Summary:

Bestræbelsen på at reducere CO_2 udledning er blevet et globalt mål, som er jaget på forskellige sociale niveauer. I takt med at vedvarende teknologier, som sol- og vindenergi, forbedres og dermed bliver mere pålidelige, bliver de samtidig et bedre alternativ til fossile brændstoffer. Det forventes at disse teknologier er i fortsat vækst, med fokus på selvforsyning. I forlængelse af dette har de seneste studier fokuseret på at flytte disse teknologier ind i den almene husholdning med mål om at ændre vores daglige rutiner. Dette har medført en vision blandt udviklere hvori energiforbrugere samles i såkaldte "energy communities", med en fælles bestræbelse om en grøn omstilling.

Ovennævnte initiativer taler ofte til det rationelle i den almene energiforbruger ved at forsyne dem med "shifting strategier" og "eco-feedback". Disse initiativer er ofte designet ud fra et top-down teknologisk perspektiv, som udelukkende indebærer udviklernes forestillinger og forventninger af energiforbrugeren uden at inkludere de social dynamiske aspekter ved energiforbrug.

Nærværende speciale har til formål at belyse hvorvidt top-down perspektivet af et energy community, stemmer overens med normerne og værdierne i den almene husholdning. Dette vil blive gjort ved at kvalitativt studere brugen af en community baseret app, designet ud fra top-down perspektivet. Mere specifikt, vil vi anbringe denne app i seks forskellige husholdninger i én måned og derigennem etablere et energy community baseret på udviklernes vision. Vi vil gennem kvalitative interviews undersøge deltagernes oplevelser på husholdning og community niveau. Den indsamlede data vil derefter blive tematiseret for at danne et overblik over deltagernes oplevelser og dermed belyse hvorvidt designet stemmer overens med deltagernes normer og værdier. Denne data vil yderligere blive brugt til at diskutere fremtidige community baserede energisystemer.

Questioning the Top-Down Design Vision of an Energy Community: A Field Deployment Study

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ABSTRACT

The idea of establishing energy communities has been debated and investigated within sustainable Human-Computer Interaction (HCI) in the last couple of years. In this paper, we investigate an energy community developed through a top-down design vision, which is represented in a community based mobile app. To do so, we gathered six households in an energy community and deployed the app into each household for one month. Through a qualitative study, we describe the households' experiences of living with the app on an individual and a community level. Our findings are presented in five categories, which provide an insight into the participants experiences. Finally, we discuss alternative design visions for energy communities and how these can be beneficial for future development. The main contribution of this paper is twofold: 1) a field deployment study of a top-down designed energy community facilitated through an app. 2) a discussion on alternatives to the top-down design vision.

Author Keywords

Energy community; top-down; shifting; eco-feedback; sustainability; field deployment study; content analysis

INTRODUCTION

An effort to reduce carbon emissions is a global ambition, which is pursued on multiple societal levels. Intergovernmental organizations such as the UN have through initiatives like the 13th Sustainable Development Goal pushed national governments to collaborate in policymaking to reduce emissions through the utilization of renewable energy [24]. As renewable technologies such as solar energy and wind power are improving, they become more reliable and thereby better alternatives to fossil fuel-based solutions [30]. The continuous development of these technologies has also made them more scalable and affordable, which enables countries to leapfrog to more sustainable alternatives. This technological empowerment is especially present within the EU, where citizens are able to produce, store and sell their own renewable energy. It is expected that the growth of renewables will continue to increase, especially in the form of self-consumption [45]. In addition to this, recent studies are supporting the idea of reducing carbon emission by moving these technologies into our households, aiming to change the way in which we go about our everyday practices [36, 40].

This has led to developers envisioning a world where consumers are taking energy-conservation [32] to another level by coming together as energy communities and cooperating as a unit in the pursuit of being "green" [8, 25]. In connection to this, organizations are seeing the potential for developing technologies and applications, which seek to help the average consumer to control and manage the use of home appliances such as dishwashers and vacuum cleaners [29, 46, 47]. Most of these sustainable initiatives speak to the rationality of consumers by providing shifting strategies through eco-feedback. Shifting is an energy-conservation strategy where consumers move energy consumption to a different and more sustainable time [16, 32]. These initiatives are often designed from a top-down technological perspective, where system design is based on the developers' assumptions and expectations of energy consumers without embracing the socio-material complexity of energy use [18]. Through the top-down perspective, energy consumers are usually portrayed simply as either consumers or prosumers driven by environmental or economic benefits [18]. But how well do these sustainable technologies actually fit into the everyday practices of the family members that make up a household? And do these technologies fit into a community of different households? Does the information they provide even help a community of becoming green? Or are they obtrusive or simply a hassle to use?

In this paper, we investigate if the top-down design vision of an energy community and its associated activities, align with the intended members' daily lives including their everyday practices, interests and willingness to change habits. In other words, we will investigate if the intended use of these technologies corresponds to a real-world scenario. Our investigation will be based on participatory use of the unreleased web-based app, Energy Planner. The app emphasizes energy shifting through the establishment of energy communities. Based on this, Energy Planner allows the community members to take advantage of time intervals where electricity from home appliances is favorable to consume. We will be following the behavior of six households and their experience of living with the app for one month. Based on this, we propose the following research question:

How does the top-down design vision of an energy community align with the everyday lives within households?

