

6.2.1 Using the application

The placement of the laptop and screen was considered satisfactory, although three staff members pointed out that having a wall-mounted screen, as they had been told was the long-term plan, was preferable. When asked about their experiences using the app, all staff stressed that while actually using the app was easy and straightforward, remembering to click the appropriate buttons was the main obstacle; factors that made remembering harder mainly consisted of stress due to workload, and the distance between the laptop and the appliances being switched on or off. While one staff member described the laptop as being "easily accessible, no more than 10 meters away", another remarked that it would be easier if each button that needed to be pressed was located on or close to its kitchen appliance, and a third found it more difficult to remember clicking when washing dishes in a separate room.

A concern raised by one staff member was that if appliances are turned on more sequentially to reduce power peaks, this involves more trips to the computer than if many are turned on at once: Instead of turning everything on and making one trip to the computer, turning appliances on at three separate times would require three separate trips if trying to contribute accurate time data. Essentially, attempts to decrease power peaks create more work using the application. Another staff member did not seem to agree that the addition of the dishwashers and food heating buttons was necessary, as these were almost constantly in use during the day.

6.2.2 Teamwork

When asked about teamwork, all staff agreed that reminding each other was important for the use of the application. Initially not all staff received instruction on how to use the app or why, but with time those who had been instructed taught the ones who had not, and teamwork was perceived as improving. A pattern emerged where if one staff member was close to the laptop, they would ask their colleagues what appliances they should click. Alternatively, their colleagues would take the initiative and ask them (the person standing close to the laptop) to click on appliances they had recently switched on or off. One staff member pointed out that one of their colleagues took a particularly large responsibility for making sure that clicking was done correctly, which they perceived as positive.
6.2.3 Design of application

Staff generally felt that the design of the app was clear, and especially appreciated that the placement of appliance buttons reflected appliances’ layout in the kitchen: “You can tell someone who hasn’t done it before ‘Look, it’s like the kitchen: Oven 1 is up here.’” While the map was clear, none of the staff had noticed the pattern by which the list of turned on appliances was ordered (by wattage rating, descending); one staff member thought that the machine you clicked last showed at the top. This could be explained by their mostly being in charge of machines with comparatively high wattage ratings. Aesthetically, there seems to be room for improvement: One staff member remarked that the application could look more “fun”, although it was not essential, and another described it as feeling ”flat” and ”unfinished”, and in need of more visual polish.

6.2.4 Effect on power awareness

When asked about the application’s effect on power awareness in their work, staff’s responses indicated that there had been some improvement:
Staff member 1: ”You understand the big picture and want to change it, and that small means may suffice.”
Staff member 2: ”If you could turn them (the ovens) on within a 10-minute interval (rather than all at once), and it would work for us, you could decrease the power peak. We’ve been thinking about that, which we didn’t all in the beginning. It’s been sort of incorporated into how we work.”
Staff member 3: (example of thinking more about how appliances are used) ”Shit, all ovens are running now, do we really need to start another one? Could we wait a bit?”
Staff member 4: ”I don’t know anything about electricity, but I now understand that there’s a lot of electricity involved. Before, I never reflected upon the fact that we have these peaks and that electricity costs more during these peaks than when less electricity (power) is used.”

While staff had gotten an idea of the overall power use of the kitchen, when asked about the power consumption of individual appliances, knowledge seemed less improved: Most considered it unchanged, one noting how the use of many appliances coincided with each other, and how this made telling their individual impacts apart difficult. One staff member pointed out the fact that they had yet to see the results of the collected data, implying that seeing that data visualized would probably make a difference in how they perceived their power use. Another suggested that more obvious positive/negative feedback would make staff both more aware of power peaks and motivated to minimize them.

A different staff member was surprised when, after turning off all machines, the power usage as indicated by the graph did not drop. They attributed this to a delay in power measurements (although the cause is likely something else, as the delay is currently only one minute).
6.3 Visualization of collected data

Figure 9 shows the collected appliance usage data for the period 2021-05-06 - 2021-05-28, manually added on top of a Grafana graph of total power usage for the same period. There is one row for each machine, and the rectangles in each row show the use times for that machine.

Figure 9: Grafana graph overlaid with kitchen appliance usage data
7 Discussion

Staff in general had a positive attitude towards the application, the deployment of which is in line with two of the most successful Intervention Functions of the BCW, as identified by Staddon et al. in their review of workplace interventions: "Enablement (including direct support and greater control to employees), Environmental Restructuring (particularly automated and retrofitted technologies) and Modelling (various forms of social influence)."[4] The application is a form of Environmental Restructuring, as it is a retrofitted technology that provides Enablement in the form of information (the power graph) that supports staff in their efforts to reduce power peaks.

