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Visualizing household energy use in the interest of developing sustainable energy systems

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Abstract

Energy is an important social resource on which we depend in our everyday lives; however, energy-related emissions constitute a major environmental burden, so in Sweden a major political goal is to reduce total energy consumption and to use energy more efficiently. To achieve this, users need to transform their behaviour and start reflecting on their energy use. This paper discusses three different methods for visualizing energy use, namely information tools, keeping time diaries, and using the “Power-Are Cord.” Each method has its pros and cons, but combining different methods could prove a useful way to drawing attention to household energy use and the possibilities for energy reduction. By combining the data gained from the different methods, we are more likely to find strategies that are better suited to people’s behaviour.

Key words: user studies, energy, visualization

Introduction

The European Union has agreed on a new energy policy. In the policy goals both energy efficiency and reduction of total energy use is central parts and the end-users are important factor in the development and creation of a long-term sustainable energy system. The users are also ultimately the ones who have to pay for the transformation or adaptation of the energy system, which increases their importance as a key component in the system.

Household interest in the environment increased throughout the 1990s, and protecting the environment has been cited as a reason for becoming more energy efficient. However, people's *stated willingness* to behave in environmentally friendly ways have not yet been proven to have had any effect on their actual behaviour. Despite their stated good intentions, people do not seem to behave in environmentally sustainable ways. This discrepancy between what people say and what they do may be partly because households want to answer survey questions in a "politically correct" way; alternatively, their responses may reflect what they really consider desirable, and they may really aspire to live up to what they say, but it may be difficult to translate that desire into practical action (Axelsson and Lönngren, 1995; Nyberg, 1999). This problem could also possibly be explained by the fact that the *connection* between a behaviour and its environmental consequences is invisible. Technical equipment (e.g. heating systems) is often built into our buildings, and is hence hidden, as electrical wiring generally is as well. By striving to visualize everyday energy use, enhancing the visible connection between natural resources and such energy use, we may also strengthen the connection between attitudes and actual behaviour.

We will discuss three different methods to visualize energy in households that we have analysed in our case studies. These are: energy advice directed to households, keeping time-diaries and using the Power-Aware Cord. We will discuss the effects of these methods for making the energy system visible and inducing its users to reflect on their energy use.

1. Energy advice as tools for visualizing energy use

The general invisibility of energy *consumption* presents special problems for those interested in energy efficiency and energy conservation. It is impossible to know if you have saved energy without first finding some means of identifying and quantifying consumption (Guy and Shove, 2000:39). Furthermore research demonstrates that the task of simply informing people of patterns of energy use is persistently challenging (Guy and Shove, 2000; Vareide and Wilhite, 1986).

State-financed energy guidance has been used under periods in Sweden and can be viewed as a type of information instrument used to influence households to become more energy-efficient. Swedish municipalities first began receiving state funding for municipal inspection and advisory activities during the years 1978-1986. These energy advice offices did house calls. The house call soon became compromised to relatively standardized advice recommending additional insulation, furnace adjustments and window sealing (Palm, 2004). The state began guaranteeing that municipal inspection and advisory activities would be state-funded as of the 1985/86 budget year. State support for municipal energy guidance was withdrawn from 1986 to 1998, but resumed on January 1, 1998 (STEM 1999). This guidance concerns areas such as energy, technology and consumer advice, but cannot include inspections, so house calls are no longer possible. During the 1990's efforts have instead been concentrated on providing general information and answering incoming telephone calls (Palm, 2004).

By comparison, energy conservation guidance provided to businesses does involve conveying general information, but much time is spent conducting individual energy audits at companies, which often have shown to be very successful (Gebremedhin and Palm, J, 2005). Studies do

however indicate the importance of giving more individual advice also to households (Shove et al, 1998; Palm, 2004; Bladh, 2005). Shove *et al.* (1998) have shown that household energy use is closely related to the creation of identity and the “image” that the household wants to maintain. Understanding the household’s assumptions and perspectives is thus significant in an advisory context. An energy-saving measure that is consistent with one household’s process of identity creation may not be consistent with another’s, even in cases in which factors such as family constellation, age, and type of residence are similar. Individualized energy guidance is thus important in making it possible to provide individually tailored information that is consistent with other household values.

Individually tailored information is of course expensive. Though, it is interesting to notice that in Sweden there are companies who offer energy guidance in principle for free. We have experience an increased interest from the energy companies, such as E.on. and Vattenfall to offer their customers advice on how to save energy. For these companies this is mainly a way of “branding” electricity meaning, constructing a specific image or profile to attract customers (Summerton, 2004). This was however something tried out in Norrköping in the beginning of the 1990’s when the municipality-owned energy company NME (now acquired by E-on) offered customers an opportunity to receive a summary of their energy consumption. Based on the statistics, the energy advisor at NME was then able to discuss customer behaviour and offer concrete suggestions for improvement. The opportunity for customers to monitor their consumption statistics before and after an energy conservation investment was a popular service and resulted in reduced energy use (Palm, 2004). In some cases the reduction was due to new investments in for example better insulation, but according to the company’s own estimations the majority of the energy reduction was due to change in behaviour such as closing doors and windows and turning off the lights.