RELATED WORK

Energy Communities

The concept and establishment of an energy community has been debated and investigated during the last couple of years. Despite the large amounts of attention from various fields, the concept still appears rather intangible. Due to this, researchers are still investigating different interpretations of the emerging concept. However, most of these investigations seem to follow the top-down design vision with focus on the endless possibilities of new emerging technologies rather than the human interaction and adoption. Investigations following this top-down design vision tend to focus on the ability of making solar [1, 2, 5, 10, 12, 13, 14, 21, 23, 25, 26, 27, 33, 37, 40, 43], wind [1, 2, 5, 21, 23, 34, 40, 43] or hydro [5, 34] energy shareable between members of a community. These communities are supported by various technological artifacts such as visualization feedback devices [7, 21, 25, 34, 40, 43], smartphone applications [27, 40, 43] and communication channels [7]. In addition to this, some of these energy communities are virtual [7, 34], which indicate that the members do not necessarily have any personal or geographical relationship. Currently, most of these energy communities are still on a conceptual basis [1, 2, 5, 10, 12, 13, 21, 23, 26, 33, 43]. The top-down design vision assumes that if people are equipped with the right technological artifacts and information, they will change their habits and adapt to the technology. Furthermore, this vision of an energy community emphasizes financial gain as the primary motivational factor for changing consumer habits. As an example, Mahes et al. presented a design vision, which is based on the perception that community members biggest interest is financial gain [23]. Additionally, the authors of this study had their main focus on the development of the technology rather than the actual use of it. This example illustrates a recent trending paradox within the development of energy communities. A lot of research is being put into the development of new technologies and the possibilities of them, but only a small percentage of these technologies have been empirically tested and deployed in real world scenarios.

The energy conservation strategy of shifting has been investigated on a household level within the field of sustainable HCI [16, 17, 19, 35]. In connection to this, Kjeldskov et al. argued that saving money was the main motivation for shifting energy [19]. Shifting on a community level, has also been slightly touched upon within the field of HCI. As an example, Simm et al. investigated an energy community on the Scottish island Tiree, where members share a community owned wind turbine that distributes energy to the members [40]. Furthermore, the members had access to a so-called eco-forecast display informing when renewable energy was available [40]. By displaying eco-forecasts, the authors proposed the strategy of shifting with the aim of making it favorable to change everyday practices. Even though this is an example of investigating shifting on a community level Jabbar et al. pointed out that the community aspect is still a rather unexplored area within HCI [14].

Contrarily to the top-down approach, some researchers have tried to incorporate the users in the design process through participatory design [4, 8, 9, 44]. Wilkins et al. sought to elaborate on how to design for community members through participatory design [44]. This example indicates an alternative approach, which can be considered bottom-up. In this study the authors sought to incorporate the users in the design process of a Peer-to-Peer energy trading platform for an energy community. This approach correlates with Bødker who states that potential users should participate in the design process and incorporate their everyday life instead of having technology forced onto them [3]. Even though designing for an energy community has been slightly touched upon, the actual use of community-based applications in everyday lives is still to be investigated.

The Top-Down Design Vision

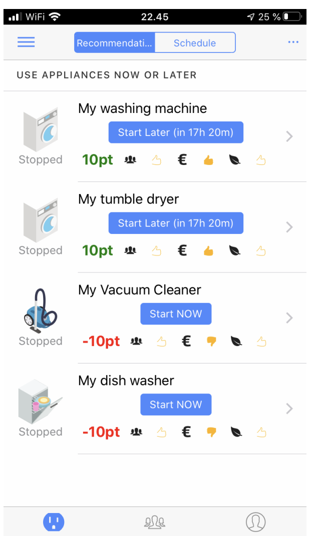
Within the HCI community, complications of a top-down design vision of future systems have been a topic of concern. It is believed that the energy industry is subject to resource bias, which is represented in a misconception of the general energy consumer [42]. Strengers argues that the top-down design vision constitutes a so-called "Smart Utopia" where the social and environmental challenges in the energy sector can be solved by data and technology [41]. This vision imagines and requires a new type of energy consumer who is intended to engage in this vision while significantly benefiting from its possibilities [41].

This new consumer is referred to as the "Resource Man" and is imagined as the ideal citizen of this Smart Utopia. The Resource Man is a smart energy consumer that is technologically interested, gendered and is involved in managing his own consumption [41]. He understands his own energy habits through data and rationally seeks to operate home appliances as efficiently as possible in order to reduce consumption or receive financial benefits. Through the use of energy feedback technologies, the Resource Man actively plans his activities within his household and is driven by data about kilowatt hours (kWh) and greenhouse gas emissions. He is further explained as a social individual who seeks to share and compare his energy data with other resource men. Strengers stresses that this consumer is a misconception based on the vision and consumer expectations defined by the energy industry. This misconception may lead to the exclusion of other visions of sustainable solutions [42].

In contrast to the related studies on energy communities, our study will not solely focus on the functionality of the technology, but rather the adoption and willingness to use it in the everyday lives of households. Our study will further follow Strengers' work on the energy industry's design vision of a Smart Utopia including the concept of the Resource Man and investigate how these assumptions align with actual households. We will focus on how far the top-down design vision is from the real world by studying how a top-down product, designed for communities is received when it is deployed into a community of actual households.

THE STUDY – ENERGY PLANNER

Energy Planner is a web-based application, which purpose is to establish energy communities and generate consumption recommendations for its members. The app has been developed through a top-down approach by the company FlexShape, whose vision is that future energy systems are best viewed through the idea of energy communities [48]. Energy Planner is connected to external data centers, which provide a prognosis of electrical prices and CO2 predictions. The prices are based on trading prices, which are slightly lower than the actual consumer prices. Everything is visualized through an interface, which is accessible through smartphones and personal computers. Through Energy Planner, household members can add their home appliances. In a "My Demand" tab (see Image 1), the members can press "start now" for immediate use of an appliance or press "start later" to postpone the use to a more environmental or economically advantageous time. This tab also gives the members the ability to narrow the households' time flexibility for shifting by pressing the three dots on the top right corner (see Image 1). Additionally, the app has an integrated point system, meaning the "start later" option will award 10 points whereas the "start now" option will deduct 10 points from the community score.