Looking at the Fogg Behavior Model[6], the application seems to have both increased ability (thanks to the graph) and provided triggers to think about power consumption and adjust behavior (all parts of application). Without a graph, there was simply no way for staff to accurately perceive how much power was being used, severely limiting their ability to reduce power peaks. While it would be possible to attempt reducing power peaks based on intuition and guessing, for example by turning on power demanding appliances sequentially, it would be difficult to know exactly how long to wait between turning on appliances to achieve the desired reduction, and the extent of the achieved reduction. Receiving actual feedback in the form of a graph likely also increases motivation, as the results of staff’s efforts can be viewed by staff themselves. While groups for both interventions studied by Kantzeff et al.(2013)[7] described frustration over not being able to influence what they saw, the kitchen staff using this app would hopefully feel the opposite as their efforts are "rewarded" by a visible decrease in power peaks.

Considering the Ancestral Tendencies presented by Griskevicius et al.[8], the application seems to harness the potential of 3, "proclivity to unconsciously copy others", and address the issue of 5, "proneness to disregard impalpable concerns". Based on the interviews, the teamwork aspect of using the application seems absolutely essential to its success at gathering data, as staff are both encouraging each other to click when turning on/off appliances and clicking for each other. When staff as a group do their best in using the application, individual staff members are more likely to do the same (they copy seen behavior, consciously or unconsciously). The risks associated with this copying of behavior, is that if the opposite happens (some staff members stop using the application/are not carefully with the timing of clicks), that behavior risks spreading, and the quantity/quality of collected data will go down. The graph, and perhaps the clicking of appliance buttons, has certainly made the issue of power peaks caused by kitchen activity more palpable, as it is now something that can be perceived in the working environment. The interactive aspect of the app has prompted staff to approach the computer, but there is a risk that as the novelty of using the application decreases, or it is replaced by a fully automatic presentation of power data (as was envisioned in Figure 2), staff’s interest will decline.

Just as the live graph provides staff with a clear result of their efforts at reducing
power peaks, the result of their efforts clicking (gathered data) should be presented to
them in an intuitive and useful way. As was noted during the interviews, the "payoff"
staff receives is not yet clear to them, and receiving this payoff is most likely essential
to providing meaning to both the work done so far and future work.

In Figure 9, the visualization of the collected data, some observations can be made:
There are both very large rectangles (conspicuously spanning non-working hours), indi-
cating times when staff has forgotten to turn off appliances in the application, and very
small rectangles. A zoomed in view of data for 2021-05-14 in Figure 10 shows the pat-
tern more clearly: The small rectangles could be explained by: 1) accidental clicks (i.e.
clicking on the wrong appliance and correcting the mistake); 2) the intentional addition
of a "symbolic" use time rather than a literal one (i.e. someone forgot to click for a
turned on appliance before and are now compensating) in order to provide temporally
flawed data rather than no data; 3) the data truly reflects how the appliances were used
(sometimes only a few minutes at a time), according to staff’s perception of what con-
stitutes the "turning on/off" of an appliance. 1 and 2 are the more likely explanations
for times spanning two minutes or less, while times of five minutes or more could very
well be accurate, and so explained by 3.

By monitoring the day-to-day data collection, two "incidents" were also noted: In the
morning of 07/05 staff did not know how to access the app (as indicated by a lack of
collected data), and on 17/05 the newly introduced dishwasher and heating buttons
were unused while others were used. This was confirmed to be due to considerable staff
absence, rather than technical issues.
The precision of the data is much greater than that of the pen and paper notes that staff kept earlier (see Figure 3 for mapping), and so it is possible that staff’s work is characterized by short, burst-like uses of appliances. This would be important to consider when trying to decrease the intensity of power peaks: While some of the overlapping use of appliances may be difficult to get around, it may be possible to delay the use of some appliances by a few minutes to decrease the intensity of peaks. A dialog with staff is necessary to determine how their actual work patterns translate to the collected data, and what changes to behavior are realistic to make, without them being a detriment to productivity or job satisfaction.