Also Bladh (2005) demonstrated that it is important to understand each individual household's activity pattern to be able to offer apt advice. Bladh (2005) conducted an in-depth study of lighting and home electronics in one household in which all lights and electrical appliances were inventoried, and energy use was measured by having the users keep records of when they turned their lights and appliances on and off. For example, he observed major variations in how often lighting fixtures are used. Hall and window lighting was used frequently in the study household, while bedside lamps, for example, were used less. This has a bearing on matters such as the fixtures in which low-energy bulbs should be installed and the behaviour-related issues on which attention should be focused. The microwave oven was another appliance that was used little in the study household (Bladh, 2005). One possible conclusion to be drawn here is that this household should not spend much time collecting information about the energy-efficient microwave ovens on the market, but should perhaps focus more on gathering information about conventional ovens.

The methodology used in this study is similar to keeping time-diaries, that we will be discussing next. But in Bladh's study the household only keep record of when and where they used electricity (or different artefacts) and he did give feedback of the result to the household for own reflection.

If the goal is to reduce energy or at least use the energy more efficient in households the members of the households need to start to reflect on their energy use. One way of achieving this is to inform and give energy advice to households. But as earlier studies indicates these advices need to be more adapted to the single household's conditions, which can be hard to achieve if we also considered factors as time and money. One way to personalize general energy advice is to use methods as self-evaluation and self-reflection, aspects included when letting households keeping time-diaries.

2. Time-diaries to visualize energy-related behavior

The keeping of time diaries can be used as a self-evaluation tool: it allows households to visualize their energy use so it can be reflected on and discussed. In the time diary, study participants record everything they do over a certain period, at what time and using what equipment. Writing the diary is itself intended to visualize the behaviour of the people writing them. These diaries are then collected and the behaviour is depicted using graphs of the behaviour over the chosen days. In this case study (Löfström, forthcoming) the time diaries have been followed up by in-depth interviews. During these in-depth interviews, visual graphs produced from the actual time diaries of the person being interviewed are shown to and discussed with the interviewee(s). The purpose of showing interviewees graphs of their everyday behaviour is to prompt them to reflect on their energy use behaviour. This graphic approach visualizes behavioural patterns in the household and facilitates the interpretation of their movements and activities; a better and clearer view of the everyday life of the informant in its entirety can thus be obtained.

However, measuring time use is complicated. For example, that more than one task can be performed at once, complicating both the writing and the interpretation of time diaries. However, one advantage of time diaries is that one continually, if not completely synchronically, takes notes regarding what activity is being performed. We use open-ended time diaries and not grids of pre-defined activity categories, time intervals, and locations. The benefit with this is that particular activities are not presupposed and it is not suggested that these activities should take certain amounts of time. Time diaries do not suggest what is “normal,” so the risk that a person keeping a diary may try to live up to the researchers’ expectations is minimized.

Through interviews we obtain information regarding the contexts of various decisions, and also obtain insight into the possibilities of a household changing its energy-related behaviour. The graphic presentations generated from the time diaries are used as support during the interview, helping the informant gain an overview and impartial view of his/her everyday activity patterns; the understanding engendered can inspire the informant to change his/her energy-related behaviour.

In our study, which included eight households, all of the households recognized their everyday lives in the graphs, which indicates that the method is good for visualizing behaviour. However, identifying one's own behaviour does not necessarily mean that one will change it. In the interviews it was clear that all the households had reflected on their everyday behaviour when keeping the diaries, but that not all of these reflections were directly connected to the use of energy. They recognized their own everyday activity patterns when looking at the time-diaries as well as at the emanated visualizing graphs. In five of the eight households there had been some kind of reflection on the actual energy-related behaviour. One person noticed for example that she goes around turning the lights out in every room after the other family members. Another young girl said that she could not understand why she opens the refrigerator so often, even though she is not taking anything out of it. She was also surprised to realize that she uses her cell phone almost constantly. Another woman said that she uses the washing machine several times each day, and that she wants to change this behaviour. One man said that he really ought to turn the computer off once in a while—at least when he is not using it. This shows some reflections that a time-diary can result in.

One problem with the method is, naturally, that it is quite demanding: it is a time-consuming process, and getting people motivated to keep time diaries is not always easy. In this study, however, all of the informants did complete their diaries, and some of them were surprised that it

was actually “quite fun once you got used to it”. It is a also time-consuming process for the researcher as well to compile and analysis all the data.

3. The Power-Aware Cord

Energy efficiency has been defined as a technical issue, and research has been performed mainly in the technical sector (Guy and Shove, 2000:55). However, knowledge of how these technological improvements are actually used in people’s everyday lives is less widespread. Since new technology is not effective unless it is implemented successfully in the environment for which it is intended, this is an important area of study. There has been interesting research in this area, but much remains to be done.