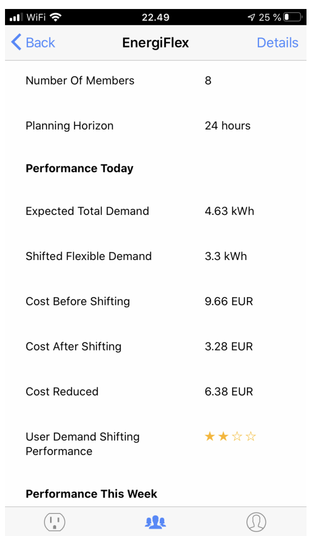


Image 1: "My Demand", Image 2: "Group Demand"

The "Group Demand" tab (see Image 2) is the community feature of the app, as it allows members to join a specific group. Each group has a collective goal of either saving money on electricity or saving the environment. The feature allows members to monitor collective consumption and see how activities affect the community, as activities are recorded and included in the group data. Group Demand resembles the concept of a virtual energy community. This implies that members of the community do not necessarily need to obey location constraints to join a specific community. The group interface shows the overall savings in kWh and euro (see Image 2). Furthermore, each group is given a star-rating based on their performance and ability to hit point rewarding time slots outside peak demand.

METHOD

In this study we seek to investigate a virtual energy community facilitated by Energy Planner. To investigate how the design vision of the app aligns with its intended users, we want to exploratively study how actual users interact with the app and how they feel about the concept itself. To do so, we conduct a field deployment study, which implies that we investigate how users interact with Energy Planner in situ. We chose this approach as "*(...) field deployments provide rich data about how closely a concept meets the target population's needs and how users accept, adopt, and appropriate a system in actual use over time*" [39]. Based on this, we gathered qualitative data to understand how the app was received and how the households interacted with it. From this data, we do not seek to generalize but rather study the participants' experience in the given context.

Participants

We recruited six different households for our study through social network and snowballing. These households did not have a personal relation to each other as we wanted the app to solely be the mediator for the energy community. In the recruitment process we wanted the participants to vary in demographic characteristics. We did this to investigate how the app aligned with different types of users with potential differences in motivation and standpoint towards sustainability. In addition to this, we made sure that all households consisted of at least two people, in order to investigate if the app would interfere with the social dynamics in each household. The total number of participants in these households were 18 people, whereas the actual users of Energy Planner were 12 adults whose age ranged from 28 to 70. The households were all located in Denmark, mainly Jutland, representing multiple parts of the peninsula, whereas one household was located in Zealand. Throughout this paper, we refer to each participant by their alias and city location (see Table 1). After the recruitment of the six households, we gathered the participants in a pre-established virtual energy community, which we named EnergiFlex. To accommodate for equal engagement, we configured EnergiFlex to display both energy and financial savings.

We ensured that every participating household had at least three of the following four home appliances: washing machine, dishwasher, tumble dryer and vacuum cleaner. We chose to focus on these appliances as we presumed they were frequently used, flexible and highly energy consuming. Furthermore, the chosen appliances have a certain chore element to them whereas leisure items and items of sudden needs are not suitable for shifting [19, 35].

Household	Demographics	Appliances	Initial motivation
Aalborg	René, 30, electrical engineer Anna, 28, jurist	Washing machine Tumble dryer Dishwasher	Financial benefit
Albertslund	Jens, 50, key account manager Lise, 43, department manager. Three children: 10, 14, 17	Washing machine Tumble dryer Dishwasher Vacuum cleaner	Environment
Grenaa	Arne, 68, retired Susanne, 65, retired	Washing machine Dishwasher Vacuum cleaner	Environment
Hornslet	Michael, 37, sales person Julie, 39, speech-language pathology Two children: 4, 7	Washing machine Tumble dryer Dishwasher Vacuum cleaner	Environment
Skagen	Johnny, 58, IT manager Bettina, 56, self-employed	Washing machine Tumble dryer Dishwasher Vacuum cleaner	Financial benefit
Svenstrup	Jannie, 47, professional consultant Kaj, 70, retired. One child: 14	Washing machine Tumble dryer Dishwasher Vacuum cleaner	Financial benefit

Table 1: Overview of household demographics (aliases are used)

Data Collection

Our primary data was collected through two semi structured interviews [20] based on open-ended questions [39], which were structured after an interview guide [31]. The data collection lasted from the end of March until mid-May 2020. Due to security constraints initiated because of the COVID-19 outbreak, we chose to conduct the interviews through online video calls, which offer the closest resemblance to onsite semi-structured interviews [15]. The first interview was a preliminary demographic interview that lasted from 10 to 15 minutes and was held with both adults in the household as a group interview. These preliminary interviews started with a monolog followed by questions regarding demography, environmental standpoint, electricity knowledge and chore distribution [Appendix 1]. The preliminary interviews were transcribed and partly used to structure the second interview guide. Afterwards, the participants were given a thorough installation guide of the app [Appendix 2] in which we assisted them through video calls. The second interview was held after one month of deployment of Energy Planner and ranged between 30-50 minutes. This interview served as an in-depth interview with the adults of the household as a group interview [Appendix 3]. The interviews were carried out by one interviewer as well as an observer. The observer would spectate and silently alert the interviewer through direct messaging with additional and follow-up questions. These interviews concerned the participants' experience with being a member of the virtual energy community, EnergiFlex. In addition to this, the interview also sought to illuminate usage of the app, including which appliances were used for shifting most frequently and the motivation for shifting the use of them. The possible difficulties the participants may have faced were also asked to determine whether the app aligned with the participants everyday practices.

In addition to our interviews, we wanted to receive continuous feedback from the participants during the deployment period. This was obtained through short and simple text messages [22] sent to our participants twice a week [Appendix 4]. These contained a few questions regarding their interaction with the app, the group activity of their energy community and their home appliances. To gain insight of how the app was used in situ, we asked the participants to attach pictures of their use. Furthermore, these messages functioned as a way of keeping the participants engaged with the app and to establish credibility [11]. The questions were asked in a neutral language [22] and were asked to see if the participants had had any inconveniences scheduling their appliances. These text messages further helped us structure our second interview guide.

Data Analysis

After conducting our second interviews, we transcribed the six interviews in preparation for the data analysis. Through transcribing and listening closely to the interviews, we familiarized ourselves with the data, which served as a good foundation for beginning the analysis. With this data, we used Conventional Content Analysis (CCA) as a method to interpret meaning from the interviews through inductive category development [11]. One advantage of using CCA is to gain direct information from the participants without utilizing preconceived categories [11]. In addition to this, CCA is also appropriate when existing research literature is limited [11].