The application has already started engaging and educating staff, in a way that a less interactive approach might not have: By manually registering the use of appliances, a connection between physical work and abstract power may have been formed at a conscious or unconscious level. This connection may help with understanding the power and appliance usage data when presented with it, as well as future, automatically collected data; the "graphs on the screen" are not just pictures, but the result of staff’s behavior in the kitchen. Hopefully, the application has helped bring "power" into staff’s professional vocabulary, and made it less abstract.
8 Conclusions

The application has made kitchen staff more aware of how their work requires power, and that peaks in power consumption are less preferable than a more even power consumption. They have also gained some understanding of how these peaks can be avoided. Much of this is thanks to the graph part of the application, although the interactive clicking of buttons in the application when turning machines on and off might have played a role in engaging staff. Interacting with the application was generally perceived as positive, and not a major disruption of normal work flow.

The visualization of appliance use times, based on the collected clicking data, will hopefully give important insights into how behavior changes can reduce the intensity of power peaks in the future. These behavior changes need to be decided upon through dialog with staff, dialog which may be anchored in the application and the data collected through it.
9 Future work

A rough visualization of collected data has already been made, but it could be improved in different ways: color coding (with the same colors used for appliances in the application) would make data for different appliances more easily distinguishable; through dialog with staff, the presented data could also be sanitized by changing the values of/not including erroneous data, such as extremely short/long use times. The manually created overlay (Figure 9) would be more useful if done automatically, as well as if it was made interactive (changing views etc.). As a separate application, this could be used not only by kitchen staff, but meal planners as well: With the insights gained from looking at past data for total power consumption, appliance use and meals prepared together, future meals could be planned in a more power conscious manner.

A further improvement to the application would be to implement a dynamic visualization of a "power allowance". As both JavaScript graph libraries and Grafana proved difficult to add the desired style of visualization to, this was left as future work. The ideal would be a "heat map" style gradient background in the live graph, that shows which times are especially sensitive to power peaks. It could be based on electricity price data, as a forecast of supply and demand would approximately reflect the use of power in the region: At times with high prices, a lot of power will (likely) be used, and peaks will occur. The implementation of a similar concept, but added beneath the graph rather than inside it, was started (Figure 10). This animation of bars would match the pace of graph updates, and show which hours are more or less sensitive to power peaks, through the use of colors.

![Figure 11: Concept for peak visualization](image-url)

The application was only tested in one kitchen, and for a limited time. It would also
therefore be worth investigating its use in other professional kitchens, as well as for a longer period.

10 Acknowledgements

I would like to thank my Subject Specialist and Reviewer Mikael Laaksoharju. Since being my teacher in his Advanced Interaction Design course, he has been a source of great inspiration and invaluable support. With everything from evolving my interest in interaction design and establishing my contact with STUNS, to discussing design ideas and how to implement them, he has gone above and beyond. For this, I am incredibly grateful.

I would also like to thank my supervisors at STUNS, Fredrik Björklund and Magdalena Boork. They have provided me with plenty of encouragement and guidance, addressing issues big and small, and the opportunity to make my bachelor’s thesis about something meaningful.

I owe my thanks to the members of my project group in the Advanced Interaction Design course, ”The Wondrous Experience Team”: Li Chen, Hao Sun, Tom von Sydow and Hugo Vialle. I had lots of fun Theorizing, Hypothesizing and designing with you, and much of what we did served as a basis for this thesis!

My academic advisor Olle Gällmo was of great help in resuming my computer science studies after a long hiatus. I want to thank him for his good advice, and assistance with practical matters.

Finally, I would like to thank my girlfriend for her support, and inspiring me to do my best with this thesis.

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11 References


12 Appendix

12.1 Script for staff interviews (Swedish)

0. Vad tycker du om placeringen av laptop och skärm?

1.a Hur upplever du användningen av appen, rent allmänt?
1.b Påverkade användningen av appen någon del av ditt/ert arbete positivt eller negativt? Hur?

2. Hur har appen påverkat din uppfattning om:
2.a kökets effektanvändning som helhet?
2.b olika delar av ditt arbete, t.ex. att koka, diska?
2.c enskilda maskiners effektanvändning?

3. Kan du ge exempel på:
3.a Hur det har gått för dig att klicka?
3.b Teamwork kring användningen av appen, t.ex. att påminna varandra om att klicka eller klicka åt varandra?

4.a Vad tycker du om appens design?
4.b Hur upplever du de olika delarna av appen, d.v.s. grafen, listan av maskiner respektive knapparna (kartan med maskiner)?
4.c Märkte du något mönster i hur maskiner var organisera?

5.a Vad upplever du är det bästa respektiva sämsta med att använda appen?
5.b Vad skulle kunna förbättras med appen?
5.c Vilka funktioner skulle du vilja se i en framtida version av appen?

Övriga kommentarer?