Energy information provided to households has increasingly focused on making it easier for consumers to choose among energy-efficient alternatives based on environmental ratings. Although follow-up research into the importance of the environmental rating at the time of purchase has yielded somewhat mixed results, it does indicate that people are at least aware of the existence and meaning of environmental ratings.

One way to use technical artefacts to increase people’s reflection on their energy use is to design everyday products to draw attention to the energy needed for a household’s daily activities. The households that kept a time-diary, described above, also used a prototype energy-visualizing product, the Power-Aware Cord, which is a redesigned power strip that glows with different intensities depending on the amount of electricity passing through it. This is done by dynamic glowing patterns produced by electro-luminescent wires moulded into the transparent electrical cord. The technology in the cord itself of course uses energy, but its amount is negligible.

The *Interactive Institute, Power* (<http://www.tii.se/power>) is developing new ways of representing and interacting with energy in electric products intended for domestic environments. One such product is the Power-Aware Cord here tested. The households used the cord for two whole months.

Our focus has been on the ability of the cord to get people to reflect on the electricity consumption of various appliances. We saw that the households used this cord differently over time. At first, the cord was used simply as an experimental tool for examining household appliances. This was highly informative for the household members, and the fact that the cord displays energy use more intuitively than do traditional energy ratings of household appliances was seen as positive. Representing the amount of electricity by using light, and not a numerical display, supports the notion of ambient information displays that do not force the user to approach the device but rather to receive the information at a glance from a distance. For the first time, households could get an intuitive understanding of the difference in energy demand of different types of appliances, such as vacuum cleaners, coffee makers, and microwave ovens. Only one of the households in the study would have preferred a device measuring energy use numerically instead. However, all of the households in the study thought that the cord was informative, and all had some “aha experiences” in connection with it. After the first “enlightening” period, however, the cord was mainly regarded purely as decorative—all the households likened the cord to Christmas lighting. Some had views regarding the design and functionality of the cord, and some suggestions for improving it were made. All except one informant in one household were receptive to the Power-Aware Cord idea, but not all were interested in buying one in the future. Several informants thought that the Power-Aware Cord would be better suited as an educational tool for schools and day-care centres, than for households. It was also suggested that the cord itself could be used as standard equipment, for example, on coffee makers and electric kettles.

Concluding remarks

Every approach to energy conservation has its advantages and disadvantages. This paper has highlighted three different approaches to energy conservation: energy advice, keeping time diaries as a means of self-evaluation, and the Power-Aware Cord as a technical design.

It is difficult to elicit involvement solely through public information dissemination; instead, it is essential to provide personal contacts on top of impersonal information. In Sweden, energy guidance targeting households has tended to neglect such personal contacts. House calls have currently being uncommon and available resources being devoted to general advice intended for everyone. The importance of personal contacts has been demonstrated with respect to households in several studies. This also points to the difficulty to generate interest in energy issues through generally applicable pronouncements about doing the laundry with the machine fully loaded, putting lids on saucepans, air-drying clothes, etc. Conversely, interest in energy issues is aroused in connection with events that relate to the individual, or when it becomes apparent that energy costs are accounting for an increasing share of household expenses.

The time diary approach starts with household behaviour and attempts to understand household energy use. Though the method is time consuming for both respondents and researchers, the time diary allows us to analyze alternative behavioural paths. In our study all of the households could recognize their own everyday lives in the graphs, which indicates that the method is good for accurately visualizing behaviour. However, identifying one's behaviour does not necessarily mean that one is willing to change it. It is important to be aware that this method can only be effective (i.e. as a means of *change*) if the household members are actually interested in changing their behaviour. No matter how informative and interesting the method is, it does not

matter if the household members themselves are not interested in changing anything in their daily routines. Thus, the motivation for change is crucial. Also, visualizing and discussing household energy use could have an effect on behaviour in the short run, but their long-term effects need further study.

Technical installations is a well-used methodology, while technical design is not that commonly used for pedagogical purposes, to draw attention to what products use more or less electricity. Our study indicates that the Power-Aware Cord is an accessible and intuitive means for achieving a better understanding of energy consumption; however, its effects are not lasting. The “aha experiences” engendered by using the Power-Aware Cord are temporary. The cord appears mainly to be perceived as a decoration for the home environment.

So, one conclusion is that combinations of different methods are needed to promote household energy conservation. Another conclusion is that we need to find conservation-promotion methods that are based on the individual household's pre-requisition and understanding of the energy system and their use of it. The results that come from using time diaries and technical artefacts, such as the Power-Aware Cord, must be included when evaluating different means to ends and in discussing how we are going to meet environmental demands for reduced energy use. By studying how households implement a technology in practice and how and when energy is used, we can achieve a better understanding of effective ways to influence energy use in society.

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