The process of analyzing through CCA was done in three steps. In the first step, we thoroughly read through the data and identified code suggestions from expressions in the interviews. As we have been working remotely, our coding was done individually, which meant that some codes had the same meaning but were named differently e.g. "saving money" and "economical savings". To accommodate for this, we collectively merged corresponding codes. In the second step, we narrowed the codes down to derive sub-categories from the aforementioned code suggestions. As an example, we derived the sub-category Financial Benefit from the quote: *"There is quite a lot of money to save if you choose the right start times"* (Kaj, Svenstrup). In the same way, the quote *"I guess you can say that being a part of a group creates a bit of a motivation to compete"* (Jannie, Svenstrup) would derive the sub-category "Competition Between Members". In the last step, we aggregated the sub-categories into general categories. As an example, the previous sub-categories "Financial Gain" and "Competition Between Members" would constitute the category "Motivation". By deriving general categories, we established a structure for the extracted themes, opinions and emotions that appeared throughout the data.

FINDINGS

The data analysis resulted in the five categories: "Usage", "Motivation", "Perception of an Energy Community", "Flexibility" and "Tensions". Each category was derived from additional sub-categories, which will be accounted for in the following sections.

Usage

The use of Energy Planner varied across the households. While some households managed to incorporate the app into their daily routines, others tended to forget to use the app due to a busy everyday life. Additionally, some of the households reported that Energy Planner required some level of cooperation within the household. Based on this, we chose to structure this category from the two sub-categories: "Changing Everyday Practices" and "Cooperation Within the Household".

Changing Everyday Practices

The participants reported that their use of the app span from five to fourteen times a week. Despite the use of the app seemed relatively high, some households reported that their use was decreasing during the deployment period. The Skagen household reported the most frequent use of the app: *"Approximately twice a day"* (Bettina, Skagen). However, this household were also the ones who used "Start now" the most, which could be an explanation of their frequent use of the app. The Skagen household referred to themselves as "woops-users" of the app, as they tended to forget to use the app as a planning tool, but rather as a spontaneous action. The Skagen household suggested that their "woops-use" could be due to their busy everyday life.

As a possible solution to this, several participants suggested that a notification feature would be helpful: *"It could be something like the app notified us by saying 'Now is an optimal time to start your dishwasher'"* (Bettina, Skagen). Other participants stated that they would like some sort of notification after they have used their appliances: *"It would be great if it told us something like 'your appliance is now done and you have saved this amount of money and gained this amount of points'"* (Anna, Aalborg). In relation to this, the Grenaa household had to use a notepad and pencil in order to remember to start their appliances. However, they incorporated the app into their morning routine: *"Just like when you start your day by watching the news, you open the app each morning and think to yourself 'Well, how are the recommendations today? Do they fit my schedule or are they totally off?'"* (Susanne, Grenaa). This quote suggests that the household felt that the app should adapt to their everyday life and not the other way around. The Grenaa household consisted of two retired individuals, which could partly explain why they were able to easily incorporate the application into their everyday practices. However, it seemed like the busy career minded households and the households with children had a hard time incorporating the app into their everyday practices:

> *"Something that has been difficult about the app, has been using it as a family as it was stressful to integrate it into our everyday routine and try to meet the suggestions. This might have something to do with our ad hoc activities"* (Julie, Hornslet)

Image 3: Energy Planner in situ in the households. From left to right, household Grenaa and Aalborg.

Cooperation Within the Household

It was common for all households that one member used Energy Planner more than the other. However, this way of distributing the app was reported to require some level of cooperation between the participants: *"It has been mostly me who have said: 'Well Arne, we have to vacuum at 17:05'"* (Susanne, Grenaa). This implied that Energy Planner not only affected the direct user, but the household as a whole. As an example, multiple households reported that one member used the app, while the other did the chores: *"It was mostly me who scheduled the times and mostly Kaj who did the chores"* (Jannie, Svenstrup). The Hornslet household reported that the cooperation and distribution of the app created some challenges in the household: *"As the app has been installed on Michael's phone, I often had to find him in the garden, and ask: 'What is the status of the app?'"* (Julie, Hornslet).

Motivation

In this section, we investigate if the top-down design perception of motivational factors corresponds to what actually motivates the users. From our findings, it was clear that the participants were motivated by either financial gain, environmental concern or competition between the other community members. Each of these motivational factors will be accounted for in the following sub-categories.

Financial Benefit

In our preliminary interview, three of the six households stated that their primary motivation would be to save money on their electricity bill: *"It would be nice if our electricity were cheaper(...) If you knew that you saved several hundred/thousands a year by doing it a more clever way"* (Anna, Aalborg). However, in the second interview some participants stated that the amount saved through shifting was not sufficient to motivate them, as the numbers were simply too small: *"I don't think there were many benefits from waiting... The numbers and amount saved were so small that I thought to myself 'Screw this, I need my clothes dry now'"* (Bettina, Skagen).

In connection to this, Anna from household Aalborg stated that if she would have saved 100 kroner each time it would be motivating, but that the numbers were too small to motivate her. This further implies, that even though the participants might be motivated by financial benefits, the amount saved has to compensate for their loss of freedom and convenience. However, one household was positive about the amounts saved as they viewed the difference in percentage:*" Sometimes it may only have been a couple of kroner and øre but compared to what we should have paid, we thought it was a lot when we looked at the percentages"* (Jannie, Svenstrup). The Svenstrup household was the only household that was satisfied with the amount saved by the group. The remaining households reported that the overall financial benefits were not sufficient to motivate them by itself.

Environmental Concern

The act of being 'green' or environmentally friendly was also present as a motivational factor during our study. Half of the households stated that their primary motivational factor was that their actions were environmentally friendly: *"I think it would be great if we could help save the environment. I think that is our motivational factor"* (Susanne, Grenaa).

In the second interview, the participants from the Grenaa household reported that the environmental change they had seen by using the app had been sufficient. Unlike the participants who were motivated by financial savings, these participants seemed satisfied with the savings as long as they felt they made a difference: *"We have to protect the world for the next generations - yes, we are motivated by being green"* (Susanne, Grenaa). The Hornslet household shared the same opinion about the environment and further suggested: "*The adults can be the pioneers for this app, but I think it could be a lot of fun to include the kids in it as well*" (Michael, Hornslet). Julie stated that she would have been more motivated if she could see their impact on the environment when using the app. Furthermore, she exemplified how better visualization could be beneficial: *"If you could see that there is one less tree to be cut down"* (Julie, Hornslet).

Competition Between Members

The last motivational factor found in our study was the competitiveness some households showed during the study. This motivational factor was, unlike the two others, not explicitly suggested by the app but was rather established by the participants themselves: *"It was because we were a part of a group. We definitely didn't want to be the most expensive family. There was kind of a competition"* (Jannie, Svenstrup).

However, some of the participants stated that their motivation to compete was limited, as they could not compare themselves directly to the other members in the group. They further elaborated that if they knew who the other members were, they would be even more motivated to "beat" the others. Some participants suggested a ranking system for the group as a part of the competition element: *"You could have a top-10 ranking in your municipality where you could see who had saved the most. To motivate people. I would like it to be a bit of a competition"* (Johnny, Skagen). Household Aalborg shared this idea and reported that they would have felt motivated if they knew how the other households were doing: *"I would be awesome if it was like 'Team green house is doing amazing! They have saved 50 kroner this weekend, shouldn't you get started too?'"* (Anna, Aalborg).

Only one household reported that they had different motivational factors within their own household. Household Aalborg discovered that René was motivated purely by financial benefits whereas Anna was driven by the competition aspect of the group: *"I think that René and I may be motivated by different things(...) René is all about saving money, whereas I like the competition aspect"* (Anna, Aalborg). René further responded that they might be able to combine the two motivational factors by framing it: *"Who can save the most money in a month"* (René, Aalborg).

Perception of an Energy Community

All participants were open to the idea of an energy community, which also led to various perceptions of how a virtual energy community should be constructed. These ideas and feedback created three different sub-groups, which is the basis for this overall category. These include "Community Feeling", "Relationship Among Members" and "Knowing Community Members".

Community Feeling

The participants were asked if they felt any community feeling by being a member of the EnergiFlex community. To this, all households answered that they did not experience a direct community feeling. When asked, the households in Skagen, Hornslet, Albertslund and Grenaa made similar statements to: *"We definitely didn't experience any community feeling that is for sure"* (Bettina, Skagen). The household in Svenstrup said that they had a look at the community feature but did not know what to do with it. The household in Aalborg said they did not feel any connection, however, they were not happy to receive any minus points when using the "start now" option. Multiple households mentioned that a crucial reason why they did not feel connected, was the lack of information about the other members. One household explained: *"Well, it was kinda like a platform with some people on the other side, who I didn't know at all. I didn't feel any responsibility for them about my* *consumption whatsoever"* (Lise, Albertslund). Another household emphasized this with a similar statement: *"I bet they sat around and cursed because I had pressed 'start now' three times in a row, but I just thought it was kind of funny and I didn't really care"* (Bettina, Skagen). Despite missing a community feeling, some households felt bad when they used the "start now" option instead of scheduling their use. The household in Hornslet explained: *"Well, I felt a bit guilty on behalf of the group without really feeling it anyway… I also told you, Michael, that we must be the worst participating members. We just drag the group down"* (Julie, Hornslet).

The same argument was used by the Aalborg household who stated: *I think it's kind of embarrassing to be the one who drags the group down"* (Anna, Aalborg). This argument suggests that the participants, who frequently chose the "start now" option, felt some level of guilt. One could argue that this guilt came from how they are perceived among other group members rather than their environmental or economical actions. Other difficulties faced by the participants were adapting to how their activities influenced the group performance:

> *"We didn't have the energy to think about the group as it required a lot just to follow the app suggestions in our own home. We ran our own routine and didn't have the extra energy to check up on the group"* (Michael, Hornslet)

Overall, the participants did not experience any social connection to the other members. However, some participants showed signs of guilt when their consumption choices had a negative impact on the group.

Relationship Among Members

There was a mutual desire for more elaborative information about the other members, but they had different ideas about what data they were willing to share. Multiple participants suggested an energy community integrating limited personal information: *"You could be assigned an alias? Like the town you live in and that your house or apartment is 100, 200, or 300 m2"* (Johnny, Skagen). Lise agreed on the idea of partial anonymous profiles: *"I mean, you don't have to see people's faces. It could maybe just be some kind of profile"* (Lise, Albertslund*).* The Aalborg household emphasized that they preferred not to share information with strangers: *If it was completely public, I wouldn't like John Doe from Vejgaard to know how much I am using my washing machine. I wouldn't like that"* (Anna, Aalborg). Furthermore, multiple participants suggested that an energy community should be based on similar types of households with equal demography and sizes. Susanne from the Grenaa household suggested two possible segmentations, where one could be "families with kids" and another could be "seniors". This correlates with the following idea:

> *"It would have been easier to get motivated by a family similar to us and see 'Alright, there are other families with children like us who have succeeded to follow the apps recommendations - we should be able to do the same'"* (Michael, Hornslet)

Knowing Community Members

There were multiple examples of participants suggesting personal or familiarized communities as they were not willing to give too much information to strangers. Also, this would arguably make it easier for them to communicate across the community: *"Then you would have someone to chat with like 'It's going pretty good, with the app?' You know, to keep the fire alive"* (Jannie, Svenstrup). Another participant argued: *"A kind of relationship where it is not just fictitious people you are connecting with. It is actually him and her who have this kid"* (Julie, Hornslet). Furthermore, the participants believed that being able to communicate with the community would give opportunities to help each other as suggested by household Albertslund and Grenaa:*"You would be able to share tips and tricks in the group. Maybe someone else figured out a smarter way of doing stuff and would like to share it with the rest of the group?"* (Arne, Grenaa).

When the participants reported being familiar with the rest of the community, multiple argued that it would be harder to choose the "start now" option. One household explained: *"If it was within the family or with the neighbors on the street, you could hear a bit about why they haven't used it enough. You would also have somebody to blame if they did not use it"* (Jannie, Svenstrup). The benefit of knowing other community members was further emphasized by the Albertslund household: *"We live in a housing cooperative and if we had an energy group then we would be in it together and that may have made it easier"* (Lise, Albertslund).

Flexibility

In the different households it became evident that there were very different levels of flexibility and that compromises were easier to manage in some households. Shifting and the way it interferes with everyday practices and general flexibility, served a major role in the interviews. It was discussed in relation to how using the app affects convenience and how the participants tried to adapt to optimal times of consumption through the app itself. The category flexibility serves as a main category which is derived from the two sub-categories: "Compromising Convenience" and "Adjusting to the App", which we will explore in the following sections.

Compromising Convenience

By including households of varying demographics, there were different daily routines as well as different levels of engagement. These were affected by the participants' initial stand on environmental behavior and their approach to the financial side of energy consumption. Therefore, the act of compromising everyday practices was somewhat polarized in the sense that some households had more time to sacrifice to achieve optimal consumption times than others. This polarization of compromises was especially visible in the households with children such as the Hornslet household versus the households where one or both participants were retired as in the Grenaa household: *"We are so privileged not to work anymore so we can wash our clothes in the middle of the day or we can also wait if necessary"* (Arne, Grenaa). In addition to this, the household added that they mostly found the suggestions appropriate: *"I think it has been alright. There were a few times when the suggestions were at 04:00 and they have been hard to follow(...) We skipped those"* (Susanne, Grenaa).

As a retired couple, household Grenaa had the opportunity to wait for optimal times of consumption. They exploited this opportunity to engage with the app: *"We have almost only used 'start later'. I think we have only used 'start now' once or twice. Probably because we do not work anymore, we can be flexible, right?"* (Susanne, Grenaa). The household itself, also reflected on how the situation might be different in households with children: *"It has something to do with our household as there aren't any school children and such. With younger kids you need to be able to wash the snowsuit in the evening and such, right?"* (Susanne, Grenaa).

This assumption correlates well with the app's impact on the Hornslet household's daily lives. Living with two children at the age of 4 and 7, it seems that despite a rather high level of commitment, the parents were challenged by the social dynamics of the household: *"As a family with children, I think it's hard for us to compromise our everyday flexibility. It's just difficult to follow the suggestions when you have to have clean clothes ready for the kids next morning"* (Michael, Hornslet). Furthermore, the household explained how committing to the app had limitations in terms of the start-times that were recommended, as they sometimes conflicted with the logic of the activities following the start of an appliance. The household typically avoids using the dryer and hangs their clothing outside after a wash. Using the app did not always correlate with their perception of rational behavior. Julie exemplified this by telling how she wanted to dry their clothes when there was sunshine, but the app suggested her to wash and dry eight hours later, when it was dark outside: *"In that situation I pressed the 'start now' button as it simply didn't make any sense to wait and dry our clothes outside when it turned pitch black and humid"* (Julie, Hornslet).

As a family of five, the Albertslund household experienced similar difficulties of incorporating the app into their everyday practices. Jens suggested that the app should provide the user with multiple possibilities instead of the binary "start now" or "star later" options: *"If I was able to get an overview of the energy prices for the next 24 hours and thereby be able to control my own delay, I can assure you I would use it!"* (Jens, Albertslund). This statement highlights the need for better transparency and more time options in Energy Planner. During the interview with the Hornslet household, one participant noted how she became self-aware of how dependent the household was on their freedom to act, which was far more than she expected:

> *"We have learned that we are pretty dependent on our flexibility… Our flexibility means a lot to us as a family. Actually, we are not that good at complying with the app. We would have our freedom and our flexibility means so much to us"* (Julie, Hornslet)

This implies that by challenging the participants' everyday practices, they reflected on their norms and values. Furthermore, the Svenstrup household also expressed how the app did not allow them to follow their routines of washing followed by immediate drying: *"The problem is if the tumble dryer time suggestion isn't right after the washing machine finishes. I think it may bring some challenges if you have to wait 17 hours after your clothes is washed to get it dry"* (Jannie, Svenstrup). In the Albertslund household, the family is living in a housing cooperative, which further challenged the participants' flexibility: *"We live very close to our neighbors and I don't think it would be nice to wake them at 5 on a Sunday morning. There are some considerations in terms of neighbor respect"* (Lise, Albertslund).

The norms of respecting neighbors and keeping quiet during the night and early day restricted the household's ability to start the washing machine when suggested by the app, even though it might have been an optimal start time. It was not only the neighbors that would be disturbed from starting machines in the late hours. In household Aalborg, the participants claimed that it would disturb their own ability to sleep at night: *"We don't want our tumble dryer and washing machine to run at night, because they are pretty close to our bedroom. They simply make too much noise"* (Anna, Aalborg). In the Skagen household, a busy day also created friction with the participants willingness to use the suggested start times as the benefits of the app were overshadowed by the convenience of starting the machines when needed: *"In this busy world, where everything should happen immediately, I don't think you are considering waiting 6 hours to save a small amount of money"* (Johnny, Skagen).

Overall, it seemed that the social dynamics and the demands of work including limited hours at home challenged most participants. The luxury of doing house chores at one's own convenience appeared to be difficult to disrupt.

Adjusting to the App

Despite being challenged with their convenience some households learned new things about their appliances. The different households also experimented with adjusting their in-app flexibility interval from 24 hours to slimmer time intervals. These smaller intervals would help them plan accordingly to the app, but other problems arose when adjusting to the app. In the Aalborg household, the participants tweaked their in-app flexibility interval from

08:00 to 16:00 and experienced that even though they used the suggested timing, their actions had a neutral impact on the point system, which meant that they were not able to achieve positive consumption:

> *"I actually haven't really used 'start now', but I have adjusted my flexibility in the app, which has caused me to never get any plus points but only neutral scores. I haven't got plus points the last couple of weeks"* (Anna, Aalborg)

The impact of proper timing also came to light in the interview with the Albertslund household. Here the participants learned that the full benefits from shifting were mostly gained during larger time intervals: *"You learned that if you waited briefly, it was slightly better than using the "start now" option but not as good as if you waited 17 hour for example"* (Janni, Svenstrup). With an emphasis to accommodate early and late start suggestions, the household also learned new things about their home appliances: *"The good part is that we figured out that our washing machine had a timer function so it doesn't have to run during the day"* (Janni, Svenstrup).

Image 4: Household Svenstrup using the timer function

Tensions

Besides being challenged by adjusting to the suggested energy offers, the participants encountered other obstacles during their time with the app. Some of these obstacles led to annoyance while other obstacles led to the participants questioning the concept of the app. The tension category was derived from the two sub-categories: irritation factors and aspects of confusion, which we will be elaborating on in the following sections.

Irritation Factors

The participants described scenarios of irritation while interacting with the app. These scenarios were related to the concept in general and stability issues, which they had experienced. In the Hornslet household, the participants described how the app went from being new and exciting to be a stressful chore:

> *"In the beginning it was more exciting and we were more curious 'Now, what is this?' and then it slightly started to become an irritation factor instead because 'Oh well, I forgot it again, now I have to check the app, now I didn't start it correctly or should I have waited?'"* (Julie, Hornslet)

In addition to this, the household explained how they experienced stability issues, which added further irritation to the usability and limited their desire to plan their appliances as the app sometimes would not allow them to register their consumption: *"We must admit that there have been some situations and days where we haven't had time or haven't been able to register our actions as there have been challenges with the app"* (Michael, Hornslet). These issues were also experienced in other households. In the Albertslund household, stability issues led to short patience:

> *"I had to log in every time I wanted to open the app or at least once a day. And then it was remarkably slow at starting up. Sometimes I had to wait 15 minutes after I logged in until the app was ready. I have to admit that my patience can't handle something like that"* (Lise, Albertslund)

Aside from technical issues, the Grenaa household explained how they felt that their commitment to the app was sabotaged by the other households: *"Sometimes you feel that your great effort from the last 2-3 days can be ruined by some of the other members"* (Arne, Grenaa).

Aspects of Confusion

During the deployment, it appeared that there were things about the app, which raised additional questions and confusion. In the Svenstrup household, the participants found that the visual representation of their actions did not correspond with their intuition: *"I think it took a while before I figured those points out... If it was good to get plus or if it was good to get minus?"* (Jannie, Svenstrup). A majority of the households were confused by the data representation. Some households commented on how the units of measurements were intangible and affected their understanding of their savings: *"Well, we have saved 0 kroner this week and month? I can't figure out how to read this. Cost reduced, 0 euro this month?"* (Anna, Aalborg). Both Anna from Aalborg and Jens from Albertslund explicitly said that they would prefer if the currency would have been in kroner instead of euro. When asked about the point system given in the app, the participants gave very different answers e.g. Susanne explained: "*I like the point system. You can kinda hide your score by starting a cycle where you lose 10 points"* (Susanne, Grenaa). The Aalborg household agreed on this as well. Contrarily, both the household in Albertslund and Hornslet never fully implemented the points into their routines: *"I don't think we have had that much focus on that point system and the measuring units"* (Julie, Hornslet). In Aalborg, the household were confused about the data representation and suggested the following alternative: *"I think it would be nice if there were red, yellow, green and blue members in the group. I would also like to see their statuses visually each on an individual bar to see who has the best progress"* (Anna, Aalborg). Some participants also questioned the concept of the app and wondered about how shifting would help them make greener choices: *"But we haven't saved the environment for anything, if we use the machines as much as we used to?"* (Lise, Albertslund). The same questions were also raised in the Skagen household as one participant noted that the household would eventually use the same amount of energy by not using the app, as the chores had to be done: *"We don't save the environment by starting the vacuum cleaner two hours later, because it will still use the same amount of kWh, right?"* (Johnny, Skagen). Generally, the participants thought that the app lacked visual data representation, as they desired tangible facts and statistics.

DISCUSSION

The findings of this study have raised several questions for discussion in relation to the establishment of an energy community. In the following sections, our findings and their influence on future work will be discussed. Furthermore, our discussion will incorporate prior studies to enlighten how our study has contributed to the field of sustainable HCI.

Is Shifting Really Green?

One of the core principles of Energy Planner is to promote shifting as a way of reducing CO2 emission [49]. However, several of our participants questioned if the practices of shifting really were sustainable: *"Can we agree that my vacuum cleaner uses the same amount of power no matter when I use it?"* (Johnny, Skagen). Jensen et al. commented on this topic and questioned the activities that shifting might bring and whether or not shifting as a whole can be seen as sustainable [17]. In their study, the authors found that some participants actually started to use their appliances more frequently to fit the suggested times. In our study, we experienced a similar situation as some participants stated that their consumption increased when they started using Energy Planner. Furthermore, prior studies also found that shifting may force people to choose unsustainable options as the suggested times may not correspond to when it is possible to e.g. dry clothes outside [17, 35]. The same challenges were experienced in our study by the Hornslet household who had to choose the unsustainable option and press "start now" as they did not want their clothes to be drying outside at night. Likewise, Jens from household Albertslund shared a similar concern as he reported that by drying clothes inside, he would need to open the windows and afterwards turn on their heater, which would use even more energy. Overall, shifting appeared to challenge the social dynamics of the individual households as it required the participants to sacrifice freedom and convenience in order to comply with the shifting strategy.

In addition to this, several participants did not fully understand how shifting could be sustainable as they used the same amount of power. Jens from household Albertslund questioned this and suggested that instead of shifting energy, people should be taught to use less energy in general: "*If you want to incorporate the sustainability aspect, I don't believe it should concern when you use your appliances but rather how much you use them*" (Jens, Albertslund). This quote adds to the discussion whether or not shifting is the most suitable and efficient way towards a more sustainable future.

Community vs. Competition

Unlike studies focusing on shifting on a household level, our study sought to investigate it on a community level. Our findings showed that multiple households began focusing on themselves through a competitive mindset rather than being a part of the community. This was emphasized as: *"I just wanna battle! (...) Yeah! We wanna taunt someone!"* (Anna, Aalborg). In connection to this, Morschheuser et al. argue that individualistic competition can challenge the collective mindset and shared goals [28]. However, Hasselqvist et al. argue that energy communities can be motivated by cooperating and competing against other communities in being the "greenest" [8]. Nevertheless, challenges of competition in general were expressed by one of our participants who argued that the competition aspect could influence consumption in a negative manner: *"You shouldn't start your washing machine multiple times just to win a competition, because then you'll start using it more than you even need to?"* (Jannie, Svenstrup). This quote adds to the discussion of whether the design of Energy Planner can even be considered sustainable.

Furthermore, we found that the current design did not succeed in establishing any relationship between the members as all of our participants stated that they did not experience any community feeling. Some participants suggested that the community should focus on cooperation by helping each other by sharing tips and tricks for sustainable actions: "*If we found a good balance between low price and convenience, we would like to share this with others*" (Jens, Albertslund). In contrast to these suggestions, the participants felt a sense of guilt by being in the community. This was present when their actions affected the community in a negative way: *"I felt extremely bad every time I had to use 'start now'(...) Even my stomach hurt the times I did it"* (Arne, Grenaa). This may raise a discussion, if designing through guilt is an ethical way of motivating members in an energy community. Dourish comments on the problems of framing environmental concern through moral choices and argues that those who are not able to follow sustainable recommendations would be subject to stigmatization [6]. This correlates with how some of our participants stated that they felt sabotaged when other households did not perform well. In addition, Sengers et al. argues that guilt as a design choice is both unpleasant and counterproductive to positive environmental action [38]. The authors further state that sustainable design should move away from guilt and instead focus on enjoyment and personal interests. This implies that the vision of Energy Planner needs to be re-examined as the current design entails guilt rather than enjoyment.

The Right Design Approach?

From our findings, it has been clear that the top-down design approach did not align with the everyday lives of our participants. If this approach is not suitable, how should developers design in order to accommodate the norms and values of households? Jensen et al. argue that in order to obtain more sustainable everyday practices, it is crucial to incorporate every household member and not just the tech-minded member [16]. Our study adds to this statement, as we found that one member seemed to use the app more than the other, which led to tensions and limited them in reaching their full potential of becoming sustainable. As a way of incorporating more members, Wilkins et al. used a bottom-up approach in the design process of a peer-to-peer energy trading system [44]. The authors argue that due to the overwhelming possibilities of future energy systems, potential users need to be incorporated in the design process [44]. Through participatory design, Wilkins et al. found that their participants valued the ability to gather the community around shared values and to configure their own foundational business model for the system. This corresponds to how our participants would like to be able to personalize and segmentize their energy community. In relation to this, Hasselqvist et al. incorporated community members in an iterative design process of an app aimed to reduce collective energy use. This led to a semi-interactive mockup of the app, which was later iterated based on member feedback to support the community's expectations [8].

Our study adds to this, as we found that participatory design might only be the first step towards an optimal energy community solution. As Hasselqvist et al. suggest, we agree that members of a community should experience proposed technologies through an iterative design process. The need for design iterations was also present during our study, as several participants initially stated that financial benefits would be enough to motivate them but after the deployment period the same participants stated that the financial benefits were too small to motivate them anyway. The participants initially proclaimed themselves with a mindset similar to that of Strenger's Resource Man [41, 42] but eventually found that plain data was not sufficient to keep them engaged in the energy community. This further questions the feasibility of the top-down design approach as well as the existence of the Resource Man. In other words, we agree that the Resource Man is a misconception of the energy consumer and that this perception needs to be readjusted. Actual norms and values of an energy community can be difficult to identify purely by developers and we believe that it is crucial to listen and incorporate actual community members as they are the ones with first-hand experience and domain knowledge.

LIMITATIONS

As a basis of determining the validity of our paper, we will in this section acknowledge the limitations of our study. The study has been reliant on participatory usage of Energy Planner and the communication with our participants. Due to the COVID-19 outbreak, we were limited in finding more participants. In addition to this, we were also challenged in our interaction with the participants as we were not allowed to arrange workshops or conduct physical meetings to ensure proper installation of the app. This appeared to be a challenge as the app itself currently is a minimum viable product with limited functionality. To meet these challenges, we conducted a user-friendly installation and usage guide to provide as much remote help as possible [Appendix 2]. In addition to this, we also provided our phone numbers to the participants for additional support.

Even though Energy Planner was active for one month to represent the daily lives of the households, the overall usage and willingness to engage in flexible electricity offers would arguably have been different during a period outside the current circumstances of the quarantine. The isolation may also have had an impact on the participants interest in the app and also their ability to commit to recommendations that they normally would not have been able to accept. Lastly, we acknowledge that the deployment period of one month may not be sufficient to make participants completely change habits and attitudes.

CONCLUSION

In this paper, we presented a study on how the top-down design vision of an energy community aligned with the everyday lives of six households. This was done by deploying the app, Energy Planner, into the households for one month. We qualitatively examined the energy community through interviews and identified five categories concerning topics such as motivation, community feeling and tensions. Our findings reveal that the top-down design vision did not align with the actual norms and values of the community members. The members lacked a community feeling as they did not experience any relationship with the other members. Furthermore, our study contributes beyond the findings as we discussed alternative design visions for future energy communities. By relating prior research in sustainable HCI, we discussed how design should move away from guilt and instead focus on incorporating enjoyment and personal interests. Finally, we discussed future directions for energy community design by stressing the importance of incorporating community members in the design process.

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